TOBB UNIVERSITY OF ECONOMICS AND TECHNOLOGY
GRADUATE SCHOOL OF ENGINEERING AND SCIENCE

A NATURAL LANGUAGE PROCESSING AIDED RELATIONAL INFORMATION MANAGEMENT APPROACH FOR ARCHITECTURAL KNOWLEDGE FABRICATION

MASTER OF ARCHITECTURE

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Department of Architecture

Supervisor: Assis. Prof. Aktan ACAR

APRIL 2022

DECLARATION OF THE THESIS

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work. Also, this document has prepared in accordance with the thesis writing rules of TOBB ETU Graduate School of Engineering and Science.

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ABSTRACT

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Throughout the ages, the cumulative production of knowledge has driven civilization forward. The knowledge fabrication process is extracting and analyzing meaning from unstructured information heaps and the knowledge of architecture is not an exception to this. Accordingly, the organization of this information is one of the most vital elements for developing disciplines. Human collects and juxtaposes information within its capacity and limitations, which may inadvertently lead to biased and bounded conclusions. Therefore, no matter how detailed and extensive the content of architecture is, the fabricated knowledge will be within the boundaries of the researcher's knowledge, interest, and capacity.

There is a complex body of data for the architecture discipline spread over many fields and fed from various disciplines, events, and approaches. It can be claimed that each piece of information that dwells in architecture is relationally intertwined with each other creating a network. This study aims to try a new relational information organization method for architecture that might lead to new theoretical expansions by making complex and undiscovered relational analyzes readable and manageable for researchers' perceptions.

Obsidian.md was deemed appropriate for this study, which is a hypertext-based networked content tool that produces layered, relational, and expandable networks between semantic data pieces. With a potential auxiliary tool to embody and simulate the network of relationships for architectural knowledge, it is aimed to manage the chaotic information into meaningful and readable expertise to the human and reveal uncharted associations for researchers. Due to the sheer volume of data and the need for a systematic, consistent, and rapidly established structure, the use of artificial intelligence algorithms for such a tool has emerged. For this reason, the artificial intelligence field NLP (Natural Language Processing), which is used for semantic data organization, is included in the study.

The scope of the thesis covers two themes: the presentation of NLP and a relational content management tool as a possible axillary tool for architectural information organization; and the investigation of fundamental principles and definitions to be used for this NLP aided content management approach for structuring and exploration of architectural knowledge.

As a result of the study, a workflow was established between NLP technology tools and Obsidian.md. Within the scope of the determined subject Ankara Roman Bath, a relational knowledge network was obtained through the Obsidian.md tool and the integration of future source texts into this network graphic was optimized.

Keywords: Architectural knowledge, Information management, Semantic networks, Natural language processing

ÖZET

Yüksek Lisans Tezi

MİMARİ BİLGİ FABRİKASYONU İÇİN DOĞAL DİL İŞLEME DESTEKLİ İLİŞKİSEL BİLGİ YÖNETİMİ YAKLAŞIMI

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Çağlar boyunca kümülatif bilgi üretimi medeniyeti ileriye taşımıştır. Bilgi fabrikasyon süreci, yapılandırılmamış veri yığınlarından anlam çıkarmak ve analiz geliştirmek olarak özetlenebilir. Bu bilgilerin düzenlenmesi disiplinlerin geliştirilmesi için en hayati unsurlardan biridir. İnsan, kapasitesi ve sınırları dahilinde bilgi toplar ve yan yana getirir. Bu durum, istemsiz şekilde taraflı ve sınırlı sonuçlara yol açabilir. Aynı şekilde mimarlığın içeriği de ne kadar ayrıntılı ve kapsamlı olursa olsun, üretilen bilgi araştırmacının ilgisi, bilgisi ve kapasitesinin sınırları içinde olacaktır.

Mimarlığın birçok alana yayılmış ve çeşitli disiplinlerden, olaylardan ve yaklaşımlardan beslenen karmaşık bir veri yapısı vardır. Buna göre, mimaride yer alan her bilgi parçasının ilişkisel olarak iç içe geçerek bir ağ oluşturduğu iddia edilebilir. Bu çalışma, mimarlık alanı için yeni bir ilişkisel bilgi düzenleme yöntemini denemeyi amaçlamaktadır. Bu sayede, karmaşık ve keşfedilmemiş ilişkisel analizleri araştırmacıların algıları için okunabilir ve yönetilebilir hale getirerek yeni teorik açılımlara imkân tanınacaktır.

Obsidian.md bu çalışma için uygun görülmüştür. Bu program anlamsal veri parçaları arasında katmanlı, ilişkisel ve genişletilebilir ağlar üreten hipermetin tabanlı bir içerik örgütleme aracıdır. Mimari bilgi için bu ilişkiler ağını somutlaştıracak ve simüle edecek yardımcı bir araçla, kaotik bilgiyi insan için anlamlı ve okunabilir bir hale getirmek ve araştırmacılar için keşfedilmemiş çağrışımları ortaya çıkarmak amaçlanmaktadır. Veri hacminin büyüklüğü ve sistematik, tutarlı ve hızlı bir yapıya duyulan ihtiyaç nedeniyle yapay zekâ algoritmalarının kullanımı gündeme gelmiştir. Bu nedenle semantik veri organizasyonu için kullanılan yapay zekâ alanı DDİ (Doğal Dil İşleme) çalışmaya dahil edilmiştir.

Tezin kapsamı iki temayı kapsamaktadır: mimari bilgi organizasyonu için bir yardımcı araç olarak NLP ve ilişkisel içerik yönetim aracının sunumu; bu NLP destekli içerik yönetimi yaklaşımı için kullanılacak temel ilke ve tanımların araştırılması.

Çalışmanın sonucunda NLP teknolojisi araçları ile Obsidian.md arasında bir iş akışı sağlanmıştır. Belirlenen Ankara Roma Hamamı konusu kapsamında Obsidian.md aracılığı ile ilişkisel bir bilgi ağı edinilmiş ve gelecek kaynak metinlerin bu ağ grafiğine entegrasyonu optimize edilmiştir.

Anahtar Kelimeler: Mimari bilgi, Bilgi örgütleme, Semantik ağlar, Doğal dil işleme

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To Tashkent, Uzbekistan where I completed most of the work, and to my small family I acquired there.

Finally, to my family whose presence kept me going.

CONTENTS

ABBREVIATIONS AND DEFINITIONS

NLP	: Natural Language Processing
AI	: Artificial Intelligence
BIM	: Building Information Modelling
ANT	: Actor-Network Theory
NLTK	: Natural Language Toolkit
AAT	: Art and Architecture Thesaurus
WebGL	: Web Graphics Library
CSS	: Cascading Style Sheets
LOD	: Linked Open Data
RDF	: Resource Description Framework
Chunking	: A meaningful phrase building tool. After finding the grammatically and semantically labels of the tokens obtained with Parts of speech, chunking segments these parts and groups them as multi-tokens.
Lemmatization	: A technique for pruning and reducing words to their base words.
NEM	: Known as Named Entity Recognition, is a significant form of chunking in NLP. Named entities are defined noun phrases that corresponds to specific sorts of individuals, organizations, dates, locations and so on.
POS Tagging	: Known as grammatical tagging, is the technique of determining the parts of speech of a certain piece of text from its use and context.
Stemming	: A linguistic normalization method that reduces words to their root word or removes derivational affixes.
Tokenization	: The process of breaking down phrases, sentences, paragraphs, and chapters into tokens that assist the computer understand the text better.

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1. INTRODUCTION

"Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?"

— *T.S. Eliot, The Rock*

The organization of architectural knowledge is the process of accumulating, arranging, classifying, organizing, and archiving every piece of data and information about the abstract and tangible products of the architectural discipline. Any written, oral, and digital data can be included in this discussion. Every piece of information plays a vital role in developing any discipline. Throughout its history, the field of architecture has succeeded in producing a collective accumulation that can be transferred to future generations with textual and architectural practices.

However, it is open to debate that these ongoing knowledge organization approaches are the ideal method for dealing with the knowledge of architecture. Continuing strategies have adopted common approaches for general knowledge management and have not been tailored to the characteristics of the architectural discipline. This research focuses on searching for an alternative information organization and management system for architectural knowledge. This chapter will introduce the background and context of this study and provide information about the study's aim, method, and scope. It will also provide an overview of the general flow and contents of the thesis.

"Data" is a raw, unprocessed, and unfiltered form of information. "Information" is a refined and organized version of data that can be used for analysis. "Knowledge" is an interpretation of the collation of data and information with human insight (Kelley, 2002). The" information organization" studies the methods, tools used, and activities of accumulating various information resources for human use (Joudrey et al., 2017). Along with all kinds of tangible elements such as datasets, documents, images, maps; memories, culture, verbal agreements, collective consciousness can also be counted among these data sources. With the development of technology, locations for information storage have been dramatically transferred to the digital environment. A digital copy of almost every written, drawn, and concrete piece of information has been recreated (*Internet Archive: Digital Library of Free & Borrowable Books, Movies, Music & Wayback Machine*, n.d.). The human mind can reflect, capture patterns, categorize, and associate with intuition. On the other hand, today's digital tools come through strongly to gather, process, and analyze large amounts of data. To store, process, and share data, manage information flow, and boost productivity, databases, spreadsheets, communications platforms, content processing tools, and data managers are employed. In each setting, information is derived from data, arranged, and interpreted (Matysek & Tomaszczyk, 2020).

While this ensures the endurance and accessibility of data, it also offers new opportunities for its reconfigurations. Apart from the presence of computers' digitized data, the discovery of the internet marked a turning point in the organization and production of knowledge. The internet, an infinite set of interconnected data, has become a revolutionary approach to organizing the already linear and singular stored pieces of data. With the inclusion of digital culture, it produced new concepts on the organization of information, such as metadata, hypertexts, semantic networks, thesauri, and ontologies.

The knowledge of architecture has taken its share of this situation and continues to do so. Written texts, drawings, and analytical means of expression have been the main areas of communication and capturing architectural information (Crowe & Hurtt, 1986). Various approaches such as theoretical discussions, historical and archival studies have been actively used to organize this architectural knowledge to date. With the inclusion of computational culture, the discipline of architecture has begun to move its information organization systems to digital. One of the most well-known studies in this field is the structured information organization tool called BIM (Building Information Modelling). This system, developed on building knowledge, represents the discipline's open-mindedness and deficit in this sense.

1.1. Research Problem

The organization of information is one of the most vital elements for developing disciplines for the fabrication of new knowledge and content and understanding the existing state of phenomena. Obtaining, producing, and synthesizing knowledge about a situation or phenomenon is shaped in line with the possibilities offered by its system of information gathering. Therefore, the methodology of the organization gains tremendous importance.

Traditionally, there is a tendency to separate data into controllable and definable parts by categorizing, classifying, and chronologically editing it. Although these approaches have achieved remarkable success in producing the cumulative knowledge of the civilization, they are all managed by people. The human brain is inherently flawed. It collects and juxtaposes information within its capacity and limitations, which may inadvertently lead to biased and limited conclusions.

Similarly, for architectural knowledge, no matter how detailed and extensive the data is, the product will be within the boundaries of the researcher's knowledge, interest, and capacity. Like historical documentation, managing the information of architecture becomes suitable and dependable for the observer. A political scientist, a historian, an economist, or an architect would have different analytical perspectives and outcomes on the same subject. In that sense, it can be claimed that there are many histories or knowledge, written with different approaches and inferences in the world. This may mean missing and excluding some crucial connections to observe the subject extensively. Therefore, it can be claimed that the integrative vast data and the complex relations they hold are yet to be discovered.

Today, it is known that there is a complex body of data that is spread over many fields and fed from various disciplines, events, and approaches. The architecture consists of the combination of these data in multiple forms. Degrading architectural knowledge into physical entities might be unjust to its highly complex and interconnecting nature. While there are various tangible elements such as material, structure, economy, and form which are easily detectable and documentable, many intangible factors should not be ignored. Numerous entities such as cultural, temporal, and spatial data, personal history, memories, and documentation are inalienable parts of the existence of architecture. And included in this data heap, each element has a unique contribution to another, causing an inseparable network of relationships.

1.2. Research Aim and Questions

Data are associated with various combinations. Each time they come together a new outcome occurs; different gatherings result in various information. Elements accepted as information can be used as data for another study. This situation causes possible knowledge that is overlooked, neglected, or unnoticed. Architectural fields store and organize data in mostly independent pieces with its traditional information organization tools, standing in a distant approach to this diversification potential. For this reason, it is argued that a new perspective is needed for the reorganization of architectural information.

With a principle, where these different gathering situations can be observed and managed, other inferences can be made theoretically. In this study, the idea of a new information organization method and tool was opened for discussion to discover, observe, recall all these existing knowledge potentials, and make them manageable by the researcher.

For this new perspective suggested for the rediscovery of knowledge, Antione Picon's proposal on the materiality of architecture was taken into account. Picon defines the materiality of architecture as a relational network. According to him, every concrete and abstract information, concept, and phenomenon in the universe are related; they complement, feed, and create each other (Picon, 2018). In this sense, each piece of information that dwells in architecture is relationally intertwined with each other.

As materials becomes more linked with its transporters and platforms, the future of content is networked. Content evolves in sync with the technology of its medium. Furthermore, academics from various fields must broaden their approaches and tools for networked content analysis. They will need to develop new concepts and visual languages for mapping, analyzing, and describing this networked content (Niederer, 2018, pp. 98-99). As each entity contains a complex web of relations existing independently of the observer's awareness, the idea of an auxiliary tool that rearranges and simulates this intangible network came to the fore. A more comprehensible knowledge structure can be achieved by filtering, arranging, and visualizing the relational positionings of information. Overlapping concepts that cannot be experienced simultaneously otherwise can be observed.

Accordingly, a semantic networked content tool *Obsidian.md* came to the fore. This tool, which is used to produce layered and hierarchical networks between semantic data pieces stored in text form, was deemed appropriate for this study. It models the relational structure defined by Picon, both with its information organization system and its graphical tools and interface. It integrates every data provided as input into its system and produces a legible, tamperable, and expandable information network. As a result, this application generates a semantic hypertext with the information provided and visualizes it with a semantic network graph.

With its structured and standardized knowledge representation, a web of semantic data makes it possible to automate the process of the meaning of information, relate and integrate heterogeneous data, deduce implicit information from existing information (Sack & Alam, n.d.). Since the data inputs will be selected by the researcher, the network established is subjective, and the knowledge that is examined and produced changes and becomes customizable each time. Among the research of this thesis, it is hoped that this tool has the possibility and potential to spark untapped theoretical debates.

Although it is tried to be defined and systematized by principles and rules, the human factor still heavily influences this method. Due to the sheer volume of data and the need for a systematic, consistent, and rapidly established structure, the use of artificial intelligence algorithms for such a tool has emerged. For this reason, the artificial intelligence field NLP (Natural Language Processing), which is used for semantic data organization, is included in the study.

This thesis aims to try a new relational information organization method that might lead to new theoretical expansions by making complex and undiscovered relational analyzes readable and manageable for researchers' perceptions. The research questions are as follows:

- Can a semantic knowledge network on architecture be reproduced, managed, and represented?
- Can this relational method of information organization uncover potential overlooked knowledge waiting to be discovered?
- What contributions can semantic AI tools make to architectural information organization systems?

1.3. Research Motivation, Scope, and Method

The primary motivation of this study is to enhance the mind's potential with this interface that works as a second mind and to increase its efficiency by taking time to interpret the data instead of organizing it. Therefore, a tool has been utilized, which automatically scans the new data entry, takes this data into its body, constantly expands with a method that will reveal new relationships, makes relational arrangements, and organizes them for meaningful, patterned inferences.

The scope of the thesis covers two themes: the presentation of NLP and a relational content management tool as a possible axillary tool for architectural information organization; and the investigation of fundamental principles and definitions to be used for this NLP aided content management approach for structuring and exploration of architectural knowledge.

A fully functioning knowledge engine that is entirely polished or finished is not in the scope of this thesis. Instead, this is a study to extend the conventional and standardized approaches in terms of architectural knowledge. For this reason, the method research study focuses on areas such as approach, method, use of tools, the potential of the application, and development route. Aiming for the augmentation of mind, this approach is not initiated with and intended to produce any theory or knowledge on architecture but serves as a source and guide for these productions. The difference between this study from BIM-like organizations is that it does not try to organize data for the construction of a particular structure or product. It is investigating the possibility of producing theoretical knowledge from these collected data. In short, unlike BIM-derived tools, this study aims to offer new opportunities for knowledge production, not to produce the knowledge itself. In this direction, the knowledge network created on the "Ankara Roman Bath," which is studied as a case, is far from expressing the entire relational information set about the structure. In addition, in integrating artificial intelligence tools into such a system, the applicability and potential of the methods and tools were tried. A working code sequence was reached, but a holistic integration between the two agencies was not achieved.

As the methodology of this thesis, from a theoretical point of view, Antoine Picon's concept of relational materiality in the structure and organization of architectural knowledge is discussed. (Picon, 2018). As an approach that can represent and organize semantic written data relationally, a non-hierarchical hypertext construct was preferred within the conceptual framework defined by Picon. The learning type semantic network, which is open to expansion and updating, was found suitable for the network produced as a final product. (Sowa, 2006). “Obsidian.md” was chosen as the most suitable application for the targeted networked content management model (*Obsidian.Md*, n.d.). This semantic hypertext engine was chosen due to its structural and interface advantages and an effective learning type semantic network graph. NLP (Natural Language Processing), one of the artificial intelligence applications, has been applied to minimize the human factor and its disadvantages.

A sample study was conducted to demonstrate the method and tool. Historical heritage ruin "Ankara Roman Bath" was chosen for this study because of its suitability in terms of content and logistics. However, the subject studied for this thesis is not of importance. Any other architectural product could be selected and applied. This is because the focus of the thesis is the research methodology rather than the content of the case study. While Mahmut Akok's article "Roman Bath in Ankara City" was chosen as the primary data source (Akok, 1968), "Ankara Promotion Brochure" was also included in terms of content diversity (D. Acar, 2013).

The case study consists of two main phases. In the first stage, a manual knowledge network application was tried through the obsidian.md application, and in the second stage, the automation of this experimental work was studied through Natural Language Processing (NLP) algorithms. Optimization studies were carried out to produce an effective information network in the case phase1. After the selected resources were uploaded to the obsidian.md tool, data cleaning, organization, and arrangements were made manually in line with the application’s requirements. The method was tried to be systematized with various principal studies, and the results of these studies formed a base for the next phase. In the second phase, the NLTK toolkit, one of the NLP tools using Python coding language, was tested to automate this manual and human-managed method performed in the first phase. NLP tools such as Tokenization, Stemming, Lemmatization, Named Entity Recognition, POS Tag, and Chunking were used via the Jupyter Notebook editor.

This system aims to produce a constantly growing network by adding new data, uses already existing information processing systems. The contribution of this study is to bring these tools together to discuss their suitability for the discipline of architecture and to construct an automated, fast, and easily expandable system. In this sense, it is necessary to mention the source data processing processes of the two stages of the case study (Figure 1.1). In the first phase, the source texts are individually processed manually and added to the knowledge network. This process was carried out within the framework of specific rules determined by the author. It is a relatively slow, limited, and individual process. The system used in the first phase was chosen to evaluate the use of the tools provided by the Obsidian.md program for the discipline of architecture and to determine the system and principles accordingly. The second phase was developed to adapt this currently used system to the intense and ever-expanding content situation of the field of architecture. In the second phase, source texts are added to the network through a standard and automated artificial intelligence process. This process provides a fast, unbiased, and optimized environment for expanding and layering information stacks. In this way, much more data is processed more systematically. Considering that researchers' evaluation of architectural texts is traditionally read separately and carried out with individual associations, such automation can make a significant difference.

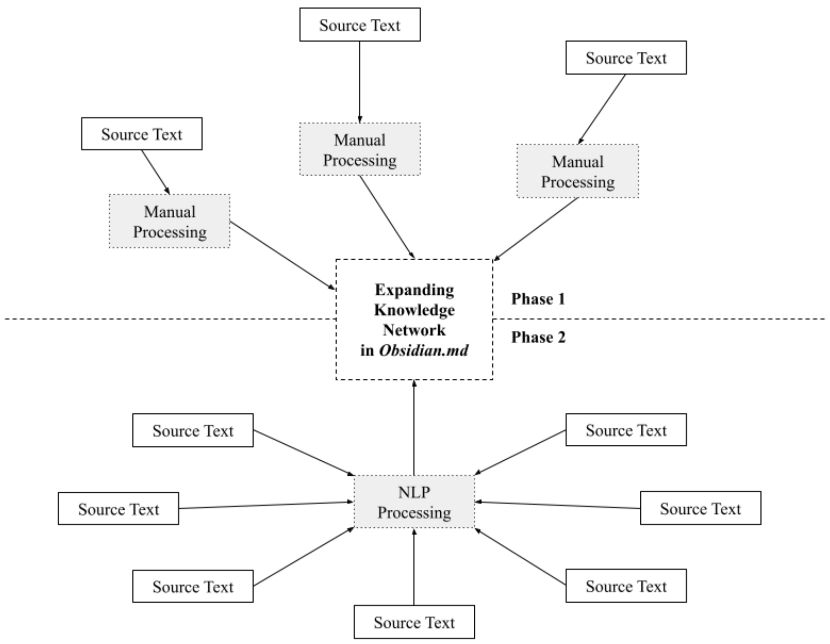


Figure 1.1: Graphic Explanation of the Case Phases (Author)

It is necessary to think about the use of this study in various products of the architectural discipline. Architecture covers; existing structures, the construction, and the design process. There will also be a discussion of the potential contributions of this work for these three phases of architecture later.

Since a historical heritage has been studied in the case study of the research, a review of existing structures on which a lot of data has accumulated has been covered. An arrangement has been proposed on the organization of the data stock accumulated over the years, and an automation for speed and optimization has been proposed. In this way, it is intended to grasp the dynamic structure of the past and to acquire new information from it. In addition, the use of this tool in architectural design and building construction processes should also be discussed. Such a tool can be suggested for the design process so that any possibilities and potential relationships can be highlighted and evaluated in different ways. In ongoing construction projects, interdisciplinary work can enable strong relationships to be established, and various overlaps and regulatory requirements may come to light. Above all, it can be predicted that an automated information processing operation will save significant time in all areas of the building discipline.

1.4. Structure of the Thesis

This thesis consists of five main sections.

The second part discusses the knowledge of architecture, its qualities, and its relations with other disciplines. In line with the definition presented by Antoine Picon, the relational quality of architectural materiality is discussed. After mentioning the distinction between the concepts of data, information, and knowledge, formal knowledge acquisition approaches and the method suitable for the discussed characteristics of architecture are examined.

The third chapter discusses semantic knowledge structures and their management. The concepts of hypertext and semantic networks, proposed as methods for managing architectural semantic data, are introduced.

In the fourth chapter, the two-staged case study process is explained. The manual approach for the proposed information organization system with the Obsidian.md application is introduced in the first phase. The second phase describes restructuring this study with Natural Language Processing (NLP) tools.

In the conclusion part, the results and inferences of the study are mentioned. The contribution of this study to academic and field research, its potential, positive and negative aspects are discussed. Suggestions for the development of the study are also included in the further research section.

2. RELATIONAL KNOWLEDGE FOR ARCHITECTURE

2.1. Understanding Architectural Knowledge

2.1.1. Qualities and types of architectural knowledge

According to Cambridge Dictionary, knowledge is the “understanding of or information about a subject that you get by experience or study, either known by one person or by people generally” (Cambridge Dictionary, n.d.). Knowledge for architects is based on buildings and design, and the combination of the "past and future, art and science, demand and supply, decision making and reflection" in the context of action. It can be claimed that architectural knowledge is the compilation of all kinds of qualitative and quantitative inferences on building, built environment and space and is expressed through a unique combination of tools, processes, and things (Aravot, 1993, p.163). Some of these are technical drawings, sketches, photographs, models; catalogs, archives; historical and explanatory texts, theoretical and practical narratives, collective and professional memory; digital platforms, computer programs, algorithmic digital formats and countless more fields and forms.

It was claimed that the architectural profession’s duty includes the supervision of that body of knowledge, its continuous improvement, and its transmission to following generations through education (Duffy & Hutton, 200 p. 120). Since a single definition, classification, and limitation on the knowledge of architecture was not standardized, reflections on the knowledge of architecture diversify, overlap, and diverge occasionally. In this section, the characteristics, types and approaches of architectural knowledge and various discussions on it will be mentioned.

Russell (1982), Ryle (1946) and Baron (1980), theorizes that each human practice consists of these three types of knowledge: “Know-That” or “propositional” knowledge, “Know-How” or “skill”, and “Acquaintance”. Know-That knowledge is the substance of any rational, discursive, and communicative sentence of the type "X is

Y" and its variants (Aravot, 1993, p. 164). As an example, Nikolaus Pevsner's (1943, p.151) famous introduction statement can be considered: “A bicycle shed is a building; Lincoln Cathedral is a piece of architecture”. "Know-How" or "skill" refers to practical, nearly instinctual knowledge that uses intellectual capacity and/or proper body use. It is defined by Baron as "the ability to apply knowledge to the performance of several related tasks in order to reach certain goals." (Baron, 1980). Every creative act, including the modification of architectural forms or their construction into an entity, involves the individual executing the activity's Know-How. Lastly, Acquaintance knowledge includes identification of an item as a specific object or as belonging to a class of items (Aravot, 1993, p.164).

In his comprehensive work *Towards a Framework of Propositional Knowledge in Architecture*, Aravot (1993) reevaluates these classifications of knowledge over the knowledge of architecture. He claims that most architects' daily and scientific work require all three types of knowledge. However, acquisition of new shareable information, discussion, and critique are entirely dependent on "Know-That" or "propositional" knowledge. He then divides the propositional knowledge for architecture into two other parts: workshop knowledge and directive knowledge. “Workshop-Knowledge” is a storage of accessible and practical knowledge as rules, formulas, or relationships such as data collections, product catalogues, building codes, standards, and norms, and so on. “Directive Knowledge” is the architect's "Know-That", which aids their practical decisions by providing aims and reasons with answering the questions: "What for?" and "Why?". In contrast to Workshop knowledge, Directive Knowledge refers to broad areas of reality and, once embraced, it consistently predominates in the architect's thinking, leading, and supporting his or her judgments. Most crucially, verification and justification of Directive Knowledge are not presupposed but are necessary components of the knowledge itself, requiring the adoption of Directive Knowledge as such. (Aravot, 1993, p.164)

Taking one step further, he also sections the Workshop and Directive Knowledges (Figure 2.1) (Aravot, 1993).Workshop Knowledge is divided into two parts: “Technical Knowledge” and “Architectural Canons”. Technical Knowledge answers the architect's inquiries "what?", "how much?", "by what means?", "in which way?", and so on, with no prerequisites other than the architect himself or herself. Architectural Canons are foundational Gestalten that provide guiding notions for measurements, relationships, materials, colors, and so on. The “canon” term is due to the meanings of “general rule”, “standard” and “principles”. It exemplifies of architectural knowledges transitioning from Know-How to Know-That.

Directive Knowledge is divided into two parts: “Theories” and “Values”. Architectural Theories handles "why?" questions, generally indicating reasons and rarely implying causes. They are aimed to explain current situations and provide forecasts as a foundation for design decisions. Architectural Values contain reasons for design processes and products, both as a-priori directive concepts and as a-posteriori criteria for judgment and evaluation.

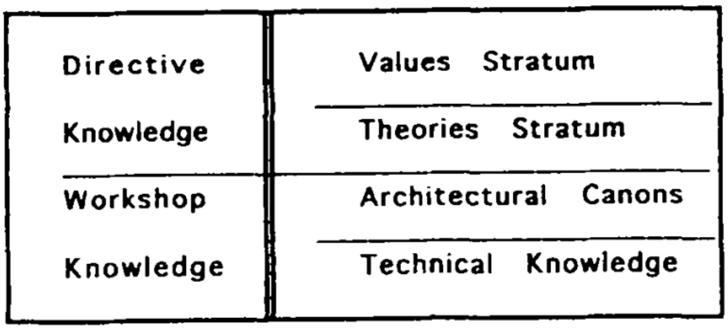


Figure 2.1: Four subsections of propositional knowledge in architecture (Aravot, 1993)

This comprehensive classification study by Arovat is not the only distinction regarding the knowledge of architecture (Figure). There are many approaches to architectural knowledge, in various details, which may or may not parallel this classification.

