Augmented Reality Based Lifelogging System for Reminiscence

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Abstract. In recent times, Human Computer Interaction(HCI) related research has shown an increasing interest in systems designed for supporting human memory. As regards, the extent to which Augmented Reality (AR) being used to experience the reality is blooming and being applied to each and every sector of HCI thoroughly. In this paper, we are presenting a mobile based system and its design, build-out and procedure to reminisce past memories using life-logging system where users store images with related details in cloud storage based on location. When the user comes back to the location, using the concept of Geo-location-based AR, the stored images are augmented into the pre-existing reality. As a result of tapping onto the objects, the pre-stored images with provided details are overlaid on the view screen. We propose that such approaches can encourage more mindful engagement with life-logging system and AR promoting positive effects linked to reminiscing with a little to no cognitive work.

Keywords: Augmented Reality · Life-logging · Reminiscence · Crowdsourcing · Memory Retrieval.

1 Introduction

Developments in technology have numerous applications and one of them is that people can record and store vast quantities of personal information which is necessary to recall past events. That being the case, retrieving memories has always been a substantial area in cognitive science. Apart from sentimental longing for a moment in the past, recollecting previous memories have other demands. In our aging population, the number of persons suffering from chronic diseases is increasing. Persons suffering from memory impairment may lose the ability to recall names, past activities, and objects. Not only for the aged population, if we think about the younger generation, but there are also many minute details of past events that are not being fetched properly, sometimes the important information is being overlooked, other times it is taking a long while to get the facts

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necessary at the moment. For this reason, Lifelogging has become a necessity and with the increase in mobile devices available to the population, it now has an easy outlet or practice as mentioned in [1,2].
In this article, [3] lifelogging is described as the practice of individuals recording their quotidian lives in different degrees of detail for a number of reasons, and it is a highly strong tool for reminiscence. The record comprises a database of a person's life and actions that is more or less complete. The information may be used to learn more about how individuals spend their lives. A life-logger is a system that can attain this capacity. Reminiscence may be defined as the process of recalling prior events or experiences, as described in this study [4]. For example, if a person visits a place of interest today and after several years he returns to the same spot again, his brain tracks down that particular memory engraved deep inside years back and tries to incorporate it by relating to that location. This whole act of memory recall or recognition falls under reminiscence [5].
As per the studies, predominantly recognition works better than recall. One common explanation is that recognition can exhibit psychologically simple results of enhanced cognitive fluency induced by priming [6]. Priming is a process in which exposure to one stimulus impacts a reaction to a second stimulus without conscious instruction or purpose. Priming effects are quite strong; subjects will display priming on a cue they viewed or experienced once, a year ago, for less than a second [7]. Cues or memory cues are extensively necessary to trigger the brain responses to fetch the memories and the simplicity of the retrieval process is directly dependent on the comprehensiveness of the cue. In the case of memory recognition, all the conventional ways to fetch memories stand in need of real-world experience. AR, an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, widens engagement and interaction while providing an enhanced user experience [8]. Different types of AR methods include Projection-based, Recognition based, Location-based AR.
The objective of this study is to establish a system, where subjects can experience an enhanced real-time experience while recognizing memories using their lifelog data. An amplified user experience to view the memory cues through a system centered on geo-location-based AR. We intend to make the system comprehensive yet simple and aim to retrieve memories with apparently little to no cognitive effort as our proposed system will be providing certain stimuli which are significantly easier to process than others.
Some gaps are prevalent in the existing methodologies and it is important to address those. The existing image based lifelogging systems did not consider important inputs e.g. time, date, location, weather, information associated with images and the impact of the aforementioned inputs in lifelogging for reminiscence. Furthermore, some works have used multimodal data in lifelogging system but there is still considerable room to utilize those data to its zenith to reduce the cognitive effort for memory recall. In some approaches, data attaining proce-

dure requires a lot of effort which reduces the usability of the system. In view of the issues presented above, this article aims to make the following contributions:

- Proposes an unconventional geo-location AR based lifelogging approach.
- Recommends a quantitative metric of evaluation of memory recall (An event specific questionnaire considering the important factors like visual, coherence, time, perspective details).
- Introduces an approach of using relevant crowdsourced data as a tool for reminiscence.

In this study, we discuss about the Related Works of Reminiscence and Life Logging, followed by the Challenges and Problem Discussion. After that we provide our Proposed Methodology and Architecture that tackle the problems followed by Experimental Results and Conclude this study.

