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Tarih Araştırmalarında Dijital Araçların Rolü: Aurillac'lı Gerbert'in Entelektüel Ağı Üzerine Bir Çalışma

The Role of Digital Tools in Historical Research: A Study on the Intellectual Network of Gerbert of Aurillac

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Öz- Bu çalışma, Papa II. Sylvester'ın (Aurillaclı Gerbert) entelektüel ağını dijital araçlar kullanarak görselleştirmeyi ve bu araçları desteklemek için mevcut literatürü kullanarak hibrit bir anlatı oluşturmayı amaçlamaktadır. Çalışma, spesifik bir yöntemi kapsamlı bir şekilde uygulamak yerine, üç farklı dijital aracın ilk kullanımlarındaki faydaları ve sınırlılıklarını literatürle karşılaştırarak ortaya koymaktadır. Metin analizi yönteminin uygulandığı ilk bölümde, bu analize arka plan sağlaması açısından Gerbert'in Reims'e kadar olan yaşamı ele alınmıştır. Voyant Tools aracılığıyla, Gerbert'in yayınlanmış mektuplarında sıkça geçen kelimeler görselleştirilmiş ve böylece onun dünyasına genel bir bakış sunulmuştur. İkinci bölümde bir yapay zekâ (YZ) görselleştirme aracı olan Map-This kullanılmıştır. Bu araç, Gerbert'in mektuplarındaki dizin verilerine dayanarak bağlamsal bir grafik oluşturmakta ve Reims'teki görev süresi boyunca kurduğu ilişkileri görselleştirmektedir. Bununla birlikte, orijinal kaynak metinde bulunmayan terimler görselleştirmeye dahil edilmesi dikkate alınması gereken bir dezavantajdır. Son bölümde, web tabanlı bir görselleştirme aracı olan Flourish kullanılarak onun entelektüel ağını temsil eden bir sosyogram oluşturulmuştur. Sosyal ağ analizi yöntemi Gerbert'in kitap talep eden mektuplarının alıcıları üzerinden onun bilgi edinme ağını ortaya çıkarmaktadır. Kitap taleplerinin teolojik konulardan ziyade seküler alanlara odaklanması, onun entelektüel çevresinin tipik papalık bağlamından ayrıştığını göstermektedir. Bu çok araçlı ve aşamalı yaklaşım dijital araçların tarihsel ağları incelemedeki etkinliğini göstererek, daha ileri çalışmalar için bir temel oluşturmaktadır.

Anahtar Kelimeler– *Aurillac'lı Gerbert, Entelektüel Ağlar, Metin Analizi, Yapay Zekâ (YZ), Sosyal Ağ Analizi, Dijital Tarih.*

Abstract – The objective of this study is to create a visual representation of the intellectual network of Pope Sylvester II (Gerbert of Aurillac) through the utilization of digital tools and to construct a hybrid narrative based on existing literature to support these tools. Rather than applying a specific method comprehensively, the study reveals the benefits and limitations of the first use of three different digital tools by comparing them with the literature. In the first chapter, where the text analysis method is applied, Gerbert's life until Reims is discussed to provide the background for this analysis. The application of Voyant Tools has enabled the visualization of words frequently appearing in Gerbert's published letters, thereby providing an overview of his world. In the second part, Map-This, an artificial intelligence (AI) visualization tool, was employed. This tool generates a contextual chart based on index data from Gerbert's letters and visualizes the relationships he established throughout his tenure in Reims. However, including terms in the visualization that are not found in the source text is a drawback that should be considered. In the final section, a sociogram representing Gerbert's intellectual network was created using Flourish, a web-based visualization tool. The social network analysis method reveals Gerbert's information network through the recipients of his letters requesting books. The fact that his book requests focused on secular rather than theological issues shows that his intellectual environment differed from the typical papal context. This multi-tool and phased approach demonstrates the effectiveness of digital tools in examining historical networks, providing a basis for further studies.

Keywords– *Gerbert of Aurillac, Intellectual Networks, Text Analysis, Artificial Intelligence (AI), Social Network Analysis, Digital History.*

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INTRODUCTION

Gerbert of Aurillac, who later became Pope Sylvester II (945-1003), occupies a significant position in the history of European intellectual thought. His extensive correspondence provides a critical resource for understanding the intellectual currents of his era. While traditional text-based methods have long been employed to study his letters, this research uses a multi-tool digital approach with the objective of enhancing our understanding of Gerbert's intellectual network. By using tools such as Voyant Tools, Map-This, and Flourish, this study aims to identify novel patterns and associations within Gerbert's correspondences that may have remained undetected through conventional analysis. Digital tools, with their capacity to process and visualize intricate data, present a distinctive opportunity to reconstruct and examine the complex network of relationships that shaped the intellectual landscape of the 10th century.

The initial section examines Gerbert's life before his tenure at Rheims Cathedral School through a literature-based approach. This includes analyzing his early education, mentor, visit to Spain, and the lessons he learned there. Furthermore, the first social networks he established upon his return from Spain to Italy and his meeting with the Pope and Emperor of the time were examined. In addition, to provide an overview of Gerbert's intellectual world, this part of the article uses Voyant Tools, a web-based text analysis platform. This initial overview helps researchers gain a general understanding of the content and identify areas for further investigation. However, Voyant Tools' strength lies in providing an initial point rather than conclusive interpretations, as the complexity of historical documents often requires deeper analysis.

To address this limitation, the second section of the study employs Map-This, an artificial intelligence (AI) language model. AI language models can analyze textual data and identify potential relationships within documents. Here, Map-This examines the index data in Gerbert's letters, potentially revealing previously unseen connections between people and concepts. However, it is crucial to recognize the potential limitations of AI models. These models are trained on existing datasets, which may introduce bias or the inclusion of training data in the analysis. Therefore, historians must carefully evaluate and validate the results generated by AI tools. To address this challenge, the subsequent parts of this section will analyze the complex social relations established by Gerbert in Reims based on current literature. This chapter examines the process of his educational journey at the Cathedral School of Rheims, emphasizing the subjects he studied, the texts he used in his teaching, and his instructional methods. To clarify the narrative, this section will discuss his administrative career, which led initially to the archbishopric of Rheims, then to Ravenna, and finally to the papacy.

