Coffee Shop Line Length Monitoring Using Smartphones

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1. INTRODUCTION

Long and unpredictable lines at coffee shops, stores, etc., is an inconvenience of our daily lives. Many scientific studies indicate the customers' dissatisfaction with respect to the long line lengths [3]. In fact, most of the time, many of us are willing to pay more to wait less. In this context, a system to detect and report the current/future line length is of great use and could enhance the quality of our lives by providing us to make more informed choices.

In our previous work [2], we present a crowdsourced line wait-time estimation service called LineKing. LineKing utilized the proximity alert service on the participants' smartphones to detect the time spent at the coffee shop in our campus. Then using the aggregated crowdsourced data and by leveraging on the computational power of the cloud, our system is able to forecast future wait times with 2-3 mins mean absolute error.

In this work, instead of focusing on wait-time, we focus on the line length of the coffee shop. Our approach has three-fold. First, we detect the user's presence at the coffee shop. Once we detected the user's presence, then we measure the line length using the accelerometer sensor on the participant's smartphone. Lastly, since the line length will be uploaded to our server once the customer exits the coffee shop, we need to forecast the current and future line lengths using the previous history of the uploaded data. Below, we describe the components of our system briefly.

Presence Detection: First step is to detect the presence of the user at the coffee shop. In here, we use the similar approach as described in our proximity alert work [1]. In this approach, our method is to use the distance of the user from the coffee shop along with the transportation mode of the user to dynamically determine the location sensing interval and the location providers to be used.

Line Length Detection: Once we detected the presence of the user, our system utilizes the accelerometer sensor of the smartphones to detect the line length at the coffee shop. Our intuition is that when a user is in the coffee shop, she could make three basic activities; *Idle (I)*, *Low-speed walking (L)* and *Normal-speed walking (W)*. Moreover, while the user is in the line, she could exhibit a combination of I and L (while occasional W is also possible). Based on this, we first classify user's activities in every 10 seconds using the variance of the accelerometer readings as a feature. Then we find the region that exhibits the longest sequence of combination of I and L while allowing short/occasional W. In this region, we count the number of transitions from a lower-speed activity to a higher-speed activity such as I to L or L to W. We assume that the number will roughly correspond to the number of people in the line.

Figure 1-a shows the $l^2 - norm$ graph of the line waiting activity from entering to leaving (no sitting at the coffee shop). In this example the line length was 7. Figure 1-b shows the detected base events for every 10 seconds. As shown in the figure, there are 8 transitions from lower-speed activity to higher-speed activity. Since the last one corresponds to the service time, we could successfully detect the line length as 7. Our preliminary evaluation indicated that the accuracy of our system is around 2-3 person mean absolute error.

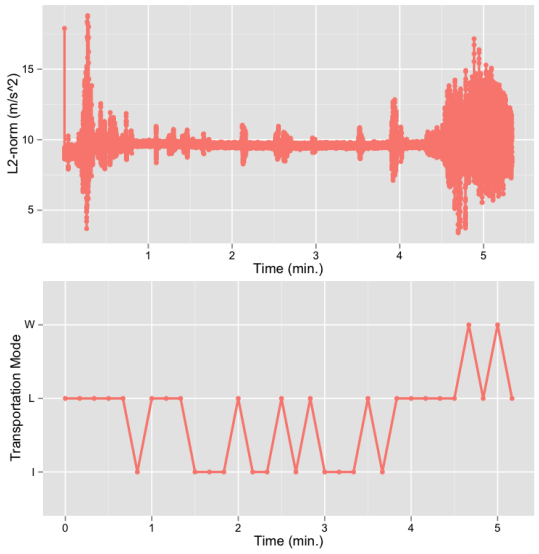

Figure 1: a) Top: $l^2 - norm$ of accelerometer readings. b) Bottom: Detected base events.

Ongoing work: In ongoing work, we are building the forecasting component which exploits the past data to predict the future line length. We plan to distribute and test our system as a part of our Android LineKing application [2] which has been actively collecting tens of accelerometer readings daily from more than 300 active users.

2. REFERENCES

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