Towards A Smartphone Based Lifelogging System for Reminiscence

Md. Abed Rahman, A. M. Esfar E Alam, Md. Hasan Mahmud and Md. Kamrul Hasan

***Abstract*—The proliferation of mobile devices have enabled us with the capability to store and make sense of passively gathered records of everyday human activities. This is called lifelogging. Every mobile device currently comes with a range of sensing abilities which includes but not limited to a camera, accelerometer, GPS and digital compass. All of these can be used to gather data unobtrusively. This data can then be made sense of by leveraging cloud computing. In this work, we build towards making a complete smartphone based lifelogging system, one that unobtrusively saves data as well as shows how it can be used to benefit the user. Another focus of lifelogging is to help users remember past events i.e. reminiscence. However, being able to find a good way to trigger memories is a challenge in itself. We explore the possibility of using music and background noise as a memory recalling tool and see the implications that it can have on reminiscence in a smartphone based lifelogger.**

***Keywords*—Lifelogging, Memory Aid, Information Storage and Retrieval, Personalized Recommendations.**

I. Introduction

Lifelogging in general has varied in its scope and how it has been defined in related literature. We adhere to the definition of Dodge and Kitchin [1], where lifelogging is referred to as "a form of pervasive computing, consisting of a unified digital record of the totality of an individual's experiences, captured in a multimodal manner through digital sensors and stored permanently as a personal multimedia archive". The purpose of lifelogging is to record and archive everything that happens in our life or during selected periods of our life. Compared to other forms of data collection which is traditionally perceived and archived by others, lifelogging is a form self-surveillance, i.e. capturing information of oneself for retaining precious information [2]. The motivation behind lifelogging stems from human desire for reminiscence as well as its utility in helping patients with diseases that effect long-term memory (like patients of Alzheimer's disease) [3]. While lifelogging has been used to facilitate both recall and recognition [4], [5], [6], the two different types of memory retrieval, we use users' ability to recall as a way to measure performance among users. A complete lifelogging system should facilitate better reminiscence, be more compact and should be scalable enough to support many users. Despite, there being several attempts at making lifelogging systems that focus on certain aspects of the overall technology, such as making recommendations [6] or monitoring potentially harmful behavior [7], there has not been enough work that shows a Smartphone based lifelogging system made for maximizing reminiscence. A lifelog ideally contains information about a person's activities such as when and where an activity took place, and the content of what was done and said, etc. [8]. We make the following contributions towards the making of a Smartphone based lifelogging system that aspires to provide the maximum reminiscence :

- We provide an architecture for a smartphone based lifelogging system, one that leverages cloud services to store, process and represent logged data in order to facilitate better reminiscence.
- Using music and background noise as a context-dependent memory retrieval cue [9] to facilitate better reminiscence.

The rest of the paper starts with an overview of related work, followed by challenges in the development of a lifelogging system. Next, we illustrate the proposed architecture, our implementation of proposed system and evaluation of our system.

II. Related Work

Evolution of lifelogging is tied to the development of lifelog capturing and visualization tools. SenseCam [10], a prominent lifelog capturing tool, is a wearable digital camera that usually goes around the user's neck and is used to take photos that are logged in to a lifelogging system. To make sure photos that are meaningful from a lifelogging perspective are taken, there are two photo capturing modes, temporal and sensor based. In temporal mode, the pictures are taken after a certain time lag. The pictures are taken at random based on the user's current position and thus a picture of user's surroundings is taken. On the other hand, in sensor based mode, the photo capturing is triggered by certain events. The camera 'senses' change in the surroundings and takes a picture of it's surroundings automatically. The triggering can be events like light, motion or temperature etc. An example of this could be invocation of the SenseCam whenever the user leaves a certain area [10]. Another popular method of capturing information is to use Global Positioning System (GPS) and put markers of locations on a map as the user moves throughout the day to create a record of daily movements of a user [5].

