Lifelog Sharing System based on Context Matching

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***Abstract*—In this paper, we propose a lifelog sharing mechanism based on matching the situation context of audience users and shared lifelogs. Sharing lifelogs can promote information sharing among people and benefit people who face similar situation. However, it is difficult and tedious for audience users to access useful or interesting information from lifelog data taken in chronological order. Our proposed lifelog sharing system pushes appropriate shared lifelogs to audience users by matching the context in real time. Audience users can get information in an unobtrusive way by wearing a head-mounted display. The system also allows audience users to give feedback and customize their preferences. To collect lifelog data, we assume sharing users to capture lifelogs with Autographer and Android smartphone. When uploading captured data to share, sharing users need to set sharing preferences to protect privacy. From the preliminary evaluation, we have obtained a positive feedback.**

Keywords–Lifelog; Wearable camera; Sharing mechanism; Situation context matching; Augmented reality.

I. INTRODUCTION

Lifelogging is the pervasive activity that assists people in recording their daily events in detail. In 1980, Steven Mann built a wearable personal imaging system, which is equipped with head-mounted display, cameras and wireless communications. The prototype system could capture images from first-person perspective [1]. The miniaturization enables devices to be more unobtrusive and gain more social acceptance. More and more commercial wearable devices have been produced and entered the market.

Existing wearable cameras include SenseCam, Vicon Revue and Autographer, which can capture photos passively and continuously. For example, Autographer is a wearable camera that has 6 built-in sensors [2]. The accelerometer measures the change of speed when the camera is moving; the color sensor is used to perceive light and brightness; the passive infrared sensor detects moving objects before the camera; the magnetometer detects the direction in which the camera is facing; the temperature sensor measures environment temperatures; and the integrated Global Positioning System (GPS) locates the camera's position. Autographer will capture photos automatically after certain elapsed time periods, such as 30 seconds. The sensor changes also can trigger the camera.

The lifelog data generated by lifelogging brings new opportunities for many research fields including quantified self, healthcare, memory augmentation and so on. Nowadays, Social Networking Service (SNS) is getting more and more popular, which enables people to communicate and share knowledge with each other. Sharing lifelogs can promote the information sharing among people because lifelogging can record all the details of our daily experiences and one's experience can benefit other people who face similar situation or have common interest. However, current SNS is not suitable for lifelog sharing. For the users who view shared lifelogs, so-called audience users, the accessing method is limited. It is difficult and tedious to access useful or attracting information among the vast amount of lifelogs, because current systems manage shared photos in chronological order mainly, and users can only search photos with hashtags and location. However, the format of hashtags that were added by sharing users are not uniform.

Because the amount of data produced by electronic devices is increasing, recommendation systems are available for users to access relevant information from the vast amount of information [3]. Also, context-aware recommendation system has been researched in various domains, such as e-commerce, multimedia, tourism, to provide a better personalized user recommendation leveraging contextual information. The possibility of using context-aware computing in lifelog retrieving has not been investigated yet.

Some previous research proposed approaches about how to retrieve lifelog more efficiently [4]–[8], but less attention is paid to how to share lifelog and how the users access shared lifelog based on their current situation in real time. For example, you are running outside for exercise and you might want to view other's nearby running record to motivate yourself.

Our target is to propose a lifelog sharing system, which enables audience users to access useful or attracting information easily from shared experiences when they are facing specific situation.

The rest of the paper is structured as follows. In Section II, we describe the goal and approach. In Section III, the sharing mechanism is presented. We provide an overview of the lifelog sharing system in Section IV. Then, we describe user study and results in Sections V. In Section VI, we discuss related work. Finally, conclusion and future work is discussed in Section VII.

II. GOAL AND APPROACH

In this paper, we aim to propose a lifelog sharing system. There are mainly two roles using the sharing system, including sharing user and audience user (Figure 1).

