Dream Album: A Dream Log with Photos

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ABSTRACT

This paper presents a system that records face expressions and visualizes emotion logs in user interface for helping users to recall the dream scenarios and classify their dreams after they wake up. The system is an interactive system that combines several technical components together, including smart bracelet with heartbeat rate detection, webcam with high resolution and high frame rate. This design can not only facilitate dream recall of normal users, but also can be used in dream and facial expression researches. A validation experiment, in which the sleeping states of participants were monitored, was performed to analyze the performance and effectiveness of the system. The results suggest that this system can assist most of the users to recall more emotions and scenarios in their dreams. Therefore, the dream album is proved to have positive influence on dream recall.

General Terms

System Design, Validation Test, HCI

Keywords

Human-computer Interaction, Sleep, Rapid Eyeball Movement, Dream Detection, heart rate

1. INTRODUCTION

Sleeping experience can be an important part in our daily life. People may have different types of dreams during sleeping. We could have some exciting experience, or some brilliant ideas in our dream, but after we woke up, they are all gone. Also, dreams have significant influence on our normal life, horrible dream can cause a man decided to suicide, sweet dreams can make a despair man decided to fight again, all these phenomena indicate that the dreams also affect our mental states after we wake up [2]. Therefore, it is meaningful to record the dreams so that dream logs can provide references to find the connections between type of dreams, sleep quality, mental states and life experience.

However, people usually can't remember the dreams after waking up, and sometimes we can't even notice that we had a dream during sleeping. Some studies reveal that dream forgetfulness is related to the brain chemicals norepinephrine and serotonin, which plays a role in transforming short-term memories into long-term memories. During the period of rapid eyeball movement (REM) sleep, these chemical materials are suppressed

and the activity of brain circuits for short-term memories is attenuated [3]. Moreover, the evolutionary explanation states that the brain function of dream memories has been degenerated since our ancestors were confused of their dream experiences and waking experiences in the past [3]. Therefore, clear majority of dreams are erased from our memories, and the dream memory is weak and unstable in our brain.

The basic idea of this project is to enhance the dream memories when parts of short-term dream memories still exist in our brains by taking advantage of visual stimulation. This work commits to build a system that captures facial expressions while users are dreaming, and then utilizes these images to help the users recall their dreams and strengthen their memories. Since emotions during a dream have some links with the dream itself [5], this system should be able to recall the user's dream memories by show them their emotions and some guessing of their emotions.

This system is an interactive system which consists four main elements: smart bracelet with heartbeat rate detection, webcam with high resolution and high frame rate, program for data streaming and face recognition, and graphical user interface. There are some smart electronic products to record relevant data of physical conditions during sleeping, such as heartbeat rate and breath frequency. These products can be used in Dream Album system, which helps us to detect the sleeping stages and make dream auto-capture plausible. Moreover, we designed a validation experiment to test the performance and effectiveness of the system. The experiment test this system with 4 different people, and received a positive feedback.

We think these are the key contributions of Dream Album system:
- Validate the idea of capturing dreams' clues for the users to recall their memories.
- Establish a prototype system of experiment
- Fill the blank of the research area of dreaming recall applications
- Provide possible solutions to the further experiment, in which psychologists can carry out deeper researches in dreams, face emotions and mental states

2. BACKGROUND AND RELATED WORK

There are lots of previous studies focusing on how to identify the dream types by using external behaviors, such as emotion, body posture and sleep talking. Meanwhile, these studies also elaborate how to detect the dream state according to physiological features of a person, including eyeball movement, heartbeat rate and mouth muscle. The researcher studied how these features are related to the dreams we have, which provides reliable references for us to decide which is the most suitable features for dream identification and detection. Moreover, many researchers studied the factors that affects the sleeping quality, such as temperature, light density and music. These kinds of studies help us set an appropriate environment for participants to sleep when we conducted the validation experiment.

