

A fully automatic system for assessing day similarity

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Abstract

Due to the explosion of multimedia quantities such as archived TV broad cast videos, various multimedia resources released on the Internet, intense work in multimedia retrieval domain has aimed to provide efficient and accurate functionality for users to access the desired information. The rapid access to these huge multimedia resources and automatically assess day similarity or an experience from this collection of unstructured egocentric data presents major challenges that require efficient algorithms. As everything is nowadays automated, the main goal of this work is to apply a new method to automatically assess day similarity using a real image dataset called Egocentric Dataset of the University of Barcelona (EDUB) of 4912 daily images acquired by 4 persons in order to evaluate the performance of our system.

Keywords

Lifelogging, similarity measure, day similarity, local binary pattern, EDUB, dynamic time warping.

1. Introduction

The earliest motivation behind automatic generation of personal digital archives can be traced back to 1945 when Bush expressed his vision that our lives can be recorded with the help of the technology and the access can be made easier to these 'digital memories'. This new way of autobiography generation has become more and more realistic recently, with the advances of lightweight computing devices and highly accurate sensors. Mobile devices are approaching a more capable computing ability, dwarfing the most powerful computers in the past. The low price and the embedded nature of smaller and lightweight sensors (cameras, GPS, Bluetooth, accelerometers, etc.) make computing devices portable or even wearable to enable life recording to be done unobtrusively. The large volume of data storage and high-speed wireless networks needed for this help the mobile platform to turn into people-centric sensors capturing multidimensional sensory inputs besides spatial and temporal data. Lifelogging is the term describing this notion of digitally recording aspects of our lives, where the recorded multimedia content is the reflection of activities which we subsequently use to obtain the meaning of daily events by browsing, searching, or querying.

In order to create a mapping between the digital world and the real world, numerous context scan be recorded for the capture of the true meaning of daily activities. Here, contexts refer to the information which can be used to characterize a situation. A huge variety of contexts can be used in lifelogging such as textual photos, information, video clips and audio, environment information (temperature, pressure, light, etc.), bio-information (galvanic response, heart rate, etc.) and special information (acceleration, co-presence, location, etc.). These contexts are dynamically changing, and they can be used as cues to our activities and accessing information in our personal digital libraries.

To enhance this further, a variety of digital devices embedded with sensors should be applied to capture the above-mentioned contexts. Among all the devices emerging, the digital camera is the most commonly lifelogging device used (see figure 1) (El Asnaoui et al. 2017a) (El Asnaoui et al. 2017b).



A variety of life-logging wearable devices: (a). GoPro (2002). (b). Looxcie (2011). (c). Google glasses. (d). SenseCam (2005). (e). Narrative (2013). (f). Bracelet.

The lifelogs composed by the data gathered, by the continuous recording of data (user life), over long periods of time, provide a large potential of mining or inferring knowledge on people's way of life (El Asnaoui et al. 2017a), hence enabling a huge amount of application. A special study published by the American Journal of Preventive Medicine (Doherty et al. 2013) has verified the efficacy of the visual lifelogs captured through a SenseCam from numerous viewpoints. It has been demonstrated that, used as a tool to understand and track lifestyle behavior, visual lifelogs would enable the prevention of non-communicable diseases associated to unhealthy trends and risky profiles (such as obesity or depression, among others). Furthermore, the lifelogs can be used as a tool for re-memory cognitive training; visual lifelogs would enable the prevention of cognitive and functional decline in elderly people (Hodges et al. 2006) (Doherty et al. 2012).

Several measures are taken when trying to analyze a person's behavior, way of life, habits. One of the common questions that come up is: how to measure the day's similarity in order to assess the diary routines. Such information can be much interesting for different health applications: for example, days when the wearer of the camera is less active could predict beginning of depression or physical pain, while days that are too busy could lead to stress and fatigue.

Our main goal in this work is going to present new tools by introducing the concept of visual lifelogs and the contextual data captured from physiological signals. Toward this end, we developed and tested our algorithm for assessing the similarity of a person's days based on 4912 daily images acquired by four persons using a wearable camera.

In this work, a fully automatic system for assessing day similarity is proposed. The paper is structured as follows: Section II introduces typical applications of lifelogging. section III deals with privacy in lifelogging. Feature selection is explained in detail in section IV. Images acquisition and preprocessing steps are detailed in section V. Section VI is preserved to give the experimental results and to give details about the dataset used on which we apply our method. The conclusion is given in the last section.

2. Typical applications of lifelogging

Owing to its various advantages, lifelogging is required in numerous areas to gratify the needs of different groups. Its applications can be summarized as a tourism guide, an automatic diary, a memory aid, diet monitoring tool, ADL analysis tool, or recording and lots more. The details on some of these are as follows:

Digital diary: the documentation is usually carried out manually and involves material choices in traditional diary writing or blogging. The selection of contents and inclusion of value choices need to be considered to decide what is important and worth recording in the diary. An efficient and effective lifelogging recording and summarizing tool

could be used to automatically fulfill this task, in addition in addition, with heterogenous and unstructured multimedia data. In order to deal with huge personal data collection, intelligent techniques are needed to search, structure, and browse through this collection for locating significant events in a person's life. In (Lee and Dey 2008), three stages used to construct a digital diary. One of such stages is the processes of capturing and structuring SenseCam images after which they are displayed to an end user to review. In (Lee et al. 2008), an animated slideshow comprising of SenseCam images is presented in a lightweight storytelling form, along with some associated location information recorded by GPS. The main considerations and challenges are also analyzed in order to archive significant autobiographical digital information from lifelog collections (Gemmell et al. 2005). In (Byrne and Jones 2008), (Conaire et al. 2007), image features are explored in conjunction using sensor readings such as accelerometer data to group a day's worth of SenseCam images into meaningful events in a bid to allow for quick digital diary browsing. Tourism Guide: Many lifelogging systems have enabled the ability of applications to identify locations. Incorporated this technology into the various tourism applications, will make it possible for locations to be traced in real-time though this is solely dependent on the wearer's context semantics. (Herty and Smeaton et al. 2008) designed and developed a mobile system, known as Micro-Blog, for information sharing, querying, and browsing. A scenario is also depicted in (Gaonkar 2008) for the interaction with the system in the application of tourism, by playing audio-visual experiences shared by tourists. In (Wood et al. 2004), the area of tourism for SenseCam is highlighted, followed by (Blighe et al. 2008), which explores museum experience enhancement with respect to the captured museum artifact images by SenseCam.

Memory aid: Memory aid is a medical benefit supported by lifelogging technologies. After examining and recording various aspects of our daily activities, lifelogging will provide an approach for wearers to re-experience, or look back through past events. In (Hodges et al. 2006), a study is conducted using a patient suffering from amnesia with SenseCam. The aim was to keep records of the patient's various events through images. It was found in (Hodges et al. 2006), that the use of SenseCam to capture images facilitates people's ability to connect with their recent past activities. The authors opined that lifelogging systems capture a set of cues (data) which can trigger the remembering of human experience, rather than capture the human experience. In (Sellen et al. 2007), the challenges were faced with a pervasive period of Human Digital Memory (HDM) generation (2 years and 2 million images) which are presented and architectural requirements for managing such archives are also illustrated. Similar applications of turning lifelogging into a short-term memory aid can also be found in (Gurrin et al. 2007) (Berry et al. 2007) (Vemuri et al. 2004).

Lifelogging can also be used for medical purposes such as Diet monitoring. Though dietary patterns have been proved as a critical contributing factor to many chronic diseases (Vemuri and Bender 2004), adequate medically prescribed dieting can help low these numerous health ailments. More efficient, accurate, and useable techniques are needed to analyze an individual's dietary information. Visual media such as images and videos, which provide enormous increased sources of sensory observations about human activities, can also monitor diet analysis. The application of visual lifelogging in diet monitoring can assist both obsessed patients and health care professionals to properly analyze diets. DietSense (Vemuri and Bender 2004) is an example of such lifelogging software system which uses mobile devices to support automatic multimedia documentation of dietary products. The captured images can be post facto audited by users and researchers with easy authoring and dissemination of data collection protocols (Vemuri and Bender 2004). Experienced researchers can also profit from diet intake studies with the assistance of lifelogging browsing and annotation tools. Cameras and audio recorders are cameras in (Reddy et al. 2007). Their practices suffer from under-reporting owing to the non-confident use of a tape recorder and camera. Other researches made use of camera mobile devices, such as personal digital assistants (PDAs), and mobile phones, in (Aczkowski et al. 2000) (Wang et al. 2006), etc.

ADL analysis: The analysis of activities of daily living (ADL) is yet another application of lifelogging. More concerns are now being shown in modern society about the individual health and well-being of everyday life. However, any long-term investigation into daily life comes across lots of difficulties in both research and the medical treatment area. Occupational therapy aims to analyze the correlation between time spent and our actual health, and there is a growing body of evidence indicating the relationship (Farmer et al. 2005) (Law et al. 1998). Observational assessment tools are required to effectively establish care needs and identify potential risks. Long-term daily routines and activity engagement assessments are necessary to evaluate the impact on activities of daily living caused by diseases or old age, and to provide a proper program towards the needs of each patient. While traditional self-reporting or observational measures are time-consuming and have limited granularity, lifelogging can provide an efficient approach to providing broader insights into activity engagement. Lifelogging is a technology to automatically record everything happening to us, hence it can provide an accurate way to measure activity engagement and affecting factors. Project IMMED (McKenna et al. 2007) is an ideal application of lifelogging to ADL, the objective of which is to assess the cognitive decline caused by dementia. Both video and audio data of the instrumented activities of a patient

are both recorded in (McKenna et al. 2007) and indexed for medical analysis. In (Mégret et al. 2010), a wearable camera is used to record videos of patients' activities of daily living. An approach for indexing human activities is also proposed for studies the dementia diseases. Doctors can use of the indexes to navigate through the individual video recordings to detect signs of the dementia in everyday activities.

Besides the above described areas, lifelogging can also be applied in other areas like education (Karaman et al. 2011) (Barreau et al. 2006), work-related task observation (Fleck and Fitzpatrick 2006) (Byrne et al. 2008), accessibility within business (Kumpulainen et al. 2009).

3. Privacy in lifelogging

When we talk about visual lifelogging, the most fundamental question arises here is about the privacy in visual lifelogging. In this section, we explain a definition of privacy in lifelogging.

In any advanced society, one of the key human rights is the privilege to privacy life. It supporters and encourages instruments to maintain the protection of all people inside the society. Nevertheless, what is private is exceptionally discussed. This is on the grounds that privacy has societal, lawful, psychological, political and specialized connotations (Allen 2008). Much more, protection is considered dynamic nature. With time, what is viewed as private in a general public can change significantly. A large number of these progressions are determined by innovative headways. We are currently confronting another influx of specialized progressions that have broad protection suggestions than any current technologies. One such innovations are lifelogging.

