EECE 518 Human Interface Technologies

Dream Album: A Dream Log with Photos

Technical Report

Haotian Zhang #85979169

Xi He #81319162

Abstract

This is a system that use heart rate to detect the dream, and capture the data that help the user recall their dreams. We use smart bracelet to capture the heart rate, then use the camera to capture emotions, and gather all the data to the user interface. At the same time, the user interface has a quick input method, and present the tips when they logging.

Notice

Every martial used in this report can be found in the package and also can be found in https://github.com/zht1hao/518-project/ .

Declaration of Originality

We declare that this technical report is our original work except where stated.

Haotian Zhang, Xi He

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Contents

Glossary

API	Application Programming Interface
GUI	Graphic User Interface
REM	Rapid Eye Movement
NREM	Non-rapid Eye Movement
HRV	Heart Rate Variability

1. Introduction

1.1 Needs and requirements

This system's idea comes from your daily life, when we awake, we just can't remember the dream, and even we can remember some after awake, we still will forget most part of it. This system is created to save some of the memory fragments of the dream.

The user group should be the men curious about the dream, or someone that want to remember and log their dreams, so this is designed for a personal use, so all the equipment should be reliable, and easy to access.

The requirements of the system are obvious at this point; and this system needs to contain the following features:

- Dream detection
- Dream data collection
- Dream data analysis
- Recall tips display
- Fast log input

And at the same time, the system's equipment need to be used during sleeping, so safety and comfort should also take into concern.

1.2 Project Development Cycle

The timeline covers the whole period of this project, which started from January 2017 and ended in April 2017. Most of the time in the first two months was spent in background reading, and the most important parts are finished in March and April.

At the beginning of this project, it was planned to utilize eyeball movement detector to detect the dream states during sleep. However, the eyeball movement detector would bring the discomfort to the participants. Therefore, we changed the design and decided to use smart bracelet, which uses heart rate to indicate the REM sleeping state.

To sum up, most missions were finished on time in each stage. The changes of design were taken nearly extra two weeks. Fortunately, this delay did not have an adverse influence on the progress of this project. The practical work was finished at the beginning of April.

1.3 Report Layout Overview

This technical report totally consists of 5 chapters.

Chapter 2: In this section, all relevant system design on which this project is based are briefly explained. We originally intended to use eyeball movement detector to detect the REM sleeping state. However, considering the discomfort brought from the eyeball detector during the sleep, we decided to replace the eyeball detector by the smart bracelet, which collects the heartbeat rate and uses this data to trigger webcam.

Chapter 3: This part illustrates the processes of setting up the validation experiment and improving the procedures of validation testing. We will consider the factors that influence the successful rate of the experiment, and try to improve the quality of the test.

Chapter 4: This chapter introduces the results of the validation experiment. The analysis of questionnaires and the system performance will also be included. In the end, the self-assessment of the system and the validation testing will be presented.

Chapter 5: The short conclusion and the self-assessment of this project are included in this section. The scope of future work will be mentioned at the end.

2. System Design

2.1 Original Thinking

This is our original idea at the beginning of the project

2.1.1 Analysis

At the first phase, we find we can split this question into 4 different question

- How to detect
- What need to be collect
- How we deliver the data
- How can we validate the idea

The following is the analysis of the questions.

How can we detect the user is dreaming?

Since the sleeping process normally lasts for 6 hours or more, it is impossible to collect data for that long time and to show all data to users. Fortunately, the dream can be detected with the eyeball movements and other health parameters, and the detection only lasts for about 5 minutes per cycle. There are hundreds of papers researching this point, such as Dream imagery: relationship to rapid eye movements of sleep (Roffwarg, Howard P.) and Dream recall and eye movements during sleep in schizophrenics and normals (Dement, William). There is a piece of paper providing methods for eyeball movement detection, so it is feasible to detect the dream and to collect data in a reasonable period. Also, Sympathetic-nerve activity during sleep in normal subjects (Somers, Virend K., et al., 1993) and The human tongue during sleep: electromyographic activity of the genioglossus muscle (Sauerland, E. K., and R. M. Harper, 1976) suggest we can use the blood pressure, heart beats and muscle movements to detect the dream sequence.

