Integrating spatial information systems with smart sensor networks to build **inclusive smarter cities**

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SHARING SMART CITIES SUMMIT
LUZERN, SWITZERLAND
14 JAN, 2020

Background

- Recent catastrophic events in and around cities in both Australia and India highlight the need to improve their preparedness and resilience to extreme events.
- **Jul 2016, Gurgaon, India:** had thousands of commuters stranded for more than 12hours in the worst ever traffic jam caused by rains and overflowing flood.
- **Sep 2016, South Australia:** around 10,000 citizens of South Australia were cut off from electricity supply when a storm knocked down transmission towers and lines
- **Dec 2019, NSW and Victoria:** Bushfires have claimed 27 human lives and millions of cattle and livestock so far with thousands of homes and businesses destroyed

Australia is burning

Introduction

- With **rapid urbanisation** around the world, more people than ever now live in metropolitan and regional cities and contribute to a major share of our economic output.
- This rapid growth is putting **pressure on our urban and sub-urban infrastructure and social ecosystems** e.g. housing affordability, jobs availability, environmental hazards, traffic congestion, crime and social disorder etc.
- Need to rethink the way our cities are **planned, built and managed** today, to secure our future prosperity, global competitiveness and sustainability of our resources.
- All levels of government and society need to work in **partnership with all the stakeholders** (e.g. ordinary citizens, small and big businesses) to achieve this vision

Scope

- **Engage and include the citizens** to create and maintain urban services by building inclusive smart cities in Australia and India.
- Use Internet of Things (IoT) as backbone to **integrate spatial information systems** such as Indian Regional Navigation Satellite System (IRNSS) with sensor networks
- Deliver a scalable model for a smart city that is **aware, empowered, inclusive and resilient**.

Objectives

- Combine the existing network of mobile phones of the citizens with the embedded high precision sensors to develop a **robust and economical** information management system
- Facilitate a **seamless two-way communication** between the facilities managers and the citizens.
- Validate our model in two distinct socio-economic and demographic environments to **assess its scalability** in other urban landscapes around the world.

Approach

- Multi-disciplinary: Engineering + Business
- Develop the following technology modules using the sensor driven data backbone:
  - smart mobility, both pedestrian and motorized
  - smart and inclusive infrastructure
  - smart energy management (both grid and home)
  - smart human comfort management
- Develop business models for commercialization of these modules in both retrofitted and greenfield cities around the world.

Key Features

- A **sensor network** with a combination of crowdsourced mobile phone sensors and high precision embedded sensors for an efficient information management system.
- A **framework for democratisation of urban services** through a seamless two-way communication between the facilities managers and the citizens.
- **Development of two smart precincts**, one each in Australia and India, that will act testbeds for a host of new smart technologies.
- **Smart mobility:** Optimal use of transportation networks and infrastructure to manage multimodal urban mobility issues such as positioning and communication with vehicles, devices, people and infrastructure.

Key Features

- **Smart infrastructure:** Develop and test smart platforms that engage and enfranchise citizens in the performance and monitoring of infrastructure through smartphones
- **Smart Energy Management:** Improve energy management processes, increase productivity and lower operational costs by networking with building and precinct energy systems.
- **Smart Comfort Management:** Enhance and optimise precinct scale human comfort through regulation of heat distribution by active and passive means using embedded control systems to mitigate urban heat island effects.
- **Develop business models** for commercialization of the above technologies, especially for the projects initiated through the Smart City Mission of Government of India.

Internet of Things (IoT)

- **Internet of Things (IoT)** refers to a world where spatially distributed objects are connected by communication and data networks forming large interconnected and interdependent systems.
- In this project, IoT describes the data collected from an **array of sensors** that is combined with geospatial data from other sources and analysed in real-time or near real-time to deliver the planned improvements.
- The IoT component will provide sensor, computation and storage resources as well as software and data science resources to undertake the required **advanced analytics**.

Sensor Networks

- **Sensor Networks** are spatially distributed sensors used to measure, monitor, compute and communicate physical or environmental conditions for analyses and decision making
- Helped by Increased spatio-temporal resolution in real-time the new wave of technologies in intelligent sensor platforms, wireless communication, and localized and collaborative processing
- We will use low-cost, high-precision GNSS-sensors for the integration with the spatial network information to ensure granularity of the spatial information (e.g. localization, weather and timing as well).
- Supported by the Indian satellite navigation system (IRNSS) that became operational in May 2016.

Infrastructure

- This project will focus on **smart maintenance of transport infrastructure** such as road and bridges to overcome the limitations posted by existing monitoring techniques
- We plan to use **smartphones to sense the anomalies** in the road surface from moving vehicles and integrate this smartphone application with the IoT platform to develop a comprehensive network of infrastructure monitoring.
- The anomaly classes will be mapped through IRNSS geo-reference database and **visualization of road conditions** will be realized on Google maps.
- We will evaluate the **impact of community participation** in maintenance of road infrastructure and develop business models to scale up the system at national level.

Mobility

- Mobility of non-motorized users such as pedestrians and cyclists faces challenges posed by rising vehicular traffic, poor quality of walk-bike networks and lack of physical connectivity between existing networks.
- This project aims to improve the inclusiveness and resilience of pedestrian and cyclist users with state-of-the-art sensor and processing technologies.
- We will capture the volume and movement of pedestrians and cyclists along spatial and temporal dimensions using the sensor network data.
- We will construct predictive models based on the proximity of amenities, quality of connectivity, environmental conditions and their accessibility to plan, design and monitor local-level solutions for mobility

Energy

- Smart energy management systems require customer awareness and participation in demand response (DR) and energy efficiency with an advanced metering infrastructure (AMI) that uses smart meters with two-way communication abilities.
- In this project, each dwelling or unit in the test sample will have a home energy management [HEM] system, which will control the appliances in the unit.
- Each home will take command from a centralized controller in order to provide instantaneous balance between available power and its consumption.
- We also plan to account for the availability of renewable sources like solar cells and battery storage.

Human Comfort

- Urban Heat Islands (UHI) are caused by accumulation of heated air from heat generating components such as buildings, vegetation, and people in a living habitat.
- Absence of natural ventilation in urban areas due to high building density, solar heating and artificial heat generated within buildings also fuel urban heat islands.
- These heat islands are not desirable both from the point of view of sustainable living and human comfort, leading to high energy consumption rates and harmful health effects in the long-term.
- This project aims to combine computational fluid dynamics modelling and laboratory/field experiments with sensor data to address this problem by developing a full-fledged synergistic design model.

Business Models

- We need sustainable business models and effective policy frameworks to ensure the longevity of the proposed actions and outcomes of this project.
  - Assess existing policies, service levels and delivery systems, institutional capabilities and governance systems, infrastructure and financing mechanisms.
  - Next, we would estimate the impact of this project on all sections of the society, its cost effectiveness, improvements in the living environment and service delivery, innovation and scalability etc.
  - Finally, we would make specific recommendations to make and track substantial improvements and include the communities and government agencies through consultations via a Web and mobile-based portal.

Expected Outcomes

- **Manage** urgent urban mobility issues using real-time data and algorithms based on spatial information and analysis.
- **Develop** infrastructure monitoring, software and operational tools for including citizens in the delivery and monitoring of precinct infrastructure via smartphones
- **Improve** energy and building management processes, increase productivity and lower operational costs
- **Enhance** human comfort through the identification and mitigation of urban heat island (UHI) effects and uptake of 'cool materials' for construction and pavement applications
- **Develop** business models to design, plan and deliver innovative solutions in a cost-effective and efficient manner

Thank You!

Comments & Suggestions