Sharing user uses Autographer and Android smartphone to capture the lifelog data. Autographer is used for taking photos. Android smartphone is used for monitoring activities

Figure 1. Wearable devices for sharing user and audience user.

by analyzing the signals from multiple sensors embedded in the Android device. After recording, sharing user should upload the lifelog data to share. By leveraging computer vision service and location-aware service, our system extracts context within the shared lifelogs automatically, which can be used to match the audience user's situation in real time.

For the audience user, we introduce the Augmented Reality (AR) and context-aware computing technology. Through the head-mounted display, our system presents appropriate shared lifelogs to the audience user by matching the context in an unobtrusive way without interrupting what the user is doing. In this work, we choose Epson Moverio BT-300, which contains smart glass and controller.

III. Sharing Mechanism

We propose a new sharing mechanism for our system: pushing appropriate shared lifelogs to audience user by matching the situation context of user and shared lifelogs in real time. By replaceing explicit request with active push, we aim to save audience user's effort in searching and filtering useful information.

To find out valuable information in describing situation and define the situation context in our research, we summarized some previous work. Dey [9] proposed a generic definition of context. Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object. Grubert et al [10] categorized context into three high-level categories, including human factors, environment factors and system factors. Also, our previous research [11] found several cues are important in describing an event, which can help people understand what happened, including where and when the event happened, what object the user interacted with. Therefore, situation context in this research consists of human and environment factors (Figure 2).

Human factors focus on the user, including activity and preferences. *Activity* is the bodily movement, such as walking, running, etc. *Preferences* has a different meaning for lifelogs and audience users. For lifelogs, it means the sharing preferences that are set by sharing user; for audience users, it refers to the objects that audience user prefers or has interest in, such as food, park, etc.

Environment factors describe the surrounding of the user in which the experience took place. *Location* and *time* mean

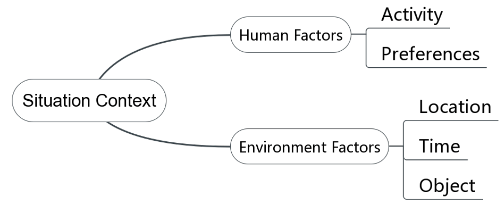

Figure 2. Situation context.

where and when the experience happened. *Object* is what appeared in the user's sight.

IV. Lifelog Sharing System

In this section, we will describe our lifelog sharing system. We will provide an overview and describe our state of the development.

A. Usage Scenario

- Scenario 1. A person is walking on the street in the morning and approaching a bakery that he has never been in. One other person shared lifelog photos that were taken when he bought bread in this bakery. These photos may be useful for this person. If he has interest or thinks the bread looks delicious, he can go into the bakery and buy some bread for himself.
- Scenario 2. A person is running outside for exercise in the evening. He might feel boring or tired. Some other people also ran nearby and shared photos and running record that were taken when they were running. The person can view the photos and running record such as the running speed of others via the head-mounted display without stopping running, and he may be motivated to run at a proper speed.

B. System Overview

Our proposed system mainly contains two parts (Figure 3). The most important part is for audience users accessing shared lifelogs. The AR-based viewer pushes appropriate shared lifelogs to the audience user by matching the situation context of audience user and lifelogs.

The other part is for sharing users capturing and uploading lifelog data to share to others. The lifelog uploader will extract

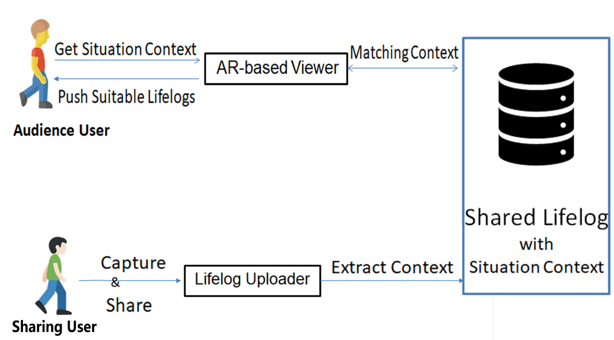

Figure 3. System overview.

situation context, including *location*, *object*, *time* and *activity*, from input data and store them into the database.

C. Sharing User's Part

1) Activtiy Recorder: The activity recorder implemented on Android is used to track and upload share user's activity records.