2 Related Works

The review work by Ksibi et al. (2021) in [9] mentions that lifelogging is a popular research area because of increasing demand from a variety of applications but getting insights from egocentric experiences, utilizing a massive deluge of unlabeled and unstructured data, remains a serious difficulty. Lifelogging has proved itself to be a useful method in state-of-the-art technology in reminiscence. Caprani et al. (2011) in [10] proposed a technique through which a device named Sensecam will be used to record day-long activities and the user will be able to view those lifelogged records and use them as cues to recall memories. Josef Hallberg et al. (2009) in their research mentioned in [11] named their system Review Client where lifelog data include past activities and events with other people with a varying range of cues. This system proved to be helpful for people with dementia. Another lifelogging system was proposed by Matthew L. Lee (2008) in [12]. In their article, they proposed a system consisting of three parts. The first part is *Input Section* where the records or cues will be stored. The second part is *Cue Chooser* where subjects will be provided memory cues by their caregivers. This will be determined by the specific needs, since persons with memory impairment may require more than a variety of numbers and types of cues. And in the final part called *Viewer*, subjects will view those cues along with their caregivers so that they can guide them through if they struggle to remember the events. Paul McCullagh, H.Z. Chris Nugent (2014) in this article [13] develops a design for people with impaired memory and evaluates its efficacy for reminiscence using life-logged data. The main focus was to make the system simple to use while attaining significant success in reminiscence.

In the research [14], Svetlana Nikitina et al. (2018) have proposed a smart conversational agent that can help older adults in the reminiscence process. They talk about conversational agents and cognitive services as the base for building upcoming reminiscence applications and establish the idea of a smart reminiscence agent. Interference from different sources is a part of our daily lives and some of these often become so severe that sometimes they can directly affect our memory. Benton (1957) states that when the source of interference is removed, forgetting drops from around 75% to about 25% over the course of 24 hours. Other methodological factors can lower this amount by at least 10%, leaving 15% as an estimate of the forgetting during a 24-hour period in [15]. This makes it evident why there is a strong necessity for lifelogging. Furthermore, van Teijlingen et al. (2021) mentions in [16] that memory loss is one of the primary causes of chronic impairment globally, affecting over 50 million people and resulting in over 10 million new cases each year and mild memory impairments might occur as a result of normal aging. Thus in recent decades, there has been a significant surge in interest in rehabilitation strategies for dealing with memory loss.

Crowdsourcing has proven to be effective with reminiscence. Korovina (2016) mentions in their study [17] that by living active social lives, older people can reduce loneliness. Elder people-friendly tags need to be used during photo labeling. Publishing photos of those social contexts help refresh the memory of the people and this concludes that Reminiscence positively affects people. Taking the previously mentioned work to a further level, Svetlana et al. (2018) in [18] discusses the identification of effective and scalable crowd-based strategies for content preparation, conversation logic, and meaningful benchmark for a reminiscence conversational agent(chatbot) aimed at older adults. Yung-Chin Tsao et al. (2019) in [19], discusses the potential usefulness of incorporating AR and VR in reminiscence which engenders an enhancing effect in terms of user experience. The entire system is meant to apply as a therapy to the target subjects by alleviating the memory setbacks.

Augmented Reality (AR) has a multitude of uses ranging from entertainment to educational purposes. The use of augmented reality (AR) to increase memory recall and learning experiences in human anatomy and physiology is investigated in [20] by Chen et al. (2019). They have used Microsoft HoloLens for this purpose.

3 Problem Definition

Humans have always used visual-based methods to help them remember information; which started from cave drawings, clay tablets, and continued to text and images, or video. Lifelogging and other personal informatics systems help users collect data for self-monitoring and reflection. Human memory is unquestionably a vital cognitive ability but one that can often be unreliable due to memory fog, mentioned in the research of [21]. External memory aids such as diaries, photos, alarms, and calendars are often employed to assist in remembering important events in our past and future[22].

The existing methodologies of reminiscence are insufficient concerning robustness and comprehensiveness for memory recognition and in turn, fail to build real-time experiences in terms of visualization while retrieving memories. Consequently, they demand a great deal of cognitive work to meticulously remember past events. Therefore, for proper memory retrieval, a detailed and entrancing experience is essential. This study aims to explore the immersive experience offered by Augmented Reality in reminiscence which intends to make the entire retrieving process more efficient while reducing the cognitive effort to the minimum.

