An Integrated Method to Build Read-Aiding E-Books Based on Text Mining and Interactive Aesthetics

Weijun Li, Fukai Yang, Ruibing Jia, Renmin Li, Minghao Yin

Northeast Normal University

Changchun, Jilin, China

{liwj531,yangfk959,jiarb066,lirm554,ymh}@nenu.edu.cn

ABSTRACT

Although text mining is helpful in extracting complicated character and/or place relationships of text, how it could be utilized to enhance the reading experience has not been well studied. We propose a four-stage method to build read-aiding e-books directly from text, integrating the technologies in text mining and the ideas in interactive aesthetics. By applying this method, we manage to identify and present multiple complex relationships in the classical Chinese novel *Romance of the Three Kingdoms*, providing readers with vivid scenes and rich interactions for better comprehension.

CCS CONCEPTS

• **Human-centered computing** → **Information visualization**;
• **Computing methodologies** → *Information extraction.*

KEYWORDS

interactive e-book, text mining, information visualization

1 INTRODUCTION

In the past decades, great success has been witnessed in the application of text mining. However, previous works mainly concentrate on the technological aspects, such as improving scalability or performance, lacking attention on its potential usage of enhancing the reading experience and effects. For example, complex plots and obscure language in books are usually unfriendly for readers, and text mining techniques such as extracting keywords and relationships are helpful in solving this problem.

On the other hand, many researchers have focused on designing e-books with interactions, such as the story book built by Aliagas et al. [1], but universal methods for conversion from text to interactive e-books are not well researched. Ping et al. proposed LitStoryTeller+ [5] for visual storytelling of scientific papers by text mining. Yet it does not accommodate to general readers

and pays insufficient attention to the importance of interactive aesthetics.

In order to reduce the cognitive load of the readers and build an immersive interactive environment that helps readers understand the contexts of the text, we propose a universal method for building interactive e-books based on text mining technologies and interactive aesthetics. It is helpful for diving into the literary content and displaying it in a visual and interactive way.

2 THE DESIGN METHOD

We have developed a coherent and general framework to transform the text in the book to an fully interactive e-book, which contains four stages as shown in figure 1.
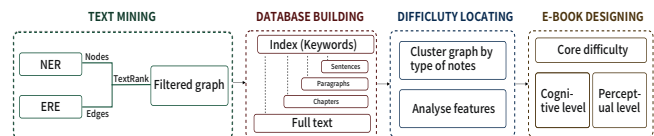

Figure 1: Four stages of our proposed method.

Text mining. In general, reading difficulties may result from multiple factors, such as numerous character occurrences, fast spatial & temporal changes, or complicated relationships between them. In order to extract these information, we utilize the techniques of named entity recognition and entity relationship extraction, to build a graph of items (as nodes) and their relationships (as edges). To avoid overwhelming the reader with potentially excessive amount of items, we apply the *TextRank* algorithm [3] to assign each extracted item a weight w_i and filter them with a empirical threshold w_s to keep only the keywords in the graph.

Database building. For the convenience of finding all corresponding text associated with each keyword, we need to build a database from the original text. It preserves all hierarchical information like chapters, sections and paragraphs, and uses the set of keywords to construct inverted indices. Using this database we could perform queries on any level (such as find all sentences or chapters containing certain keyword) quickly.

Difficulty locating. After extracting keywords, we need to find out the core difficulty in a specific text. Note that each node (or extracted item) in the graph has an attribute indicating their type, such as name of characters, places, or time of events. Thus we could cluster the graph by these types and analyze their features to grab such features semi-automatically. For example, a large aggregation of place names might indicate a frequent spatial switching in the text, while dense connections between characters demonstrate puzzling relationships.
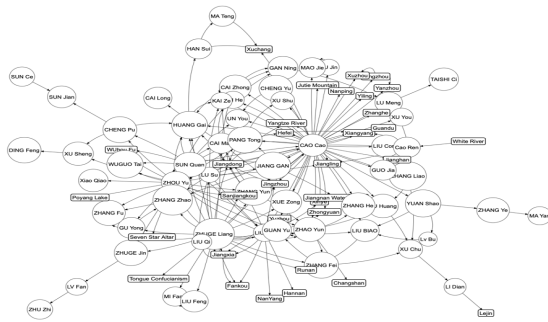
Figure 2: Extracted items and relationships (in English). Nodes with circle / square borders are characters / places.

Figure 3: User interface of the e-book for *Battle of Red Cliff*.

