PulseCam: Biophysically Driven Life Logging

Evangelos Niforatos
Università della Svizzera italiana (USI) Via Giuseppe Buffi 13
6900 Lugano, Switzerland
evangelos.niforatos@usi.ch

Veranika Lim
Designed Intelligence Group
Department of Industrial Design
Eindhoven University of Technology, The Netherlands
v.lim@tue.nl

Christian Vuerich
Università della Svizzera italiana (USI) Via Giuseppe Buffi 13
6900 Lugano, Switzerland
cristian.vuerich@usi.ch

Marc Langheinrich
Università della Svizzera italiana (USI) Via Giuseppe Buffi 13
6900 Lugano, Switzerland
marc.langheinrich@usi.ch

Agon Bexheti
Università della Svizzera italiana (USI) Via Giuseppe Buffi 13
6900 Lugano, Switzerland
agon.bexheti@usi.ch

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Abstract
Life logging emerged as a way to capture and remember more mainly through pictures. However, as life logging becomes increasingly mainstream, the volume of captured content also increases but our capacity for reviewing diminishes. In order to limit picture taking on such devices to only the most memorable moments, we propose a biophysical driven capture process that adapts the camera capture rate based on one's heart rate. In our prototype – called PulseCam – an Android smartphone worn on the body acts as the picture capture device, adjusting its capture rate based on one's heart rate as measured by an Android-based smart watch. The purpose of this work is twofold: a) we will examine the potential of PulseCam to capture pictures of significant moments and b) investigate the potential of such pictures to improve one's ability to remember. This paper introduces the general approach, describes our current prototype, and outlines the planned study design.

Author Keywords
Life logging; biophysical data; mobile; episodic memory; memory recall.

ACM Classification Keywords
H.5.m. Information interfaces and presentation.

Figure 1: A Narrative Clip.

Figure 2: PulseCam prototype comprised of a LG G smart watch for continuously measuring one's heart rate and a Nexus S mobile device for capturing a picture. The Nexus S is situated on one's arm using an armband.

Traditionally, pictures have for long been a way for preserving our memories. Ever since the invention of photographic film to the debut of digital cameras, pictures have been constantly becoming hugely popular. Nowadays, social network users (e.g. Facebook) post myriads of pictures daily as a way of sharing experiences with friends. In fact, certain social networks, such as Flickr and Instagram, were developed with pictures as their primary focus. Eventually, hardware minimization and the need to capture more gave rise to a new paradigm, that of life logging. Life logging entails the capture of personal experiences in an automated and continuous fashion, utilizing hardware that spans from small digital cameras to positioning technology and physiological sensors.

With today's abundance of cheap and large storage possibilities, life logging devices are becoming smaller with the capacity of collecting sheer amounts of data. Soon, manual capture may be the past and the use of life logging devices such as Narratives Clips[1] may become a standard practice. Life logging in its current state, however, comes with shortcomings. For example, a single day of Narrative Clip (Figure 1) use can easily produce more than a thousand images. These images need to be organized and prepared for user review. Specialized software typically filters out low quality or blurry images and groups them in time series and episodes, in order to ease the otherwise manual review process. This filtering process however, may result in discarding images of significant moments for the user. Even though filtering reduces drastically the amount of collected pictures, it leaves behind way too many pictures with little if any meaning for the user (e.g. thousands of pictures of you looking at the computer screen). Furthermore, research has shown that rich content (i.e. abundance of pictures) does not guarantee effective recall of past experiences [20] as it would contain too many details with little relevance to support episodic memory recall [4].

Biophysical data is becoming increasingly available as wearable devices are (remain) closer to human body and can monitor its biophysical responses such as, heart pulse rate, galvanic skin response (GSR), electroencephalography (EEG), electromyography (EMG). One of the latest "consumer trend" in the field of wearable computing is the smart watch. Smart watches are bigger than smart wristbands (e.g. Fitbit and Jawbone) because they are also equipped with a touch screen at the size and shape of typical wristwatches. Smart watches can host a large variety of sensors, some of which are dedicated for monitoring biophysical responses. For example, an optical sensor embedded in the side that touches the inner part of one's wrist can detect one's current heart rate. Though yet not able of achieving the accuracy of professional medical instruments, it can however provide a clue of one's current physiological state (e.g. excitement levels).

In this workshop paper we present our approach on how to augment the capturing and reviewing process of life logging content, with the aim to improve one's memory recall (see Figure 2). We believe a way to accomplish that lies in capturing those moments that are truly significant for life logging users. Similar approaches have shown promising evidence (i.e. AffectCam) but they were limited by monitoring somewhat slower biophysical responses such as GSR,

[1] http://getnarrative.com/

as opposed to heart rate [13]. We consider heart rate able to reflect almost instantaneous variations in one's excitement levels. Hence, we propose PulseCam, a biophysically driven life logging system to capture moments of excitement. PulseCam relies upon one's current excitement levels as measured via one's biophysical responses for capturing a picture. The system consists of a LG G3 Watch for the monitoring of one's biophysical state, which then sends a picture capture event to a mobile device attached to a participant's body. We expect that excitement levels, as derived particularly from heart rate, will enable us to capture images of the most significant moments of one's daily routine. Later, when one reviews PulseCam images, we expect we will be able to detect an overall improvement in one's ability to recall these moments.

