Detecting and Modeling People Using Bluetooth

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Abstract

Detecting the amount of people in a certain area can be very useful in making a smart city more efficient. Some users could access the information to avoid densely packed areas while others could target the highly populated areas when needed. Current solutions to do this today depend on processor heavy image processing or power draining cellular or WiFi monitoring.

Choosing Bluetooth as a solution would save power and still have the capability to accurately predict the amount of people in a small area. Bluetooth Low Energy (BLE) also known as Bluetooth Smart can take the power profile even lower than standard Bluetooth.

The number of detectable Bluetooth devices would not always equal the exact amount of people in an area. To account for this a probability model was formulated as the basis for this project. If the amount of devices per person could be predicted with high probability, this solution could accurately predict the amount of people in an area.

Using a Raspberry Pi 3 and a custom Python script, multiple samples were taken which counted the Bluetooth devices in the area while the actual population was recorded. These numbers were used to get the number of people per device at that time. That data was used to give a number of devices per person with high confidence.

Motivation and Background

Detecting people was a challenging yet vital goal to be able to make transportation more efficient and safe. The ability to do this would allow better traffic management and allow commuters to better plan their drive around densely packed areas. Current solutions for this problem are expensive, complex, and use a lot of power.

The current solutions include computer vision, analysing WiFi traffic, or analysing cell phone signals. All of these can be extremely complex and for the solution that we were looking for, they consume too much power. The University of Maryland used Bluetooth to analyze car travel times on highways proving that Bluetooth can be used as a way to conduct traffic analysis. Instead of travel times, counting the amount of Bluetooth devices could give the amount of people in the area. Bluetooth has a small range of around 10 meters so it could give an estimation of how many people are in a small area.

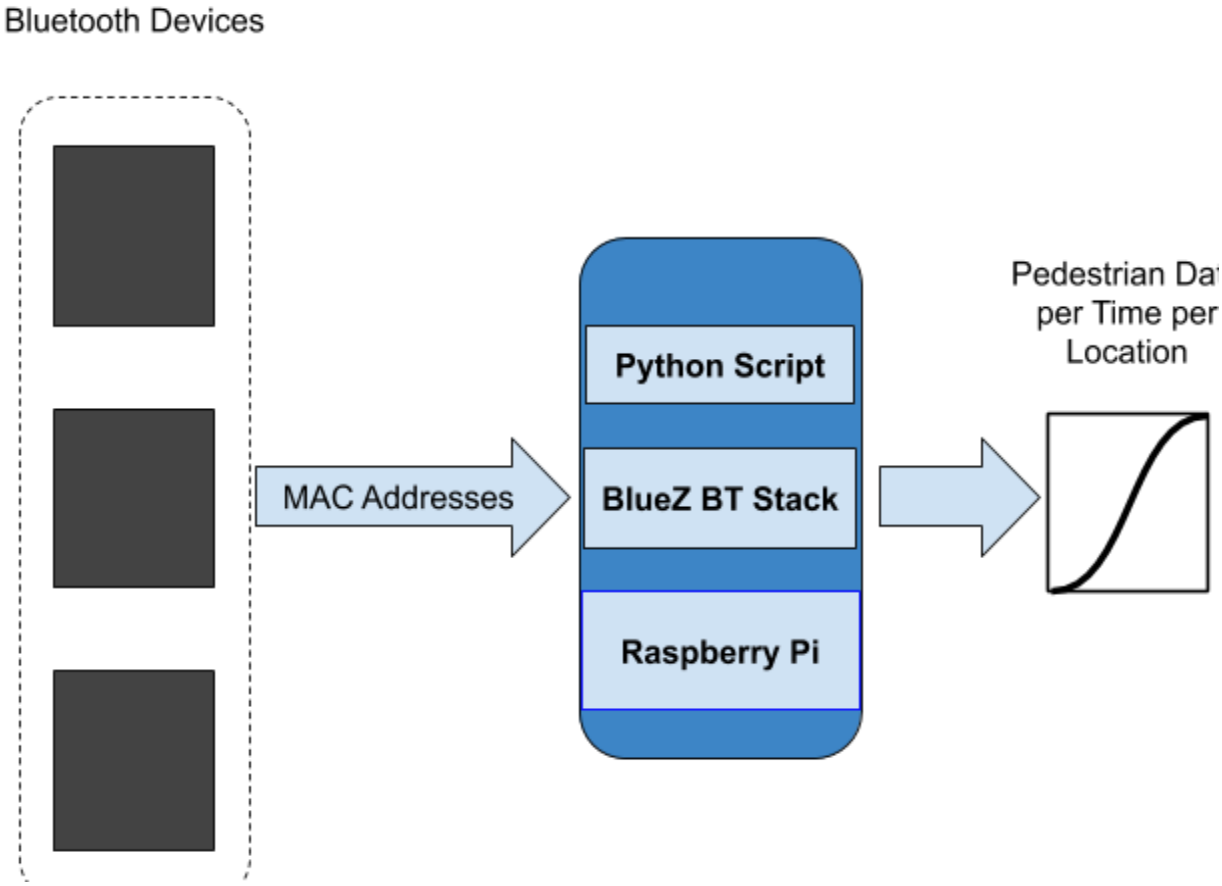
One problem with Bluetooth is that not all people carry a Bluetooth device and even when they do it is not always activated and detectable. To combat this experiments had to be conducted to create a probability model of how many Bluetooth devices there are per person. These experiments allowed us to correlate the amount of devices and the population in a small area and then accurately predict the population using the data we previously recorded.

