Analysis of Appropriate Timing for Information Notification Based on Indoor User's Location Transition

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Abstract

The purpose of this study was to explore the convenient timing for information notification of the users in their daily life. Using the location and the time interval since a location change, we have examined the features of the user's response to information notification. For a period of three weeks, four subjects carried mobile terminals which randomly notified them about daily information. The obtained results showed that the responsiveness is high just before and after change of subject's location. The responsiveness decreased with the increase of the time interval since a location change. The change of the responsiveness differed with the subject location and its change through time was symmetric for the time intervals before and after the location change. An effective control of the notification timing could be obtained using the information about the user's location and the time interval since the change of user's location.

1. Introduction

Recently, the number of systems or email magazines which automatically provide everyday life information such as store advertisements or news is increasing [1]. However, the numerous alerts (sound, vibration, etc.) could become annoying for the users as many of the systems generate notification as soon as they receive the information, thus strongly hindering the user notification attendance. Moreover, in many cases, the user's task is barred and the productivity is reduced [2][3]. Therefore, it is necessary to be able to control the notification timing according to the user's situation.

The systems that deliver information according to the user's status are roughly divided into two groups by content type. The first is a system that delivers content directly relevant to the user's context where a typical system delivers information relevant to that particular time and that particular location [4]. Since the content of the notified information relates to the user's situation and the timing and user information requirements are relatively clear, it is usually used for sightseeing guidance [5][6], or as reminder notification [7]. The second type of system delivers content not directly dependent on the user's situation [8]~[12]. They usually assume cases of work/office related information where the notification timing is controlled based on inputs such as schedule information inputted beforehand, presence or absence of a dialog, working with a computer or not, etc. As the work related information usually contains time critical information such as email, urgent telephone calls or meeting appointments, it is important to deliver the notification as soon as possible. However, in the case of the everyday life information, user preferred timing for the notification is more important than early notification. It is already known that the perception of suitable timing depends on the period of the day, such as lunch break is always appropriate [13], suggesting that the suitable timing also changes with location, such as notification in the conference/meeting room is always inappropriate. Therefore time and user location should be sufficient to effectively control the notification timing for everyday information on a mobile terminal, especially as the users prefer notification immediately after a location change [14].

This research particularly paid attention to the *change of user's location* events in order to experimentally verify the feasibility of effective notification timing related to the time interval after the change. In order to analyze the dependency of notification timing effectiveness on the time interval since location change, we conducted an experiment using wearable information terminals that notified the users about everyday life information at a random timing. We then investigated the property of the subject's reading response to the notified information. The obtained result showed that the probability that information will be read is very high when it is notified before and after location change. The read-probability

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decreased rapidly as the relative time from a location change increased. Moreover, the change of responsiveness differed with the user's location and it was symmetric for the time intervals before and after the location-change event. Therefore, we can effectively control the information notification timing by the type of location and the relative time from location transition event.

2. Analysis of the notification timing using a response history

Most of the conventional examinations of the appropriate notification timing are based on the subjective self-assessment of the users [8][9][13]. However, they usually do not consider that the users may have missed some actual notifications and were thus unable to accurately evaluate the actual disturbance or burden by the reading action. When dealing with content of everyday information of low importance, a more detailed and realistic *in-situ* investigation is required. In this research the users were asked to continuously carry a mobile terminal which notified them about news information with a light or sound alert. The suitable notice timing was investigated by analyzing the presence or absence of a user's reading response to the notified information.

It was reported that users preferred information notification immediately after a location change when they usually do not perform tasks such as reading, or having a meeting [14]. However, when certain time has passed after the location change, the user begins a new task and is inconvenienced by the information notice. When time vs. location for the same user were compared, it was reported that location had more influence on the user response property [14]. A location may influence not only the average response property of a user, but also the time transition of the response property of the location change event. Furthermore, depending on the possible specific functionalities of the locations, the tasks that the user performs may differ. A system that notifies the user about such location functionalities, such as restaurant - a place where eating and drinking is possible - was also proposed [15]. Therefore, depending on the location, the changes of the response time until the user initiates a task as well as the time after finishing the task and moving may also differ. In this research, we have examined the changes of the user's response to information notification depending on the relative time interval since a location change. We have also investigated how the response property from a location change event changed for every location.

