The UK Urban Observatory Programme – Newcastle:

Towards slightly less dumb Cities

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Summary
The concept of smart cities is predicated on an observation platform that measures how a city operates at many different scales and across many different sectors. Here we introduce Newcastle's Urban Observatory, the most advanced of the UK's wider Urban Observatory programme. We describe the vision and goals of the observatory and note the challenges encountered so far and the future direction for observatory implementation and research.

KEYWORDS: cities, urban monitoring, sensor networks, urban observatories, environmental monitoring, urban data systems.

1. Introduction

Astronomical observatories predate the modern era with examples from ancient Babylonia, Greece and China (Hoskin 1997). Long term observation underpins many of the key breakthroughs in astronomical science some of which have been based on the serendipitous collection of data e.g. background cosmic radiation (Dicke, Peebles, Roll, et al. 1965), the expanding universe (Hubble 1929) and exoplanets (Latham, Mazeh, Stefanik, et al. 1989).

The concept of an Urban Observatory (UO) is an attempt to ape the breadth, longevity and success of astronomical observatories in understanding how cities operate at many different scales. Observatories are predicated on observations made through measurements from sensor networks and are therefore often confused with or rolled into the "Smart Cities" idea and it seems that there are few cities that aren't in some way smart (Sanchez, Muñoz, Galache, et al. 2014; Open University 2016; Mayor of London 2016; Amsterdam Smart City 2016). Many implementations of "smart cities", when examined in detail, are often limited examples of using digital technology, data and observations to optimise certain processes or functions (e.g. traffic flow), many bounded by small geographies or sector specific. Angelidou (2014) examined many of the smart city policies and highlighted the many approaches and shortcomings to smart city development policies. A cursory reading of the popular press (e.g. (The Guardian 2016)) would also have us believe that the only thing standing between magnificently optimised smart cities is the vision and economic will to deploy sensors and consume data. The reality is that the observation and monitoring platforms to deliver smart cities at the multiple scales that cities operate on are still in their infancy and the governance, finance, maintenance, ownership, performance,

scale, technology, cultural, social and economic capital that underpin their development are poorly understood and the empirical evidence base is at an early stage. Hence, we may be some way off developing truly smart cities buy may make our cities slightly less dumb and improve the lives of their citizens.

2.   A Vision for an Observatory

The Newcastle Urban Observatory is part of a wider network of Urban Observatories funded through UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC 2016).   The concept of an UO is not new e.g. (Barnes 1974) but through IoT devices and digital networks we now have some of the technological building blocks to realise them.   Newcastle's vision is based on the simple concept that the only way to understand how to monitor a city is to try and monitor one.   That is, the monitoring platform must match the scale, complexity and scope of our modern cities.   This is not just the spatial scale but also the breadth, resolution and type of measurements taken, but also cognisant of legislative and administrative arrangements. Figure 1 shows some of the many challenges that UO programmes could consider which highlights the scale and complexity of the problem because of the considerable overlap and interconnection between issues e.g. transport policy affects GHG mitigation and subsequent public health impacts,
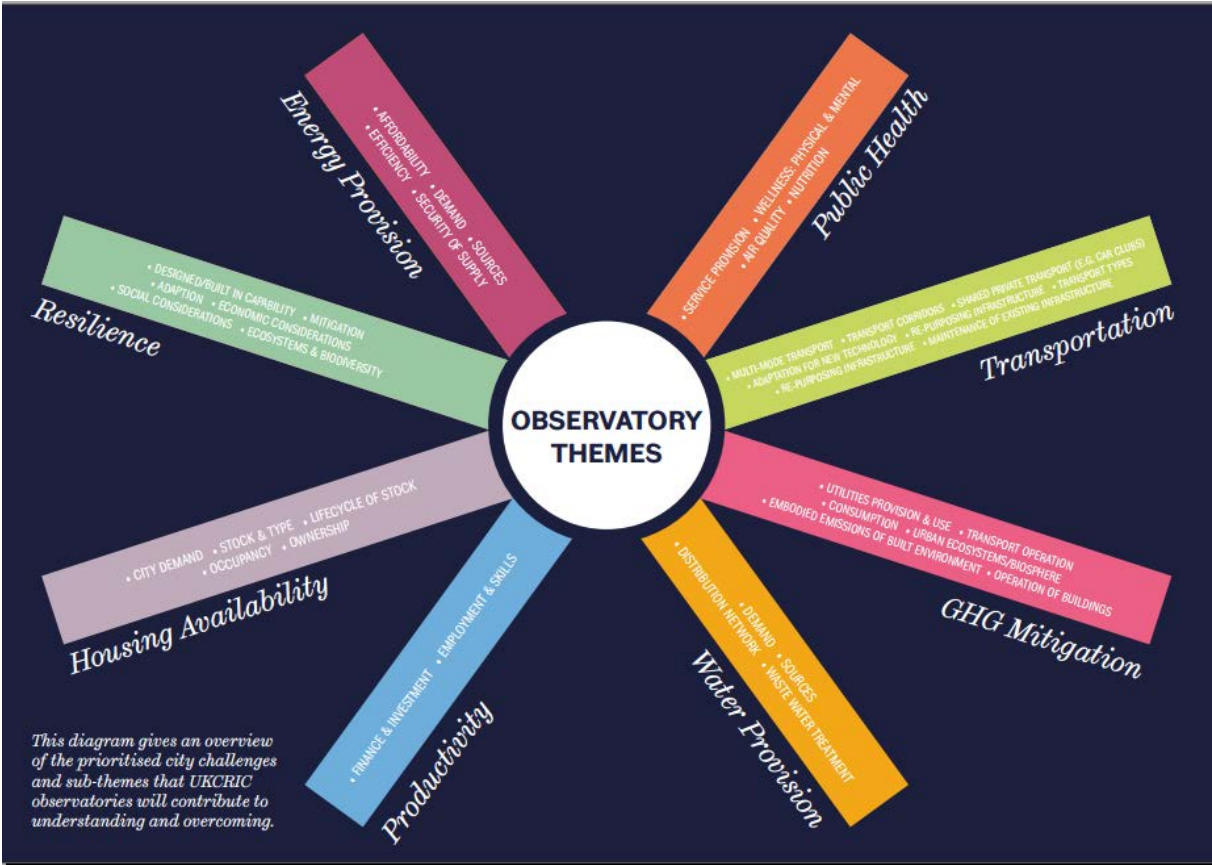