The opposite pairs such as “conservative-volatile, existence-non-existence, subject-object, discourse-practical, theoretical-tectonic, textual-structural, virtual/ representational-real, concept-building” play an active role in the perception, comprehension, formation, and conceptualization of our built environment (Mennan, 1999). Such dichotomies are frequently observed in studies on the definition and interpretation of architecture's discipline, knowledge, and scope. Durand also mentions various dualities of *specific* against *general*, *physical* against *abstract*, *subjectivity* against *objectivity*, *art* against *science* and so on. These debates provide great value causing to reference these in any discussions on systematization the knowledge of architecture (Madrazo, 1994).

From a perspective on how it was acquired, Habraken (1997) distinguishes practical knowledge from systematic knowledge. Accordingly, the "basic or fundamental knowledge of architecture", the architect's training and mastery of "knowledge acquired through practice", comes to fore. This second type of architectural knowledge is considered as vague, personal, and not easy to define compared to the first. It is difficult to convert this “only earned through work information” into a systematic knowledge (Uraz Ulusu, 1999). From a tangibility standpoint, Durand reflects one of architecture's recurring challenges in his theoretical discourse: the separation of the abstract and the physical reality. He then evaluates them from two perspectives: first, as materials and construction, and second, as form and proportion (Madrazo, 1994). Tanyeli (1999) also stresses a division as “real” and “theoretical” architectural knowledge. Some of these discussions will be furtherly investigated.

Banham (1996) argues that while architectural artifacts, buildings, and cities are frequently discussed and criticized, the underlying design knowledge is rarely examined. It is argued that there never is a single dominant episteme in architecture. On the contrary, as the critic Charles Jencks demonstrates in his famous chart of the developments of twentieth-century architecture, numerous epistemes appear to function concurrently in our discipline. Epistemes are specific thought models that architects use to analyze, comprehend, and intervene in the built environment. They are complementary and simultaneous in architectural culture, and they serve as a link between study and projection, analysis, and design. They also provide a framework for the delineation, conceptualization, and composition of architectures. Avermaete (2021) tries to uncover some of these uncountable amount epistemes of architecture. The first episteme he identifies in architectural culture is typology, the study of types. In general, a *type* is defined as having qualities in common with other persons or objects and, as such, creating an identifiable group within one broader set. Phenomenology is another episteme that has dominated architectural thinking and practice primarily concerned with perception and experience. Semiology is a third key episteme of architecture that treats the built environment as a compilation of signs that may be understood or even “read” like a language. Lastly, since there is a longstanding tradition of perceiving the built environment through its practice as discussed before, the distinct practices of dwelling and construction are at the center of attention at this episteme. These are just a few instances of how architectural culture interacts with a wide range of epistemes (Avermaete, 2021).

According to (Duffy & Hutton 2004), architectural knowledge includes two distinct features. The first characteristic is that it is particularly combinatory and complex. It links the understanding of user needs to the capacity of structures to meet those requirements. Due to the vastness and duration of the existing building stock, it also considers what was done successfully in the past with projections of what should be conducted better in the future. Because buildings are such vast, complicated, and value-laden items, they combine practicality with artistic judgment and unite many disparate parts, the second unique aspect of architectural knowledge is that it is primarily concerned with the deontic instead of the descriptive. Focusing on what things should be rather than things as they are. Duffy and Hutton (2004, pp.132-133) claims the following about architectural knowledge: Firstly, architectural knowledge is distinct from other types of information. Secondly, the importance of developing, applying, and transmitting this unique type of knowledge is very crucial. Lastly, custody of this information requires architects' intellectual and practical responsibilities.

Among many other qualities and definitions of architectural knowledge, it can be claimed that a wide variety of perspectives can be embraced to address this issue. Within the scope of the considerations of this thesis, following statements will be examined:

- The dual classification of architectural knowledge as practical and theoretical approaches in the discipline.
- The interdisciplinary qualities of architectural. Its tendency to be drawn into its own physical/objective existence in search of a solid ground. Architectural space as an eclectic system of thinking above its physical entity.
- Architectural knowledge consisting of a complex network of relations, and the process of sense making of knowledge as an effort to make its relative and floating reality tangible.
- Relational materiality of architecture through Antoine Picon’s and Actor Network Theory
- Further explanations of data, information, and knowledge in terms of the search for new management approaches for architectural information.

2.1.2. Practical and theoretical approaches for architectural knowledge

Tanyeli (1999) claims that architectural thought can be discussed in two main categories. These are the idea that architecture is the subject and is the object. The idea of being a subject includes everything related to the realization of architecture as a series of acts. On the other hand, architecture as an object, does not mainly aim to "perform" architecture in whatever form. It focuses making architecture the object of all kinds of "thinking and understanding" activities. In summary, on the subject's side, architectural knowledge comes into existence by being and taking place; contrarily, there is a theoretical activity that takes this happening as an object and aims to understand it.

Architecture is claimed to be a rather practical and specific discipline in its essence. Therefore, when architecture is handled as a subject, the thoughts on architecture's practical and constructable material may come to the fore. Buildings, their construction methods, and the people who live in them all becomes topics of architectural knowledge (Duffy & Hutton, 2004). Considering the building ontology of architecture, it can be tried to create a repertoire that goes on and on. Weight of the building, ground, topography, ground water, humidity, precipitation, sun, water supply, soil pressure, ground shaking, material erosion, wind, living things (bacteria, maggots, vines, moss), radiant materials, produced materials, building blocks, mortar, building physics, chemistry, durability, lightness, heaviness, linearity, curvature, fragmentation, continuity, mergers, geometry, dimensions... (Yücel, 1999).

In these rough definitions of architectural knowledge, types of knowledge that are not reproduced and created to bring architecture into physical existence tend to be excluded from the picture (Tanyeli, 1999). Therefore, a discrimination needs to be made among architectural products and architectural conceptions. Buildings, building components (accessories, elements, furnishings), and building compositions (squares, streets, neighborhoods) are all architectural products that are either produced or envisioned. On the other hand, the theoretical system that describes, controls, and evaluates the products is formed by architectural conceptions (Aravot, 1993, p.164).

The architectural products and conceptions are mutually influential and cyclical in their relationship, in that the products shapes the concepts and vice versa. It means that architecture needs neither neglect nor exaggerate its non-subjective side. Observing, quantifying, and systematic measurement, which is crucial in engineering, strongly impacts architectural knowledge. However, it is claimed that, in the case of giving far greater importance than it already does, it is likely to be overshadowing the overarching, relative, and qualitative concerns such as taste, originality, fitting in, standing out, achieving the sense of place (Duffy & Hutton, 2004). Accordingly, Schön (2013) stresses that practical knowledge alone is not enough. And architecture faces challenges concerning its own specific knowledge regarding both its practical contribution and its position as an academic, intellectual field (Aravot, 1993, p.164).

In ancient times the primary efforts were to define specific areas of architectural practice. This intellectual focus was more often involved in the methods of construction of architectural structures themselves (Süveydan, 1999). Starting from Vitruvius until the second half of the 1950s, design and architectural issues were intertwined in the architectural discourse. By conveying all tried knowledge, all experience, and even new personal inventions, it is claimed to be informing architecture and design while nurturing intuition and creativity. In this discourse, architectural design is nothing but the acquisition of a product with specific features; it is reduced to its features (Özkan, 1978).

The historical breaking point in architectural knowledge claimed to begin when this activity and knowledge field, which existed purely as praxis for hundreds of years, created a discourse for itself starting from the 15th century. Until Alberti, architectural knowledge is a social institution that defines the realities of its field. The traditional knowledge institution, which consists of the truths agreed upon by the society that it belongs, contains only "knowledge of doing." Architecture cannot yet be thought of independently of performing it and creating it as a product, and it exists only as of the constructed work presented. The only surviving written source on the knowledge of the architect from the ancient times is the *Ten Books on Architecture* (Vitruvius, 1999). Various interpretations of the concepts fabrica/practice and ratiocinatio/theory used by Vitruvius also constitute the source of the theory/practice distinction that continues to be valid today. However, despite Vitruvius' mentions, many of these inferences are far from distinguishing between the architect's professional knowledge and the way the profession is practiced. Knowledge of intellectual design decisions can be defined as theory, and knowledge of the implementation of these decisions, that is, the management of manufacturing, can be defined as practice (A. Acar, 2021). Gwilt interpreted Vitruvius in this framework. He translated the part in which “practice/fabrica” was defined as "comprehensive thinking, detailed reasoning on the management of craftsmanship or manufacture, for the best and appropriate processing of the material". He defined "theory" as the result of this reasoning and expressed it as "explaining and showing the process by which, the material is subjected to meet the needs of the design" (Vitruvius, 1826)

Still and all, this social institution gradually collapsed starting in 15th century Italy. In this case, the world of architecture tried to build and adopt an artificial new institution replacing the destroyed knowledge organization. Instead of an institutionalized real knowledge structure that is automatic, undisputed, and valid for the society to which it belongs, another real knowledge building will be established, the validity of which is based on its rationality. The premodern real architecture knowledge, which everyone unquestionably believes to be accurate, is replaced by discourse, which has been made into a written text, and its reasons have been determined meticulously, which is determined according to its persuasive capacity (Tanyeli, 1999). Starting from the eighteenth century, the poetic, traditional production of architecture has been converted into the modern manner of making, with theoretical knowledge being a primary condition of design (Vesely, 1984, p.121).

Tanyeli (1999) suggests that there are two different types of architectural knowledge: “real architectural knowledge” and “theoretical architectural knowledge”. The relation between reel architectural knowledge and architectural theory is parallel to the formerly discussed subject-object relationship. While real architectural knowledge approaches architecture as a subject, the latter acts as if it’s an object of thought. The “real architectural knowledge” claims to direct and lead the facts. From an epistemological point of view, it does not differ from, for example, roof insulation information, fire protection regulations or a building information handbook. All kinds of "instruction" that guides the execution of architecture, no matter the abstraction level, is the property of real architectural knowledge. From a pragmatist point of view, architecture is perceived as a basic social science with its "useful" and easily put into practice knowledge structure. However, Balamir and Erkal (1999) claims that this approach utterly avoids slippery and uncertain areas and sees them as useless. Consequently, ignores the possibility of architecture being fed by something other than itself.

On the other hand, in theoretical thinking, the process is "about it" rather than "for it.". How it should be done is not questioned, and the main aim is to try to understand how it was made and is being done. It provides an understanding of what exists. Theoretical thinking does not question how the world should be but how and why it is. It considers the activity, praxis, product, and discourse of architecture as an object tries to analyze it and tries to draw a post-factual view of reality by producing models and hypotheses (Tanyeli, 1999). In short, theoretical concerns are not with architectural products, but with discourses about them. It aims to expose theoretical constructs and value premises that dictate what is architecturally important, acceptable, and valid (Aravot, 1993, p.164).

> “Architectural knowledge gets produced and then reproduced. Theoretical knowledge is this reproduced knowledge. To think theoretically is to think about what has been thought.” (Tanyeli, 1999).

Theoretical study is an activity that can make other theoretical studies an object for itself, trying to analyze them in their own historicity. However, real knowledge does not focus outside of itself. Thus, this is the major difference between theoretical and real knowledge thinking, it is not a comprehensiveness difference. While theory tries to understand the existing, real knowledge claims to direct the facts. Still, it might be misleading to assume that the main issue for architecture is theory and not real architectural knowledge. The duality in the nature of architectural knowledge will not be fully grasped not until it is accepted that thinking to make and thinking to understand are not the same thing (Tanyeli, 1999).

Architectural knowledge does not thrive when skills are separated from ideas when practice is removed from theory, but rather when all these elements are put together in the context of action (Duffy & Hutton, 2004, pp. 132-147). Linder claims that, in its simplest form, every theory is a form of practice, just as every practice needs some kind of theory (Linder, 1992, pp.167-168). Tanyeli (1999) discusses the flow and hierarchy between these two concepts as following. While the idea that theory can lead to practice is quite common, statements such as "Theory determines practice" needs to be questioned. Of course, including practice, it serves to model, analyze, and understand partially or completely the very wide area of praxis. Praxis, on the other hand, includes all kinds of architectural representation tools and objects (project, perspective, model), the act of making as in the "real architectural knowledge", as well as including the most familiar types of architectural performance such as building production and implementation of practice. They are strongly interconnected; but there is no direct route from theory to real knowledge.

2.1.3. Above itself: Chaotic structure of interdisciplinarity

In his essays, Banham attempt to analyze the value of knowledge generated during the act of architectural design. Concurrently, he criticized architecture for isolating itself from all other fields of knowledge in society due to its closed and obscure nature (R. Banham, 1996). Theorists generally mentions architecture by relying on methods, terms and concepts that can only be marginally “architectural”. On the other hand, architectural content occasionally encounters with the objects that are not products of architecture. Theoretical attempts to understand architecture inevitably consult to the authority of disciplines that are perceived as more universal and more agile (Linder, 1992, pp.167-168). Architecture can add these objects to its structure by conducting a broader cultural discussion. By rethinking the professional requirement in terms of knowledge, the political and intellectual isolation of the discipline can be reversed; and theoretical discussions that are perceived as "outside" can be included (Leach, 2005, pp.19-21). Giedion (1928) takes a unique approach to the spatial sensations of this intermingling and interpenetration by converting them into a definition of the new architecture that also serves as a guideline for future developments. The new architecture starts with the demise of hierarchical paradigms and the weakening of borders on all levels, social and architectural. In this way, a mutual relationship is established between a new concept of space and a social world. However, the concept's multilayeredness casts doubt on the limiting the definition of “architecture” and raises the questions: What belongs to architecture? Where does it start and where does it end?

Balamir and Erkal (1999) claims that the boundaries of architecture are not easy to grasp, and architecture is not a field that can be analyzed just by itself, and its knowledge does not begin and end in itself. Also, arguing that architecture can only exist through its own acquisitions, risks restricting the discipline. This age, in which the concept of "discipline" is already questioned, is a period in which disciplines discover their own competencies within other disciplines. These melting boundaries are both a trigger and a consequence for radical changes in epistemological structures (Mennan, 1999). Concepts and methods produced for other fields of knowledge can be easily adapted to architecture by turning their contents upside down. A lot of information, none of which has been put forward without any thought of architecture, effortlessly flows towards architecture on a slippery ground. Architecture absorbs everything like a giant sponge or functions as a "free-thinking exchange zone" with exceptional liberalism (Tanyeli, 1999). As architectural products, processes and resources exist outside of their disciplinary boundaries, none of the fields of "architectural research, architectural theory, architectural history, architectural criticism" can be excluded from this transdisciplinary situation for architecture, which must constantly change its ground to create and verify itself. The flexibility of the border from the natural sciences to philosophy, from the social sciences to the economy is essentially the effort of the discipline to establish itself (Mennan, 1999). A wide range of disciplines, including economics, history, information technologies, mechanical, industrial, and structural engineering, many social sciences from psychology to anthropology, art, business studies, and material sciences, in an unusually broad, interconnects everything in the cause of design in a sometimes superficial, sometimes meaningful way. Architecture becomes related to other disciplines through the exchange of its own needs and products (Duffy & Hutton, 2004, pp.11-12) (Süveydan, 1999). In short, there is an expanding and branching architectural intellectual activity and an epistemological struggle to catch up with it (Tanyeli, 1999).

A seeking for what is permanent, essential, and fundamental is claimed to be one of the main agendas of architecture. The search for the foundation becomes necessary for the relaxation of the discipline, and this relaxation is provided by the self-reliance, durability, permanence, and immutability of the foundation (Mennan, 1999). When architectural space depends to analysis and synthesis, its inherent ambiguity and undefinedness may arise (Vidler, 1999). Mennan (1999) discusses that the process of weakening the boundaries of disciplines essentially starts with the weakening of the epistemological foundations. These knowledge-theory expansions, which shakes the existing fiction, lead to a "crisis" by causing loss of boundaries in disciplines, change of belonging, uncertainty of knowledge production and method. Now that knowledge is produced in an interdisciplinary area, this crisis changes the defined and solid boundaries including all forms of knowledge production. This crisis emerges when disciplines that remain constant on the epistemological plane question their own foundations. Therefore, they struggle to exist in the face of these redefined forms of knowledge production (Mennan, 1999).

The fragmentation and uncontrollability brought about by the new interdisciplinary structuring may lead disciplines to be experimental and open to new pursuits. The immeasurability of the various theoretical frameworks and the environment of uncertainty may be the results of this process. This criticism that claims immeasurability and uncertainty by questioning the universality and certainty assumptions of disciplines is called "counter-foundationalism". It contrasts with the existing and, in a sense, celebrates this diversity. This critical theory, which exists as an antithesis to “fundamentalist” discourse, causes a kind of "gestalt shift" in philosophy, science, epistemology, historical and semantic narratives (Mennan, 1999). Oppositely, “foundationalist” discourse, claims that a communication, activity, or research can accommodate on unchanging and solid foundations and can be removed from the context (Fish, 1989). Counter-foundationalism questions the robustness of this assumption, its independence from time and context, persistence, and reliability. It undermines the weak aspects of the fundamentalist approach by creating the potential for new epistemic structures, shaking not only epistemology but also ontological structures. However, the goal of counter-foundationalism is not to destroy the fundamentalist understanding. It aims to initiate the process of rebuilding the fundamentalist perspective, yet the fundamentalist approach is highly resistant to this slippery ground (Mennan, 1999).

In the objectivist tradition, architecture can be viewed as an act of embodying which is sustained by closing in on itself, searching for its own essence and foundation. In this self-definition, architecture defines its foundation as corporeal. What becomes essential is the structure itself, that is, an object, a substance that occupies space. When transdisciplinary experiences cause disappointments due to loss of solidity, architecture, which wants to find its autonomous disciplinary base, seeks the basis of its activity in the “matter”. The immeasurability as well as the diversity of the transdisciplinary sources of architecture may also feeds this “discomfort”. As the epistemological dimension of the crisis increases uncertainty, architecture's longing for autonomy and primes may also increase. It may be impulsive for architecture, whose desire to reconstruct, recognize, and control its structure may be rising, returning to an act of dealing with the physical being (Mennan, 1999) .

The reason architecture's desire to protect the object and material getting more vital can be the reaction to the acceleration and gaining of the value of the virtual and representative. Architecture is conceived as tectonically organizing physical reality. In other words, it transforms a cultural order into a material one. The main issue facing such an understanding of architecture today may be the gradual disembodiment of resources, processes, and products. The idea that physical reality is no longer wholly and accurately readable undermines objectivist frameworks from its roots. Hierarchical displacements in the bilateral relations of the virtual and the object, non-existence, existence, thought, and the matter is complicated processes that challenge tectonics. In short, in an age where the corporeal becomes insignificant and matter rapidly replaced by the intangible, the craving for "matter" thus might take over the architectural agenda (Mennan, 1999).

> "Humanity is born when it reacts to the resistance of objective reality" (Sennett, 1999).

Yet, above all else, one thing is certain; architectural space is an entity beyond its physical existence. Because space cannot be explained only by its physical presence, among the features of architectural form, the most difficult to grasp is the space (Vidler, 1999). According to (Yücel, 1999), the constructed is not the only material expression of a system of thought. Architecture is an increasingly eclectic system of thinking. Of course, it does not mean that the "material space" as Lefebvre states does not exist (Lefebvre, 1991). The physical limitation and use of space is a constant factor of our lives through the utilitarian expansion, consumption and reproduction of space and its boundaries. In this sense, space is 'produced' like any material object, depending on the social, political, and economic influences involved (Vidler, 1999). Giedion (1928) implies that architecture is no longer about objects: if it aims to remain, it must become a part of a larger domain in which spatial relationships and ratios are more important than objects. He proposes a new understanding of architecture, questioning the discipline's very nature. Moreover, most intriguing is the idea that architecture should evolve into a more comprehensive profession that focuses on the entire environment and blends with social reality and life itself rather than remaining limited to constructing representative structures.

In the light of all this, Mennan (1999) claims that approaches that cannot adapt to the new interdisciplinary situation becomes shallow and gets trapped in their objects. Ones who cannot make creative use of interdisciplinary experimental fields confine the architectural discussion to its aesthetic dimension. Thus, aesthetic concern postpones the critical dimension. To put it another way, the importation of discussion confines the discussion to its aesthetic dimension. Importing here means that the networks in its cultural transmission - books, information, representations - cannot be assimilated, shared, and reproduced in the place, language, and culture they are transported. This type of conservatism, which brings the aesthetic dimension to the fore, may block the self-conceptualization efforts of architecture. The concept of building as a purely aesthetic object again may emerge as an extension of the objectivist tradition. It is fed by the rejection of intellectualism and academism, which is powered by the counter-foundationist argument. It is suggested that, at the end, the whole architectural profession needs to overcome denial to intellectual matters which has been fostered in architecture by the combination of the anti-intellectual materialism of arts and crafts tradition and the inferiority complex fomented by proximity (Duffy & Hutton, 2004, p.12).

2.2. Relational Nature of Architecture

There are countless complicated applications and branches that complement what we mean by architectural knowledge (Duffy & Hutton, 2004, p.148). It can be claimed that beings are inherently impregnable and complex. When considered as a singularity, they can be considered within the factors that are not determined by spatio-temporal coordinates and only change constantly depending on an environment. Especially for these reasons, they stay out of generalities and pluralities. They are linked by mechanisms that seem simple at first glance, but these repetitions become more complex as they are in multifaceted and unfolding and ever-differentiating movements (Süveydan, 1999). According to Leach, architecture is not an autonomous art, as it is often positioned. Buildings are designed and constructed within a complex web of social and political relations. Ignoring the conditions under which architecture is put into practice, means failing to understand the social implications of architecture (Leach, 2005). The theory of space becomes stronger by establishing a link between the act of construction and the abstract thought of architectural objects. Thus, any spatial analysis is an exploration of the ability to make the infinity tangible and connect the sublime with the real. (Vidler, 1999).

2.2.1. The relativity of reality

> “Every day, we enter different processes of becoming, consciously and unconsciously, and meanwhile, what we call "I" gets doubled, tripled, and so on.” (Süveydan, 1999).

As Habermas states, the theory is based on an ontological assumption that the world has a structure independent of those who know it. So, the world already works in the same way before the theorist realizes it (Bohman & Rehg, 2017). The point here is not to create a new "architecture", but simply to invoke it. As Süveydan asks (1999), how could an architect or theorist create a new architecture or a new society anyway? They can only reveal what is already coming, what is slowly starting to show itself. In short, nothing new is produced, elements that already exist are called upon and each element waits for discovery of its truth.

While the traditional (pre-theoretical) architectural knowledge is claimed to be inadequate to an understanding beyond the facts; theoretical thought, as Aicher (1995, p. 67) describes, is not only tasked with illuminating the truth, starting from the point where it emerged; In fact, it changes the definition of reality. Architecture can no longer be tied to a land, a nation, a region, or a particular "time"; it is floating in a sea of relativity. Every method or style always remains in relativism, whereas theory means demanding knowledge. Therefore, inevitably, the theory of architecture can now exist only on the concept. Theory in this form is no longer a knowledge of building, but a knowledge of architecture acquired through concept (Süveydan, 1999).

In the historical-cultural context, space can be seen not as a constant, but as a concept that changes over time and according to the perceiver (Vidler, 1999).Therefore, the place “has a history”, or, if we consider its plural definitions in different academic and professional fields, it “has many histories” (Burgin, 1991). Far from being an innocent and obvious phenomenon, space can be seen as a complex cultural and intellectual structure whose construction, application and utilitarianism are constantly changing in the light of these histories. Space, although measurable, may not be an unchanging and universal a priori, as Kant and his heirs thought (Janiak, 2020).

Perception of space requires more than simple sense organs or intellectual tools. The effect of the same space may vary depending on the subjective and individual states of mind; can take different roles depending on social status, gender. It even includes the existence of the perceiving subject. Even the existence of the experiencing person adds new layers to the formation of architecture (Vidler, 1999). Tanyeli (1999) exemplifies this relativity as following: for the Byzantines as well as for the 16th century Ottomans, Hagia Sophia is a singular structure that can only be understood as itself. However, while making sense of it in its singularity, both societies place it within the institutionalized mentality patterns of their own societies. Since its perception and use is a product of individual and social phenomena, space becomes controversial in its origin. As the sociologist Georg Simmel (1997) has pointed out, space is not a matter of distance or proximity, as it has a 'specific psychological content' mutually produced by individuals (Vidler, 1999). With the element of relativity, once the method of history shifted from document restoration to document analysis and formulation, its methodology crossed lines and became a synthetic and subjective history of thought and knowledge. As a result, when "victors write history," it is no longer the genuine history, nor is it the initial emergence of this knowledge and ideas (Cai et al., 2021, p.4). In the light of all these discussions, in the next chapter, the relative and relational qualities of architecture will be evaluated through the concept of materiality.

2.2.2. Relational materiality of architecture

The term, materiality is one of the concepts that are used to define the knowledge, content, and existence of entities holistically. Materiality is not a matter of material being, but different forms of incarnation. One of these forms is the relational state of all phenomena that have or have influenced the entities. In his *book La materialite de l'architecture,* Antoine Picon refers to materiality as connections. He claims that materiality is not necessarily the matter, but it is the complex relationship that we build with the physical world and objects that we think we can interact with (Picon, 2018, p.15). Materiality is a separation and a connection between phenomenon, mute objects, and communicable elements (Picon, 2018, p.73-75). Therefore, it is a subprocess of co-production that includes all resources and elements in each age and society.

Similarly, Daniel Miller (2005, p.11) states that materiality is not necessarily the entities physical self, rather the networks of elements and relationships between them.

Its existence resists our willingness and establishes itself without control. Within every entity there is a complex web of relation and network. This network exists independently of our knowledge and awareness. Although it is impossible to fully estimate its content and overall situation, it may be possible to obtain a more comprehensive perspective on this body of relationships. We are trying to understand the elements of this complex form that we call materiality.

Created by Bruno Latour and Michel Callon, the “Actor-Network Theory (ANT)”, is considered as an adaptable method of mapping how the material entities participate in human lives (Kien, 2016). Latour claims that reality occurs in the networks, not individuals. According to his theory, all things are relational, distributed, and shared in an “assemblage”(Latour, 2005). In this regard, ANT embraces a definition of materiality that emphasizes the unavoidable production of the networked and collective actions. Even though ANT never intents to explain materiality directly, in the material culture, it seeks to explore the relations between humans, technologies, actors, and networks. This method gives the material object its own voice and identity to describe its own alliances and struggles (Kien, 2009). John Law describes and names this issue with the term "relational materiality" (Law & Hassard, 1999)

Traditionally the world is considered as it appears to be. However, ANT suggests "a more democratic and symmetrical" way of the chaotic and relentless emergence of the world (Lieto & Beauregard, 2016, p.13). Indeed, matter and its entity are far more complex than humanistic senses and physical existences (Picon, 2018, p.67).

Despite that traditional view may create an appearance of it, there cannot be autonomy or an actual singularity. Each entity has multiple identities and connections with other beings and cannot be perceived in a singular way (Kien, 2009). Accordingly, ANT rejects any pure categorizations and supports a heterogeneous world of hybrids. Things assemble not because of their similarities but because of their overlapping interest of matters. In this sense, it emphasizes connections rather than separations (Lieto & Beauregard, 2016, p.12). This understanding causes a rejection of definite definitions of things. Instead, this is a "Translation" process that the mechanism of the social and natural world progressively take form. Therefore, materiality becomes a part of the process of translation and performance through the relationships constituting that process (Kien, 2016).

It can be claimed that humanity both produce and are the product of the happenings of the world (Miller, 2005, p.8). ANT suggests that "the social is nothing other than patterned networks of heterogeneous materials and relations" (Law, 1992, p.381). It supports that each participating thing in this network has equal weight in the assemblage, even equal to humans (Lieto & Beauregard, 2016). In many similar qualitative kinds of research, humans get privileged. In the material culture, although the ruling factor seems to be human, objects and phenomena take over from time to time. This process is not linear, logical, or even predictable (Kien, 2016).

