Mobile Sync-application for Life Logging and High-Level Context Using Bayesian Network

Tae-min Jung, Young-Seol Lee, and Sung-Bae Cho

Dept. of Computer Science, Yonsei University
134 Shinchon-Dong, Seodaemoon-Gu, Seoul, 120-749, Korea
{realone,tiras}@sclab.yonsei.ac.kr, sbcho@cs.yonsei.ac.kr

Abstract. Recently, the global mobile device market is growing up and the functionalities of the mobile devices expand continually. As the expansion of mobile device usage and functionality, it is possible to collect various kinds of personal information such as photographs, GPS coordinates, and multimedia contents. Some researchers have studied data management and transfer of personal information collected in mobile environment. Also, many applications are developed for managing and transferring mobile personal information to a personal computer. However, new technology for effective management and visualization as well as data transfer is necessary to overcome difficulties to manage and interpret the information. In this paper, we propose an application with effective interface for search, summarization and analysis about mobile personal information. It also provides statistical analysis and visualization of user's movement patterns on the map which uses NAVER map Open API (open map API provided in Korean website).

Keywords: Mobile Device, Bayesian networks, Mobile Data management, Life logs, Meta Data.

1 Introduction

In 2006, the global mobile device market reached one billion units. The market expanded more than 22.5 percent from the previous year. According to EIC, the market is expected to expand more than 1.6 billion units in 2010. Mobile phones with digital camera made an appearance in early 2000, and the market share of mobile-phone with camera rose to 59% in 2008 from 23% in 2004 in global markets. During the same period, the market share of MP3 phone increased from 9% to 61%. As the market is growing up, the functionalities of mobile devices expand continually.

As the expansion of mobile device usage and functionality, it is possible to gather life logs (photo, GPS log, log of multimedia usage, etc) on mobile device. There are many kinds of mobile devices such as cellular phone, PDA, smart phone, MP3. The devices help us memorize and manage our life, and the importance of life log increases for personal management.

These days, many researchers are studying life log collection and visualization using mobile devices [1–3], and it requires software for synchronization between PC and mobile devices. Most previous synchronization software had used to transfer PIMs data from mobile device to PC. But nowadays, it transfers many kinds of logs

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because mobile device has various multimedia data. Nokia provided software called "Nokia Photo," which saves photo and SMS visualizes them as ordered by time and allows us attach annotations and comments [4].

In this paper, we propose a novel system for log collection, log management, retrieval of special information, abstraction of life style, statistical analysis and visualization on a mobile device. This system visualizes various kinds of personal information on map with GPS coordinates. Also we show the feasibility of the proposed method with a prototype of synchronization software.

2 Background

Microsoft Research Center collected many logs, which are photos using SenseCam, GPS log, windows count in PC, date, time and personal information, in MyLifeBits project. They are stored in MS SQL Server database and visualized with several applications [1]. But they focused visualization of GPS and photos only and did not develop the propose protocol of data transfer from mobile devices to database server.

In University of Helsinki, Nokia 60 series are used to collect life logs (voice data, photo, battery usages, GPS, phone logs, SMS, and so on) from a smart phone. The system could send collected data to sever using HTTP and Bluetooth [2]. But this research only focused life log collection and do not try to visualize them.

University of Melbourne in Australia gathered life log from ten users using Nokia 7610 handset. These logs in mobile devices are synchronized with server. The users could observe them using Nokia Life Blog Software. The Nokia Life Blog show photo, SMS, and other context, but the system visualized SMS and Photo only. The visualization tool is provided for Nokia users [3].

Fig. 1. Examples of Data Transfer Applications: Microsoft ActivSync and Windows Mobile Device Center, Nokia Photo, and Samsung PC Studio

Many mobile device manufacturers deployed data transfer application. Microsoft developed ActiveSync and Windows Mobile Device Center [5]. These applications are to synchronize personal information in desktop PC and PDA which has Microsoft Windows Mobile OS. Nokia also released Nokia Photo that upload photos to web blog and manage photos, SMS, etc [4]. Samsung AnyCall, LG Cyon and Pentech also provided similar applications. Fig. 1 shows various data transfer application. These applications helped us transfer phone book, photos, multimedia files such as MP3 to PC. Most of them provide only simple data transfer function and photo tagging. It is difficult to use various life logs for recollection and management of events in real life.

