LIFER: An Interactive Lifelog Retrieval System

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ABSTRACT

In this work, we outline the submission of Dublin City University (DCU) team, the organisers, to the Lifelog Search Challenge (LSC) workshop at ICMR2018. We developed a prototype interactive lifelog search engine for use in answering interactive search topics. We also demonstrate how the proposed system can be used to solve the development topics.

CCS CONCEPTS

•**Information systems → Digital libraries and archives; Personalization;** *Users and interactive retrieval; Evaluation of retrieval results;*

KEYWORDS

Search Engine, Lifelogging, Personal Life Archive

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1 INTRODUCTION

Lifelogging is defined as "a phenomenon whereby individuals can digitally record their own daily lives in varying amounts of detail and for a variety of purposes" [4]. With the recent advances in sensors and wearable devices, individuals can now easily track their daily activities such eating, commuting, exercising, working and sleeping in detail that can be considered as an actual blackbox of life experience. Such a lifelog can also contain information/content created or consumed by the individual during their everyday interaction with their mobile phones and personal computers [7]; the type of information that is normally maintained on our behalf by online service providers.

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Ideally, this huge amount of personal data is stored in a secure and always-on multimodal storage service that contains many different sources of time-stamed sensor data, aligned and organised in a way that allows us to perform typical data processing techniques such as content analysis & enrichment, information retrieval, data browsing, and summarisation. Before that, data typically goes into steps of data cleaning, temporal alignment and/or normalisation of the different sensor outputs and other methods of data linking and aggregation in attempt to have a consistent and comprehensive lifelog of the individual [6].

In real life applications however, the situation is usually different from the ideal scenario described above. The data generated by lifelogging tools and software is usually noisy, has errors, is unaligned, unorganised, and essentially overwhelming for the individual [8]. This is due to several factors, some of them are: 1) the variety of devices and sensors used for data gathering, which commonly are incompatible and from different companies/manufacturers. 2) the long and intense nature of the data logging process, that can easily result in missing data and/or faulty sensors. 3) the huge amount of data in different formats, representation and time stamps. This raises the need for more research and effort to be invested into the development of lifelog retrieval systems that can address these challenges and meet the potential and opportunities such comprehensive personal data promises. One of the interesting use cases is data retrieval and accessibility applications; allowing the individual to search and access previous life events in efficient and timely manner to behave as an external digital memory that can be called upon for different purposes. This is yet unsolved challenge and to address this, collaborative benchmarking exercises and workshops have been organised recently such as NTCIR-13 - Lifelog [5] and ImageCLEF2017lifelog [10]. We note that there is still no standard or typical approach to developing a lifelog search engine arising from these benchmarking exercises.

In this paper, we report our recent work in such benchmarking activities, the Lifelog Search Challenge (LSC) workshop at ACM ICMR 2018, in which participants are asked to retrieve moments, semantic events or activities from a provided testset of lifelog data. Specifically, we propose here LIFER, an interactive lifelog retrieval system, in the spirit of the MyLifeBits [3] seminal lifelog database, that can be queried based on many different forms of lifelog metadata.

The remainder of this paper is organized as follows, first we present the proposed LIFER search engine and how to exploit it. This is followed by a detailed results on the development phase of the LSC task. Finally, we draw some discussions and conclusions.

2 INTERACTIVE LIFELOG SEARCH ENGINE

The main goal of this work is to build an interactive retrieval system based on the provided LSC dataset of one month of lifelog data from one lifelogger. This interactive retrieval system builds on an existing baseline search engine [9], which was developed to provide a starting point for researchers in the area. In this section, we first summarise how the interactive search engine operates and then introduce how to it can be used to address the challenging LSC topics.

We follow the study in [9] to build a core search engine system, as follows: consider each image as basis retrieval unit (as required for the LSC challenge), all the raw lifelog data is transformed as features represented for the related image, i.e., time, locations, biometrics, visual concepts, user activities and music (that the user was listening to) are all added to the database as fields represented for the information of the image. Finally, an API/Interface is developed, which returns all images that matches with a given query criteria and supporting users to interact with the results to find the most appropriate answer. This whole process of LIFER is summarised in Figure 1 and the interactive search engine is shown in Figure 2.

