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Retrieval of Life Logs based on Users Context

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Abstract: Lifelog devices are proficient in logging huge amounts of information to assist memory recollection but they lack a swift information retrieval method, which is important when a person needs to take instant action based on previous experiences. This paper presents a mechanism for recalling past events by combining appropriate context with lifelogs. A user's location is recorded together with the identity of people in close proximity and objects in the vicinity. Later, appropriate logs are retrieved based on the user's present context. The system is programmed on a Nexus S smartphone that is connected to an infrared transmitter and receiver pair to recognize people nearby, and an image-recognition engine is used to distinguish three-dimensional objects via the smartphone in real time. In an evaluation, we compared our proposed approach to a Vicon Revue lifelog device and determined that our system is capable of retrieving useful logs related to a user's present circumstances.

Keywords: Lifelogging, Human Proximity, Location.

1. INTRODUCTION

Lifelogging is a method for capturing and storing information indiscriminately so as to help in recall. The data gathered by various sensors are valuable and may improve the ability to recall past events in one's life. Advancements in the acquisition and retrieval capacities of modern devices have led to the development of lifelog systems. Devices such as Sensecam (Hodges, *et al.,* 2006) and Narrative (Kallstrom, 2013) passively capture everything, but they are not effective for identifying an individual or the objects around them. The lifelogs are organized by date and manually tagged information, making it difficult to explore the data or search for specific logs. To retrieve needed information, accurate details of a past event must be used as input, but people have a tendency to forget exact points in time or the particulars of their past experiences. Furthermore, the lack of a comprehensive context in association with the logs makes the process of retrieving appropriate logs time-consuming and boring.

We believe that in the near future wearable lifelog devices will become widespread and dominant; therefore a swift procedure to access appropriate lifelogs when needed is required. If the lifelog device is capable of autonomously identifying people and objects around the user while logging, past lifelogs can be easily retrieved based on the people and objects currently near the user. Likewise, lifelogs related to the present or a user-defined location may also be directly accessed if the lifelog device has records of previous visits to that place. To achieve this purpose, we propose a lifelog system that automatically links the logs captured at a particular moment with key elements: nearby people, contextual objects, and present location. By exploiting one or more of these key elements, a user is able to receive the most appropriate logs, which may help the user to recall similar situations in the past. A recent study (Peesapati, *et al.,* 2010) concluded that people are more likely to reminisce about people and things rather than places or experiences. When capturing lifelogs, our prototype system not only records the location but also identifies people and objects near the device wearer. Hence, a person requiring past logs of an interaction with a friend has only to meet with the friend to access those logs. Similarly, lifelogs related to objects that are present can be retrieved. The lifelogs of a particular location can be obtained by selecting that place on a map or by revisiting the place.

Identifying people and locations is useful in a variety of situations. For example, a couple eating in a restaurant for the third time may want logs of their past dining orders in that restaurant to select their meal. By making use of all of the present key elements concurrently, they could access the precise lifelogs for their current situation. We present our prototype smartphone system, which functions as a lifelog device and enables users to look back over previous events in a proficient manner. The results of a comparison to Vicon Revue (Lifelogging camera: Vicon revue) demonstrate

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that our system is efficient in retrieving logs that are relevant to the present situation of the user.

The paper is organized as following. The related work is discussed in Section 2. Section 3 presents the proposed model and the Section 4 has the description about the prototype system. Experiments, comparison and results are highlighted in Section 5. Finally we conclude the work in Section 6.

2. RELATED WORK

Several recent studies related to our research emphasize the need to address the issue of retrieving lifelogs on a mobile platform. A mobile context-aware system has been developed (Belimpasakis, Roimela, & You, 2009) that provides a Web-based lifelog explorer to visualize users' experiences. The presence of people at a particular place is determined by Bluetooth and WLAN services. A system developed by Sumi et al. in (Sumi, *et al.*, 2007) was collaboratively used by multiple users to capture shared experiences and promote their further creative collaborations. By using their system, experiences could be recorded by multiple viewpoints so that individual viewpoints became obvious. Furthermore, their system automatically generated video summaries for individual users that were used as an interaction medium for experience sharing. Another study (Aizawa, *et al.*, 2004) emphasized conversation scenes in lifelogs and detected human faces via skin color (Tancharoen, *et al.*, 2003) and voice. However, this approach is prone to errors in crowded areas and may result in false alarms or missed detections, whereas our technique accurately determines the people within sight via infrared sensors and facilitates the ability to retrieve logs of past meetings with them instantly. Another method (Alallah *and* Hinze, 2011) marked moments to capture and recall past experiences. A single-button device was used to mark moments, and a researcher observing the participants captured the required data, which were used later when participants were asked to recall information. In that study, several participants suggested that additional situation-related information should be captured to allow easy retrieval.