It is inevitable that architecture which deals with the project of organizing the connections between human and matter, faces the problem of alteration in materiality and the mechanisms and objects that determine its own evolution (Picon, 2018, p.70). What can be considered is something that as unpredictable and complex as the nature of the subject that are dealt with. To achieve this and make sense of this complex structure, a new way of looking is needed to transform these data into meaningful pieces of information.

2.2.3. A thought shift in the discipline

Mennan (1999) claims that, a new cultural arrangement needs restructuring as forms of discourse and action. Collective criticism, which develops with the opening of the borders of the disciplines, gains change, differentiation, and diversity through diffusion. It allows to determine which of the constantly competing forms of thought and action is remarkable. To oppose this diffusion, which carries the hope of a more critical tradition, means to make its borders more defined and closed, and to keep new opportunities and creative experiment areas at bay. With the shake of the ontological ground, a rhetorical ground is opened. On this rhetorical ground, architecture opens a chance to communicate with its own foundationalist tradition as well as with other disciplines. Reproduction and shaping the unprocessed material can be initiated by using this chance (Mennan, 1999).

Accordingly, Duffy and Hutton (2004, p.12) stresses the critical need for architects to reassert their profession's intellectual foundation. It is to ensure that the built environment design takes its rightful place in a society that is increasingly based on the development and transmission of all sorts of knowledge by aligning it with other rapidly growing disciplines. Tanyeli suggests that (1999) architecture occasionally aims to write and re-institutionalize its own real knowledge by producing discourses. The field of knowledge has always had a hard time accepting that the institutionalized reality has been fading away. It may be for this reason alone that architecture is still engaged in constructing reality as an institution. However, in the future, it should be expected that the production of discourse within the real architectural knowledge will disappear completely and the normative (moralistic) knowledge of "how to do" will be replaced by the theoretical knowledge of "how it is done" (Tanyeli, 1999).

Therefore, the modern world is promised with new developments. As the original products of architecture come to light, a new architecture, a new architect, and in this way a new society will emerge (Süveydan, 1999). After all these expansions, it becomes necessary to define a model of change for architectural thought (Tanyeli, 1999). The only option for architects to assess quality is to employ architectural knowledge in a systematic and collaborative manner (Duffy & Hutton, 2004, p.147). According to Aicher (1995, pp. 63-64), a modern conception should be developed in which reality is defined as a principle, that is, with certain parameters, units, and criteria. Just as modern science defines realities by putting them into mathematical models, architecture will begin to understand the realities of its own field by constructing its own models (Tanyeli, 1999).

The potential for improvement is rapidly increasing, thanks to the ability to harness much more significant amounts of data to better impact through shared networks of information technology. It remains to be seen whether architects will quickly reform their professional structures to capitalize on this shift in public opinion, which has only been made possible by significant advances in information technology. They may need to establish new forms of practice, collaborate with other professionals in the construction industry on multidisciplinary projects, and take the lead in making the construction sector more productive. Regardless of the outcome, success becomes evident in doing something more significant in its implications for the upcoming century (Duffy & Hutton, 2004, p. 14).

Above, the theoretical and practical approaches, interdisciplinary features and relational nature of architectural knowledge were discussed. The inclusion of further approaches and methods for the organization and fabrication of this knowledge comes into question. In the next chapter, the concepts of data, information and knowledge and approaches to its management and acquisition will be discussed.

2.3. Managements of Data, Information and Knowledge

2.3.1. Data, information, and knowledge

Data, Information and Knowledge are terms that are often used instead of each other. Although the closeness in their content causes various ambiguities, a clarity about their meaning is required to study about information processing and organization. With extensive conceptual thinking, these terms deal with comprehensive semantics and abstract concepts (Liew, 2007). Therefore, for a clear understanding the definitions were gathered from knowledge management researchers in line with the course of the research. In order to make sense of the management of information, the definitions and scopes of the concepts of data, information and knowledge should be clearly understood.

According to Cambridge dictionary, data is "information, especially facts or numbers, collected to be examined and considered and used to help decision-making, or information in an electronic form that can be stored and used by a computer"; information is "facts about a situation, person, event, and so on.". And knowledge is "understanding of or information about a subject that you get by experience or study, either known by one person or by people generally".

In his article *Understanding Data, Information, Knowledge, and Their Inter-Relationships,* Liew (2007) compares all the definitions and scopes of these concepts and summarizes the inter relations between the phrases. According to him, these three concepts are defined by each other. The main reason why the definitions of concepts are so confused might be the difficulty of defining them independently of each other. There are various attempts to explain the interconnected relations between these concepts. Amidon (1997) simply puts "Data are elements of analysis. Information is data with context. Knowledge is information with meaning.". According to Kelly (2002); data consists of raw, unprocessed, and unfiltered information. Information is a refined version of data that can be used for analysis. Knowledge, however, occurs only with the collation of data and information with human insight.

Liew sums all the relational definitions by stating the following (Figure 2.2). “Data” is the storage of authentic meaning. The primary goal of data is to capture the genuine picture by recording situations. "Information” is a message containing relevant implication or input for a decision or an action. According to him, Information is derived from both instant and processed data sources. Essentially, the intent of information is to assist people to decision making or to problem solving. “Knowledge” is the cognition, capacity to act, and understanding that is contained within the mind. In short, the purpose of knowledge is creation of value. Data and information are occasionally referred as “explicit knowledge” (Liew, 2007, p.8).

To understand the relationship between information and knowledge, knowing where the information resides is critical. As mentioned, information is a message generated by activities and situations. However, information exists in the form of data in storage media or in the human mind as knowledge. So where does data stop information begin, information stops, and knowledge begins? A "book" is knowledge from the author's point of view, an information for the reader, and a data stored in a written media (Liew, 2007, pp.7-8).

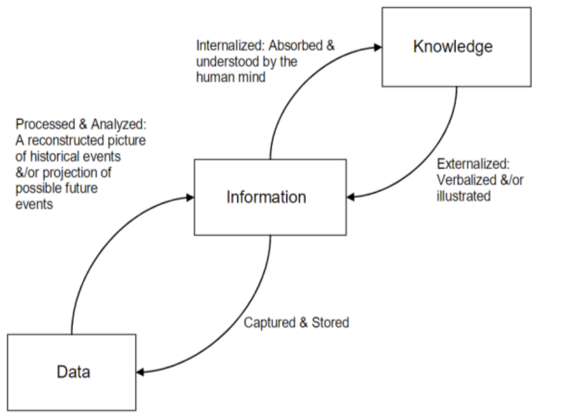


Figure 2.2: Diagram of the relationship among concepts (Liew, 2007)

The processing and managing information also need to be clarified within the scope of this thesis. Capturing, storing, structuring, compiling, and analyzing records is considered as “data management”. The reconstruction of any sort of record creates and manipulates the input for decision making. Including the reconstruction of events, projecting, and predicting future events and analysis of problem solving is under the scope of “Information management”. Thereafter, actions can be reviewed. “Knowledge management” in its core is the administration of human capital of tacit knowledge, relationship capital, and explicit knowledge which is also referred as data and information. Also, the flow of knowledge relates to the development, sharing, and use of knowledge to build or maintain organizational value. Knowledge management is not a stand-alone notion (Liew, 2007, p.8).

Parallel to these definitions, problem of the thesis was the process of organizing and interpreting architectural information. As a result of these definitions, it was decided to define the process as an information management and knowledge fabrication process. To clarify the approach to the problem, it is important for the course of the thesis to understand how the knowledge fabrication is handled in the organizational studies. In the next section, approaches on making sense of human knowledge are examined.

2.3.2. Approaches for obtaining and managing knowledge

Before discussing the organization of information, it is necessary to mention the approaches to the organization and fabrication of knowledge. Epistemology is the philosophical analysis of the nature, origins, and boundaries of human knowledge (Stroll & Martinich, n.d.).

The acquisition, definition, and scope of knowledge are among the cognitive achievements that the field of Epistemology tries to comprehend. The Greek words "episteme" and "logos" are used to form the term "epistemology." "Episteme" means "knowledge," "understanding," or "acquaintance," whilst "logos" means "account," "argue," or "reason.". Plato's epistemology was an effort to comprehend what it meant to know and how knowledge benefits the knower. Locke's epistemology attempted to grasp the operations of human understanding, Kant's epistemology attempted to understand the circumstances of human understanding's possibilities, and Russell's epistemology aimed to explaining how modern science might be justified by appealing to sensory experience (Steup & Neta, 2020). In each of these cases, epistemology strives to comprehend the levels of cognitive success or failure.

In his “World Hypotheses” article, Pepper (1942) argues that human knowledge is a constant process of cognitive refining. Pepper's four world hypotheses give a framework for understanding the various qualities and sorts of information produced in organizational studies. These assists to have a better understanding the arguments of researchers who have diverse conceptions of knowledge (Tsoukas, 1994, p.770). All the classical epistemological discussion that defines the qualifications and acquisition of knowledge, can be summarized with these four frameworks: formism, mechanism, contextualism and organicism.

Among these approaches, the compatibility of "Organicism" with the relational and networked structure of the architectural materiality defined by Antoine Picon, was discovered.

2.3.2.1. Formism

Objects, events, processes - all sorts of phenomena - are construed as discrete facts that can be classified in several ways. “Formism” is based on the human capacity to identify similarities and differences - in short, to categorize. To some extent, all human knowledge is inherently formistic. Accordingly, relentless classification is among one of the most frequently used method for management. (Tsoukas, 1994, p.763-764).

On the other hand, in this method, facts are collected from their sources of origin and interpreted as they are (Pepper, 1942, p.142-143). In other words, differences, and similarities among distinct objects of study are intended to be captured without considering for the underlying mechanisms responsible for any found similarities and differences. Some formists believe that their typologies accurately reflect the world as it is. However, this type of classification is considered more as a social construct rather than a fair representation of an objective reality. It is not enough to simply detect similarities and differences without comprehending the mechanisms responsible for the appearance (Tsoukas, 1994, p.763-764).

2.3.2.2.Mechanism

Mechanism, like formism, is an analytical world theory in which the elements aren't complex or have contexts. Unlike formism, mechanism is integrative, the world appears to be orderly and well connected (Tsoukas, 1994, p.765).

In mechanism, the object of study is regarded as ontologically given, fully describable, and algorithmically compressible. Facts happen in a specific order, and if enough information is available, they can even be predicted or defined (Pepper, 1942, p.142).

Mechanists avoid examining singularity and uniqueness. Instead, they favor investigating general and logically related abstract qualities. The sole concept of time accepted by mechanists is schematic time: the chronological ordering of separate events. (Tsoukas, 1994, p.767-773).

They assume that elements have distinct parts that have a strong relationship between. Apart from our common perception of them, these parts of an object of study are re-described in some quantitative form in this understanding. Among these parts, there are qualities that can be considered primary and secondary. These background secondary qualities are linked to the object of study by a kind of "principle" (Tsoukas, 1994, p.767-773).

Despite its widespread use, mechanistic thinking may not have been a complete success (Tsoukas, 1994, p.766). As Payne (1975) argued, even if mechanistic categories of knowledge had appropriate predictive potential, the amount of data required to apply them would be excessive.

2.3.2.3. Contextualism

With the limitations of the types of knowledge created by formism and mechanism, it is nearly impossible to establish social systems that produce stable forms and regularities. Therefore, contextualism steps in with the metaphor “historic event, continuously changing over time”. According to contextualist idea, an event is never limited to what is directly visible, but also includes its own continuous past and present (Tsoukas, 1994, p.767-768). An historic event is supposed to be at the crossroads of numerous trajectories, the roots, and destinations which are unknown to the researcher. (Barrett & Srivastval, 1991)

Novelty and change are core concepts for contextualism. They believe that change as an inherent part of the universe; the social environment is constantly in motion (Cooper & Fox, 1990). Not any situation repeats itself and every new event reconducts an existing pattern. Therefore, each moment needs to be treated as unique (Tsoukas, 1994, p.767).

Contextualism, unlike formism and mechanism, is synthetic. Rather than a series of distinct facts, it studies a pattern, a gestalt. Like in formalism, the facts are accepted to be loosely defined, without any lawful systematic connection

(Barrett & Srivastval, 1991). They believe that since the world is not algorithmically constructed, systematic analysis of it is not possible. Human understanding can only be guided by loose and brief frameworks (Tsoukas, 1994, p.768).

2.3.2.4. Organicism

An “integrated whole” is the main metaphor for organicism. According to organicism, with some predetermined steps, the organic process eventually leads into the ultimate, most extensive structure. The organic operations are progressive, and evolves towards to more inclusive, determinate models. Unlike how it seems, the world is consistent and well-integrated. It is a cosmos, and it is possible to observe how it is assembled. (Tsoukas, 1994, p.769).

With organicism, the integrated wholeness from the analogy of the neurological system is carried over into the organizational domain (Tsoukas, 1994, p.770). It views events as meaningfully related fragments, but in often insufficient or contradictory ways. A higher and inclusive synthesis handles conflicts in a chain of events. While acknowledging the uniqueness of fragments, it surpasses and integrates them in this more inseparable whole and parts. When it comes to the integrated whole, organicism seeks for comprehensiveness and underlying structures, however it leaves a little space for autonomous human action (Castoriadis, 1975).

Without the systematic existence, as believed in formism and contextualism, a shortcut or an algorithm to interpreting the world is not to be expected. As mentioned in contextualism, the constant change of events keeps the researcher in the dark. While the world acts at its own pace, changing itself and moving in any direction, unlike the linear chronologic understandings of mechanism, it is researchers’ responsibility to discover a way to degrade the world to one’s perceptive capacity.

In line with the course of the thesis, this classification provides us with the necessary approaches for defining and organizing knowledge. The "integrated whole" approach of organicism has been evaluated within the scope of this thesis since it suits the overall sense-making of the chaos of knowledge. To comprehend the “integrated whole” within its dynamic, chaotic, unsystematic, and interconnected expansion nature the focused solution to make sense is the “relational knowledge”- “networked content” theory.

These four categories offer various approaches to the meaning, structure, and interrelation of knowledge. As a result, relevant perspectives need to consider against information management approaches. In the next section, semantic information management will be discussed.

3. RELATIONAL MANAGEMENT FOR ARCHITECTURAL KNOWLEDGE: HYPERTEXTS AND SEMANTIC NETWORKS

3.1. A Contemporary Approach for Semantic Data: Hypertexts

3.1.1. Digital wisdom

The discussions made in the field of obtaining formal knowledge brings out the necessity to have novel and radical approaches to organize the information. With this complex and relational data structure what is needed is quality over quantity, attentiveness than a distraction, and more wisdom than unstructured information. Since its early days, the purpose of a tool has been to elevate its user by upgrading their ability to become smarter, stronger, or more precise. Modern computer technology comes to the fore as a wisdom tool for improving thinking and problem-solving (Matysek & Tomaszczyk, 2020). However, technology alone may not replace judgment and problem-solving ability. Humans can also enhance themselves to become wiser, but it is tough to compete with work against technology (Prensky, 2012b, 212).

The human mind can reflect, capture patterns, categorize, and associate with intuition. On the other hand, today's digital tools come through strongly to gather, process, and analyze large amounts of data. To store, process, and share data, manage information flow, and boost user productivity, databases, spreadsheets, task and project managers, communications platforms, note-taking tools, and reference managers are employed. In each setting, information is derived from data, arranged, and interpreted (Matysek & Tomaszczyk, 2020). It cannot be denied that both humans and technology have advantages and disadvantages during the information synthesis process. A stance on this situation may combine the human impulsive and complex thought process with the power and automation provided by technology.

Marc Prensky describes the term *Digital Wisdom* as “integrating the technology of our times into our thinking and decision making, doing it wisely, and sharing the results”

(Prensky, 2012a, 47). It refers to the capability to integrate the activities of the mind and computer to produce the most efficient responses to questions. (Shaughnessy et al., 2010, 30). Since human judgment is flawed when assessing risk in complicated settings, technology, and the mind can complement each other in decision-making processes (Ryan-Wilkinson, 2020).

Therefore, digital tools bridge humans' and computers' realms, bringing the outcome of expanded human intellect and digital wisdom. What the unenhanced mind loses by outsourcing routine duties, the produced digital wisdom can be more than compensated for by the wisdom gained (Prensky, 2012b, 211). Digital wisdom is enhanced by tools that help organize thoughts, increase thinking and understanding, observe phenomena from multiple perspectives, and link seemingly unrelated ideas. It involves allowing machines to perform functions where they exceed humans, such as calculation, visualization, and "memorization" of enormous amounts of data (Matysek & Tomaszczyk, 2020). Individual wisdom expands when it is shared and merged with collective wisdom and machine wisdom, in other words, artificial intelligence (Sadiku et al., 2017, 72).

"We shape our tools," explains John M. Culkin (1967, p. 70), "In return, our tools shape us back". It indicates a two-way relationship. Tools are made to improve our abilities; as our abilities improve, we will create better tools. We utilize and upgrade digital technology to become smarter and wiser (Matysek & Tomaszczyk, 2020).

Just as any device is updated over time, our knowledge synthesis and wisdom tools constantly change. Written texts, which have been with humans for thousands of years to store information, can be considered as one of the most important tools. Since its first appearance 5500 years ago in Mesopotamia, writing is an essential part of human history (Clayton, 2019). With various archaeological excavations in addition to obtaining information from objects and structural remains, the most comprehensive and direct information was obtained after the written documents began to be left. So much so that the deciphering of ancient languages can be considered a turning point in this sense. Due to its compatibility with human perception, text format has become one of the most used methods to store data and information, consequently effecting the knowledge fabrication process.

In his white paper Daniel Mayer (2011) declared a manifesto about “Networked Contents”. He mentions this concept as a foreshadow of a new paradigm shift at the crossroads of access of information and content management. Networked Content, in its most basic form, establishes a network of semantic relationships between documents, enabling new kinds of navigation and improving extraction from a set of documents. Essentially, text organization techniques like hypertexts are used to retrieve semantic metadata from various documents.

Historically, content enrichment was a fully manual process that was time-consuming, expensive, and frequently required subject matter abilities and expertise, making it difficult to scale. Nevertheless, in recent years, this procedure has become increasingly automated with the usage of text analytics or text mining. These computational approaches use a combination of:

- Linguistic and Semantic Resources which are taxonomies, ontologies, and thesauri. One of the most famous thesauri is Art and Architecture Thesaurus (AAT). Regarding its relationship with the topic AAT will be mentioned on the following chapters.
- Rule-Based Systems from basic regular expressions to fully developed syntactic pattern detection algorithms.
- Statistical Methods that make use of bulk training processes to identify and infer suitable classes or extractions for supplied content.

Ultimately, Networked Content is a concept for how content might be better managed and dispersed by employing semantic content enrichment. This vision is supported by extensive technological ecosystem (Halper, 2011). To sum up, during the rapid evolution of content management and information access technologies, Networked Content is emerging as a critical upcoming stage. It improves the quality of search queries and allows efficient end-user content exploration by combining search engines' fast indexing and processing with relevance, depth, and semantic structures. Beyond conventional, dedicated information access interfaces, it is also competent in proactive distribution of highly relevant content suggestions to end-users (Mayer, 2013).

Technological developments have been full of innovations for the semantic tools that has been with us since primitive times. On the contrary of humans, for computational technology, texts are not the most readable format. Due to its frequent use, making computers to “understand” the written text has become an extensively studied area for computer science. A very promising example of this research is Artificial Intelligence, more specifically Natural Language Processing (NLP) which will be mentioned in the following chapters.

Architecture’s borders are obscured by the multi/inter disciplinary nature of it. The architectural thinking, writing, and production have taken on the metaphorical shape of "hypertext," in which each entity is a compressed realm of knowledge in relation to an endless number of others (A. Acar, 2015). Concepts like Hypertext, which is one of the updates that the text has acquired from technological developments, adapts text to process the semantic data into computational source material. Parallel to all the qualities discussed about the knowledge of architecture, the semantic data organization principle, hypertext will be discussed in the next chapter.

3.1.2. Semantic knowledge management: Traditional text vs hypertext

We cannot speak of a uniform typology for semantic tools used as a repository and a media for knowledge. Regardless of the content it stores, text as a medium can take various forms. Especially, with the development of “hypertext”, questions about arranging and structuring information displays have emerged. Alternative formats for writings that are traditionally structured to a fixed format are started to be investigated (Dillon, 1991). In terms of storing, processing, and representation information the concept of hypertexts holds new potentials that traditional text was not capable of providing. While traditional texts are linearly structured written documents such as books or articles, hypertext is a non-linear alternative to semantic information organization.

In the means of finding flexibility of the associative structure of mind within the premise of mechanized system, “hypertext” was developed by Ted Nelson during the 1960s (Nelson, 1967). According to (Smith & Weiss, 1988) it is “an approach to information management in which data is stored in a network of nodes connected by links.”. Mentioned nodes, or in some cases the networks, are built to be viewed through a structured interactive interface. Hypertext-based approaches have been widely adopted in the knowledge management systems. It offers several advantages, including nonlinear access to massive amounts of data, the capacity to study material in depth on demand, interaction with the content and being a natural portrayal of the human mind (Khalifa & Shen, 2010).

On the other hand, traditional text dominates the semantic information storage systems. Its simple yet effective structure creates a common understanding. Unlike hypertext, the logical and physical structure of most traditional texts are closely connected. While the sentences and lines physically structured in a linearity, also logically it is subsequent. Discourses lay in words that are in sentences in paragraphs under sections (Smith & Weiss, 1988). In that sense, traditional texts offer various navigation and discourse cues, such as chapter headings and page numbers, to assist the reader in regaining their bearings (McDonald & Stevenson, 1996). Mostly under hierarchical structure, in linearity that guides and encourages reader accordingly, apart from some exceptions such as dictionaries or encyclopedias that divides the logical and physical aspects. During the logical process, the reader will naturally discover various references and relationships. Conventional text may attempt to associate it with concepts like "See also" to document this situation. Despite the effort however, their sequential logic is insufficient for the complex pattern of the mind. Hypertext documents combine the versatility of reference works with several additional capabilities. Information is kept in nodes connected by links in a hypertext, and each node can be related to another. Therefore, the joined section of information enables to view the whole picture (Smith & Weiss, 1988)

To clarify, there is no definitive proof that hypertext is superior to linear text in terms of assisting knowledge processing and sharing (Khalifa & Shen, 2010). However, it is necessary to evaluate the divergence between these two systems in line with technological developments in the sense of storing information in a digital environment. The fundamental difference between hypertext and traditional types of computer-based navigation is that hypertext enables quick non-linear access to vast amounts of information while also extending the user's control by allowing them to explore the text according to personal research agenda (McDonald & Stevenson, 1996).

With benefiting from both Semantic Network -which will be introduced in the following chapter- and Hypertexts, one further step for the hypertext would be the Semantic Hypertexts. They are regarded to be superior to linear text in terms of aiding knowledge structure acquisition. In comparison to linear text, semantic hypertexts not only offer a better structured representation, but also provides more interaction between users and the presented content, resulting in higher levels of engagement (Khalifa & Shen, 2010). Eveland and Cortese (2004) further claims that such structural models defining the core of hypertext navigation design could have a direct influence on human-computer interaction during transferring knowledge. In these systems, any element or piece is called to as a "node," and each connection between any two nodes is referred to as a "link." The main objective is to map the links between nodes (Duffy & Hutton, 2004).

By describing knowledge as node-link assemblages, where nodes represent concepts and links indicate connections between concepts, such representations resemble the human mind's associative nature (Jonassen, 1992), and therefore are predicted to aid in the development of knowledge structure (Khalifa & Shen, 2010). In the comparison of hypertext and traditional text, structural form, which affects logical and physical orders, is one of the frequently encountered concepts. The structural approach affects the text in many areas such as flexibility and legibility. To analyze this, it is necessary to mention the most used structural concepts for hypertext.

3.1.3. Structural strategies for semantic hypertext

Shin (1994) claims that hierarchical and network structures are the most preferred for hypertext. Hierarchical structures, as the name implies, allow nodes to be connected in a rigid hierarchy, with nodes at one level having access to nodes directly above or below (McDonald & Stevenson, 1996). Network structures, also referred as associative structures, allows a node to be linked to some other node in the hypertext to construct a complex structure with many linkages, which are often mentioned as non-linear referential links (Locatis et al., 1989). To clarify, any stated phrase of “non-linear” and “associative” refers to the networked structures while the “linear” phrase alludes to the traditional approach mentioned on the previous chapters.

As stated, the main difference between these structures is the linking philosophy. Also referred as hierarchical links, direct links apply to concepts that reside in the same hierarchy. They can be used to define general concepts in terms of more particular concepts. Cross-links, however, connect concepts from various hierarchies, creating a non-linear approach without any order (Figure 3.1). They can be used to show meaningful relationships among complex concepts (Khalifa & Shen, 2010). While the hierarchical approach remains with standard collapse expand function by the child and parent nodes as an outline view, the associative and non-linear "spider views" are limited to the neighbor links (Revere & Blustein, 2020).

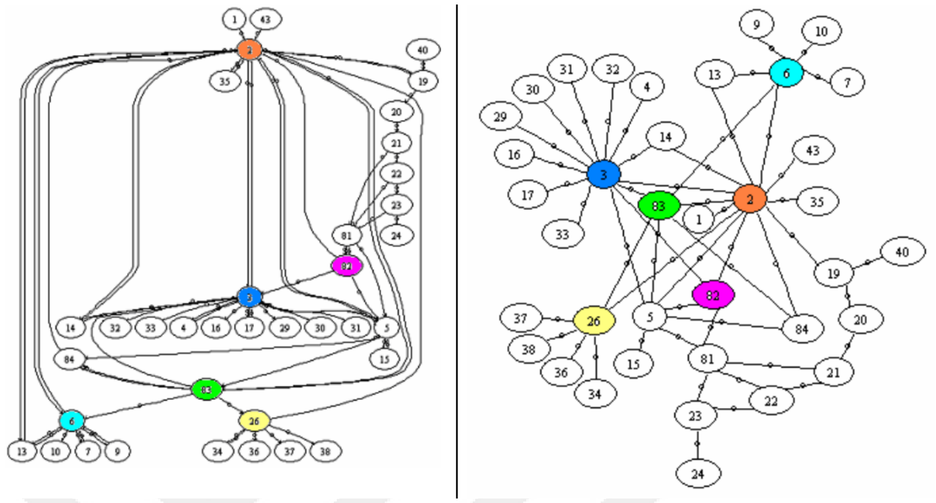


Figure 3.1: Hierarchic (left) and non-hierarchic (right) structures of hypertexts (McEneaney, 2002)

Schema theory claims that knowledge is reserved in long-term memory in the forms of networks of information bundles (Rumelhart, 1984). These are dynamic networks in respect that they are constantly recreated because of continuous knowledge acquisition. According to the schema theory, knowledge acquisition is defined as the act of assimilation and accommodation (Anderson & Pearson, 1984). Assimilation is the integration of latest information into an existing schema, whereas accommodation is the alteration of the existing schema to adapt the new information. A relational schema is a form of mental model that includes the structure of a situation or activity in the environment that cognitively represents elements and relations between elements (Khalifa & Shen, 2010b). Accordingly, such structured representation will allow users to better understand the inherent structure of the knowledge base (Halford et al., 1998).

On the other hand, despite its limits, the broad use and generalizability of hierarchical structure across varied interface elements like tables of contents, menus, chapters, and heading levels, indicates its widespread use and generalizability. On epistemological basis, hierarchies have been criticized for confining knowledge representations to categorical and typological connections that disregard or ignore the fluid, associative quality of semantic connections (Revere & Blustein, 2020). Utting and Yankelovich (1989) note that hierarchically organized systems can easily overcome the problem of data size by grouping and minimizing the visible data, using a collapse-expand system. However, they also admit the limitations: "Intermedia links, however, form a network rather than a hierarchy. Our attempts to design a way to collapse and expand sections of our network were unsuccessful".

The contrast in performance between hierarchical and non-linear settings could be explained by the user's distinct number of options in terms of the amount of linkages and paths they can trace and explore. Although a hierarchical content does not limit the user to a single route through the text, its organizational structure somehow restricts the user's actions and their flexibility (McDonald & Stevenson, 1996).

McDonald & Stevenson (1996) created three test groups to compare the abilities of these structures; traditional, non-linear and hierarchical conditioned subjects were assigned by the same tasks. In terms of speed, the subjects in both hierarchy and traditional condition performed faster than their non-linear counterparts. Hierarchy conditioned subjects significantly fell behind from the traditionally conditioned subjects. In terms of size perception, subjects in the linear conditioned were able to make closer estimates of the size of the documents, compared to subjects in the non-linear condition who grossly underestimated. However, on research with a question-answer task, participants who uses a hierarchical hypertext outperforms subjects who are using a traditional version of the exact document (Mohageg, 1992).