What data do we need to collect when the user is dreaming?

This is the main part of this project: what kind of data do we actually need to form a helpful dataset for the user? First, the eyeball movements, the heartbeats or other periodical parameters of health are very helpful to dream detections. These data will help to keep the data in order and to minimize the data in a reasonable length. Second, we should collect the data that can help the user to recall the memories. This is really a hard part, because there are a lot of elements that can contribute to

recall dream memories. Sleep after learning aids memory recall (Gais, Steffen, Brian Lucas, and Jan Born., 2006) suggests that mental states in a dream can help users to recall dream memories, but it is hard to collect relevant data and to present this kind of element. Other pieces of paper indicate that the descriptions of environment and the verbs of actions can also help for dream recall. However, these elements are not strongly related to the feelings in a dream. Across all these elements, one of the feasible ways to recall one's dream is using emotions. Several pieces of paper indicate that emotion is an appropriate element to reflect our feelings in a dream: Mood and memory (Bower, Gordon H., 1981), Emotion, memory and the brain (LeDoux, Joseph E.), and Emotional memory systems in the brain (LeDoux, Joseph E.). Third, Patterns of sleep talking (Rechtschaffen, Allan, Donald R. Goodenough, and Arthur Shapiro.,1962) suggests that sleep talking may happen during all sleep stages, so an individual recording system with noise filter would be helpful to provide more information for dream analysis.

After comparisons, the most important element for recalling our memories of dreams is facial emotion. Other pieces of paper show that when we are dreaming, we have many varieties of emotion on our face, and emotion is strongly correlated to the dream recognition: Emotion and cognition: feeling and character identification in dreaming (Kahn, David, Edward P., 2002), Sleeping position, dream emotions, and subjective sleep quality (Agargun, M. Y., Boysan, M., & Hanoglu, L. 2004.) and Sleep deprivation impairs the accurate recognition of human emotions. (Van Der Helm, Els, Ninad Gujar, and Matthew P. Walker., 2010). Therefore, facial emotion is reliable for dream detection in this experiment.

However, 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 and we need to use monitors for surveillance. There are several papers providing the algorithms of 3D face recognition, such as Three-dimensional human face recognition (Choudhury, 2009), Three Dimensional Face Recognition: An Eigensurface Approach (Heseltine et al., 2004) and Three-Dimensional Face Recognition: A Fishersurface Approach (Heseltine et al., 2004). All of these methods provide effective ways to collect the facial information in real time.

Moreover, the dim light condition will limit the accuracy of recognition. Usually, people are used to closing all lights during sleep, which leads to the difficulty of applying face recognition. Fortunately, the paper An algorithm of face recognition under difficult lighting conditions (Forczmański et al., 2012) addresses the problem of face recognition for images with different lighting conditions – flashes, shadows and very low brightness level.

How can we deliver these data in an efficient way?

This problem is basically equal to how can we use our data? In the first step, we transfer the periodical data into a timeline that shows the dreaming sequence with specific time. This step helps us form the frame of the digital dream album, which is similar to the track order of an ordinary music album. Then we fill the dream album with relevant videos, photos and sleeping talks that the system records. This step helps us complete the whole dream album, which is used to recall dream memories. When users play the dream album via their smart electronic devices (smart phone, tablet, MP4, PC, etc.), they will see the UI structure that is shown in Figure 1. In this UI, each dreaming track presents the specific time period, the photo of facial emotions, the general emotion analysis, the general dream description or conclusion, and the last playing history. According to these kinds of information, users can choose to play the tracks that make them interested. If users click one of the tracking cover (photo), they can view the video records, the collections of their facial emotions and the detailed dream analysis during this time period. Therefore, the usage of the dream album is very similar to the video playlist in Youtube.
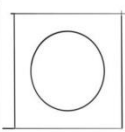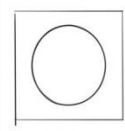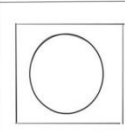

Fig.1 The UI structure of the dream album

Are these data really helpful to the user?

