TTI Model: Model extracting individual's curiosity level in urban spaces

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ABSTRACT
Recommendation systems have become widespread, however these systems only determine information inputted from the customers through a browser, and cannot be used when actually moving around outside. This paper presents TTI Model, a model extracting individual's curiosity level in urban spaces on their spare time by collecting behavior data from sensors. It calculates person's real time curiosity level by analyzing behavior depending on the walking speed within the city, such as window shopping or just hanging around by themselves. This paper evaluates this model with a sensor device prototype, and elaborates possibilities when understanding individuals in detail, by extracting the curiosity predicted from current behaviors using sensors.

Author Keywords
User Analysis, Bayesian Networks, Curiosity, Urban Experience

ACM Classification Keywords
H.5.2 Information interfaces and presentation: [Prototyping]

INTRODUCTION
Recently, many recommendation systems have been developed for web-based marketing. People use these systems to find out and buy anything that interests them, however these systems only determine information inputted from the customers through a a browser, and cannot be used when actually moving around outside. Therefore, there have been new applications starting to use information about individual's current behaviors directly [8].

This paper presents TTI Model (Time Transient Interests' Model), a model understanding people's curiosity level as a probability when walking around the city using their spare time of meeting somebody out. It aims to understand individual's real time interests by not relying on information the people input on purpose, but by collecting behavior data from sensors. It calculates person's real time curiosity level by analyzing users' behavior depending on users walking speed, collected from sensors. This is because we were motivated by the fact found from a case study of a person spending the spare time that 'gradually slowing down when finding something interesting' and 'stopping after a gradual decrease of speed, a person's curiosity level is quite high at the moment'. To verify this aspect, we have prototyped a sensor device to be worn on the users' waist with TTI running inside analyzing the sensor data, to be used when spending their spare time within the city, such as window shopping or just hanging around by themselves. By analyzing users with this prototype, the real time curiosity of a user can be calculated, which can lead to connecting users that have the same range of interest within a city by not using clustering. It can be used to calculate out hot-spots in the city by not clustering, but using each and everyone's original interest on a range from 0 to 100 percent. This paper elaborates possibilities when understanding individuals in detail, by extracting the curiosity predicted from current behaviors using sensors.

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RELATED STUDIES
CityFlocks is a mobile phone application facilitating social navigation in urban public spaces both directly and indirectly [2]. It utilizes average ratings and comments from local residents by categorizing and retrieving location in urban places, using tags generated by users to show comments or recommendations. CitySense is a mobile application within smartphones for people in San Francisco to find out hot-spots and where people-like-me are now in the city [7]. It happens by providing a map based summary of current hot-spots summarized by clustering the analyzed real time feeds of activity using the collected GPS data in smartphones to understand everybody's daily activity and detect anomaly outbroken or elevated clusters. Magitti is a context-aware mobile recommender system, generating recommendations of content matching from user activities [1]. These previous works enables users in urban spaces to find out what place may be suitable for the user by categorizing or filtering the user's activities on purpose, to be used for urban navigation. Our study aims to find out individual's curiosity points in the city by focusing on the unintentional behaviors users take when spending their spare time in Tokyo, Japan.

Schechtner et al. developed a recommendation system aiming to influence people's movement patterns within a national park for conserving [10]. User's real time location

data is collected using GPS and others sensors, and route suggestions or other information designed to influence the user's movement in the park is provided to the user on a PDA screen. Krumm presents a novel method for predicting the location of a driver's destination during the drive [6]. The prediction, based on the common intuition that drivers tend to chose efficient routes, is shown as a probability along with a map of driving times to compute the probability of any candidate destination from a database of driving trips they gathered with GPS receivers. Drivers use the prediction as a guide to decide which information to automatically present to the driver, depending on where the driver is going. These works predicts user's behaviors and use the data for suggesting what routes or ways to go next moment. Our study aims to understand individuals' behavior patterns and predict the curiosity level from them which we feel it has relevancy. The predicted curiosity level will be tagged with the GPS data, which the prototype consists, and produce an original map of curiosity. This will be able to use for recommendations or suggestions for people to head to as well.

CONCEPT

Detecting correlation of curiosity and walking speed

We focused on a female university student taking a random walk to spend her spare time in Kagurazaka, a town in Tokyo. Kagurazaka is a town of many ancient aspects, consisting many narrow roads easily leading to places that cannot be seen from the main broad road as if it were a maze. She was going to meet up with her friend, however her friend was tardy on time. We asked her to spend her spare time in the town with a 3D accelerometer and a GPS sensor taped on her arm, and kept track of the time by taking pictures and recording with a video camera. The sensors, connected to a laptop held by another person, were used to understand what kind of movements she will take when walking around the town, and tag the movements with a GPS value to keep track of where she walked. She walked around the town for about an hour, until her friend arrived.