For people with mild dementia, a mobile-based memory support tool named MemoryLane (Hallberg, *et al.*, 2009) has been proposed to recall past activities and maintain associated memories. People and objects can be recognized only if tagged by Bluetooth devices whereas location is obtained by GPS. Users can manually change the location, add or remove people, and choose what recorded media to keep, but the process of recognition by Bluetooth in crowded places such as at a bus stop or a shopping center can result in false alarms. Our approach effectively identifies the individuals involved in a conversation with the user at any location. Another study (Lee *and* Dey, 2008) proposed a lifelogging system to help people suffering from episodic memory impairment (EMI) and employed Sensecam (Hodges, *et al.*, 2006), voice recorders, and a GPS logger to provide passive logging. However, reminiscing depends largely on the expertise of the caregiver, who must input cues and reveal the desired lifelogs to the person with EMI. Another system was proposed (Hoisko, 2000) to trigger episodic memories of past events by recognizing the context using infrared beacons that were placed in rooms and attached to people and objects. This approach is impractical because in the real world infrared sensors cannot be implanted in each and every object. Past information was retrieved on a head-mounted display in the form of pictures and audio.

A context aware system was developed (Holleis, *et al.*, 2010) in which stationary tags on objects and wearable sensors worn by presenters and visitors logged human-human and human-object interactions at an exhibition; that study mined visitors' interests based on differences in the time spent at each exhibit. Other work (Cheng, *et al.*, 2005) incorporated RFID technology with a mobile platform and tagged places and objects with RFID tags. The users developed personal weblogs and were allowed peer-to-peer communication to enhance the social quality of shared life experiences. Mobile Lifelogger (Chennuru, *et al.*, 2012) was proposed to index lifelog data so that a person could efficiently retrieve log segments of interest. By converting sensory data such as accelerometer and GPS readings into activity language, statistical natural language processing techniques could be applied to index, recognize, segment, cluster, retrieve, and infer high-level semantic meanings of the collected lifelogs. In another study (Hamm, *et al.*, 2013), an Android-based smartphone was programmed to collect images and audio, location, and accelerometer data. With the help of multiple annotation tags, daily logs could be reviewed and segmented into meaningful events. In that study, much time was required at the end of the information-learning process to segment and tag the data.

A broad range of concepts has been proposed in the recent past to resolve the issue of lifelog retrieval; however, very few of them have recommended a real-time lifelog system that is capable of performing this task efficiently and spontaneously. We believe that our proposed system is practical and sufficiently convenient for use as a lifelog device.

3. PROPOSED MECHANISM FOR RETRIEVAL OF LIFE LOGS

We configured our lifelog device to capture three types of key elements in conjunction with the lifelogs: the identity of any people in sight of the user wearing

the lifelog device, the context of objects/things in the neighborhood of the user, and the current location of the user. The device captures the lifelogs in the form of photographs and audio clips at regular intervals. The logs are uploaded to cloud storage and their URLs can later be used to retrieve them based on the user's present context. The primary key element captured by the prototype device as part of the lifelogs is the identity of people in close proximity to the user. In addition, textual information describing three-dimensional (3D) objects in the vicinity is also collected together with the present location coordinates of the user. Each log's URL is associated with the detected key elements, i.e., identified people, recognized objects, and location coordinates for the given time (t). Multiple people and objects can be associated with a single log URL but only one location, as shown in **(Fig. 1)**. We further illustrate a log URL at time (t) as follows;

URL^t [Person(A,B,..,Z),Object(A,B,..,Z),Location]

Where Person and Object represent people and objects distinguished by the device and Location is the GPS sensor reading at the time of log capture (t). Consequently, a user may acquire a particular log URL by providing one or more present key elements that are identical to preceding elements.

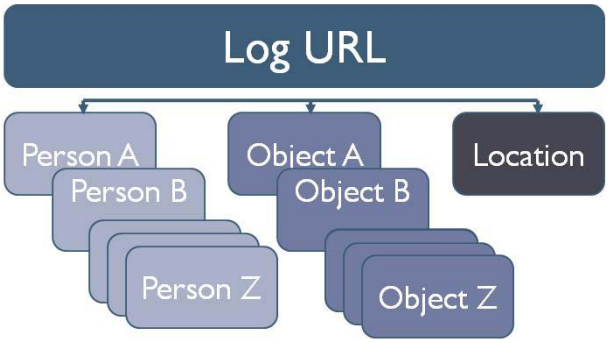

Fig. 1: Associating Log URL with key elements

A previous study attempted to create metadata out of sensor data from a set of heterogeneous sensors (Kim, *et al.*, 2008) that recognized a person within sight by post-processing the logged video, but that technique consumes a lot of time and processing power. Furthermore, the sensors identified only objects that were tagged with RFIDs. Our approach identifies people by using infrared sensors and recognizes objects by employing an efficient and quick image-recognition engine. Thus, when a user requests lifelog retrieval, they are retrieved instantly based on the present key elements, i.e., the present situation of the user.