4 Proposed Methodologies

We have divided our proposed system into three subsystems. Since smartphones have become the de-facto lifelogging device, and smartphone-based lifelogging (SBL) research has become a popular pastime as a result of technical improvements mentioned in [23] by Ali et al. (2020), we have used a smartphone-based approach. The Input Subsystem takes input using the Smartphone and sends it to the Cloud Subsystem which handles storage and processing capabilities. Lastly, the output subsystem provides an output that is meaningful for the user. As for input, the user will have to select some images that he would like to store for reminiscence and some additional information associated with it. The additional input parameters will be described later on in the article. Then comes the information stored into the cloud subsystem which will not only be responsible for storing the data sequentially and systematically rather it will also have to do some processing in there. Finally, our output subsystem will consist of several features. In this subsystem, the points known as Point of Interest or POI will be protruded whenever the user means to use the system where that POI was previously saved. An interesting aspect of the output subsystem is the Crowdsourcing feature where the user can tag other users into his images, therefore, building a connected grid. So even if the user is not the creator of that POI, he can view that POI thus helping him to recognize the memories in a secondary way.

4.1 Input Subsystem

The Input subsystem consists of the following properties: Image, Date, Time, Coordinates, Weather (Temperature, Humidity), Event Name, Person behind the camera, People associated with the image, and other description.

4.2 Cloud Subsystem

The cloud subsystem will have two parts:

Storage: the cloud subsystem will incorporate data and store them respective to the POI. The information the user has stored will be saved accordingly there.

Crowdsourcing: The tagged people will be crowdsourced and connected via this feature. The user will get tagged if someone decides to mention him and he can do so as well to others. He will be able to view the POI of other people as well. This processing of crowdsourced data will be done on the cloud subsystem.

4.3 Output Subsystem

The output subsystem will be responsible to give the users comprehensive information with the ideal environment. When the user will revisit a place and turn on the camera through the app and view the area around him, all the POIs were created by him or the POIs where he was tagged by another user will be popped up. Upon accessing a POI, data will show the image(s) associated along with some of the information that he had previously saved. These cues will be containing all the major details which the user might require to recognize the past events without putting any cognitive effort. At the same time, the interface of the system will provide a real-world environment thus assisting the users to relive the memories without any interference.

4.4 System Flow

The system architecture in Figure. 01 will show how the data flow is occurring here:

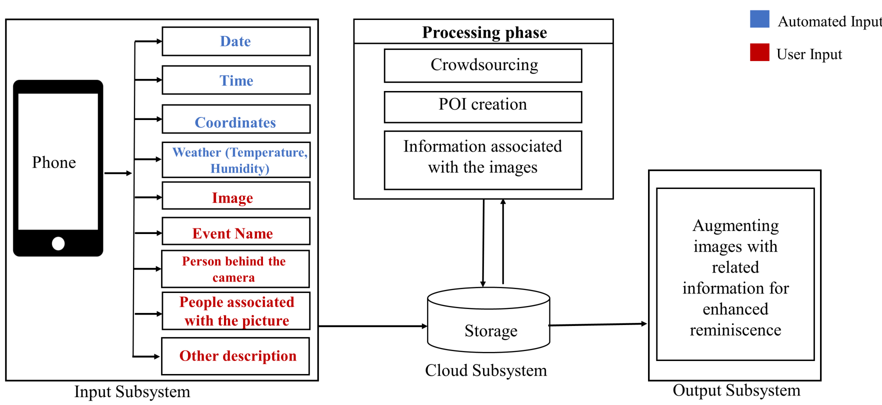

Fig. 1. The overall architecture of the entire proposed system

From the input subsystem, after obtaining the required inputs the data will flow into the cloud storage and be saved there. During this phase, the processing part of the crowdsourcing and POI creation will occur virtually on that location. After that when the user will come to that location, and view through the application using his camera, he will be able to view those POI and while clicking the POI he will be able to view the data stored there, e.g. the images and the associated information.

4.5 System Implementation

For our system to be implemented, we had picked the most available form of smartphone which was android and thus we had worked on android studio for building our application. Also, we decided to use the WIKITUDE SDK[7], because it contains some built-in functions and API endpoints that ensure easy build-up of geo-location-based AR implementations.

