OPTIMAL AUTO-REMINDER-CALLING ALGORITHM FOR SELF-REPORTING TYPE SAFETY MONITORING SYSTEM BY USING TELEPHONE FOR ELDERLY PEOPLE

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Abstract: An increasingly aging society is a significant problem in advanced countries. Safety monitoring is required for elderly people especially in a rural area. This paper describes a self-reporting type safety monitoring system by using telephone and the field experimental results in Iwate prefecture and Aomori Prefecture in Tohoku area of Japan. In this system, a user (an elderly person) makes a daily wellness call to the Iwate Prefecture Council of Social Welfare (IPCSW). The IPCSW staff calls the user to check his/her wellness if no wellness-report is received from the user. However, the system introduced a new work load to the IPCSW staff when many users forgot to make the call. Our project is to reduce the staff's phone work load by an automatic wellness-report reminder call. In this paper, the daily reporting time of long-term using users is analyzed and a new algorithm to determine an optimal auto-calling scheduler for each user based on the analyzed results is proposed.

1 INTRODUCTION

Social isolation of elderly people has become a significant problem in Japan as well as in other developed countries (Japanese Cabinet Office, 2011). In addition, the "solitary death" rate among senior citizens is increasing year by year. In December 2009, Iwate Prefectural University and the Iwate Prefectural Council of Social Welfare (IPCSW) developed and introduced a self-reporting type safety monitoring system by using telephone for elderly living alone to minimize the occurrence of "solitary death". A problem exists in that, in an automated scheduling system, elderly people sometimes forget to report their status to the system. Therefore, an IPCSW staff has to establish over telephone the status of those forgetful users. Unfortunately, confirmation itself becomes a burden in the case of many users. By contrast, this system has a preset auto-calling function for these daily confirmations. However, if confirmation is performed via this auto-calling function, the self-sending motivation for a user decreases. This research proposes an algorithm for optimally-scheduling automated calls in a self-reporting type safety monitoring system for elderly people.

2 SELF-REPORTING TYPE SAFETY MONITORING SYSTEM

Figure 1 shows the self-reporting type safety monitoring system that we developed and introduced to Iwate prefecture and Aomori prefecture in Tohoku area of Japan. In the system, elderly people (users, clients) can send a status report by pushing a selected phone key, such as "1= Fine", "2=Not so fine", "3=Bad" and "4= I want to talk", in response to a voice command. Subsequently, an IPCSW staff can confirm the user's status on a Web page. The Web server can send the information by e-mail to pre-registered neighbors and family members living away from the users. Nearby support members (supporters) can also send status information of an

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elderly user by cell-phone, e-mail or a website information board. The IPCSW staff can also send daily messages for the entertainment of elderly users.

In essence, the main feature of the system is that elderly users can send status information themselves, and various people such as an IPCSW staff, neighbors, nearby supporters, and families can monitor and share that status information. Crucial to the implementation of this system is using the mobility and capability of the users to report health and status information. This particular information cannot be obtained using other systems such as in sensor-type monitoring and emergency calling. These systems have problems of lack of privacy and frequent false alarms. Furthermore, in our system, since users only require a telephone connection, the initial set-up cost is not an issue and it is very easy to operate (Report of Iwate Prefecture Council of Social Welfare, 2009).

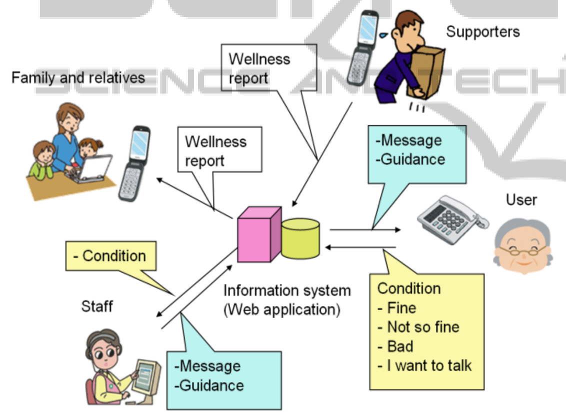

Figure 1: Self-reporting type safety monitoring system.