3. Outline of the response experiment for information notification

In order to investigate the relationship between the user's response and the relative time from the user's present location and a location change event, an experimental PocketPC-based notification terminal was developed. Four subjects working in the same office carried the notification terminal for a period of three weeks. The terminal notified the subjects about new daily information (mainly news) by a blinking light and sound effects on average once every 3 minutes, 24h a day. The sound volume or mute was selectable by each user. In order to evaluate the notification timing of the information, we analyzed the presence or absence of the user's reading response. After an information notice has occurred, if a user pushed the notice stop button, the notice sound and the blinking stopped and the terminal displayed the information content. If the users read the information after it was displayed, they pushed the reading confirmation button. If the users did not notice the notification and the notice stop button was not pushed for a fixed period of time, the terminal stopped the alert automatically. In the case that subjects did not want to read the information and only wanted to stop the alert (as it was hindering their current task), they did not push the reading confirmation button. We assumed the user's reading response was present only in the case that the user pushed the reading confirmation button.

A great portion of time in the actual everyday life is often spent inside known buildings such as offices or houses, thus it is important to know the user's exact room position. Instead of a GPS based system, the user location in our experiment was detected by the terminal built-in Bluetooth module searching for Bluetooth landmarks. We placed 12 Bluetooth landmarks at places that are commonly visited by the users at their working place (sitting-room, cafeteria, conference room, smoking room, toilet, etc.) or at their house. When the terminal was not able to detect a neighborhood landmark, the location was marked as unknown. A location change occurrence was defined as an event where a landmark was no longer detected (user moved to unknown location far from the previously known landmark), or a new landmark was detected (user moved to a new and known landmark location). Since the effective Bluetooth communication range is about 10 m, a location change event occurred as the user was moving. For example, for a user moving from a sitting room to a toilet, the location change event was recognized after the toilet landmark was detected.

4. Experimental results and discussion

4.1. Response property and location change

We have calculated the users' response probability (number of read information notices over the total number of information notices) for three cases – *just before location change*, *immediately after location change* and *others*, as shown on Fig. 1. For a user move from location A to location B, the *just before location change* value is calculated for the period of one minute before a user has left location A, while *immediately after location change* is calculated for the period of one minute after the user arrived at B. *Others* is the response probability calculated for all other periods while *total* is the users' overall response probability. As shown in Fig. 1, both response probabilities, before and immediately after location change events, were about 55%, much higher than that of about 7% for *others*. The results suggest it is effective to perform information notification just before and immediately after the users change their location.

Figure 2 shows the calculated user's response probability per minute since the location change event. The positive relative time is the lapsed time from a location change event until an information notice, while the negative relative time is the lapsed time from an information notice until a location change event. The curves are represented using 6^{th} order polynomial approximation. As we can observe on Fig. 2, the response probability has high values just before and after a location change, but decreases rapidly with the increase of the relative time until it stabilizes at a certain low value. We feel this rapid falloff in response probability is linked to gradual task uptake upon location change. The information notice is convenient immediately after location change when the users are not performing a task, but as time progresses, the user begins to concentrate on his next task, making the information notice inconvenient.