Among, the most prominent lifelogging visualization tools, there is Snaps, Tracks and Snaptracks [5]. Snaps are a picture viewer where the user can see his/her daily pictures in a temporal order to see what events in a day occurred and

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how the user ended up in a particular place. For example- A typical day of an ordinary man can be getting up in the morning, having a breakfast, taking a cab, reaching office, taking a coffee break etc. Photos that determine each of these events can trigger effective recall or inference of how the day actually progressed as there is a particular sequence in the data. Tracks on the other hand is the logging of timestamp data on a map that signifies the overview of a user's whereabouts within a day. So users movement through a map can be seen in a temporal order. Tracks seem to facilitate better remembrance than Snaps. Snaptracks, which essentially combines Snaps and Tracks is the best tool in facilitating remembrance [5].
Several field studies were conducted to explore the user experience of different activity and context logging, a technically feasible form of lifelogging. Lots of the lifelogging systems are wearable that went through its own evolution. For example, the evolution of the human cyborg system by Steve Mann as shown in Figure 1 shows how it became smaller at later iterations. Then came today's software context loggers. Significant amount of work has been done to improve on both of these types of systems. Now-a-days social networking sites like flickr.com, youtube, myspace and facebook timeline has added a new dimension to this concept [8]. There have been extensive studies on mobile context logging as well [11].

Fig. 1. Evolution of lifelogging wearable systems by Steve Mann.

III. Challenges in the development of Lifelogging and our approach for solving them

There are a couple of considerations that are needed to be made before we can talk about our proposed architecture. We will discuss these issues and would try to compensate for those in our proposed system.

A. Storage

Storage is an issue with lifelogging systems that rely on smaller devices like Smartphones. Binary data such as audio, video or pictures, some of which are needed to be stored in a lifelogging system, consume a lot of disk space. While, storage is becoming cheaper everyday, reliability and storage limitations have become a primary concern for lifelogging systems. A storage device suffering from data loss defeats the purpose of logging user data. Moreover, mobile phones, like other portable computers, are more vulnerable to loss or damage than a Personal Computer (PC) [12].
To solve this issue we use cloud storage. Cloud storage is more reliable then physical storage and it is scalable to increased storage needs. A cloud storage would also provide ubiquitous and scalable accessibility [13]. Thus, our proposed architecture makes use cloud storage to ensure reliability.

B. MultiModal Data

A recent trend in lifelogging research has been the incorporation of multimodal data and the different varieties that exist, such as keeping photos, videos, GPS locations etc. There is significant interest in the specifics of how multimodal data can be collected or how that data can be used to model user behavior activity [14], [15]. As we mentioned before, Snaptracks is a multimodal tool that facilitates reminiscence the most [5]. To improve the performance even further, we can use music or background noise [sound from now on] as a type of data that can help in reminiscence. Sound is proved to trigger memory [16], [17]. Music that the user is listening while doing a certain activity or surrounding noises of where the user is at the moment are inputs of our new proposed system. Our reasoning for adding sound is as follows:

- When we go to places and listen to music, that music become incorporated with that place or experience. So saving the music played and playing it back with the pictures should help better reminiscence. For example, if we hear a song when we are going on a journey, that song gets tied to the memories of that journey. Hence, hearing that song later on might invoke memories related to that journey. Capturing this phenomenon in a lifelogger would be the intuition behind adding sound.
- When the user is not listening to music, the system will capture background noise while taking a picture and play it with the picture. This is also expected to improve performance as background noise might trigger similar memories as music does.

IV. Proposed Architecture

The device used in our proposed architecture is a Smartphone with its usual capabilities such as accelerometer, GPS tracking system, camera etc. Data uploading in lifelogs are done manually [18], automatically [15], [16], [19] and both manually and automatically [20]. We allow for both manual and automatic upload of data which has been used in contemporary works [20]. The inputs are picture and GPS data [needed for Snaptracks], web history and multimedia software for media list. The inputs will be taken, processed (if needed) and stored in the cloud. The cloud will provide services for:

- Snaptracks generation based on GPS data, timestamp and pictures.
- Summarizing based on feedback from the user (both daily and weekly).
- Give suggestion based on users' area of interest.
- Use acoustic sounds (picked up automatically) or music (user feedback) for reminiscence.

Our proposed system will give us the following outputs:

- Search based on user input.
- Personalized recommendations for the user.

- Snaptracks enhanced with Sound [Enhanced Snaptracks from now on].
- Reminders of upcoming events.
- Weekly highlights.

A. Subsystems

As shown in Figure 2, our proposed system has 3 subsystems. The Input Subsystem takes input using the Smartphone and sends it to the Cloud Subsystem which handles storage and processing capabilities. Finally, the output subsystem, provides output that is meaningful for the user.

