INSIGHT: Dynamic Traffic Management Using Heterogeneous Urban Data

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Abstract. In this demo we present INSIGHT, a system that provides traffic event detection in Dublin by exploiting Big Data and Crowd-sourcing techniques. Our system is able to process and analyze input from multiple heterogeneous urban data sources.

1 Introduction

In this demo we present a traffic monitoring system that is currently *deployed* in Dublin and utilized for city event detection. The purpose of this demo is to show, that, using novel data mining techniques we are able to monitor diverse data coming from city-wide infrastructures and extract useful information to present to the city operators. We collaborated with Dublin City Council (DCC) and designed a system that is able to process *real-time* data from diverse input sources such as sensors mounted on top of buses, traffic sensors embedded in street intersections or even citizen's tweets. INSIGHT identifies events of interest such as traffic congestion, construction works and accidents [1].

Although sensor data are available to smart city authorities, it is very difficult for human operators to monitor the vast amount of information. Figure 1 shows the DCC control center, where one of the screens displays INSIGHT[1]. Our system identifies events and aids operators to react in a timely manner by providing tools that: (1) Automatically identify the locations where abnormal sensor behaviour occurs, (2) Analyze historical data and build models that capture the sensors' normal behaviour, and (3) Exploit ubiquitous human sensors to complement the existing data sources.

[1] `http://www.insight-ict.eu/` - INSIGHT was funded by an FP7 EU grant

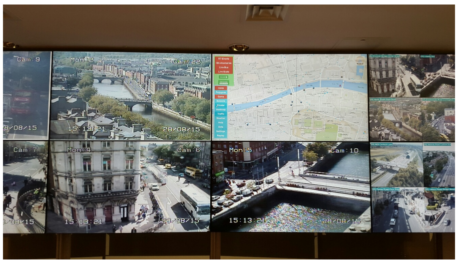
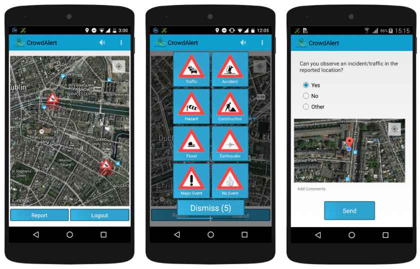


Fig. 1: DCC's traffic control center. INSIGHT system is running at the top monitor



(a) Events (b) Report (c) Queries

Fig. 2: CrowdAlert App

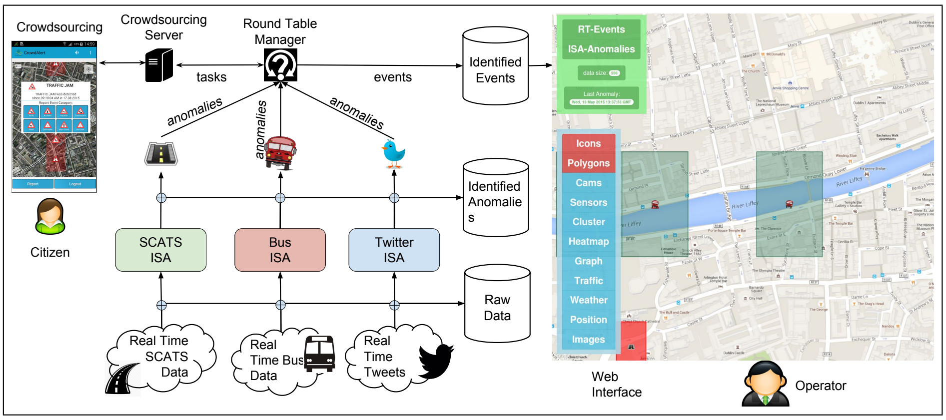


Fig. 3: Overview of the INSIGHT system showing the data inputs, the interface to the operators and citizens, and the connectivity between the individual components.

2 System Description

Our system, as described in Figure 3 consists of multiple components; each is responsible for monitoring an individual data source. Data are generated from a set of heterogeneous traffic sensor networks in Dublin. Each stream is processed by an *Intelligent Sensor Agents (ISAs)* that identifies *anomalies*. Detected anomalies are utilized to infer *events* (see Round Table below) and are presented to the traffic operators. In case of uncertainty, Crowdsourcing tasks are initiated.

Data Sources. Our system analyzes heterogeneous streaming data from the following input sources: (i) *Buses* that transmit their GPS location and information regarding their route. (ii) *SCATS* sensors that are deployed at intersections and transmit traffic flow measurements and the degree of saturation. (iii) *Tweets* that are posted by users in the Dublin area. (iv) *Crowdsourcing* input from users that provide feedback by reporting an event or answering to dynamic system queries using the CrowdAlert app from their mobile devices.

