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CAMAS: A Citizen Awareness System for Crisis Mitigation

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1. INTRODUCTION

Responding to natural or man-made disasters in a timely and effective manner can reduce deaths and injuries, contain or prevent secondary disasters, and reduce the resulting economic losses and social disruption. During a crisis, responding organizations confront grave uncertainties in making critical decisions. They need to gather situational information (e.g., state of the civil, transportation and information infrastructures), together with information about available resources (e.g., medical facilities, rescue and law enforcement units). Clearly, there is a strong correlation between the accuracy, timeliness, and reliability of the information available to the decision-makers, and the quality of their decisions. The 'Responding to Crises and Unexpected Events' (RESCUE) Project [2] was recently conceived with the objective of radically transforming the ability of organizations to gather, manage, analyze and disseminate information when responding to man-made and natural catastrophes. Dramatic improvements in the speed and accuracy at which information about the crisis flows through the disaster response networks has the potential to revolutionize crisis response, saving human lives and property.

In the RESCUE Project, our focus is to transform the speed and accuracy with which information flows through disaster response networks, which consist of numerous response organizations as well as the general public. We are developing information technology solutions that dynamically capture and store crisis-relevant data as it is generated, analyze this data in real-time, interpret it, share it across heterogeneous organizations, and disseminate the resulting information to decision makers in the forms most appropriate for their various tasks. Challenges in realizing such IT solutions arise due to the scale and complexity of the problem domain, the diversity of data and data sources, the characteristics of the communication and information infrastructures through which the information flows, the diversity of responding organizations, and the dynamic nature of their activities.

Among the most valuable sources of information for situational assessment during crisis response is the human input in the form of eyewitness accounts, and first responders' observations and interpretations at the crisis scene. Leveraged properly, such "humans as sensors", with the benefit of human cognizance, can play a vital adjunct to instrumented sensors as tools for situation assessment resulting in much more accurate situation awareness and hence better response. Yet existing crisis response systems do not systematically exploit such information. The prime impediment in realizing the "human as sensors" concept is the limitation of today's technologies in seamlessly and unobtrusively capturing, collecting, analyzing, and interpreting human input. Technological innovations to facilitate the first responders/eyewitness accounts into the situational assessment of crisis sites is one of our major research thrusts of RESCUE.

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2. EVENT EXTRACTION & ANALYSIS

An integral part of the "human as sensor" concept is an end-to-end data analysis system that captures and analyzes multimodal data (e.g., voice and video input from in-field officers and cameras, GPS, sensor data), extracts meaningful events/information from transcriptions, populates key databases, and uses this information in real-time as input into a damage and impact assessment system. The figure below shows various components of such a data analysis system we are building. Below we list the components and describe a few modules in more detail.

Speech Recognition system – that allows for (near) real-time speech to text conversion in distributed noisy environments

Data Mediation Infrastructure – a system that enables dynamic access to heterogeneous databases in the context of diverse tasks and varying access control policies to data. Such a mediation infrastructure can provide access to the knowledge/database useful in information extraction as discussed below.

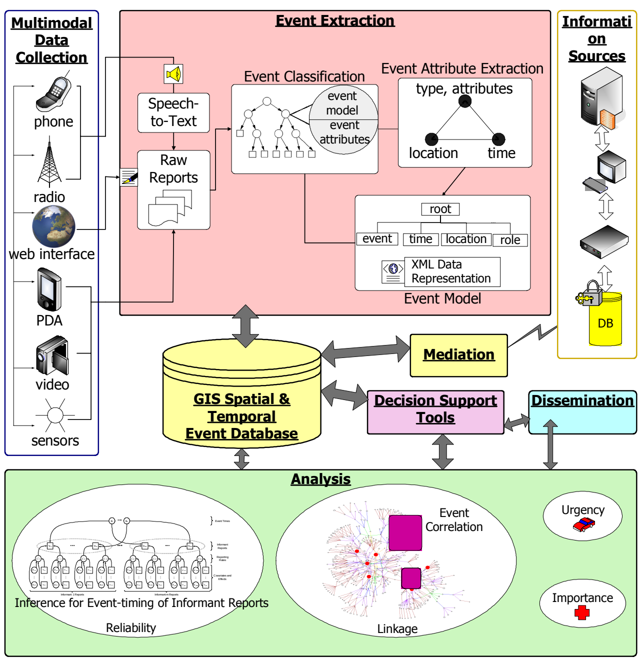
Event Extraction from Multimodal Data Streams: This component extracts meaningful events from the multimodal input. Since human input is among the most valuable sources of information, we focus on event extraction from text. Information extraction from unstructured text - even in restricted domains - is notoriously difficult. The approach we are exploring is to first develop a dynamic taxonomy of event types with each of which an event model is associated. Classification approaches based on the event models are used to determine the type of events. Then the set of properties associated with the event are extracted. The context provided by additional information can be used to restrict the space of possible events and their properties improving the accuracy of the extractor. For example, textual data can be supplemented with location information (from GPS), video data, as well as knowledge existing in current knowledge/data bases.