3.1 Key element 1: People nearby the user

The identity of people nearby is noteworthy and may help to recall past meetings with them (Cosley, *et al.*, 2009). Our system recognizes one or more people involved in a conversation with the user, thus helping the user to recall any past logs linked with the same people instantly, without the need to input details such as date or location. Here, we focus on face-to-face interactions between people and refrain from taking into account people behind the user. By doing so, we avoid retrieving irrelevant logs in crowded places, as the lifelog device will retrieve only logs related to people in front of the user. There are situations where a neighbor not belonging to the user's group is captured, however, during the retrieval process, the proximity of any one participant (either of the same or different group) will retrieve the lifelogs related with that event. The recognition of participants as neighbor participants when they are actually in different groups does not matter in our system, since it is not required that all the participants be present in the current context to retrieve lifelogs of a past event.

Recognition of people belonging to different context is an open issue. But the infrared sensors employed in our system are efficient in determining the proximity of people present just in front of the user wearing the prototype device. These sensors work at any light and weather conditions. Furthermore, the range of these sensors is similar to a TV remote control, hence, they do not capture those who are farther away. There might be situations where a person in transit meet several other people, may record them, but those moments are less likely to be recalled. In other situations like partying, the user is again in close proximity with several other people. Once the user meets with a person who was present at that time, the infrared sensors swiftly recognize that person and get back the lifelogs of that event. The system does not filter numerous people around the user and captures all those who are facing the front of the infrared sensor worn by the user. When many people are moving in front of the user, it will add more context to the lifelogs instead of adding background noise (in terms of irrelevant people). The user may retrieve back those lifelogs by the help of any one person who was captured at that moment.

To understand the process of identifying an individual in close proximity, imagine two users, A and B, talking with each other in a crowded place, where everyone is wearing the lifelog device. To know whether User A is interacting only with User B, we attach an infrared transmitter and receiver to the lifelog device. Bluetooth is used to share the user's name and unique infrared ID with all the other lifelog users in the vicinity. The transmitter attached to the device emits an infrared ID of 12 bits on a 40-kHz carrier wave every the devices receiving this ID, via infrared receiver, can then compare it with those already shared via Bluetooth

to identify the individual in their sight. Once the person in sight is identified by the lifelog device, the logs generated at that instant are linked with that person. We pursue a similar wearable system as Sociometer (Pentland, 2002) that was used for identifying human proximity and understanding face-to-face interactions between people.

3.2 Key element 2: Context of objects

Recognizing the context of objects around a person in real time can be used efficiently in lifelogging to retrieve any past logs associated with those objects. Context has been well explained (Brown, *et al.,* 1997), however, in regard to an object, context is any information that can be used to categorize that object. An object can be described with some textual details to elaborate the means of use of that object, but the problem is to make an object distinguishable from other objects at a given place. There has been extensive research in the field of computer vision to distinguish 3D objects from two-dimensional (2D) images (Brooks, 1981), (Lowe, 1987), (Marr *and* Nishihara, 1978). At present, it is possible to recognize objects via smartphones and image-recognition engines such as Moodstocks (Moodstocks API), VisionIQ (Iqengines), ClickPic (Clickpic). These engines provide the ability to recognize millions of sample images in real time. We acquired the services of Moodstocks API for real time 3D object and barcode/QRcode recognition. The current image recognition engines are not perfect, but we asked the users to select the objects which have some textures for easy recognition. We stored the images of those objects in the Moodstocks database before the experiment. As a result, the objects were easily recognized by the prototype system. The rest of the objects around the user were not recognized by our system, so there was very minimal chance of incorrect recognition. Storing the images of objects in the database on a larger scale is not appropriate; however the objects may be recognized by bar codes/ QR-codes. The system may also read the textual information written on the objects to classify them. Object classification and identification is difficult on a larger scale and it is an open area of research. In this research we attempted to highlight its importance while retrieving appropriate past life information of the user.

Here our research aim was to add object recognition as a key element for lifelogs retrieval, therefore, we did not focus on the accuracy of object recognition. Our retrieval result showed the lifelogs related with the recognized objects when the user preferred to obtain lifelogs based on those objects. The manual retrieval may also cause human errors, as sometimes it is difficult to recognize objects by looking just at the image. In our case, the image recognition failure can also happen. But, we are very optimistic that, in the near future, the image-recognition engines will be able to recognize all objects around a user. We consider annotation of an object via Moodstocks API a key element and associate it with the lifelog captured at that moment. In this manner, objects present in the vicinity are recognized simultaneously and the user can find their past logs associated with these objects.