2.1 Emotion and Dream Identification

Mental states in a dream can help users to recall dream memories, but it is hard to collect relevant data and we need to find a measurable element that can reflects more details of a dream [6]. Some studies show that we have many varieties of emotion on our face during the dream period, and emotion is strongly correlated to the dream recognition. Kahn et al. investigated the relationship between dream emotion and dream character identification. They found that emotions are almost always evoked by our dream characters and emotions are often used as a basis for identifying dreams [7]. Els et al. also found that there is a close relationship between the dreams in sleep and the recognition of facial expressions [8]. Therefore, facial emotion is an appropriate element to reflect our feelings in a dream.

Many scientists strongly believed that facial emotion is also a reliable source to recall our memories of dreams, so they tried to verify their opinions. Bower and Gordon conducted experiments in which happy or sad moods were induced in a dream to investigate the influence of emotions on memory and thinking [9]. LeDoux and Joseph also studied the relationship of emotions and memories in our brain [10] [11]. Richards et al. tested the hypothesis that expressive suppression should reduce memory for emotional events but that reappraisal should not [12].

The results of these experiments proved the correctness of these scientists' thinking. Bower and Gordon showed that an emotion serves as a memory unit that can be associated with coincident events [9], which indicates that activation of this emotion aids retrieval of events in dreams. LeDoux and Joseph found that emotional processing is a type of cognitive processing in human's brain, which means that emotions can help people cognize the event when relevant memories are evoked [10] [11]. Richards et al. had a similar conclusion that there is a tight connection between facial emotion and dream memories [12]. To sum up, facial emotion can be used to judge the feelings in dreams, and it can play a leading role in boosting dream recall.

Except facial emotion, some scientist attempted to find another feasible way for dream identification. Agargun et al. examined the relationship between sleeping positions, dream characteristics, and subjective sleep quality. The result showed that the rate of nightmare sufferers with fear emotion was significantly higher in left-side sleepers than in right-side sleepers [13]. It also presented a phenomenon that the face emotion of relief-safety was more common among right-side sleepers than the others [13]. According to these results, body posture can serve as an assistive way to judge the dream feature, but can't act as a main element for dream identification.

2.2 Heart Rate and Dream Detection

Dreams can occur in almost all stages of sleep, but they are most common during REM sleep, particularly towards the end of the sleep period [14]. In the experiment conducted by Bonnet and Arand, they assessed heart rate variability during the night sleep of 12 normal adults. They found the increases in high frequency components and decreases in low frequency components of heart rate during NREM sleep. And there was opposite changes during REM sleep and wake [15]. This result is valuable because we can use the growth of low frequency component of heartbeat rate to detect the state of REM sleep.

Similarly, Berlad et al. also investigated autonomic activity during NREM and REM sleep stages and wakefulness by spectral analysis of heart rate variability. The results showed that high parasympathetic activity was found in NREM, while REM was characterized by attenuated vagal tone and augmented sympathetic activity [16]. Heartbeat rate is controlled by the two branches of the autonomic (involuntary) nervous system: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) [14]. More studies found that sympathetic muscle nerve activity has a close relationship to the dream states [17] [18], which verifies that the heartbeat rate can serve as a valuable variable for dream detection.

Except heartbeat rate, many pieces of paper revealed that rapid eye movement (REM) is closely associated with dreaming. In these experiments, scientists used a method of waking up sleepers during a REM phase to obtain dream reports. They found that sleepers awakened from REM tended to give a longer and more narrative descriptions of the dreams they were experiencing [19] [20]. Therefore, we can observe when a dream happens by detecting the rate of eyeball movement. However, the discomfort brought from the eyeball detector should be taken into consideration. In the comparison of smart bracelet detecting the heartbeat rate, the larger volume and heavier weight are the main disadvantages of the eyeball detector. The eyeball detector may give a larger pressure on our face and eyes, so we prefer to use heartbeat rate for dream detection instead of the rate of eyeball movement.

2.3 Factors Influencing Dreams

Many experiments showed that lots of factors contribute to experiencing more "pleasant" dreams and falling asleep quickly. Some of these factors include the sleeping environment, the physical condition of the person and basic things such as having the lights turned off [22]. Since nervousness makes our brain activities keep continuously too active, the feeling of sleepiness can be generated more easily with as little stress as possible [22]. Once the dream state is detected, sound and light stimuli can be played to alter the dream [23]. Although it is difficult to assess the efficacy of music to induce or improve sleep [24], we can try to use light music to help participants to have a good sleep.