Since the non-linear structure puts no restrictions on the user's movements, it provides a complete opportunity to explore a richly interconnected network of ideas. As it appears from the results of the comparative studies, this freedom does have some associated costs. Issues like understanding the context, dealing with complexity, and orientation through information are among the biggest. The unfamiliarity of such a format, as well as learning through browsing, likely worsens the navigation problem with the non-linear structures (McDonald & Stevenson, 1996).

3.1.4. Navigational problems and the transclusion concept for non-linear hypertext

A structural system adjusts the navigation of its user. Researchers agree that among other it is easier to get lost navigating through a hypertext (Batra et al., 1993; Edwards & Hardman, 1989). Users are frequently overwhelmed, puzzled, or disoriented by the vast number of options provided by hypertext, to the point where they lack a clear comprehension of the system's dynamics (Elm & Woods, 1985). Conklin (1987) defines the *disorientation problem,* also referred as *navigation problem* or *lost-in-hypertext phenomena* as: "the tendency to lose one's sense of location and direction in a non-linear document.".

Foss (1989) has noted a variety of other potential issues that hypertext users may encounter. These issues are grouped as “The Embedded Digression Problem” and “The Art Museum Phenomena”. "The Embedded Digression Problem" addresses the issues that develop due the range of options provided by most hypertexts. Users may become immersed in a densely interconnected network of information, which may serve to shift their attention away from their intended path and end up causing them losing their place in the text (McDonald & Stevenson, 1996). "The Art Museum Phenomena" describes a set of issues related to learning through browsing. Browsing's non-directive nature means that users may frequently roam through a hypertext without pausing to examine or consider the ideas presented. As a result, users may be unable to identify which nodes were viewed or which parts of the text have yet to be seen (McDonald & Stevenson, 1996).

To conclude, these findings support the idea that people using non-linear hypertext may fail to perceive the totality of the network and hence appear disoriented (McDonald & Stevenson, 1996). On the contrary, hierarchies offer a predictable structure that struggles less compared to the non-linear texts "disorientation problem".

Nevertheless, it is possible to use the best aspects of each method. “Transhierarchy” is a combined strategy that aims to overcome the navigation problem of non-linear systems and constraints of hierarchical structure. It is a technique for navigating through hypertext within an interface that is reliable and somewhat hierarchical. Also, it uses a “transclusion” methodology that enables the reader to cross beyond hierarchical boundaries without abandoning the advantages of a tree structure. It provides a way to navigate nonlinear hypertext within a familiar and clear format (Revere & Blustein, 2020).

The term "Transclusion" also created by Ted Nelson (1981), refers to the process of embedding content from a different area so that the alterations to the original are evident in the embed (Figure 3.2 and Figure 3.3). The usage of transclusion within hierarchy is motivated by the desire to preserve some sort of context (Revere & Blustein, 2020). Nelson (1995) does not deny hierarchy, but he does argue for its inclusion in a variety of structures. He states, “It would be hyperarchical, permitting the same material to be organized into simultaneous alternative structures—hierarchies, sequences, hyperplexes”. Transclusion allows readers to simply retrace their steps while providing visual cues to help them avoid the "disorientation problem". (Revere & Blustein, 2020).

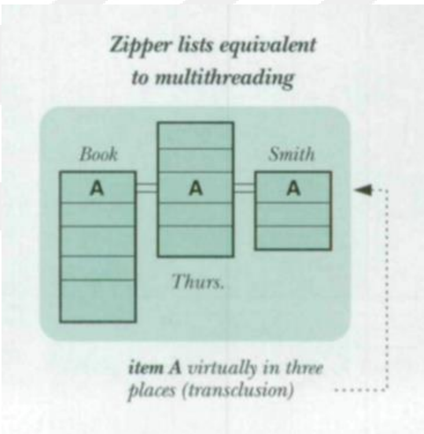


Figure 3.2: Example for Transclusion (Nelson, 1995)

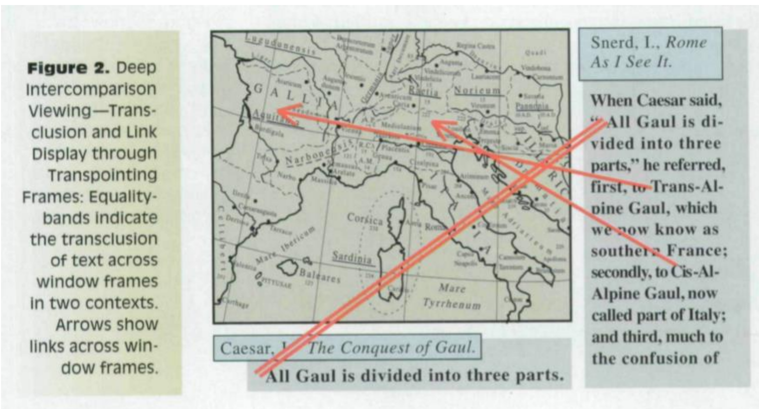


Figure 3.3: Example for Transclusion (Nelson, 1995)

To provide a sense of context, unlike the orderly approach of “parent to child” of hierarchy, Transclusion offers a variation of hierarchy that allows to show all the “parent-child” relationships. In each networked structure there are repetitive and cyclical nodes, the graph view which shows the intensity and density of linkages between nodes already creates some sort of hierarchical understanding. More outer connections may make a node to seem like a more comprehensive element in the network. Although this structure does not produce a traditional sense of hierarchy, it does work as a sort of classification and interpretation aid. The idea of transclusion suggests emphasizing retroactive contextual content in this circular and fluid structure that tends to be overlooked.

Utting and Yankelovich (1989) are particularly interested in the relationship between historical information, also called the path, and contextual information, in other words the map. A path defines the reader's orientation within the hypertext, while simultaneously providing a specific context. Each time the reader navigates through the network, a new path is established. The way to make sense of the hierarchy without losing the current context is through graded path finding. Path contains all connections to a node. Each degree node on the path is called primary, secondary, tertiary degrees. In this way, parent and child nodes, as well as sibling (sharing a common parent) and ancestor (high-ranking, container nodes), can be inspected. This review is used to make sense of the context and establish a non-limiting, transclusive hierarchy. In this way, the reader can navigate the peripheral content within the transhierarchical view without losing the context.

Transclusion effectively encodes the reader's decision to open a transhierarchical view and pursue an inbound link at a specific node in the tree's ancestors. The navigational path is preserved since cross-references are inserted transclusively without removing the current context. As a result, the reader's ancestors' chain gives a condensed historical trail of their navigational movements. The hierarchy of enlarged nodes in this model is provided by the depth-based vertical navigation, whereas lateral navigation is mainly ephemeral (Revere & Blustein, 2020).

In the process of making sense of all these systems and relations, the preferred representation typology gains great importance. In this sense, the graphic and typological formations created by the hierarchical and non-linear structures discussed so far are called “semantic networks”. With the proper network typology, users will not only have a clearer view of the knowledge structure, but they will also be able to interact with nodes or representations of schemas, as well as labeled connections that establish propositional links between nodes if the design is done this manner (Khalifa & Shen, 2010). All these examined systems are explained in a simple tree view, but they all break the “one-parent-per-child” principle that trees are defined by. The simplistic tree structure generally illustrated here does not support the “typed links” (links that have definitions of relations), which may be necessary for navigating ontologies and semantic networks (Revere & Blustein, 2020). To have a further understanding, it is necessary to examine the semantic networks.

3.2. Semantic Networks for Knowledge Structuring

“All thought is diagrammatic.” -Charles S. Peirce (1880)

A network is a simple technique to organize data in a computer or database (Lehmann, 1992). A semantic network, also known as a net, is a graphic representation of knowledge in the form of sequences of interconnected nodes and lines. (Sowa, 2006). Similarly, defined by Wang and Rada (1998, p.373) networks are “a directed graph in which concepts are represented as nodes and relations between concepts are represented as links”. Essentially, a semantic network is a representation of the pattern of meaning in the form of a graph. Object-Oriented languages, systems, and databases, like architecture, utilize ideas from semantic networks such as inheritance and procedural attachment. Since objects communicate by exchanging messages to one another; if not perceived in an interconnected manner, these elements remain encapsulated, and their internal structure stays hidden (Lehmann, 1992).

Abstraction is the ultimate organizing principle of mind. One can exclude irrelevant detail while drawing several conclusions about an element based on its inclusion in various classes by assigning specific things to abstract categories. Any sentence in any language has an underlying semantic structure, a network of interconnected conceptual units that can be represented by a “map”. This net-like graph works like a composite structure that exists in every concept, event, situation, or an object. Instead of adopting extremely arbitrary and imprecise natural languages, knowledge can be expressed by employing abstract conceptual structures known as semantic networks. Containing "taxonomies," "thesauri," and "hierarchies," among other things, semantic networks define the structure of interconnected abstract categories and then use that structure to make inferences. This is represented by a similar organization of nodes representing conceptual entities and direct links reflecting relationships between the entities. When you give each node and link a meaning, an abstracted graph network becomes semantic. Semantic networks aim to represent any type of knowledge that can be expressed in natural language. This system provides ways for automatically generating a much bigger structure or body of implicit knowledge from the explicitly stored network structure (Lehmann, 1992). A node includes a concept as an information unit that may be expressed by a phrase or a word and whose meaning is embedded in its relationships to other ideas. Relations are a type of a concept that illustrates the connections across and among concepts. Therefore, semantic networks can be multidimensional and complex since one concept might be related to many other concepts (Fisher, 1992).

Semantic networks seem to be originally utilized in computer implementations for AI and machine translation, although previous forms of it have long been used in the fields of psychology, philosophy, and linguistics. The Greek philosopher Porphyry created the first documented semantic network in his commentary on Aristotle's categories in the 3rd AD (Sowa, 2006). Figure 3.4 is an early example of a semantic network. Proposed in the Middle Ages, it was believed to be used by God himself. It explains the trinity; the Father is not the Son, nor is the Holy Spirit, but God is all the three (Fahlman, 1979)

Figure 3.4: Explanation of Trinity (Fahlman, 1979)

Semantic networks are employed in practically every AI application area, including natural language processing, logical databases, library document recovery, analogical reasoning, computer-aided design, visual pattern recognition, and many others. (Lehmann, 1992). With its structured and standardized knowledge representation, a web of semantic data makes it possible to automate the process meaning of information, relate and integrate heterogeneous data and deduce implicit information from existing information (Sack & Alam, n.d.).

There are many advantages of using the semantic networks. Contextualization, visualization, and conceptualization are some of the main ones (Wang & Rada, 1995). Firstly, through the connection of information with a concept, employing semantic networks for knowledge representation provides a richer domain context. Such type of linkage contains contextual information that reflects the contributor's intended thinking. The second benefit of semantic networks are their capacity for visualization. By mirroring the associative aspects of the human mind, Semantic networks can aid in the externalization of the professional's knowledge structure (Jonassen, 1992). Lastly, as strengthen by the contextualization and visualization, semantic networks may also enhance the conceptualization of the information that has been offered to them. Conceptualization happens when a person adds meaning to recent information by linking it to their own mental pattern (Wittrock, 1974). Semantic networks provide a framework for information processing by meaningfully linking information as a network structure which is more suited with human cognition than a sequential model (Last et al., 2001).

There are some key concepts that are necessary to understand the distinctive qualities of semantic networks. Contrasting to the "structural" or "definitional" links, there are "assertional" or "descriptive" links. The phrases refer the relational graph representing a simple statement about individuals; nodes represent existing entities in the depicted world, and links indicate relations alleged to exist between them. (Lehmann, 1992).

3.2.1. Types of semantic networks

As discussed earlier in the chapter "Structural Strategies of Semantic Hypertext," there are various approaches to hypertext manipulations. Hierarchy of structure might come from one of three places: The designer selects which concepts belong to which and provides all the links by hand. Secondly, some other formal structure can generate the concept hierarchy structure. Lastly, the statistical properties of a set of data can directly influence the concept hierarchy. (Lehmann, 1992).

Parallel to hypertext strategies, semantic networks have different structural, hierarchical and content wise formation that needs to be discovered. Each having their own qualities, these types of Semantic Networks are used for specific purposes. According to Sowa (2006), all semantic networks have a descriptive graphic representation in common that may be used to represent knowledge or aid automated processes in reasoning about knowledge. Some versions are somewhat informal, while others are properly defined logic systems. Six of the most frequent types of semantic networks are listed below. These types are Definitional, Assertional, Implicational, Executable, Learning, and Hybrid, which only implies combining two or more of these techniques.

As mentioned in the reflections on the knowledge of architecture, architecture is shaped in a structure that expands, develops, and diversifies. Among these network types, "Learning type Semantic Network" was deemed as the most appropriate method in that may be applied in architectural knowledge.

3.2.1.1. Definitional type

Definitional networks stress the "is a" relationship between a concept type and a new added subtype. The network, also known as a generalization or subsumption hierarchy, follows the rule of inheritance by copying properties provided for a supertype to all its subtypes. As definitions are always true, the information in these networks is usually considered to be entirely true (Sowa, 2006).

Removing any literature element, this type aims to find the core, the “naked truth” of any content by reducing it to its essence. An example of this type is the “Knowledge Language One” network that has been created by Brachman & Schmolze (1985). As an example, this graphic can be read as: “Every truck is a vehicle. Every trailer truck is a truck that has as part a trailer, an unloaded weight, which is a weight measure...” (Figure 3.5) (Brachman & Schmolze, 1985).

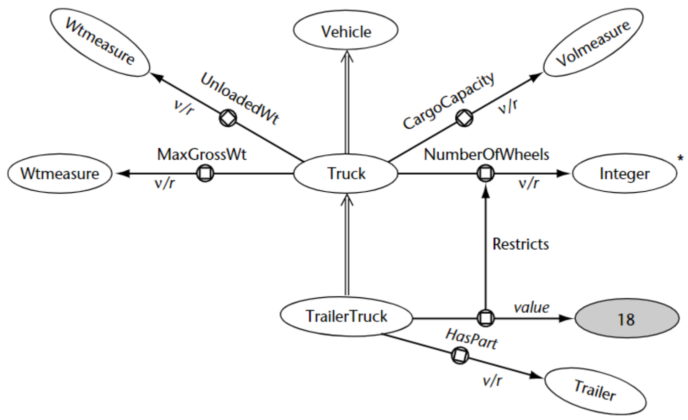


Figure 3.5: The TrailerTruck concept defined in KL-ONE (Brachman & Schmolze, 1985)

This type may use both *Entity-Relationship models*. Entity-Relationship Model indicates a typology of the links (Sowa, 2006). While tagged links describes interrelated things of interest in a specific domain of knowledge, specifying relationships that can exist between entities; simple linking does not carry any additional meaning other than connecting two entities.

3.2.1.2. Assertional type

Assertional networks are intended to assert propositions. In contrast to definitional networks, information in an assertional network is presumed to be situationally true unless specifically indicated with a modal operator. Assertional networks are proposed to model the underlying conceptual structures of natural language semantics (Sowa, 2006). An early example of this type is Charles Sanders Peirce's Relational Graph (1880). With an expressive power, this graphic can be read as "A Stagirite teacher of a Macedonian conqueror of the world is a disciple and an opponent of a philosopher admired by Church Fathers." (Figure 3.6).

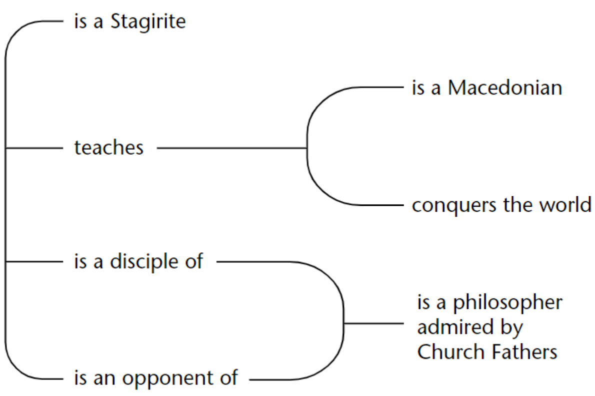


Figure 3.6: Charles Sanders Peirce's Relational Graph (Peirce, 1880)

In this type, each node becomes an indicator of the content. Rather than identifying or tagging the links itself, nodes specify the relationships with other nodes as well. Various logical operators, such like disjunction, negation, or the universal quantifier, are used to designate nodes. Although multiple variations of assertional semantic networks use distinct syntactic techniques to associate relational content with propositional nodes, formal translation rules for converting one version to another can be defined (Sowa, 2006).

3.2.1.3. Implicational type

An implicational network is a subset of an assertional semantic network that connect nodes using implication as the main relation. They can be used to illustrate belief patterns, causality, or judgments. Various relations may be layered within the propositional nodes, but the inference processes ignore them. The same graph can sometimes be used with some or all these interpretations. Depending on how they are interpreted, such networks may be referred to as belief networks or causal networks (Sowa, 2006).

An example of this type of network is given on the figure 3.7. According to this graph, if it is raining season, the arrow marked T indicates that it has recently rained; otherwise, the arrow marked F indicates that the sprinkler is in operation. The correctness of the first assertion entails the truth of the second for boxes with just one outgoing arrow, while the inaccuracy of the first implies no judgment about the second (Sowa, 2006).

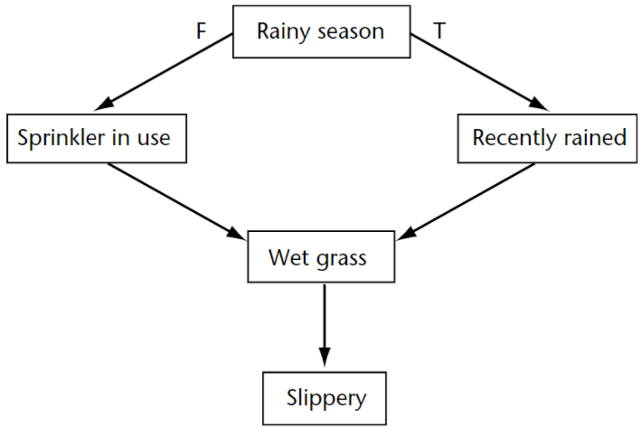


Figure 3.7: Implicational Network graph for Reasoning Wet Grass (Sowa, 2006)

3.2.1.4. Executable type

Executable networks feature mechanisms that may make judgments, send messages, and look for patterns and relationships. These mechanisms even have the potential to alter the network itself. This executable system distinguishes itself from networks that are fixed data structures that can only be changed by external programs. Dataflow graphs are the simplest networks with attached procedures, consisting of passive nodes that keep data and active nodes that collect data from input nodes and transmit outcomes to output nodes (Figure 3.8) (Sowa, 2006).

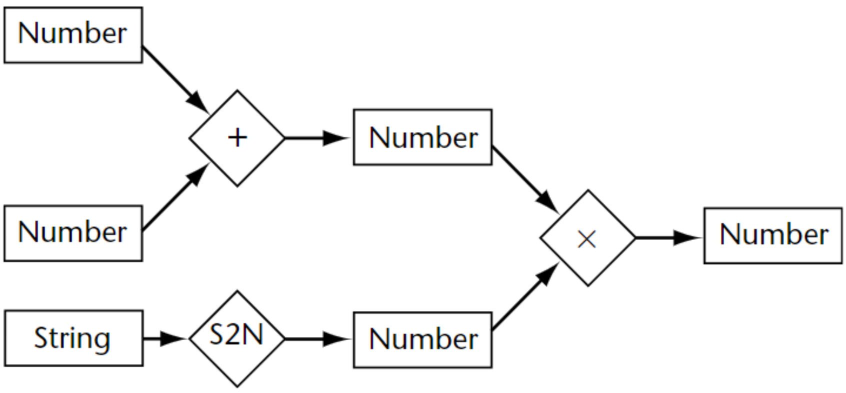


Figure 3.8: Dataflow Graph (Sowa, 2006)

3.2.1.5. Learning type

Learning networks construct or extend their representations by learning from examples. Any new information may alter the existing network by adding and removing nodes and links, or by adjusting numerical values, also known as weights, associated with the nodes and links. A learning system reacts to new information by updating its internal representations in such a way that the system can adapt to its surroundings more effectively. Network representations can be modified in three ways (Sowa, 2006):

- *Rota Memory*. Adding new information without any other alterations to the current network is the simplest form of learning for a network.
- *Changing weights*. Weights are numbers associated with nodes and edges in some networks. It can be simply stated as number of the links. Each occurrence of a pattern increases the projected chance of its recurrence.
- *Restructuring.* The most complicated form of learning involves fundamental changes to the network's structure. Since the amount and variety of structural modifications are limitless, studying and classifying restructuring methods is the most challenging but possibly the most rewarding task.

Commercially, rote memory is crucially significant since the global economy is dependent on precise record keeping. Information is frequently stored in tables for such purposes, as in relational database systems (Sowa, 2006).

A neural network is an example of a learning type graph. This network types do not generally use a tagged entity relationship model; all the relationships exist due to any type of connection context (Figure 3.9). In line with the ever-expanding and updated structure of architectural knowledge, this typology naturally fits into the structure of architectural knowledge. New information is constantly being added, relationships that cannot be clearly structured from various disciplines take their place in the circulation of architecture. After this stage of the thesis, the narrative will continue through example networks in this typology.

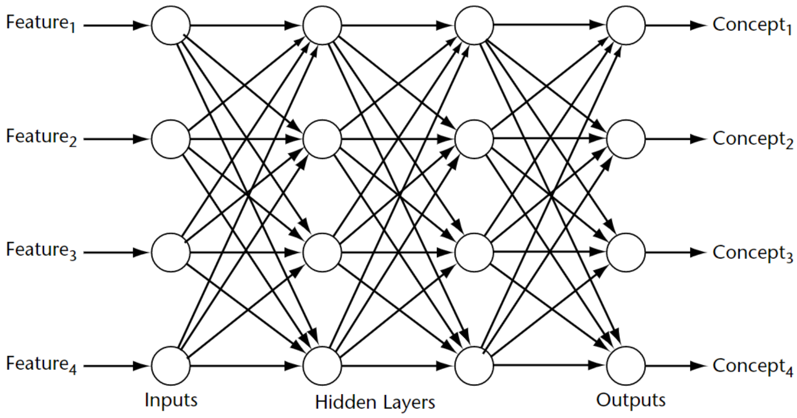


Figure 3.9: Neural Network Graph (Sowa, 2006)

3.2.2. Examples of "learning type" semantic networks

For organizing semantic knowledge there are many tools that works in various ways. While some of them only focuses on the specific sets of data, some solely visualize written data. Although it is not possible to gather all the similar work, it was intended to mention some of the work with similarities regarding to content, input data or technical approach. Of course, there are uncountable number of tools focusing on similar tasks. To touch on some that specifically works with large amount of data, *iVisClustering* (Lee et al., 2012), *TopicNets* (Gretarsson et al., 2012) and *VisiRR* (Choo et al., 2018) can be mentioned. However, open-source applications were focused due to their research friendly approach.

3.2.2.1. "OntoText" by Sirma Group Holding

Previously known as *Sirma AI*, *OntoText* is a project of *Sirma Group Holding*, a private company. The project aims to extract meaning across diverse and massive datasets of unstructured information. By enabling machines to interpret, analyze data and creating an interlinking graph that models the knowledge reflected in human brain. This application aims to reach beyond the human thinking patterns and acquire complex and hidden information by generation of the metadata (OntoText, 2000).

By using semantic graph database, text mining, machine learning, the company has multiple professional services like Consulting, Data modelling, Text Analytics and Mining, Technical Support and even Semantic Technology Courses. It is commonly used by businesses to get to the bigger picture of their data. It also has a downloadable free version to use.

3.2.2.2. “Textexture” by Nodus Labs

Textexture a visualization tool that aims to turn any text into a network graph developed by the Nodus Labs company (Figure 3.10). Formerly using the open-source *Gephi* Software and *Sigma.js* toolkit, this tool no longer functions and is replaced with the *InfraNodus* by the company (Textexture: The Non-Linear Reading Machine, 2015). Like their later work, the aim was to build a hypertext reading aid that produces a graph view out of the relations within a text. Their objective is to demolish the linear reading and knowledge consuming experience and turn it into a comprehensive one (*Textexture*, 2012). Textexture is referred to as “a nonlinear reading machine” that focuses on one text and its semantic metadata (Textexture: The Non-Linear Reading Machine, 2015). Although it works smoothly for building a relational network graph, it lacks the ability of cross generating information due its focus on single text document. For the sake of example, a network was developed from a chapter of bible, showing the most influential keywords it contains.

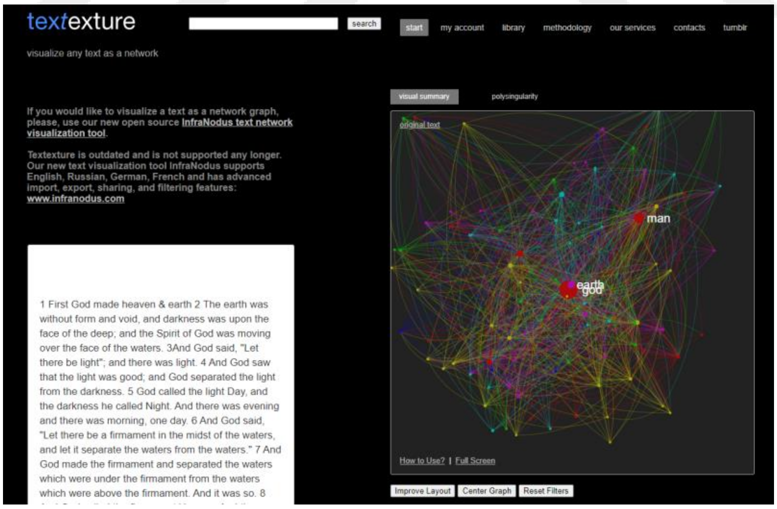


Figure 3.10: Networked graph of a section of the Bible (Textexture, 2012)

3.2.2.3. “InfraNodus” by Nodus Labs

Developed as a successor of *Textexture*, *InfraNodus* is a web-based commercial text network graph tool that aims to reveal links and patterns in data by networked thinking built by *Nodus Labs* (Figure 3.11). By using social media data, spreadsheets, or even raw text it aims to visualize any data as networks via Text Analysis. It can be purchased by variable monthly pricing options. Since its launch in 2011, many institutions benefit from its abilities (InfraNodus, 2011).

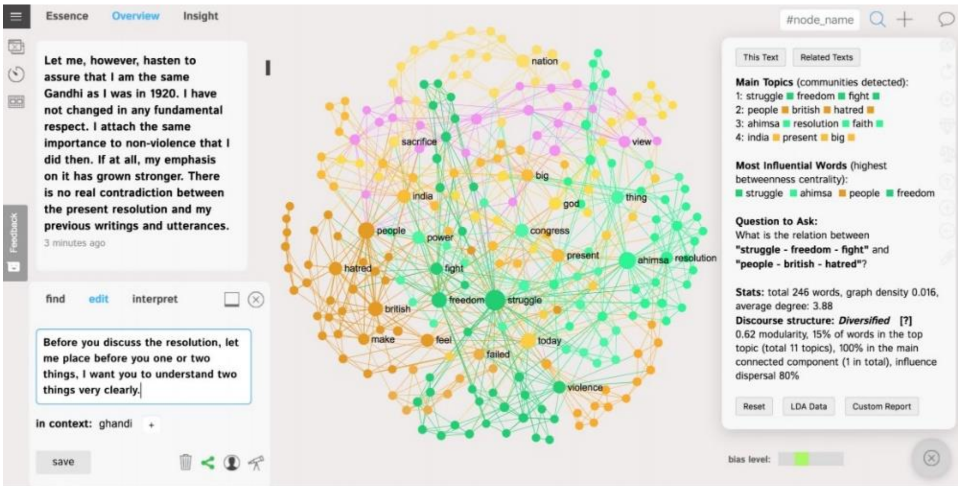


Figure 3.11: Interface of InfraNodus. Visualized text, primary topics, discourse structure, and bias index (Paranyushkin, 2019)

By analyzing and visualizing data as networks, it aims to untangle patterns to clarify evolving complexity of knowledge. Approaching data from both as an overview and zoomed into any area, this tool mainly focuses on the structural gaps in the data and generating innovative research ideas. While it's detecting the obvious, it can also crack the gaps that have not yet discovered.