In our work, we make use of *Moves API* [12]. It can automatically record any walking, cycling, and running the user does and generate daily activity summaries, including step count, distance, duration and consumed calories for each activity.

2) Lifelog Uploader: The web-based lifelog uploader assists sharing users in uploading the photos captured by Autographer (Figure 4). It is implemented based on Browser/Server architecture and mainly uses the combination of the Spring Boot and the Hibernate.

Before sharing, sharing users need to set the sharing preferences, which consider two aspects. One is the scope of visibility, sharing users should choose to share their lifelogs with friends or all users. The other is to choose whether to expose location or object information within the lifelog. For location information, sharing users can set to share location at country, city or street level.

The lifelog uploader extracts situation context from uploaded data according to the sharing preferences set by sharing user by integrating with several existing computer vision service and location-aware service, including *Google Cloud Vision API* and *Google Maps API* (Figure 5). To protect bystanders' privacy, the system blurs the detected faces in lifelog photos using *Marvin Image Processing Framework*.

D. Audience User's Part

For audience users, we develop the AR-based viewer on the Epson Moverio BT-300, which adopts Android as the operating system. The viewer system mainly provides three functions: viewing shared lifelogs, giving feedback to pushed photos and customizing preferences.

1) Viewing Shared Lifelogs: The viewer system displays appropriate shared lifelogs that match the users current situation (Figure 6). When there are more than one pushed lifelog photos, audience users can view more by clicking the Next button. If audience users don't want to view any information at present, they can click the Close button to hide the display panel, which will appear again when the system get new pushed lifelogs.

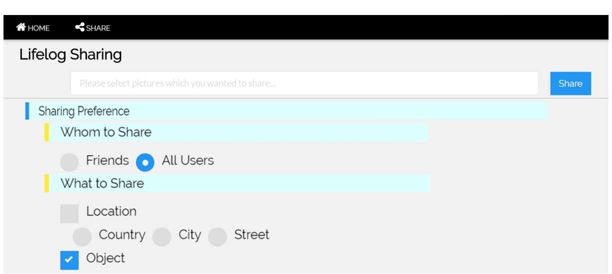

Figure 4. User interface of Lifelog Uploader.

Input: Sharing preferences and lifelog data;
Output: Processing result;
Detect faces within photos with Google Cloud Vision API;
Blur the detected faces using Gaussian Blur;
if Expose *Location* information at *Country* level **then**
    Extract the country address component from the human-readable address got from the location service;
else if Expose *Location* information at *City* level **then**
    Extract the country and city address component from the human-readable address got from the location service;
else if Expose *Location* information at *Street* level **then**
    Keep full human-readable address got from the location service;
else
    Do nothing;
end if
if Expose *Object* information **then**
    Detect objects within photos with Google Cloud Vision API in the object service;
else
    Do nothing;
end if
return results;

Figure 5. Extracting context according to the sharing preferences.

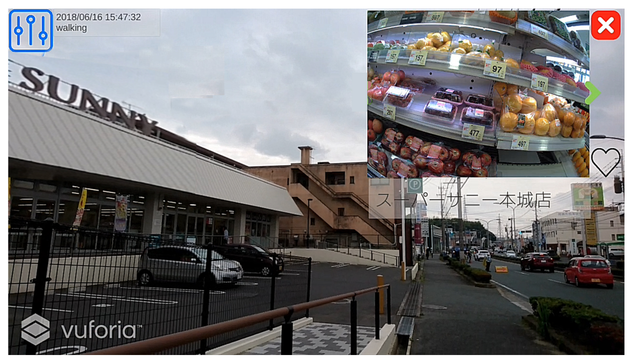

Figure 6. Viewing pushed lifelogs.

To select appropriate lifelogs, we propose a push strategy which pushes appropriate lifelogs to audience users automatically by calculating the situation context similarity between user and shared lifelog data (Figure 7).