1) Input Subsystem: The Input subsystem consists of the following components:

- *Accelerometer*: The accelerometer is used for taking movement input for the system. Users' movements and their positional information is logged into the system.

- *GPS*: GPS data is needed for Snaptracks positioning. Source is a smart phone. GPS with a timestamp is used for mapping an event to a time and a place. In a nutshell, it will give track record of users day to day activities as a feedback; a key functionality of lifelogging systems. The acquired track record is displayed to the user. This data can be used to figure out the users regular routine and help the user to maintain it.

- *Camera*: Taking pictures for logging automatically has become the norm with lifelogging systems [15], [16]. Photos will be taken when the user wants to take a picture of something memorable or once the user moves to a different location, photos would be taken at regular intervals.

- *Music and Media History*: Music that the user is listening during a log data is taken or surrounding noises are inputs of our new proposed system. The intuition behind adding noise and/or music is human tendency to mapping certain noises or music to places or events. Music has been shown to help trigger memory in dementia patients [17]. The intuition behind this choice is that logging the background noise/ appropriate music may help trigger memory better.

- *Web History*: This data shall also be collected from the user's smart phone to understand their area of interests. Keeping log of history and providing news and links can be a key to a better system.

2) Cloud Subsystem: The cloud subsystem has two components, Storage and Web Services.

- *Storage*: Lifelog requires a huge amount of data storage. Since, we aspire to make the entire system Smartphone based, we need a cloud storage. Apart from scalability and redundancy which is typical of cloud storage, cloud storage has the added benefit of being able to access across multiple devices. For our proposed system, all the collected information would be stored in a cloud storage.

- *Web Services*: The cloud subsystem would have web-services for Snaptracks generation. Most of the processing done in the cloud end would be done using separate web services. After GPS, pictures taken and sound is uploaded, a Snaptracks generation service would synchronize that information and generate the Enhanced Snaptracks. Media and web history will be used to give effective recommendations which will have it's separate cloud service. Supervised learning strategy should be applied to build the notifications and alarm which makes the Reminders service. Finally there would be a service for generating Weekly Highlights.

3) Output Subsystem: Using the stored data and web services the following would be generated and given to the user as output.

- *Enhanced Snaptracks*: As mentioned before, putting together the sound memory cue and Snaptracks, the cloud service would generate them for each user.

- *Recommended Services*: As we are using Smartphones as our primary logging device it is easy to get web and media history from the mobile. We can use this to help the user by giving out personalized recommendations. Various online recommendation system works by giving the user a generic list of widely used products and then slowly personalizing them based on user activity. With day to day information, it should be possible to generate better personalized recommendations, devoid of bias towards any particular organization.

- *Reminders*: From personal work and logging patterns, it is possible to generate reminders for people. For example, if someone goes for a walk everyday of the week, the system can generate alarms for the user by studying their logs.

- *Weekly Highlights*: From logged data, weekly summaries can be drawn, highlighting special events that might have happened over the week.

B. System Flow

Figure 3 shows the system flow of our proposed system. The Smartphone collects all of the logged data. Then it is stored in the limited space of the internal memory and supplied to cloud storage without user intervention. In cloud, the data is automatically synchronized and all of the pictures along with background noise is saved based on timestamp. It works on the background so the user is not disturbed.
For output, the user can see his entire day as Enhanced SnapTracks to review their entire day. Multilevel views are provided using cloud services. Friends can access certain amount of data that the user wants to provide. As mentioned,