Figure 1 Urban Observatory: City Challenges from (Pearson, Jubb, Mayfield, et al. 2016)

The Newcastle vision is to collect a wide range of measurements from many different instruments and platforms to develop a baseline of data across the city at many scales and for many sectors.   This baseline provides the evidence base for policy intervention, a benchmark to monitor effectiveness of policy and a valuable asset for simulation and experimentation.   The supporting technological platforms to retrieve, store, analyze, visualize and share this data are also required.   The socio-technical processes that enable

deployment across the city of many sensors (e.g. powering sensor gateways from existing city infrastructure requires the support and cooperation of the local authority and highways staff) and the people networks and processes needed to support them also form an integral part of the UO.   Like other cities (Bristol is Open 2016) we work closely with the Local Authorities to deploy sensors and share data.   In Newcastle the UO has adopted sensors paid for from the public purse to keep them operational and works with the City council to replace monitoring equipment and we rely on formal and informal partnerships to support deployment.

Although there are many similar, albeit smaller monitoring activities going on across the world there is a relative paucity of publicly available data.   We believe that serendipitous data discovery, data mining and potential unforeseen economic and social benefits can be greatly encouraged through adopting an open-data policy (Attard, Orlandi, Scerri, et al. 2015).   It is in this spirit that all the data and metadata collected are published in real-time.   Whilst, this provides many challenges as not all data is of the same quality it is through a "warts and all" open publishing policy that we promote acceptance, uptake, cooperation and partnerships.   This open approach has already encouraged interactions and projects with community groups, technology manufacturers, businesses and decision makers.

Another pillar of the UO programme in Newcastle is to be platform and technology agnostic.   There are a many commercial organisations keen to grow business opportunities from potential investments in sensor technology for cities.   The platform must support many different types of sensors from many different manufacturers because the scale of the problem can only be addressed by an evolutionary approach to deployment, adding new sensors as the technology improves and growing the network organically and piecemeal reflecting changing priorities, funding and technology.

3.   Progress, challenges and future direction

The UO Newcastle is currently beginning phase 2 of a 5 phase, six year project.   To date we have deployed approximately 700 sensors using many different technology platforms.   We measure over 56 different variables and collect city related data from social media (James, PM; Dawson, RJ; Harris, N; Joncyzk 2014). We have developed a hybrid NoSQL, spatial, relational data platform based on PostGIS clusters which currently holds over 250,000,000 observations and a middleware platform to provide data input and output. The currently daily throughput is over 1,000,000 observations.   We have complemented a number of "low-cost" environmental monitoring networks with specialised monitoring platforms such as high-precision AQ monitors and a rain radar.   A restful JSON API and download plus numerous visualisation tools have been developed (Figure 2).
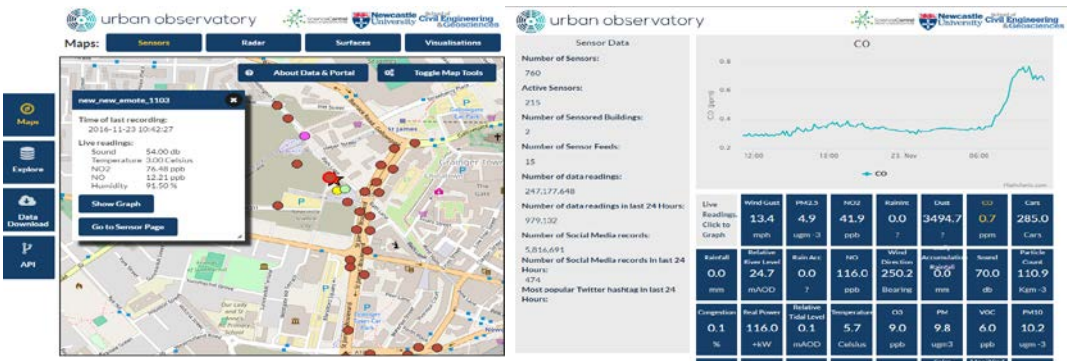