Figure 1. Case study of a student's random walk

Undergoing an interview asking how her walk was, she found many things that interested her for example, a temple and a bookstore, especially curious at stairs near the end of a narrow road. She said this road suited her image of Kagurazaka, a nostalgic town. By analyzing the video recording her activities within the walk and having interviews, we found out she gradually lost speed when coming across an old general store and a bookstore, which she actually was curious about. When walking the narrow road that captured her heart the most, her walking speed was very slow. She seemed to repeat the action of stopping her feet for a second but start walking again very slowly. From her movements, we found out that individuals may gradually lose speed when walking and finding something that interests him/her. When actually stopping after a gradual decrease of speed, a person may be very curious at the time.

To support this hypothesis, we pursued an informal observation on Tokyo Station, the largest terminal station in Tokyo. In Japan, especially in Tokyo, most of the people use trains for their commuting, and not cars. According to a research executed by the Japan Railway company, there are nearly four hundred thousand persons a day using this station [1]. There are 12 different lines connected from this huge station, therefore there are department stores, large waiting rooms, restaurants, and even hotels within the station. People spending spare time in Tokyo station are waiting for their next train, meeting up with somebody, or just hanging around. We observed the department store underneath the terminal floor of the station, for many people young and old, male and female, are window-shopping. Most people who walk through the department store as a passageway do not even take a look at the stores around them, nor do they hardly change the speed of their walk. However, the people who are wandering around and window-shopping are all walking slowly, and slowing down when finding anything that caught their attention. After taking a close look, they started walking again heading towards the next store, which they lose speed and stop again. From this observation, the hypothesis of 'walking slowly when finding anything interesting and stopping after the gradual decrease of the speed, the curiosity level may be quite high' was strengthened. In addition, when walking at a rather fast constant speed, a person does not have much interest at the moment. We figured it may be possible to extract a person's real time interest considering the walking speed.

Model

We prototyped a sensor device to be worn on the users' waist, consisting 3D accelerometer sensor module "KXM52-1050" and GPS sensors to capture the speed change of a person. This prototype device is connected with a laptop computer by USB, to collect the axis with java synthesized Arduino Pro mini at a sampling rate of 50Hz. The synthesized data will be converted by FFT at a speed of 64 set of data per second to derive the power spectrum of accelerometer as other research executes [3]. The derived value of power spectrum will be categorized every second by Support Vector Machine algorithm into four groups; standing still, walking slowly, normal speed, and walking fast. The output of the SVM are values 1.0, 2.0, 3.0, and 4.0, each corresponding with the four states mentioned above.

Since every person's average walking speed differs, there is a need to collect data for supervised learning. We have done a test to record the walking speed of 20 university students,

[1] Japan Railway Statistics http://www.jreast.co.jp/passenger

and collected the 4 states of walking as mentioned above; standing still, walking slowly, normal speed, and walking fast. We asked the students to have 3 sets of walks of the school hallway for 10 meters, asking them to assume "the walk when are just taking a random walk", "the normal walk of when not thinking about anything in particular", "the fast walk when you are in a hurry". We considered these 3 types of walks as "walking slowly", "normal speed", and "walking fast". The sensor data divided into 4 groups will be used at the input of the TTI Model.

We figured Bayesian Networks will be suitable for calculating the real time curiosity from sensors. Bayesian Networks consist of a graphical structure and a probabilistic description of the relationships among the variables in a system. The variables represented as nodes can be connected by links of the network representing the properties of conditional on the configuration of its conditioning parent variables [4]. Bayesian Networks has become a popular artificial intelligence representation for reasoning under uncertainty for its effectiveness in describing dynamics [5]. This model has applied Russell's filtering [9].

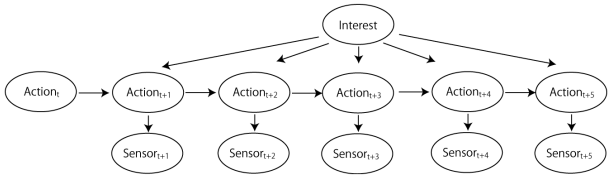

Figure 2. TTI Model

This model is used to calculate the probability of interest when sensor data is collected from the person every second. The data is the input, extracting the noise of sensors through the link under a probability of normal distribution, connected with the node of the action; standing still, walking slowly, normal speed, or walking fast. The interest probability considers the change of speed, regarding the action taken the second before. To implement out the TTI Model, we have used *Netica* [2], a commercially available java based modeling software, using diagrams to evaluate the expected value of functions.

EVALUATION

We wanted to verify whether the model understands individual's real interests by collecting behavior data from sensors, therefore we executed three field evaluations. All the evaluations were based on the interview and recorded the test using videos. First, we had a female university student spend her spare time for 20 minutes in Jiyugaoka, Tokyo. Jiyugaoka is a town in Tokyo with many vintage shops and general stores which many young girls feel attracted to, and has many open cafes and restaurants. After the experiment, we showed the subject the whole video during the walking and asked her to evaluate the places which she actually felt interested with value between 0 and 1. In this way, we confirmed the places of interest to the subject. This female is a foreign student, and has only lived in Japan for just over a year. She has always wanted to go out and find out how amazing Tokyo is, but she never had the chance. She was just the right person to have as our first prototype user.

