Visualizing semantic space of online discourse: The Knowledge Forum case

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ABSTRACT

This poster presents an early experimentation of applying topic modeling and visualization techniques to analyze online discourse. In particular, Latent Dirichlet Allocation was used to convert discourse into a high-dimensional semantic space. To explore meaningful visualizations of the space, Locally Linear Embedding was performed reducing it to two-dimensional. Further, Time Series Analysis was applied to track evolution of topics in the space. This work will lead to new analytic tools for collaborative learning.

Categories and Subject Descriptors

1.2.7 [Natural Language Processing]: Text analysis; K.3.1 [Computer Uses in Education]: Collaborative learning

General Terms

Algorithms, Experimentation, Measurement

Keywords

Discourse Analysis, Text Mining, Semantic Analysis, LDA, Knowledge Building, Collaborative Learning

1. INTRODUCTION

Online discussion platforms have been widely applied to support collaborative learning from K-12 to tertiary education. As the usage has grown, so has the need for effective tools to interpret and facilitate online discussion. In this area has emerged a rich body of leaning analytics research that turns online discourse data into insights about collaborative learning. A variety of tools have since been developed to tackle important aspects of online discourse, ranging from social interactions to temporal patterns [1, 3]. Among these studies, analysis of textual information has been a constant focus, as written language dominates communication in most online dialogues. Text mining—the process of extracting interesting patterns from text documents [9]—has been identified as one of the most widely applied techniques in educational data mining [5]. Combined with visualization techniques, patterns revealed by text mining could be used to re-present online discussion in meaningful ways to promote collaboration and reflection [4].

Research of Knowledge Building (KB), a social constructivist pedagogy engaging learners to collectively advance knowledge through communal discourse [8], has maintained a long-standing interest in analyzing online discussion. Knowledge Forum [7], the most widely used KB environment, is implemented with a suite of assessment tools to interpret and facilitate KB discourse [10]. Because of KB’s emphasis on communal discourse, the evolution of public community knowledge has been a key concern of KB analytics. The major analytic questions in this area include: What is the state of community knowledge? Is the discourse effective in advancing knowledge? Where is the community discourse heading? The present study represents a recent experimentation to analytically tackle these questions. Applying topic modeling and visualization techniques, it attempts to explore meaningful ways to represent online discourse to promote reflection and “metadiscourse.” Results will contribute to an ongoing Knowledge Forum rebuild with new means of representing knowledge to facilitate idea improvement.

2. SUMMARY OF PRELIMINARY RESULTS

Building on prior work, the present study aims to apply text mining and visualization techniques to achieve the following goals: (1) to model semantic space of KB discourse focusing on its emergent topics or discussion themes, (2) to visualize interpreted semantic space and inspect roles of different variables (e.g., time, students, and views) in KB discourse, and (3) to track student participation in different discussion themes over time.

To achieve these goals, I experimented with a range of techniques using a well-documented Knowledge Forum dataset. This dataset was produced by a Grade 4 class when they were studying a science unit “Light.” This dataset contains 308 notes from six views,1 with names such as “How Light Travels,” “Colours of Light,” and “Shadows.”

To achieve the first goal of modeling semantic space, Latent Dirichlet Allocation (LDA), a probabilistic topic-modeling technique [2], was applied on this dataset. A list of topics were identified, turning discourse into a high-dimensional semantic space represented by topics. For each topic, its

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1In Knowledge Forum, students post ideas to their community in the form of notes, which can be conceptually organized in a view to serve idea improvement.
probabilistic associations with terms are computed, making it possible for interpretation. For example, one topic was mostly associated with word stems—“mirror,” “look,” “angl,” and “bounc”—and so was clearly about “reflection.” At the same time, each note’s probabilistic memberships of topics were also calculated, so popularity of a topic could be approximated by the count of associated notes.

To visually represent topic modeling results, I further reduce the modeled high-dimensional space into two dimensions. Locally Linear Embedding, which is thought to be superior to multidimensional scaling [6], was applied to achieve this goal. Notes could then be visualized by different variables, such as topics, views, timestamps, and students, to explore usefulness of different visualizations. For instance, Figure 1 maps notes by topics and views. Given further assistance with interpretation, users could use this visualization to identify interested topics in each view and connect semantically related but physically isolated ideas across views.

Finally, I applied time series analysis to trace development of topics. By tracking participation in each topic across time, knowledge development of different topics becomes visible. Figure 2 presents the results of the top five topics. According to this figure, different topics had their “rises and falls.” For example, the beginning of the discourse mostly focused on “how light travels,” while “refraction” and “reflection” dominated the end. “Sources of light” and “light and materials” were discussed throughout the unit, while the other three topics had their own “golden times.”

In summary, the present study seeks to advance current learning analytics of online discourse by providing new means of interpreting and visualizing knowledge. It will inform development of new Knowledge Forum analytic tools emphasizing development of community knowledge. Broadly, it contributes to the important area of group-level, discourse-centric analytics focusing on the social aspect of learning.

3. REFERENCES