This paper proposes novel system that transfers collected logs from mobile device to desktop PC. The system provides tools for visualization special log search tool

management tool, summarization tool and high-level context such as statistical information and event or emotion of person and. Fig. 2 show overview of system. This system visualizes them on PC application, and is developed on Microsoft .NET platform in Windows. We also provide visualization on map by using NAVER Map API (http://map.naver.com/).

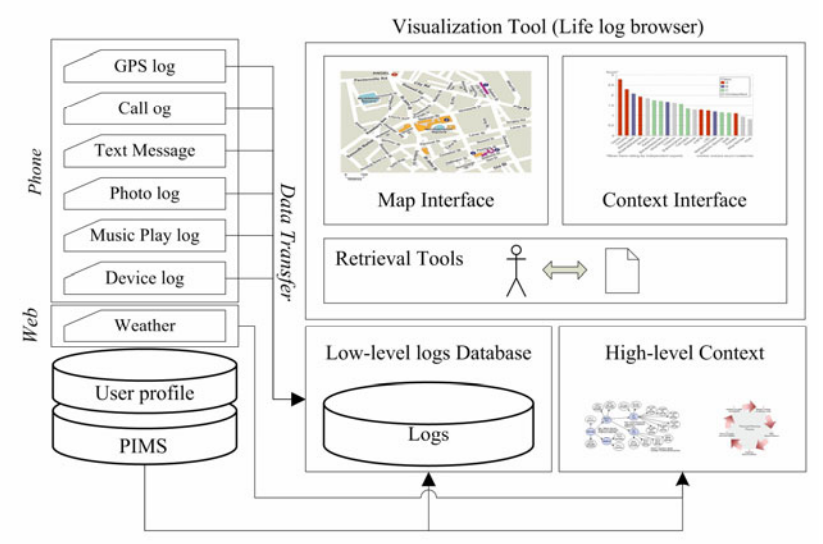

Fig. 2. Overview of Proposed System

3 High-Level Context

Here, we define high-level context as statistical information. The statistical information provides location, social network, call, and text message history, and extended definition includes semantic information that presents people's activity, special event or emotion [12]. We use Bayesian inference modules and statistics information analyzer in order to get this high-level context. Table 1 shows log information collected on a mobile device and on the internet. These logs are used for high-level context and visualization tools.

Table 1. The log information that was collected on a mobile device

Log	Information
GPS	Latitude, longitude, velocity, direction, date, time
Call History	Caller's phone number, type, time span, start/end time
Text Message	Sender's phone number, type, time span, start/end time
Photo	Photo file name, taking time
Weather	Weather, visibility range (km), cloud degree (%), temperature (℃), discomfort index, effective temperature (℃), rainfall (mm), snowfall (cm), humidity (%), wind direction, wind velocity (m/s), barometer (hPa)
MP3 Player	Title, time span, start/end time
Changing	Charging status, time span, start/end time

Bayesian network is used to infer context information, because it is an appropriate method to manage uncertainty (activity, and emotion in real life) in mobile environment [6, 8]. Bayesian networks for context inference are constructed by expertise (or expert knowledge). Mobile metadata are input to Bayesian network the input node of to infer context information [7, 9].

3.1 Bayesian Inference Modules

In order to take high-level context of activity, event or emotion of people, we used Bayesian networks. Various mobile log data is collected by mobile device, and then the Bayesian inference module detects the high-level context. The BN reasoning module performs probabilistic inference.

BNs refer to models that can express large probability distributions with relatively small costs to statistical mechanics. They have the structure of a directed acyclic graph (DAG) that represents the link (arc) relations of the node, and has conditional probability tables (CPTs) that are constrained by the DAG structure [11]. Fig. 3 shows an example BN that was designed by human and used for the application of this paper. It shows a DAG structure, node name, state name and inferred probabilities.