Considering a bit of a lifelogs including a picture of another individual, which has been captured by a lifelogging device. To demonstrate the influence of a privacy breach in visual lifelogging, we can suppose that such a lifelog at the side GPS coordinates and timestamp implanted into it has been unjustly exposed to an aggressor.

This is often not a far-fetched suspicion. In fact, there are a few commercial lifelogging gadgets in the market place such as Narrative Clip and Autographed.

In addition, some lifelogging devices as Google Glass (augmented-reality smart-glasses) are prepared with sensors that permit to embed GPS coordinates of the position where the lifelog has been captured. In order to distinguish the individual in the lifelog and suppose his location, the aggressor can use the ever-powerful and ever-accurate face detection and picture search algorithms, using GPS coordinates and the timestamp. This shows the threat to the intrusion of privacy with just one single piece of lifelog. This is really effective compared to any textual information as one single piece of such textual information cannot be abused to gather this sort of knowledge.

The study isn't straightforwardly identified with lifelogging. Notwithstanding, there are discourses on a few comparable security issues that can be connected for lifelogging too. Essentially, it has been repeated that individuals will forfeit a specific measure of protection to a framework just if the framework and the discharged data give significant value.

In (Allen 2008), the author diagrams a few protection issues in lifelogging. The principle two concerns raised by the author are:

- The capacity for lifelogging innovation to be utilized for malicious records enabling a lifelogger to review, replay, and recall for short, noxious memory;
- Pernicious observation — enabling a state to manhandle the lifelogging innovation for gigantic scale reconnaissance where the lifelogger goes about as the kin of the “big brother”.

Concerning the first angle, the author plots a few situations where lifelogging could be manhandled. The main situation includes the limit of the lifelogging innovation to catch and store a humiliating snapshot of an individual for a more drawn out timeframe, perhaps for eternity. We contend this to be valid for other accessible advancements, for example, photography or video-taping utilizing computerized cameras or cell phones, thus the stress ought to not be raised for lifelogging as it were. In any case, there is an unmistakable distinction among lifelogging and different advancements, as the previous has the capacity to catch minutes in the inconspicuous and pervasive way. This offers it the chance to catch pictures in spots where no picture ought to be taken. The second situation is the “voluntary, but pathological rumination”: permitting the lifelogger to live in the past, which may have hindering impact in the psychological well-being as it is unrelated against our normal procedure of being neglectful and pushing ahead.

Another user thinks about, announced in (Nguyen et al. 2008), has explored the frames of mind and protection worries of the clients “surrounding” everyday following and recording advancements, to be specific, steadfastness cards, electronic toll frameworks, web server logs, CCTV (Closed-circuit television) cameras and RFID labels. Members in the examination have detailed genuine concerns with respect to data security, yet they appear to be less concerned regarding the protection issues of these following innovations. As per this examination, members have communicated

their worries regarding data security in following and recording innovations, particularly as for unnoticed gathering and unapproved auxiliary use.

Furthermore, female members have been more concerned with respect to their protection than their male partners. Most of the members have remarked that it is implausible to anticipate any dimension of security out in the open spots. They contend that such information is generally put away by various associations or even Governments and they are bound by lawful frameworks not to mishandle such information. Be that as it may, it doesn't have any significant bearing to lifelog since they can be put away by lifeloggers who have no such commitment, legitimately and morally, not to mishandle lifelogs. There is a disparity in dispositions of clients utilizing such advancements and their desire for security. The outcomes exhibited in the paper have recognized two basic discoveries:

- People battle to recognize the conceivable dangers related with these advances,
- They neglect to evaluate their abilities and alternatives to limit these dangers and enable them to arrange how unique private data is spread to different gatherings.

Inspired with the accessibility and popularity of modern photography and printing press and their suggestions on the individual's privacy, Samuel Warren and Louis Brandeis characterized privacy as: "the right to be alone" (Gurrin et al. 2004). It is assumed to be the first explanation of privacy (Warren and Brandeis 1980) and formulated with the inspiration to ensure individuals from curious correspondents who would take their photos without their assent (Langheinrich et al. 2001).

Regrettably, this definition has misplaced its viability within the advanced day society where taking photos of other individuals in public spaces is now not considered a breach of privacy of those individuals, lawfully as well as publicly. This idea of privacy is all approximately capturing the one's right to be in isolation and to ensure him/her from interruption in a physical space. Thus, it is seen as the security of individual circle (Pötzsch 2008). A novel idea of privacy named Information Privacy, within the innovation domain begun to pick up attention from 1960s forward. Thanks to the computers popularities, computing systems and the conceivable outcomes of putting away huge quantity of individual information into these systems and the ability of progressed data preparing components.

The authors in (Wolf et al. 2014) have investigated distinctive parts of lifelogging running from the inspiration of lifelogging exercises and where to put a lifelogging gadget to catch the most ideal lifelogs. Furthermore, authors have likewise contacted upon the lawful and moral issues identified with lifelogging in broad daylight places. The authors have featured the inconsistency of lawful necessities in various nations with respect to the assent for taking photos of a person. At that point, the authors contend that regardless of whether the lifelogging may not be lawfully denied, numerous individuals would be awkward with the possibility of lifelogging. The authors have likewise brought up the absence of control as far as sharing and assent and security issues of the caught lifelogs.

