# **ENAMUL HOQUE PRINCE** | Research Statement

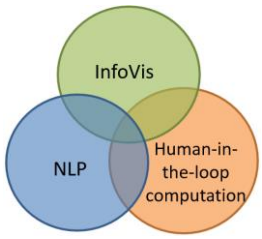
The inception of the World Wide Web, followed by the rise of social media, and the recent emergence of big data have led to rapidly growing information spaces. This phenomenon can be considered as a double-edged sword: while the abundance of data opens up a great opportunity for important discoveries, the information overload problem poses critical challenges, for both understanding and presentation.

I explore and address the information overload problem using an interdisciplinary lens, combining information visualization (InfoVis) and human-computer interaction (HCI) with natural language processing (NLP). Through this lens, I have examined a variety of real world problems that arise due to the complex nature of both structured and unstructured data. In particular, I have developed novel intelligent interfaces by combining visualization and text analytic techniques to support users in analyzing and exploring large datasets.

## VISUAL TEXT ANALYTICS FOR ONLINE CONVERSATIONS

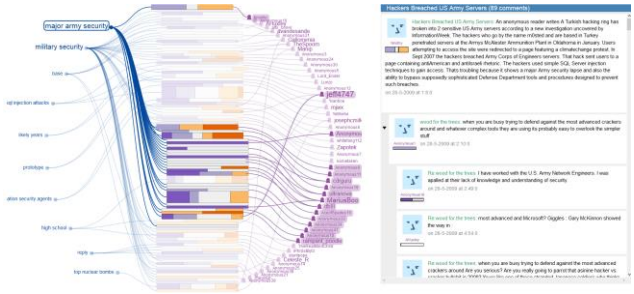
With the proliferation of web-based social media, there has been an exponential growth of asynchronous online conversations. Asynchronous conversations, such as blogs, may start with a news article or editorial opinion, and later generate long thread with hundreds of comments that readers may become interested in exploring and analyzing to seek a variety of information and opinions. Such large amount of conversational data often leads to an information overload problem, where the user finds it very difficult to get insights about the ongoing (or past) discussions. To address this problem, most of the previous works have focused on either introducing advanced text analysis methods or developing new information visualization techniques, however only little efforts have been made to tightly integrate them together.

My dissertation has focused on how to support the user in exploring a large set of online conversations by tightly integrating text analysis and interactive visualization techniques. For this purpose, I developed the following approach: First, I apply an InfoVis design study methodology to uncover data and task abstractions. Second, I apply NLP methods for extracting and summarizing the identified data to support the corresponding tasks. Third, I incorporate human feedback in the text analysis process when the extracted data is noisy or may not match the user's mental model and current tasks. In essence, my research aims to identify and leverage critical synergies at the intersection between three main research areas (as shown in the right).




*My PhD research falls into the cross section between three main research areas.*

In order to evaluate the effectiveness of my approaches, I explored a two-dimensional design space: the scale of conversations (a single conversation vs. a set of conversations) and the topic modeling choice (static model vs. human-in-the-loop model). To explore and validate this framework, I developed and evaluated a set of systems as described below.

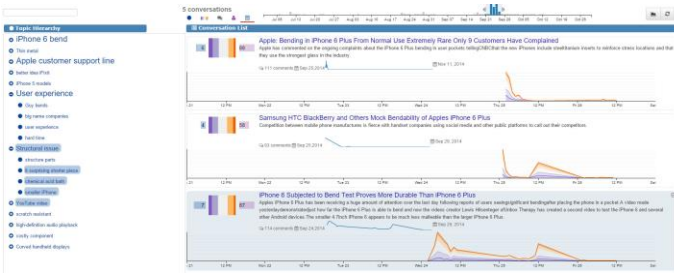



*ConVis [8] consists of an overview+details interface. In the left, a high level overview of what was discussed by whom (i.e., topics and authors) and a visual summary of the whole conversation is shown. The actual conversation is presented in the right.*

**Designing visual text analytic systems:** In my initial work, I proposed a visual text analytic system that supports users in exploring a single conversation [8]. Following the design study methodology in InfoVis, I started with a user requirement analysis for the domain of blog conversations to derive a set of design principles. Based on these principles, I designed an *overview+detail* interface, named ConVis [8] that provides a visual overview of a conversation by presenting topics, authors and the thread structure of a conversation. The underlying topic modeling approach was specifically designed for asynchronous conversations that takes into account the unique

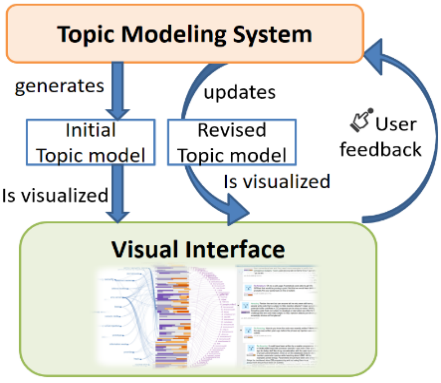
features of conversations (e.g., reply relationships and use of quotation). By using this approach, I group the sentences of a conversation into a number of topical clusters using a graph-based clustering technique and label each cluster by generating semantically meaningful descriptor. The visual interface provides various interaction techniques such as highlighting based on multiple facets (e.g., topics and authors) to support the user in exploring and navigating the conversation.