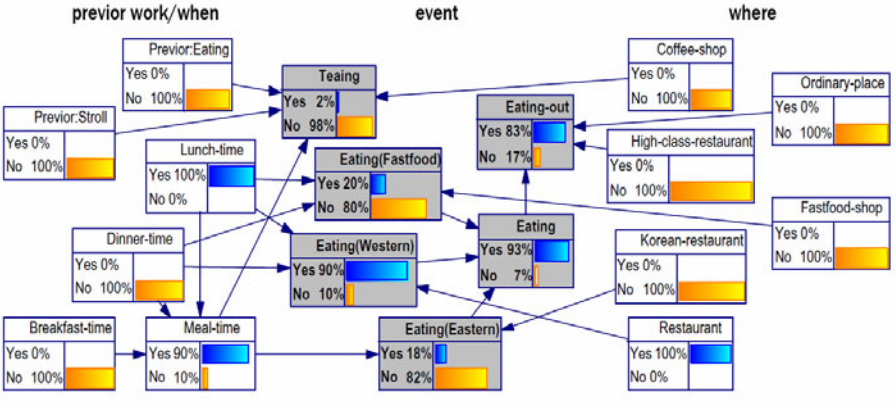

Fig. 3. The event inference BN designed for 'Activity in restaurant' in this paper

The high-level context inference is obtained by the belief probability, thresholds and weights of each Bayesian networks. The threshold is used to tune the context extraction model. The weights are used to apply the preferences or life-patterns of the given user, so if the context is a preferred by a user, the weight has higher value than others and the context can be selected more easily.

3.2 Statistical Information Analyzer

The other high-level context is statistical information. Statistics is used to analysis pattern of things. Statistics of life logs present people's life pattern. It can be also used to construct social network by call log and text message history. In this paper, we provide three-types of statistics information.

First is spatial statistics. It helps a user to know one's life pattern by frequently visited location and time. GPS data have just low level data, which it needs to translate semantic information. We use Location Positioning System (LPS) which is semiautomatic annotation tool. It provides map-based GUI, and allows a user to allocate personal semantics to specific spot. This system automatically updates location information to annotated (or registered) place. Finally statistical information analyzer used this semantic information for spatial statistics information by counting the frequency and time of visiting.

The statistics information for other log such as call history and text message has two standards. The one is person for construct social networking, and the other is day or weeks for life pattern. Call and text message are most important logs for social networking, because these logs has information about relationships among people using a mobile device. It can be measure of intimacy between a user and his friend. On the other hands, statistical information about day or weeks means degree of busyness. In person information extract by day and the others form whole data.

The statistical information is updated when new data are transferred from mobile device to PC, by statistical analysis. Our system visualizes daily and weekly statistics for SMS and call history in graphs, which can provide a user with interesting information. (It is mentioned chapter 4).

4 Visualization Tools

We propose system which data transfer application using life logging and high-level contexts. This system provide function data transferring mobile to desktop PC,

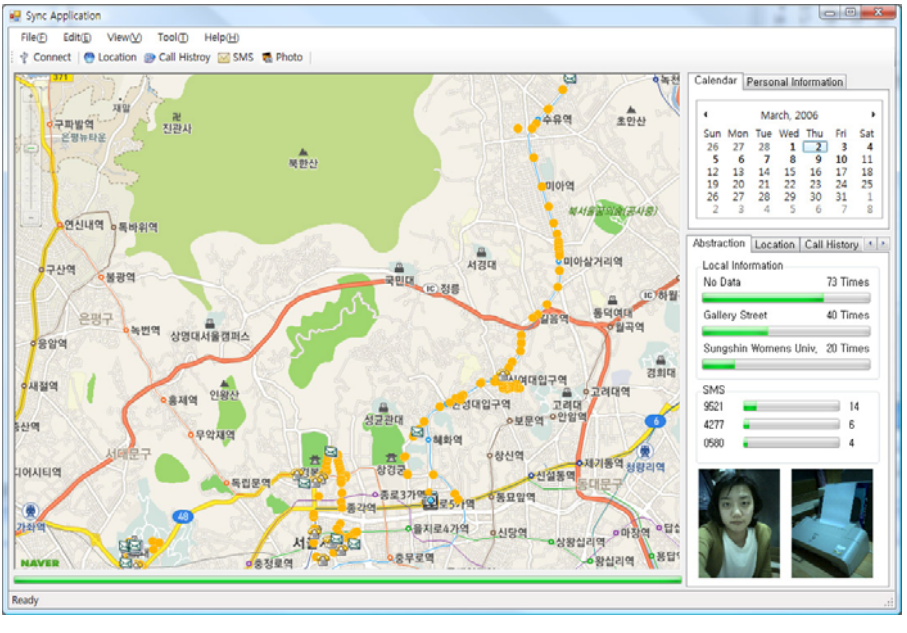

Fig. 4 A Screenshot of the Proposed System. It shows loaded one day life logs, the system provide visualization tool map, photo, SMS, call history, and Statistical Analysis.

and it can provide life logging service such as review one day, manage phone book, and so on.