This is a validation problem: can the dream album make the users recall their dreams? Although many pieces of paper show that facial emotions can reflect the variety of dreams, it is possible that the users can't remember their dreams even if they view the records in the dream album. Therefore, it is necessary for us to organize a test and invite some participants. In this test, the participants will be asked to sleep in a quiet and comfortable environment. During this process, we will record relevant data and use these data to complete the dream album. When the participant wakes up, he will be given some time to recall the dream. Then we will conduct a questionnaire survey to check how well the dream memorization can be. In the next step, we will present the dream album to the participant, and give him some time to view the whole album. Finally, we will conduct the same survey again to check whether the dream album can help the participant to recall more details in the dream and to fix some bias in dream memories. The setting of questionnaire can be referred to Understanding the Factors that Govern Dreams and Dream Recall (Evans et al., 2017). We will compare the differences and similarities of the test results, and try to find whether the dream album is really helpful for dream recall.

2.1.2 Objective

As the project analysis indicated, there are 4 research steps in the procedures:

1. Find a way to build the whole system.

2. Build a UI or a small application to show the results to users.

3. Find 3-5 participants to test the system.

4. Design a survey for the validation part.

2.1.3 Equipment

For the whole system, we need the following devices to finish it.

- Eyeball detector

  It is expensive to buy a commercial product. The paper DreamThrower: An Audio/Visual Display for Influencing Dreams (Kamal, N., Al Hajri, A. and Fels, S.) provides us a method to detect rapid eye movement (REM).

- Recorder

  Since we need to do recognition on the sound part, we need a recorder with noise filters to provide the voice with high quality.

- Face capture device

  The face motion is one of the important part of this design. The face capture device is required to work during sleeping, so the camera should have a night vision feature with a medium resolution. Moreover, since the body movement is unpredictable during the sleeping, we might need two cameras to cover all the angles.

- Computer

  As the console of output.

Except the hardware, we need software to do the analysis job.

- Time counter

  It forms the timeline for the data, this is the necessary part.

- Sound-edit program

  It should be compatible with any sound-edit software that supports sound wave.

- Face recognition program

  We never used relevant software or algorithm before, and we hope that some open source programs may be useful in this part.

- UI for the result

  Relevant data can be output into excel if we don't have enough time to design UI presenting all results.

2.1.5 Original System Design

The dream detector

Dream Thrower: An Audio/Visual Display for Influencing Dreams (Kamal, N., Al Hajri, A. and Fels, S.) provides the design of eyeball detector that can fit the experiment well. The structure design of eyeball detector is shown in Figure 2. The main components of this device are IR emitter and IR detector. When the eyeball is stationary, IR light is blocked in the emitter and the detector