The first phase is detecting user's activity to determine the push frequency. The viewer system recognize activities using HARLib, which is a human activity recognition library on Android proposed by Yang et al [13]. For each activity, the push strategy provides a default frequency depending on the average moving speed of the activity. Especially for transport, the system won't push any information considering user's safety because the pushed information may interfere user when he is driving. The second phase will get candidate lifelogs and rank them by calculating the similarity score between user's situation context and lifelog data's situation context, which will be performed once after the time period corresponding to current detected activity. Then, the system will push the lifelogs that have the similarity score over the threshold, which is set to 2.4.

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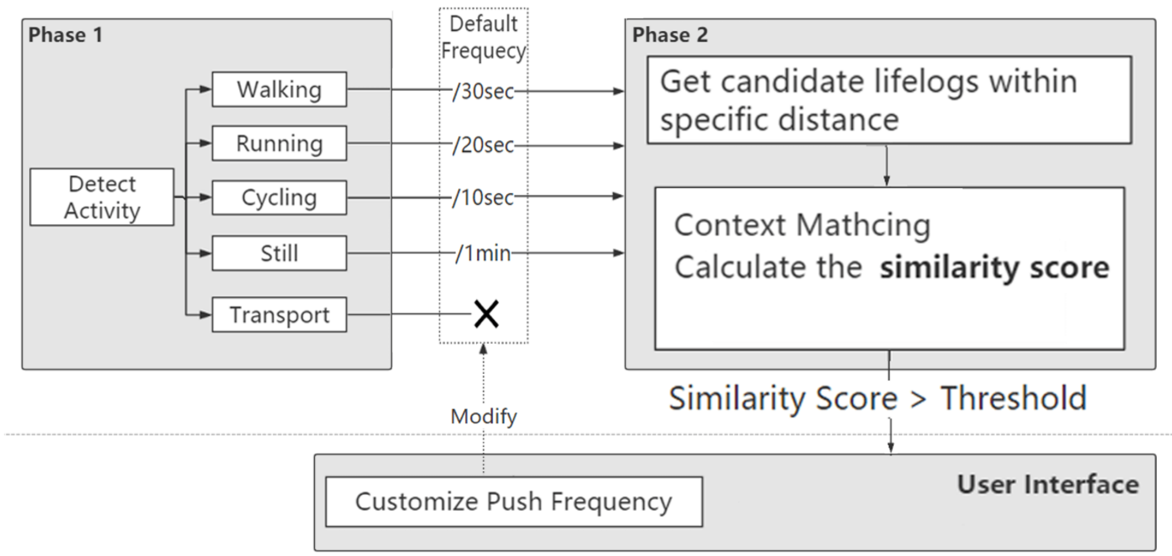

Figure 7. Push strategy.

In order to deal with the huge data volume and improve the query performance, we make use of Haversine formula to filter out lifelogs that are created within 100 meters from the audience user as the candidate lifelogs, and only calculate similarity score for these candidate lifelogs.

The similarity value contains four situation context factors, including *location*, *activity*, *object* and *time*, in the range (0,4]:

$$similarity = locationFit + activityFit + objectFit + timeFit \tag{1}$$

where $locationFit$ is determined by the distance between audience user and lifelog's creation location:

$$locationFit = \begin{cases} 1, & l_u = l_p \\ x, & x = inverseDistance(l_u, l_p) \end{cases} \tag{2}$$

where $inverseDistance$ is a negative exponential function of distance in the range (0,1]. $ActivityFit$ compares audience user's activity and the corresponding activity of lifelog photos:

$$activityFit = \begin{cases} 1, & a_u = a_p \\ 0, & a_u \neq a_p \end{cases} \tag{3}$$

and $objectFit$ evaluates the suitability between lifelogs and user's preferred objects, which is inferred from user's liked photos history in the range [0,1]. The $offset$ is used to solve the cold start problem. When audience user has not given any feedback, the $offset$ will be set to 0.6 to eliminate the impact on the final similarity score, and the value of $offset$ will get smaller with more feedback are given:

$$objectFit = \frac{intersection\_size(o_p, o_{ul})}{size(o_p)} + offset \tag{4}$$

and $timeFit$ evaluates the degree of difference in time in the range (0,1]. We define 6am to 10am as *morning*, 10am to 2pm as *noon*, 2pm to 6pm as *afternoon*, 6pm to 10pm as *evening* and 10pm to 6am as *night*. The closer the time, the higher the $timeFit$ value.