In the third chapter, the letters he wrote to his acquaintances to request books and their contents will be mentioned. In this part of the study, social network analysis applications, which are powerful tools for visualizing historical relationships, were used. *Flourish*, a user-friendly web platform is used to visualize Gerbert's intellectual network based on his book request letters. Visualizing Gerbert's letter recipients with this tool allows us to identify those to whom he primarily directed his requests for information. This approach provides a more nuanced understanding of Gerbert's intellectual landscape than relying solely on word frequency or named entities. Therefore, in this study, the findings from the literature review and the outputs of three digital tools will be compared.

1. Gerbert's World at First Glance: Corpus Analysis of Letters

Gerbert of Aurillac, born in 945, received his early education at the monastery of Saint-Géraud in his hometown. There, he developed his grammatical skills under the tutelage of the monk Raymond. This formative experience laid the groundwork for Gerbert's subsequent development of a sophisticated intellectual social network.[1] However, Gerbert's relationship with his teacher, Raymond, was particularly influential. Raymond's passion for classical literature deeply inspired Gerbert, significantly shaping his intellectual growth. In later years, Gerbert expressed his sincere gratitude to Raymond for his invaluable mentorship.[2] In 967, Gerbert's intellectual trajectory underwent a significant change when

[1] Roland Allen, 'Gerbert, Pope Silvester II', *The English Historical Review* 7, no. 28 (1892): 627, http://www.jstor.org/stable/547412.
[2] Oscar G. Darlington, 'Gerbert, the Teacher', *The American Historical Review* 52, no. 3 (1947): 459.

Count Borel of Barcelona, on a visit to the monastery of Saint-Géraud, took him to Catalonia, Spain. There, through Borel's mediation, Gerbert received extensive mathematical instruction from Hatto, Bishop of Vich. This newly acquired knowledge earned him the praise of Pope John XIII and Emperor Otto I.[3] The available records indicate that Gerbert also spent some time studying at the Benedictine monastery of Santa Maria de Ripoll in Catalonia. The specific courses he took and the texts he studied beyond mathematics remain unclear. Nevertheless, it is thought that the artifacts he observed were not known to the Western European populace at that time. However, it is believed that his experience there included works that were unfamiliar to Western Europe at the time.[4]

While the exact way Gerbert acquired knowledge of Indo-Arabic numerals is uncertain, two primary hypotheses prevail: first, that he learned them during his studies in Catalonian monastic schools, and second, that he was influenced by Joseph Ispanus' work. The first assumes that he learned them from texts he encountered during his studies in Catalan monastic or cathedral schools. Another assumption is that he acquired this knowledge from a work entitled *De Multiplicatione et divisione numerorum* by Joseph Ispanus (also known as Joseph Sapiens). In 983, while at the cathedral school of Reims, he wrote a letter to Miro Bonfill, Bishop of Girona, probably someone he had met during his time in Catalonia. The letter requests a copy of *'De Multiplicatione et divisione numerarum'* by Joseph Ispanus. However, the delivery of the letter to the bishop remains unconfirmed. The book he requested was given to Gari, the abbot of the monastery of Sant Miquel de Cuixa in Girona. Gari took the book from Girona to the monastery of Saint-Geraud'Aurillac and informed Gerbert. Gerbert later wrote to the Abbot of Aurillac, Geraldus, asking for the book that Gari had entrusted to him. It is believed that this book reached Gerbert. Therefore, it is assumed that he did not come across this book during his stay in Spain but rather observed it for the first time in Reims and used it in his lectures.[5]

In the tenth century, Spain became a land of science and culture under the rule of the Andalusian Umayyads. During the reign of Abdurrahman III (r. 912-961), numerous academies and libraries were established, and vast collections of texts were collected. This intellectually stimulating environment is likely to have influenced Gerbert and possibly contributed to his acquisition of knowledge, including the acquisition of Arabic numerals.[6] We argue that Spain played a significant role in Gerbert's intellectual development and the formation of his networks. It is noteworthy that among the people to whom Gerbert wrote letters requesting books were acquaintances from Catalonia.

Gerbert, who had been in Spain for some time, went to Rome with Duke Borel and his mathematics teacher Hatto to obtain the Pope's approval for the establishment of an archbishopric in Vich. After Spain, Rome would be the second most important place in the formation of his intellectual and political networks. As mentioned above, Pope John XIII (965-972) was impressed by his mathematical expertise and introduced him to Emperor Otto I (961-973). After informing the Emperor of his proficiency in mathematics, Gerbert expressed a desire to focus on logic. He was initially assigned to teach the imperial students. In this period, Gerannus, the renowned logician and archdeacon of Reims, arrived in Italy. With the emperor's permission, Gerbert then went to Reims with Gerannus.[7]

Gerbert, who was eager to learn logic, agreed to teach mathematics to Archdeacon Gerannus of Reims in exchange. It is known that another reason for Gerbert to travel to Reims was Archbishop Adalbero's invitation. Adalbero welcomed Gerbert's arrival to revive the Cathedral School of Reims as a center of cultural and scientific excellence, implementing reforms in this direction and establishing a long-lasting friendship. Gerbert served as abbot of St. Columban's monastery in Bobbio between 981 and 983. He then returned to Reims, where he remained until 997.[8]

[3] Allen, 'Gerbert', 627.
[4] Courtney DeMayo, 'The Students of Gerbert of Aurillac's Cathedral School at Reims: An Intellectual Genealogy', *Medieval Prosopography* 27 (2012): 99–100, http://www.jstor.org/stable/44946481.
[5] Thomas Freudenhammer, 'Gerbert of Aurillac and the Transmission of Arabic Numerals to Europe', *Sudhoffs Archiv* 105, no. 1 (2021): 14–15, https://doi.org/10.25162/sar-2021-0001.
[6] Horace Kinder Mann, *Lives of Popes In the Early Middle Ages*, vol. 5 (St. Louis: Herder, 1910), 12–15.
[7] Allen, 'Gerbert', 627–28.
[8] DeMayo, 'The Students', 100.