To summarize, when we talk about privacy in visual lifelogging, it is necessary to say that the right to privacy is one of the fundamental human rights in any modern society. It advocates and facilitates mechanisms to uphold the privacy of all individuals within the society. However, what is private is highly debated. This is because privacy has social, legal, psychological, political, and technical connotations. Even more, privacy is of dynamic nature. What is considered private in a society can change considerably with time. Many of these changes are driven by technological advancements (El Asnaoui and Radeva 2018).

4. Feature selection

Feature selection and dimensionality reduction is an essential phase in any image processing task. Therefore, in order to construct any feature descriptor with good values, only the important information must be selected using a feature selection approach. In this work, we have utilized a Local Binary Patterns and 2D histogram in HSV color space as a feature selection and reduction technique. These tools are further explained in the following subsections.

4.1 Local Binary Patterns

Local Binary Patterns (LBP) is a non-parametric method used to summarize local structures of images efficiently by comparing each pixel with its neighboring pixels. It has been successfully applied in image processing and computer vision. The LBP ability to tolerate monotonic illumination changes and its computational simplicity, are some of its most important properties. LBP was initially developed for texture analysis (Ojala et al. 1996) but has, however, proven to be a simple and powerful tool used to defined local structures. LBP has also been widely exploited in lots of applications, such as face image analysis (Ahonen et al. 2006), image and video retrieval (Hadid et al. 2004), etc. The LBP can also be described as an image operator used to transform images into an array or integer labels describing small-scale appearance of the image. These labels or their statistics are used for further image analysis. The most common used versions of the operator are designed for monochrome still images, but it has currently been extended

for multi-color images, videos and volumetric data. As shown in Fig.2: Each pixel is compared with its eight neighbors in a 3x3 neighborhood by subtracting the center pixel value; The resulting strictly negative values are encoded with 0 and the others with 1; A binary number is obtained by concatenating all these binary codes in a clockwise direction starting from the top-left one and its corresponding decimal value is used for labeling. The derived binary numbers are known as Local Binary Patterns.

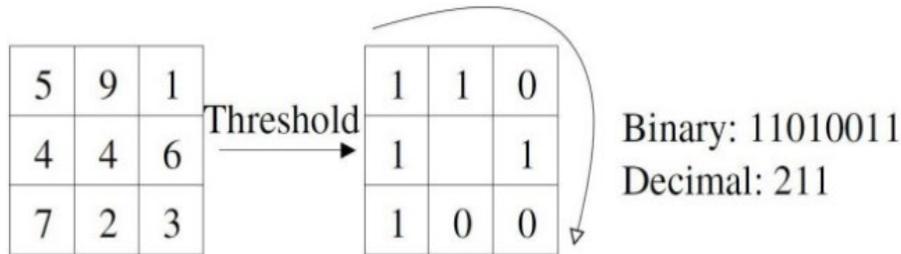


Figure 2. An example of the basic LBP operator.

LBP methodology was recently developed with lots of variations to enhance its performance. These variations aim at different aspects of the original LBP operator such as:

- (i) Enhancing its discriminative capability;
- (ii) Enhancing its robustness;
- (iii) Selecting its neighborhood;
- (iv) Extension to 3D data;
- (v) Combination with other approaches.

4.2 2D histogram in HSV color space

The color histogram is easy to compute, simple and effective in characterizing the global and the local distribution of colors in an image. The color histogram extraction algorithm uses three steps: partition of the color space into cells, association of each cell to a histogram bin, and counting of the number of image pixels of each cell and storing this count in the corresponding histogram bin. This descriptor is invariant to rotation and translation (El Asnaoui et al. 2014) (El Asnaoui et al. 2015a) (El Asnaoui et al. 2016a) (El Asnaoui et al. 2016b) (Ouhda et al. 2017) (Ouhda et al. 2018) (El Asnaoui et al. 2015b) (Chawki et al. 2016) (Chawki et al. 2018a) (Chawki et al. 2018b) (Chawki et al. 2015). Furthermore, it is noted that the HSV color space is fundamentally different from the RGB color space because it separates the intensity of the color information (chromaticity), and it has been shown that the HSV space is a perceptual color space. These three components H (Hue), S (Saturation), and V (Value) correspond to the color attributes and are closely related to the way that human eyes perceive colors (El Asnaoui et al. 2014) (El Asnaoui et al. 2015a) (El Asnaoui et al. 2016a) (El Asnaoui et al. 2016b). Many works related to the color image have been developed using this color space. For these reasons, we are using an approach based on the hierarchical analysis of the 2-D histogram using the HSV. This method was extended in (El Asnaoui and Radeva 2018).

4.3 Dynamic Time Warping

In order to make lifelog matching, we used the Dynamic Time Warping (DTW) that allows to find the minimal distance between two sequences, which can have different lengths. DTW was first proposed for speech recognition. This algorithm has been applied in many fields (El Asnaoui and Radeva 2018).