Similar to many graph views, more relationally influential nodes are shown bigger. It is possible to zoom in and gain insight about the inserted data by its automatic recognition of absence of possible relations, visualized keywords, topics, and links. *InfraNodus* uses most text analysis abilities as text mining, sentiment analysis bias detection and so on InfraNodus is open-source and uses Neo4J graph database, *SigmaJS* visualization library, NodeJS and *Textexture* algorithm and some other open-source libraries (*InfraNodus*, 2011). *InfraNodus* takes various steps to clean and structure the data. First is the lemmatization of the word to merge the different variations of the words (e.g. "bathing" turns into "bath"). Second step is to remove the stop words that does not hold meanings (e.g. "is", "the, "are", etc.). Cleaned texts then gets converted into network graphs. After the scanning of the nodes and links each node is weighted by the number of their links. It is then possible to identify the most influential nodes.

Via various visual coding the graph becomes more readable for the human eye (Paranyushkin, 2019).

Main handicap of this tool is that while it can combine various text documents, it primarily finds the relations within one text document. Therefore, works on the meaning analysis and interpretation of a given text rather than comparing and combining extensively.

3.2.2.4. "VOSviewer"

Designed by the Centre for Science and Technology Studies at Leiden University, *VOSviewer* is a program that allows you to create and visualize bibliometric networks (Figure 3.12). These networks can be built via citation, bibliographic linking, co-citation, or co-authorship relationships, and they can include journals, researchers, or individual articles. Text mining capabilities is also included in VOSviewer, which may be used to create and monitor co-occurrence networks of relevant terms retrieved from a collection of research literature (*VOSviewer*, 2016).

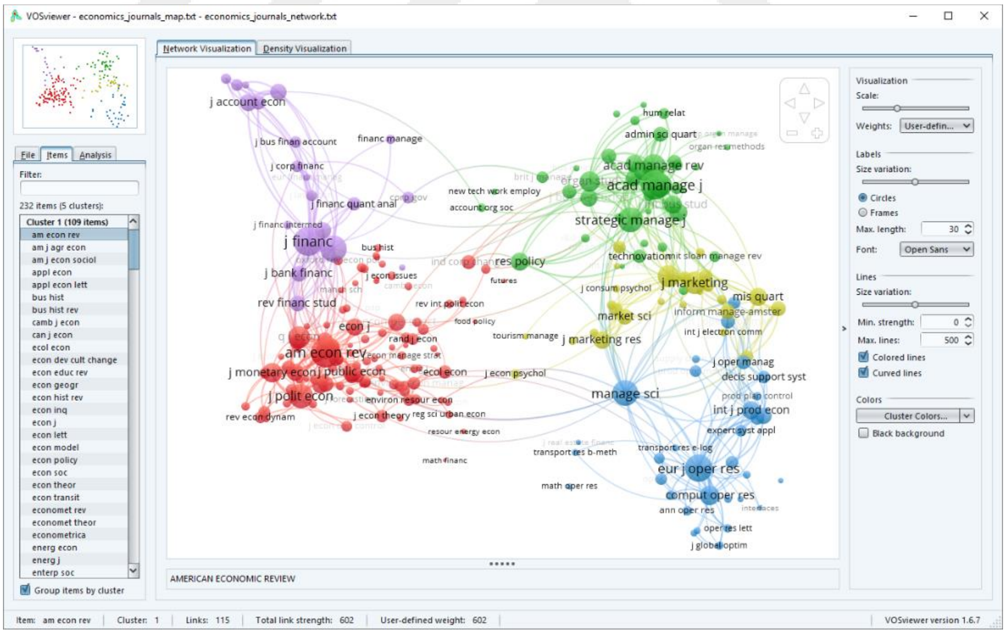


Figure 3.12: VOSviewer Interface (VOSviewer, 2016)

There are many academic publishing regarding to this tool, either about the technicality of it or projects that held with the help of it. To the gathering of the data, apart from extracting data from various online databases, reference management apps like Zotero and Mendeley, or given sets of DOIs are also usable. NLP techniques and various clustering and visualizing tools has been used for its development. While there is a downloadable application for the main usage, there is also a web version that can be used (*VOSviewer*, 2016).

3.2.3. Examples of semantic network graph generators for art and history knowledge

3.2.3.1. “The Museum of the World” by the British Museum

With the slogan “History Connected”, *The Museum of the World* is an interactive website built for the *British Museum* with the partnership of *Google Cultural Institute,* that helps to investigate through ages, regions, and cultures, showcasing some of humanity's remarkable objects. Users can choose a time period and a continent, then explore artifacts in novel ways. Rather than viewing artifact individually, both period, continent and any relational object is shown with a dynamic interface (Figure 3.13). In addition to the chronological and geographical order, the *British Museum* has categorized the artifacts by “Art and Design”, “Living and Dying”, “Power and Identity”, “Religion and Belief”, “Trade and Conflict” (The Museum of the World, n.d.).

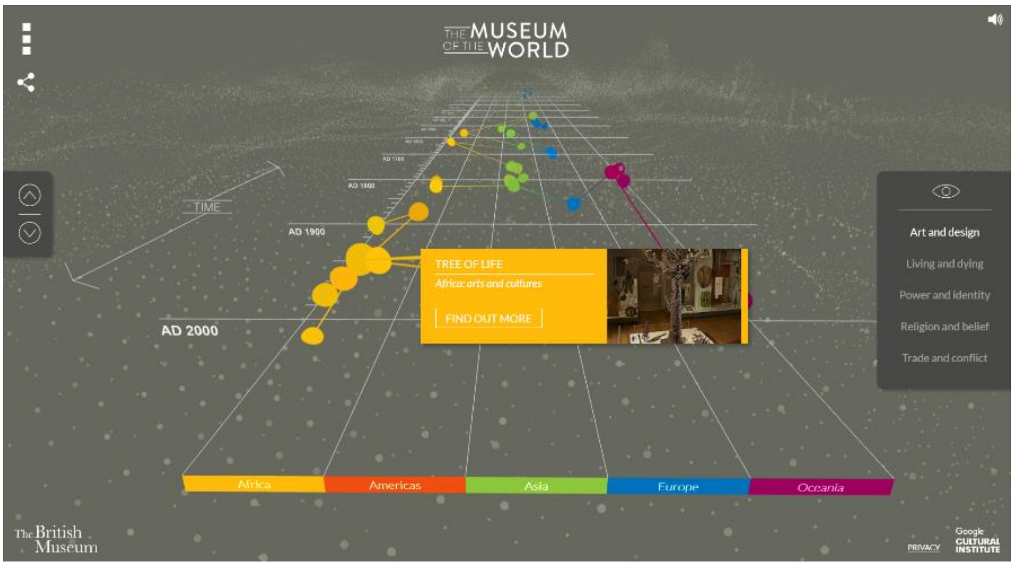


Figure 3.13: The Museum of the World (The Museum of the World, n.d.).

The website was built using WebGL (Web Graphics Library) technology with the Conteful API to display nodes and elements in three dimensions for over 2 million years of data. The site was built on top of a Python/Appengine system. By the site's global publication, new approaches to experiencing collections online has inspired universities and institutes across the world (Weirandwong, 2016).

3.2.3.2. "Palladio" by Stanford Humanities and Design

Palladio is an outcome of the National Endowment for the Humanities Implementation project (July 2013-June 2016), Networks in History: Data-driven Tools for Analyzing Relationships Across Time. The objective of this work is to learn how to create graphical interfaces using humanistic inquiry as a foundation (Figure 3.14). The project was centered on the creation of a general-purpose suite of visualization and analytical tools based on prototypes produced for the Mapping the Republic of Letters project, which investigates academic societies and knowledge networks from 1500 to 1800. A Palladio project starts with a tabular dataset uploaded into the interface. Then it can be processed and visualized to be stored as an .json file in the local storage (*Palladio. Visualize Complex Historical Data with Ease.*, 2016).

Previously only visualized in the minds of historians, early modern communication networks can now be seen graphically connecting the understanding of enlightenment thinking. The technology, developed by a Stanford collaboration of four core humanities faculty, graduate students, and foreign collaborators, aimed to generate new avenues for knowledge production. They claim that it is widely known and acknowledged as a data visualization example that can alter historic research. However, their main inference was the need for the investment for tool development regarding perusing the upgrading of historic research.

Main limitation of this app is that although it has multiple variables for each element, it can only compare and relate two dimensions. To work with this tool, a refined dataset needs to be prepared beforehand. Concordantly, it does not work with complex heaps raw data.

Figure 3.14: Palladio Interface (Palladio. Visualize Complex Historical Data with Ease., 2016)

3.2.3.3. "HistoGraph" by CVCE Digital Humanities Lab

HistoGraph is an opensource graph-based exploration and indexation for multimedia bundles, developed by the *CVCE Digital Humanities Lab* by Lars Wieneke, Daniele Guido, and Marten Düring. Its main focus of this knowledge graph generator is to make sense of the complex and hierarchical historic data into a relational one. As input, *HistoGraph* gets sourced by various written and visual data from historic news and documents. It simply links two keywords together if they were mentioned in a document together, works in the logic after the frequency of the co-occurrence (Figure 3.15) (*HistoGraph*, 2018).

It cross references all the data into nodes with upper classifications. Such as places, people, or events to make it more clear to the reader. Then by tagging these keywords inside these documents it builds a relational map by linking the keywords that are common in documents. When clicked in these nodes created by keywords, all documents related to them is shown. When clicking to a relational line between these nodes it displays the common document that include both keywords. It also develops a timeline and shows the busy dates related to that specific subject. There are also filters by date, entity, and type of documents. Apart from creating graph from two entities such "people- places", it can also reveal relations between same entities as "people-people.

Figure 3.15: Relation of Places and Events (HistoGraph, 2018)

HistoGraph uses a combination of tools for its desired outcome like *YAGO-AIDA* for auto-detection of places, people etc. for name entity recognition. With the rich database of *DBpedia* and *VIAF*, *it* creates nodes and links from documents. Despite its advanced technique human validation is still necessary. It is a lightweight application works on a browser. It was built on *Neo4J* graph tool and uses frameworks as *Angular*, *NodeJS* and *SigmaJS* visualization library. All the code is available under *MIT license* (*HistoGraph*, 2018).

Focus being the historic documents and semantic identification, this tool is quite related to the case this work is focused on. However, while trying to create a non- hierarchical exploration of current meta data and indexation, *HistoGraph* chooses to use inclusive classification for the sake of clarification. While it eliminates hierarchy, this choice may make the knowledge in this tool relatively controlled.

4. CASE: ANKARA ROMAN BATH ON “OBSIDIAN.MD” AND NLP

4.1. A Hypertext Content Management System: Obsidian the “Second Brain”

Looking at the examples given at the previous chapter, the tools used for relational information accumulation in the fields of art and architecture are seen as interfaces produced by professionals rather than an average user. In this sense, in this study on the knowledge of architecture, a search for a tool was started for easy use of the complex and ever-expanding data pool. The usefulness of written data and semantic network graphs for this study has been mentioned in previous sections. In this direction, hypertext note-taking tools that use traditional written text as input come to the fore.

It is known that while hypertext offers more flexibility and convenience than traditional texts, it gains far more impact and appeal when used in computing settings (Smith & Weiss, 1988). The latest trend of computer technologies that combines the concepts of notetaking and knowledge management is these hypertext note-taking applications. These programs, presented as the "Second Brain," have been actively used by various researchers, content producers, and students in the last few years. On a meta scale, this system has also been used by the author to produce this thesis, editing its content, and organizing its data.

A wide variety of examples stand out as a notetaking and content management system. Linear note-taking tools such as Evernote and OneNote are among the most popular for configuring the data. These common examples traditionally manage a variety of textual content that has been moved to the digital platform. Although they contain hypertext features at various scales, they cannot make a revolutionary breakthrough in the management of information. These new generation note-taking applications, presented as the Second Brain, can construct complex hypertext structures by using digital facilities efficiently. Some of these tools include Roam Research, Obsidian.md, and Dynalist. The pioneering program, Roam is a note-taking program that stresses the use of "networked thought" to handle "bidirectional links" (*Roam A Note-Taking Tool for*

Networked Thought., n.d.). After Roam Research, which only started allowing users in 2020, applications such as Obsidian and Dynalist also adopted this system with minor changes.

These tools, produced for the relational rearrangement of all kinds of written and interconnected information, have two main features. A connection setup called Backlinking or Bidirectional Linking and the graphical visualization interfaces of the learning type semantic network they produce.

4.1.1. Bidirectional linking / backlinking

Bi-directional references or backlinks that have been recently included in the notetaking apps, is a milestone in the development of linked notes. The initial idea for such a system was sparked by Niklas Luhmann's Zettelkasten method (Ahrens, 2017, 12-20). He created a technique that allowed him to organize notes on wider topics to uncover linkages between individual bits of information that are often not obvious in itself individually. By writing each note on its own card, hierarchically numbering them so that new notes can be added to convenient places and keeping track of connections between the notes. Even though such a strategy can be quite effective, it takes a long time to set up and maintain (Matysek & Tomaszczyk, 2020)

Inspired by the Zettlekasten method, the bidirectional linking is basically a linking strategy between each note page. Each note page has various written content on it. In contrast to a linear hierarchical note setup, in this system each note page can reference to the other forwards and backwards notes. Each note inserted into the repository can have an undirected relationship with the parts of the note added before it and will be added after it. Aside from live searching and grouping by tags, bi-directional references, or backlinks, may be used to show the content of multiple notes on the same subject at the same time. To put it another way, any notes that relate to the note we're looking at, might be accessed (Matysek & Tomaszczyk, 2020). In this sense, the system called bidirectional linking, or backlinking, is used to emphasize this transhierarchy. Wikipedia and other Wiki pages are the best-known examples of this.

These bi-directionally connected notes can be found in the "Linked References" or “Linked Mentions” sections. With the help of bi-directional linking, a researcher can always view the paragraphs related to the subject highlighted in the current note. There is no need to go through the notes one by one. The whole note is not viewed; instead, an isolated paragraph blocks from various notes where the topic is mentioned can be seen, as well as the context or in other words, source. When a user creates a normal link, backlinks are generated automatically. The program also informs which notes have not yet been interlinked, allowing the user to determine if it is beneficial to connect them (Matysek & Tomaszczyk, 2020).

This feature encourages serendipity and inspiration. It is worth noting that systems with bi-directional links do not only handle descriptive and didactic information, but they also alter researchers' ways to take and connect notes. In a sense, backlinking is a new way of arranging the brain. When the researcher discusses concepts and attempts to integrate them, the major cognitive activity is done at the idea level (Matysek & Tomaszczyk, 2020).

Also, for transclusion, backlinks are quite substantial. The term transclusion refers to the process of embedding content from a different area so that the changes to the original are evident in the embed (Nelson, 1981). Transclusion accelerates the writing process by aiding the gathering and synthesis of ideas. As an example, Roam Research allows to view a single integrated file as a composed of sections dynamically built from several notes. (Matysek & Tomaszczyk, 2020).

4.1.2. Visualization of the semantic network: The graph view

Statistical data, as well as other complicated information, are frequently visualized. Further to that, visualization can also aid discovering information hidden in your unstructured notes. Human eye registers structures as patterns, thus visual representation of content may expose what brain doesn't nonvisually grasp (Fekete et al., 2008) (Keim, 2002, 1). Graphs built through note-taking software like InfraNodus (2011), are dedicated to map the patterns and relations in unstructured semantic data, substantially improving the human capacity to link distant bits of data. The ability to interact with, alter, and analyze data in a visual format gives new insights, helping users to reach faster decisions (Matysek & Tomaszczyk, 2020).

Tools like Roam research and Obsidian make it possible to visualize the network formed by the notes' interconnections (Figure 4.1). It also allows filtering or removing notes from the visualization set, along with zooming in and out of the graph to emphasis on the details or the broad picture (Matysek & Tomaszczyk, 2020). In addition to mapping all the notes in the dataset, they can also create a graph of the relationship between the note pages in double-triple combinations. There are various controversies over the legibility and usefulness of these charts. Although the criticisms about the unclear and chaotic legibility are justified, this complex structure is an expected result in line with the non-taming structure of the infrastructure it represents.

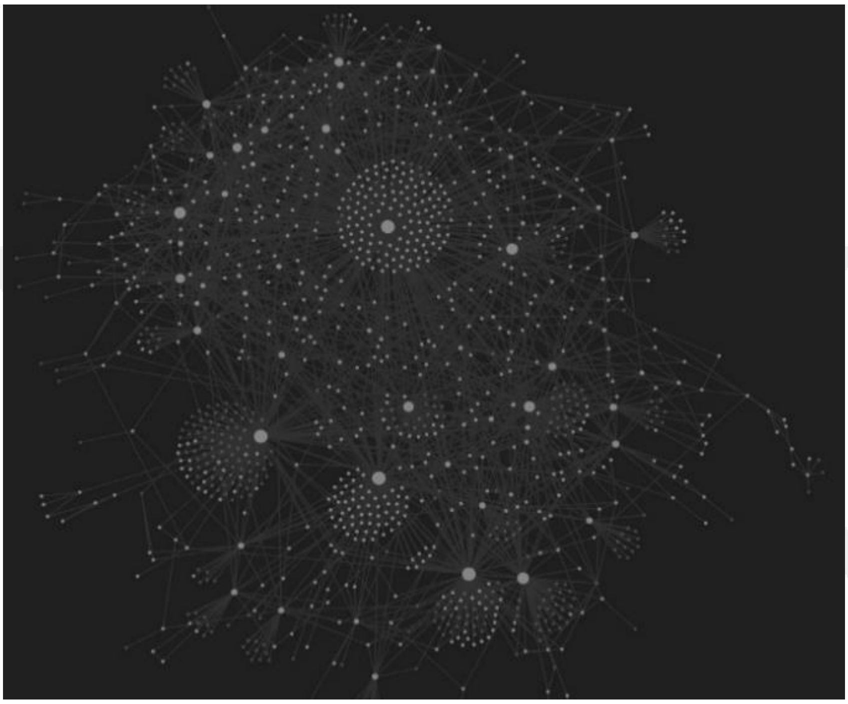


Figure 4.1: Obsidian.md Graph View

4.1.3. Obsidian. md

Obsidian is a strong knowledge base built on a local folder containing plain text Markdown files (*Obsidian.Md*, n.d.). This practice, which is built with a philosophy on the non-linear nature of the human brain, which jumps from idea to idea, is promoted as the "second brain". It stands out as an alternative to Roam Research, which has made a big impact in the note editing industry with its debut but has a fee and security problems. Obsidian includes many of the features of the aforementioned next-generation note-taking tools. In addition to Backlinking and Graph view features, it also has a feature that specifies potential links called Outgoing links.

It is not an open-source app however user contribution is highly encouraged. Various plugins, themes and upgrades are developed by users individually and as a group. It also guides the developers with the discussions carried out in the very actively used forums. As stated on its website in January 2022, around 50,000 users contribute to the improvement process of the application as a community (*Obsidian.Md*, n.d.).

One of the most important features of this application is that it is open to all kinds of add-ons, collaborations, and expansions. All kinds of customization, partnerships with external programs and technologies are facilitated with plugins, themes, and custom CSS. While the app itself is not open source, most of this additional content is shared and distributed on GitHub.

Unlike other applications in this field, the data is under the control of the user rather than the provider. Notes stored in Markdown format, which allows human and machine readings, are stored locally on the user's own device instead of a cloud or server. In this way, it is guaranteed that the notes will not be lost even if the application is switched off. Markdown files stored on the device can be used in partnership with other programs, encrypted and protected as desired, or stored in a preferred cloud system. In this way, the system can continue to operate even when there is no internet.

The interface is also highly customizable, with a several key sections (Figure 4.2). A file management window in which all existing notes in the dataset are listed, the main window where the contents of the selected note are displayed, the relational graphic visualization of the displayed note called local graph, the Linked and Unlinked Mentions parts where the backlinking system works, and the outgoing links tab that shows the data that can potentially be related in the text are some of them. (*Obsidian Help*, n.d.). Words or phrases enclosed in double brackets “[[]]” represent pages of notes that have been created or are expected to be created. In Obsidian, each note page corresponds to a node in the semantic graph. In this way, each node may or may not have content inside. Blank note pages are also included as nodes in the system and are a part of the network.

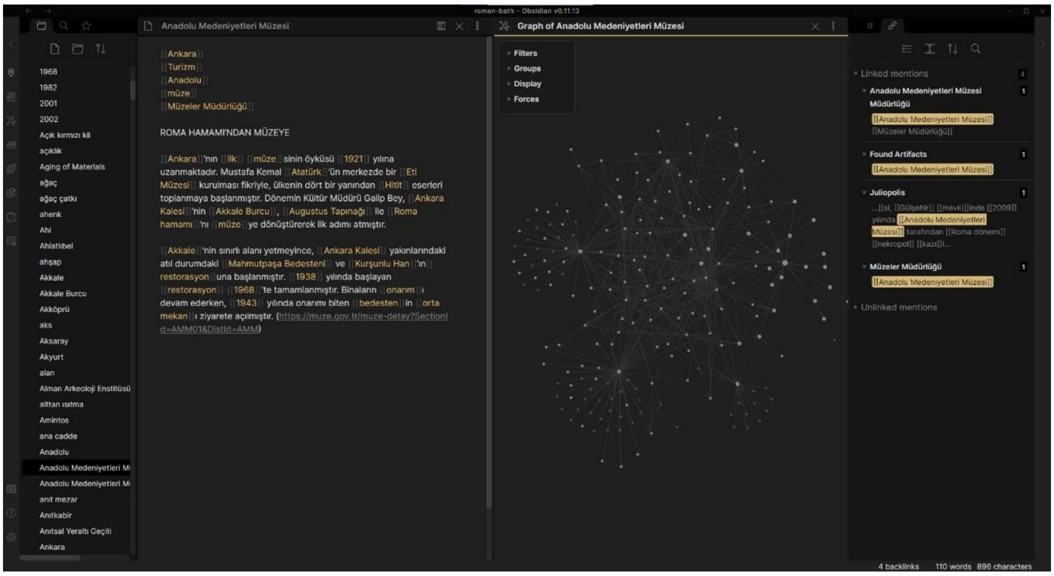


Figure 4.2: Interface of Obsidian.md

Backlinks are rendered actively and effectively in Obsidian.md. Inbound links are divided into two categories: "Linked References" that are established consciously by the author, and "Unlinked references" that are generated dynamically in response to a search query. Each article that refers to a node is mentioned under the title "Linked References". The node's content is repeated below each article, and descendants are presented under it through transclusion. Following these directed links creates a somewhat hierarchy; employing the transhierarchy to transclude the contents of an external link, creates associations. It results of a significance in the user's navigational behavior (Revere & Blustein, 2020).

Fully transcluded tree views are generated for both sorts of references. Child nodes can be displayed to any depth and modifying any child node in the embedded view will update the original**.** In Obsidian, this graded node tracking (node weights) and the idea of closing and opening neighbor links, besides tracking the linear hierarchy (parent-child nodes), examines the status of associate internal relations that give the topic "trans" title. Obsidian's implementation of Linked and Unlinked Reference illustrates a transhierarchy by providing navigation beyond hierarchical limits and preserving context through transclusion (Revere & Blustein, 2020).

Despite initial user experience shows that the stability of the hierarchy along with user-directed initiation of transclusion may be adequate to prevent disorientation, this design choice comes at the sacrifice of some stability. The text is connected, necessitating interpretation via a web of interconnections. Some claim that in Obsidian.md no transclusion is used to show additional information. As one user put it, "It is very difficult to make out context from backlinks. I think the current implementation is similar to showing search results. I feel true power of backlinks only comes with Context"(“Fully Transcluded Backlinks,” n.d.). This emphasizes the need of bidirectional linking as well as transclusion in dynamic hypertext systems (Revere & Blustein, 2020).

It is a fact that obsidian has difficulties in providing context. However, while presenting the complexity to the user, it tries to minimize this difficulty with the tools and interface it uses. (Figure 4.3) shows a typical obsidian worksheet. While all the concept pages in the database are listed on the left, a concept page with its content is seen in the middle of the screen. The network graph of the page is shown at the bottom right. This chart is set to show only outgoing first-degree neighbor connections. This interface, enriched with various settings and filters, allows to manipulate the network structure, which is perceived as complex and uncontrolled, according to the needs. The level of detail (Figure 4.4) that can be detected with the settings is also shown.

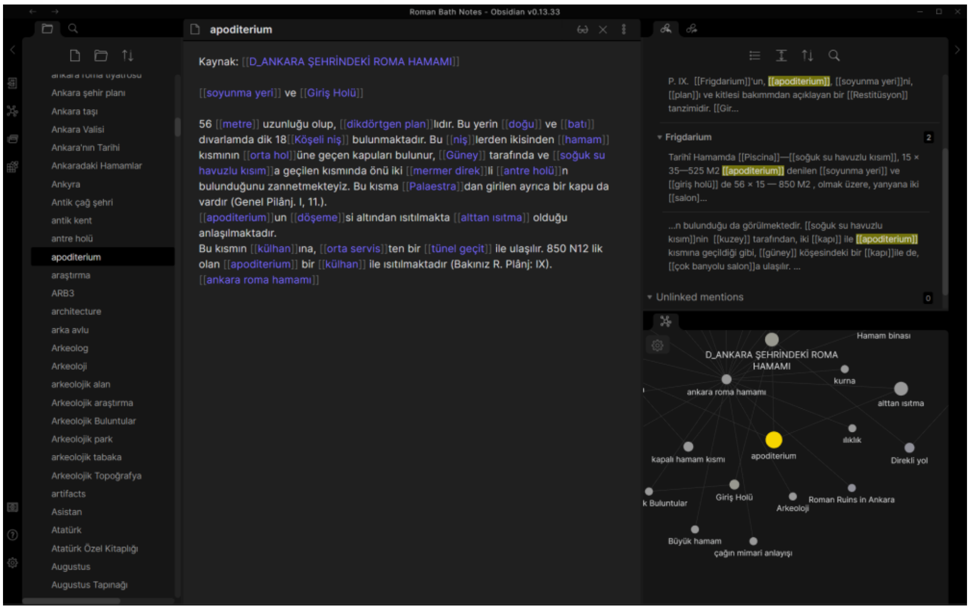


Figure 4.3: Interface of Obsidian.md

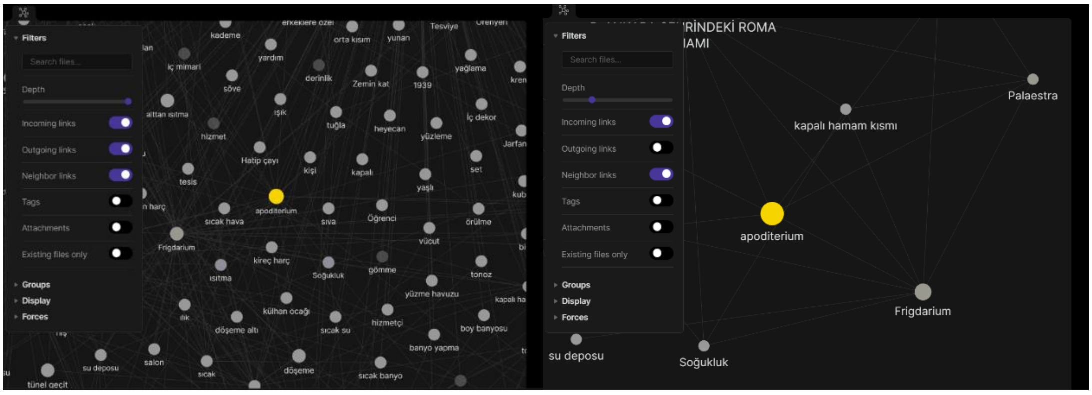


Figure 4.4: Graph View Details

Likewise, the backlinking interface is designed to provide context. For example, the knowledge that the concept of Apoditerium can be found on the content page of Phrygdarium forms the core of the backlinking system. As can be seen in (Figure 4.5), this interface has been expanded and narrowed to increase the visibility of how they are related in which context.