The city of Rheims represented a pivotal moment in Gerbert's life. During this period, his intellectual pursuits flourished, and he cultivated a wide circle of influential contacts. This period also saw him compose a voluminous collection of letters to various individuals. The extensive network of which Gerbert was a part is evidenced by the large number of letters he wrote. However, in order to gain a deeper understanding of Gerbert's world, it is necessary to adopt a different approach. In such cases, text analysis tools become indispensable. By employing digital analysis, researchers can more effectively navigate the extensive corpus of Gerbert's letters, uncovering previously obscured patterns and connections that might otherwise remain undetected through traditional methods.

Text analysis tools provide researchers with a range of visualization techniques for exploring large data sets. This allows text to be examined at a macro level, providing insights that would otherwise be difficult to obtain. Beyond basic functionality, Voyant offers twenty-eight text visualization tools for both novice and experienced researchers. Comprehensive documentation and support resources ensure a smooth learning curve. The standard interface provides core tools, such as word clouds and contextual readers, with customization options. Most importantly, Voyant modules work together, allowing changes to propagate throughout the analysis. Users can further personalize the experience by swapping out individual tools or using different preconfigured layouts.[9]

Having established Voyant Tools as a valuable tool for initial textual analysis, we now examine the word cloud it generates to gain a preliminary insight into Gerbert's world (Figure 1). This visualization prioritizes content-rich terms by removing expected terms such as "Gerbert," "pope," and "letter," allowing us to focus on the key figures and concepts that populated his life. The prominence of words such as "archbishop," "bishop," "Reims," "king," and "Otto" provides insight into Gerbert's social and intellectual circles. It is evident that he interacted with the clergy, from fellow "bishops" to the highest authority, the "emperor.

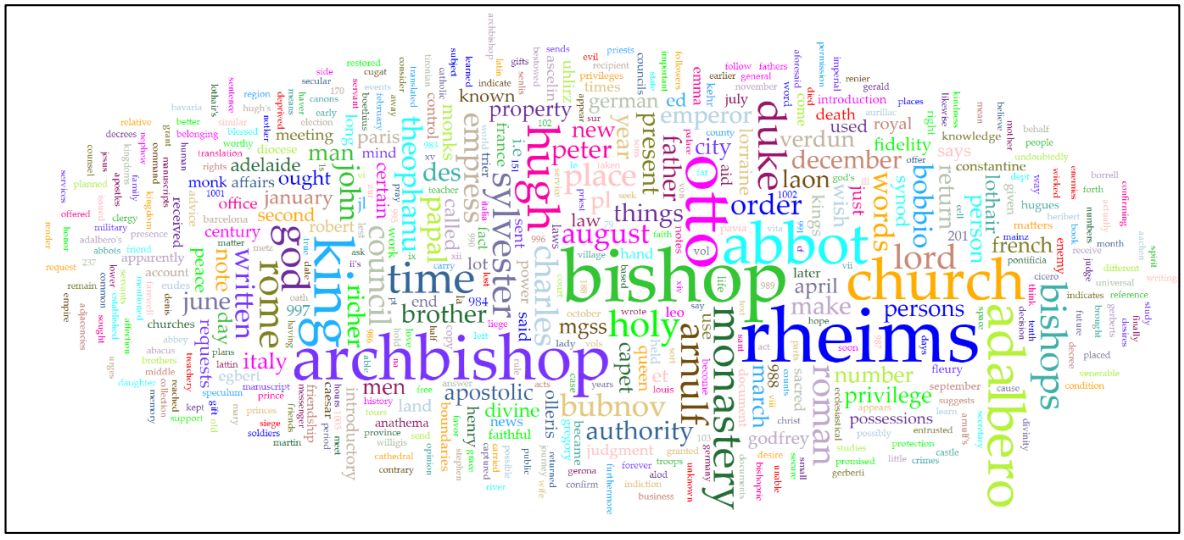


Figure 1: *Word cloud created with Voyant Tools based on the most frequent words in Gerbert's letters.*[10]

A closer examination of the word cloud reveals certain individuals who were potentially associated with Gerbert's network. The presence of "Reims" suggests a significant connection to this important urban center, perhaps due to the time he spent teaching there. An analysis of the personal names within the word cloud, including Adalbero, Arnulf, Lothair, and Charles, reveals Gerbert's prominent social

[9] Laurie J. Sampsel, 'Voyant Tools', *Music Reference Services Quarterly* 21, no. 3 (3 July 2018): 153–57, https://doi.org/10.1080/10588167.2018.1496754.

[10] Stéfan Sinclair and Geoffrey Rockwell, 'Voyant Tools' (Voyant Tools, 2024), https://voyant-tools.org/?lang=en&view=Cirrus&stopList=keywords-33bd7654ed3c4add4cc18757baaa0fd5&corpus=5702007a9934263ec3e70e15a9e4fae3.