3.3 Key Element 3: Location of the user

The user's location is significantly important and may assist in the retrieval of logs pertaining to a particular place, as previously emphasized (Kalnikaite, *et al.,* 2010), (Kelly, *et al.,* 2009). We employ the built-in GPS sensor of a smartphone to record the user's location and save it as a key element. Each location is represented in the form of latitude and longitude coordinates. When a user arrives at a place, all of the logs generated are associated with that location. Later, if the user goes back to a previously visited location or selects the location manually on a map, the lifelogs within a 100-m radius of that location are retrieved. For accurate calculations regarding the user's current or selected location in relation to locations visited in the past, we use the "Inverse Formula". The users location in indoor environment may be determined through Wi-Fi hotspots and Bluetooth. However, in the current prototype we have only focused on outdoor locations (Vincenty, 1975).

3.4 Exploitation of all the key elements present

Retrieving lifelogs on the basis of any one key element expands the range of the retrieved data; conversely, making use of all of the key elements simultaneously narrows down the search and fetches precise logs that are related to the current situation of the user. Here, we explain the advantage of exploiting all of the key elements simultaneously to retrieve past logs accurately by using an example scenario.

A user meets with a friend at a supermarket and requires lifelogs pertaining to a prior encounter with the friend but cannot recall details such as the exact date or the few grocery items suggested by that friend. The user could employ the prototype lifelog device to obtain the logs of the previous meeting simply by providing the present location, people, and objects in the vicinity **(see Fig. 2**). Making use of all of the key elements present will retrieve the logs precisely related to that friend at the supermarket, which may assist in remembering the details of the previous meeting. However, if the user's friend was not present at that moment, then the logs obtained would be based on the location and surrounding objects and consists of all previous visits to that supermarket by the user. Our example scenario clarifies that using multiple key elements reduces the

number of logs retrieved, and those fetched will be the most suitable to help the user in the present situation.

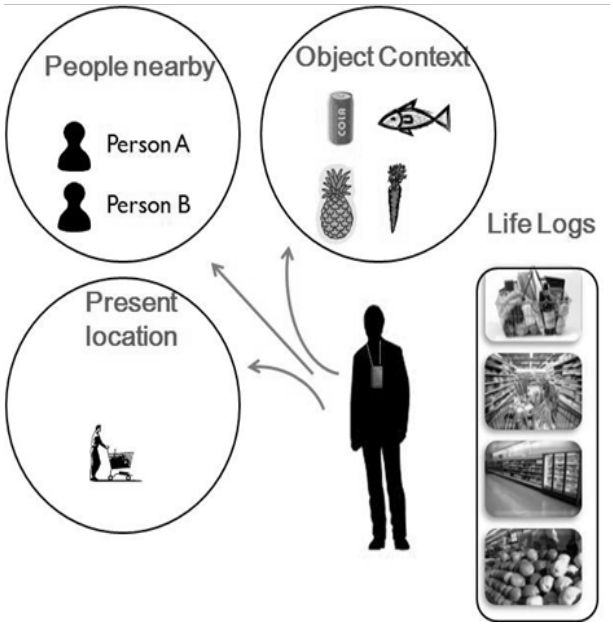

Fig. 2: A user at the market retrieving logs based on multiple key elements

4. THE PROTOTYPE SYSTEM

Our prototype system was developed using a Nexus S smartphone running Android 4.1. It works as a lifelog device with the capacity to retrieve past information instantly from huge numbers of logs. We used an infrared LED (model no. TLN110) as a transmitter, which emits a unique infrared ID as an individual's identification. This transmitter is normally used in remote controls and switches. The infrared receiver (model no. PLIRM2121-A538), together with the transmitter, is further employed to acquire reception from adjacent transmitters and to send those signals to the smartphone to identify the people around the user. To communicate with these sensors smoothly via the smartphone, an Arduino Mega ADK board (Arduino mega adk board) was used. The user wears the device with the help of a 15-inch neck strap that carries the infrared LED and receiver, and attaches the Arduino board to the waist, as shown in figure (Fig. 3). This system is identical to our previous system (Memon, *et al.*, 2012), which was employed for ensuring privacy in pervasive logging. All the users have to wear our prototype device for proper functioning. In order to make the system more practical, there are several other alternatives. One of them is RFID sensors, which can be carried by the people to identify themselves among nearby people. The people nearby can also be identified by bluetooth enabled devices (Smartphones, PDAs, etc) that are carried by them all the time.