only receives very low amount of IR signal. Therefore, the A/D converter in Arduino Board is supplied with low voltage to indicate stationary state of eyeball. In the contrast, the IR detector can receive large amount of IR signal when the eyeball moves, so Arduino Board is supplied with high voltage to indicate eyeball movement. The A/D converter will transfer the analog signal (electric signal) to digital signal. Moreover, this system can do noise filtering and reduction in the pre-processing step, which is reliable in this experiment.
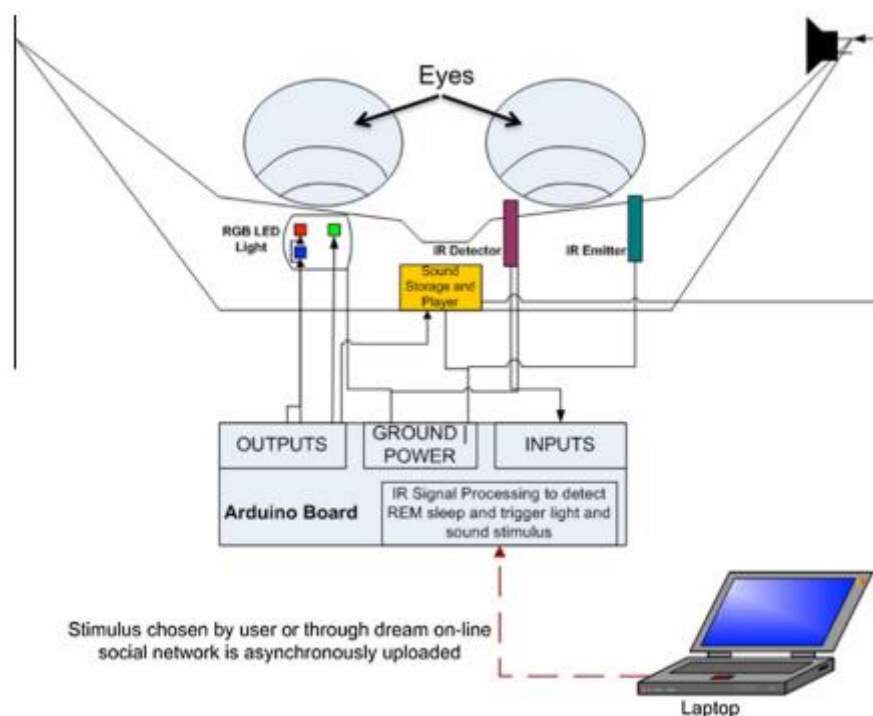
Fig.2 The structure design of DreamThrower

Also, we can add a heartbeat detector and observe the muscle movements though the camera to ensure the accuracy of the result.

The face capture device

The device of the face recognition is one camera basically. We assume that the application of face recognition is perfect and we can use our eyes to detect the face emotions. In this experiment, we focus on whether the dream album can help the participants to recall their dreams, but we won't really focus on how to code for face recognition. Therefore, the face capture and the emotion detection are not the most important parts, and they should not affect the test performance. In other words, the quality of face recognition is not considered as an element to affect the result in this

experiment.

Furthermore, some pieces of formal paper show that face capture is a reliable technique: Face recognition using eigenfaces (Turk, Matthew A., and Alex P. Pentland, 1991), and Two-dimensional PCA: a new approach to appearance-based face representation and recognition (Yang, Jian, et al., 2004). Also, another piece of paper Emotion recognition in human-computer interaction (Cowie, Roddy, et al., 2001) shows that emotion recognition is also a developed technology that can be used in the field. Therefore, we have sufficient reasons to believe that the face capture is totally dependable, and there is no need to validate the part of face recognition anymore.

2.1.6 failed reason

We thought this is a suitable design for our project at the first place, but as the time goes, the idea finally meet its evaluation. There are many reasons, but the most important reason is time and comfort level of the equipment.

First, the time is the biggest issue of this plan, the work amount of the eye movements detector is huge, and the part of it needs to be delivered by online shop, and if we need to make some changes, this will cost at least 4 weeks, for a 2 months' project, it's nearly unacceptable.

Second is the equipment, the detector itself has some chips and are big enough to prevent the user from most of the sleeping posture, which will highly interrupt the experiment.

2.2 Revised Design

After the evaluation, we came up with a new idea, that use heart rate to detect the REM period, and try to make the device small and leave the face area clean.