Let us consider the two days $A = (a_1, a_2, \dots, a_N)$ and $B = (b_1, b_2, \dots, b_N)$. the DTW distance between these days is computed as follows:

$$\text{First row: } D(1, j) = \sum_{k=1}^j c_{1k}, j \in [1: M]$$

$$\text{First columns: } D(i, 1) = \sum_{k=1}^i c_{k1}, i \in [1: N]$$

Other elements:

$$D(i,j)=c_{i,j} + \min\{D(i-1, j), D(i-1, j+1), D(i, j-1)\}, i \in [2: N], j \in [2: M]$$

Where D is defined as Accumulated Cost Matrix or Global Cost Matrix, and local cost matrix

$C \in (\mathbb{R}^+)^{N \times M}$ representing all pairwise distances between A and B :

$$C = \{c_{i,j} \in \mathbb{R}^+ / c_{i,j} = |a_i - b_j|, i \in [1, \dots, N], j \in [1, \dots, M]\}.$$

5. Proposed contribution

Many schemes and methods are presently available for lifelogging application. Unfortunately, automatic assessment method for day similarity using lifelogging images is not attempted successfully. The first work was (El Asnaoui and Radeva 2018). Following similar objectives of the daily similarity, the question is how to use visual lifelogs as lifelogging images give richer information about human behavior compared to GPS: visual lifelogging images contain information about the environment of the person, the events he/she is involved, interactions and daily activities, etc. Our work is aimed at assessing day similarity, usually using visual lifelogs. One advantage of this is that visual lifelogs contain relevant information of users. The objective of this model is to extract the relevant features from images to efficiently assess day similarity. For this purpose, the developed system is comprised of three stages: preprocessing, distance computation and displaying results. The proposed dataset is taken as the input for the model. The sequential flow of these steps is shown in figure 3.

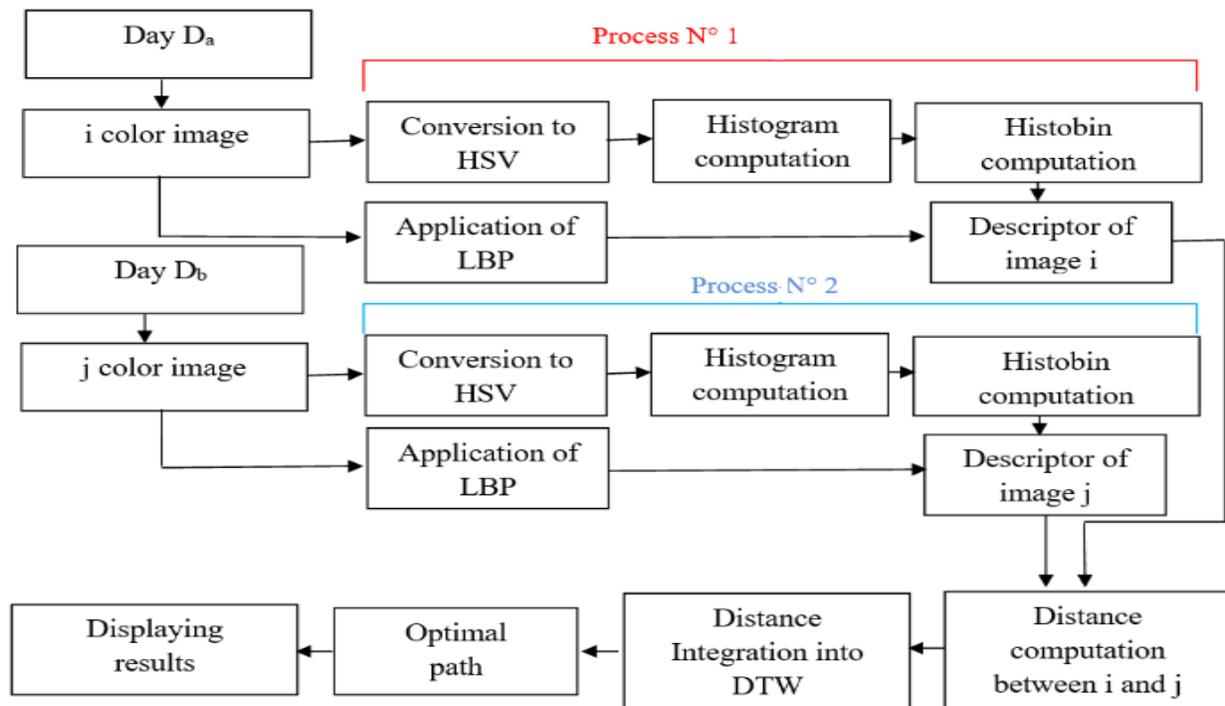


Figure 3. System architecture of proposed Model.

Different steps in the proposed model is explained below:

5.1 Preprocessing

Preprocessing stage extracts the relevant features of images given in the input. The input format of the dataset is as an image file. This preprocessing is given as follows: Each input image i and j in D_a and D_b days respectively; $i = 1, 2, \dots, m, m \in \mathbb{N}$ and $j = 1, 2, \dots, n, n \in \mathbb{N}, a = 1, 2, \dots, 8$ and $b = 1, 2, \dots, 8$. We first create two processes for each day D_a and D_b . The first process converts images to HSV and then it computes their 2D histograms and their histobins. While the second process calculates local binary pattern. These processes work in parallel, and finally we combine the results to have the final descriptor for images in day D_a . The same processing has been applied to day D_b to obtain the final descriptor. Finally, we have two descriptors for two days D_a and D_b .

5.2 Distance computation

After that, we compute the distance between these two images i and j using the intersection of histograms in the HSV space. Finally, we edit the standard distance used by Dynamic Time Warping (DTW) with that obtained by Swain's distance (Ojala et al. 1996). This process, that can be very long, is continued until the completion of all the images of D_a and D_b days. For the distance $dtw(1, 1) = 0$, we edited it by the distance between the first images of D_a and D_b , ie $dtw(1,1) = 0$ by $dtw(1, 1) = d(1, 1)$.