2.4 Emotion Recognition

Several pieces of paper outline the approach to construct an emotion-recognizing system. A neural network architecture can be constructed to handle the fusion of different modalities (facial features, prosody and lexical content in speech) [25]. This architecture utilizes different kinds of element for dream identification, which is mentioned in Section 2.1. Therefore, it is possible to obtain reasonably good results on classification of the emotional states of human subjects.

Since sleeping posture of human body is not still, the capture of facial emotion needs some small changes from static capture. In this case, using 2D images are not practical since we need to use monitors for surveillance in real time. There are several pieces of paper providing the effective algorithms of 3D face recognition to collect the facial information in real time [26] [27] [28]. Both of the algorithms of 3D Eigensurface and 3D Fishersurface can reduce the Equal Error Rate (EER). However, for the optimum surface representations, the Fishersurface system can produce only 11.3% EER, which is lower than 24.5% EER for the Eigensurface method [28]. Moreover, it is also verified that the Fishersurface system is particularly suited for use in security and surveillance applications. Therefore, Fishersurface is the best choice for the further development of our system.

3. SYSTEM DESIGN

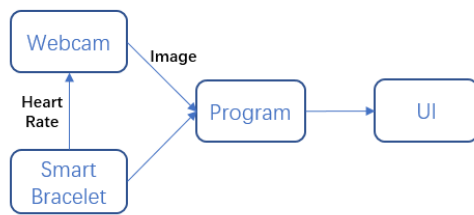The system consists in four parts, which is shown in Figure 1.

Fig.1 Design of system structure

The webcam and the smart bracelet are used for the dream detection and facial emotion captures during dreaming period. With these two devices, we are able to gather the face emotions, which are the most useful data in this experiment. After the images of face emotions are captured, we should have a program to control the webcam and the smart bracelet. It is necessary to establish a link between them for signal transportation. Finally, for the users, the graphic user interface (GUI) allows them to obtain fast speed and tips to log their dreams.

3.1 Smart Bracelet

The bracelet is one of the data collectors in this system and provides the reliable data that help to detect the REM sleep period. It triggers the webcam to take a shot when the REM sleep is detected, which regulates the timeline of the dream log. With all these concerns, we need our bracelet to have following features:
- comfortable
- Heartbeat rate detection
- API for data transfer with PC

During sleeping, users are required to wear smart bracelet for the data collection of physical conditions. Therefore, the bracelet must be comfortable to wear, so the users won't be disrupted by the equipment.

Heartbeat rate is used as a parameter to detect the REM stage, which is mentioned in Section 2.2. When the users are dreaming, they will have a significant heart rate change when the REM stage occurs and disappears. With this data, we can make the automatic capture possible. According to the research by Chouchou and Desseilles, there is a huge increase in REM occurrence and a shape decrease in REM disappearance [31]. The change should be significant and easy to observe. One study provides more accurate parameters: heart rate during the surges rose an average of 26.4%. So the heart rate change should be easy to detect with the Fitbit bracelet, and can use the heart rate back to normal as a sign of REM period's end.

API is another important part. We need to make sure the camera is linked with the terminal so that it can be controlled by the data from the bracelet. Otherwise, no data can be collected by the camera automatically.

According to all these requirements, we choose Fitbit Charge 2 as our smart bracelet. It can't even be felt by the users during sleeping. It achieves an extremely accurate heartrate tracking and affords a web API that ensures the fluent data transfer we need.

3.2 Webcam

Webcam is another data collector in this system. The camera should stably capture the frames with high resolution. It should support high frame rate and can be used in the dark light condition. As the commercial product can satisfy these requirements of this experiment, we choose Logitech Webcam HD Pro C920. This webcam provides a full 1080 resolution and a high-speed socket for data transfer.