The overall algorithmic flow of the system is explained below:
1. A POI needs to be created using the mobile app which will enable the users to store their lifelog data. This POI creation is handled by a method ‘createPOI()’ which calls an API endpoint of WIKITUDE SDK.
2. The input subsystem will be responsible to upload the image the user has taken and its associated information to the cloud storage. The image and its associated information will be taken as an input in JSON format. The ‘imageDetails’ object shows an example of an input object.

```
imageDetails = {
    "id": "0"
    "image":"IUT.png"
    "date": "15-10-2019"
    "time": "15:40:34",
    "coordinates": "N-52.58.110, E-45.04.173",
    "weather":{"temperature":"30","humidity": "12%"},
    "eventName": "Farewell",
    "personBehindTheCamera": "Ifaz Ahmed Aflan",
    "personTagged": [{"id": "0","name": "Fahim Shahriar Reed"},
            {"id": "1","name": "Junaid Mahmud"}],
    "description":"it is an example of JSON data"
}
```

3. The cloud subsystem will be responsible to store and provide necessary data. The crowdsourcing feature mainly depends on the stored data.
Here, ‘saveImageInformation()’ demonstrates the post method of the cloud subsystem.

```
/* takes one parameter, 'imageDetails'.*/

saveImageInformation(imageDetails){
    /* posts the input data into cloud storage by calling
    an API endpoint of WIKITUDE SDK. */
}
```

Then, the previously created POI will be mapped with the stored image and its information for future purpose in ‘mapImageInformationWithPOI()’ method.

```
/* mapImageWithPOI is a map object where the key will be the POI
and the value will be corresponding image and its details.*/

mapImageInformationWithPOI(){
    mapImageWithPOI.set(POI, imageDetails)
}
```

Also the ‘crowdSource()’ method will be responsible to fetch POI accordance with the images where the user was tagged into.

```
/*using the get method of an API of WIKITUDE SDK, we will receive
'fetchedData' object and check whether the user was tagged in any
of the images.*/

crowdSource(){
    for each data d in fetchedData{
        if user == d.taggedUser {
            /* show corresponding POI where the user was tagged */
        }
    }
}
```

4. The output subsystem is accountable to exhibit the corresponding information to the user. After opening the app camera, the system using the geo location based AR shows the user all the POIs he had saved before or was tagged at. Since this is a geo-location based concept, the user will be able to see his previously set POI only when he is nearby the location of his saved POI(s); Under this condition, the user is provided with a notification to open his camera from the application to view his previously saved POI. The view will be an interactive and augmented object containing all the necessary stored information. A snap of the user interface is shown in Figure. 02. The image shows that the user has some POIs and after tapping one of the POIs, related information appeared with associated details.

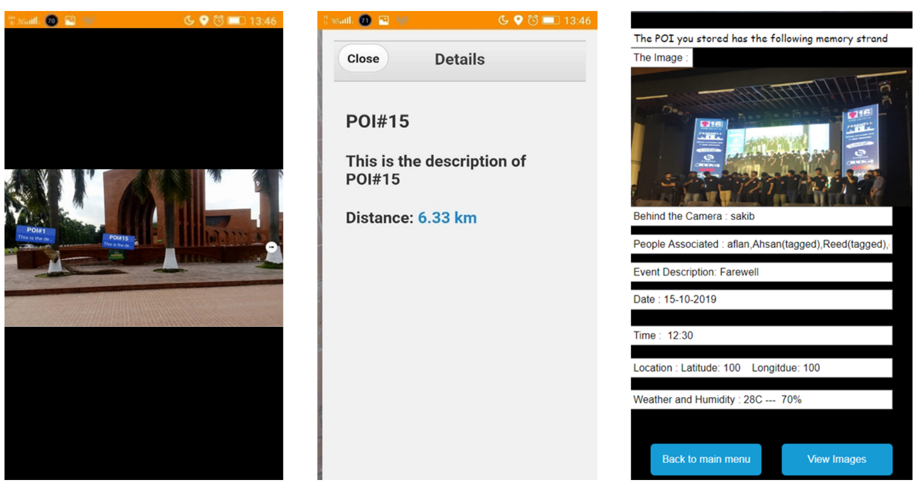

Fig. 2. A user interface with some POIs (left) and Some details after tapping one of the POIs (middle) and A user interface after selecting an image saved in a POI (right) (The interface is built using Wikitude SDK) [7]

5 Experimental Results

To see whether our system really boosts reminiscence as it is supposed to, we developed our own experiment [24]. We recruited 12 participants and after taking full consent from them we conducted the evaluation. The participants were all university students from the age group of 21-25 without any prior history of memory impairment issues. We considered the event of the Farewell Program of a university in Bangladesh and based on that event we prepared a set of questionnaires consisting of 6 questions which were answered before and after using the system. This questionnaire session took place 1 year after the event which gave us ample time to check for memory recognition. This set of questionnaires was not randomized rather we followed standard metrics. For recalling memories of any particular event we need to consider several properties while setting up a questionnaire [4]. According to that, we have considered visual, coherence, time, and sensory details for the 6 questions we used. Instead of using any predefined and generalized questionnaire, we prepared a custom questionnaire, taking into consideration that self-generated cues provide a strong development for episodic memory[25].

