

# Research Statement

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Civic decisions based on public-generated data critically impact government policies on healthcare, transit, and urban planning at a personal, local, or national scale. As such, analysis, sensemaking, and utilization of public-generated data are crucial to support the exercise of a successful decision-making process. However, off-the-shelf data analysis tools and techniques, and traditional public engagement methods and practices fall short of fulfilling data analysts and decision-makers' desire to derive insights from rich qualitative public-generated data for informing policy decisions that has significant impact on people's lives. Novel technological interventions are therefore necessary to enable decision-makers to forage, peruse, and sublimate public-generated data into concrete and actionable insights. To address this need, I conceive, design, develop, and evaluate end-to-end solutions by exploring two major thrusts of research — (1) facilitating sensemaking of public-generated data for informed decision-making and (2) empowering inclusivity in the public engagement process. To do so, I take a human-centered approach to identify and understand users' and stakeholders' needs; design and develop tools, techniques, and methods to address their specific needs and support their broader goals; deploy the technologies in real-world settings to evaluate their efficacy using quantitative and qualitative data, and iteratively refine the technologies by working with the stakeholders.

In my research, I follow an interdisciplinary approach by combining knowledge and practices from Human-Computer Interaction (HCI), Applied Machine Learning, Information Visualization, and Social Computing. I bridge the gap between these research domains by building novel computational tools and techniques to address real-world complex socio-technical problems. To that end, I closely work with stakeholders including community members and government officials to build technological interventions that facilitated decision-making around critical resource allocation during major societal crises (e.g. COVID-19 pandemic), planning and urban design (e.g. redesign of downtown Amherst), climate change issues (e.g., raising climate awareness at East Boston), and public policymaking (e.g., rewriting rental bylaw at Amherst). For my contributions, I have received two best paper awards (CSCW 2020, EuroVIS 2022), a best paper honorable mention (DIS 2021), Professor Victor Lesser scholarship in Artificial Intelligence (2018), and the UMass computing for common good fellowship (2022). My work has also led to internal and external grants including UMass IDS Grant 2020 (\$20K) and NSF SCC grant (SCC-PG #2125183, \$147K). Below, I describe my two main areas of research.

### Decision-Support Tools and Techniques for Sensemaking of Public-Generated Data

Public-generated data is predominantly comprised of free-form texts as comments, shared through social media, public engagement platforms, and review websites. Current approaches to support decision-makers to analyze and make sense of public-generated data is to provide them with analysis tools that are designed to generate aggregated summaries and numerical statistics such as topic distributions and sentiment analysis. Although these methods are useful for generating quick summaries, decision-makers often demonstrate a strong preference for gathering rich qualitative input by moving past simple measures of public preference (e.g., surveys, voting, polling, star rating) to understand people's priorities, issues, and viewpoints. However, textual data is often unstructured, ambiguous, and nuanced which poses a challenge for off-the-shelf computational methods to support decision-makers' needs. As such, existing methods fall short of enabling comprehensive exploration and knowledge discovery from the actual text and often run the risk of marginalizing unpopular opinions. In the first thrust of my research, I explore the design, development, and evaluation of technical interventions and frameworks to facilitate and accelerate informed data-driven decision-making. Following are three of my works in this area ranging from civic policymaking to making informed purchase decisions.

**CommunityPulse.** Textual public-generated data collected as comments through public engagement platforms and social media is difficult to parse and analyze due to their high dimensionality, inherent ambiguity present in natural language, and often unclear boundaries to distinguish positive and negative sentiments. While sentiment analysis is a popular choice for aggregating public-generated data, sentiment categories (i.e. positive, neutral, and negative) do not represent fine-grained categorization of public perception (e.g., anger, concern, disappointment). The lack of tools and techniques to identify such nuances often results in public-generated data being left unanalyzed and unutilized in policymaking. To address this issue, I interviewed 14 civic leaders, who grapple with the challenges of making sense of public public-generated data, to understand their practices and requirements. Based on these insights, I designed and developed CommunityPulse [1], an interactive system that combines text analysis with interactive information visualization to scaffold different facets of public-generated data. In CommunityPulse, I implemented an emotion classifier to detect five categories (Excitement, Happiness, Neutral, Concern, and Anger) by training a transformer-based (BERT) model.