Event Data Management System -- an XML based model for representing, querying, and analyzing spatio-temporal events.

Event Analysis: Once basic events have been extracted, they are subjected to variety of analysis tasks. These analysis tasks are vital in proper interpretation, ranking, prioritization, and triaging of information to decision makers. For example, a same event may be reported multiple times (e.g., due to multiple observers making and reporting the same event). Alternatively, two events might be linked or correlated in some ways. Similarity matching and data mining techniques properly enhanced to handle spatio-temporal events can be used for this purpose. Another important task is ascertaining the *reliability of human reports*. Informant accounts are known to be highly distorted in a number of ways [1] due to a multitude of factors. Exacerbating circumstances include intentional abuse, confusion, linguistic ambiguity etc. Due to the flow of information through social networks, individual errors in perception may be compounded by factors such as rumors and exaggerations. Another related task is determining *importance and urgency* of an event. Importance and urgency are two tightly coupled factors that play a crucial role in information triaging/filtering.

Event Visualization System -- a GIS based framework that supports spatio-temporal event monitoring in the context of specific tasks such as activity planning, activity monitoring, etc using multi projector displays.

Event Mining system – a system that looks for unusual patterns and correlations among events



3. CAMAS TESTBED

The Crisis Assessment, Mitigation and Analysis System (CAMAS) is one of the testbeds of the RESCUE project designed to evaluate technologies being built to realize the human-as-a-sensor concept, as well as, to validate the importance of leveraging human input in crisis response. The initial testbed consists of a problem-reporting facility for the UCI campus. The choice of this specific application was decided upon based on its scale, its similarity to the expected CAMAS problem domain, availability of accurate campus geospatial data, easy access to buildings and facilities, access to domain expertise from maintenance, computer support and campus networking personnel, and access to the rich archive of problem reports over the past 10 years. Users, acting in the context of their roles, can report using multiple modalities (e.g. telephone call, email or via a web interface) a variety of problems ranging from the functioning of public facilities (e.g., damaged phones, broken windows, electrical problems, parking problems) to computer support issues (e.g. inability to access wireless networks) as well as potentially serious issues that could lead to fires, gas leaks or other infrastructure problems. The reports are made in natural language text which is then parsed, analyzed, classified, ranked and triaged via a notification-based event dissemination module that is capable of alerting appropriate personnel using a variety of modalities such as email, telephone calls using standard text-to-speech translation systems.

While currently CAMAS focuses on a facilities problem reporting system, as a next step, we plan to instrument significant portion of the UCI campus to create smart corridors and open spaces. The instrumented space will mimic (in our campus setting) facilities such as airports, nuclear facilities, and research laboratories that may have existing surveillance and network infrastructure that may be partially/completely operational and can be used by first-responders for crisis mitigation. The instrumented spaces will be used to conduct and monitor emergency drills planned in collaboration with the UCI emergency management personnel. The human-as-sensor concept along with the related technologies will be field tested in such emergency drills in the future.

4. DEMONSTRATION

The prototype CAMAS application that will be demonstrated will be a problem reporting facility for the UCI campus. The demonstration will walk a viewer through the processing of information in the CAMAS system starting from a raw user report (e.g. text) followed by the event extraction and analysis phases and ending with contextualized dissemination of alerts (if necessary). Through examples and experiments, the walkthrough will illustrate the strength of our extraction module, the capabilities of the event refinement interface, adaptivity of our system to unexpected events, and the notification system for triaging the information.

5. ACKNOWLEDGEMENTS

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