Related Work

Previous work has demonstrated that life-logging camera devices aid recall. The reason why images are so effective in supporting recall is explained by the nature of episodic memory, the human memory component responsible for storing past experiences. Episodic memory is innately dominated by visual imagery and episodic memories of a past experience are retrieved in the form of a series of images [1]. Thus, visual cues (e.g. pictures or videos), when available, can greatly amplify one's ability to remember a past experience. In fact, images are known for maximizing the information they contain by representing objects in relation to each other [1].

Passively capturing images were found to have the potential of even causing people to remember *more* events than they would with their own actively-captured images [7,15]. On the other hand, however, a recent study argues that when users are fully engaged in photo-taking and use their cognitive processes, the photo-taking impairment effect that happens when participants take a photo of every object as a whole is eliminated (Henkel 2013) [6].

Factors Improving Memory

Various studies in neuroscience and psychology have shown a correlation between arousal during an attended event and memory recall of details related to that specific event. Viewing arousing stories, for example, can result in experiencing a greater emotional reaction to the story than when viewing neutral stories, which subsequently exhibits enhanced memory for the story [5]. The intensity of an emotion experienced by a person (i.e. arousal) was found to account for significantly more variance in autobiographical memory characteristics than did valence or age of the memory [9,18,19]. Emotional memories result in better recall of perceptual, sensory, and semantic elements of an event in comparison with neutral memories [14]. Findings, however, are not always consistent. Although, Shah et al. found a statistically significant positive association between measures of Heart Rate Variability (HRV) and verbal, but not visual, Story Recall Test (SRT) scores, the most statistically significant unadjusted association was found between very low frequency (VLF), HRV and verbal total recall SRT [16]. Besides the effects of intensity, emotions and HRV on memory enhancement, positive memories were found to contain more sensorial (visual, smell, taste) and contextual (location, time) details than negative or neutral events [2].

Biophysically Driven Life Logging

The idea of using biophysical data to distinguish moments of interest during life logging is not new. In fact, some life logging approaches rely solely on monitoring biophysical data. A type of life-logging device that does not involve pictures is the Affective Diary, a system that records “body memorabilia” (i.e. sensor inputs) from body sensors and mobile media from users’ mobile phones. Users of the system were able to remember and reflect on their past using sensor inputs in the form of so-called body memorabilia [17]. Sas et al. proposed AffectCam [13], a wearable system that combines a traditional SenseCam with a Galvanic Skin Response (GSR) wristband for measuring bodily arousal and selecting the most relevant pictures captured. During picture review, an algorithm post processes the recorded GSR values for identifying arousal peaks and then matches them with the most temporarily adjacent pictures. Early results showed that pictures captured during increased arousal greatly improve (> 50%) one’s ability to recall as opposed to pictures of low arousal. The authors also noted the significance of their approach in reducing the large number of pictures captured via life logging devices such as SenseCam.

Based on the encouraging results that related work has demonstrated, we will examine the potential of heart rate to drive picture capture. With PulseCam, we will be able to monitor one’s heart rate continuously and thus, detect in time and in situ any changes in one’s excitement levels that will in turn trigger a picture capture. This provides a strategic opportunity to capture pictures of higher significance as sampling happens right at the moment of a significant occurrence for the user. In fact, heart rate is highly variable and corresponds greatly to the levels of one’s engagement to current experience [12].

PulseCam

The early PulseCam prototype is consisted of a smart watch and a smartphone (see Figure 2). The smart watch is typically strapped to one’s wrist and measures continuously one’s current heart rate. The smartphone on the other hand, is situated on one’s body with its back camera facing forward, for capturing one’s field of view. Both the smart watch and the smartphone are paired over Bluetooth Low Emission (BLE). Next, we have developed two Android apps, one for the watch and one for the smartphone, that communicate with each other via Android Wear platform. When heart rate surpasses a certain level, the watch signals a picture capture event to the smartphone. So far, we have been experimenting with a LG G watch for measuring one’s heart rate and a Nexus S phone for taking a picture. Our first trials showed that the smart watch battery can withstand up to 8 hours of continuous heart rate monitoring. For now, PulseCam captures a picture every 2 minutes. Every heart rate reading is compared to the moving average of all heart rate readings and if found 10% higher, a high heart rate picture is captured.

