

モバイルセンシングによる人流推定

Human Crowds Estimation based on Mobile Sensing

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ABSTRACT

The estimation of human crowds has been widely used in urban design, traffic management, disaster evacuation and mobility prediction. Currently, several common methods of crowd flow estimation have different performances in terms of accuracy, cost and scope of application. In this research, we propose a client-server system based on Bluetooth scanning to obtain crowd information. Our proposed system has the advantages of low cost and location flexibility. The system can detect any area without pre-deployed, as long as there is a sufficient number of users involved.

INTRODUCTION

A crowd is a deformable group of people occupying a particular area. By detecting people crowd and capturing the context information within a specified area, we can analyze and even predict the mobility of crowds, such as people's number, direction or speed [1]. Crowd estimation has a massive impact on several applications including surveillance and security, situation awareness, crowd management, public space design, etc. For example, the government can decide how

to widen existing roads to alleviate traffic congestion based on the location information of high-density populations [2]. Besides, merchants can decide to place the advertising labels where can attract the most customers according to the walking track of the crowd on the commercial street. In the real-time environment, once a sudden increase of people in a certain area is detected, staff can immediately make evacuation work to avoid injury caused by crowding. On the other hand, users in a disaster area can select a road with a low people density according to the real-time information reported by the human crowd detection to avoid secondary damage caused by congestion [3].

Because the equipment and methods used to collect the raw data are different, the existing approaches have different performance in terms of cost, accuracy, and the scope of application.

MOTIVATION

We propose a client-server-service-based system that provides users with real-time crowd information. Our goal is to achieve a low-cost crowd detection system that is not limited by the location of the equipment installation, which means that the system can detect crowd information in almost any location without the

need to install the detection equipment in advance.

SYSTEM OVERVIEW

The workflow of the entire system is as Figure 1. A user can receive the crowd information by carrying a smartphone with our application installed. The application automatically collects surrounding crowd information every 10 seconds. Then send the data to the server through the Hypertext Transfer Protocol (HTTP) method. The server receives the data from smartphones and stores the information in the database. After analysis, the server sends crowd information inside that area back to the smartphones. The smartphones display the crowd information to the users through the graphic interface of our application.

We define the following roles to make our system easier to understand.

1. The user: After people installed our application on their smartphones, they become users and can check the crowd information in their area through the application. At the same time, their smartphones become crowd sensors, sending the crowd information surrounding them to our server through the network at regular intervals.
2. The Bluetooth device: Bluetooth devices are the devices detected by the smartphones through Bluetooth scanning. It could be any Bluetooth device that can be discovered, such as mobile phones, watches, headphones, etc. We estimate the crowds information by acquiring the information (number, location, movement

direction, etc.) of the Bluetooth device.

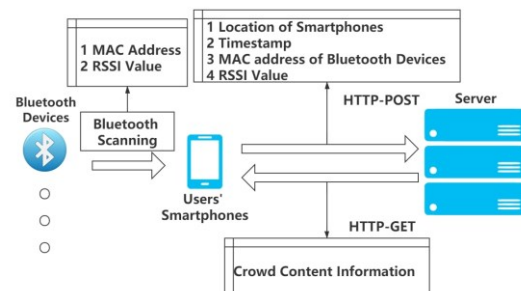


Figure 1: Structure of the System

3. The server: The server is the computer we set to provide the crowd information for the smartphones. After processing the information sent by the smartphone, the server sends the result back the smartphone, such as people crowd's density, mobility and location.

When the application on the smartphone starts working, it will scan the surrounding Bluetooth devices in BLE mode, then upload the device information to the server every 10 seconds. The message includes the timestamp, the location of the smartphone, and the RSSI value and the Media Access Control (MAC) Address of the scanned Bluetooth.

After collecting the crowd information from each user, we need to further analyze the data on the server to provide useful information for the users. Each piece of data is stored by the format including the timestamp, MAC address, geographic location and RSSI value. The specific meaning is that at a certain moment, a certain location, a Bluetooth device with a certain MAC address is found.