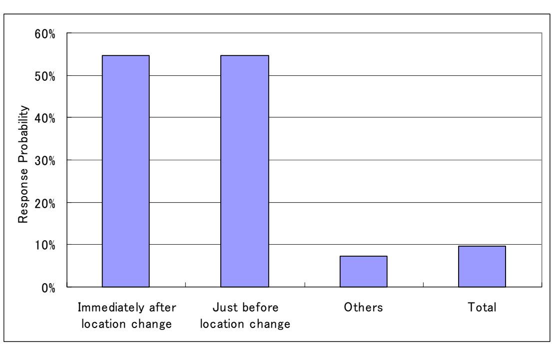

Figure 1. Response probability immediately before and after user's location change event

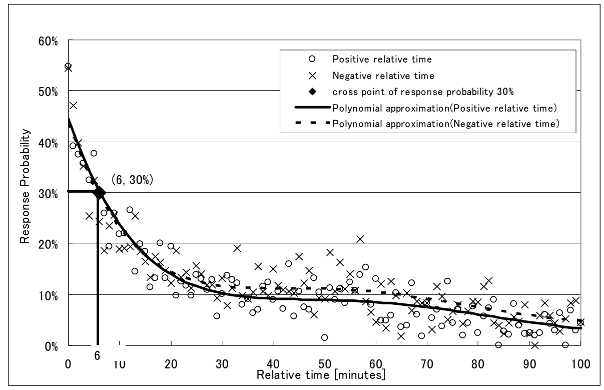

Figure 2. Response probability relative to the time around change of user's location

Furthemore, we believe the users like the information notice just before a location change in order to end the task which was being performed. Therefore, it is important to notify information while the response probability is high, i.e. as a task is ending or just before a new one has begun. As an example from Fig. 2, if we want a notification response probability of 30%, it is necessary to deliver the notification within the first six minutes after the location change event happens.

4.2. Classification of the response transition

Figure 3 and Fig. 4 show the results of the calculated response probability transition per minute for different locations. The relative time of Fig. 3 is positive, and it is the time lapse from location arrival to notification. The relative time of a Fig. 4 is negative, and it is the time since an information notice until user's location change occurs. By detecting the location dependent properties and type, we can perform an efficient notification timing control. As shown in Fig. 3 and Fig. 4, the transition of the response probability differs for each location and can be classified into three distinct categories as follows:

1. *L-type:* The vaguely exponential curve follows the shape of a letter L. Although the response probability just before and after a location change is high, when the relative time from a location transition event becomes long, the response probability falls rapidly to stabilize in a low value. The degree to which a response probability decreases depends on the location. From Fig. 3, although the conference room's response probability immediately after a location change is comparable with a sitting-room (living-room), its transition inclination is larger and the time until it stabilizes is shorter. Moreover, when compared with a conference room, the probability value of sitting-room after it stabilizes is higher.

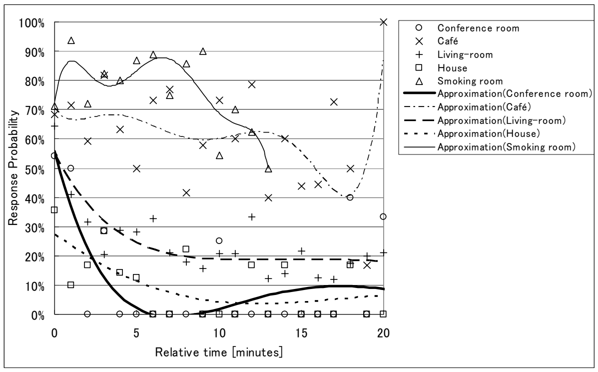

Figure 3. Response probability since change of user's location

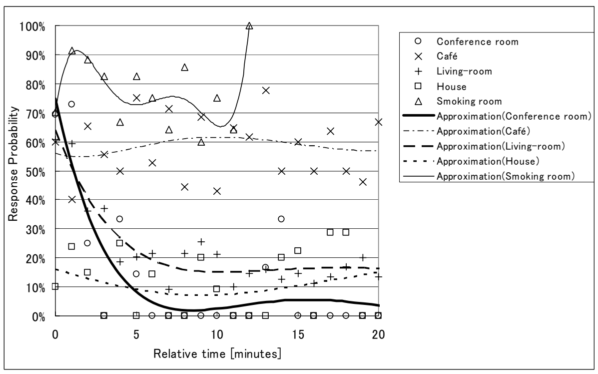

Figure 4. Response probability until change of user's location

This is because the tasks which a user performs in a conference room and a sitting-room are different. Therefore, it is important to deliver information notification at locations with L-type property before the response probability has fallen significantly.