The proposed system provides map-based interfaces. Spatial information well explains people's activity and life, because main interface in the proposed system is map. It can help low logs generated location and time. It supports location based search and browsing. And we proposed query-based search interface and statistical information visualization tools. Fig. 4 shows screenshot of proposed system.

4.1 Life Log Browser

Location information is meaningful in human life. As location affects people's activities and emotions, we provide browser tool using map interface for geographical presentation. People's locations are represented with orange circles on the map and call record, text message logs, photo logs are illustrated with icons. These icon have mouse over event, user can examine by just mouse moving. It allows users to explore various logs in short time. Fig. 5 explains how to show each log details.

Fig. 5. Log Visualization with Icons (A) Location information (GPS): place name, visited time, (B) Text Message: memo, type, send/receive time, sender call number, (C) Call record: send/receive time, type, sender call number, photo (if exist), (D) Photo log: place name, picture time

Table 2. Result of Limitation Distance Each Map Scale Level

Map Scale Level	1:200m	1:800m	1:3.2km	1:12.8km
Subject 1	0	75	90	201
Subject 2	0	51	84	254
Subject 3	0	30	72	222
Subject 4	0	99	114	241
Subject 5	0	48	78	222
Average	0	60.60	87.60	228.00

We define GPS sampling rate one/min, it enough abstract user's life. However, it has some problems. GPS logs may be lost because of battery problem or missed in the shadow of building or tunnel. Other logs (text message, photo, and so on) can be also observed while GPS signal is lost. In this case, all logs may be displayed on the same location of the map because many logs have the same information place. We use mouse click event for solving this problem. Clicking log view visualizes next logs in the same place.

Another problem is log centralization in life log browser. If too many logs are visualized on map interface, it is difficult to browse specific logs. The Higher map scale, the closer distance between logs is. We automatically change the number of log visualized on the map according to map scale. Euclidean distance between logs is calculated with GPS coordinate (latitude and longitude). We define a threshold of distance constraint empirically.

In order to get the best thresholds, we conduct experiments to determine thresholds of distance in each map scale by five people. Table 2 shows the result of the experiments, in which has four levels of map scale. Applied result is shown in Fig. 6.

This proposed life browser visualizes various logs on the map interface. It informs us of the locations where a user creates logs. It seems suitable for management

Fig. 6. Location Log Visualization with limitation distance. (A) is original view and (B) is view of limitation distance 87 (B). The map has the scale of 1: 3.2km.