Generally, the Euclidean distance is used as a distance cost function in the DTW algorithm to build a local cost matrix (Ojala et al. 1996). In our method we have used Swain's distance (equation (1)) because it provides results and more performance than the Euclidean distance (El Asnaoui et al. 2014) (El Asnaoui et al. 2015a) (El Asnaoui et al. 2016a) (El Asnaoui et al. 2016b) (Ouhda et al. 2017) (Ouhda et al. 2018) (El Asnaoui et al. 2015b) (Chawki et al. 2016) (Chawki et al. 2018a) (Chawki et al. 2018b) (Chawki et al. 2015).

5.3 Displaying results

When we have the DTW matrix of all-day images of D_a and D_b , we afterwards calculate the optimal path using the algorithm of "Backtracking" from point $P_{end} = (M, N)$ to starting point $P_{start} = (1, 1)$ using the algorithm described in (El Asnaoui and Radeva 2018).

6. Experimental results

The details of our implementation and the evaluation of our algorithm are elaborated in this section. We start by introducing the utilized dataset and then we introduce the results according to the used workflow. Toward this goal, we evaluated the performance of our algorithm with a public dataset namely Egocentric Dataset of the University of Barcelona (EDUB) (figure 4) that composed of 4912 images, their sizes are 384x512, acquired by 4 persons using a wearable camera Narrative (Figure 1.d). This device is typically clipped around the chest area or on the users' clothes under the neck. Figure 4 shows an example of the images in the EDUB dataset (El Asnaoui et al. 2017a) (El Asnaoui et al. 2017b).

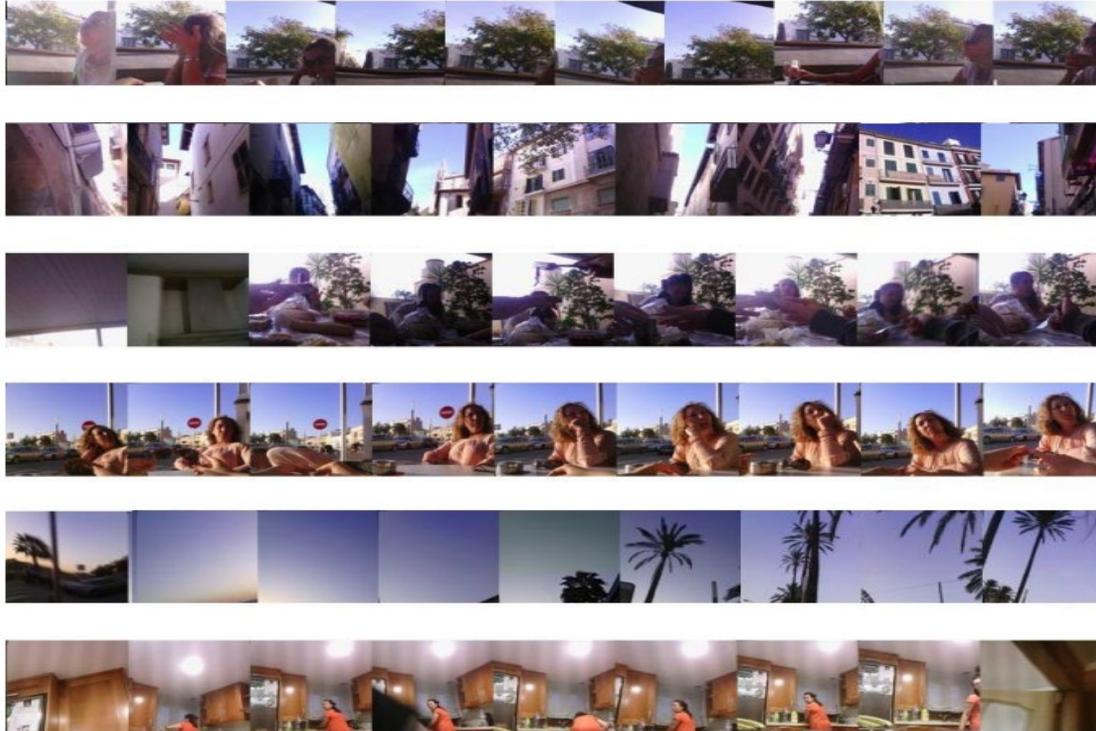


Figure 4. Example of images on EDUB 2015 dataset acquired by the wearable camera Narrative.

6.1 Retrieval experiments

The outcome of the day similarity is depending on the goodness of the algorithm to compare 2 days. To depict it, first, we checked if the chosen Swain's distance could efficiently detect similar images. To ascertain, we carried out several tests using a query image and retrieved the most similar images of it. Figure 5 gives an example of the retrieval process. Images correspond to the 14 most similar images to the query image at the top-left corner sorted and displayed according to the score given by the histobin intersection (El Asnaoui and Radeva 2018) in descending order, from left to right and top to bottom. From the results obtained, images retrieved were similar to what a user visually could find; in particular, the algorithm recovered images from the same scene than the query image. Numerous experimental results obtained from this basis confirm the accurate choice of the histobin distance for the DTW algorithm.