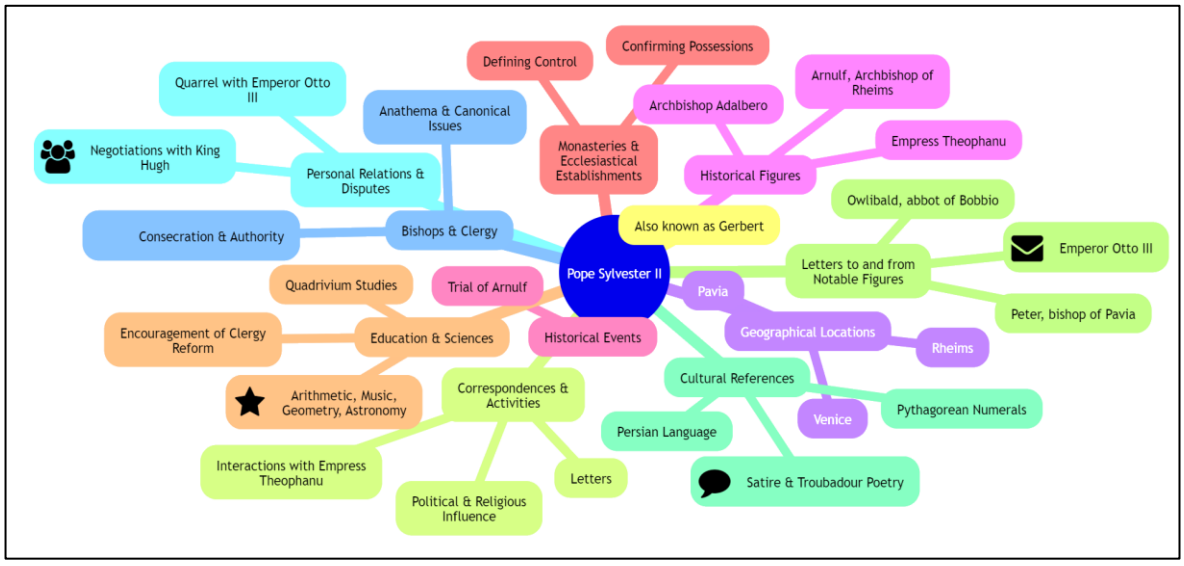
network. Of particular note is the importance of Adalbero, the Archbishop of the Cathedral School of Reims, who played a key role in transforming the institution into a major cultural center and was one of Gerbert's closest friends. He is one of the most influential figures in the development of Gerbert's intellectual knowledge and social network. He was a student of Arnulf Gerbert, a member of the Carolingian dynasty, and later became archbishop of the cathedral school in Reims, succeeding Adalbero. It is important to remember that a word cloud offers only a cursory examination, and a fuller understanding will require a deeper dive into Gerbert's letters using the other tools provided by Voyant. This preliminary analysis provides a foundation for further investigation and demonstrates the potential of digital humanities tools to illuminate the intricacies of the intellectual domains and social networks of historical figures. By integrating the names of individuals and places with the thematic terms, the word cloud provides a more comprehensive first glimpse into Gerbert's milieu.

2. Effective Use of the Data Already Available: AI-Powered Graph Generation

The integration of artificial intelligence (AI) and data visualization provides a powerful toolset for historical research. AI-based data visualization applications offer several benefits. First, AI automates time-consuming tasks, streamlining the data analysis process. Second, data visualization enhances understanding through intuitive visualization and interactive exploration. Finally, the most advanced integration of visualization and AI, known as VIS+AI, enables AI to learn from human interaction and communicate insights visually.[11]

A notable example of an AI-based data visualization tool is Map-This.com. Map-This transforms dense PDF documents into visually engaging and easily navigable mind maps. This easy-to-use tool facilitates learning, improves information retention, and allows users to upload PDFs, create mind maps, and save them for future reference. Map-This is suitable for students, professionals, and anyone who wants to organize their thoughts effectively. Obviously, this visualization tool is not suitable for analyzing high-dimensional text. Consequently, in this study, Figure 2 was created using the index section of Gerbert's published letters. In contrast to traditional textual analysis tools, the use of artificial intelligence-based visualization allows for a more comprehensive and descriptive representation of the social relationships established by Gerbert in Reims.

Having discussed the potential of AI-based data visualization for historical research, we will now examine Figure 2, a mind map created using Map-This. This tool addresses a challenge inherent in traditional text analysis by transforming the index of Gerbert's letters into a visually appealing and interconnected map.



[11] Xumeng Wang et al., 'VIS+AI: Integrating Visualization with Artificial Intelligence for Efficient Data Analysis', *Frontiers of Computer Science* 17, no. 6 (8 December 2023): 176709, https://doi.org/10.1007/s11704-023-2691-y.

Figure 2: The chart created using Map-This, with the Index to Gerbert's Letters

In contrast to the linear text, this mind map offers a more comprehensive and descriptive representation of Gerbert's social relationships during his tenure in Reims. The central circle labeled "Gerbert" radiates outward, visually connecting him to a variety of people mentioned in his correspondence. These connections can be broadly categorized into four areas: "Personal Relations", "Letters to and from Notable Figures", "Historical Figures/Political Figures", and "Education and Science". The "Personal Relations" branch includes figures such as "King Hugh" and "Emperor Otto III". Similarly, "Letters to and from Notable Persons" includes names such as "Owlibald, Abbot of Bobbio," "Emperor Otto III," and "Peter, Bishop of Pavia. "Historical Figures/Political Figures includes names such as "Archbishop Adalbero," "Arnulf, Archbishop of Reims," and "Empress Theophanu. Finally, in the fourth category, "Education and Science," the names of the quadrivium studies (arithmetic, geometry, music, and astronomy), which include four of the seven liberal arts, stand out. Moreover, terms such as "astronomy," "arithmetic," and "geometry" indicate his interest in scientific and philosophical disciplines, underscoring his embrace of the liberal arts at a time of relative intellectual stagnation.

While AI-based visualization tools like Map-This provide valuable insights, there are limitations. For instance, the mind map in Figure 2 cannot definitively determine the nature or frequency of Gerbert's interactions. This is because the term "Persian Language" appears based on the tool's training data, not Gerbert's letters. Similarly, the name of Constantine, a close correspondent and student, is missing. Despite these limitations, the mind map serves as a springboard for further investigation. By combining AI data visualization with traditional historical scholarship and a close reading of Gerbert's complete correspondence, we can gain a more nuanced understanding of his intellectual world and social networks during his time in Reims.