Architecture. Our system receives raw data from the heterogeneous data sources and channels processed information to the corresponding *ISA*[2]. The *SCATS ISA* checks whether the SCATS sensor's behaviour deviates significantly from its neighbours behaviour, using a multivariate ARIMA model .

The *Bus ISA* is responsible to detect anomalies, monitoring the streaming bus data. This component exploits the Lambda architecture sending the streaming data to concurrently running Complex Event Processing (CEP) engines, that monitor whether the streaming data trigger the set up rules. This component enables the automatic adjustment of needed resources (elasticity), estimating the system load in upcoming time windows, using Gaussian Processes [4].

The Twitter ISA utilizes tweets that are geo-located in the Dublin area and identifies those that describe an event (traffic, flood, or fire). In order to achieve this an SVM text classifier is used. The Twitter API sets a number of constraints in terms of how many users, keywords or locations can be tracked at the same time. INSIGHT utilizes a dynamic filtering approach that continuously evaluates candidate keywords, users, and locations and selects an optimal subset.

The output of the ISAs is integrated in the *Round Table* component, which aggregates information [3], infers about what is happening and forwards the detected events either to the DCC operators through a web interface or to the crowdsourcing users requesting clarification. The *Crowdsourcing Server* acts as a middleware among the system and the users. Its main responsibilities are: (i) to keep track of the active users that are able to participate in the crowdsourcing tasks, (ii) to assign tasks to the Crowdsourcing users, in order to resolve possible ambiguities [2], (iii) to receive reports asynchronously from the users when an event occurs, and (iv) to provide feedback to the users regarding ongoing events near their location. The *Crowdsourcing App* is an Android application, called CrowdAlert[3] (illustrated in Figure 2) that enables the human crowd to monitor the ongoing traffic events and provide feedback to the authorities.

User Evaluation. INSIGHT has been recently evaluated by the Traffic Management team at DCC. A set of employees with diverse responsibilities were selected, evaluated the system and filled a questionnaire. The questions regarded the usefulness and accuracy of the system and how it affected their workflow. The team members were quite happy with the system that provided them accurate events in real time and a set of tools that visualize real-time and historical data[4].

3 Demo Description

We will demonstrate the web interface and the CrowdAlert app that visualize the detected events, from the Bus, SCATS and Twitter *ISAs*. During the demonstration, both, real-time, and historical data will be available, to highlight multiple

[2] `http://www.insight-ict.eu/sites/default/files/deliverables/D2-1.pdf`

[3] `http://crowdalert.aueb.gr/`

[4] See `www.insight-ict.eu/sites/default/files/deliverables/D6-2.pdf`

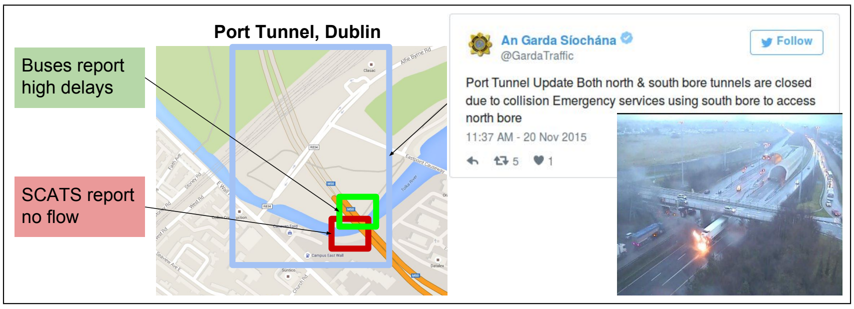


Fig. 4: Visualization of a fire event in Port Tunnel, Dublin

aspects of the system. An example of an identified fire event is shown in Figure 4.

Equipment. We will be using a laptop in order to demonstrate the front-end of INSIGHT, which is currently used by DCC. We will also be using Android devices to demonstrate the CrowdAlert app.

Demo Plan. The users will be able to view and interact with the system that is currently deployed and running at DCC. They will be able to overview information about the anomalies and events identified by the analysis components in real time. Moreover, the users will be able to select past time periods, redefine the analysis thresholds and parameters and re-run the system. Users will be able to generate plots that visualize data originating from the Buses and the SCATS sensors. Finally, we will also demonstrate the CrowdAlert app using smartphones and tablets. The users will be able to use CrowdAlert and interact with our system. Thus, they will be able to observe events that take place in Dublin in real-time as well as to report events and provide feedback through crowdsourcing tasks.

References

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