Situation Detection and Control using Spatio-temporal Analysis of Microblogs

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ABSTRACT

Large volumes of spatio-temporal-thematic data being created using sites like Twitter and Jaiku, can potentially be combined to detect events, and understand various 'situations' as they are evolving at different spatio-temporal granularity across the world. Taking inspiration from traditional image pixels which represent aggregation of photon energies at a location, we consider aggregation of user interest levels at different geo-locations as *social pixels*. Combining such pixels spatio-temporally allows for creation of social images and video. Here, we describe how the use of relevant (media processing inspired) situation detection operators upon such 'images', and domain based rules can be used to decide relevant control actions. The ideas are showcased using a Swine flu monitoring application which uses Twitter data.

Categories and Subject Descriptors: H.4.m [Information Systems]: Miscellaneous

General Terms: Human factors, Design

Keywords: Situation, Event, Control, Microblogs, Twitter

1. INTRODUCTION

We are currently witnessing an explosive growth in the popularity of micro-blogging platforms like Jaiku and Twitter. Hundreds of thousands of users distributed globally are posting millions of microblogs each day on various events and topics of interest. With its real-time availability, sheer volume, and inherent spatio-temporal nature; if combined properly, this data can give immediate insights into the global situation or 'pulse of the world'. Clearly such macro situation assessment is relevant to multiple application domains. Health care agencies tracking swine flu, disaster management agencies responding to fire or earthquakes, political activists looking for support patterns, business firms looking for product reviews and customer reaction, and military agencies looking for abnormal activities, would all be interested in such geo-spatial situation assessment.

In order to support such applications we need to create tools which disambiguate the relevant from the irrelevant (based on space, time, thematic, and user settings), and combine the relevant data into meaningful representations. In this work, we demonstrate the use of simple user-defined bag-of-word models to capture relevant user interest for any time-window at a given geo-location. Next we combine such geo-located interest patterns into multimodal (image and video) representations, and define a set of analytic operators for assessing situation parameters from this multimodal representation. The application designers can choose the right situation detection operators and define domain based temporal rules to support decision making and control actions from this data.

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2. SYSTEM DESIGN

The overall system architecture for our approach is as shown in Fig. 1. We geo-code the user microblogs coming from different parts of the world.

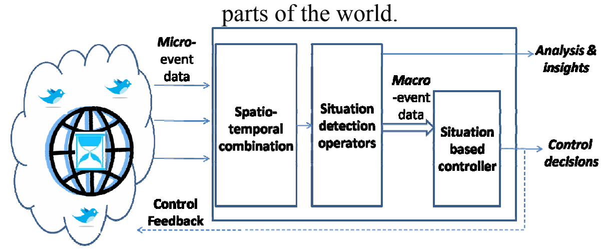

Figure 1: Overall architecture

Micro-event detection
We adopt a simple bag-of-words approach for event detection at micro-level in real time. The bag-of-words is configured by the application designer based on application theme.

Spatio-temporal aggregation using *social pixels*
For macro-level understanding, we aggregate user interest patterns in (space and) time windows (e.g. moving window of 7 days, across the US). We undertake the aggregation using a 'social pixel' based approach. Just like the combination of energies coming from multiple *photons* at a particular position was captured as a *pixel* in traditional imaging sensors, here we capture the combined user interest levels or excitation energies coming from a particular geo-location as a *social pixel*. Thus a *high* user activity pattern about 'swine-flu' at geo-location [latitude, longitude], can be represented with a high intensity value at the corresponding pixel location. Combining multiple such pixels spatially allows us to create 'social images' (see Fig. 3(a) for an example), and adding the temporal aspect allows to create 'social video' streams for each theme of interest. We argue that this is a good approach because:

1. Such a visual representation, allows for intuitive understanding, and supports 'situation awareness' for human decision makers.

2. Such a representation allows us to use rich repository of media processing algorithms like, edge detection, flow patterns, segmentation and so on to easily derive semantically useful situation information. Such analysis would be very tedious in a text-based corpus of micro-blogs or even as querying based approach in databases where (relatively simple) media processing operators like *convolution* and *segmentation* are yet to be mapped effectively.

The use of this 'social image' and the affordances provided by the (media processing inspired) situation detection operators differentiates our work from previous efforts like [2, 3] which also analyzed spatio-temporal microblogs.