Reims is another important city in the development of Gerbert's networks. His reputation as an authority stemmed from his efforts at the Reims Cathedral School, which included copying books, building a large library, giving lectures, and instructing students. His most important contribution, however, was to challenge the prevailing monastic curriculum, which limited the study of ancient authors. Gerbert advocated a more diverse curriculum, including secular texts, and placed a strong emphasis on the seven liberal arts, integrating them into the school's program. These included grammar, dialectic, rhetoric, arithmetic, astronomy, geometry, and music. It is documented that in these courses, he taught the works of experts in these fields, especially those from the ancient period.[12] In rhetoric, as in the other seven liberal arts, Gerbert had the works of classical authors copied, read in his classes, and explained to his students. These classical works included the Roman orator Quintilian's *Institutio oratoria*, Cicero's *De Oratore*, and the Roman Gaius Marius Victorinus' *Commentary on Cicero's De Inventione*.[13] James Midgley Clark notes that the science of geometry was largely neglected in the Middle Ages due to a perceived lack of practical value and a lack of qualified textbooks. He highlights Gerbert's pioneering efforts in the field of geometry education and research, particularly in relation to his discovery of Boethius' Geometria and his subsequent contributions to the discipline.[14]

Gerbert underscores the importance of this discipline by emphasizing the practical relevance and utility of geometry in area measurement and numerous other areas. He notes that God created all things with a specific measure and number.[15] In Gerbert's lessons, it is seen that he uses text-based education as well as applied methods and techniques in lessons such as rhetoric. In addition, he used tools such as the abacus in arithmetic, spheres and diagrams in geometry, and the monochord in music, indicating that

[12] Allen, 'Gerbert', 634–35.
[13] For further detailed information regarding the rhetorical studies conducted at the Reims cathedral school, the books Gerbert utilised and copied during his rhetoric lessons, and his method and methodology, please refer to: Justin Lake, "Gerbert of Aurillac and the Study of Rhetoric in Tenth Century Rheims", The Journal of Medieval Latin 23 (11 Mart 2013): 49-85, http://www.jstor.org/stable/45019730.
[14] James Midgley Clark, *The Abbey of St. Gall as a Centre of Literature & Art* (Cambridge: The University Press Cambridge, 1926), 120.
[15] G.R. Evans, *Fifty Key Medieval Thinkers* (Routledge, 2002), 63.

he was using an effective teaching method that was ahead of its time.[16] It is also known that Gerbert attached great importance to observational research in astronomy. In this context, he used observational instruments and devised mechanisms for measuring and determining time.[17] It is known that Gerbert made at least three clocks for the purpose of measuring time and making astronomical observations. Marek Otisk evaluates these clocks attributed to Gerbert with reference to three sources but notes that the information often expressed in contemporary studies that Gerbert actively used an astrolabe is not true and that no evidence has been found for this.[18] The most important witness to Gerbert's time, and also a student of his, was Richerus, a monk at the St. Remi monastery in Reims and a historian. In his work Historiarum, Richerus states that his teacher was the most learned person in Gaul and possessed remarkable oratorical skills. Another noteworthy aspect of Richerus' work is that it provides detailed information about the books Gerbert used in his classes and his teaching methodology. An examination of these books reveals that Porphyrios' *Isagoge*, based on the translation of Boethius on Logic and the rhetorician Victorinus, serves as an introduction to Aristotle's *Category*. Gerbert, who believed that poetry played an essential role in the acquisition of rhetorical skills, had his classes read the works of Roman poets such as Vergilius, Horatius, Iuvenalis, Persius, Statius, Lucanus, and Terentius.[19]

It is possible that Gerbert used Cassiodorus' program as a basis for his course syllabus and method, but his inclusion of the Logica Vetus course syllabus and his first use of Boethius' works are unique to him. Gerbert's activities should not be evaluated only for his own time. Gerbert's encouragement and efforts in this field are remarkable in that they paved the way for the inclusion of logic education in schools' curricula in the XI-XII centuries and for the writing and use of books in this field.[20]

Gerbert further improved the educational experience for his students by writing his own textbooks. Of note, his *'Regulae de numerorum abaci rationibus'* incorporated the use of Arabic numerals on the abacus, exemplifying his pioneering approach to mathematical instruction.[21] Gerbert's authorship extends to a mathematics text, demonstrating his expertise in the field. The book's frequent use of Greek terminology suggests a command of the language. Some scholars suggest that Gerbert acquired this knowledge during his tenure as abbot of Bobbio, a monastery known for its extensive collection of Greek manuscripts. Alternatively, others suggest that his exposure to Greek may have occurred while he was a teacher at the court of Otto I, who was married to a Byzantine princess. The question of whether Gerbert acquired his knowledge of Greek at Bobbio or at the imperial court remains controversial.[22]

The social network he created through his students attracted students from all over Europe because of his success as an educator. In fact, the administrators and nobles of the time sent their children to Reims to be educated by Gerbert. For example, Hugh Capet, who was to be crowned King of France, sent his son Robert to Reims instead of Fleury. Gerbert, before coming to Reims, was Otto I's son II. He was Otto's private tutor, and after his departure from Reims in 997, he became Otto III's private tutor. It is well documented that Gerbert educated numerous individuals, including members of the Capet and Otto dynasties, as well as Richard, Otto, and Arnulf, sons of Lothar, a member of the Carolingian royal family.[23] Gerbert also had many students who went on to prominent positions. Among them were Fulbert, who founded the renowned educational institution at Chartres; Ingon, Robert's cousin and later abbot of St. Germain des Pres; Girard, bishop of Cambray; Leutheric, a learned archbishop of Sens; and