I improved upon existing topic representation strategies by identifying the most representative phrase from the texts associated with certain topics to enhance the understandability of topic distributions. After evaluating CommunityPulse for two weeks, 15 experts suggested the system’s efficacy in surfacing people’s reflections, priorities, and hidden insights while reducing the required time, effort, and expertise for public-generated data analysis could be a *game-changer*. For example, using CommunityPulse, decision-makers of an urban planning project in San Diego could identify that people prefer pedestrian crossing compared to roundabouts at an intersection. For my work on CommunityPulse, I received a **best paper honorable mention award from DIS 2021**.

**Of Course it’s Political!** Visual analytics systems such as CommunityPulse [1] can not only enable analysts and decision-makers to make informed decisions based on public-generated data but also act as a conduit for communicating public perception towards policy decisions with the people to maintain transparency and accountability. However, the dynamics of analysts and consumers who use such systems are markedly different in civics [2], which needs consideration when addressing political ramifications such as the structure of authority and means of representation. My collaborators and I explored the political aspects of text visualization in the civic domain in the context of democratic decision-making [3]. Based on a critical perspective on information visualization, the surveys of text visualization in general, and a critical analysis of the status quo of civic text visualization, we argued that civic text visualization acts as a double-edged sword. On the one hand, it provides a variety of tools and techniques that help improve the tractability and efficiency of the public-generated data analysis process. On the other hand, the application of text visualization techniques treats the political process of public commenting as an exclusively analytic endeavor. This framing leads to a series of issues and challenges in the fundamentally political context of civics, such as misinterpretation of data, missing minority voices, and excluding the public from decision-making processes. My collaborators and I provide a series of two-pole conceptual dimensions such as, from singular user to multiple relationships, and from complexity to inclusivity of visualization design, from data aggregation to articulation. We argue that these dimensions can help visualization researchers, designers, and practitioners attend more intentionally to information visualization design and balance between their political context and analytical framing to account for the subtleties inherent in civic text visualization. **This work received the best paper award at EuroVIS 2022.**

**Serendyze.** Beyond civics, public-generated data often influence decision-making in social media and e-commerce domains. These decision-making processes can be studied and incorporated in civic decision-making. For instance, in e-commerce, due to the abundance of product reviews, customers often make biased and uninformed purchase decisions based on incomplete Extant recommendation systems are often focused on relevance and popularity that may guide the customers in reading reviews that the system *thinks* are important for the customer. As a result, useful comments might be pruned out in favor of popular ones that might bolster a customer’s confirmation biases toward a product, leading to purchasing an inferior product. To combat such effects, I investigated how supporting serendipitous discovery and analysis of product reviews can encourage customers to explore reviews more comprehensively before making purchase decisions. To that end, I designed and developed a visual text analytics system called Serendyze [4]. In Serendyze, I introduced three interaction-driven exploration Metrics that act as an awareness mechanism to help customers understand and track their review exploration progress and patterns through visual indicators. I also proposed a biased mitigation model design to help readers to balance their holistic understanding, increase data coverage,

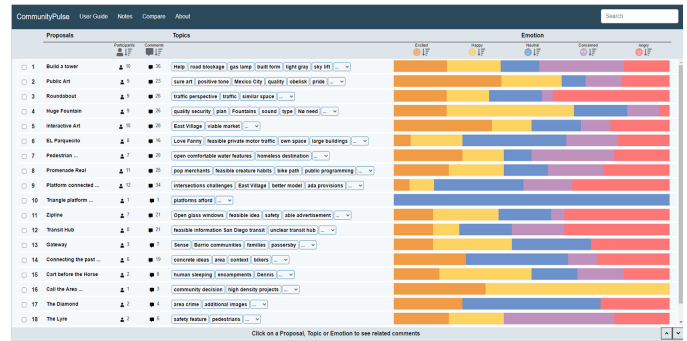


Figure 1: CommunityPulse uses visualizations as scaffolding to explore public-generated data to help analysts and decision-makers identify public reflections, priorities, and insights.