2.2.1 System Structure

The system consists in four parts, which is shown in Figure 3. The first part is smart bracelet, which is used for detecting the heart rate in the sleep. It triggers the webcam to capture an image when the heart rate reaches to a certain value. The second part is webcam, which captures a user's emotions and send the image to the program. The third part is program, which implements face recognition to detect face emotions and finish classification. The fourth part is user interface, which provides a friendly interface for users to view and edit the dream log conveniently.
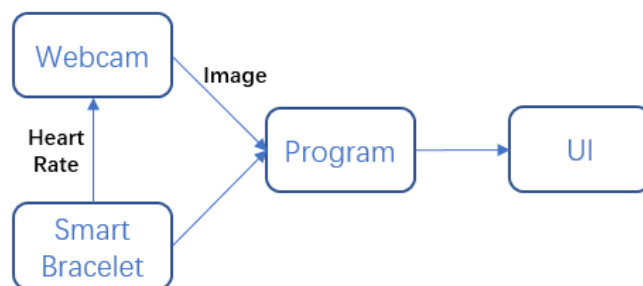
Fig.3 Design of system structure

In the new structure design, we decided to replace eyeball movement detector with smart bracelet. Although eyeball movement is strongly correlated to the REM sleeping state, it is likely that the participants (users) feel uncomfortable when they sleep wearing such kind of device. 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 [14]. This result is valuable because we can use the growth of low frequency component of heart rate to detect the state of REM sleep. Since heart rate also has very close relationship to the REM sleeping state, and there is many commercial products to detect the heart rate precisely, smart bracelet is chosen to provide trigger signal to the webcam.

2.2.2 Equipment And Relevant Parameters

● **Smart Bracelet**

  The brand of smart bracelet chosen in this project is Fitbit Charge 2. Relevant information and parameters can be checked online:

  https://www.fitbit.com/charge2.

  It can be used in the heart rate observation. The application of Fitbit Charge 2 supports the prediction of each sleeping stage. It provides the web API to stream the data of heart rate in real time. This style of smart bracelet not only provides comfortable using experience for customers, but also offers good customer services.

● **Webcam**

The brand of webcam chosen in this project is Logitech Webcam HD C920 pro. Relevant information and parameters can be checked online:

https://www.amazon.ca/gp/product/B006JH8T3S/ref=oh_aui_detailpage_o01_s00?ie=UTF8 &psc=1.

This product can stably capture the frames with highly quality. It supports high frame rate and can be used in the dark light condition. Similarly, it also provides good customer services.

- **Program**

AForge.NET is a C# framework designed for developers and researchers in the fields of Computer Vision and Artificial Intelligence, including image processing, neural networks, genetic algorithms, machine learning, robotics and so on. Therefore, after the face emotion is captured, the image can be streamed to PC in real time. It is available online:

http://www.aforgenet.com/news/2013.07.17.releasing_framework_2.2.5.html

Microsoft DirectShow is used to create GUI to present the dream record (dream log) to users. It supports C++ and can be developed in Visual Studio. Some relevant toolkits are available online:

https://msdn.microsoft.com/library/windows/apps/hh452744

AVBlocks is a cross-platform software development kit for audio and video processing, encoding and decoding. The AVBlocks SDK can be used from C, C++, and .NET languages like C# and VB.NET. AVBlocks is currently available for Windows, Mac, Debian Linux and Ubuntu Linux. We can check which video codecs, audio codecs and audio/video file formats are supported by the AVBlocks Audio SDK online:

http://www.avblocks.com/

2.3 Problems in Implementation

- **Webcam**

So far, streaming capture has been down so there being delay between the emotion capture and image delivery. Although the webcam can work in the environment with dim light, certain extent level of light is still necessary to make the webcam work and ensure the quality of images. The camera should be at one side of the participant. It should be put at the side that a user is likely to be so that the webcam can capture most of the movements. According to the

paper *Multimodal Sleeping Posture Classification* written by Weimin Huang, Aung Aung Phyo Wai, Siang Fook Foo and Jit Biswas, the camera should be set at the upper top on the comfortable side of the user.

- **API**

  The fitbit API is now off, they should fix this in a few days, if this won't work, can use the screen capture, and detect the heart rage in their application.

- **Program**

  There are multiple library of video, some of them use picbox and some use panel in their example, both would work when in all kinds of video lib.