Similarly, face recognition is also a good alternative where the lifelogging camera may be used for dual functions, for logging as well as for face recognition of people nearby. User's current location obtained via GPS can also be employed to determine people in the vicinity. Nowadays, social networks are being regularly used by the people revealing their real location. Considering this factor, the people nearby a user can be identified accurately. Since, there are various other alternatives for recognizing nearby people, we believe that in future, the prototype device can be configured to recognize people nearby using alternative methods if primary method is inappropriate in a particular situation.

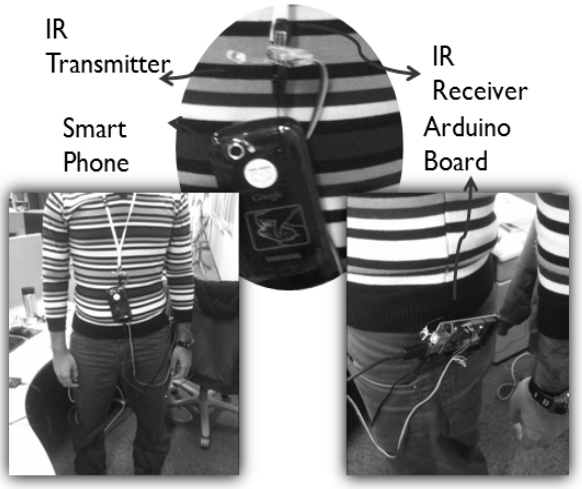

Fig. 3: The Prototype device \cite{memon2012}

In the current prototype, images and audio clips are collected as two types of lifelogs by employing the integrated camera and microphone sensor of the smartphone, respectively. We use the Dropbox API (Dropbox api: Store files and access any where) to store this logged data permanently in the cloud for future retrieval. In addition, Moodstocks API is used to recognize 3D objects in the vicinity of the user or those scanned by the user. We list the hardware and APIs used to make the prototype work in **(Table 1)**. The prototype system takes a picture and records a 10-s audio clip every minute. The proposed system was designed on the working principle of Sensecam. Sensecam was the first available lifelog camera that captured lifelogs in the form of images. Sensecam is now named as Vicon Revue. There is not much difference between Vicon Revue and our prototype system for recording the lifelog. The difference is that the Vicon Revue takes a picture in every 30 seconds and it is also equipped with light and motion sensors which trigger the camera when a sensor records any change in the environment.

Table 1: Sensors and APIs used by Prototype System

Sensors	Purpose
Camera	Capture logs in the form of images
Microphone	Capture logs in the form of audio records
GPS	Sense the current location
Bluetooth	Share users name and Unique Id with by-standers
Infrared Transmitter	Emit appropriate infrared signals to neighboring devices
Infrared Receiver	Receive infrared signals from neighboring devices
APIs	Functions
Dropbox API	Store logs in the cloud and retrieve log URL
MoodStocks API	Scan objects around the user and acquire their context

We do not have a mechanism to take a picture when a sensor records any change in the environment. Since the Vicon revue device produced approximately twice the logs generated by our prototype device, we observed that taking a picture depending on the environment change did not play much important roles in our experiment situation. It might be true that the proposed system is good for continuous event such as meetings but not good for capturing for instant events since our system lacks the mechanisms which trigger the camera when a sensor observes changes in the environment. However, we could not confirm the differences explicitly from our experiments. The participants of both the devices were able to retrieve back the lifelogs for the given events. Therefore, comparison experiment between our prototype system and Vicon Revue is appropriate.

The differences of recording device and that of retrieval tool are independent. In this paper, we focused on the retrieval of lifelogs. It is also possible to configure the device to take a picture in every 30 seconds and equip our prototype with light and motion sensors which trigger the camera.

In the present implementation, the user has to upload all of the lifelogs generated to the cloud storage using the given application. We are considering automatic transfer of lifelogs to the cloud storage at regular intervals in future versions.

4.1 Capturing and storing life logs with key elements

We designed an app that incorporates the features of logging life events and attaching meaningful context to those logs. It runs constantly, as presented in a snapshot of the prototype device in **(Fig. 4)**. The screen of the device shows the live camera view and some widgets. The key elements detected by the device are listed under the labels "People Nearby" and "Object Context", while the images and audio clips are recorded in the background. The current location of the user is also monitored as a background process and not displayed on the screen. The system detects an individual within sight of the user when an infrared signal is received, and displays the name on the device screen. Objects and barcodes scanned and recognized by the prototype lifelog device are also displayed. The lists consisting of the people and objects identified are refreshed automatically following any change in the user's current position. When the user moves to another location, all of the key elements detected are acknowledged for the logs being generated at that time and are saved as distinct listings on the lifelog device until the user uploads the lifelogs to the cloud storage.