The number of users has been increasing and it becomes about 400, recently. In June 2011, the number of users, supporters and managers is over 700, 500 and 150, respectively and the total number of system users is over 1,300.

Some elderly users occasionally forget to send status information for various reasons such as being very busy or through some medical condition such as progressive dementia. In this case, an IPCSW manager can check the user's status by phoning such users at a specified time. However, if there is large number of users, the task involved becomes burdensome. According to our experience in field tests on the system in the Kawai area of Miyako city in the Iwate Prefecture of Japan, the average no-call rate for 30 to 40 users was 12.3 %. This result means that 3 or 4 users on average per day would not report status information, and these users needed to have their status established by direct calling. If the number of system users was to increase to 1,000, which would be a typical expected number in the future, an IPCSW officer would have to make over 100 telephone calls per day, placing a heavy scheduling load on them.

The system we have developed has an automatic calling function that schedules daily specified times for users. The method for determining the specified time was not studied and this function is not used now. If the specified time was too early, users' motivation in sending status reports would decrease, and if too late, the delay would be of concern to relatives. In this paper, we have analyzed the daily scheduling data for each user, and studied an algorithm that optimizes auto-calling times in these user-interface monitoring systems.

Conventional sensor-type monitoring systems are used to notify any abnormal activity in an elderly user by detecting the difference from normal behavior patterns (Shigeki Aoki, 2002, Yoshimitu Sinagawa, 2005, 2006). Those studies have yielded algorithms for determining normal/abnormal patterns using daily-acquired sensor data. Our algorithm decides the optimal auto-scheduling time for each user and is basically different from those studies for sensor-type systems.

3 ANALYSYS OF STORED DATA

3.1 Variability of Daily Reporting Time

Our algorithm objective aims to automatically determine a scheduling times for calls from the system to each elderly user so as not to decrease the motivation of a user from reporting in but also not to be too late in the day. To develop the algorithm, we analyzed actual reporting time data obtained from our experimental system.

Carrying out the experiments, we found that there were various user types on the daily reporting time. Figure 2 shows a distribution graph on the daily reporting time of a typical-user type. The average reporting time of this user type is 7:50 am. We can see that the user type usually sends the safety information between 7:30 am and 8:00 am.

On the other hand, there is random-user type, which is difficult to know a usual reporting time because the time distribution area is very wide and there seems to be no regulation. We think the system should wait for a long time to make an automatic reminder call for the random-user type.

In contrast, there is an accurate-user type, which is reporting the wellness report everyday at almost the same time for example just 7:50 am. If the accurate-user type would send the information at the different time from usual time, the possibility to be abnormal condition seems to be high. The research goal is to find the abnormal condition and make a reminder call to the user as sooner than other type users from system. So, we think there is an optimal calling time depending on various type users.

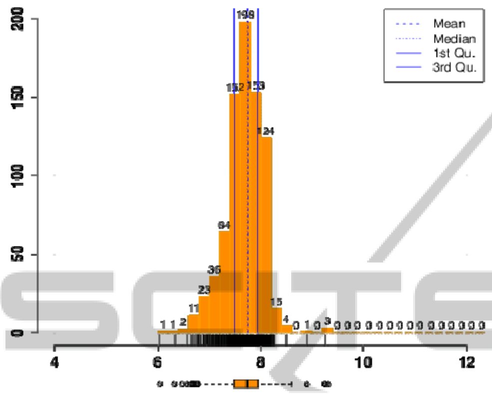

Figure 2: Distribution of self-reporting time of a typical-user type.

We believe that the data should be obtained from long term users (real system users) and therefore we selected data for 67 elderly people from the current 440 users, as these selected users habitually reported in over more than a 360 day period.

Table 1 shows the degree of variability which indicates the difference in daily report times for each user in our study group. In Table 1, IQR stands for the "Interquartile Range", which is defined as

$$IQR = Q_3\ Q_{1,} \tag{1}$$

where Q_1 is the 25 percentile and Q_3 is the 75 percentile of daily reporting times for a user.

Table 1: Variability of daily reporting time.