Research Aims

The aim of this study is to examine the potential of pictures captured during increased heart rate levels to improve one’s ability to remember. In particular, we will attempt to answer the following research questions:

a*) Do pictures captured during high excitement levels (i.e. high heart rate levels) help one to recall more about a past experience?* Research in the field of cognitive psychology and neuroscience has displayed evidence that increased blood flow leads to the formation of more vivid memories [10,16]. This is ascribed to the function of hippocampus, a lower area in the human brain that is strongly related to memory creation. In fact, increased blood flow as result of exercise has been found to increase the size of hippocampus and thus, improve one's memory [3,19].

b) *What types of elements appear in pictures that were captured during high heart rate levels?* Naturally, one would expect that most of the pictures captured during high heart rate levels would imply increased physical activity, such as exercising in the gym or climbing stairs. However, we expect to unveil additional daily encounters that increase one's excitement levels and are considered memorable. For example, a conversation with a colleague at work or a friend at the street might be exciting enough to increase one's heart rate levels for PulseCam to capture a picture. In fact, it was found that people appearing in a picture were often associated with rich recollections during review [7]. Hence, one of the reasons might be increased engagement or excitement during social interactions, which in turn may result in vivid memories.

c) *Are pictures captured during high heart rate more interesting as opposed to pictures captured during normal heart rate?* We expect that pictures captured when participants exhibit high heart rate levels will be considered more interesting or/and of increased importance in contrast to pictures captured when participants were generally calm. We attribute this effect to the increased biophysical response (e.g. heart rate) that engaging experiences imply.

Methodology

We will test the use of our PulseCam prototype over a course of 5 days (Monday-Friday). We purposefully limit the study duration to workdays that most probably imply a stable routine schedule. Thus, we avoid any memorable events that could happen in the weekend (e.g. leisure activities) and could confound our study findings. After the collection of images, interview sessions will take place to test memory performances through a combination of different methods.

Participants

We plan to recruit participants from the university community. This is mainly due to the fact that youngsters are familiar with modern technologies and curious to explore emerging ones.

Study Design

In the course of 5 days, PulseCam will capture pictures automatically based on participants' heart rate levels. Pictures will be captured randomly during low, medium and high excitement levels. Semi-independent and parallel to the capturing of pictures, participants will receive an Experience Sampling Method (ESM) questionnaire on the mobile device or smart watch asking to assess their arousal levels on a 5-point Likert scale. Prompting will not occur for more than once every 15 minutes.

At the end of each study day, participants will complete a self-assessment arousal recall task. Participants will individually review all of their pictures captured during that day in a random order and will rate their feelings on a 5-point Likert scale (i.e. among others, stress and arousal) for each picture. Then, they will make a selection of their top 5 most interesting pictures of their day.

One week after the last capture day, each participant will go through two recollection sessions. In the first session, participants will be randomly given pictures captured with PulseCam during all 5 days and will be asked to freely recall as many details as possible. Each of these sessions will be fully recorded and transcribed. We will measure each participant's ability to recall based on memory richness, as applied by Sas et al. in [13] and initially proposed by Levine et al. in the Autobiographical Interview [11]. In particular, we will encode each picture and its transcript based on 5 informational categories mentioned: a) event, b) thoughts, c) emotions, d) location and e) time. Then, for each picture, we will assign one point for each category if it is mentioned during the session. For example, "*This is when going to the University and was a bit anxious waiting for the slow traffic light to turn green because I was running late*" makes a score of 4 out of 5 (1 for event, 0 for thoughts, 1 for emotions, 1 for location and 1 for time). Hence, for each picture, the score will vary from 0 (no details recalled) up to 5 (all details recalled).

In the second session, participants will be asked to review a random non-reviewed subset of their pictures on the eye tracker. This is for identifying which areas and eventually what elements in a picture draw one's attention the most during episodic memory recall. Simultaneously, we will be monitoring the participants' brain activity with an EEG headset during picture review. Research has shown that alpha and theta wave oscillations as measured via EEG reflect cognitive and memory performance [8].

Discussion

In overall, with the proposed study design, we expect we will be able to answer our research questions. In particular, we expect participants will be able to recall significantly more accurately their excitement levels when reviewing pictures of increased heart rate versus pictures captured during idling, on a 5-point Likert scale. Likewise, pictures captured during high heart rate would result in a significantly higher score of recalled characteristics in contrast to picture of normal or low heart rate, as derived from participants' recollection sessions.

Eye tracking data will help us answer the second research question and in particular, identify those elements in a picture that draw attention the most during recall. Based on previous work, we expect people in pictures to provide the best recall triggers [7]. Furthermore, we will be able to evaluate the effect of social interactions on one's biophysical responses (i.e. heart rate) and evaluate how this affects one's ability to remember. Although EEG data analysis is hard to provide useful insights if the device does not meet high medical standards, we expect a commercial EEG will be able to detect plausible brainwave variations among pictures of high and low heart rate. In particular, we expect pictures of higher heart rate to trigger richer recall and thus, result in a higher alpha and theta brain wave activity as opposed to pictures of normal heart rate.

Finally, we expect that the top 5 pictures of each session will be mostly comprised of those captured during increased heart rate. This would answer our third research question and possibly indicate that PulseCam captures pictures of higher importance for the participants.

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