2) Giving Feedback: Audience user can give feedback to pushed lifelog photo by clicking the Like button (Figure 8), which means the user has interest in this photo or the objects that appear in it.

3) Customizing Preferences: The AR-based viewer allows audience users to customize what kind of specific information they want to view and how often they would get new pushed lifelog. The customization panel contains three parts (Figure 9). Audience user can select specific objects to reflect their object preferences. They can also select the activity to view corresponding activity record of the pushed lifelog photo (Figure 10). To provide a better user experience, the viewer system assists audience users in customizing the push frequency instead of the default ones. This feature can adapt to the situations where audience users want view more or less information.

V. Preliminary Evaluation

We conducted a preliminary user study to verify whether audience users can get useful shared lifelogs easily with our proposed system and evaluate the usability of the system.

Figure 8. Giving feedback to lifelog photos which contain Bread object.

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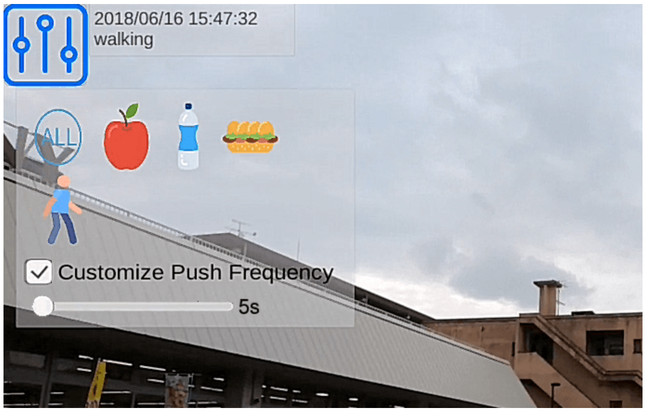

Figure 9. User interface of customizing preferences.

Figure 10. Viewing the lifelog photos with corresponding activity record.

We need to collect lifelog data first. We let 4 people capture lifelogs for one day using Autographer and Android smartphone and they were free to switch off the devices during their private time. After capturing, we let these 4 people set their sharing preferences and upload lifelogs to our system to share. We got 784 lifelog photos in total. After collecting shared lifelogs, the user study can be carried out.

A. Participants

We invited 8 participants to use our system as the audience users, ranging in age from 23 to 25 and including 6 females and 2 males. All of them have regular computer skills and they were given a brief introduction of our system.

B. Method

Each participant needs to use our system to view shared lifelogs by wearing the head-mounted display for at least half an hour. To ensure all participants can get pushed lifelogs, during they use the system, the range of activities of participants should be within the area of shared lifelogs captured places.

After that, the participant will be asked to fill in a questionnaire. The questionnaire has following 4 questions and these questions use the 5-point Likert scale:

1) Do you think pushed lifelogs are useful or interesting?
2) Do you think the preferences customization is helpful in viewing shared lifelogs?
3) Do you think the push frequency customization is helpful in viewing shared lifelogs?
4) Do you think the system is easy to operate?

C. Results

After collecting the questionnaire results from the 8 participants, we calculated the average scores of each question (Figure 11).

Question 1 is used to ask participants about the subjective feelings of the pushed lifelogs. All participants used our system for average 40 minutes and the average score of question 1 is 4.25. The results suggest that the participants generally found the pushed lifelogs are useful or interesting in their specific situation.

Question 2 and 3 are used to judge the design of the customization function in our system and the average scores for these two questions are 4.625 and 4.125. Results of question 2 indicate that each participant thought providing preferences customization is helpful to reflect their interested objects. For question 3, the results show that enabling users to customize the push frequency is helpful. Most of the participants claimed that customizing push frequency makes the lifelog displaying much more flexible.

