Spread of the Renaissance through Publication Networks

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Introduction

Networks are a complex system of *vertices*, that we commonly refer to as *nodes*, as well as *edges* that connect them. They can be both *directed* and *undirected*, with the former referring to networks where the edges include directions of flow between nodes, and the latter simply connecting related nodes without flow. Popular examples of directed networks include food webs, delivery routes, paper citations, and disease spreading. Examples of undirected networks, on the other hand, include the World Wide Web, social networks, and climate maps.

The Renaissance was a cultural and intellectual movement that took place on the continent between the 14th and 17th centuries. It bridged the Middle Ages to the Age of Enlightenment and was marked by the development of Humanism, the rediscovery of classical Greek philosophy, as well as a critical evaluation of the role of religion in society. Many Renaissance ideas were spread through literature and direct correspondence between scholars, relying on trade networks and routes for communication. The Renaissance fundamentally shaped the way Europeans viewed and understood themselves within the context of the arts and sciences.

In our research, we decided to apply network models to the spread of the Renaissance in 15th century Europe, particularly between 1450 and 1500. In particular, we decided to examine this spread through the lens of book publications, tracking the exchange of ideas between European cities by identifying shared books and comparing their dates of publication to extrapolate directionality. We then examined SIR disease models using our system of city-nodes to compare our real-life data to that predicted by established models of idea spreading.

Network Development

To develop our model, we relied primarily on library catalogues.(1)(2) We organized the data in Excel according to Latitude, Longitude, Country, City, Book Title, Author, and Publication Year. Each unique book was assigned a corresponding "Book Reference" number and "Humanist" or "Religious" tag, when applicable, to ease sorting and data analysis. We had 83 unique city-nodes and 751 catalogued books, resulting in 172 edges.

This data was then loaded onto MATLAB and organized into corresponding tables and arrays. Book spreading was captured through weighted adjacency matrices for both directed and undirected networks. Entry α_{ij} represented the number of books sent from city i to city j in the directed adjacency matrix while entry α_{ij} in the undirected matrix represented a shared book printed in both city i and city j. Using this structure we constructed directed adjacency matrices for every decade between 1450 and 1500, as well as adjacency matrices for the directed networks of Humanist and Religious idea spread. These matrices were plotted visually using the *digraph* and *plot* functions, establishing *graphplot* objects for later manipulation. All plots relied on geographic latitude and longitude data for visualization.

Sources:

(1) Butler, Pierce. *The Newberry Library - Checklist of Books Printed during the Fifteenth Century.*, The Newberry Library, 1924.

(2) Maggs, B. D., and E. U. Maggs. *Books from Famous Presses - Fifteenth to Twentieth Century*. 1st ed., vol. 561, Courier Press, 1938.

Network Figures

Observed Publication Data:

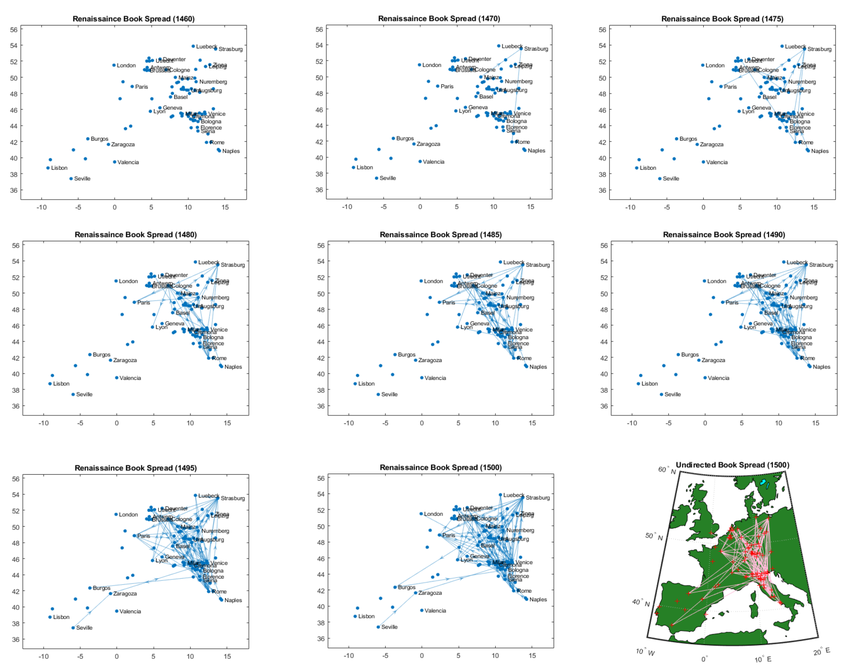

Figure 1. Growth of the Publication Directed Network over Time (1450 - 1500 C.E.)