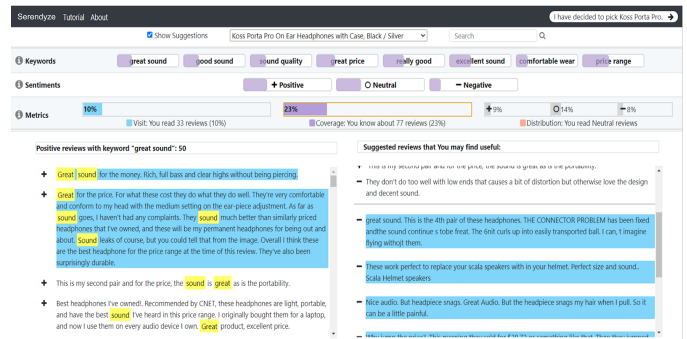


Figure 2: Serendyze allows customers to track their review exploration patterns and suggests reviews that can reveal a product aspect they might not have considered yet.

and mitigate bias towards specific review sentiments by providing them with sentiment and semantically-different suggestions. Based on an evaluation with 100 crowd workers, I found that exploration metrics can enable customers to efficiently cover more reviews in a balanced way, and suggestions from the bias mitigation model can help them to make confident data-driven decisions. Serendyze can be expanded to public-generated data analysis to combat biases while making decisions based on a more comprehensive data exploration.

## Technologies to Empower Inclusivity in the Public Engagement Process

An effective decision-making process must include inclusive public engagement methods to facilitate decision-makers to collect public-generated data, identify the values in public perceptions, and incorporate them into the decisions. However, traditional public engagement methods (e.g., face-to-face meetings, public forums, and town halls) rarely provide opportunities for inclusive public participation. For instance, reticent meeting attendees often struggle to speak up and articulate their viewpoints due to fear of confronting outspoken and dominant individuals. This lack of inclusivity in traditional face-to-face engagement methods results in an uneven representation of the public and inhibits the collection of broader perspectives from meeting attendees. As a result, these traditional methods often fall short of achieving the desired exchange of perspectives between decision-makers and the people [5], [6]. The second thrust of my research involves designing, developing, and evaluating technological interventions to improve public engagement methods by empowering the public to share their opinions more freely and allowing decision-makers to account for and incorporate the increased public-generated data in the decision-making process. I present two of my research works in the following that aims to enhance current public engagement methods.

**CommunityClick.** Despite a lack of inclusive participation and challenges in capturing public opinion, local governments often depend on traditional public engagement methods such as town halls for community consultation. During these town halls, attendees are expected to speak up, which discourages silent or reticent participants — who prefer to avoid confrontations — to share their thoughts and opinions during town halls. To address this gap, I designed and developed CommunityClick [6], a communitysourcing system that captures all attendees’ feedback during the meeting and enables organizers to conduct post-meeting analysis to author semi-automated comprehensive reports. I used modified iClickers to allow reticent attendees to provide real-time feedback silently and anonymously during town halls and captured this feedback in augmented transcripts. I also proposed a novel feedback-weighted text summarization method that incorporates iClicker signals from reticent participants into transcript summaries. Traditional text summarization methods would be ineffective here due to their focus on the transcript texts that exclusively capture vocal attendees’ inputs and neglects silent attendees’ iClicker input. I augmented the TextRank algorithm by incorporating iClicker responses when computing relative sentence importance and replacing its similarity function with the BM25 ranking function which demonstrated increased performance. This resulted in text summaries that included transcript texts that gained the most attention from both vocal and silent attendees. Furthermore, CommunityClick’s interactive dashboard enabled decision-makers to generate more accurate, accountable, and comprehensive reports by leveraging the augmented transcripts alongside CommunityClick’s report authoring features. I deployed CommunityClick at several town halls in Amherst as field experiments, which demonstrated how the system can provide multiple avenues for attendees to share opinions and enable organizers to capture, reflect on, and make informed data-driven decisions. For example, using CommunityClick at a town hall regarding parking in downtown Amherst, the organizers identified that the silent attendees outnumbered vocal attendees who advocated for backward parking. It could not have been possible by following the traditional voting or polling methods during town halls that limit attendees’ expressivity of opinions. For my work on CommunityClick, I received the **best paper award at CSCW 2020**.