2. *High-type:* This response probability category does not depend on the relative time and has a high value overall. For example, if we look at the plots for café (dining-room) or smoking room, they have a relatively high response probability as a whole and do not depend on the time after or before location change. It may suggest that café or smoking room are locations where users do not perform critical tasks, thus the information notification is not a hindrance. Therefore, at high-type locations, it is sufficient to deliver the information notification without consideration of the location change times.

3. *Low-type:* This response probability category does not depend on the relative time and has a low value overall. For example, in the case of *house*, even if we have notification just before and after a location change, the response probability is low overall. At low-type locations we should not deliver information notifications.

4.3. Symmetry of the response probability transition at a location change event

As shown in Fig. 2, Fig. 3 and Fig. 4, the response probability does not depend on the relative time being positive or negative, and its transition is very similar at the absolute relative times around location change. In order to verify this similarity, the average of the absolute difference of the response probability before and after location change event was calculated. The calculated results represent the degree of dissimilarity and their values for different locations as well as the total are shown in Table 1. As the degree of dissimilarity is very low and similar overall, we infer that at each location, at equal times before and after location change event, the response probability is symmetrical. The dissimilarity for *café* and *smoking room* is slightly higher due to the higher values and the large variation of the response probability. Based on the symmetric property, we conclude that the positive and negative relative time around location change event can be treated equally.

Table 1. Response probability dissimilarity between positive/negative relative times

Location	Conf room	Cafe	Living room	House	Smoking room	All
Dissimilarity	0.09	0.19	0.06	0.02	0.13	0.03

4.4. Detection and prediction of location change

If the location change event is detected after the user has already changed the location, the information cannot be notified before the event happens. Therefore, it is required to predict when a location change event could happen. In this research, we wanted to investigate whether an occurrence of location change event could be predicted by predicting the user's length of stay for every location. Up until now, the time action pattern was detected based on analysis of the users schedule or the computer-operation history. There are already some research efforts trying to detect when somebody would return from an absence to a sitting-room by predicting the length of stay based on time information [16][17]. However, those approaches are effective only for actions that solely depend on time, such as going to a dining-room during lunch break. As in everyday life there are very few strictly time-dependent user actions, we examined the possibility of *length of stay* presumption using place information. The distribution of the length of stays calculated as a frequency (# stays of x minutes in location A / total # stays in location A), for *conference room* and *café* is shown in Fig. 5.

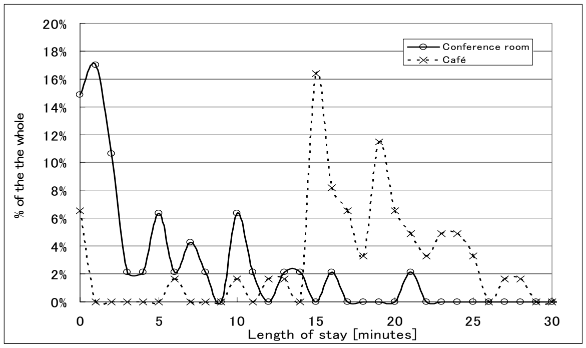

Figure 5. Distribution of *length of stay*

We were looking for a level of predictability by obtaining the frequency at which the subjects stayed a particular amount of time in any given location, e.g. 16% of the time the subjects were in the café for 15 minutes. Although several peaks exist, none was significantly set apart to help us in the prediction of the length of stay. In order to further investigate the peak variation we have calculated the standard deviation of the *length of stay* (minutes) and the results are shown in Table 2. *All* is the standard deviation for the distribution of all users' length of stay, while *user A* is the standard deviation for the length of stay of user A only. Although the standard deviation for a single user becomes smaller for some locations, it is still substantially bigger than the short period in which the *L-type* response probability decreases rapidly. For example, if the response probability is stabilized in several minutes after a location change event, it is necessary to have a very small variation within those several minutes in order to be able to predict the stay length. Despite the big variation in length of stay and not being able to predict a location change event, depending on the type of location, the variation may still become small and a location change event may be predictable. One approach would be to use a gyroscope module attached to the mobile terminal, detecting the user's motion such as change from sitting into standing position, and the information can be notified before a location changes completely.