In subsequent work, I focused on supporting readers in exploring a collection of conversations related to a given query (e.g., 'ObamaCare', 'iPhone bending problem') [3]. Exploring topics of interest that are potentially discussed over multiple conversations is a challenging problem, as the volume and complexity of the data increases. To address this challenge, I devised a novel hierarchical topic modeling technique that organizes the topics within a set of conversations into multiple levels, based on their semantic similarity. Similarly to what was done for extracting topics from single conversations, the hierarchical topic modeling technique for a collection also takes advantage of conversational features to enhance the quality of the topic model. For this purpose, I extended the topic modeling approach for single conversation to generate a topic hierarchy from multiple conversations by considering the specific features of conversations. I then designed a visual interface, named MultiConVis that presents the topic hierarchy along with other conversational data. The resulting interface supports the user exploration, starting from a possibly large set of conversations, then narrowing down to the subset of conversations, and eventually drilling-down to the set of comments of one conversation, which is visualized with the ConVis interface. A series of user studies illustrate the potential benefits of our approaches, when compared to a traditional blog interface for exploring conversations.



*The MultiConVis interface [3], showing a subset of conversations. Here, the user hovered on a conversation item (highlighted row in the right). As a consequence, the related topics from the Topic Hierarchy were highlighted (left).*

**Introducing human-in-the-loop computation:** A preliminary evaluation of *ConVis* suggested that while generally the participants were positive about the interface, the results of the topic model were sometimes noisy and did not match their current information needs. This was particularly evident from the interviews and observational data, where users expressed a pressing need for enhancing their ability to revise the topic model according to their own information needs. Motivated by this experience, I proposed a novel interactive topic modeling approach that revises the topics on the fly on the basis of users' feedback [5]. I then designed a visual interface, named ConVisIT, by extending *ConVis*, where the user can explore long conversations, as well as revise the topic model when the current results are not adequate to fulfill her information needs. By analyzing the tasks in our target domain, I devised a set of topic revision operations that are critical to the user. For instance, the user can perform a merge operation on two topics if these topics are talking about similar things. In other cases, if a topic is too generic the user can split this into further smaller sub-topics. The system subsequently updates the topic model by either creating new topics (clusters of sentences) and/or generating new labels for those. By revising topics, the user can build a topic model that better matches her mental model and current information needs. A lab-based user study showed that the new interface outperformed both a traditional blog interface (similar to Slashdot) as well as the original *ConVis* along several subjective metrics.




*Interactive topic modeling framework for exploring online conversation [5].*

**Impact and applications:** Since our visual text analytics systems have been made publicly available, they have been tailored and adopted in a variety of conversational domains, both in our work as well as in others' research work. For example, we conducted a design study in the domain of community question answering (CQA) forums, where our *MultiConVis* system was simplified and tailored to support information seeking tasks for a user population possibly having low visualization expertise [4]. This system was recently evaluated in an online user study by deploying it on the web, where it was used by hundreds of real users. In addition to our work, several other researchers have applied or partially adopted the visual encoding of MultiConVis and ConVis in a variety of conversational genres, such as news comments [9] and online health forum [10].

## RESEARCH AGENDA

I will continue to research integrating NLP and InfoVis techniques to address the information overload problem in general and focus on the different genres of online conversations in particular. In the longer term, I intend to scale up our systems for big data, as well as enhance the input and output modalities of interfaces to further support users in exploring and gaining critical insights from data.

### Visual text analytics for online conversations

**How can we scale up our systems for big data?** As social media conversational data is growing in size and complexity at an unprecedented rate, new challenges have emerged for visualization. In particular, I will focus on the following key aspects of big data that need to be addressed for designing visual text analytics for online conversations:

*Volume:* Most of the existing visualizations are inadequate to handle very large amounts of raw conversational data. For example, ConVis scales with conversations with hundreds of comments; however, it may not be able to deal with a very long conversation consisting of more than a thousand comments. To tackle the scalability issue, I plan to investigate computational methods for filtering and aggregating comments, as well as devise interactive visualization techniques to progressively disclose the data from a high-level overview to low-level details.

*Velocity:* The systems that I have developed do not process streaming conversations. Yet in many real-world scenarios, conversational data is constantly produced at a high rate, which poses enormous challenges for mining and visualization methods. For instance, immediately after a product is released a business analyst may want to analyze text streams in social media to identify problems or issues, such as whether customers are complaining about a feature of the product. In such cases, timely analysis of the streaming text can be critical for the company's reputation. For this purpose, I aim to investigate how to efficiently mine streaming conversations and how to visualize the extracted information in real time to the user.

**How can we support the user in tailoring our systems to a specific conversational genre?** While our current visual text analytics framework is quite generic, it requires a lot of programming effort to re-design the interface for a specific conversational genre. For example, when we applied our system to a community question answering forum, we had to spend a considerable amount of time modifying the existing code in order to re-design the interface for the new text genre. In this context, can we enable a large number of users – not just those who have strong programming skills – to author visual interfaces for exploring conversations in a new genre? I will research how to construct an interactive environment that supports custom visualization design for a large variety of conversational genres without requiring the user to write any code.