E-book designing. The designing of e-books follows the principles of interactive aesthetics and should consider both cognitive and perceptual levels. Interfaces for multi-sensory interactions is provided at the perceptual level, while immersive interactive scenarios need to be constructed at the cognitive level. Note that designing should be based on the core difficulty previously identified, such as presenting a 3D map for distinguishing different places, a family genealogy for sorting out character relationships, etc.

3 IMPLEMENTATION

We implement the above four stages mainly with Python.

`Jieba` is used to segment the text with sentences as basic units, where the *Chinese Dictionary of Ancient and Modern Place Names* is used as user dictionary to improve the accuracy. Then we use the `LTP` toolkit [2] to perform POS (part-of-speech) tagging,named entity recognition and relation extraction on the segmented text, generating binary pairs of items with relational information that are used to build the graph.

We implement the *TextRank* algorithm to calculate the weight of items and filter them to obtain a sub-graph of keywords. We set damping coefficient to 0.85, convergence threshold to 10^{-5}, and window size to 3. These keywords are later used as indices in a `MySQL` database storing the full text.

For difficulty locating, we use a heuristic method: project the graph to Euclid space by `word2vec` [4] and plot it using different colors for different types of nodes. By observing the graphical features we could easily identify the representation of difficulties, such as clustering items and dense connections.

In terms of e-book designing, we use `Unity3D` to present the visualized scene and provide user interactions, with `3ds Max` to build delicate 3d models used in the e-book.

4 CASE STUDY

Romance of the Three Kingdoms is one of the most outstanding historical novels in China, of which wars are the most important component. They are typically complex and systematic, involving many names of people, official posts and places, thus hard to understand. *The Battle of Red Cliff* is one of the most famous battles in the novel, which we choose to apply our method to.

Figure 2 is the preliminary visualization after going through first three stages, showing that our work could extract the relationship between the characters and the places well. It finds not only the key characters that affect the plot development, but also important details that are likely to be neglected. For instance, CAO Cao is one of the most important characters in *The Battle of the Red Cliff*, and Jingzhou is a key location. CAI Mao, ZHANG Yun and Cao have close relationships, while the implicit connection between KAN Ze and GAN Ning promotes the development of the story.

An interactive e-book are then constructed based on the two easily-located reading difficulties — place & character relationships in the battle. We position the places on a topographic map of eastern China, then transform it to a height map with `Substance Designer`, which is later imported into `Unity` to generate the terrain. Next, we create a network of character nodes and correspond them with places. In this way, the relationships between all characters and places are shown clearly on a 3D sand table.

Figure 3 demonstrates the user interface of the book. We set a starting point for reading and generate reading paths based on the original text. Users can click on the nodes to view the original text. The links between one node and its related places and characters are highlighted upon clicking. By referring to the prompted reading paths, users can easily decide what to read next.

ACKNOWLEDGMENTS

REFERENCES

[1] Cristina Aliagas and Ana María Margallo. 2017. Children's responses to the interactivity of storybook apps in family shared reading events involving the iPad. *Literacy* 51, 1 (2017), 44–52. https://doi.org/10.1111/lit.12089 arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/lit.12089
[2] Wanxiang Che, Zhenghua Li, and Ting Liu. 2010. LTP: A Chinese Language Technology Platform. In *Proceedings of the 23rd International Conference on Computational Linguistics* (Beijing, China) *(COLING '10)*. Association for Computational Linguistics, USA, 13–16.
[3] Rada Mihalcea and Paul Tarau. 2004. TextRank: Bringing Order into Text. In *Proceedings of the 2004 Conference on Empirical Methods in Natural Language Processing*. Association for Computational Linguistics, Barcelona, Spain, 404–411.
[4] Tomas Mikolov, Ilya Sutskever, Kai Chen, Greg Corrado, and Jeffrey Dean. 2013. Distributed Representations of Words and Phrases and Their Compositionality. In *Proceedings of the 26th International Conference on Neural Information Processing Systems* (Lake Tahoe, Nevada) *(NIPS'13)*. Curran Associates Inc., Red Hook, NY, USA, 3111–3119.
[5] Qing Ping and Chaomei Chen. 2018. LitStoryTeller+: An Interactive System for Multi-Level Scientific Paper Visual Storytelling with a Supportive Text Mining Toolbox. *Scientometrics* (06 2018). https://doi.org/10.1007/s11192-018-2803-x