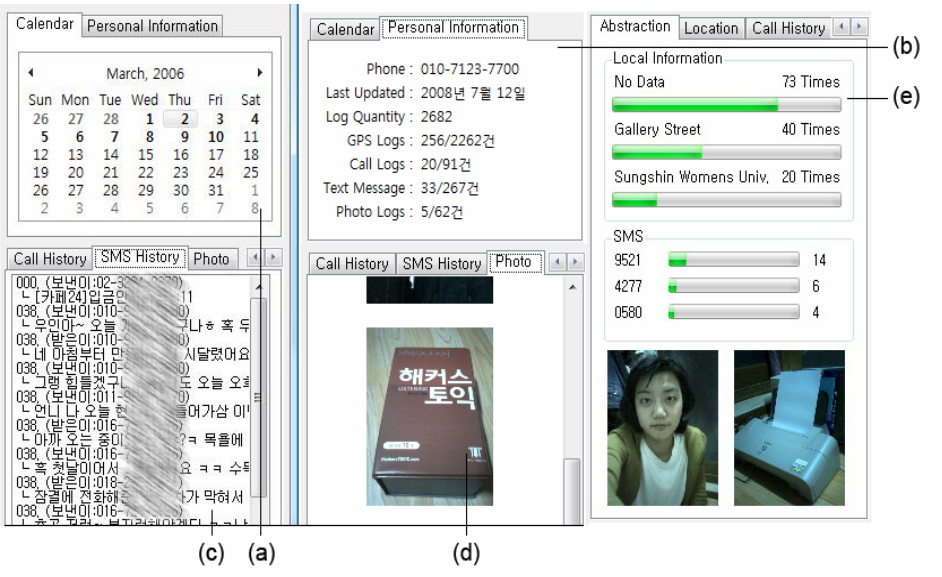

Fig. 7. (a) Calendar component: It helps to find some day. (b) Personal Information: It simple statistical logging information like total. (c) Text message history: It is ordered by time, and provides list view. (d) Photo logs: It is photo list and provide search by

human's life [13,14]. Additionally, it can use human memory assistance like memo or diary.

Map-based interface easily visualizes user's spatial patterns related to activity, but does not summarize personal temporal life patterns. We provide additional visualization tool for it. The interface has two components; one is a calendar component, and the other is list component. The calendar component is used to select and retrieve specific day or days from database for visualization. Second, list component shows the details of personal information sorted in temporal order. User can see the location of the item on map by double-clicking a specific item, which user wanted, in the list view.

4.2 High-Level Context Visualization Tools

The system provides two kinds of high-level context visualization tools. The one is graph interface for statistical information. It demonstrates various kinds of information. Fig. 8 is an example of this text message graph of visualization tool which provides pie, chart, curve, and other types of graph. The interface helps user understand life changes easily with resizable map and log list view. It can also interact with a user to find necessary logs on the map.

For visualization of inferred context on map, each GPS coordinate is assigned to each context. Various inferred context information can be placed at the same location. Each context has probability and priority [6, 9]. If context has

probability value more than 0.7 and priority more than 5, it is represented in bold characters. Change of context is marked as smile icons and shows the details by laying mouse over event. It can help human memorization and can be funny information [15].

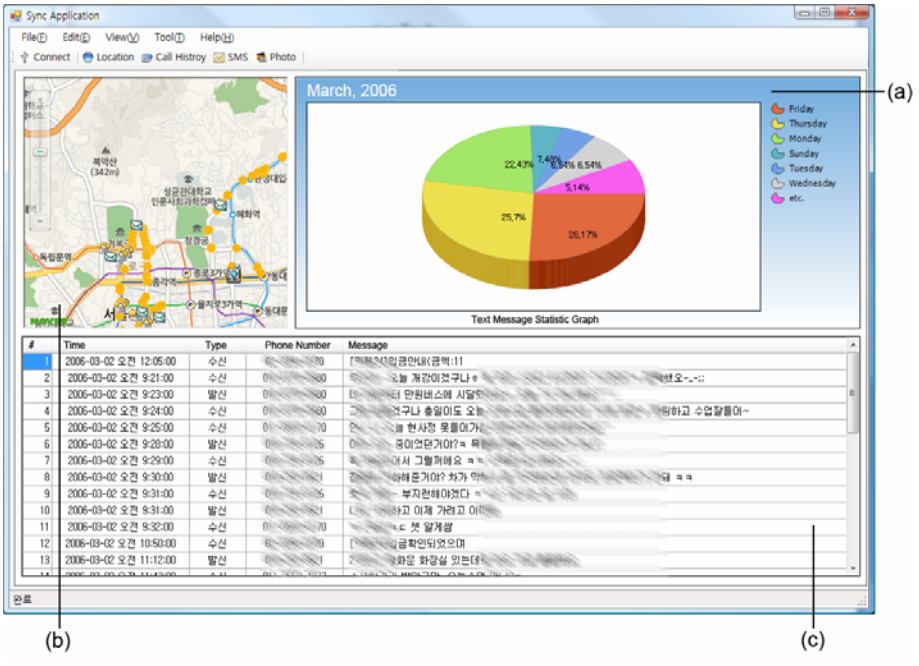

Fig. 8. An example of graph visualization (a) Graph interface, (b) Map interface, (c) List interface

5 Experiment and Result

Mobile personal data are collected in real life and the proposed method is applied to them to show the performance of visualization and summary. We also conduct usability test for evaluating the feasibility of the proposed system.