The effectiveness of the proposed method measured by the recall/precision curve (El Asnaoui et al. 2014) (El Asnaoui et al. 2015a) (El Asnaoui et al. 2016a) (El Asnaoui et al. 2016b) (Ouhda et al. 2017) (Ouhda et al. 2018) (El Asnaoui et al. 2015b) (Chawki et al. 2016) (Chawki et al. 2018a) (Chawki et al. 2018b) (Chawki et al. 2015) on our EDUB dataset is interesting. Moreover, we note that the results are very similar to what a user could find visually (Figure 5, 6). The reason is this method uses the color, which is usually a rich description of an image. In addition, it is an important significant part of human vision. The color became the first signature used for image search by content because of its invariance to scale, translation and rotation. According to the recall / precision curves (Figure 7), we see that all the curves of the EDUB dataset used are generally decreasing, the accuracy decreases gradually as irrelevant images were found. This can be explained by the fact that we have chosen the best descriptor and nature of images in the dataset are suitable.

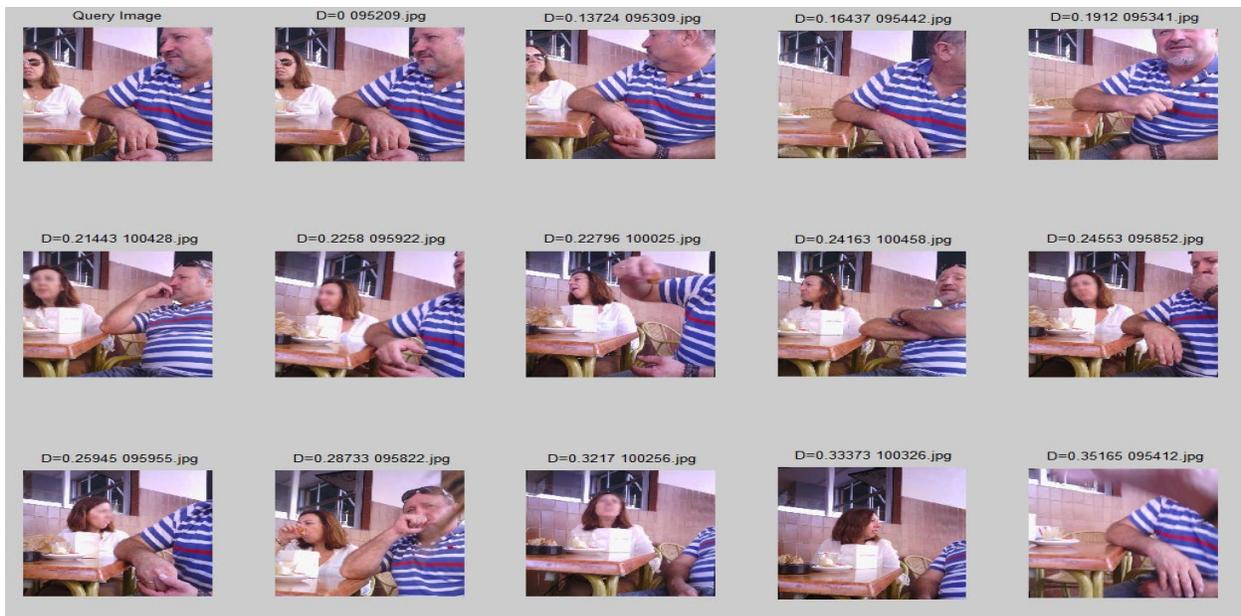


Figure 5. The most similar images of a query image at the top left corner using the histogram distance.



Figure 6. The most similar images of a query image at the top left corner using the histogram distance.

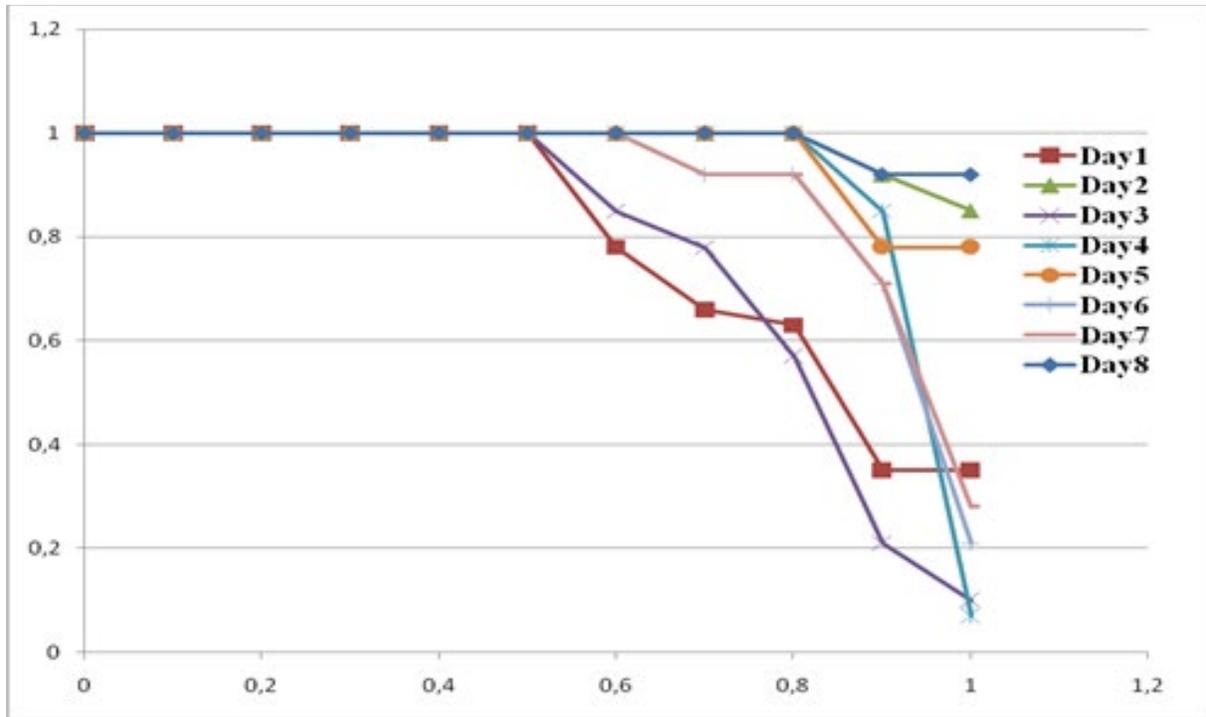


Figure 7. Recall/precision on EDUB 2015.