The webcam should be controlled in two ways. It is controlled not only by the heart rate of REM sleep, but also by the program of face recognition. When the change of the heart rate comes up, the webcam receives a signal that tells it that's the time to work. Then it constantly takes 1 picture per 1 mins. Also, if the camera detects the emotion change on the user face, it should also take a picture.

3.3 Program and User Interface

The program and user interface are both on the PC side, so they are included in the same section.

The program needs to control the data input and output, so it has two inputs for the bracelet and the camera, and one output for the user interface. The following basic functions should be included:
- Bracelet data collection
- Camera control and data collection
- Face recognition
- User interface supporting data display and edition

Bracelet data collection is the basement of this system since the heartbeat rate provides trigger signals to the webcam, and provides a timeline of the dream log.

Face recognition is a part that is really needed, but we didn't draw much attention until our 1st pilot experiment. The original idea of this part is to use as a guessing system to help the user to get an idea of what that emotion is, as the person just not fully awake sometimes has some trouble of recognition work. But we changed our idea when we find the emotions can be changed so fast, that even 1 picture per 20 secs can't always cover them all, and sometimes the face just stay unchanged for 5 mins. Therefore, the face recognition can also be used as a trigger of the camera, in order to make the data set small enough for 5-6 mins, but also have enough data for user to use.

The UI is the only output to provide emotion record for users. This UI functions should include two features, which are data display and fast input. The recorded data should be organized by timeline as this is the most comfortable way for users to view. The UI also needs to show guess of emotions and pictures of the emotion. For the input, the text edition should be included, but also need some drawing space for the user to write down some details.

4. EXPERIMENT DESIGN

We will have 2 groups of participants, one group wears all the equipment, and use the system to log their dream; Another group also wears the equipment, but they are given only a blank notepad and with pen and paper.

4.1 Participants

A total of 6 participants (1 female, 5 male) completed the study. The age range of participants is from 20 to 25. We choose the younger people as participants because their brain activities are more active than the brain activities of the old. Therefore, it is more likely that the young participants will fell asleep much more quickly and have some dreams during the 2-3 hours sleeping time.

4.2 Experiment Procedure
- teach participant how to wear bracelet, and sign the certification
- set the camera
- show them how to use the UI, if they are in the first group

Table 1: Results of questionnaire

	Control Group	Experimental Group
R1. The average uncomfortable level of the smart bracelet (1 for strong uncomfortable, 7 for no influence)	6.33 SD =0.5774	5.33 SD =1.1547
R2. The average clear level of the dream (1 for very vague, 7 for very clear)	3.5 SD =0.7071	4.5 SD =0.7071
R3. The average number of scenarios can be recalled	2 SD =0	2 SD =0
R4. The average clear level of the recalled scenarios (1 for very vague, 7 for very clear)	4 SD =0	4.25 SD =0.7071
R5. The average number of details can be recalled	3 SD =1.4142	5.5 SD =0.7071
R6. The average clear level of the recalled details (1 for very vague, 7 for very clear)	3.5 SD =0.7071	5 SD =0
R7. The average percentage of facial emotion captures that are consistent with the feelings in dreams	NA	84.0% SD =0.0872
R8. The average useful level of the system for helping to recall dreams (1 for useless, 7 for very helpful)	NA	4.5 SD =0.7071

Fig. 2 Result about dream scenario recall

Fig.3 Result about dream detail recall

- participant lie down to the bed, broadcast some relaxing music
- record the heart rate after they fall asleep as the normal value
- look for significant heart rate changes
- After the change occurred, take 1 picture per min, also can take some additional one if the participant has face changes
- stop until the heart rate drop back to normal value
- wake the participant up about 10 mins after the data recorded

4.3 Experiment Adjustment
The experiment is based on 100% face recognition rate, since the recognition system error rate has no influence to this idea, we finally decided to use human eyes as a recognition tool to make sure the recognition rate is perfect.

Also, due to the API of the Fitbit is down since April 4th,2017 until now, we read the heart rate data though the smart phone, and manually trigger the camera.

4.4 Experiment Environment
We implemented the test mostly in each participant's home, for the participant should feel the most comfortable, and they could fall asleep more easily. During the test, we reduced the light density by adjusting the blinds or curtains, and leave some light to help the camera. And we used light music to help the participants relaxed.