**CommunityClick-Virtual.** During societal crises such as the COVID-19 pandemic, it often becomes impossible to maintain traditional public engagement processes including face-to-face town hall meetings. Successful interventions for face-to-face meetings such as CommunityClick [6] are also rendered ineffective due to their dependency on physical devices such as iClickers. While online meetings provide an alternative to

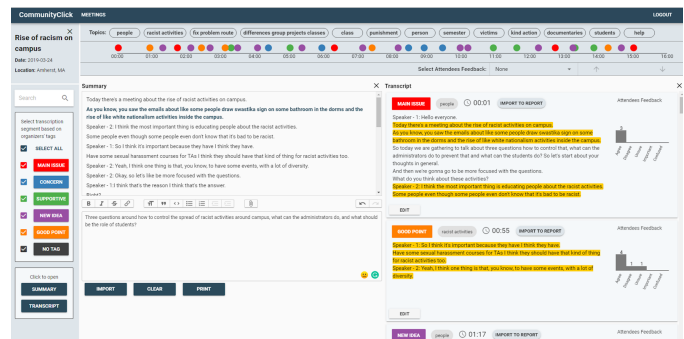


Figure 3: CommunityClick’s dashboard allows organizers to analyze public-generated data collected during town halls to generate comprehensive reports.



face-to-face meetings, they often adopt the rigidity present in traditional town halls where attendees have to share their opinions by identifying themselves and speaking up, which may not be comfortable for everyone. To address this issue, I built on CommunityClick to design and develop CommunityClick-Virtual, an online web-based public engagement platform that allows attendees to anonymously share their opinions in real-time during online public meetings. In CommunityClick-Virtual, attendees can use six customizable feedback options to share their opinions. They can also send public and private text messages to elaborate on their shared opinions, ask questions, and share new ideas. To keep the conversation civil, I implemented profanity and spamming detection alongside moderation controls where organizers can remove messages containing inappropriate language or themes including personal attacks, offensive language, and disruptive elements. CommunityClick-Virtual also provides a real-time dashboard to enable organizers to track people's interests in the discussed topic and conversation flow to adjust the meeting discussions on the fly. CommunityClick-Virtual has been deployed several times by the town of Amherst in critical town meetings involving budgeting, urban planning, and new policies and has seen tremendous success in increasing public participation during meetings. For instance, during an online meeting regarding the redesign of the downtown Amherst parking area, the meeting transcript reflected that only seven out of 32 attendees spoke up during the meeting. However, thrice as many attendees (25 attendees) actively participated through CommunityClick-Virtual during the 2-hour-long meeting, generating over 250 responses. Due to its success, **CommunityClick-Virtual has been adopted by the town of Amherst government** and continue to be deployed in critical meetings as a companion application.

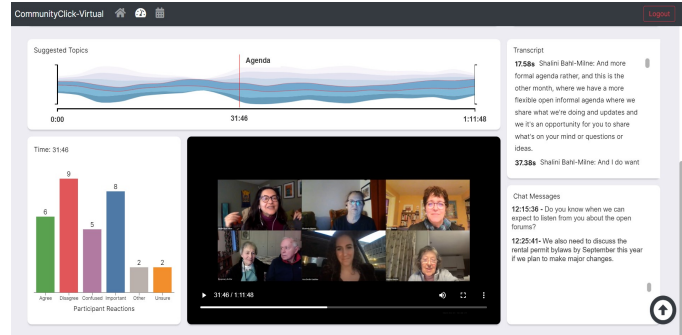


Figure 4: CommunityClick-Virtual enables attendees to share opinions and allow organizers to analyze attendees' feedback alongside meeting recording, transcript, and chat messages.