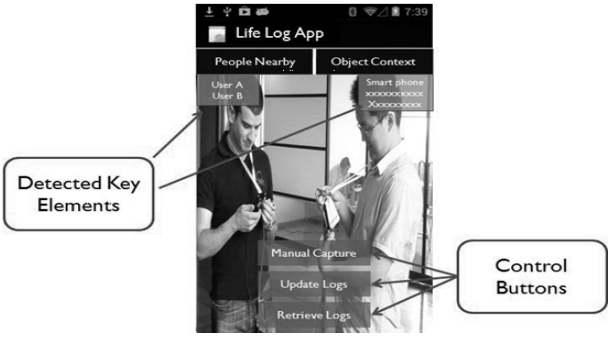

Fig. 4: Live camera view showing captured key elements

We also provide three control buttons to manipulate the lifelog device. The "Manual Capture" button triggers the camera and microphone to deliberately record when required by the user, overriding the routine logging every minute. The button "Update Logs" sends all of the captured logs to the cloud storage and obtains their URLs. Each URL is associated with the current unique date and time stamp to provide a reference ID. The listed key elements are linked with this reference ID and pushed to a designated server that is configured using MySQL database to store the URLs together with all of the key elements recognized by the prototype device. Later, the user may query the server to retrieve appropriate logs by offering the key elements present. The "Retrieve Logs" button serves this purpose and passes one or more key elements selected by the user to the server. The server compares the given key elements with past key elements and returns the matching logs to the user of the lifelog device. The following section discusses the retrieval of lifelogs.

4.2 Retrieval of life logs associated with the present key elements

In contrast to an ordinary lifelog device that requires a user to transfer all of the data to a personal

computer to view the logs, the users of our proposed system can retrieve past logs while on the move, even if they do not exactly remember the trivial details of their past. We take advantage of the user's present key elements to find information that best fits their current circumstances and helps them to recall similar events that occurred in the past. Based on their requirements, a user may select one or more key elements that is present, which will be reflected in the lifelogs selected for retrieval when querying the server. The interface shown in **(Fig. 5)** (a) allows a user to select "People nearby", "Object context", and "Current location" or "User-defined location" to retrieve appropriate logs. On selection of a single key element, the server will return all past logs that match the preferred key element.

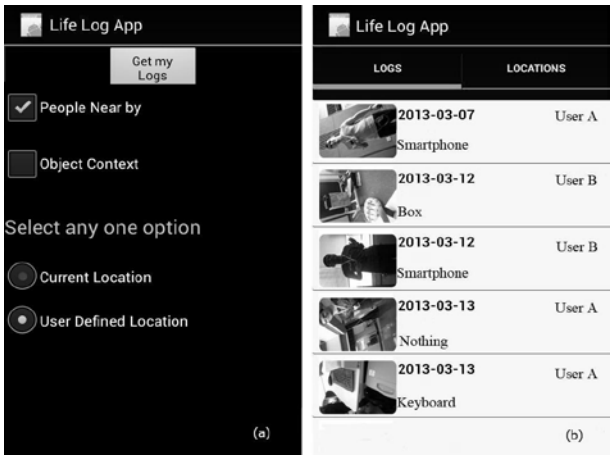

Fig. 5: (a) Selecting key elements for retrieving life logs (b) Life logs displayed with date taken, context attached and associated people

For example, if the user selected "People nearby" all logs related to people currently in front of the user would be retrieved. Alternatively, when all of the key elements are selected by the user, the server first filters the logs based on the current or selected location of the user. Once all of the past logs pertaining to that location are sorted, the people and objects associated with those logs are compared to the key elements identified by the device. Finally, the user can receive past logs from the lifelog device that match the current condition. There might be a situation in which the prototype device identifies several people and objects concurrently. In such a case, the logs associated with all of the recognized people and objects would be retrieved and displayed on the device.

As shown in **(Fig. 5)** (b), the retrieved logs are displayed as images with a resolution of 320-240 together with the date of log generation, contextual objects, and the names of people who were identified as present at the moment the images were taken. The logs shown were acquired by selecting "People nearby" and "User-defined location" as the key elements. The "Locations" tab displays a map marking the exact locations where the logs were captured. An audio clip is also attached to each image that can be listened to by clicking on the desired image. Hence, the procedure to acquire desired logs that match the present situation of the user is simplified, sparing the user from the need to specify particular details of past events.