3. Problems in experiments

3.1 Participants

Some participants are too nervous to fall asleep when others are in the room. Even though light music was used to make the participants relaxed, it took a long time (0.5-1 hour) for them to fall asleep completely. In this case, we conducted another experiment when the participants felt tired so they could sleep more quickly. Another problem is that the sleeping period of some participants was too short, which indicates that they only stayed in light sleep but not deep sleep. In this case, the participant was asked to keep on sleeping so that we could collect enough data in the dream record.

3.2 The experiment details process:

- teach participant how to wear bracelet, and sign the certification
- set the camera and show them how to use the UI
- participant lie down to the bed, brocast some relaxing music
- record the heart rate after they fall asleep
- look for significant heart rate changes
- take 1 picture per min, also can take some additional one if the participant have face changes
- stop until the heart rate drop back to normal value
- wake the participant up about 10 mins after the data recorded.

3.3 Webcam

Although the camera can work in low level of light density, we needed to introduce some sunlight into the room or adjust the lamp to provide appropriate light density. Since different people have different sensitivity of the light when they sleep, the light density could not remain in the same level for each experiment. Also, the light maybe better when it comes from the different side of the user's usually postures.

3.4 possible questions

Why not wake them up just after the data collection?

> Because we want to make the experiment environment like the normal sleeping environment, if you wake them in REM, they will surely remember the dream, but normally we don't wake

up at that period.

Why not only one picture?

Because the dream can contain multiple scenarios, and in each of them, user also can have different emotions and have multiple reactions. One picture can't represent these emotions. Also, the system is not 100% accurate, so more shots will make it easier to hit the target.

Why face recognition?

Because except of guessing, face recognition also an important element to judge if the camera needs to take a picture. I tried to take 1 picture per 20secs, but this will make the data has 30 or more rows, that is actually slowing down the user. But if we don't take enough photo, that might means the user can't find any useful data though all the pictures.

Why time line format?

The time line format makes the most sense, when you try to remember something. It can make some connection between the thing you remember and lost memories.

3.5 Notice

During our research period, we found papers that indicate heart rate doesn't have a significant change during sleep, some of the papers have the opposite result in their experiment as the heart rate change significantly, also there are multiple papers show that heart rate is stable during REM. Our experiment shows the heart rate did have a significant change, but not very sure if there are any accidents makes the result this way. A more accurate way is to measure the heart rate variability(HRV), with HF(High Frequency)/LF(Low Frequency) change the stage change can be 100% accurate.

4. 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.

5. Future work

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.

5.1 API

In this project, the API of Fitbit was down at the moment, so we used your eyes as the API. In the further work, this should be the 1st thing to fix, so that the system can finally operate automatically

5.2 Extend sleeping time

Though the detection is successful, we only have 1 REM period during 2-3-hour sleep. Maybe there will be some changes if we introduce another period. So extend the sleeping time of the experiment is very important in the future. This will make the system more reliable and stable.

5.3 UI

The UI is an important part of the system, but now it's appearance is not that good for use, maybe change some color and make the system more automatic will help a lot.

5.4 Audio record

we can think mic will make the user feel uncomfortable, but it could be captured if the mic has a good recording quality and the environment is quiet enough. Also the need a audio processing module to detect if there are sound in the room, then capture the voice automatically.

5.5 Dream guessing

we now only can guess the emotions using face recognition, but when we have enough data from the user(log), or link it with the dairy software, it can guess the scenarios, and the details, there are multiple papers indicate that dreams actually linked with the memories during day time.

5.6 Accuracy

The heart rate is not a very good judge for the detection, because it don't have a clear threshold that show if the user is dreaming. One possible solution is to use a better detector of heart beat, and convert the data into HF/LF ratio, this will be much more accurate than the rate.

5.7 Data extend

The location and health data could also be useful for guessing. We use the smart bracelet as a part of the system, so the data from the bracelet, like the sport time, location could also be used to generate some details or tips for the user, this is very tricky, because it can also influence the user and change the memories, so there need some experiments to identify if this will work, or this is too much.

Acknowledgments

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