5.1 Result Analysis and Discussion

After getting the answers from all 12 participants, we evaluated the answers, calculated the average of their scores, and used ANOVA(Analysis of Variance) test to evaluate the result. After that we plotted the scores to a bar chart (shown in Figure. 3) which shows the dissimilarities between two samples. First sample consists of the mean scores of those participants who used the system. And the second sample consists of the mean scores of those participants who did not use the system.

Questions	Using the System	Without Using the system
Q1	4.9	3.5
Q2	4	3.9
Q3	4.3	2.2
Q4	4.9	4.2
Q5	4.7	4.3
Q6	3	2.8
	Mean = 4.3	Mean = 3.5

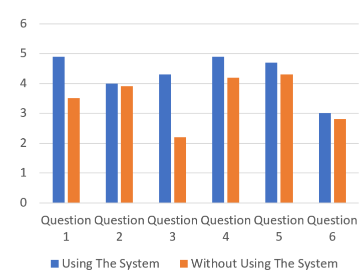

Fig. 3. Table of Mean scores of the 12 participants answering the questions (left) and Bar diagram of the average values(right)

To evaluate F-statistics value, we need to evaluate sum of squares within (SSW) and sum of squares between (SSB) and we have to denote Degree of freedom (DOM) for SSB, DOF for SSW and DOF for both SSW and SSB. From

this data gathered from Figure. 3, we evaluated all the values and form this data value, we evaluated F-statistics value. As we aim to use null hypothesis testing, so we have to determine the F-value to compare whether our system withstands.
Null Hypothesis: There is no changes in term of reminiscence after using the system.
Alternate Hypothesis: There is changes in term of reminiscence after using the system.

Now, using the formula, we have got SSW = 5.03, DOF of SSW = 10, SSB = 2.03 and DOF of SSB = 1.
If we consider F(1,10) value from F-statistics table for level of significance = 0.1, then our evaluated value has to be greater than the F(1,10) value so that we can reject our null hypothesis.

After the calculation, we get the F-value = 4.04 and from the f-statistics table [26] for alpha = 0.1 gives us 3.28 which is smaller than our evaluated value. So, we can reject the null hypothesis. This interprets that our system helps in reminiscence. Further, as we asked our participants how the system helped them to recognize past events, it was discerned that the recall rate was good.

In our system, we used image data with text information, varying a wide range of input, in order to avail adequate cues for users to reminisce with little to no cognitive effort. In existing systems, the utilization of lifelog data for reminiscence is insufficient which we attempted to mitigate using more assistive cues. Associated information with the images, e.g. time, date, weather, photo taker name, tagged people, event names have been used as context cues which will be beneficial for memory retrieval. Further, geo-location based AR provides location-based cues by augmented POI which creates an extensive user-experience. In the existing lifelogging systems, data collection demands a substantial amount of effort and in some cases, human intervention is required which contracts the usability of the system. Our proposed system consists of a simple mobile-based interface that is easily operable. Moreover, we have integrated the concepts of relevant crowdsourced data into our system. This feature enables the user to get access to POI which he had not initially created but contains information related to him, i.e. he has access to POI's where he was tagged in the images. This provides more data and more cues which will conspicuously help him recognize past events with less cognitive effort.

6 Conclusion

In this study, we have used only images with some related information as lifelog data. But for reminiscence, other data types are also important because images are not solely responsible for the recognition of memories. So, in the future, we intend to work with multimodal data like audio, video, noise, etc. alongside images and text data. Also, we wish to add a feature that will notify the user periodically by sending images of memories. These images will be blurred and the blurriness will be reduced over time which may help in memory recall. We also intend to work with patients with memory impairment since we were unable to do so in this study, given our limited time and resources. We have tried to utilize human memory as much as possible by implementing a system where the pre-stored images will be used to recognize memories using AR. Amassing lifelog data has a strong impact. Helping reminiscence through lifelogging will definitely create strong narratives for people of all ages especially the elderly and thus assist in leaving behind crucial knowledge, experience, and legacy.

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