5. EXPERIMENT TO COMPARE OUR PROPOSED SYSTEM WITH VICON REVUE DEVICE

We performed this experiment to determine whether our proposed system is more efficient than the Vicon Revue device (Lifelogging camera: Vicon revue) in retrieving lifelogs that are helpful to the user. The Vicon Revue device is a wearable 3-megapixel camera lifelog that takes a photo automatically every 30 s. The logs produced by Vicon Revue are compressed and temporarily stored on the device for later transfer to a computer for viewing and tagging. Our prototype sends all of the data to the cloud storage for retrieval at any place and any time. We tested two hypotheses:

Hypothesis 1: The time required to retrieve relevant logs for a given situation when using the prototype device is less than that when using the Vicon Revue device.

Hypothesis 2: Retrieving past logs that are relevant to a given situation is more convenient when using the prototype device than when using the Vicon Revue device.

To determine the time required to retrieve relevant logs for a given situation of a user, we set up an experiment and asked the participants to log some events with the help of the lifelog device given to them. Later, the participants had to retrieve the logs for the given events. We calculated the time required by the users of each device to retrieve the relevant logs for those events.

To measure the convenience of retrieving logs using the two systems, at the end of the experiment we asked all users to provide feedback about the overall functionality and the user interface of the lifelog device that was provided to them. We prepared four questions, which the users had to answer using a five-point Likert scale:

1. Rate your feeling of comfort about wearing the lifelog system during the experiment.
2. Rate your experience of searching the lifelogs for the past events.
3. Was it easy to operate the interface for retrieving logs?
4. Was the final screen (example shown in Fig. 5 (b)) useful to recall the past event captured by the device earlier?

5.1 Experiment Setup

The experiment was conducted with three participants at any given time. Two of the participants were given prototype lifelog devices while the other was provided with a Vicon Revue device to wear during two sessions in a single day. The first session started in the morning at 0900 h and ended at 1100 h. The second session started in the afternoon at 1300 h and ended at 1500 h. The participants had to log their everyday events using the device they were given, although they were allowed to switch off the device during their private time.

During the experiment, we asked all participants to perform two tasks, one to be performed in the morning session and the other to be performed in the afternoon session. These tasks are described in **(Table 2)**. During the morning session, all three participants had to meet at a location for a 10-min period to log the event. Similarly, during the afternoon session, the participants were asked to capture any two everyday objects that belonged to them. We asked the users of the prototype device to provide us images of these objects in advance so that we could upload them to the Moodstocks server. At the end of the experiment, we asked all of the participants to retrieve logs for the tasks performed in the morning and afternoon sessions. The participants of Vicon Revue were provided with the lifelogs captured by the device which they could view on a computer. At the end of the experiment (tasks performed in the morning and evening sessions), the participants were given the lifelogs (images) captured by the device to view one by one on the computer and select appropriate lifelogs related with the tasks. Once the lifelogs were identified, we counted those lifelogs and labeled them as lifelogs retrieved for that task by Vicon Revue users. When the users successfully retrieved lifelogs for the given events, we call it the task completion.

Table 2: Tasks performed by the participants in the morning and afternoon sessions

Session	Task
Morning (0900h to 1100h)	Capture logs of a meeting with all the participants at a location for 10 minutes period
Evening (1300h to 1500h)	Capture any two everyday use objects belonging to the participant

For our prototype system, the users were provided with the prototype device and they were asked to retrieve lifelogs of the tasks based on the present key elements using the same device. The users did not have to manually search for the appropriate lifelogs. Instead, all the lifelogs related with the selected key elements, such as, people nearby, objects and location by the user were retrieved on the device. Once the user retrieved lifelogs related with the given events, we call it the task completion.

The users of our prototype system had to use their present context to retrieve the logs related to the given tasks of both sessions, and they were permitted to use the key elements to serve this purpose. On the other hand, the user wearing the Vicon Revue device had to manually sift through the logs on the computer and search for appropriate content related to our tasks. We measured the total number of logs (images) captured by both types of logging device and the number of relevant logs retrieved for the given tasks.

5.2 Participants

For the experiment, we recruited 18 students (15 females, 3 males) aged between 23 and 27 years (mean=25.6 years) from various departments at the University of Tsukuba, Japan, and divided them into six groups of three participants, as described above. All of the participants were briefed for 30 min about the purpose of this study before being asked to start logging using their lifelog devices.

5.3 Results and observations

All participants completed the tasks successfully during the morning and evening sessions. We asked them to retrieve logs for the tasks performed in the two sessions and measured the time required to fetch relevant logs for these events. We found that the users of the Revue device required longer completing the tasks than did the users of our prototype device. **(Fig. 6)** compares the mean times required by the participants to retrieve relevant logs for the morning and evening sessions. The overall mean times were 4 s for the prototype and 94 s for the Vicon Revue. Vicon Revue users always took more time to retrieve logs, which validated hypothesis 1.