## Future research Directions

In the future, I plan to build on my current work and conduct new interdisciplinary research to build AI-assisted semi-automated hybrid decision-support systems. Existing tools and techniques are often challenged by rigid input modalities, diversity in user requirements, and limited collaboration options for distributed decision-making. My goal is to combine computational methods with local knowledge, experience, and insights from users to design new state-of-the-art tools and techniques for informed data-driven decision-making. To that end, I will pursue three areas of research that can facilitate the design and development of tools and techniques that leverage human ingenuity to enhance mechanical efficiency. These research areas are as follows.

**Integration of Multi-Modal Signals in Sensemaking.** Human-Human interaction often includes multiple input modalities including speech, gestures, and text. Communications between humans are enriched with nuances such as facial expressions, body language, tone of voice, and choice of words. However, when processed for computer-mediated analysis, the data is often abstracted into its simplest forms (e.g., video transcription), which removes non-verbal cues that constitute the majority of human communications and the subtleties of spoken words. As a result, rich interaction information is lost beyond the most basic form of information exchange. The inclusion of such nuanced signals could bolster the analysis process to be more transparent, accountable, and less open to analysts' interpretations. I plan to investigate, design, develop, and evaluate novel technologies that can incorporate complementary communication signals by augmenting behavioral cues and auditory signals with base communicative information such as text or numerical data. Based on my prior work [6]–[8], I will leverage speech tones, body languages, and hand gestures during face-to-face conversations to augment public-generated data, which could allow for additional perspectives to achieve more informed decisions.

**Adaptive Interfaces for Decision-Support Systems.** With the ubiquity of digital systems such as computers and portable smart devices, user interfaces are becoming more complex in an attempt to provide more features to diverse users with varying levels of skills, experiences, and backgrounds. While some users are *tech-savvy*, for others, it might be their first experience interacting with an interface. Especially, for the elderly, physically-impaired, technology-deprived, and often marginalized populations, working with complex user interfaces might result in disengagement and eventual reluctance to use the system. Furthermore, only catering to the needs of beginners may repel expert users who wish to utilize the system's functionalities to the fullest. While rule-based adaptive interfaces have seen success in e-learning and the education domain, they may not

translate in domains where complex and dynamic operations are performed by stakeholders who demonstrate a large variety of skill-level ranging from novices to analytics experts. I will investigate how user experiences can be leveraged for generating human-in-the-loop models to design adaptive interfaces for decision-support systems. I will build upon my work in Serendyze [4] — where I explored serendipitous content generation based on user interactions — to build interaction-driven models that can account for users’ skill levels, preferences, and agency to cater to their analysis needs. These models will lay the foundation of more generalizable smart interfaces capable of adapting to users’ occupational, cultural, and habitual preferences.

**Collaborative Analysis and Decision-Making.** In digital civics, multiple analysts and decision-makers are often involved where effective coordination, communication, and collaboration are a precursor to the success of the decision-making process. The inherent complexity of this process imposes several challenges for the technology designers such as coordination of activities and division of tasks; organizing, communicating, and validating findings; and sharing, discussing, converging, and consolidating results. Further complications involve synchronicity and incentivization of voluntary contributions made by citizen-analysts — members of the public who bring local insights and dynamic solutions to the decision-making process. I aim to investigate these challenges and build effective tools and techniques to facilitate synchronous and asynchronous collaborative analysis and decision-making of large-scale public-generated data. I plan to build upon my work in designing and developing single-user decision-support systems (CommunityClick [6], CommunityPulse [1], Serendyze [4]), micro-task based communitysourcing models for task coordination and insight gathering, and non-monetary incentivization strategies such as karma system in Reddit and reputation system from Stack-Overflow. The benefits of such systems include an effective, efficient, and transparent decision-making process with the inclusion of the public in the process. They also have potential use cases for domains beyond civics where collaborative sensemaking can support decision-making such as online content moderation, document analysis in healthcare and law enforcement, and company-wide policymaking in the industry.

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