[16] DeMayo, 'The Students', 101.
[17] Marek Otisk, *Arithmetic in the Thought of Gerbert of Aurillac*, ed. Marek Otisk (Berlin: Peter Lang, 2022), 34–35, https://doi.org/10.3726/b19269.
[18] Marek Otisk, 'Gerbert of Aurillac (Pope Sylvester Ii) as a Clockmaker', *Teorie Vědy / Theory of Science* 42, no. 1 (2020): 25–49, https://doi.org/10.46938/tv.2020.477.
[19] Richer (of Saint-Rémy), *Richeri Historiarum*, ed. Georg Heinrich Pertz and Georg Waitz, vol. 4 (Hannover: Impensis Bibliopolii Hahniani, 1877), 99–109.
[20] Fulbert of Chartres, The Letters and Poems of Fulbert of Chartres, ed. and trans. Frederick Behrends (Oxford: Clarendon Press, 1976), xxx–xxxi.
[21] Osmo Pekonen, 'Gerbert of Aurillac: Mathematician and Pope', *The Mathematical Intelligencer* 22, no. 4 (19 September 2000): 69, https://doi.org/10.1007/BF03026774.
[22] William P H Kitchin, 'A Pope-Philosopher of the Tenth Century: Sylvester II (Gerbert of Aurillac)', *The Catholic Historical Review* 8, no. 1 (1922): 48–49.
[23] Courtney DeMayo, "The Students of Gerbert of Aurillac's Cathedral School at Reims: An Intellectual Genealogy", Medieval Prosopography 27 (2012): 101-2, http://www.jstor.org/stable/44946481.

Bernelinus, who contributed to the advancement of arithmetic.[24] As mentioned earlier, another student of Gerbert's was Richerius of Saint Remi, a monk at the Saint-Remi monastery in Reims. Richerius described Gerbert's educational method and program in his work entitled Richerus Historia, which he dedicated to Gerbert. It is also known that Bruno, canon, and librarian of the cathedral of Reims, was a student of Gerbert.[25]

However, without detracting from the focus of the study, it would be appropriate to briefly mention Gerbert's administrative career. First, with regard to the process leading to the archbishopric of Reims, Gerbert's close friend and supporter, Adalbero, the archbishop of Reims, whom he considered his spiritual father, died in 989. While Gerbert expected to become archbishop, Arnulf, a member of the Carolingian dynasty, became archbishop, but after a while Gerbert became archbishop with the support of Hugh Capet's son, the Frankish king Robert. Gerbert continued to serve as archbishop for a time but was temporarily suspended from his position by the papacy. Upon his return to Italy, Gerbert, with the support of Otto and the approval of Pope Gregory V, became Archbishop of Ravenna when the post of Archbishop of Ravenna became vacant. After the death of Pope Gregory V, Gerbert assumed the name Sylvester (Sylvester II) in 999 and remained in the papal office, with imperial support, until he died in 1003.[26]

3. The Network of Gerbert's Book Supply: A Social Network Analysis Application

Social network analysis (SNA) offers a powerful toolkit for historians studying the intricate web of relationships in the medieval world. A major advantage of SNA is its flexibility. Nodes and edges, the building blocks of a network, can be defined in different ways and at different scales. This adaptability allows historians to study a wide range of social interactions, from scientific exchanges to political alliances. In addition to its flexibility, SNA excels at revealing the extensive networks that transcend geographic and social boundaries. By analyzing these connections, historians gain insight into the flow of information in medieval society and how interpersonal relationships fueled religious movements or political events. In addition, SNA helps identify hidden patterns within historical societies. By analyzing configurations of relationships and their evolution over time, SNA can uncover structures and dynamics that might remain invisible through traditional approaches.[27] The applications of SNA to medieval history are numerous. Scholars have used SNA to analyze the networks of intellectuals during the Carolingian Renaissance. Similarly, studies have explored the intricate political, economic, and personal relationships within the powerful Medici family.[28] Perhaps the most ambitious application involved French mathematicians who constructed a detailed social network based on 13th-century notarial contracts, offering a glimpse into the social fabric of a particular region.[29]

Social network analysis (SNA) applications are widely used today, with desktop tools such as Gephi and NodeXL being prominent choices. However, web-based versions offer improved accessibility. Flourish, a web-based platform, facilitates data visualization and storytelling by transforming complex data sets into interactive graphs, maps, and tools. Network diagrams are powerful tools for representing connections or relationships between objects. In these graphs, objects are represented as points or 'nodes' and connections are represented as links. They are particularly useful for visualizing social networks, corporate structures, or any other network of relationships.

Figure 3 shows a Flourish-created sociogram of Papa Gerbert's intellectual network. The color-coding system distinguishes between high-ranking individuals (red, bishops) and low-ranking individuals (lavender, monks). Papa Gerbert is placed at the center, connected to a network of scholars

[24] Allen, 'Gerbert', 635.
[25] DeMayo, 'The Students', 112.
[26] Mann, *Lives of Popes In the Early Middle Ages*, 5:50–64.
[27] K Patrick Fazioli, 'Modeling the Middle Ages: A Review of Historical Network Research on Medieval Europe and the Mediterranean World', in *Social and Intellectual Networking in the Early Middle Ages*, ed. Michael J Kelly (Punctum Books, 2023), 37–68, http://www.jstor.org/stable/jj.3452822.5.
[28] John F Padgett and Christopher K Ansell, 'Robust Action and the Rise of the Medici, 1400-1434', *American Journal of Sociology* 98, no. 6 (21 April 1993): 1259–1319, http://www.jstor.org/stable/2781822.
[29] Fazioli, 'Modeling the Middle Ages: A Review of Historical Network Research on Medieval Europe and the Mediterranean World', 38.

and institutions. It is noteworthy that the network includes both high-ranking figures and lower-ranking monks, underscoring the diversity of Gerbert's intellectual circle. Several notable observations emerge from the visualization. First, the centrality of the network around Reims indicates the city's central role in Gerbert's intellectual activities, probably due to his teaching position at the cathedral school. Second, the presence of blue nodes indicates Gerbert's interactions with high-ranking church officials, which facilitated access to knowledge and resources. Finally, the inclusion of yellow nodes highlights the importance of monasteries as centers of learning and Gerbert's connections within them.