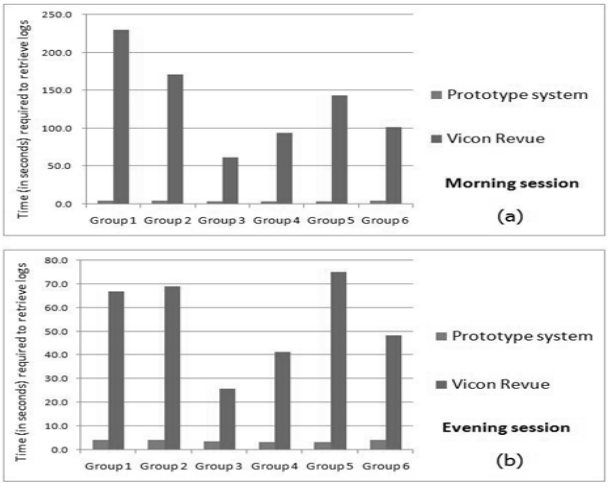

Fig. 6: (a) Mean time required by the participants for logs retrieval in morning session (b) Mean time required by the participants for logs retrieval in evening session

The users of the prototype device swiftly obtained the relevant logs for the meeting in the morning session, as their device identified the neighbor participant. These logs were displayed on the device. Again, in the evening session, the prototype identified the objects (watch, hand cream, juice box, etc.) scanned by the users and retrieved precise logs of past interactions with these objects. On the other hand, the Vicon Revue users first transferred all data to the computer and then viewed the logs one by one until the images of the meeting and the objects appeared on the computer screen. We asked the users in each group to count the number of logs retrieved (R. logs) for the given events as well as the total number of logs (T. logs) generated by their worn device during the two sessions of the day. The results are shown in **(Table 3)**.

Table 3: Retrieved and total logs generated by the life log device users

Groups	Prototype User A		Prototype User B		Vicon Revue User	
	R. logs	T. logs	R. logs	T. logs	R. logs	T. logs
Group 1	15	458	25	411	71	936
Group 2	10	398	23	401	40	786
Group 3	10	341	10	269	51	892
Group 4	09	266	08	336	47	1376
Group 5	09	266	20	421	57	1097
Group 6	19	418	20	405	39	943

The Vicon Revue device produced approximately twice as many logs as our prototype device, largely because the Vicon Revue takes a picture every 30 s. It is also equipped with light and motion sensors, which trigger the camera when the relevant sensors detect any change. Our prototype does not have this feature.

Finally, we analyzed the replies to the questions that users were asked at the end of the experiment. The users of our proposed system showed satisfaction using the device and we obtained a score of 4.1 (0.57) for question 1. For the Vicon Revue, the users responded similarly and the score was also 4.1 (0.4). For question 2, the users of our system showed utmost satisfaction with a score of 4.4 (0.51), whereas Vicon Revue users were not satisfied, as reflected by the score of 3.1 (0.4). The scores for questions 3 and 4 were 4.5 (0.52) and 3.8 (0.4), and 4.9 (0.28) and 3 (0.63) for our device and the Vicon Revue, respectively. These results confirm that our proposed system is more convenient for retrieving appropriate logs than the Vicon Revue device, thus satisfying hypothesis 2.

The retrieval of lifelogs based on key elements reduces the overall burden of remembering accurate details for retrieving necessary logs.

5.4 Benefits and limitations

Our prototype lifelog device works very well in situations where a user needs to recall past experiences quickly that are similar to their present situation. The lifelogs are stored in cloud storage so there is no issue of past lifelogs exceeding the storage space. Because the lifelogs are automatically tagged with key elements, users need not worry about manual annotation. On the other hand, Revue device users have to add manual tags for easy retrieval, otherwise the retrieval of logs becomes difficult consumes a significant amount of time.

6. CONCLUSION

With advancements in everyday devices, digitization of episodic memories is becoming a reality, but people require an effective and robust lifelog retrieval mechanism to obtain appropriate event logs. The proposed memory system includes a smartphone-based lifelog device that is able to recognize the present situation and search for relevant past episodes. We focused on people in sight, objects of interaction, and the location of lifelog device wearers, individually as well as collectively. Our vision of a prospective lifelog device consists of a self-reliant and compact system that can amass and search for the most appropriate logs relating to the present state of a person. The evaluation results show that our system is far more efficient than the Vicon Revue device in retrieving suitable lifelogs.

We will further investigate new key elements that can be annotated with lifelogs, such as body movements and other environmental factors, to analyze users' present state and assist in the process of accurate reminiscence.

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