For this LSC challenge, we build LIFER based on six sources of information that were readily available in the LSC dataset:

- Time. The most basic unit of data in the LSC dataset, time gave us the possibility of including more semantic concepts, such as days of the week, weekday/weekend, times of the day, etc. In our system, we choose start_time and end_time to get a period of time and images. In LIFER, we consider the unit of time as minute, i.e., each image is attached to a minute. These time is extracted (and linked to the image) directly from the provided data.
- Locations. Semantic location were provided in the LSC dataset which provided localised names for all locations visited. For example 'The Helix', 'Dunnes stores', 'Dublin City University' and so on.
- Visual Concepts. The LSC dataset provided a set of visual concepts extracted by Microsoft API [2], which that accompany each image. These visual concepts were indexed in our lifelog retrieval system. Visual concepts describe the content of the lifelog images included in the dataset. Each image has one (or more) concepts identified and tagged. The concepts (in text form) were indexed.
- User Activities. The physical activities of the user (e.g. walking, sitting, running, etc.) were indexed as additional search terms.
- Biometrics. The biometrics of the user were also indexed as semantic labels. These included the Galvanic Skin Response (stressed/excited, relaxed) which can be considered to be a correlate of stress or excitement levels, and the level of physical activity (exertion / resting) as identified from the heart rate.

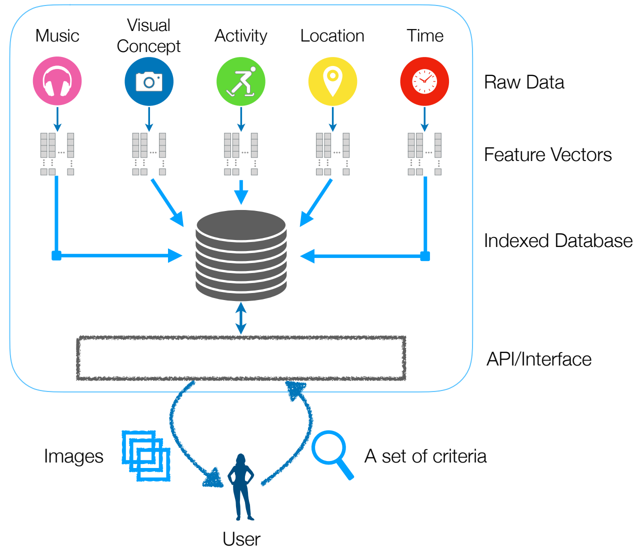

Figure 1: Schema of LIFER.

- Music. A log of the music listing history of the lifelogger was included in the collection and we considered that it could be an important aspect of some topics. The song_name and song_artist are two options which are used to search results.

These six sources of information are instantiated in the user interface as facets of a user query, as sgown in

2.1 Finding and Ranking Content

()The next aspect of LIFER is the retrieval process. We note that the past efforts from the collaborative benchmarking exercises (as outlined earlier) did not yet result in the selection of a 'typical' approach to lifelog retrieval for textual queries. Without any prior evidence, we looked at the approaches taken by interactive search tools for lifelogs in the past and selected the faceted filtering mechanism as pioneered in MyLifeBits [3] and the Doherty Lifelog Browser [1].

The LSC sample topics are temporal in nature, with an increasingly detailed textual description being made available every thirty seconds with a maximum query processing time of 3 minutes, meaning that there are six different topic descriptions provided. Since there will be negative scoring in place for incorrect answers at the LSC, the focus of LIFER was on fine-grained faceted search as opposed to the conventional fuzzy ranked list that is common in today's web search engines. This means that the facets of retrieval can be updated to generate a new result set as the query becomes more detailed over time. We felt that a ranking function that returned a fine-grained ranked list in decreasing order of similarity to a textual query would not be appropriate for this collection for reasons such as the fact that lifelog documents (as in the LSC) are synthetic in nature and will not contain repeating terms within one document (i.e. conventional text ranking will likely not be effective), hence our primary retrieval approach relied on the faceted query to filter out matching content from the collection and present them to the user in temporal order. Since the collection was small, this temporal order is unlikely to be too large for fast human browsing and selection.