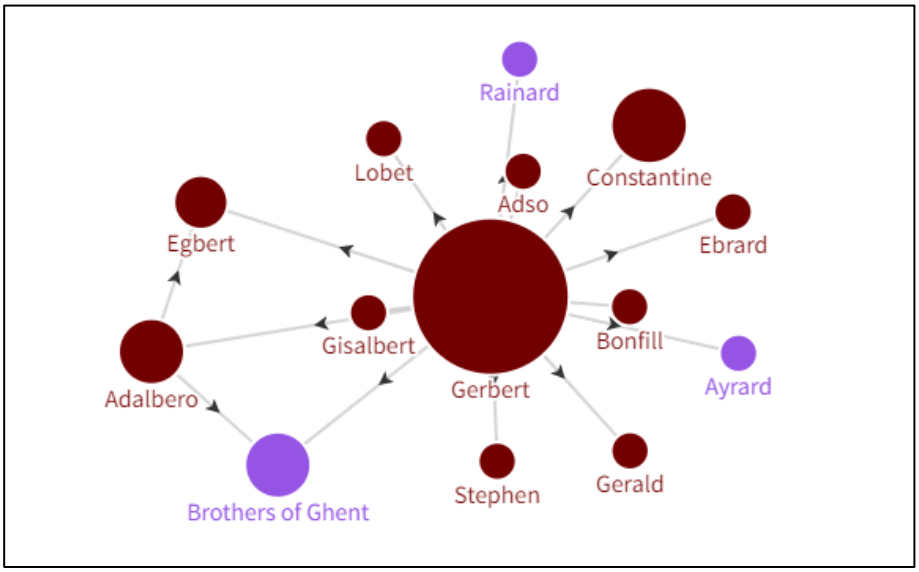


Figure 3: The Flourish sociogram with Gerbert's letter request book[30]

Although the SNA graph offers an initial visual representation of connections, a more detailed analysis is necessary to gain a comprehensive understanding of the nature and frequency of these interactions. As is the case with numerous graphs employed in the field of historical network analysis, this one offers only a partial view, constrained by the number of characters subjected to analysis. In order to gain a deeper understanding of these connections, whether through traditional methods or the use of digital tools, it is important to recognize the inherent limitations of the data. For example, while the graph suggests that figures such as Constantine and Adalbero may play a pivotal role within Gerbert's network, it does not provide comprehensive insight into the nature and depth of their relationships with him. In the context of historical research, sociograms are not intended to be definitive representations; rather, they are tools that facilitate the expansion and clarification of our understanding of the past. Unlike technical fields where graphs can provide conclusive results, in historical contexts they are best used to support and enrich existing narratives, revealing patterns that require further investigation and interpretation. Therefore, while the SNA graph provides essential clues, only by examining the content of Gerbert's correspondence can we achieve a deeper understanding of his scholarly pursuits.

Gerbert's letters offer valuable insight into his scholarly pursuits, particularly his endeavors to obtain and disseminate knowledge through a network of intellectual exchanges. In his letters from 978 to 980, Gerbert engaged in a correspondence with Constantine of Fleury, elucidating mathematical concepts from Boethius's *De Musica* and *De Arithmetica*.[31] This illustrates Gerbert's profound engagement with classical texts and his aspiration to disseminate intricate concepts to a broader audience. His efforts to elucidate Boethius's work demonstrate not only his comprehension of ancient mathematical concepts but also his role in the preservation and dissemination of these ideas. Gerbert's intellectual pursuits extended beyond mathematics, as evidenced by his 982 or 983 letter to Ayrard in Reims, wherein he requested that his student correct Pliny the Elder's *Natural History*.[32] This request

[30] 'Intellectual Network of Gerbert', Flourish, 2024, https://public.flourish.studio/visualisation/17757404/.
[31] Pope Sylvester II, The Letters of Gerbert with His Papal Privileges as Sylvester II, ed. & trans. Harriet Pratt Lattin, Records of civilization (New York: Columbia University Press, 1961), 39-43.
[32] Pope Sylvester II, *Letters*, 53.

illustrates Gerbert's emphasis on the accuracy of classical works, reflecting his dedication to both the integrity of the texts and the significance of natural history in his studies. Gerbert fostered a collaborative academic environment by involving his students in these efforts.

In a letter dated June 22, 983, Gerbert informed Archbishop Adalbero of Reims about his discovery of Boethius's *De Astrologia (De Astronomia).* and forwarded a letter from Abbot Adso requesting a copy of *Commentarii de Bello Gallico*. This illustrates Gerbert's function as an intermediary of intellectual resources, linking scholars and facilitating the exchange of valuable works. His request for supplementary materials, such as Demosthenes's *Ophthalmicus* and Cicero's *Pro rege Deiotaro (Defense of King Deiotaros)*, highlights his extensive scholarly interests, which encompassed astronomy, medical knowledge, and rhetoric.[33] Gerbert's pursuit of knowledge is further exemplified in his 984 correspondence with Abbot Gerald of Aurillac and Bishop Miro of Girona (Bonfill).[34] In these letters, he requested a copy of Joseph of Spain's *De multiplicatione et divisione numerorum*, which had been translated from Arabic into Latin.[35] This illustrates Gerbert's awareness of and engagement with knowledge from other cultures, particularly the rich intellectual tradition of the Arab world. Furthermore, his interest in this work reflects the growing influence of Arabic scholarship in Europe during this period.