Situation detection operators
We allow the application designer to choose from a variety of spatial and spatio-temporal situation detection operators to detect

S. No	Type	Input	Output	Operator(s)	Real-world application
1.	Setup	NA	NA	Selecting the bounding box and minimum resolution	Choosing the spatial and temporal boundaries for which analysis needs to be done. e.g. USA for last one week. Similarly, choosing the minimal granularity at which to deal with the data e.g. large scale applications may deal with latitude, longitude boxes, while local application may require meter square level resolution.
				Selection/ combination between channels of data	Studying multiple aspects of data in a combined fashion. For example different channels can capture different moods of users related to the same topic like 'iPhone' launch.
				Combining terms	Different related terms can be combined to create a common representation. e.g. flu OR H1N1, Obama AND Clinton.
2.	Global	Image or video	Single value i.e. Number	Statistical properties (e.g. Min, Max, Mean, Variance, moments)	Average/highest/lowest/variance of interest in a chosen topic
				Geometric properties (e.g. Euler number)	Scale invariant property of spread pattern. Compare spread pattern of 2 different products.
3.	Spatial operators	Image	Image	Morphological operators (e.g. Erosion, Dilation, flood fill)	Useful for noise removal and easier visualization by a human users on the spread patterns.
				Interest point detectors (SIFT, Corner point)	Identify 'critical' points for the topic. e.g. Flu breakout point, iPhone launch location
				Edges	Logical separation points across zones of influence. Useful for decisions like where to set administrative boundaries for sales offices
				Textures	Characterize spread patterns e.g. Disease spread is homogeneous or in spurts
				Segmentation	Clustering into regions with different demand or interest characteristics e.g. into low, and high demand zones.
4.	Temporal operators	Video or time-varying Vectors	Event Alerts	Peak detector	Detect highest interest point in any phenomena
				(ΔValue) $\geq$ Threshold	Detect large variations in the values of any parameters or any of the vector properties listed above.
				(ΔSlope) $\geq$ Threshold	2nd order changes. Detect *sudden* variations from the general way data is changing. Perhaps a response to large external event like Earthquake, Explosion etc.
5.	Comparison with external data	Images or video	Images or video	Image algebra (e.g. Difference, Aggregation)	Comparison of data across different sources, different competing products or across different space time coordinates.
				Correlation, Convolution	Observe correlation across different patterns/ products/ phenomena. Can also be used to study the effect of different external factors (*kernels*), on the observed data.

Figure 2: Operators and their sample real world applications

important parameters, patterns and macro events. As shown in Fig. 2, we have defined 5 different categories of analytic operators to support situation detection.

Situation based control

Decision making by the system clearly requires an understanding of the domain semantics involved. For example, an end-user mentioning early symptoms of swine-flu may be given very different recommendations based on the macro-level spread of swine flu (e.g. 'low activity', 'some cases', or 'epidemic'). Such semantics are transcribed in our case using a temporal rule-based system for situation based control.

3. APPLICATION: SWINE FLU MONITORING

We downloaded the data using the 'Gardenhose' stream available from Twitter and augmented it with geo-queries on Twitter API. The geo-location is based on the 'home' location of the user, as converted by the Geonames server (www.geonames.org).

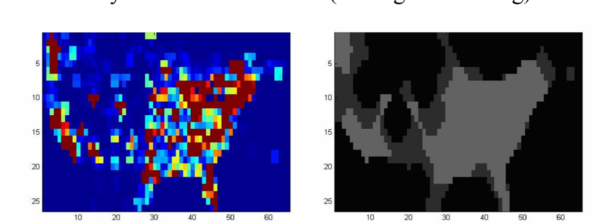

Figure 3: (a) A 'social image' representation of the 'swine-flu' interest data across US. (b) Segmentation of image into 3 regions of different activity level.

We first undertook micro-event detection on the data using keywords like 'flu', 'H1N1', 'sore-throat' etc. to detect user level micro event. Next we aggregated user interest patterns across whole US into 'social image' as shown in Fig. 3(a). Next we used a situation detection operator (***segmentation*** in this case) on the social image to segment US into different zones with 'Epidemic', 'Medium', 'Low' levels of swine-flu activity. Based on the domain rules encoded, the situation based controller came up with relevant recommendations. The recommendation for each microblogger was decided (see Fig. 4) based on a combination of the micro-level event (e.g. Sore-throat) and macro situation parameter (e.g. 'Level 3=Epidemic', or 'Level 1=Low activity'). The ability to interact with the microblogger differentiates our approach from related search engine based approaches like [1].

Figure 4: Recommendation system based on tweet events and global situation parameters

4. CONCLUSIONS

We have proposed a new way of organizing this spatio-temporal microblog data into 'social images', and defined the operators required for undertaking situation detection using them. We have demonstrated that the system can be encoded with domain rules to undertake appropriate control action. In a broader sense, this work also highlights the related concepts of 'humans as sensors', 'wisdom of the masses', and 'crowd-sourcing'.

5. REFERENCES

[1] Q. Mei et al. "A Probabilistic Approach to Spatiotemporal Theme Pattern Mining on Weblogs", in WWW'06.

[2] M. Nagarajan et al. "Spatio-Temporal-Thematic Analysis of Citizen Sensor Data: Challenges and Experiences", in WISE'09.

[3] J. Ginsberg et al. "Detecting influenza epidemics using search engine query data". Nature, 457(7232):1012-1014, 2008.