The Interface of interactive system is shown in Figure 2. The upper section of the interface is the query-panel in which the faceted queries are created. Below that is the main part of the interface which is where the selected lifelog images are displayed in temporal sequence.

In the query-panel, the search facets are shown. The facets are directly related to the indexed data:

- Time. A fine-grained time search facility is provided that allows time periods to be selected and date periods to be selected.
- Music. Song name and song artist are provided as facets in the query interface. Should topics include music details, then such data would be an excellent means to find related content.
- Heart Rate. The heart rate is represented by a simple exertion / normal / resting facet as well as an actual range filter.
- Excitement. The Galvanic Skin Response is represented in a range of stressed / relaxed as a second biometric facet.
- Location. The facets here are an ordered listing of the semantic locations included within the LSC dataset.
- Human Physical Activities. A facet to select what physical activity the lifelogger was engaged in.
- Visual Concepts. A sorted (and searchable) listing of visual concepts that the user can select one (or more) of.

Upon submission of a faceted query, the system returns a temporally organised listing of potentially relevant images. In this first version of LIFER, the query facets are combined in an AND boolean manner. This can be changed on a per-topic basis, but does not form part of the interface at present.

The temporally organised listing of relevant images is displayed in the lower part of the screen (the result-display panel). Each relevant image is listed with an overview metadata as a form of context. This metadata is configurable to display various sources of information, as required. Figure 2 shows a basic form of such metadata.

Since the lifelog interactive system for LSC normally returns a small number of potentially relevant results (in terms of the number of relevant images) to the user, we believe that there is scope to enhance how the results are presented to the user. In order to increase the chance to find the right answer to the queried topic, selecting any image will immediately display all images within an hour before or after the selected image. This allows for the fast review of the detailed context of each ranked image. The selection of one hour as the time interval is empirically set and is approximately $60 \times 2 = 120$ images. Upon finding a relevant image, the user submits it to the LSC submission system. If the image is judged correct, then the task is complete, however if not, the user may continue to browse the result system or modify the faceted query and search again.

In the next section, we are presenting the preliminary results on the development set exploiting the baseline search engine and this extended windowing process.

3 RESULTS ON LSC DEVELOPMENT PHASE

We apply LIFER to solve the six topics in the development set and found answers on four of these six topics. The system can be obtained via: http://search-lifelog.computing.dcu.ie/LSC/. Summarised in Table 1 you can see two of them (LSC03 and LSC05) were correctly retrieved within the six phases of the query expansion while the other two (LSC02 and LSC06) just got the correct day and need users to search for other moments within 3 hours from the returned results.

In Table 2, an example of how the search criteria changes over the topic expansion on LSC01 is given by a test user in an interactive setting. As you can see, as the queries getting increasing in detail, the criteria is keep being updated:

- TS0: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background," the criteria starts with *Time = Afternoon, Location = Helix, and Concepts = People*.
- TS30: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background and a plastic plant on my right side," we added *"plastic plant"* to the Concepts.
- TS60: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background and a plastic plant on my right side. There are keys on the table in front of me and you can see the cafe sign on the left side. I walked to the cafe and it took less than two minutes to get there", we added *"Key"* to the Concepts.
- TS90: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background and a plastic plant on my right side. There are keys on the table in front of me and you can see the cafe sign on the left side. I walked to the cafe and it took less than two minutes to get there. My colleague in the foreground is wearing a white shirt and drinking coffee from a red paper cup", we added *"Cafe sign"* to Concepts.
- TS120: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background and a plastic plant on my right side. There are keys on the table in front of me and you can see the cafe sign on the left side. I walked to the cafe and it took less than two minutes to get there. My colleague in the foreground is wearing a white shirt and drinking coffee from a red paper cup. Immediately after having the coffee, I drive to the shop", we added *"white shirt"* to Concepts.
- TS150: "In a coffee shop with my colleague in the afternoon called the Helix with at least one person in the background and a plastic plant on my right side. There are keys on the table in front of me and you can see the cafe sign on the left side. I walked to the cafe and it took less than two minutes to get there. My colleague in the foreground is wearing a white shirt and drinking coffee from a red paper cup. Immediately after having the coffee, I drive to the shop. It is a Monday", so finally, we added *"Monday"* to Time.