Question 4 regards the ease of use of our system. It mainly concerns whether it's easy to use the controller to interact with the system. The average score is 3.75. The results prove that the system is easy to operate. Two participants considered that the controller is not hands-free although the glasses can superimpose digital information in an unobtrusive way. It was difficult to operate the system when participants were cycling.

Overall, we got a positive feedback through the preliminary user study.

VI. Related Work

The most similar approach is the work of Memon [14], which proposed a lifelog sharing framework which can identify the target audience users who may find shared lifelogs useful based on locality. Sharing users of the system have to define their sharing strategy by declaring the scope of visibility of their lifelogs, which are, particular city, particular street or location independent. For example, 'particular city' shared logs are visible to the friends who visit that city. Audience users

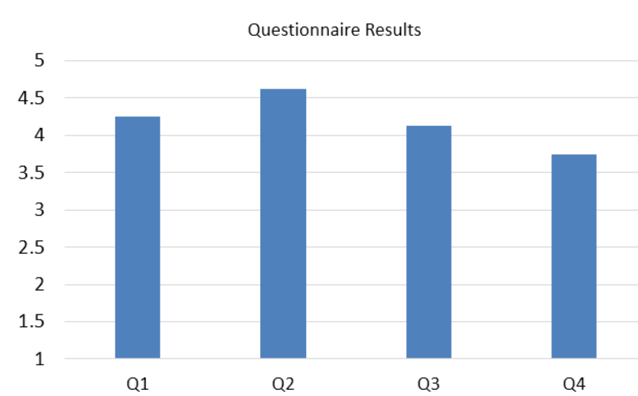

Figure 11. Questionnaire results.

can retrieve friends' shared lifelogs by sending a request to the server with their current location.

This work focused on sharing lifelogs with friends and the sharing strategy is only based on locality. In our work, we consider more specific context by defining the situation context. In Memon's work, Moodstocks API was applied to read barcodes, QR-codes or identify objects. But it needed to previously store the objects' templates at Moodstocks server. Our system makes use of computer vision service for object recognition, which needs no preparation or deployment. Another difference is that our system is presented for the scenario that the audience user is actually being in the specific situation. User can get shared lifelogs in real time without any requests. With augmented reality technology, user don't need to interrupt what he is doing.

Another important related work is the proactivity model for mobile recommendation systems which is proposed by Woerndl et al. [15]. The two-phase model can be used in a proactive, context-aware recommendation system by utilizing the available context information. In the first phase, the system determined whether the current situation needs a recommendation by calculating score of weighted combination of contexts. The second phase dealt with the evaluation of candidate items, and the system would push the items which are considered good enough in the current context to the user. A prototype for the gas station scenario was implemented, in which case that the user context refers to the fuel level, traffic is the temporal context, the geographic context is the nearest gas station and the social context corresponds to the number of persons in the car.

Based on the proactivity model, we defined the push strategy in our system. Different from this work, the contexts defined in our system are more general to meet different scenarios instead of the specific gas station scenario. Our system considers not only adapting the content represented by the system according to the context, but also system's configuration, that is adapting the push frequency according to the user's activity to provide a better user experience.

VII. Conclusion and Future Work

In this work, we propose the lifelog sharing system with the mechanism that matches the situation context of audience user and shared lifelogs.

In our proposed system, there are sharing users and audience users. To collect lifelog data, the sharing users in our system need to use Autographer and Android smartphone. When uploading captured data, sharing users can set the sharing preferences to protect privacy. The AR-based viewer developed on head-mounted display pushes appropriate lifelogs to audience users in real time, which allows audience users to view pushed lifelogs, give feedback to pushed lifelog photos and customize their preferences.

In the future work, the proposed system needs further improvement. For example, we can incorporate other useful contexts in our system and improve the push strategy to give more suitable or desirable shared lifelogs to audience users. So far, the system allows audience users to give feedback to the pushed lifelog photos and sharing users can view the feedback they get. The interaction between audience users and sharer users can be improved to enhance the communication and information sharing between people. After that, we plan to perform user study which involves more participants to get more convincing feedback. We also plan to compare our system to current SNS to justify the performance for retrieving useful lifelogs and displaying to the audience users.

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