5. RESULT AND ANALYSIS
We invited 6 participants to attend the validation testing. They were asked to fill a questionnaire to give some feedback, and help us to validate the system.

Due to the discomfort brought by the unusual environment and one person in the room, 2 participants could not fall asleep after 30 mins.

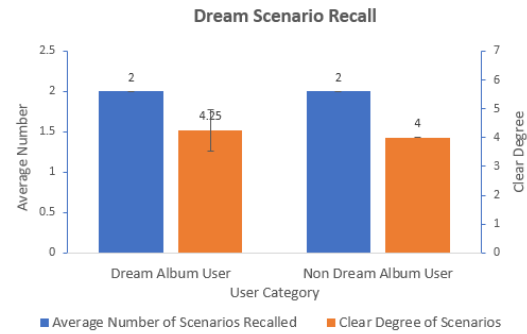The others normally feel asleep after 15 mins, and can achieve the 2 hours sleeping.

5.1 Summary of Questionnaire
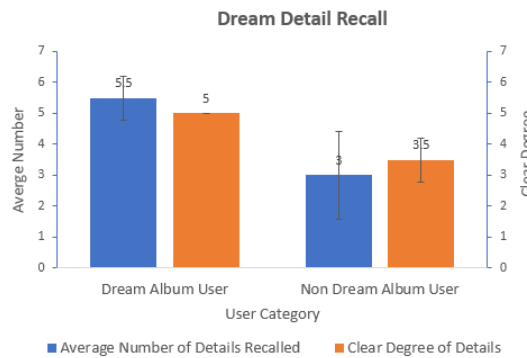The average value and standard deviation (SD) of each question in the questionnaire is shown in Table 1. Among all the participants, 2 of them can't feel asleep, so they only measured the comfort, which is Question 1. All 4 that can feel asleep answered all the questions they could, and the 2 in the control group didn't see the UI, so they can't answer Question 7 and 8.

According to R1, the smart bracelet nearly didn't have any influence on the comfort of other participants, so one of the requirements for the data collector was basically satisfied.
R2 showed that in general level, the participants using the Dream Album System think they could remember the dreams more clearly, feels like the system influenced their thought of the dreams.
R3,4,5,6 are the validation questions, will be analysis at the next few sessions.
R7 provides a proof that the facial emotions can basically reflect the feelings when they experiencing dreams, which verifies that facial emotion is a reliable element to identify the dreams and to evoke some relevant feelings during the dreams.
R8 shows that the participants think there are still many problems of the system. Although the system can more or less help them to recall their dreams, they are still not sure how much the system is contributed to the dream recall. The participants cannot distinguish whether the system plays a key role to enhance the dream memories, or they just too good to recall dreams.

5.2 Results about Dream Scenario Recall
The results of R3 and 4 is about dream scenario recall, as the Figure 2. The non-dream-album users could recall 2 scenarios on average, which is equal to the average number of scenarios recalled by the dream-album users. The participants in the blank

contrast group thought the scenarios were not too vague but also not too clear, which is approximately close to the scenario clear degree recalled by the participants in the experimental group. Therefore, using the Dream Album System or not will not have a large effect on the scenario recall of dreams.

This could be caused by the dreaming time, as they experienced one period of REM, so they could have limit amount of dream scenario. Also, as the scenario is not a important part of the dream, and don't have too much emotions linked with it, the lack of emotions could also be one reason of the result.

5.3 Results about Dream Detail Recall

The result about dream detail recall is shown in Figure 3.

The dream-album users could recall 5.5 details on average in the test, while the non-dream-album users could only recall 3 details on average. Meanwhile, the dream-album users thought the details of the dreams were quite clear, but the non-dream-album users thought the details were a little vague. Therefore, using the Dream Album System can obviously help users to recall more details of the dreams more clearly.

This could because all we remember after we awake is some impressive details that triggered the some strong emotions, and as they had a look at the face, this could recall some part of the memories.