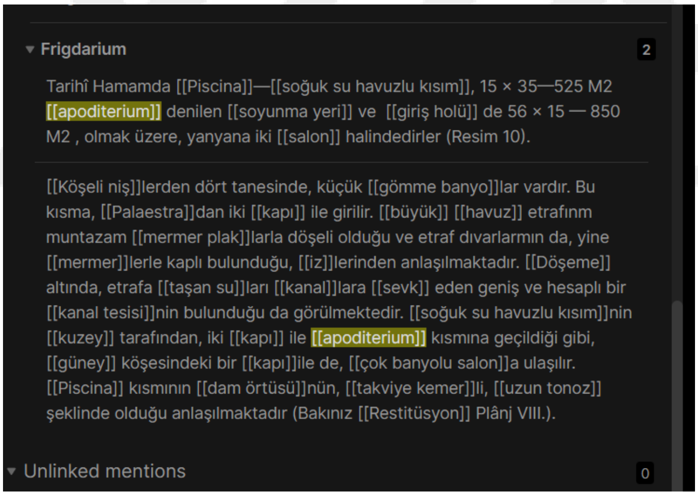


Figure 4.5: Extended Backlink View

4.2. Phase 1: Manual Method in the "Obsidian.md"

In the search for a method for the relational organization of architectural knowledge, new generation note-taking tools have come to the fore. Obsidian has come to the fore with a useful graphical engine and backlinking tools that combine the previously discussed hierarchical and associative logics, ensuring that the context and navigation is not lost while using the advantages of complexity to the fullest. As mentioned in the previous section, Obsidian is open to various integrations and developments, therefore the study started with this note-taking tool. Two main phases were determined for the case study. Phase 1, in which the application is carried out manually, and phase 2, in which artificial intelligence tools called Natural Language Processing are included. First, it is necessary to talk about phase 1, which was studied to understand the nature of the system and then guide the system to be established with artificial intelligence.

This case study is a search for a tool for the synthesis, production, concretization, and visualization of architectural knowledge. The first aim was to transform the written architectural information into hypertext format which has various potentials. The second goal is the production of a graphical tool that will make this complex assertive hypertext structure tangible.

The network system to be accessed here is an example of a non-linear hypertext. The nodes of the network establish connections back and forth as far as the obsidian application offers, and they have as much weight as the number of networks they have established. This structure, which has transhierarchical qualities, may not offer an easy-to-follow setup. This criticism of clarity, which is often made about this tool, was taken into consideration in the process. The idea of making this assertive hypertext understandable with certain contextual grounds comes to the fore with the idea of transclusion method discussed in the previous sections. However, it should be noted that this tool carries out the process of making sense of already complex and structureless structures. It is not expected that the result will draw a clear and undisputed image.

4.2.1. The case: Manually created knowledge network of Ankara roman bath

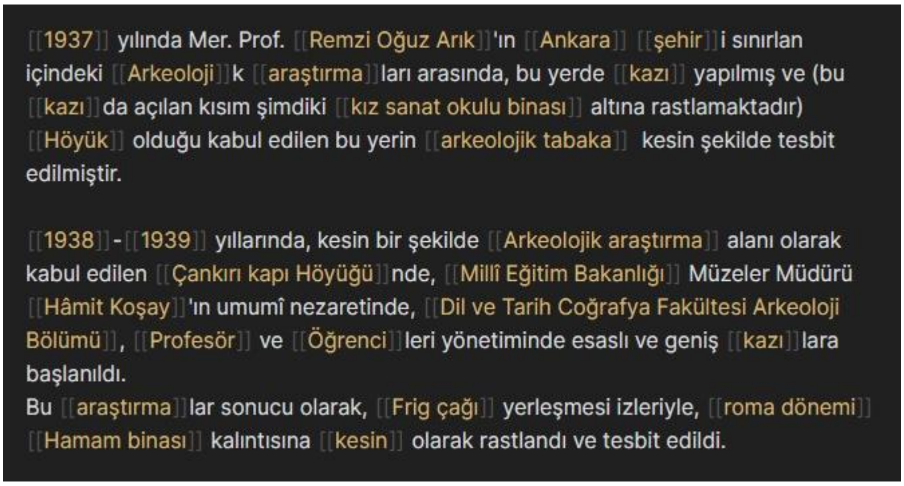
Any architectural element could be chosen to provide data for this study. Given the scope of the thesis, the structuring tool is more important than the selected architectural entity. Nevertheless, an architectural information study had to be carried out on a single building to set an example. Concordantly, the Ancient Roman Bath in the city of Ankara was chosen for this study due to its historical importance and easy to access of documents.

Ankara Roman Bath is an ancient site, located in the Ulus district, containing remains from the Roman and Phrygian ages. The building, which is considered one of the most important legacies of the city of Ankara from the Roman period, has been subjected to excavation, examination, and documentation processes since its discovery in 1926. Various research and archival studies, written and visual documents written on it have been documented. The most comprehensive text document among them is the article “Ankara Şehrindeki Roma Hamamı” written by Mahmut Akok (Akok, 1968). In this article, the discovery and restoration process of the ruins, the scientists and institutions who worked on it, and the bureaucratic processes it went through, as well as the historical and qualitative data about the structure were mentioned. It includes the physical structure of the building, the way the baths were used in the period and the way of life, and various drawings and visuals. This is one of the most comprehensive and compact studies on the Ankara Roman Bath.

Input data for Obsidian, which is a semantic tool, are written texts. For this reason, this article by Akok was chosen as the main data source for this study. To increase the diversity of data and to get input from elements other than the Roman Bath, the Ankara promotion brochure published by the Ministry of Culture and Tourism was preferred as a second source (D. Acar, 2013). It contains texts about various important structures in Ankara, including the Ankara Roman Bath. This brochure, which includes additional political and geographical information, has been added to draw conclusions about the relationship of the Bath with other elements.

Apart from these two sources, no additional input was provided. Additional resources, which are planned to be added, if necessary, were not included in the process because the system gave a very intricate and complex result even with only these two resources. Since the main sources are in Turkish, the language preference was made in this direction at the Phase 1.

Work began by opening a new workspace in Obsidian.md. Akok's related work was added to the text field named “D_Ankara Şehrindeki Roma Hamamı” and the entire text was scanned for association. As mentioned earlier, in Obsidian, tagging is done with "brackets [[ ]]". The researcher scans the manuscripts and associates the phrases that should be an element in the network by bracketing them. This process can be done manually or with the suggestions of the forward linking system. The system scans the names of previously created pages in this text and asks if you want to match them. This can be viewed as a tagged piece of text (Figure 4.6). These phrases are included in the database as a separate page in the system.


[[1937]] yılında Mer. Prof. [[Remzi Oğuz Arık]]'ın [[Ankara]] [[şehir]]i sınırlan içindeki [[Arkeoloji]]k [[araştırma]]ları arasında, bu yerde [[kazı]] yapılmış ve (bu [[kazı]]da açılan kısım şimdiki [[kız sanat okulu binası]] altına rastlamaktadır) [[Höyük]] olduğu kabul edilen bu yerin [[arkeolojik tabaka]] kesin şekilde tesbit edilmiştir.

[[1938]]-[[1939]] yıllarında, kesin bir şekilde [[Arkeolojik araştırma]] alanı olarak kabul edilen [[Çankırı kapı Höyüğü]]nde, [[Millî Eğitim Bakanlığı]] Müzeler Müdürü [[Hâmit Koşay]]'ın umumî nezaretinde, [[Dil ve Tarih Coğrafya Fakültesi Arkeoloji Bölümü]], [[Profesör]] ve [[Öğrenci]]leri yönetiminde esaslı ve geniş [[kazı]]lara başlanıldı.
Bu [[araştırma]]lar sonucu olarak, [[Frig çağı]] yerleşmesi izleriyle, [[roma dönemi]] [[Hamam binası]] kalıntısına [[kesin]] olarak rastlandı ve tesbit edildi.

Figure 4.6: Content Tagging

This process can be called text tagging. The author manually tags the text, while the application performs automated backlinking. As a result, this phase is not totally automated. Deciding on the phrases to be associated and manually tagging, slowed down the process considerably, and the labeling time of a text of approximately ten pages exceeded to four to five hours. For this reason, no matter how little input is done to establish such a knowledge network, it forces the human working capacity.

The most important factor in the labeling process are the principles applied. The phrases selected for labeling and the distribution of text content between concept pages were not chosen randomly. To relate all kinds of data about the focal point in a logical framework, the concepts that are thought to influence it have been tried to be selected. Various principles and decisions have been made to make this process systemic.

“Ankara Roma Hamamı” *(Ankara Roman Bath)* sits at the center of this knowledge ecosystem. Each node associated with it is referred as a first-, second- or third-degree connection with this coupling distance. To give an example, if the center is " Ankara Roma Hamamı ", the elements connected to it in the first degree are "Ankara", "Roma", “Türk Hamamı” *(Turkish Bath)*, “Roma Hamamı” *(Roman Bath)*, its location "Ulus", “Çankırı Caddesi” *(Çankırı Street)*, the year it was discovered "1937". concepts such as Secondary connections are all the associations that are done around these primary tags. These degrees are very important to establish the logical system when knitting the web. The text in each page determines how and to what extent it relates to other concepts.

At first, since the content of the “D_Ankara Şehrindeki Roma Hamamı” page contained all the data entry in the system, all the nodes in the relational graphic database were connected to this concept (Figure 4.7). This situation was deemed objectionable for several different reasons. First, this page is a resource page about the Ankara Roman Bath. The phrase "D_" in front of its name was introduced to indicate that this page is a document rather than a concept. Second, although each concept in the text is primarily linked to the main file, there must be a text entry in these concept pages to establish secondary links. For this reason, it is necessary to distribute the content in the source text to meaningful headings while preserving the connection between them. These titles turn into concept pages on their own, and instead of carrying all the links on the source, they are divided into parts and directed to the right information content.

Figure 4.7: Graphic of “D_Ankara Şehrindeki Roma Hamamı” page

Accordingly, it has been decided to move various sub-headings and contents in Akok's article to the relevant concept pages. As can be seen in (Figure 4.8), the text fragments found in the text for the “Palestra” and “Kapalı Hamam Kısmı” *(Indoor Baths Parts)* have been moved to the relevant pages as in (Figure 4.9). It references the source, but content from the main source has now been moved to this page. After this parsing study, a much more readable result was obtained in terms of network hierarchy.

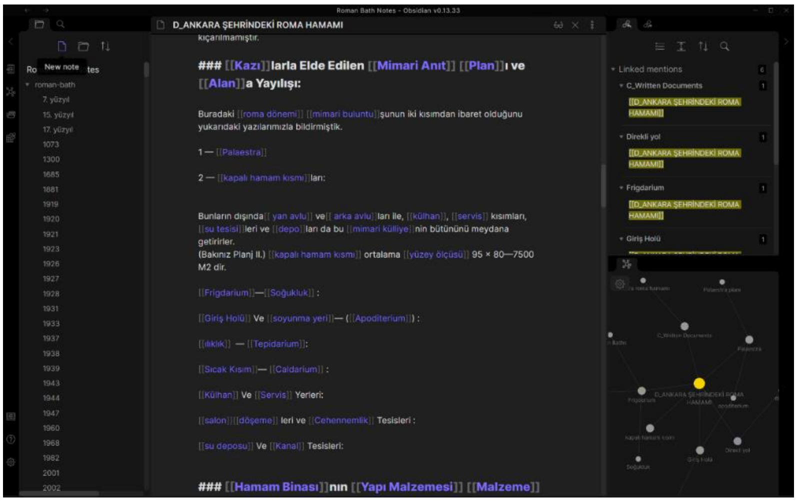


Figure 4.8: "D_ Ankara Şehrindeki Roma Hamamı" Page

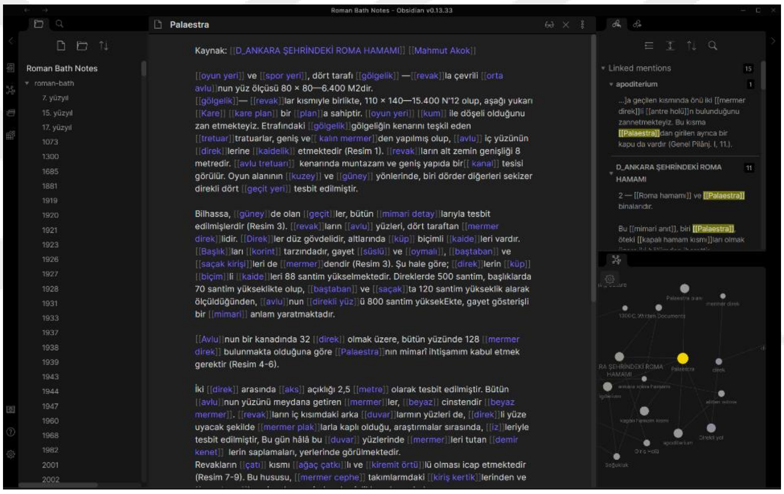


Figure 4.9: "Palestra" Page

The second and more important part is the stage of deciding on the phrases that will form the parts and nodes of the information map. Written texts are added to the source page like a blank canvas to be integrated into the system. Which concepts to choose were determined by the author in Phase 1. The applied principles are listed below:

- Names, numbers, dates, proper names, geographic and location names. Ex: "1937", "2. Yüzyıl" *(2. Century)*, "Çankırı Caddesi" *(Çankırı Street)*, "Etnografya Müzesi" *(Ethnography Museum)*, "Augustus"

- Country, nationality and period names and historical events and situations For example: “Helenistik Dönem” *(Hellenistic Period),* “Bizans” *(Byzantine),* “Gençliğe Hitabe”, “Fransız İhtilali” *(French Revolution) …*
- Any concept related to architecture and its physical counterpart. Architectural materials, building elements, place names and form definitions. For example: “Paleastra”, “Ankara Taşı” (Ankara stone), “Mermer” (marble), “Köşeli niş” *(angular niche),* “Poligonal” *(polygonal)*, “Simetrik Plan” (symmetrical plan) … There is “Art and architecture Thesarus” (AAT) as a relational dictionary of architectural and artistic concepts. This concept will be discussed later.
- All kinds of concrete and abstract concepts, actions, nouns, and adjectives that have semantic significance in the text. Although this is one of the vaguest definitions, the most subjective process has been done at this stage.
- Phrases that can be inclusive titles: “Ankaradaki Hamamlar” *(Baths in Ankara),* “Roma Dönemi Yapıları” *(Roman Period Buildin*gs), “Yıkanma Kültürü” *(Bathing Culture) ...* For example, “Arkeoloji” (Archaeology), “Arkeolojik Buluntular" (Archaeological Findings) and “Ankaradaki Arkeolojik Buluntular” (Archaeological Findings in Ankara) are included in the system as separate pages.

The most concise forms of all these words and phrases were tried to be tagged. Suffixes and plural cases that do not add meaning are not included, with exceptions. In addition, certain interventions were made to protect the semantic integrity in the tagging process. For example:

> “Ata’nın ebedi istirahatgahının yapımı sırasında Beştepeler bölgesinde iki tümülüs açılmıştır.” *(During the construction of Ata's final resting place, two tumuli were opened in the Beştepeler region.)*
>
> “Ata[[Atatürk]]’nın ebedi istirahatgahının yapımı [[Anıtkabir]] sırasında [[Beştepe]]ler bölgesinde iki [[tümülüs]]açılmıştır.” (*During the construction of Ata[[Atatürk]]'s final resting place [[Anıtkabir]], two [[[tumuli]] were opened in the [[Beştepe]] region.)*

Noun phrases and some adjective phrases that produce a new concept are especially handled. Labeling the concept of “Ankara Roma Hamamı” as a whole wherever it is encountered may be the first example. Phrases that indicate more than their parts, such as "Ankaradaki Hamamlar", are also not separated. After tagging the noun phrases such as “direkli yol” "pillared street" in the most comprehensive way possible, it is planned to add sub-concepts such as "pillar" and "street" to the concept pages as a secondary link as a second step. This type of second level tagging exercise is important for connecting concepts that would not naturally be related. For example, the element that connects "Tourism Economy in Turkey" and "21th Century Turkish Economy" in the system will be the labeling of the concept of "Economy" in the content pages of both concepts. Another method that could not be applied manually to improve this situation would be to make secondary tags according to the meanings in the sentence. As an example, “Bu kazılarda Etnografya Müzesi Asistanlarından Arkeolog Cevriye Artuk çalışmıştır.” *(Archaeologist Cevriye Artuk, an assistant to the Ethnography Museum, worked in these excavations.)* Only “Cevriye Artuk” can be tagged in this sentence; Concepts such as “Etnografya Müzesi” *(Ethnography Museum),* “Asistan” *(Assistant)* and “Arkeolog” *(Archeologist)* can be moved to the "Cevriye Artuk" concept page as secondary links.

Adjective, noun, and adverb phrases are typically taken as a whole and then fractured within their content pages. It is essential to associate semantically related concepts in the same sentence. Synonyms can be distinguished by their context.

It is obvious that some concepts are more inclusive than others. According to this system, the “kapı” *(door)* and “Roma Dönemi Giyim Kültürü” *(Roman Clothing Culture)* units are of the same importance and hierarchy. Except for the "D_" tag added to the beginning of the source document pages, no separator markers were used. Further classifications are avoided based on the belief that the complex data would generate its own content.

There are two options on the hierarchy between nodes: Giving these elements in the network beyond being equal nodes, giving upper labels and creating classes or working in equal hierarchy. According to the classification approach, certain categories may have more inclusive qualities. Top and bottom headings such as Contextual Elements, Physical Assets, Memory Sourced Data, Document Sourced Data, Time Related

Concepts can be created. However, such a categorization study can be confined to certain frameworks in line with the researcher's perception and capacity of the subject. The limitation of the human factor has also been mentioned in the previous sections. Yet even in this declassified study, bias is inevitable, as most choices are made by the author. Minimizing this situation may be one of the goals in future studies.

4.2.2. Rules And principles outcomes from the manual process

As mentioned before, this labeling and distribution process, which was done using only two sources, took much longer than expected and included many areas that were left to the discretion of the author, although certain rules were determined. This kind of system has no definite end, any added information feeds this pool that can go to infinity. However, each intervention made the network more precise and more readable. Some suggestions can be made to make inferences and examine the outcome.

The most common method is to use graphical views and backlinking windows on concept pages. The relations of any concept in the form of incoming or outgoing connections with other elements can be easily used by using these two features together. With Backlinking, you can see in which contexts this concept is used in other concept pages, while at the same time, incoming, outgoing, and neighbor relations can be examined in a graphical view.

It is possible to read the relationship between the 2nd or 3rd degree outgoing links of a particular content page in the network. In other words, some more inclusive content pages serve as a hub for examining the relationship between their child nodes. After selecting the necessary filters from the graphics settings, it is possible to make a legible map of this overarching concept. An example of this can be seen in (Figure 4.10 and Figure 4.11). Pages listed with the header “Ankaradaki Hamamlar” (Baths in Ankara) produced a perceptible result in a graph showing quadratic networks.

An Obsidian user developed the “Journey” plug-in that can be used to resolve the relationship between two unrelated concepts. This plugin allows to read the shortest path between any two elements in the system and which steps this path consists of. An example of this system is given in (Figure 4.12), in which degree and in which context the relationship is understood.

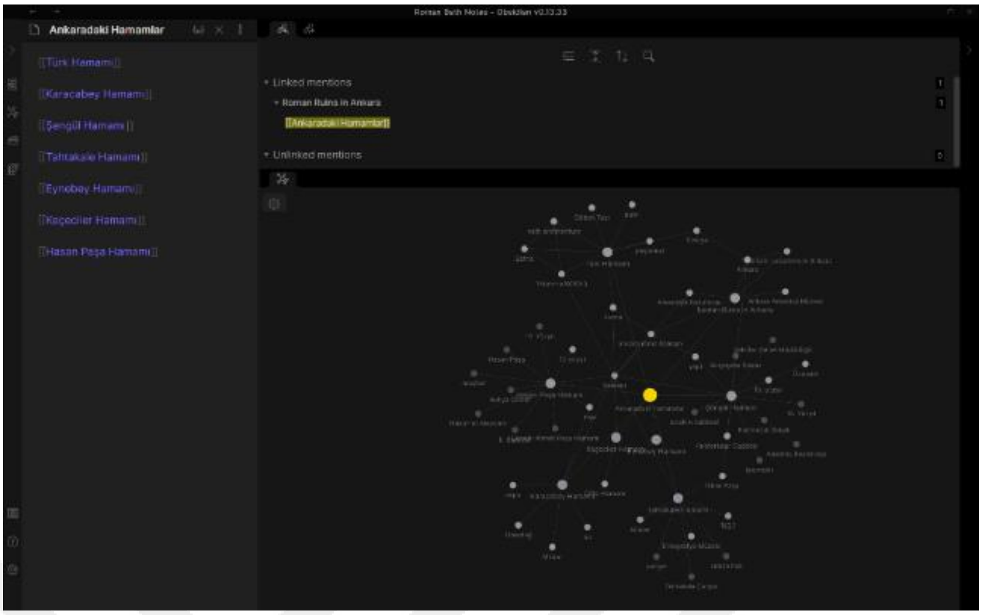


Figure 4.10: Roman Baths in Ankara

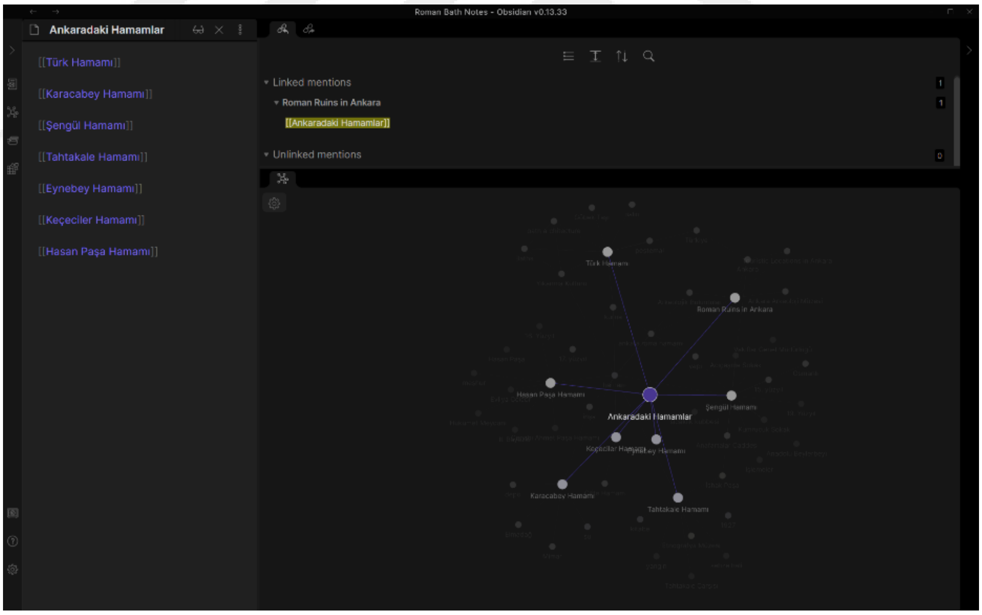


Figure 4.11: Roman Baths in Ankara

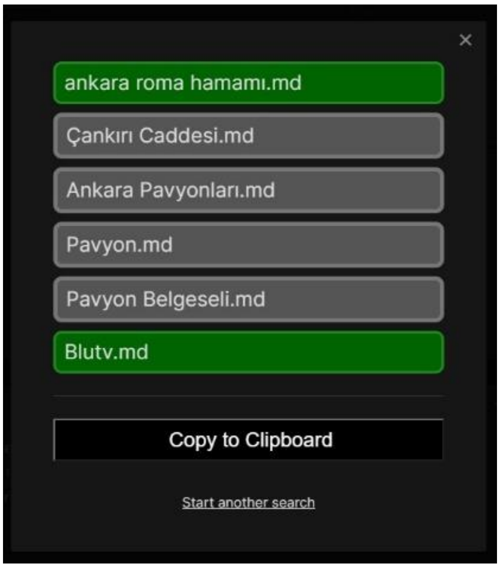


Figure 4.12: “Journey” plug-in path example

This information network, the final version of which looks like the figure 4.13, is composed of a very small piece of text about the Ankara Roman Bath and a text containing summary information about a few buildings in Ankara. The complex image of the result, ironically, suggests a solution on untie this confusion. Just as the human brain works, the relational situation of the materiality of entities deserves to be analyzed or at least to be tried.

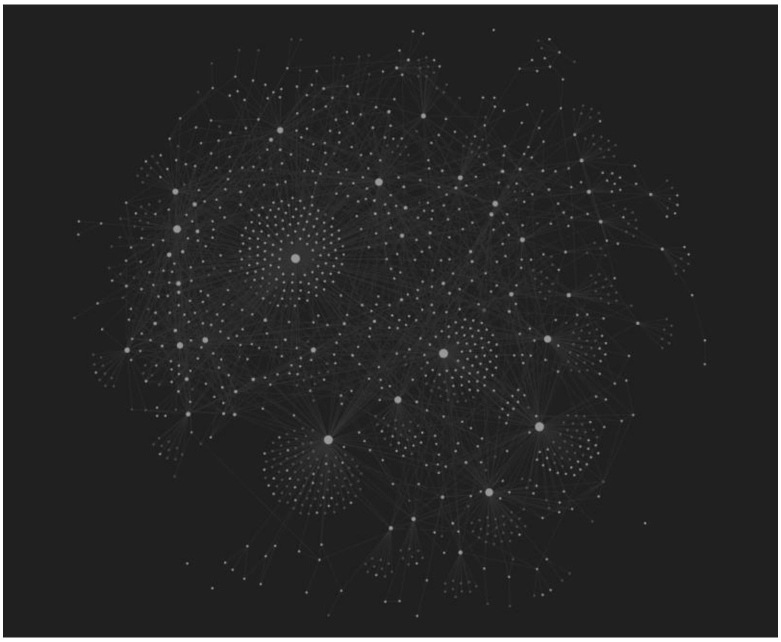


Figure 4.13: Extended Graph View

As a result of this preliminary study, some inferences can be made:

- It is a personalized shaping process of selected data to knowledge. Since the linking process was led by the author, this process is still not automatized and not self- evolving yet. This is the conclusion that inspired Phase 2.
- The database is unique and consistent on its own. Whatever is loaded into this system, the result will be in that scope. In a sense, some sort of internet is born in the context of the selected data. But again, for this reason, biased outcomes need to be studied.
- It is not possible to fully complete such a study on any subject. As stated before, in an increasingly branching network, the system can work with the amount of data loaded into it. The system does not have to be fully comprehensive, overly inclusive of every knowledge there is out there, which is already impossible to achieve. However, for a legit relationship tracking, it is necessary to see the links 3-4 levels away from the main concept.

As a result of all this manual work, the necessity of taking the work to the next stage came to the fore. It has been realized that the system is not sustainable with human time and resources. Even though a systemic setup is tried to be created, the human decisions factor adds the bias factor to the system, and the long data processing time reduces the efficiency considerably. For this reason, the use of artificial intelligence tools with the aim of reducing the human factor came to the agenda. In this language-based data system, the most appropriate tool is Natural Language Processing (NLP) algorithms. The second phase investigated the use of computational technologies to automate this process. Here are some of the takeaways and recommendations learned from the first phase to move on to the second:

- Language selection is an important element for NLP linguistic analysis. Since the language frequently used for NLP is English, it was decided to continue accordingly.
- The meanings of homonyms will need to be taken out of context. NLP's capabilities in this direction should be evaluated.
- Concepts that have the same meaning but can be expressed in different ways, including synonyms, should be evaluated under the same concept page. This situation, called “Allies”, should be considered.

- To preserve the integrity of the semantic meaning, all actions taken in the manual process must be implemented algorithmically.

4.3. Phase 2: NLP Algorithms and Adaptations

All these manual studies have shown the suitability and even necessity of computational tools for this research. Following this, it was decided to include NLP (Natural language processing), a subcategory of artificial intelligence, into the study.