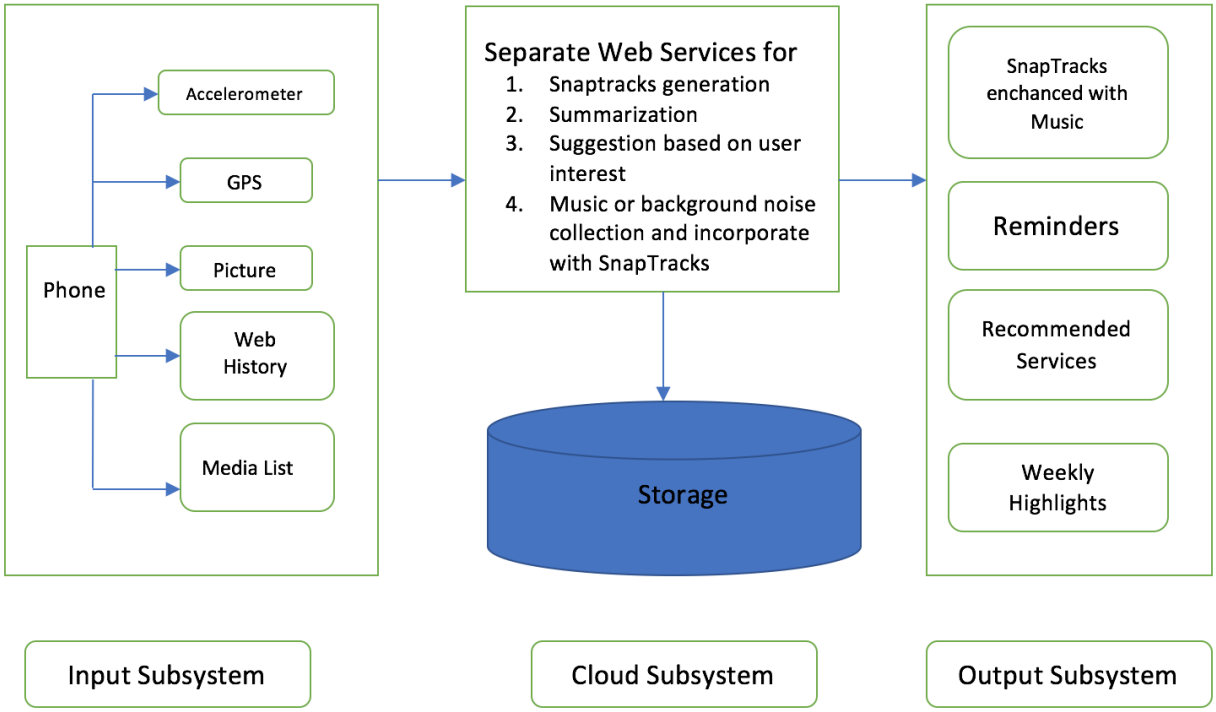

Fig. 2. Proposed System

logged data can be viewed from any device, an advantage of using cloud services.

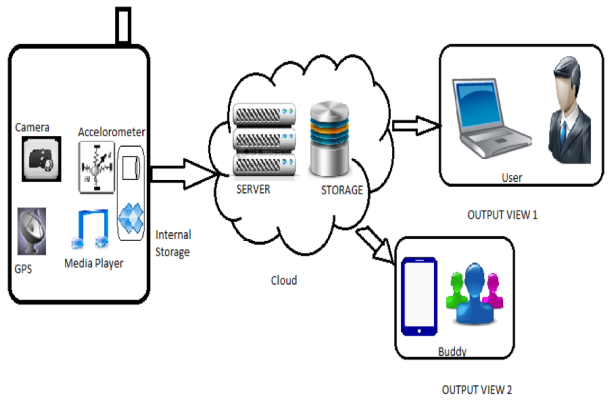

Fig. 3. System Flow of Proposed System

V. System Implementation

We have build a prototype of the system we proposed. Parallel to our proposed architecture we have 3 modules- mobile application, lifelogger server and lifelogger web interface.

A. Mobile Application

Using PhoneGap [21], we develop our mobile application client. Phonegap uses HTML and JavaScript for coding and interface. The interface is developed more like a web interface, instead of a typical drag and drop environment which is typical of Integrated Development Environments (IDE). However, JavaScript's excellent even handling capabilities along with PhoneGap's code re-usability and platform independence makes it the perfect development tool. We tested the application on an Android Phone. Figure 4 shows the Mobile Application Module.

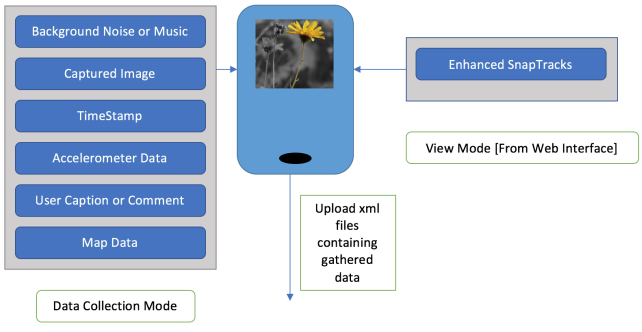

Fig. 4. Mobile Application Module

The application has two parts- Data Collection and View. The application collects background information from the environment either automatically or by user's choice. The data that would be collected are images, location and sound for Enhanced Snaptracks, user captions and comments in order to further facilitate recall. All of the location information

is uploaded on the cloud as *xml* files, one for each day. The photos along with sound are uploaded separately either automatically or by the volition of the user. Figure 5 shows the interface the user can use to upload data manually. The View module gives individual views to the user based on their access. A user has access to all the information they have uploaded or they have a limited view of others information.