Gerbert's intention to amass a substantial collection of books is made evident in his letter to Ebrard, Abbot of Tours, written in early 985. He also indicated that he had acquired books from France, Germany, and Italy and expressed his intention to have them copied. This letter not only demonstrates Gerbert's personal commitment to expanding his library but also his recognition of the importance of making these texts more widely available. His endeavors to transcribe manuscripts from St. Julien and St. Martin's in Tours serve to illustrate his commitment to the preservation and dissemination of knowledge.[36] In March 986, Gerbert persisted in his endeavors by requesting copies of books from Stephen of Reims and extending an invitation to Abbot Adso to bring additional volumes to Reims.[37] These letters illustrate Gerbert's sustained emphasis on augmenting his intellectual resources and his scholarly network. His 986 letter to the monks of Ghent demanding the return of Claudian's books and copied works underscores his reliance on these networks for the acquisition and distribution of scholarly texts.[38]

Gerbert's disquiet at the failure of the monks of St. Peter's Monastery in Ghent to honor their commitments is evident in his letter of August 15, 987. In this missive, he reprimanded them for their failure to provide the books they had promised.[39] This letter demonstrates the difficulties Gerbert encountered in his pursuit of knowledge, as he relied on the assistance of others to gain access to significant texts. His persistence in pursuing these requests demonstrates his determination to overcome obstacles in his scholarly pursuits.

Ultimately, in his 987 letter on behalf of Archbishop Adalbero, Gerbert petitioned Egbert to furnish a sacred text in addition to the previously requested volumes.[40] This further illustrates Gerbert's role as an intermediary in scholarly exchanges, acting on behalf of others to obtain significant texts. In a letter written in 988, addressed to the monks of Reims, Gerbert requests that they copy works such as Boethius's *De Astrologia, Victorius's De Rhetorica, and Domesthenes's Ophthalmics*.[41] This demonstrates his continued efforts to expand his intellectual library and support scholarly activities. Through these letters, it is evident that Gerbert was committed to the acquisition, preservation, and dissemination of knowledge. He sought to connect scholars and promote the circulation of ideas across Europe.

[33] Pope Sylvester II, *Letters*, 54–55.
[34] Pope Sylvester II, *Letters*, 69–70.
[35] Pope Sylvester II, *Letters*, 63.
[36] Pope Sylvester II, *Letters*, 90–91.
[37] Pope Sylvester II, *Letters*, 117–25.
[38] Pope Sylvester II, *Letters*, 133.
[39] Pope Sylvester II, *Letters*, 145.
[40] Pope Sylvester II, *Letters*, 151.
[41] Pope Sylvester II, *Letters*, 168.

An examination of Gerbert's letters reveals a strategic selection of individuals from whom he requested books. Since monasteries were the primary centers of book production at the time, Gerbert directed his requests to familiar clerics and students associated with these institutions. This focus on those with access to scholarly resources is not surprising. Moreover, the subject matter of his requests - mathematics, astronomy, medicine, and history - all have practical applications. This reflects Gerbert's intellectual curiosity and thirst for knowledge applicable to the real world.

CONCLUSION

The application of artificial intelligence (AI) to historical research has added a new dimension to the analysis of complex data, particularly in the visualization of intellectual networks such as that of Gerbert of Aurillac. While digital tools have been used in historical research for some time, AI language models greatly expand their utility and offer unprecedented insights into historical relationships. However, the power of AI must be balanced with a careful assessment of its limitations. AI models, shaped by the biases in their training datasets, may fail to capture the linguistic subtleties and cultural context embedded in historical texts. In Gerbert's letters, for example, AI tools may emphasize superficial elements-such as formal greetings or standardized expressions-while overlooking deeper historical meanings. To address this issue, future research should prioritize the development of AI tools that are capable of working directly with original Latin texts, thereby ensuring the preservation of the rich historical context.

AI-generated visualizations should therefore be considered complementary tools rather than stand-alone methods for drawing historical conclusions. Integrating AI with traditional approaches such as social network analysis (SNA) creates a more balanced methodology. In this study, tools such as Voyant, Map-This, and Flourish were instrumental in uncovering new patterns in Gerbert's intellectual network. Each tool provided unique insights, but their results must be interpreted within the framework of established historical scholarship. SNA, in particular, proved invaluable in mapping the flow of information and relationships within Gerbert's intellectual and political circles, offering a more structured view of the connections that shaped his career. The real power of these visualizations, however, comes when they are paired with a deep understanding of the historical narratives they represent.

Gerbert's rise to prominence, culminating in his papacy as Sylvester II, was deeply influenced by the networks he established in political, religious, and intellectual spheres. His early education, particularly under the tutelage of Raymond at Gerold's Monastery, laid the foundation for his later intellectual pursuits. His time in Spain during the Andalusian Umayyad era further enriched his academic development, exposing him to advanced knowledge of mathematics and astronomy that broadened his intellectual horizons far beyond the theological focus of many of his contemporaries. Gerbert's intellectual network, which included key figures such as Emperor Otto III and King Hugh Capet, gave him access to valuable resources and political power, facilitating his rise from Reims to the papacy. The diversity of his network-including scholars, religious authorities, and political leaders-underscores the breadth of his influence.

While this study illustrates the value of AI and SNA in visualizing such intricate networks, it also acknowledges the inherent limitations of these methods. The lack of original Latin text analysis limits the depth of interpretation, and AI's tendency to overemphasize formulaic language can skew results. In addition, AI models trained on contemporary datasets may not fully capture the historical and cultural nuances necessary for rigorous historical analysis. Going forward, it is critical for researchers to critically evaluate AI-generated results and consistently cross-reference them with primary historical sources to ensure accuracy and depth.

In conclusion, this study highlights both the potential and the challenges of using digital tools in historical research. The visualization of Gerbert of Aurillac's intellectual network, aided by AI and SNA, provides new insights into his relationships and the intellectual landscape of 10th-century Europe. However, these tools are most effective when used in conjunction with traditional methods of historical inquiry. A balanced approach—combining the precision of digital tools with the contextual sensitivity of historical scholarship—can lead to a more nuanced understanding of the past. Future research should

integrate original text analysis more comprehensively and refine the methodological framework to ensure both accuracy and depth in historical interpretations.

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