At the end of the study in Phase 1, a non-hierarchical knowledge structure was aimed through text analytics. Text analytics, which was tried manually in the first phase, is a set of software and transformation processes that seeks value in "unstructured" texts in a digital jargon. It transforms content sets into an associated data source by combining visualization, data mining, and NLP (Grimes, 2012). Considering the manual work, it is intended to apply this text analysis of architectural discourse using NLP technology. Accordingly, the artificial intelligence libraries of Python programming language have been evaluated. Natural Language Tool Kit (NLTK) (Bird et al., 2009) and core NLP (Manning et al., 2014) are decided to be used. Tokenization, Lemmatization, Stemming, and Chunking are among the NLP approaches which assisted the process. It is anticipated that a unique approach to architectural knowledge production can be developed with less manual effort on the part of humanity.

The architecture, like any other field, has its own set of meaning patterns and glossary. As a result, the Getty Vocabularies' "Art & Architecture Thesaurus" should be mentioned. Containing approximately 72,225 records and 472,602 terms as of November 2021; AAT was initiated in the late 1970s in response to a necessity to automate cataloging and indexing systems in art libraries. A thesaurus' defining feature, which differentiates it from a flat list of terms like a glossary, is the network of relationships between its terms and concepts. AAT is a polyhierarchical vocabulary based on semantic links, which are logical relations between the concepts, actions, and objects represented by the words. It provides generic terminology and associated dates, relationships, and other information on concepts relevant to or required for cataloging, discovering, and retrieving information about art, architecture, archaeology, and conservation. This thesaurus leads for powerful possibilities for knowledge creation, analysis, and exploration for digital art history and similar fields using rich metadata and links. The Getty Vocabularies are also designed to be used with Linked Open Data (LOD) (The Getty Research Enstitute, 2017).

Although the integration of AAT tools with the studied information organization method is beyond the scope of this study, it is recommended as further research. Unlike the extent of the AAT, this research does not attempt to involve all existing architectural knowledge. It aims to produce its own unique relational database with the added certain data. Nevertheless, a digital automation study was deemed necessary and NLP tools and methods were brought to the agenda.

4.3.1. Natural language processing tools, tasks and techniques

AI (Artificial Intelligence) aims to lead the machine to solve a described problem with general reasoning techniques. Like any capable human, the software may need to employ basic knowledge of the topic area and general common-sense awareness of the world. This knowledge should be introduced to the machine in some way (Lehmann, 1992). NLP (Natural Language Processing) is a branch of AI that enables computers to interpret and process human language. NLP blends rule-based human language modeling with analytical, machine learning, and learning algorithms. Some general examples of NLP usage include voice-activated systems, digital assistants, speech-to-text dictation, chatbots, and many others (IBM Cloud Education, 2020). In brief, the primary goal of NLP is to program computers to analyze and interpret massive amounts of natural language data (Sanagapati, 2020).

Since computers require structured input yet human speech is unstructured and frequently imprecise, it is troublesome to construct NLP applications. To handle the process, the Python programming language provides a large selection of tools and frameworks for tackling specific NLP tasks. Some of these tasks are Speech recognition, Part of speech tagging, Word sense disambiguation, named entity recognition, Sentiment analysis, Natural language generation, co-reference resolution, and so on (IBM Cloud Education, 2020). After examining various NLP libraries such as NLTK, SpaCy, and CoreNLP, it was decided to work with NLTK, which is one of the most essential tools for the Python language (Manning et al., 2014; Soares, 2018; SpaCy, 2016).

Created at the University of Pennsylvania by Steven Bird and Edward Loper, the NLTK is an open-source set of libraries, applications, and educational resources for developing NLP programs. It provides libraries for many of the NLP tasks mentioned earlier and subtasks, including sentence parsing, word segmentation, stemming and lemmatization, and tokenization. It also includes modules for implementing capabilities like semantic reasoning that help reach rational conclusions based on facts harvested from the text (Bird et al., 2009; IBM Cloud Education, 2020). Some of the tasks and subtasks that are related to this research is shortly described below (Navlani, 2019).

- **Tokenization** is the process of breaking down phrases, sentences, paragraphs, and chapters into tokens that assist the computer understand the text better. Tokens can be words, numbers, punctuation marks, or even entire sentences. In short, a tokenizer separates text into distinct words
- **Stemming** is a linguistic normalization method that reduces words to their root word or removes derivational affixes. For example, the words connection, connected, and connecting word are all reduced to the single word "connect.".
- **Lemmatization** is also a technique for pruning and reducing words to their base words. However, while stemmer works on a single word grammatically without considering its context, lemmatization uses lexical and morphological analysis to convert root words. For instance, the lemma of the word "better" becomes "good." (Figure 4.14).

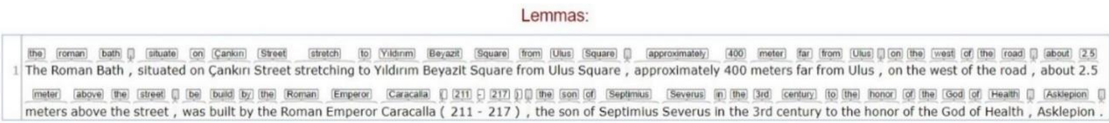


Figure 4.14: An example of Lemmatization with the CoreNLP toolkit.

- **Part of speech tagging**, also known as grammatical tagging, is the technique of determining the parts of speech of a certain piece of text from its use and context (Figure 4.15). Depending on the usage, it may be a noun, pronoun, verb, adverb, adjective, or anything else. As an example, Part of speech identifies 'paint' as a verb in 'I will paint the bedroom,' and as a noun in 'What color of paint?' For POS tagging to work, tokenization must be done first (IBM Cloud Education, 2020).

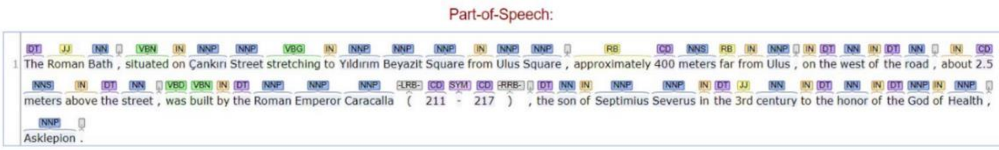


Figure 4.15: An example of POS Tagging with the CoreNLP toolkit.

- **Chunking** is a meaningful phrase building tool. After finding the grammatically and semantically labels of the tokens obtained with Parts of speech, chunking segments these parts and groups them as multi-tokens. One of the main goals of chunking is to group into "noun phrases". However, chunking is not limited to this; The desired phrases can be brought together through the grammatical rules defined by the user (Figure 4.16).

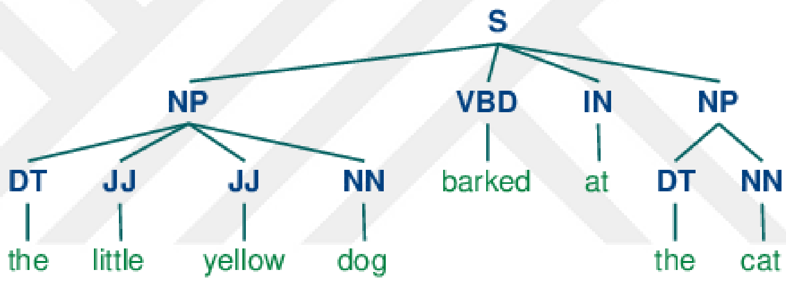


Figure 4.16: A Simple Regular Expression Based NP Chunking with NLTK (Bird et al., 2009)

- **Named entity recognition**, or NEM, is a significant form of chunking in NLP. Named entities are defined noun phrases that corresponds to specific sorts of individuals, organizations, dates, locations and so on (Figure 4.17). NEM recognizes 'Ulus Square' as a location and 'Septimus Severus' as a historical figure (IBM Cloud Education, 2020).

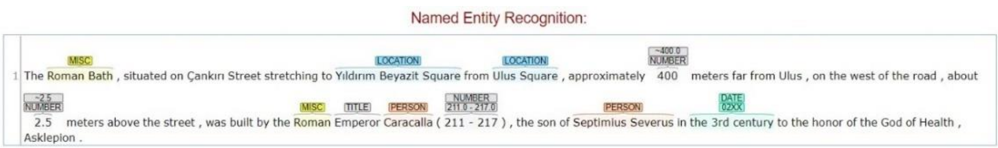


Figure 4.17: Named Entity Recognition from CoreNLP

The structure of a simple information extraction system is illustrated in the figure 4.18. The raw text from the document is first separated by a sentence segmenter, and each sentence is then subdivided into words by a tokenizer. Following that, each sentence is tagged using part-of-speech tags, to assist in the next stage, named entity detection. This stage scans for references of significant entities in each sentence. Finally, a relation detection algorithm is employed to spot potential relationships among various entities in the text (Bird et al., 2009).

This NLP study model was preferred to construct the process of this case study. Due to the integration with obsidian.md, which is already a relational inference tool, the Relation detection phase is excluded.

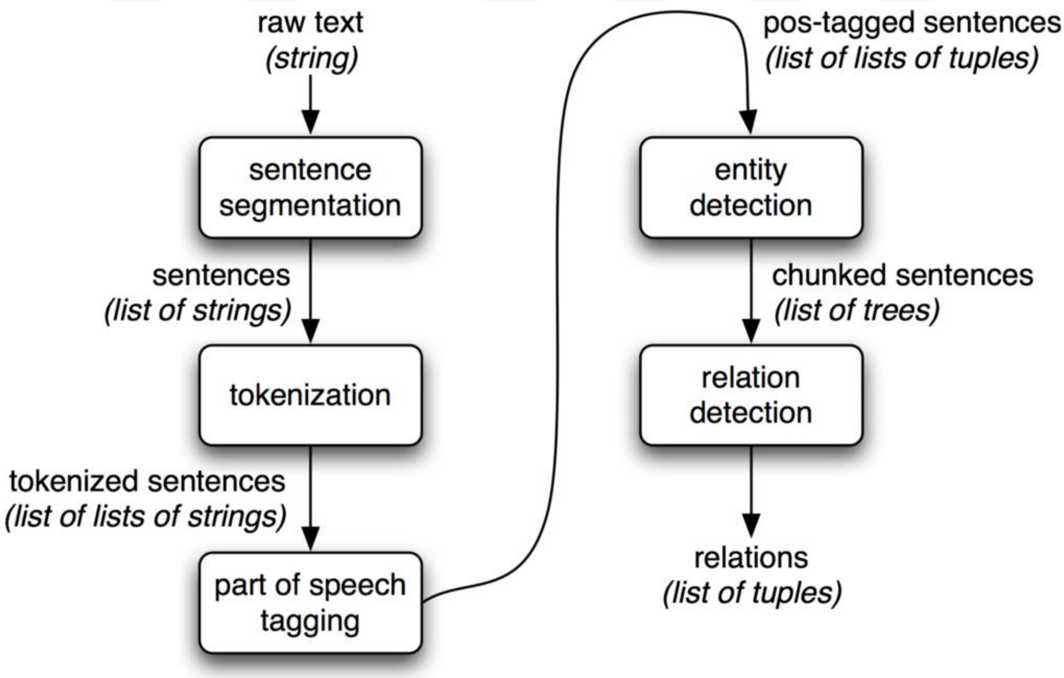


Figure 4.18: The Information Extraction System applied in this study (Bird et al., 2009).

4.3.2. Coding process

Manually executed phase one succeeded in producing a relational knowledge network. In this second phase of the case study, NLP tools were used to accelerate, neutralize, and optimize this process. In line with the Information Extraction System taken as an example, the following scheme has been planned.

1. Installing and importing the toolkits, modules and libraries required for the code.
2. Importing the source text to the code sequence in a string format.
3. Using tokenization, POS tagging and chunking to obtain a syntax tree that includes all the meaningful components of the text.
4. Using Named Entity Recognition to extract a string list containing all the noun phrases and name entities from the tree.
5. Replacing each "element" of the list by "[[element]]" in the original text to integrate with Obsidian.md.
6. Saving it as a markdown file in the location the Obsidian.md files.

First, python, pyperclip pyyaml, NLTK and numpy libraries and modules were installed on the system (Figure 4.19).

```
pip install pyperclip pyyaml

Requirement already satisfied: pyperclip in c:\users\user\appdata\local\programs\python\python310\lib\site-packages (1.8.2)
Requirement already satisfied: pyyaml in c:\users\user\appdata\local\programs\python\python310\lib\site-packages (6.0)
Note: you may need to restart the kernel to use updated packages.

pip install --user -U nltk

Requirement already satisfied: nltk in c:\users\user\appdata\roaming\python\python310\site-packages (3.7)
Requirement already satisfied: tqdm in c:\users\user\appdata\roaming\python\python310\site-packages (from nltk) (4.63.1)
Requirement already satisfied: joblib in c:\users\user\appdata\roaming\python\python310\site-packages (from nltk) (1.1.0)
Requirement already satisfied: regex>=2021.8.3 in c:\users\user\appdata\roaming\python\python310\site-packages (from nltk)
(2022.3.15)
Requirement already satisfied: click in c:\users\user\appdata\roaming\python\python310\site-packages (from nltk) (8.0.4)
Requirement already satisfied: colorama in c:\users\user\appdata\local\programs\python\python310\lib\site-packages (from cli
ck->nltk) (0.4.4)
Note: you may need to restart the kernel to use updated packages.

pip install --user -U numpy

Requirement already satisfied: numpy in c:\users\user\appdata\roaming\python\python310\site-packages (1.22.3)
Note: you may need to restart the kernel to use updated packages.
```

Figure 4.19: Installings

The necessary modules have been imported into the system (Figure 4.20). These are "nltk","os","nltk.corpus", "os.path", "pyperclip", "yaml", "sys" and "re". Secondly, the task tools to be used from NLTK tools were imported. These are "sent_tokenize" and "word_tokenize" tokenization tools, "PorterStemmer" and "WordNetLemmatizer" from stemming tools, and "ne_chunk" for chunking. Various packages have also been downloaded to the system. These are "stopwords", "maxent_ne_chunker", "wordnet", "punkt", "averaged_perceptron_tagger" and "words".

```
import nltk
import os
import nltk.corpus
import os.path
import pyperclip
import yaml
import sys
import re

from nltk.tokenize import sent_tokenize,word_tokenize
from nltk.stem import PorterStemmer
from nltk.stem import WordNetLemmatizer
from nltk import ne_chunk
from nltk.chunk import ne_chunk

nltk.download('stopwords')
nltk.download('maxent_ne_chunker')
nltk.download('wordnet')
nltk.download('punkt')
nltk.download('averaged_perceptron_tagger')
nltk.download('words')
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package maxent_ne_chunker to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package maxent_ne_chunker is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package averaged_perceptron_tagger is already up-to-
[nltk_data]       date!
[nltk_data] Downloading package words to
[nltk_data]     C:\Users\User\AppData\Roaming\nltk_data...
[nltk_data]   Package words is already up-to-date!
```

Figure 4.20: Imports and Downloads

The next step is to introduce the text source to the algorithm (Figure 4.21). This English text published by the Ministry of Culture and Tourism about the Ankara Roman bath is used as an example (T.C. Kültür ve Turizm Bakanlığı, n.d.). This text, which contains easily detectable words for Named Entity Recognition, is a demonstration of the sources used in phase one. The source text has been added to the system as a string variable. The entirety of the text can be seen in the figure 4.22.

Add information

```
name ="Roman Baths"
dummy_text="The Roman Bath, situated on Cankiri Street stretching to Yıldırım Beyazit Square from Ulus Square, approximately
```

Figure 4.21: Adding source text to the system

The Roman Bath

The Roman Bath, situated on Çankırı Street stretching to Yıldırım Beyazit Square from Ulus Square, approximately 400 meters far from Ulus, on the west of the road, about 2.5 meters above the street, was built by the Roman Emperor Caracalla (211-217), the son of Septimius Severus in the 3rd century to the honor of the God of Health, Asklepion.

It has been established that this platform, which is callled the Roman Bath today, was a tumulus and carried the remains of Roman times (partially Byzantine and Seljuk layers) on the top, and of Phrygian times at the bottom.

The dimensions of the bath are 80x130 meters, it is made of stones and bricks. The entrance on Çankırı Street leads to a wide area surrounded with the remains of a colonnaded pavillion and then to Palaestra, a place for physical education and wrestling. On the right of this part, along the colonnaded road, there are lots of angular and circular inscripted columns.

The Frigidarium (cool room) is just behind the sporting area, and Piscina (swimming pool) with stairs to sit on at the sides and an Apoditarium (place to take off the clothes) are on the left, and the cooling room with column pieces made of round bricks is on the right. The Tepidarium (warm room) has also column pieces of round bricks. The bath rooms had once been on these columns. The Calidarium (hot room) division is at the back of the bath and includes 12 stokeholes. The hot and warm rooms are wider divisions because of Ankara's very cold winter conditions. These rooms were supported with under-ground warming installations having brick columns around them to let the air to circulate easily, the upper rooms were warmed in this way.

It has been established from the coins obtained during excavations that the building, which had been destroyed after a great fire in the 7 th century, had been in use for some 500 years and had been restorated from time to time.

During the excavations of the Turkish History Institution the dressing and bathing parts of the bath, stokeholes and service paths were discovered.

Figure 4.22: The Source Text (T.C. Kültür ve Turizm Bakanlığı, n.d.)

The source text was first divided into sentences and then words, passing through the "sent_tokenize" and "word_tokenize" tools, respectively. After being tagged with “pos_tag”, a chunking operation was performed to group noun phrases with “ne_chunk_sents”. Finally, the entity names were drawn from the tree formed by the chunked sentences and turned into a string list (Figure 4.23). This sequence, which makes meaningful phrases algorithmically usable, is adapted from a code sequence shared on the Stack Overflow site in 2018 (Soares, 2018).

Chunking

```
sentences = nltk.sent_tokenize(dummy_text)
tokenized_sentences = [nltk.word_tokenize(sentence) for sentence in sentences]
tagged_sentences = [nltk.pos_tag(sentence) for sentence in tokenized_sentences]
chunked_sentences = nltk.ne_chunk_sents(tagged_sentences, binary=True)

def extract_entity_names(t):
    entity_names = []

    if hasattr(t, 'label') and t.label:
        if t.label() == 'NE':
            entity_names.append(' '.join([child[0] for child in t]))
        else:
            for child in t:
                entity_names.extend(extract_entity_names(child))

    return entity_names

entity_names = []
for tree in chunked_sentences:
    # Print results per sentence
    # print extract_entity_names(tree)

    entity_names.extend(extract_entity_names(tree))


# Print unique entity names
print (entity_names)
```

```
['Roman Bath', 'Cankiri Street', 'Yıldırım Beyazit Square', 'Ulus Square', 'Ulus', 'Roman Emperor Caracalla', 'Septimius Sev
erus', 'Health', 'Roman Bath', 'Roman', 'Seljuk', 'Phrygian', 'Çankırı Street', 'Palaestra', 'Piscina', 'Tepidarium', 'Calid
arium', 'Ankara', 'Turkish History']
```

Figure 4.23: The Code Sequence

For these phrases to be defined in the Obsidian.md system, they must be enclosed in brackets. For this reason, the word groups in this obtained string list have been replaced with brackets in the text. This code sequence is made by the author (Figure 4.24).

Tag with [ ]

```
for x in entity_names:
    while str(" "+x+" ") in dummy_text:
        dummy_text= dummy_text.replace(x,str("[["+x+"]]"))
print(dummy_text)
```

```
The [[[[Roman]] Bath]], situated on [[Cankiri Street]] stretching to [[Yıldırım Beyazit Square]] from [[Ulus]] Square, appro
ximately 400 meters far from [[Ulus]], on the west of the road, about 2.5 meters above the street, was built by the [[[[Roma
n]] Emperor Caracalla]] (211-217), the son of [[Septimius Severus]] in the 3rd century to the honor of the God of Health, As
klepion.It has been established that this platform, which is callled the [[[[Roman]] Bath]] today, was a tumulus and carried
the remains of [[Roman]] times (partially Byzantine and [[Seljuk]] layers) on the top, and of [[Phrygian]] times at the bott
om.The dimensions of the bath are 80x130 meters, it is made of stones and bricks. The entrance on [[Çankırı Street]] leads t
o a wide area surrounded with the remains of a colonnaded pavillion and then to Palaestra, a place for physical education an
d wrestling. On the right of this part, along the colonnaded road, there are lots of angular and circular inscripted column
s.The Frigidarium (cool room) is just behind the sporting area, and [[Piscina]] (swimming pool) with stairs to sit on at the
sides and an Apoditarium (place to take off the clothes) are on the left, and the cooling room with column pieces made of ro
und bricks is on the right. The [[Tepidarium]] (warm room) has also column pieces of round bricks. The bath rooms had once b
een on these columns. The [[Calidarium]] (hot room) division is at the back of the bath and includes 12 stokeholes. The hot
and warm rooms are wider divisions because of Ankara's very cold winter conditions. These rooms were supported with under-gr
ound warming installations having brick columns around them to let the air to circulate easily, the upper rooms were warmed
in this way.It has been established from the coins obtained during excavations that the building, which had been destroyed a
fter a great fire in the 7 th century, had been in use for some 500 years and had been restorated from time to time.During t
he excavations of the [[Turkish History]] Institution the dressing and bathing parts of the bath, stokeholes and service pat
hs were discovered.
```

Figure 4.24: Tagging for Obsidian.md

Finally, the resulting text was formatted as markdown to be added to the system and saved to the path within the other Obsidian.md network files (Figure 4.25).

Md file olarak kaydetmek

Eğer halihazırda bu isimle bir dosya var ise bilgiyi içeriğine ekler

```
obsidianpath = r'C:\Users\User\OneDrive - TOBB Ekonomi ve Teknoloji Üniversitesi\Roman Bath Notes\roman-bath'

name_of_file = name

completeName = os.path.join(obsidianpath, name_of_file+".md")

file1 = open(completeName, "a")

toFile = (dummy_text)

file1.write(toFile)

file1.close()
```

Figure 4.25: Saving as a Markdown file

This chapter made an information organization experiment on the Ankara Roman Bath as a case. Aiming to play an auxiliary role in thinking and knowledge production as the "Second Brain," Obsidian.md was preferred in the search for the relational knowledge and content organization discussed in this thesis. The knowledge network produced has assumed a parallel role in the intellectual process of architectural knowledge.

Two written sources are included in the system. Among these resources, phrases and concepts were tagged and made to be a unit of this knowledge network. Although the generated network has produced qualified questions for the discussion of the study, the sustainability and neutrality problems of such a manual process have come to the fore. For this reason, the contribution of NLP tools to this system is discussed.

It was aimed to automate and systematize the process by applying the grammatical and application principles applied in the manual stage with NLP tools. Using Tokenization, POS_Tagging, Chunking, and Named Entity Recognition tools, the source texts were divided into parts, and data pieces/phrases were determined as information units in the system. Finally, these phrases have been reformatted for inclusion in the Obsidian.md system and the ever-growing graphic was established (Figure 4.26).

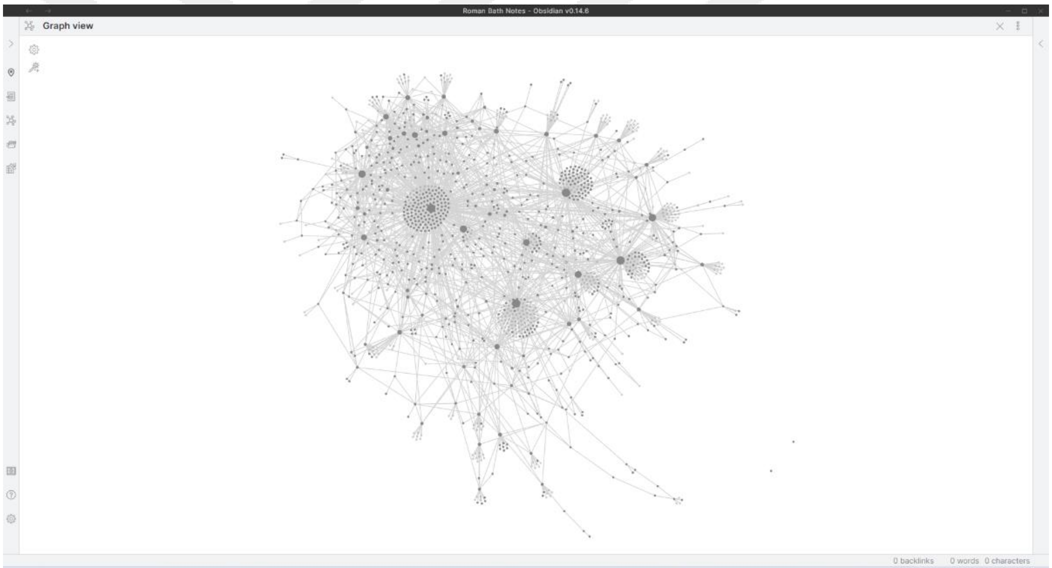


Figure 4.26: Final Graphic Result of the Network

NLP tools can have a much broader contribution to this type of study. However, it is hoped that such an interdisciplinary study, which was carried out as a preliminary in line with the Author's technical knowledge and skills, will lead to new discussions and expansions for the future of NLP tools in architectural knowledge organization.

5. CONCLUSION AND DISCUSSIONS

This work consists of five main chapters. In these chapters, the definition and characteristics of architectural knowledge; the relational nature of architecture; hypertexts and their strategies for semantic information management; semantic network graphs for the representation of the concept; and finally, the case study on the Ankara Roman Bath, which was constructed with the help of Obsidian.md application and NLP tools, was mentioned.

The concrete and intangible parts of architectural knowledge, its interdisciplinary aspect, and theoretical and quantitative approaches are discussed. The concept of materiality presented by Antoine Picon and the relational structure of architectural knowledge was considered. This relational structure formed the theoretical backbone of the thesis.

It was claimed that this structure exists independently of the knowledge of the researcher and the observer, and that new knowledge is established each time through various gatherings. Traditional information organization systems cannot do justice to this complex structure. Therefore, how the information organization is approached affects the knowledge and intellectual accumulation it can produce. Concordantly, the possibility of a more comprehensive and innovative knowledge fabrication and a potential approach for architecture to organize its information in the described relational way prompted the study.

This thesis aimed to try a new relational information organization method that might lead to new theoretical expansions by making complex and undiscovered relational analyzes readable and manageable for researchers' perceptions. The research questions are as follows:

- Can a semantic knowledge network on architecture be reproduced, managed, and represented?

- Can this relational method of information organization uncover potential overlooked knowledge waiting to be discovered?
- What contributions can semantic AI tools make to architectural information organization systems?

In line with the scope of this study, hypertexts and semantic network graphics are among the tools that can reproduce, organize, and manage this relational network. A method study was attempted with the Obsidian.md content organization tool and Python-based NLTK algorithms.

The Obsidian.md platform was first used to gather information and then associate them with each other. As a result, a unique and dynamic information network has been reached within the submitted input. This study is structured based on previously produced texts on a selected topic. The reconsideration of previously produced information intended to discover formerly overlooked or not prominent associations among the data. Although a minimal number of data was submitted in this case study on the Ankara Roman Bath, the production of a complex and somewhat broad information network was still achieved. Consequently, a more relational outcome was obtained with this new method than the linear, traditional readings of the input texts. Even though the source material is the same in both cases: Mahmut Akok's article (1968) and Ankara Promotion brochure (D. Acar, 2013).

These increases in the content produced by the same source data by these two different information organization approaches have been an answer to several central questions of this thesis. The conclusion was that a relational approach to information organization can influence and nurture the knowledge fabrication process. Also, with its interwoven frame, the knowledge of architecture was deemed suitable for such a relational organization fed by semantic data. One of the missing cases was the absence of architectural drawings and visual elements from which are the main architectural knowledge is storing areas. Additionally, the inclusion of AI tools has indeed accelerated, neutralized, and automated the process. Although a full integration has not been made, NLP algorithms have worked effectively with Obsidian.md and positively supported the process. For AI algorithms, the principles and rules applied in the manual process had to evolve and regulate. In line with the researcher's knowledge and skills in programming, the algorithmic stage could not fully implement the analytical decision stages in the manual process but was able to transcribe it.

5.1. Discussion

Architecture can be perceived as a structural, technical, formal, functional, economic or design issue. All these perspectives are inseparable parts of architecture, and they each impose new missions on it. However, they are evaluated separately or at most with controlled binary readings (form-culture, economy-structure...), and almost never examined as a whole. Considering all; thinking and writing about the knowledge of architecture is quite limited. For this reason, this study is in a search for a way of thinking.

