HUMAN SENSOR NETWORK: A SOCIAL MEDIA OBSERVATIONAL TOOL FOR IMPROVED MODELING AND MITIGATION OF EXTREME WEATHER EVENTS

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1. EXTENDED ABSTRACT

The fields of Storm modeling and Disaster Management are well established, however the use of social media in these fields is at its infancy and mostly focuses on a one way communication of "broadcasting the threat to the public". The aspect of listening to the response of the public in the social media framework is very minimal. Harvesting, analyzing and providing spatial and temporal maps from a variety of online media products available with geolocated features in near real-time to first responders during and after extreme weather events for mitigating the economic and human is currently non-existent operationally.

We have developed a novel approach that views social media data as Human Sensor Network (HSN) where social media users are viewed as "sensors" and their posts are viewed as "observations". We have previously successfully demonstrated this concept in the use-case of Deepwater Horizon Oil Spill disaster. For oil plume movement and wash-up forecast, NOAA employs the General NOAA Operational Modeling Environment (GNOME), which is a Lagrangian-Eulerian model. In the 2012 Centennial Issue of the IEEE Proceedings on Natural Disasters, we showed how to incorporate the Human Sensor Network data collected from Flickr photo sharing services into the GNOME model resulting for improving the operational oil spill forecasts.

In this presentation, we focus on Superstorm Sandy and its aftermath impact. We extend the tools developed for the GNOME oil spill model to the current NOAA operational surge model SLOSH (Sea, Lake and Overland Surges from Hurricanes). The social media data that we have harvested from the Internet consisted of Twitter feeds and Instagram photos including the metadata. We have collected over 8 million tweets and over 370 thousand Instagram images that mention hashtags related to the Sandy storm (e.g. #frankenstorm, #frankensandy, #hurricane sandy etc.) that were posted several hours before the storm made the landfall on Oct. 29, 2012 through Nov. 1, 2012.

At present, emergency responders rely on the SLOSH model for decision making in regards to response and mitigation of surge related disasters. SLOSH is a probabilistic geophysical model used to estimate the heights of the storm surge taking into account the weather forecast as well as the unique characteristics of the area where the storm makes the landfall, such as roads, rivers etc. However, there are some significant limitations to the model, since it doesn't take explicitly into account astronomical tide, river and stream flows during rain or storm events. More recent versions of the model utilize the ocean-hurricane interactions, which were not available for this study. We have developed a heterogeneous, near real-time human sensor web engine that uses streaming APIs of different social media outlets to harvest posts related to disasters.

The posts are stored in a distributed, schema-free, key-value document store database residing on an 4 dual Intel Nehalem node IBM blade cluster. To query our sensor data we use an ElasticSearch engine distributed over 32 cores. ElasticSearch is a RESTful, distributed search engine based on Apache Lucene as the underlying platform for filtering and feature content searching of the Twitter and Instagram metadata.

We have developed a hybrid system that assimilates Human Sensor data from Social Media outlets and the SLOSH model forecast outputs into a framework that integrates the geolocated products onto Google Earth based maps. Since many of the social media posts provide precise geolocation in addition to the time of the post, we

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can efficiently analyze the varying post storm concerns such as flooding, power outages, hospital evacuations, vandalism and other human needs and other problems. We further produce sentiment clouds of the affected communities based on their geo-location and time in correlation with the SLOSH model forecasts and visualize our analysis in spatial/temporal locality maps.

We will demonstrate the usefulness of our system as a novel tool for decision makers and emergency responders that allows monitoring and analyzing tweets and Instagram photos as well as SLOSH model forecasts in the same framework. Our system also allows us to analyze, understand and extract prominent components of what people are sharing and posting on the online social media during situations of extreme hardships such as loss of home, power, lack of heat, food, and access to medical care.

An important contribution of our system is in providing Emergency Responders with the ability to have an effective tool not just for broadcasting warnings but for monitoring the return channel of communication, i.e. being able to listen to what millions of affected people have to say about their distress and understand their needs based on their geolocation. Such an approach will also allow us to better understand the damage that results from the hurricanes, such as number of affected households, duration of power outages, regional sentiment of the public.

We will demonstrate the benefits of our framework by identifying microscale events and provide a sense of what happened, e.g., where and when did a particular hospital or patient care services loose power, or have it restored and at what particular time? How did different communities respond to evacuation orders over time? How did people's health concerns and sentiment change with the progression of the hurricane? Which health and safety topics were discussed?

For future extreme weather events, we will describe how to expand our framework to include advances in modeling and a variety of additional social media sources such as Google+, Facebook posts, and other emerging platforms such as Vine videos. In addition, smart phones and handheld devices can provide quantitative measurements such as pressure, temperature, radioactivity, solar radiation, aerosols, greenhouse gases etc. that in a paradigm of Citizen Science can be invaluable for the modeling and response instruments of the future.

2. REFERENCES

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