She enjoyed hanging around in Jiyugaoka, seemed to smile when taking a look at the families that were having a break by the benches, and even sat down at a bench to take a look at the children. She took a look at the open cafes that have a terrace, and stepped into a camera shop, for she spent quite a long time checking them out neatly. The feedback that we obtained from the interview was positive, which answers corresponded with the probabilities TTI Model had calculated. *"I had a great time spending my spare time here. I especially liked the camera shop, toy store, and watching the children play with their parents and taking a rest."* Figure 3 is the comparison graph of her curiosity predicted from the model, having the x axis as 1 minute and the y axis as the probability ranging from 0 to 1. It certainly looks correlative.

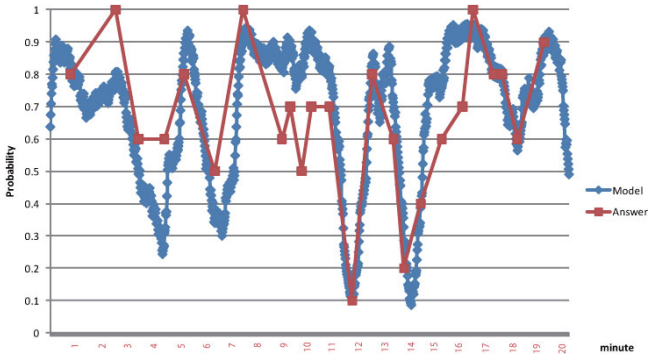

Figure 3. TTI Prediction and Interview Answers

Next, we had the same student spend the spare time around her university to prove the difference between first-visit-site and area of familiarity. The evaluation test lasted for about 20 minutes, in Hiyoshi, Yokohama. We started the field test from our school, where she met her friend and had a short conversation. There is a signal in front of the school, which she was caught and stopped for about a minute. Then she started walking straight towards the restaurant that she wanted to go to, which took a couple of minutes. She looked around a restaurant, but what caught her eye was a florist shop next to it. She had never been to the florist shop, but stopped inside and looked at the flowers carefully. She decided to buy a bunch of flowers.

Figure 4 is the analysis graph of her curiosity predicted from the model, having the x axis as 1 minute and the y axis as the probability ranging from 0 to 1. The model seems to have some difficulty dealing with red signals, which is to be discussed for refinement.

Finally, we executed a field evaluation with 20 university students spend their spare time for an hour at Ebisu, a popular place for young adults in Tokyo. We executed interviews with each and every users, which showed relevance

[2]Norsys Software Corp. http://www.norsys.com

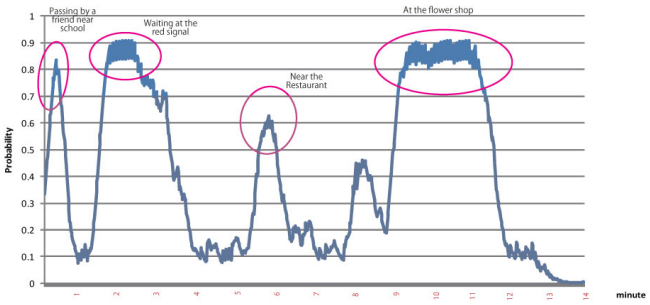

Figure 4. TTI Prediction and Analysis

as the preceding two tests did. According to the interview, any place most users felt curious about could be calculated from the model. The following is the result of the interest probability tagged with the GPS sensor to the map of Ebisu. Figure 5 is the map combining of all the students who did this evaluation. The places that have a high tower is an area that people felt interest in, according to the TTI Model.

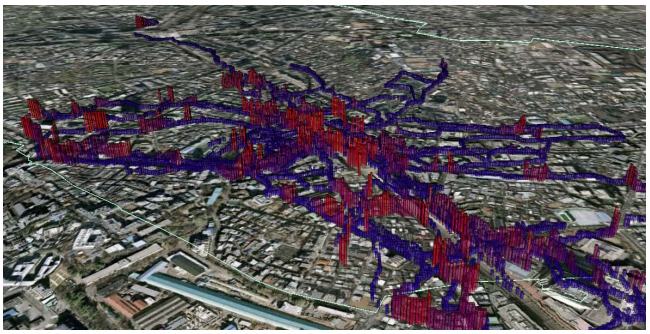

Figure 5. 20 Students' Curiosity in the city

CONCLUSION AND DISCUSSION

TTI Model was designed for extracting individual's curiosity in urban spaces by collecting behavior data from sensors on their spare time, such as window shopping or just hanging around by themselves. Despiting the refinements of red-signal stops or any other unfortunate stops, our evaluation suggests that the model is able to calculate the curiosity level by analyzing users' behavior depending on the walking speed. We elaborate possibilities when understanding the customers in detail, by the extracted curiosity from this model.

Although TTI Model has shown relevance between speed and curiosity, there are improvements to be discussed. Data privacy may be a potential concern in persuasive applications using a sensors based approach. We also need to consider that people in the city do not normally walk with sensors attached to Arduinos, therefore when collecting the information through cellular phones or smartphones which many people walk around with these days should be discussed. For future works, there is a need to specify what kind of interest the curiosity TTI extracted was, and if understanding what people's real interest is, people will be able to receive feedbacks about what they really like and want.

ACKNOWLEDGMENTS

We thank any anonymous reviewers who gave us helpful comments.

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