Observed Religious v. Humanism Spread:

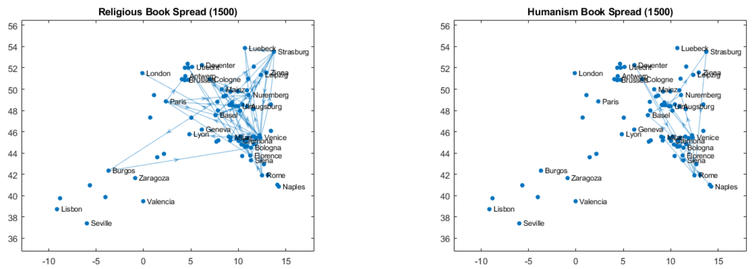

Figure 2. Directed Networks Segregated by Idea Tag (1500 C.E.)

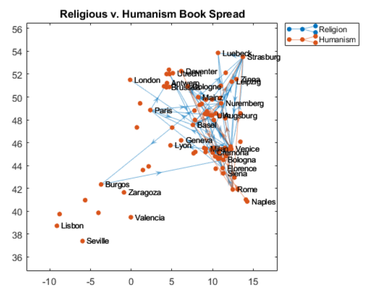

Figure 3. Combined Data (1500 C.E.)

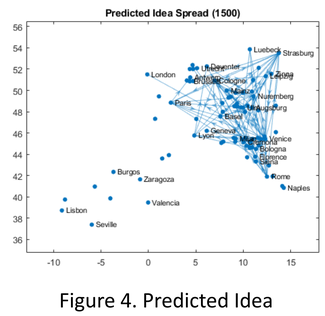

Figure 4. Predicted Idea Spread (1500 C.E.)

SI Model

SI Model Equations:

$$\frac{dI}{dt} = I\langle k\rangle p \qquad \frac{dS}{dt} = -I\langle k\rangle p$$

Coefficients Explained:

$$\langle k\rangle = \frac{\#\ of\ edges}{\#\ of\ source\ nodes} \qquad p = \frac{log_k(\#\ of\ edges)}{51\ years}$$

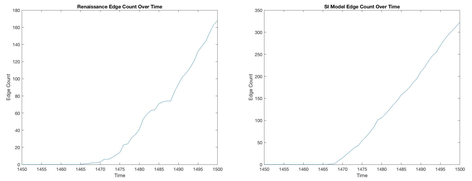

Figure 5. Edge Count over Time

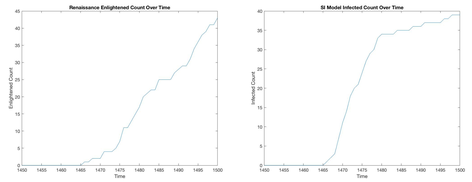

Figure 6. Infection/Enlightened Count over Time

Results and Discussion

Our analysis of the Renaissance publication network indicates that the spread of ideas was rapid and far-reaching during this important historical period. Specifically, by examining Figure 1, one can see that idea creation in the Renaissance was concentrated in the region of Italy and Germany. From this central region, ideas spread outward through Europe, creating an increasingly diffuse and inter-connected information network over time. In this way, our analysis supports the scholarly belief that Florence was the birthplace of the Renaissance.

Additionally, our analysis suggests that Religious ideas remained ubiquitous and salient during the Renaissance, even as innovative Humanist ideas began to catch on. As seen in Figure 2, the publication of Religious books formed a more diffuse network than that of Humanist texts. This was primarily due to the widespread publication of certain core Religious texts, which made the network robust. Specifically, nine Religious texts were published in over four cities, while only one Humanist text was so widely printed.

Lastly, our analysis indicates that the spread of ideas during the Renaissance was highly efficient, and closely mirrored the dynamics that would be predicted by a theoretic SI epidemic model. Furthermore, the publication network proved to be impressively diffuse, with a greater number of peripheral nodes reached than would be predicted by the SI model. This can be explained by the unbounded and dynamic nature of real world idea spread, which cannot be captured by the spread of a disease on a fixed network of relations. This also explains why the SI model exhibits threshold dynamics which are not present in the real world data.