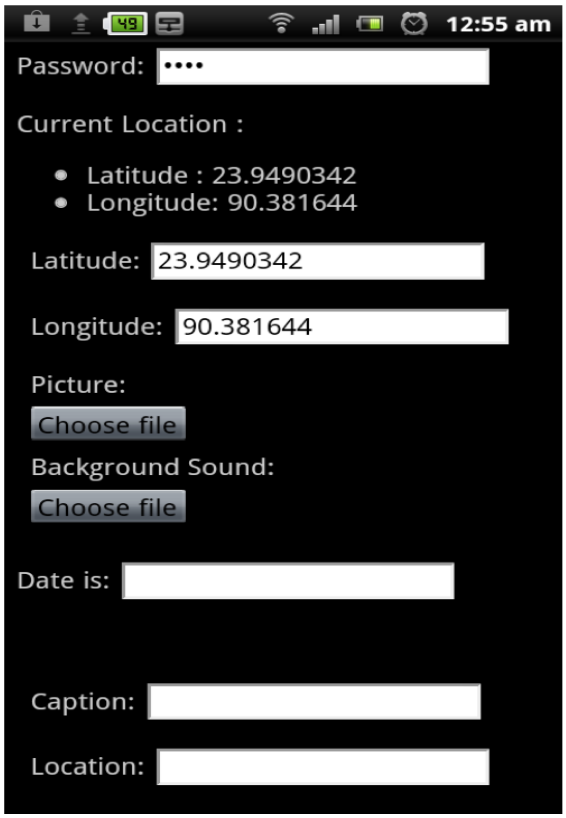

Fig. 5. Manual Upload Interface

Moreover, the user could see his/her Snaptracks of a particular day through the mobile application. We use the Google Maps API to create our Snaptracks and they contain links for each marker which shows the Enhanced Snaptracks. Same functionality is available in the website. Figure 6 shows the interface for reviewing a days Enhanced SnapTracks.

B. LifeLogger Server

As mentioned before, the cloud server has a storage where all of the xml files, pictures with sound etc. are stored. As mentioned before, there are various services. Based on the user permissions, the server sends information to the Web application or the mobile application.

C. Lifelogger Web Interface

We developed our web interface to show logged information as Enhanced Snaptracks and to give the users the ability to maintain their own information. Figure 7 shows the website architecture. After logging in, the user gets to choose what to be kept as private or personal. He/She can also upload new

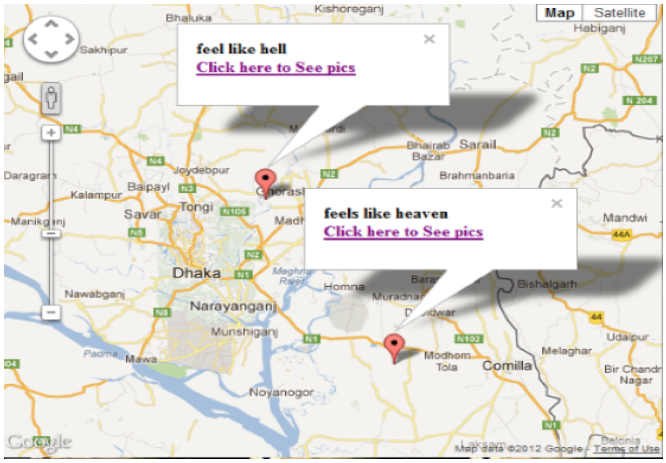

Fig. 6. Enhanced SnapTracks viewing

things manually as it can be done from the Mobile Application. Automatic content upload is not available on the website as the whole point of using Smartphones is portability and feasibility of usage. There is also the option of viewing ones own content or content of others who the user has added as friend. Only things that are shared to be public by a user can be seen by friends of that user.