Shown in Figure 3 are the best answers from the proposed approach on the first three topics. In LCS01 (Figures 3 (a) and (d)), it is quite hard to obtain the correct answer since the list of activities is lacking of "drinking" and the "coffee" concept is very common. We also noticed that some locations were not correctly annotated since there are some delay in the location detection, for example in

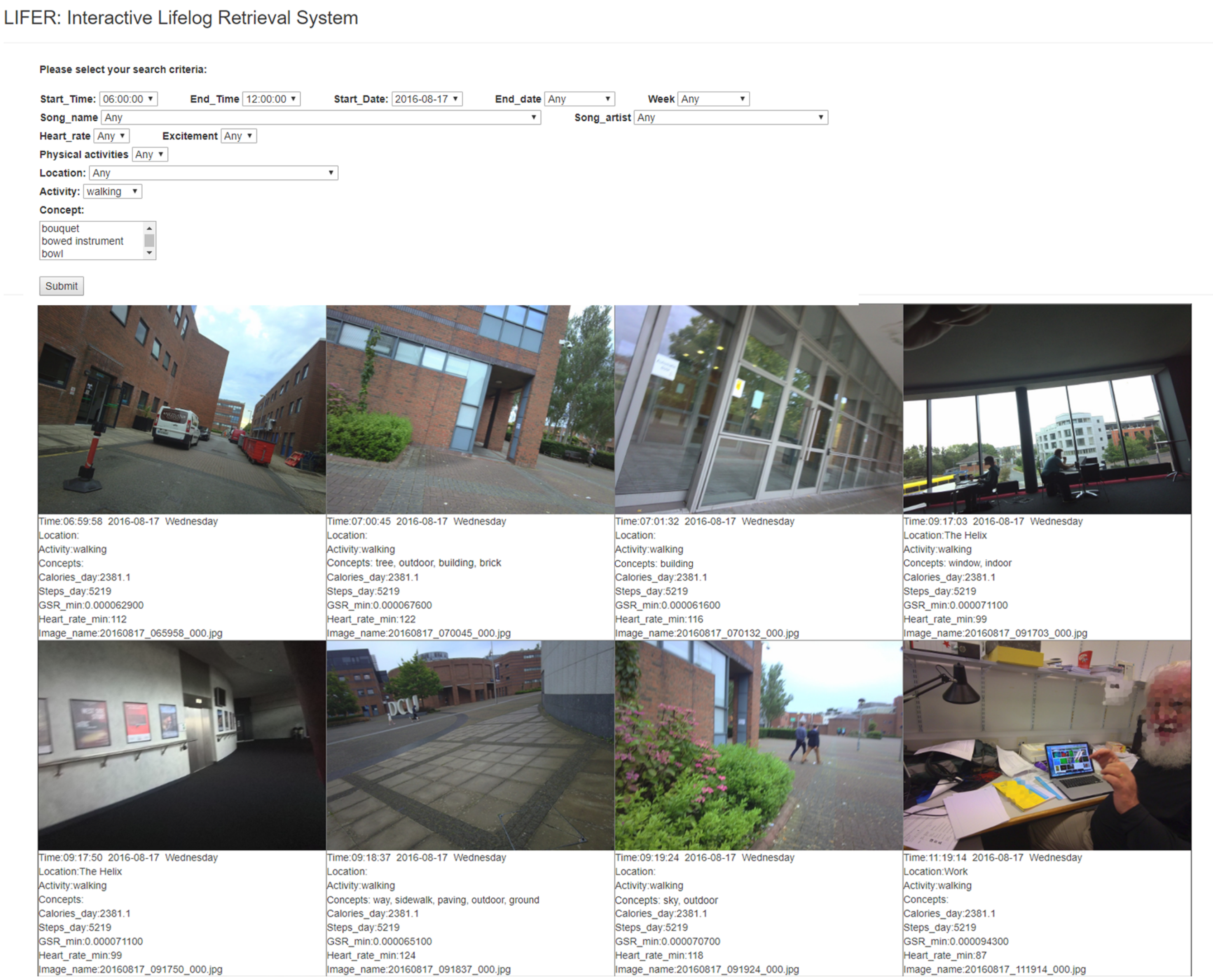

Figure 2: The basic functions of LIFER (http://search-lifelog.computing.dcu.ie/LSC/**)**