Figure 2 Some of the UO web interfaces (http://uoweb1.ncl.ac.uk)

Attempting to monitor this city at this scale has highlighted that there are significant challenges in both deployment and technology. Firstly, the "science of sensing" in an urban environment is poorly understood with fundamental questions such as the best scale to monitor, the density of sensors needed and the type and accuracy of the sensors still needing answering. The processes involved in physically deploying, and maintaining over the long term, sensors are often hugely underestimated. Even with full cooperation of all parties, deployment can take many meetings, email exchanges and discussions, site visits and has many administrative hurdles to cross.

From a technology standpoint the performance of the sensor platforms are difficult to quantify with co-dependent variability and micro-placement impact measurements (Popoola, Stewart, Mead, et al. 2016). Figure 3 shows an example of minute by minute variability of co-located temperature sensors. However, resampling using a 5 minute median eradicates much of the noise.
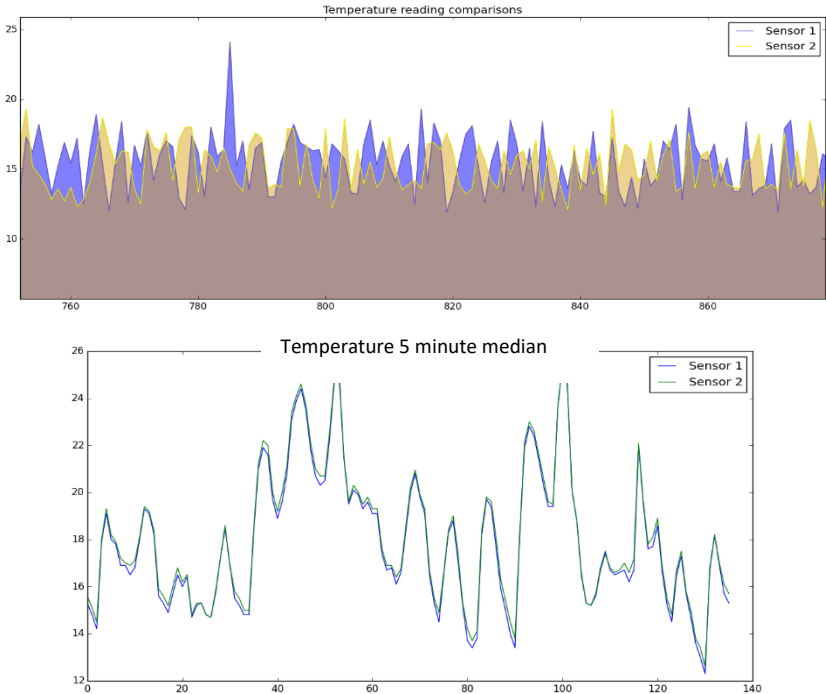

Figure 3 Minute by minute readings from co-located sensor and 5 minute resampled median values

In the pipeline, the Newcastle UO will deploy several hundred more sensors for general monitoring plus targeted research such as the impact of noise on communities and AQ exposure and health impacts. In September 2017 an 'indoor' scale to urban monitoring will be incorporated when Newcastle University's fully-sensored Urban Sciences Building opens. As other observatories come on stream we can further share expertise and good practice reflecting the individual character and challenges of our cities.

As (Jacobs 1993) stated "Cities are enormous laboratories of trial and error, failure and success…", but a laboratory requires robust and detailed observations to allow correct inferences to be drawn. It is through the UO programme at Newcastle and elsewhere that we can start to understand the science and supporting processes necessary for city monitoring, providing a long-term, robust evidence base and slowly make our cities a less dumb place to live.

4. Biographies

Mr Philip James is a Senior Lecturer in Geographic Information Science. Prof. Richard Dawson is Professor of Earth Systems Engineering. Dawson and James co-lead the UO research programme at Newcastle University. Dr Jennine Jonczyk is a researcher working on the UO programme with a focus on urban water. Mr Neil Harris is a researcher and software developer working on the UO programme. Mr Dave Pearson is a technician working on UO deployment.

5. Acknowledgement

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