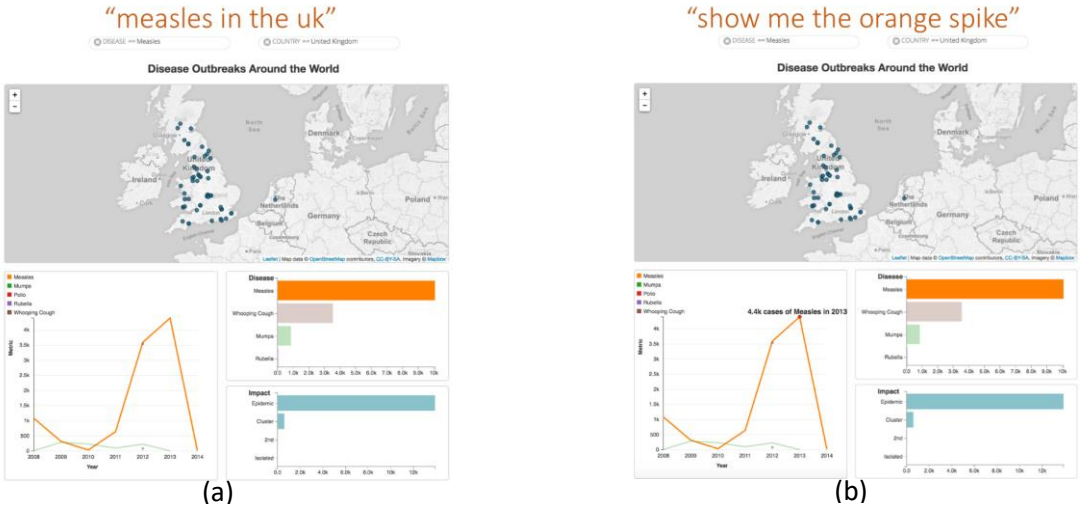
**How can the system adapt to a diverse range of users?** A critical challenge of introducing a new visualization is that the effectiveness of visualization techniques can be impacted by different user characteristics, such as visualization expertise, cognitive abilities, and personality traits. Previously, I explored the questions of *what* aspects of a visualization are impacted by user characteristics and *how* to

dynamically adapt the visualization to such characteristics [6, 7]. I plan to build on my previous work to develop advanced visual text analytics systems that can automatically adapt to user characteristics.

## Multimodal interactions for Visual Analytics to explore large datasets

While there has been a steady growth in systems and interfaces to help users perform data analysis, the communication with these systems is still quite limited, because traditional interaction techniques (e.g., drag and drop) are inadequate to allow users to express complex analytical questions or information needs. A promising way to support the user more effectively is to introduce interfaces that take a question expressed in natural language as input and return an answer to this question. However, natural language expressions can be diverse and ambiguous, making it difficult to interpret automatically. Moreover, the output modalities of these systems are either text or visualization, limiting the user's ability to interpret the results and make informed decisions.

To address the problem, I have been investigating how to effectively support the user in performing analytics, by enhancing both the input and the output techniques. During my research internship at Tableau Software, I explored the idea of natural language interaction techniques for exploring data [11]. In our system called Evizeon, the user can ask a question through text or speech. In response, the system generates a visualization response from the dataset to answer the question.




*Example results of natural language interactions with a dashboard [11]: a) an initial utterance followed by b) a reference made to properties of visualization.*

To further develop and enhance techniques for multimodal interactions with visual analytics, I will focus on the following questions:

**How can the system interpret a user's question?** To understand the question, I plan to analyze its syntactic, semantic, and pragmatic aspects. A subsequent goal is to map the question to one of the predefined action types (e.g., create new visualizations, modify existing visualizations) that can be performed by the system. For this purpose, I will extend my recent work on speech act classification to identify the user's intent from the query based on deep learning and conditional structured models [2].

**How can the system generate a multimedia summary that answers the user's question?** A multimedia output that combines text and visualizations can be very effective, because those two modalities can play complementary roles; while visualization can help the user to discover trends and relationships, text can convey key points about the results by focusing on temporal, causal, and evaluative aspects. To generate visualizations as output, I will extend automatic graphical presentation techniques form the InfoVis literature. I will also investigate natural language generation techniques to create coherent textual summaries that describe the important patterns and trends within the visualizations.

**How can we leverage multimedia generation techniques to develop advanced storytelling tools?** Data storytelling has been increasingly popular among InfoVis practitioners such as journalists, who integrate visualizations into their narratives to convey critical insights. Unfortunately, even sophisticated visualization tools like Tableau provide only limited support for authoring data stories, requiring users to manually create textual annotations and organize the sequence of visualizations. In this context, I aim to investigate how to leverage multimedia generation techniques (as mentioned above) to create effective semi-automatic authoring tools for data storytelling. For this purpose, I will explore the rich design space for organizing multimedia content and choosing the sequence in which the content is delivered to users.

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