# Estimation Activity In Urban Areas Using Passively Collected Data - A Case Study with Smart Street Sensor Project.

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I, Balamurugan Soundararaj confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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*Doctor of Philosophy*

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# Acknowledgements

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# Abstract

- data is everywhere but no information - need to understand population in detail - this research connects this two quests - Wi-Fi probes in built environment = detailed footfall information - we conduct experiments collect two sets of data. - we process the data with different methods to get footfall - we establish the application of the data with series of examples

# Impact Statement

- we live in era of explosion of data. - everyone is looking for ways to use data - this research looks in to one such data set - deals with collection, processing and application. - we develop a open-source toolkit for doing all the above - the research resulted in publications - Outputs with C.D.R.C and subsequent use of the data - methods communicated to data partner for industry application - (Gandomi and Haider, 2015)

# List of Outputs

1. Amsterdam Conference
2. Mexico Conference
3. Data natives
4. Retail futures Conference
5. C.D.R.C footfall dashboard
6. C.D.R.C footfall indicator
7. C.D.R.C footfall atlas
8. I.J.G.I.S paper
9. Transfer Entropy Paper
10. Medium data paper
11. GISRUK 2017
12. GISRUK 2019
13. Workshop talk - Tank
14. C.D.R.C book
15. Humans book
16. Footfall package R (to be done)

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# Chapter 1

# Introduction

We talk about the theory of cities and built environment. We start from how these have been perceived as function of the form and gradually changed to people, activity, economy and information. Built environment is manifestation of information exchange that happens in them. We talk about the change in theory regarding this. We talk about how this information exchange has been becoming more and more open and the opportunity it provides us planners, geographers and researchers to understand these things better.

Along with the information age there is an explosion of open data. The data collection has changed from structured high effort activity to low effort scraping activity. The data generated by scraping is unprecedented and staggering. Most of the Big-data research has gone into this in the past decade. Disadvantages of structured data which the unstructured data fills. This is changing how we view, understand and experience the world. Some of these datasets fall into this unique medium size category as well which are neither big data nor trivial. There is a need for methods and tools to collect, convert and use these data.

Talk about the ubiquity of the mobile technology. Everyone has a device which connects them with world wirelessly. Major ones cellphone and Wi-Fi Wi-Fi is uniquely placed in between Cellphone and Bluetooth. The design of Wi-Fi gives us amazing opportunity. This has been done before for the past decade by loads. The privacy advocacy has become a new thing. The change is from both ends. Collectors are regulated, cellphones are getting sneakier. Need for method to collect data and analyse it without compromising on privacy. The conversion of this unstructured data into something tangible and measurable is not a trivial problem. There are loads of such data and measurements. Examples - banking vs economic activity, oyster card data vs movement.

The potential use of such information is immense. Give examples of smart city paradigm and connected city where real time census is possible. We can not only take snapshot of the state of the city, we can record and understand the built environment as living, breathing organism. The insights we get by combining this information with other similar info is more than sum of their parts.

It can revolutionise understanding , planning, policy etc, urban management and finally industry such as retail, transportation etc. city mapper, sharing economy etc.

# Chapter 2

# Literature Search

## 2.1 Themes of Research

## 2.2 Technologies Used

## 2.3 Challenges Faced

## 2.4 Research Gaps

# Chapter 3

# Data Collection


**3.1 Wi-Fi as a Source of Data**

**3.2 Initial Experiments**

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# Data Processing


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# Conclusions

# Appendix A

# Source Code for Tools

## A.1 Wi-Fi Sensor Stack

## A.2 Footfall Data Toolkit

## A.3 Footfall Indexer

## A.4 Footfall Dashboard

# Appendix B

# Open Source Projects Used

## B.1 Programming Languages

## B.2 Libraries

## B.3 Tools

## B.4 Datasets

# Bibliography

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