	,4 5		Number of Users
1 hour	~		22
45 minutes	~	1 hour	5
30 minutes	~	45 minutes	8
15 minutes	~	30 minutes	10
7 minutes	~	15 minutes	10
0 minutes	~	7 minutes	12

With regard to the IQR, 22 out of 67 users had a variability of more than 1 hour, while 45 (= 67 - 22) users were within 1 hour. We found that about half the number (n=32) of the long-term users (n=67) tend to send their daily status at similar times within 30 minutes. If a user in this group sends the status information more than 30 minutes from the average reporting time, he/she might forget to report. If a user in the "1 hour-IQR" group (n=22) did not report status information, then it is difficult to identify whether they might have forgotten to report because the possibility of reporting after 1 hour for such users is comparatively high.

3.2 Trend in Reporting for Users

Next, we analyzed the trend in reporting times for the long-term active users (n=67). Figure 3 shows the trend in the IRQ difference between two consecutive days for all users in all systems over a period of 360 days. As a result, we found that the difference in IQR has large variability over an initial period of 36 days, after which the variability becomes small. After 36 days, the variability for 95 % of the users becomes less than ±30 minutes.

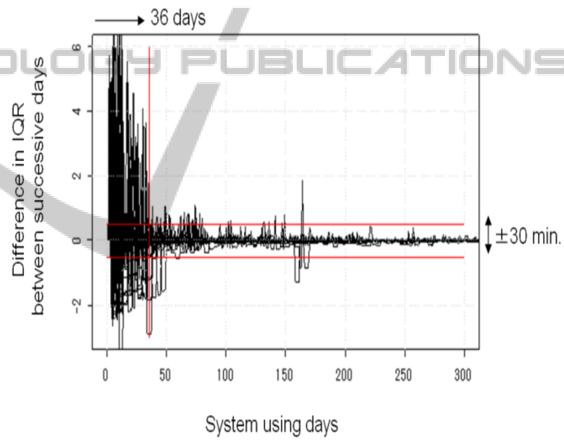

Figure 3: IQR difference between consecutive two days.

3.3 The Proposed Algorithm

Based on the above analysis, we propose the following algorithm to determine the optimal calling time:

1. Record the report times for daily calls for each elderly user.
2. If the number of days, D_{th}, that the system has been using is over a certain threshold (for example, 36 days within 5%, as determined from Figure 3), calculate the average report time, T_{av} and IQR (= Q_3-Q_1).
3. Determine a certain threshold time, T_{th}, for a report time. The threshold time (T_{th}) is calculated as follows,

$$T_{th} = Q_3 - k*IQR, \tag{2}$$

where, “k” is a coefficient to determine fitting value for the actual field work. We suppose “k” will be between 0 and 1. In actual field work, there is a limit time for example 5:00 pm to make a reminder call. So, we set the limit time T_{lm}, and the threshold time (T_{th}) must not be exceed the limit time (T_{lm}). Namely,

$$T_{th} < T_{lm} \tag{3}$$

4. If an elderly user does not call after a threshold time, T_{th} , the system make a reminder call to the user automatically.

5. If the threshold time, T_{th} ,in the actual field work is too large or too small, the coefficient, k (usually, 0 < k < 1), can be changed to an appropriate value.

6. Repeat steps 1–5 until the system is not required.

With this algorithm, the system can provide auto-calling for non-reporting users with an individual auto-calling time for variable-reporting users. For example, the system would provide auto-calling for a user with small variability range after a relatively short threshold time but auto-calling for a user with large variability range after a relatively long threshold time.

According to the proposed algorithm, we expect to realize effective confirmation without compromising user motivation to report and to reduce the daily work load of IPCSW staff in establishing the information by telephoning.

4 SUMMARY

In this paper, we analyzed the accumulated experimental data of reporting times for elderly people in the current self-reporting type monitoring system by using telephone, and we proposed a new algorithm that determines the auto-calling time in the system. Before we apply this algorithm to the current serf-reporting type safety monitoring system, we will validate the algorithm by simulation using actual data.

We plan also to evaluate the effectiveness of our proposal by interviewing elderly users and IPCSW staff.

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