Design and Experiment

The hardware we used was a Raspberry Pi 3. The Raspberry Pi has a Bluetooth module on it with the BlueZ Bluetooth stack that allows the user to control the module. A python script was written to scan and record the MAC addresses it could detect and get a count of Bluetooth devices there are by counting the number of unique addresses. Each MAC address is guaranteed to be linked to one Bluetooth device.

The experiments were conducted in front of Thompson Hall at the intersection of Garrison Ave. and Main St. Every sample taken would count devices in the area for 30 seconds. During those 30 seconds, the amount of people walking through the area were being counted. At the end of the experiment, the amount of devices was compared to the actual amount of people so in the future, the prediction for the amount of people in an area compared to the amount of devices can be made with high confidence.

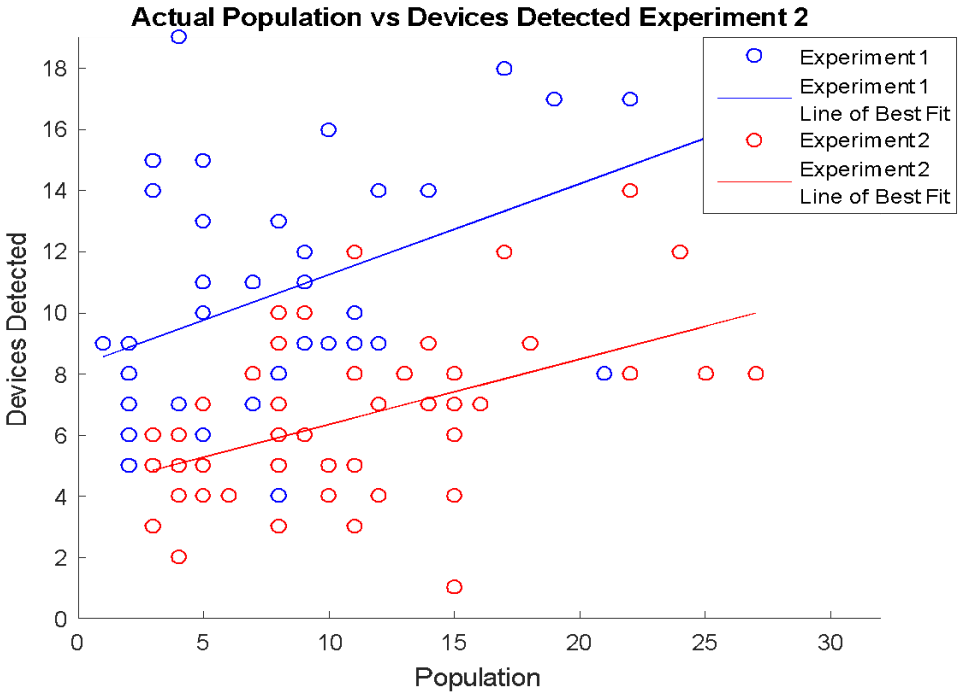
Block Diagram

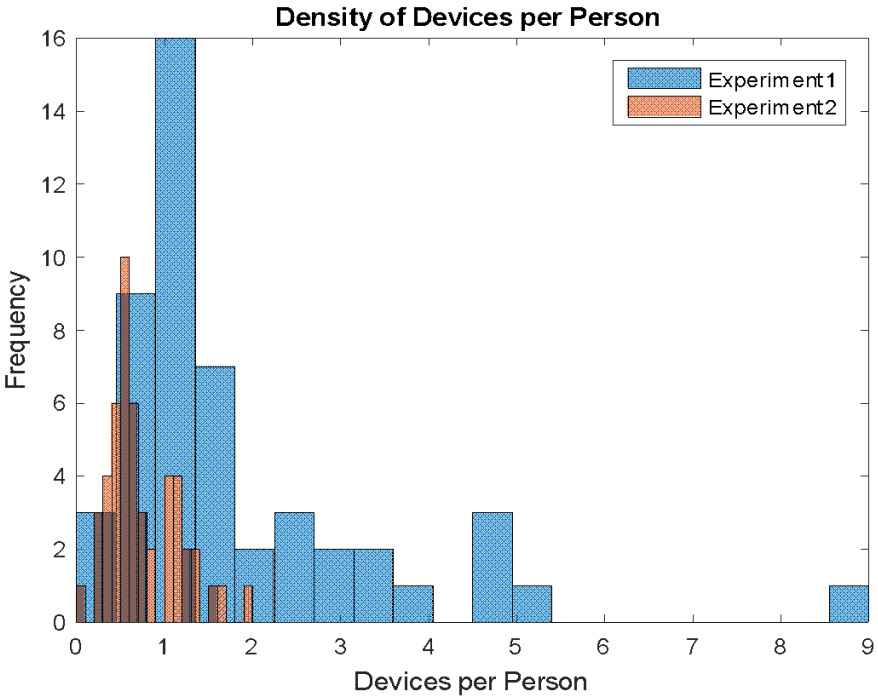


Data

	Devices per Person	
	Experiment 1	Experiment 2
Mean	1.86	0.74
Median	1.22	0.66
Standard Deviation	1.61	0.41

Correlation Coefficient	0.49	0.48





Conclusion and Future Work

These experiments proved that Bluetooth can be used to predict the amount of people in an outdoor area while keeping cost and power required low. Creating a strong probability model can make these predictions more accurate. These experiments showed that 1.5 devices can be equal to 1 person or 15 devices will be seen for every 10 people. These is the case 80 percent of the time with a confidence level of 90 percent. More experimentation can be done to get a higher percentage with a greater confidence bound.

In the future, these project can be upgraded to move away from an entire Raspberry Pi and move to a lower power Bluetooth module and use LoRaWAN to provide access to a central server using little power and cost. This data can be used to give real time predictions of population to users in Durham.