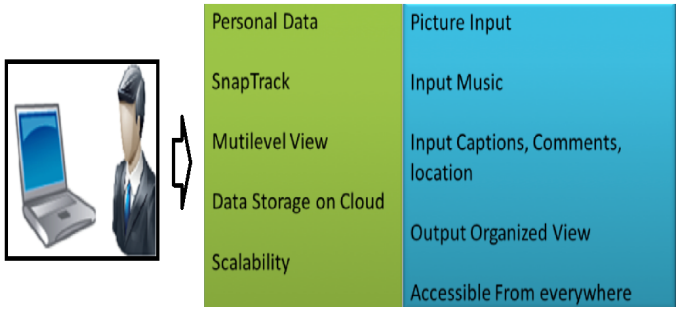

Fig. 7. Website Architecture

VI. Result Evaluation

To see whether our system really boosts reminiscence as it is supposed to, we developed our own experiment. We recruited 20 participants and we distributed them into two groups of 10. The participants are all university students without any prior history of memory retainment issues. Both of the students were given to use the system but one group used general Snaptracks [i.e. Only Images] and the other group were given to use the software with Enhanced Snaptracks [Images with background Noise]. A detailed record of their day was taken as they moved along. Then a semi-structured interview was conducted to take as much details of their day as possible. Similar interviews were conducted on the 7th and 15th day respectively. As memory decay happens over time, they were able to give less and less details than before. There responses were all scored on a scale of 1 to 10. The average of those scores are shown in Figure 8. On the first day everyone had perfect recall and hence got perfect scores. This perfect recall on the first day can be attributed to recency effects and hence

discarded from any subsequent analysis. For day 7 and 10 we take the average user scores. With these scores we did a uni-variate Analysis Of Variance(ANOVA) with Snaptracks Type [only images or images with background noise] as the independent variable (IV) and average remembrance scores as the dependent variable (DV). The ANOVA suggested the type of Snaptracks used had an influence on the remembrance scores [F(1,38) = 86.265, p $<$ .001, η_p^2= 0.694]. This essentially means Enhanced Snaptracks works better than the usual Snaptracks.

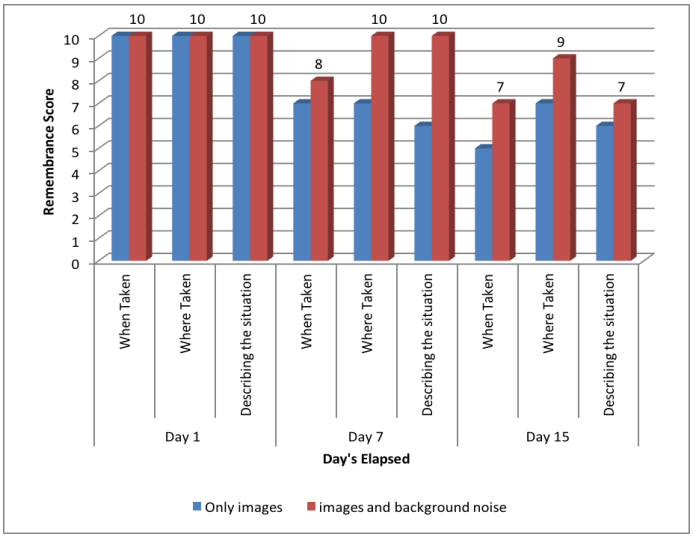

Fig. 8. Progression of Recall over time

VII. Future Works

Our implementation is incomplete as there is a lot more that can be done. The work in itself is iterative in nature and the work we present in this paper is a first pass at implementing a prototype. Future prospects include but is not limited to the following:

- *Daily or Weekly Highlights*: Summary of daily and weekly events can be an output. Therefore understand user's daily routine and notify him for daily events (e.g. Office time alarm).
- *Recommended Services*: Personal recommendations based on ones own lifelog data has potential to improve the performance of recommender systems. While personal recommender systems have got recent attention [6], [22], lifelogging based recommender systems has a lot of untapped potential. We believe it to be the next step towards making a comprehensive lifelogger.

VIII. Conclusion

Our goal was to create a Smartphone based Lifelogging architecture which facilitates better reminiscence. We have shown how our proposed architecture is more appropriate based on experimental data and achieved primary success in getting good performance. The proposed system can complete human needs of reminiscence once completed. There is work yet to be done as we have outlined already.

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