figure (d), the moment was happened 1 minute after the lifelogger was at the Helix but it is still understood as ”Helix”. In LSC02 (”*I am building a chair that is wooden in the late afternoon. I am at work, in an office environment, beside a yellow partition wall. There are plastic plants on the partition wall. Books and a trolley can be seen behind me on the ground. Since I am engaged in physical activities, my heartrate has raised above 100bpm. You can see other chairs in the background in some of the images in this event. It is a Friday in September. There are no other people in this location*”), we did not obtain the correct answer in this topic, but the best one is close to the search moment, which is only differences in one hour. In LSC03 (”I am at home in the very early morning and I am in my living room watching football on the television. There is a lamp to the right of the image and a box of things to the left of the image. After watching television, I use a computer and then drive to work. It is a Thursday.”), we got the correct answer after the last try (at the time stamp of 150). Results on the last three topics are shown in Figure 4.

Table 1: Results on the Development Set.

Topic	Stage found	Extension (hours)
LSC01	Not found	–
LSC02	Not found	1
LSC03	6	–
LSC04	Not found	–
LSC05	4	–
LSC06	Not found	3

As can be seen in the results, exploiting the baseline search engine can provide correct answers to the LSC development topics. However, there is significant potential for improvement, for example by considering the biometrics and loggerman data, or by

(a) 2016-08-15 14:49:29. (b) 2016-09-02 17:10:33 (c) 2016-09-01 05:05:39

(d) 2016-09-01 12:05:42 (wrong) (e) 2016-09-02 16:09:55 (+1 hour) (f) 2016-09-01 05:10:59 (correct)

Figure 3: Examples of the answers for the first three topics LSC01, LSC02, LSC03 retrieved by exploiting the propose baseline search. Images in the top row (a) - (b) - (c) are the ground-truth of the topics and images in the bottom row (d) - (e) - (f) are the answers for the topics.

(a) 2016-08-22 21:42:59 (b) 2016-09-05 05:28:10 (c) 2016-09-07 17:37:09

(d) 2016-08-15 15:39:18 (wrong) (e) 2016-09-05 05:28:10 (correct) (f) 2016-09-07 14:18:15 (+3 hours)

Figure 4: Examples of the answers for the first three topics LSC04, LSC05, LSC06 retrieved by exploiting the propose baseline search. Images in the top row (a) - (b) - (c) are the ground-truth of the topics and images in the bottom row (d) - (e) - (f) are the answers for the topics.

Table 2: Example of the Query Expension in LSC01.

TS	Activity	Time	Location	Concepts	Music
0	N/A	Afternoon	Helix	+ People	N/A
30	N/A	Afternoon	Helix	+ plastic plant	N/A
60	N/A	Afternoon	Helix	+ key	N/A
90	N/A	Afternoon	Helix	+ cafe sign	N/A
120	N/A	Afternoon	Helix	+ white shirt	N/A
150	N/A	Monday	Helix	N/A	N/A

improving the summarise of each photo so that the windows length can be increased (i.e. more chances to find the right moment).

4 CONCLUSIONS

In this paper, we introduce a first generation interactive lifelog search engine called LIFER, a system that allows a user to retrieve the moments from the personal life archives in a reliable and efficient manner. We designed this system to assist a user in examining their life experience to gain insights into their activities and lifestyle. We also discuss how this interactive search engine performs over the six LSC development topics.

There are a number of limitations to the LIFER search engine. The query panel is not optimised in terms of layout, the result list of images is currently only temporally sorted. The metadata highlighted could be query-specific and the metadata itself should be capable of generating a query to the system, so as to facilitate a richer browsing methodology.

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