5.4 Marks and Comments to Experiment

All participants are asked to mark the experiment to reflect their comfort of sleeping experience, the quality of the experiment and so on. 1 stands for a very bad experiment, and 7 stands for a very good experiment.

The average of the mean score is 4.5, and the standard deviation of the score is 1.0488. The result shows that the overall experiment quality estimated by the participants is quite good, but there are many drawbacks existing in the experiment, which will be analyzed in the Section 5.2.

I don't know if it's the system, or I'm just the type that can remember the dreams.

----one participant

Some participants leave the comments that the dream log is useful to let them know what happens in their dreams when they view their emotions. However, some participants were doubtful as the quote shows, they think everyone is different, maybe they can recall, just because they are good. But, most of them thought the system is a good try to use emotions to recall the dreams.

6. DISCUSSION

The results of this experiment show that the Dream Album System can basically help the users to recall their dreams. This system does a great job to make users clearly recall more details. However, this approach doesn't positively affect the scenario recall in the same level.

However, there are still lots of problems in the experiment. The first main problem is that the number of participants is too small. The sample size is not large enough to provide certain amount of experimental data, so that the results are not accurate and reliable.

Also, there is no way to fully know if the man is good at remember dream or not. To eliminate the influence by the brain of each participant, we should let the participants in the experimental group sleep twice. In the first time, they should independently recall the dreams only with paper and pens, which is same as the participants in the blank contrast group. In the second time, they should do the same things which have been

described in Section 4.1. Except the uncontrollable factors, the only difference between these two test is whether the participant uses the Dream Album System after he/she wakes up. In this case, we can basically judge whether the system can really help the participant to recall dreams according to the differences of the participant's performance. But we just don't got enough time to do this, but this can be a good optimize solution to this experiment.

Also, as the limitation of the funds, we only bought one HD webcam for experiment. In some validation tests, the REM sleep occurred when the participant was back to the camera. In this case, we need to 2 cameras at both side of the bed, lucky there is no such situation happened in this experiment, but this is very likely to happen if enlarge the participant number.

Last but not least, some participants are easily influenced by the external environment. They could be disturbed by the sound of door opening and closing in the apartment. Some participants may have a psychological barrier that they failed to fall in sleep under the surveillance of a monitor.

7. FUTURE WORK

Optimize the experiment

One possible direction is to optimize the experiment process. First is to prolong the research period into a full 8 hours circle, during that long period of time, REM could occurs at least 4-5 times, and can gather a sufficiently large size of samples.

Also, the participant can be representative, which means that the participants should cover both genders, different levels of age and so on. This can greatly contribute to the improvement of the experiment reliability.

Then, it's good to complete the part of facial recognition in the program. At present, we manually recognize and classify the emotion type, with recognition, the system can detect the fast emotion changes and make the photo more precisely.

Consider different element of detection

It's also a good direction to combine different kinds of element to detect and identify the dreams during the REM sleep. Except the face emotion, we could also introduce the elements of body posture and sleep talking to the system. These elements can act as supporting evidences to make the dream identification more robust and reliable.

Also, the HRV value, can also be treat as a main detect tool, for the value of HF/LF has a significant change during REM period.

Improve the user interface

The final possible direction in our opinion is to improve the user interface. The graphic user interface is now a classic windows XP theme. Add more color and make some change according to the face recognition result will increase the recall rate in theory.

8. CONCLUSION

The purpose of our experiment was to evaluate the performance of the system that record users' emotions to recall their dreams. We developed a system that consists the four main parts including smart bracelet, webcam, program and user interface. The smart bracelet collects the heart rate, which is used to trigger the webcam capturing emotions. The images are sent into the program to do emotion classification and generate dream album. The dream log is presented in the user interface, which provides

a convenient way for users to view and edit the record of emotions.

Responses to the post-experiment questionnaires indicated that the dream log could revise the wrong dream memories of some participants. The results suggest that this system can help the majority of users to recall some emotions and scenarios in dreams, but many details are still lost. Therefore, there is larger potential for further work in enhancing the design and functionalities of the system.

9. ACKNOWLEGEMENT

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