EXPERIMENTS

In order to verify the feasibility of Bluetooth detection, we conducted the experiments in 4 different scenarios.

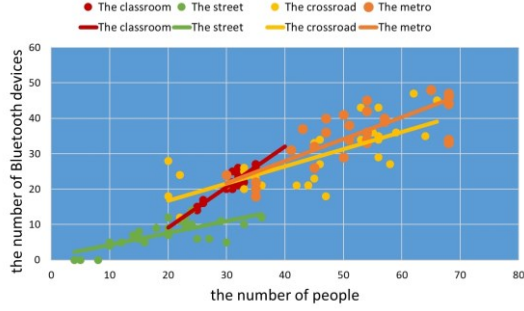


Figure 2: Correlation Between Bluetooth Devices and People

1. The classroom (20 m × 10 m) where the professor had a lecture.
2. The metro compartment (18 m × 3 m) with a random number of people getting on and off at each station.
3. The street with the low pedestrian flow
4. The crowded crossroad during the rush hour

In each experiment, every time we collect data, we scan the Bluetooth device within a radius of 15 meters with a smartphone installed our application. At the same time take a panoramic photo and manually calculate the number of people within 15 meters.

In the next experiment, we verified the feasibility of the entire system in actual use, including the case where multiple smartphones are used at the same time, the actual display of the analyzed data.

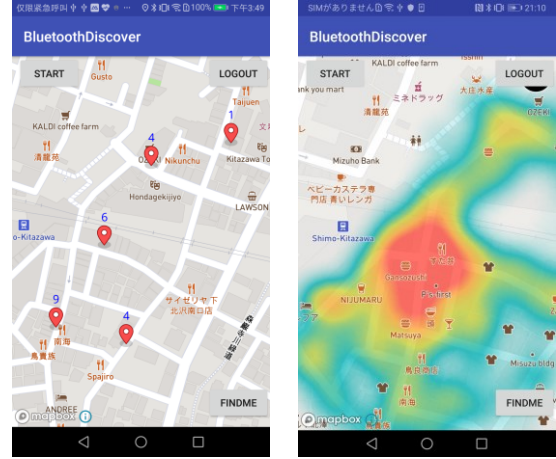


Figure 3: Screenshot of the Application

We selected the test area near the train station in Shimokitazawa, Tokyo. We asked 5 participants to walk around the station, each holding a smartphone installed our application.

The screenshot on the left in Figure 3 shows the number of Bluetooth scanned in real-time mode. The screenshot on the right shows the system displaying the flow of people from the past ten minutes in the heat map mode[4].

Finally, we will compare the proposed method with the GPS method.

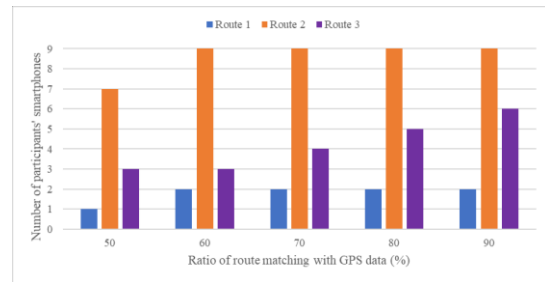


Figure 3: Screenshot of the Application

We operated the proposed system into the same environment with the GPS method to do the comparison. It proves that as long as enough people are carrying Bluetooth device, even if the number of users in the area is not large, the

proposed method can effectively capture the pedestrian flow information in the area. In the experiment, 10 people were required to obtain the route information using the GPS method. Almost less than half of the devices can use the proposed method to obtain results similar to the GPS method.

CONCLUSION AND FUTURE WORK

We propose a crowd information system based on Bluetooth scanning. It does not require the addition of equipment such as cameras or routers, so it has the advantage of low cost and flexibility. We verified its accuracy and feasibility through the experiments. We plan to conduct more experiments in other crowded environments to verify that our method can effectively capture changes in people's flow information in different environments.

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PUBLICATION LIST

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