5.1 Apply to Real Data

Real logs are collected for three weeks by an undergraduate student who belongs to the department of computer science at Yonsei University. She took a bus for going to school. It reduces GPS logs error. We asked her to report events and schedule every day. Table 3 shows a schedule in a day, and screenshot of applied system is Fig. 4.

Table 3. An Example collected Logs in a Day

Time	*Place*	*Activity*	*Emotion*
7:30	Home	Get up and Ready for school	
8:00	Bus	Go to the school	Tired
9:30	University Lecture Room A	Major Class	
10:50	Library	Ready for Study	Busy
11:40	Bus	Move	
12:00	Samchung Dong	Lunch	Good
13:00	Bus	Move	
13:40	Bank	Date with boyfriend	
15:40	Bus	Move	Hastily
16:00	University Lecture Room A	Major Class	Funny
18:20	Bus	Move	Hastily
19:00	B University	TOEIC Study	Concentrate
21:00	Bus	Shopping and Move	Happy
21:30	Bus	Go Home	Happy

5.2 Usability Test

We conduct SUS (System Usability Scale) Test for objective evaluation of the proposed system. SUS test inspects three parameters: effectiveness (whether users seem successfully achieve their objectives or not), efficiency (how much effort and resource is required in achieving those objectives), satisfaction (whether the experience is satisfactory or not) [10]. Table 3 shows SUS questions. The scale of answers of each question ranges from 1 to 5 (strongly disagree to strongly agree). After that, we sum up all scores, multiply 2.5 and normalize the scores ranged between 0 and 100.

The test is conducted by 11 subjects. We show demo movie of the application and give it to them. Figure 10 shows the result of the SUS test. The average score is more than 72, confirming the reliable performance of this system.

Table 4. SUS (SYSTEM USABILITY SCALE) ITEMS

SUS	*Quesiton*
SUS-1	I think that I would like to use this svstem frequently
SUS-2	I found the system unnecessarilty complex
SUS-3	I thought the system was easy to use
SUS-4	I think that I would need the support of technical person to be able to use this system
SUS-5	I found the various function in this system were well integrated
SUS-6	I thought there was too much inconsistency in this system
SUS-7	I would imagine that most people would learn to use this system quickly
SUS-8	I found the system very cumbersome to use
SUS-9	I felt very confident using this system
SUS-10	I needed to learn a lot of things before I could get going out with this system

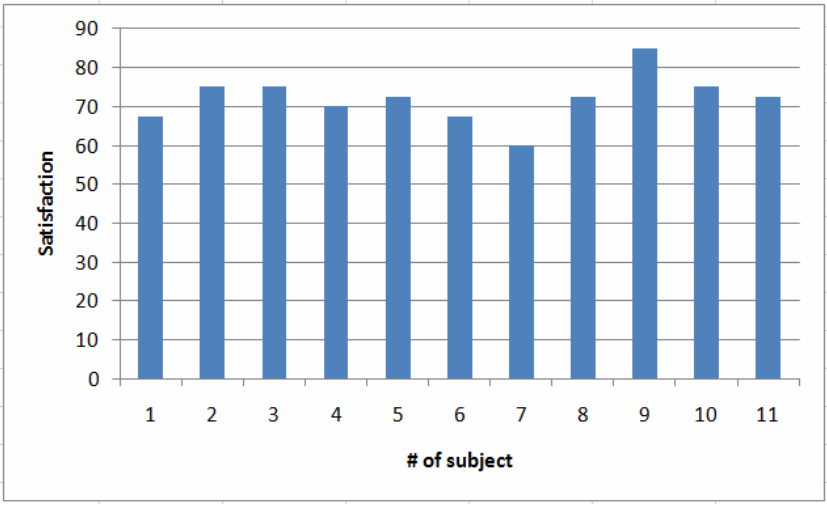

Fig. 9. Result of SUS test and average is 72

6 Conclusion

We develop a novel application for data transfer and visualization, and we also inference high-level context using Bayesian network. The system has various interfaces for life log visualization, browsing, retrieval, context view system. It will help memorization of human life and know life one's style. The usability of proposal system is evaluated through the SUS test and real data.

In future work, we will compare current logs and previous logs in real time. It helps user to find some changes of his or her life. It can be also used to recommend user adaptive service. We will implementation on mobile device. It provides real time service and can be assistant tool more concentrate human life.

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