Table 2. Normal deviation of *length of stay* (min)

Location	Conf. room	Dinning room	Living room	House	Smoking room
All	17.3	8.1	104.4	301.7	20.2
User A	52.8	5.9	68.2	82.6	11.3

4.5. Application of the timing control method

As a result of this experiment, we have discovered that the information should be notified immediately after or just before a location change, and that the response probability is remarkably symmetrical for positive and negative relative times. If a motion sensor is used for detection of location change and if the information is notified before and after that instead of at random, an improvement of about 45% in the response probability can be expected. It was also shown that the user response can be classified into three characteristic types according to the user location, and that by detecting the exact location (by Bluetooth, GPS etc.) we could obtain effective notification timing.

5. Related work

In this section we are going to describe the relationship between our research and the ongoing research efforts about notification timing of content not directly relevant to the user's situation.

Unlike computers or current communications terminals which are usually unaware of the user's situation, humans are able to better judge another human's availability. Some researchers have shown that human interruptibility models can be constructed without using complex sensors, such as vision-based techniques, and therefore their use in everyday office environments is both practical and affordable [8][18][19]. Other researchers have proposed systems which estimate the user's busyness from the amount of computer work using real sensors [9], or by using Bayesian Networks with inputs from a scheduler, user's gaze, computer activity situation or other sensors to detect the user's attention [10]. However, these are all usually focused on deskwork with the most common case being computer work. Many users, however, are not always in front of a computer nor do they perform deskwork in their everyday life. Moreover, creating a schedule imposes a large burden to the user, in addition that the user does not always act upon his schedule. For example, the action of going to a smoking room and resting during work are usually not written in the schedule and can potentially significantly influence the notification timing. SenSay, the context-aware mobile phone that adapts to the environment and manipulates the ringer volume, vibration, and phone alerts, can also provide information such as urgency of the calls, make call suggestions to users when they are idle, and provide the caller with feedback on the current status of the user [11]. It uses a number of sensors mounted at various points on the body to detect the user's context and augments that knowledge by tapping into applications such as electronic calendars, address books, and task lists. In case of voice communications channels such as telephone, that usually require urgent notification, the situations when the user cannot be

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notified are very rare. However, in our research we are targeting the everyday life information and we focus more on recognizing the suitable and appropriate notification timing rather than an early notification. CoCo is a content delivery service which, using different sensors such as location or user's posture, detects the periods when the user attention is available (such as sitting or waiting for a light signal), and urges reading of information by a sound notification [12]. However, the validity of the notification during such situations was not investigated.

6. Conclusion

This research aimed at controlling the notification timing in the automatic delivery of the everyday life information through a mobile terminal. Particular attention was paid to the user's location and the relative time from a location change event. In order to investigate the appropriate notification timing preferred by the user, as well as the properties of the notification response to everyday life information, we have conducted an experiment with mobile terminals capable of information delivery. The experimental results showed that the user's response probability to information notification was very high before and after a location change event. Moreover, the response properties differed for every location and they were classified into three categories: *L-type*, *High-type* and *Low-type*, according to the shape and the values of the response probability. We have also discovered that the response probability was symmetrical around the location change event, before and after the event at times equal in absolute values. Using these properties, it was possible to detect the user's location change event and to effectively deliver information notification according to the response property of the user at that particular location. Our future efforts will be focused on the development of advanced notification timing control based on detection of location change using motion sensors, which may help us to deliver information more efficiently in the preferred period before the change event occurs.

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