In physics, mathematics, and chemistry, there are defined and precise ways of relating concepts and symbols. Unlike these fields, architecture consists of a combination of many different elements that architecture has little or no control over. In this case, how and in what order we associate these assets can change the practice, treatment, and even definition of architecture. The need to perceive information clusters holistically, to see the relationships between them, and to grasp the weight and direction of the data has shaped this study.

Architecture is often fed by elements outside the discipline. Most of the ways of thinking, doing, and building are elements that came from outside of architecture and provided change and transformation to architecture. Artificial intelligence, Augmented reality technologies, generative design can be given examples of the recent external technologies to feed the architecture. Likewise, this tool comes from outside the field and offers an updated thinking model for architecture.

Conventionally, in a research process, written texts about a particular subject are read one by one and correlated in the mind of the researcher at human speed. Information is processed in this way and is associated with all other data feeding the subject through the human mind. The first advantage of such a tool is that it virtually eliminates this reading time required to present the texts on researcher's evaluation.

The Obsidian.md tool was used to organize, categorize, and establish mechanical relationships with information as it was. Using NLP, by teaching this tool to how to behave when new data arrives, put the researcher in a position to not to organize but to interpret all the content. This situation does not mean discharging the researcher, on the contrary, the researcher's contribution to the studies has been increased by carrying the cognitive labor and effort on the organization of information to the stage of interpretation, examination, and fabrication. Since stablishing relationships between data does not make the content senseful by itself, it still requires someone to examine and decode it to make it meaningful. One of the biggest gains for this study is that the researcher has more time to interpret and make inferences.

The study also had a goal of reducing human bias. It cannot be claimed that this tool, which is fed from existing texts, is free from the prejudices of the original sources. But with this method, getting rid of the prejudices of the researcher who examines these data provides an opportunity for diversity. By encouraging flexibility, the effects of the researcher's prior knowledge, data processing sequence and time have been tried to be minimized. In summary, it is not possible and preferable to completely eliminate bias and human limitations. But with a flexible enough mind and a flexible tool, the variety of possibilities can serve to generate more interpretations.

Such a tool, an attempt to find meaningful relationships, can be used in various fields of architecture. It can involve architectural historians, building physicists, and academic researchers and provide qualitative shifts in building technologies, architectural theory, and design. In the first chapter, predictions were made on the capabilities of such a vehicle in existing structures, the construction process and design. The following can be said about the potential of this research in these three areas of the discipline of architecture.

In the case study, an information organization study was tried on the existing building stock. Some benefits can be listed as below.

- This is a dynamic model. As new data is submitted, it gets richer and becomes one of a kind. It will increase the possibilities of discovery with a capability never seen before, beyond the computational power of the human mind. For academic researchers, these networks can work as a new way of looking and a new knowledge synthesis platform.
- Depending on how it was organized and related events, there is a narrative that depends on the author's vantage point. By reconsidering certain historical implications, this tool can reveal relationships and intersections that human

perception may miss. With such a tool, microhistories or in-depth analyzes can be made, and even alternative architectural histories can be created.

- It can be used to collect data, make sense, and increase accuracy and coverage in conservation and restoration studies.
- Except for structured dictionaries such as AAT (Art and Architecture Thesaurus), there is no common corpus of architecture and architectural products. Wiki culture, which is a relational encyclopedia, can be applied in the field of architecture with this tool.

The following can be stated about the use of the study in the construction process of buildings.

- By bringing together the contents of different disciplines, it can provide an opportunity and environment for joint studies. Collaborative work management can be organized concordantly.
- Information organization tools such as BIM have added new content to the traditional 3D modeling culture and incorporated various quantities of structures into the process. While systematizing the knowledge of buildings, it is discussed only through the 3D model. However, the architectural information does not belong only to the 3D model. The approach proposed by this study is a kind of qualitative information modeling. In this sense, the cooperation of these two approaches can offer new intersections in architectural building knowledge. A relational content setup supported by BIM and artificial intelligence can be established.
- Can be used for holistic perception and implementation of regulations.
- Conflicts in design criteria can be identified.

The following can be stated about the use of the study in the design process of buildings.

- It can be used in concept research, theoretical and intellectual processes.
- Can be used to collect and organize various project related data such as area, context, function. It can be used to see possible relationships in different formats.

5.2. Further Research

Manual stages in the research were the act of choosing which pieces of information and what kind of principles to include in the system. In this process, words and phrases were "tagged" and included in the system within specific rules. As a result, a somewhat system or dictionary was created by this method. However, such a setup already exists for the discipline studied. The Art & Architecture Thesaurus (AAT) is a regulated vocabulary to describe works of art, architecture, and material culture. A possible further study for this thesis is the inclusion of AAT in the tagging process.

In this study, results were obtained within the framework of the interface and possibilities provided by the Obsidian.md application. As a next step, a specialized tool for relational architecture knowledge can be studied. In this way, the methodology can be tailored within the framework of the theoretical research.

Ontotext GraphDB was discovered as a tool for these proposed further studies. Ontotext GraphDB is an efficient graph database that supports RDF and SPARQL. It enables connecting disparate data, indexing it for semantic search, and enhancing it with text analysis to create large knowledge graphs. It can also work with web-based semantic data structures such as Linked Open Data (LOD) (*Graphdb SE,* 2022). This program can help integrate the AAT dictionary with the proposal of this study in a customizable structure.

The addition of NLP tools significantly increased the efficiency of this study. In line with the scope of the thesis and the researcher's competence, this integration has not reached its full potential. Capturing and extracting meaningful word groups was found sufficient for the scope of this research. Furtherly, with NLP tools, relations between the nodes in this network can be made readable and modifiable by the computer.

Text-based research was conducted in the study. Formats such as drawings and images can be included to deal with architectural knowledge more comprehensively. Image recognition and reverse image search can be added as source formats.

Finally, the generated method can be used to fabricate and analyze new knowledge. Every theoretical inference, knowledge fabrication, and product produced for the architecture discipline through the proposed information organization method will achieve this thesis's final goal.

6. REFERENCES

Acar, A. (2015). *A Genuine Origin and Language for the Universal Principles of Architecture (PhD thesis).*

Acar, A. (2021). Eskiçağ'da Yedi Özgür Sanat ve "Mimar"ın Eğitimi. *Mimarlık Dergisi*, *418*, 72–76.

Acar, D. (2013). Kültürlerin harmanlandığı Türkiye Cumhuriyeti'nin Başkenti Ankara. In *Ankara Kültür ve Turizm İl Müdürlüğü*. Ankara Kültür Ve Turizm İl Müdürlüğü.

Ahrens, S. (2017). *How to Take Smart Notes: One Simple Technique to Boost Writing, Learning and Thinking for Students, Academics and Nonfiction Book Writers*. CreateSpace. https://www.amazon.ca/How-Take-Smart-Notes-Nonfiction-ebook/dp/B06WVYW33Y

Aicher, O. (1994). honourable burial for descartes. In *analogous and digital* (pp. 65–75). Ernst&Sohn.

Akok, M. (1968). Ankara Şehrindeki Roma Hamamı. *Türk Arkeoloji Dergisi*, *17*(1), 5–37.

Amidon, D. M. (1997). *Innovation Strategy for the Knowledge Economy: The Ken Awakening*. Butterworth-Heinemann.

Anderson, R. C., & Pearson, P. D. (1984). A schema-theoretic view of basicprocesses in reading comprehension. In P. D. Pearson (Ed.), *Handbook of reading research* (pp. 255–291). Longman.

Aravot, I. (1993). Towards a framework of propositional knowledge in architecture. *Architectural Science Review*, *36*(4), 163–167.

Avermaete, T. (2021). A Black Box? Architecture and its Epistemes. In L. Schrijver (Ed.), *The Tacit Dimension. Architectural Knowledge and Scientific Research* (pp. 69–81). Leuven University Press. https://www.jstor.org/stable/j.ctv1mgm7ng

Balamir, A., & Erkal, N. (1999). Dosya : Mimarlık Bilgisi Sunuş Mimarlık Bilgisine İçerden ve Dışarıdan Bakışlar. *Mimarlık Dergisi*, *289*, 5–6.

Banham, R. (1996). A Black Box. The Secret Profession of Architecture. In M. Banham, P. Barker, S. Lyall, & C. Price (Eds.), *A Critic Writes. Selected Essays by Reynek Banham* (pp. 292–299). University of California Press.

Baron, A. (1980). *Knowledge*. Sifriat Hapoalim.

Barrett, F. J., & Srivastval, S. (1991). History as a Mode of Inquiry in Organizational Life: A Role for Human Cosmogony. *Human Relations*, *44*(3).

Batra, S., Bishu, R. R., Donohue, B., G., S., & M.J., S. (1993). Effects of Hypertext Topology on Navigation Performance. *Advances in Human Factors and Ergonomics*, *2*, 175–180.

Bird, S., Klein, E., & Loper, E. (2009). *Natural Language Processing with Python*. O'Reilly Media Inc. https://www.nltk.org/

Bohman, J., & Rehg, W. (2017). Jürgen Habermas. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Fall 2017). Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/fall2017/entries/habermas/

Brachman, R. J., & Schmolze, J. G. (1985). An Overview of the KL-ONE Knowledge Representation System*. *Cognitive Science*, *9*(2), 171–216.

Burgin, V. (1991). Geometry and Abjection. In J. Donald (Ed.), *Psychoanalysis and Cultural Theory: Thresholds* (pp. 11–26). Macmillan Publishers Limited.

Cai, G., Xu, L., Gao, W., Wang, K., Hong, Y., & Wang, Y. (2021). Knowledge archaeology on relations between the Venice Architecture Biennale (1980–2018) and the Pritzker Architecture Prize (1979–2019). *Journal of Asian Architecture and Building Engineering*, *00*(00), 1–10.

Castoriadis, C. (1975). *The Imaginary Institution of Society*. MIT Press.

Choo, J., Hannah, K. I. M., Clarkson, E., Zhicheng, L. I. U., Changhyun, L. E. E., Fuxin, L. I., Hanseung, L. E. E., Kannan, R., Stolper, C. D., Stasko, J., & Park, H. (2018). VisIRR: A visual analytics system for information retrieval and recommendation for large-Scale document data. *ACM Transactions on Knowledge Discovery from Data*, *12*(1).

Clayton, E. (2019). *Where did writing begin?* British Library. https://www.bl.uk/history-of-writing/articles/where-did-writing-begin#

Conklin, J. (1987). Hypertext: An Introduction and Survey. *Computer*, *20*(9), 17–41.

Cooper, R., & Fox, S. (1990). The "Texture" of Organizing. *Journal of Management Studies*, *27*(6).

Crowe, N. A. and Hurtt, S. W. (1986). Visual Notes and the Acquisition of Architectural Knowledge. *Journal of Architectural Education*, *39*(3), 6–16.

Dillon, A. (1991). Readers' models of text structures: the case of academic articles. *International Journal of Man-Machine Studies*, *35*(6), 913–925.

Duffy, F., &Hutton, L. (2004). Architectural knowledge: The idea of a profession. In *Routledge*. https://doi.org/10.4324/9780203223574

Edwards, D. M., & Hardman, L. (1989). "Lost in Hyperspace": Cognitive mapping and navigation in a hypertext environment. In *Hypertext: Theory into practice* (pp. 105–125).

Elm, W. C., & Woods, D. D. (1985). Getting Lost: A Case Study in Interface Design. *Proceedings of the Human Factors Society Annual Meeting*, *29*(10), 927–929.

Eveland, W. P., & Cortese, J. (2004). How Web Site Organization Influences Free Recall, Factual Knowledge, and Knowledge Structure Density. *Human Communication Research*, *30*(2), 208–233.

Fahlman, S. E. (1979). NETL, a system for representing and using real-world knowledge. In *Artificial intelligence series*. http://www.worldcat.org/oclc/1170688810

Fekete, J.-D., van Wijk, J. J., Stasko, J. T., & North, C. (2008). The Value of Information Visualization. In C. N. Andreas Kerren, John T. Stasko, Jean-Daniel Fekete (Ed.), *Information Visualization: Vol. 4950 LNCS* (pp. 1–18).

Fish, S. (1989). *Doing What Comes Naturally: Change, Rhetoric, and the Practice of Theory in Literary & Legal Studies*. Duke University Press. https://doi.org/10.1215/9780822381600

Fisher, K. M. (1992). SemNet: A Tool for Personal Knowledge Construction. In P. Kommers, D. H. Jonassen, & J. T. Mayes (Eds.), *Cognitive Tools for Learning* (pp. 63–75). Springer.

Foss, C. L. (1989). Tools for reading and browsing hypertext. *Information Processing and Management*, *25*(4), 407–418.

Giedion, S. (1928). Building in France, Building in Iron, Building in Ferroconcrete. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9).

Gretarsson, B., O'Donovan, J., Bostandjiev, S., Höllerer, T., Asuncion, A., Newman, D., & Smyth, P. (2012). Topicnets: Visual analysis of large text corpora with topic modeling. *ACM Transactions on Intelligent Systems and Technology*, *3*(2), 1–26.

Grimes, S. (2012). *Smart Content Reviewed: Text Analytics & Semantic Content Enrichment*. CMS Wire. https://www.cmswire.com/cms/information-management/smart-content-reviewed-text-analytics-semantic-content-enrichment-014344.php

Habraken, N. J. (1997). Forms of Understanding: Thematic Knowledge and the Modernist Legacy. In Pollack M. (Ed.), *The Education of the Architect* (pp. 267–293). MIT Press.

Halford, G. S., Bain, J. D., Maybery, M. T., & Andrews, G. (1998). Induction of Relational Schemas: Common Processes in Reasoning and Complex Learning. *Cognitive Psychology*, *35*(3), 201–245.

Halper, F. (2011). *What is Networked Content and Why Should We Care?* https://datamakesworld.com/2011/04/12/what-is-networked-content-and-why-should-we-care/

Janiak, A. (2020). Kant's Views on Space and Time. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Spring 2020). Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/spr2020/entries/kant-spacetime/

Jonassen, D. H. (1992). Semantic Networking as Cognitive Tools. In & J. T. M. P. Kommers, D.H. Jonassen (Ed.), *Cognitive Tools for Learning* (pp. 19–21). Springer.

Joudrey, D. N., Taylor, A. G., & Wisser, K. M. (2017). *The Organization of Information* (4th ed.). Libraries Unlimited.

Keim, D. A. (2002). Information visualization and visual data mining. *IEEE Transactions on Visualization and Computer Graphics*, *8*(1), 1–8.

Kelley, J. (2002). Achieving The Competitive Advantage Through Enterprise Content Management and Optimizing Team Collaboration. In *Knowledge Nirvana*. Xulon Press.

Khalifa, M., & Shen, K. N. (2010). Applying semantic networks to hypertext design: Effects on knowledge structure acquisition and problem solving. *Journal of the American Society for Information Science and Technology*, *61*(8), 1673–1685.

Kien, G. (2009). Actor-network theory: Translation as material culture. *Material Culture and Technology in Everyday Life: Ethnographic Approaches*, *1989*, 27–44.

Kien, G. (2016, June 2). *Actor-Network Theory*. Serious Science. https://www.youtube.com/watch?v=5Uh2UIPvIhs

Last, D. A., O'Donnel, A. M., & Kelly, A. E. (2001). The effects of prior knowledge and goal strength on the use of hypertext. *Journal of Educational Multimedia and Hypermedia*, *10*(1), 3–25.

Latour, B. (2005). *Reassembling the social: an introduction to actor-network-theory*. Oxford University Press.

Law, J. (1992). Notes on the Theory of the Actor-Network: Ordering, Strategy, and Heterogeneity John. *Systems Practice*, *5*(4), 379–393.

Law, J., & Hassard, J. (1999). *Actor network theory and after*. Blackwell Publishers.

Leach, N. (2005). Rethinking Architecture. In *Rethinking Architecture*. https://doi.org/10.4324/9780203975251

Lee, H., Kihm, J., Choo, J., Stasko, J., & Park, H. (2012). IVisClustering: An interactive visual document clustering via topic modeling. *Computer Graphics Forum*, *31*(3 PART 3), 1155–1164.

Lefebvre, H. (1991). The production of space. In *The production of space*. https://doi.org/10.4324/9780203132357-14

Lehmann, F. (1992). Semantic Networks. *Computers Mathematic Applications*, *23*(5), 1–50.

Lieto, L., & Beauregard, R. A. (2016). Planning for a material world. *Planning for a Material World*, 1–181. https://doi.org/10.4324/9781315735603

Liew, A. (2007). Understanding Data, Information, Knowledge And Their Inter-Relationships. *Journal of Knowledge Management Practice*, *7*(2).

Linder, M. (1992). Architectural Theory is No Discipline. In J. Whiteman, J. Kipnis, & R. Burdett (Eds.), *Strategies in Architectural Thinking* (pp. 167–179). MIT Press.

Locatis, C., Letourneau, G., & Banvard, R. (1989). Hypermedia and instruction. *Educational Technology Research and Development*, *37*(4), 65–77.

Madrazo, L. (1994). Durand and the Science of Architecture. *Journal of Architectural Education (1984-)*, *48*(1), 12.

Manning, C., Surdeanu, M., Bauer, J., Finkel, J., Bethard, S., & McClosky, D. (2014). The Stanford CoreNLP Natural Language Processing Toolkit. *Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics: System Demonstrations*, 55–60.

Matysek, A., & Tomaszczyk, J. (2020). Digital wisdom in research work. *Zagadnienia Informacji Naukowej - Studia Informacyjne*, *58*(2A(116A)), 98–113.

Mayer, D. (2011). *The Networked Content Manifesto [White Paper]*. https://drive.google.com/file/d/0B5RkVuTtfEWaMml4S2p4bVlmWG8/view?resourcekey=0-OSCtvUt0GR8FsuPUxT3K4w

Mayer, D. (2013). From Discovery to Delivery: Publishing Opportunities on the Semantic Web. *Against the Grain*, *25*(1).

McDonald, S., & Stevenson, R. J. (1996). Disorientation in hypertext: The effects of three text structures on navigation performance. *Applied Ergonomics*, *27*(1), 61–68.

McEneaney, J. E. (2002). A transactional theory of hypertext structure. *National Reading Conference*, *52*, 272–284.

Mennan, Z. (1999). Geri-dönüşümlü bir tema: Mimarlığın "asal" sorunu. *Mimarlık Dergisi*, *298*, 36–37.

Miller, D. (2005). Introduction. In Daniel Miller (Ed.), *Materiality* (pp. 1–51). Duke University Press.

Mohageg, M. F. (1992). The influence of hypertext linking structures on the efficiency of information retrieval. *Human Factors*, *34*(3), 351–367.

Nelson, T. H. (1967). Getting it out of your system. In G. Schechter (Ed.), *In Information Retrieval: A Crifical Review: Vol. Volume 5* (Issue Number 5, pp. 191–210). Thompson Books.

Nelson, T. H. (1981). Literary Machines. In *Mindscape Press.*

Nelson, T. H. (1995). The heart of connection: hypermedia unified by transclusion. *Communications of the ACM*, *38*(8), 31–33.

Niederer, S. (2018). Five Considerations for Digital Research in the Humanities. In G. Schiuma & D. Carlucci (Eds.), *Big Data in Arts and Humanities. Theory and Practice* (pp. 89–99). Taylor & Francis Group.

Özkan, S. (1978). Mimarlıkta Kuramsal Çalışmaların Evrimi. In M. Pultar (Ed.), *Mimarlık Bilimi Kavram ve Sorunlari* (pp. 38–45). Çevre ve Mimarlık Bilimleri Derneği.

Paranyushkin, D. (2019). InfraNodus: Generating Insight Using Text Network Analysis. *'19: The World Wide Web Conference*, 3584–3589.

Payne, R. (1975). Truisms in organizational behaviour. *Interpersonal Development*, *6*(3–4), 203–220.

Peirce, C. S. (1880). On the Algebra of Logic. *American Journal of Mathematics*, *3*(1), 15.

Pepper, S. C. (1942). *World Hypotheses: A Study in Evidence*. University of California Press.

Pevsner, N. (1943). An outline of European architecture. In *Housing and dwelling*. Pelican Books.

Picon, A. (2018). *Mimarlığın Maddiliği*. Editions Parantheses.

Prensky, M. (2012a). *Brain Gain: Technology and the Quest for Digital Wisdom*. Palgrave Macmillan.

Prensky, M. (2012b). From digital natives to digital wisdom: Hopeful essays for 21st century learning. In *Corwin*. https://doi.org/10.4135/9781483387765

Revere, R., & Blustein, J. (2020). Transhierarchy. *Proceedings of the 3rd Workshop on Human Factors in Hypertext*, 1–7. https://doi.org/10.1145/3406853.3434771

Rumelhart, D. E. (1984). Understanding understanding. In J. Flood (Ed.), *Understanding reading comprehension: Cognition, language, and thestructure of prose* (pp. 1–20). International Reading Association.

Russel, B. (1982). *The Problems of Philosophy.* (M. Sternberg, Ed.). Magnes Press, The Hebrew University.

Ryan-Wilkinson, T. (2020). *Our Minds Aren't Equipped for This Kind of Reopening*. The Atlantic. https://www.theatlantic.com/ideas/archive/2020/07/reopening-psychological-morass/613858/

Ryle, G. (1946). Knowing How and Knowing That. *Proceedings of Aristotelian Society*, vol.XLVI.

Sack, H., & Alam, M. (n.d.). Week 1: Knowledge Graphs in the Web of Data. In *openHPI*. https://open.hpi.de/courses/knowledgegraphs2020/items/7EalOEt73MWIAwIizs8nIB

Sadiku, M. N. O., Shadare, A. E., & Musa, S. M. (2017). Digital Wisdom. *International Journal of Advanced Research in Computer Science and Software Engineering*, *7*(8), 72.

Sanagapati, P. (2020). *Knowledge Graph & NLP Tutorial-(BERT,spaCy,NLTK)*. Kaggle. https://www.kaggle.com/code/pavansanagapati/knowledge-graph-nlp-tutorial-bert-spacy-nltk/notebook

Schön, D. (2013). Educating the Reflective Practitioner. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9).

Sennett, R. (1999). Dokunma Duyusu. *Mimarlık Dergisi*, *289*, 7–10.

Shaughnessy, M. F., Fulgham, S. M., & Prensky, M. (2010). Interview with Marc Prensky. *Educational Technology*, *50*(2), 28–33.

Shin, E. C., Schallert, D. L., & Savenye, W. C. (1994). Effects of learner control, advisement, and prior knowledge on young students' learning in a hypertext environment. *Educational Technology Research and Development*, *42*(1), 33–46.

Simmel, G. (1997). The sociology of space. In D. Frisby & M. Featherstone (Eds.), *Simmel on culture* (pp. 137–174). Sage Publications.

Smith, J. B., & Weiss, S. F. (1988). Hypertext. *Commumications of the ACM, 31*(7), 816–819.

Soares, E. (2018). *NLTK: Extract the entity name from a string*. Stack Overflow. https://stackoverflow.com/questions/51406281/nltk-extract-the-entity-name-from-a-string

Sowa, J. F. (2006). Semantic Networks. In *Encyclopedia of Cognitive Science*. John Wiley & Sons, Ltd. https://doi.org/10.1002/0470018860.s00065

Steup, M., & Neta, R. (2020). Epistemology. In *The Stanford Encyclopedia of Philosophy* (Fall 2020). Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/fall2020/entries/epistemology/

Stroll, A., & Martinich, A. P. (n.d.). *epistemology*. Encyclopedia Britannica. https://www.britannica.com/topic/epistemology

Süveydan, Ş. (1999). Mimarlık Teorisi Üzerine Tezler *. *Mimarlık Dergisi*, *289*, 24–28.

Tanyeli, U. (1999). Söylem ve Kuram: Mimari Bilgi Alanının Sınırlarını Çizmek. *Mimarlık Dergisi*, *289*, 38–41.

Tsoukas, H. (1994). Refining Common Sense: Types of Knowledge in Management Studies. *Journal of Management Studies*, *31*(6).

Uraz Ulusu, T. (1999). Mimarlık Bilgisi " Eskizler " ve Düşündürdükleri. *Mimarlık Dergisi*, *289*, 11–13.

Utting, K., & Yankelovich, N. (1989). Context and orientation in hypermedia networks. *ACM Transactions on Information Systems*, *7*(1), 58–84. https://doi.org/10.1145/64789.64992

Vesely, D. (1984). Architecture and Hermeneutic. *Issue Magazine, 4*, 10–24.

Vidler, A. (1999). Mekânın Tektoniği. *Mimarlık Dergisi*, *289*, 14–16.

Vitruvius. (1826). *The Architecture of Marcus Vitruvius Pollio* (J. Gwilt, Ed.). Priestley and Weale.

Vitruvius. (1999). *Ten Books on Architecture* (I. D. Rowland & T. N. Howe, Eds.). Cambridge University Press.

Wang, W., & Rada, R. (1995). Experiences with semantic net based hypermedia. *International Journal of Human - Computer Studies*, *43*(3), 419–439.

Wang, W., & Rada, R. (1998). Structured hypertext with domain semantics. *ACM Transactions on Information Systems*, *16*(4), 372–412.

Wittrock, M. C. (1974). Learning as a generative process. *Educational Psychologist*, *11*(2), 87–95.

Yücel, A. (1999). " İçeriden Mimarlık " ya da Doğayı İnşa Etmek. *Mimarlık Dergisi*, *289*, 20–23.

Url-1 **Cambridge Dictionary.** (n.d.). *knowledge*. Cambridge University Press. https://dictionary.cambridge.org/dictionary/english/knowledge

Url-2 **Fully transclude backlinks.** (n.d.). In *Obsidian Forum: Vol. Post #3*. Obsidan.md. Retrieved July 1, 2021, from https://forum.obsidian.md/t/fully-transclude-backlinks/325

Url-3 ***graphdb SE*.** (2022). Ontotext. https://graphdb.ontotext.com/documentation/standard/index.html

Url-4 ***HistoGraph*.** (2018). Université Du Luxembourg. http://histograph.eu/

Url-5 **IBM Cloud Education.** (2020). *Natural Language Processing (NLP)*. https://www.ibm.com/cloud/learn/natural-language-processing

Url-6 ***InfraNodus*.** (2011). Nodus Labs. https://infranodus.com/

Url-7 ***Internet Archive: Digital Library of Free & Borrowable Books, Movies, Music & Wayback Machine*.** (n.d.). https://archive.org/

Url- 8 ***Obsidian Help*.** (n.d.). Obsidian Publish. https://help.obsidian.md/

Url-9 ***Obsidian.md*.** (n.d.). Obsidian Publish. https://obsidian.md/

Url-10 ***OntoText*.** (2000). Sirma Group Holding. https://www.ontotext.com/

Url-11 **Navlani, A.** (2019). *NLTK Sentiment Analysis Tutorial for Beginners*. https://www.datacamp.com/community/tutorials/text-analytics-beginners-nltk

Url-12 ***Palladio. Visualize complex historical data with ease.*** (2016). Stanford Humanities and Design. http://hdlab.stanford.edu/palladio/about/

Url-13 ***Roam A note-taking tool for networked thought.*** (n.d.). https://roamresearch.com/#/app/Labinteligenciaderedes/graph

Url-14 **SpaCy.** (2016). *Industrial-Strength Natural Language Processing*. https://spacy.io/

Url-15 **T.C. Kültür ve Turizm Bakanlığı.** (n.d.). *Ankara Roman Bath*. https://www.ktb.gov.tr/yazdir?162B7AE59C0AE5CBAE7069A4D5EA40A3

Url-16 ***Textexture*.** (2012). Nodus Labs. https://textexture.com/index.php?text_id=603

Url-17 ***Textexture: The Non-Linear Reading Machine*.** (2015). Nodus Labs. https://noduslabs.com/cases/textexture-non-linear-reading-machine/

Url-18 **The Getty Research Enstitute.** (2017). *Art & Architecture Thesaurus® Online*. The Getty Research Enstitute. https://www.getty.edu/research/tools/vocabularies/aat/index.html

Url-19 ***The Museum of the World*.** (n.d.). The British Museum. https://britishmuseum.withgoogle.com/

Url-20 ***VOSviewer*.** (2016). Centre for Science and Technology Studies, Leiden University. https://www.vosviewer.com/publications

Url-21 ***weirandwong*.** (2016). http://www.weirandwong.com/portfolio/the-museum-of-the-world/)