6.2 Performed tests

Our main goal in this work is not to set up a new algorithm to automatically assess the similarity of a person's days, but this paper must be considered as an improvement step of (El Asnaoui and Radeva 2018) to overcome some drawbacks encountered in (El Asnaoui and Radeva 2018).

To evaluate the retrieval effectiveness, we used the accuracy as statistical comparison parameter for the proposed method. The definition of this measure is given by the following equation:

$$A = \frac{(in/in) + (out/out)}{(in/in) + (out/out) + (in/out) + (out/in)}$$

6.3 Visual lifelogging results

In order to test the capability and robustness of the proposed method, several experiments are conducted on EDUB dataset to prove the effectiveness of our proposed algorithm. The accuracy results, variance SD between days of week are tabulated below.

6.4 Interpreting the results

We recall that this study must be considered as an improvement step to overcome some drawbacks encountered in (El Asnaoui and Radeva 2018) such as the accuracy and execution time. From the table 1, 2, we can conclude that the proposed method achieves satisfactory performance and provides an important accuracy between days. It achieves up to 85% of accuracy in automatically characterizing corresponding between days in an egocentric dataset.

According to variance SD computed (table 1, and 2), a low standard deviation means that most of the data are very close to the average. We could say that preprocessing and distance computation stages are better than those done in (El Asnaoui and Radeva 2018).

These results also show the robustness of our proposed algorithm.

Table 1. Accuracies between days

| | | | | | | | |
|----------------------|--------------|--------------|--------------|-------------|-------------|--------------|-------------|
| | Subject1_2 | Subject2_1 | Subject2_2 | Subject3_1 | Subject3_2 | Subject4_1 | Subject4_2 |
| Subject1_1 | 96 | 96 | 96 | 96 | 96 | 96 | 96 |
| | Subject1_1 | Subject2_1 | Subject2_2 | Subject3_1 | Subject3_2 | Subject4_1 | Subject4_2 |
| Subject1_2 | 96 | 93 | 85 | 84 | 87 | 72 | 78 |
| | Subject1_1 | Subject1_2 | Subject2_2 | Subject3_1 | Subject3_2 | Subject4_1 | Subject4_2 |
| Subject2_1 | 44 | 93 | 78 | 94 | 96 | 94 | 86 |
| | Subject1_1 | Subject1_2 | Subject2_1 | Subject3_1 | Subject3_2 | Subject4_1 | Subject4_2 |
| Subject2_2 | 57 | 85 | 78 | 88 | 99 | 95 | 86 |
| | Subject1_1 | Subject1_2 | Subject2_1 | Subject2_2 | Subject3_2 | Subject4_1 | Subject4_2 |
| Subject3_1 | 47 | 84 | 96 | 88 | 94 | 99 | 97 |
| | Subject1_1 | Subject1_2 | Subject2_1 | Subject2_2 | Subject3_1 | Subject4_1 | Subject4_2 |
| Subject3_2 | 45 | 87 | 95 | 99 | 94 | 91 | 95 |
| | Subject1_1 | Subject1_2 | Subject2_1 | Subject2_2 | Subject3_1 | Subject3_2 | Subject4_2 |
| Subject4_1 | 45 | 72 | 93 | 96 | 99 | 91 | 91 |
| | Subject1_1 | Subject1_2 | Subject2_1 | Subject2_2 | Subject3_1 | Subject3_2 | Subject4_1 |
| Subject4_2 | 43 | 79 | 84 | 87 | 95 | 92 | 91 |
| | | | | | | | |
| Mean accuracy | 59,12 | 86,12 | 88,12 | 91,5 | 95 | 91,25 | 90 |
| Variance SD | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

Table 2. Accuracies between days

| Method | Total Mean accuracy (%) | Total Variance SD (%) |
|-------------------------------------|-------------------------|-----------------------|
| Method (El Asnaoui and Radeva 2018) | 77,6 | 19,45 |
| Improved method | 85 | 0 |

7. Conclusion

It has become more and more practical for researchers to investigate the underlying patterns of our daily lives following the development of computer networks, large volume databases, machine learning technologies and the wide deployment of computing devices. Especially, many lightweight devices such as the mobile phone are endowed with sensing capabilities through built-in cameras and other heterogeneous sensors.

In this paper an approach to automatically assess day similarity is presented. Results of this approach shows that with improved stage of extracting the relevant features of images given in the input enhances the automatically assess day similarity. Moreover, this method helps in getting high accuracy in matching process.

As a future work, simulation and testing for the recent tools could be used and applied on a wide range of applications to work on enhanced solutions. In addition, the performance may be improved using more databases, more sophisticated feature extraction techniques like deep learning using Keras/TensorFlow, and other distance metrics.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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