Smart Photo Frame for Arousal Feedback

Wearable sensors and intelligent healthy work environment

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Abstract. The fast economy and technology development as well as the competitive markets nowadays results in high expectation on performance of employees in companies. Therefore, a working environment which can take care of the wellbeing of employees is important for an employee to stay healthy, enjoy work and be able to develop himself / herself. In this paper we propose and demonstrate a design of a feedback system for body worn wireless sensors to be used in wireless emotion monitoring. Wireless sensors developed by Holst Centre IMEC NL has are applied to monitor physiological signals related to emotions. A prototype, the Smart Photo Frame has been made as the feedback device. This device provides employees feedback on the emotional arousal status in real-time, in an effort towards reducing work-related stressful states through positive calming. The feedback system is designed to be subtle in an office related environment. The prototype demonstrates the design concept and enables users to interact.

Keywords. Health monitoring, wireless, wearable sensors, photo frame, relaxation, light, calm technology

Introduction

Nowadays, because of the fast economy and technology development, companies are trying to survive in competitive markets. The economic crisis of 2009 expects more and more top work performance from the employees [1].

Work stress is a physical and emotional tension that derives in part from work and causes change of behavior. According to report from TNO [2] work stress can be caused by a poor work atmosphere, conflicts at work and by uncertainty about the future of work. Besides that it can be caused by a combination of tension at work and at home. The biggest cause of work related stress is the presence of high work demands. Especially now, in the economic crisis employees are uncertain about their job and have high work demands which they need to fulfill. Work pressure arises when an employee is unable to fulfill his tasks and misses opportunities to solve the problems. An employee wants to stay healthy, enjoy his work and be able to develop himself. But high stress may lead to depressions and other medical conditions.

Besides the damage to employees it also has impact on the company itself. Stressed employees means low productivity, less effective and efficient work. People become less motivated, less observant and less creative and learn less. This means that

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they achieve less and more things will go wrong and more people are absent. It affects the company, because it needs to check and double check employees delivered work. Besides that less chances and opportunities in favor of the company will be taken by the employee. Overall this leads to loss of money, time, etc.

Recent advances in sensor technologies and wireless communication technologies [3-6] together with the development of the ambient intelligence concept [7] enable the creation of a new generation of healthcare monitoring systems with wearable sensors. Non-invasive monitoring covers a wide range of applications, including healthcare, sports, work, entertainment, etc. Quite some design and implementations have been reported, for example, innovative designs for vital signs monitoring and feedback systems for neonates [8-10], an adaptive entertainment system to reduce the stress of passengers on an airplane [11], a smart seat to provide adaptive support to the airplane passengers [12, 13], a user friendly EEG headset to enhance people’s wellbeing based on bio-feedback [14].

In this paper, we present a design that is based on creating a healthy work office environment for employees. A wireless wearable sensor system is applied to measure the stress level of an employee in an office environment. And then an actuation system embedded in a photo frame design gives the employee real time feedback and helps him/her aware of the stress. Results from user testing show that the sensor system and the smart photo frame have potential to adapt to the user’s behavior and to assist them continue working in a healthy way.

1. Sensors and Arousal Monitor

In 2008 Holst Centre has developed a series of wireless sensors that, when combined in a wireless sensor network, are used to monitor physiological activity related to emotions [15]. It is expected that, in the next decade, technology will enable people to carry their personal body area network (BAN) that provides medical, lifestyle, wellness, assisted living, sports and entertainment functions for the user. In this paper, These sensors need to be placed at the body of the user and are used to make the user aware of his high stress level.

1.1. The Sensors

The current system measures the autonomic nervous system (ANS) responses and consists two wireless sensors. The sensors are based on the Holst Centre UniNode as shown in Figure 1, which consists a microcontroller to process and sample data, a radio to transmit the data and a power supply, and a 165 mAh lithium-ion batteries. Each UniNode can acquire data from up to 2 sensors at a time by connecting the appropriate sensor circuit. In this paper, the network contains two UniNode sensors, to measure ECG, respiration, skin conductance and skin temperature. [15]
ECG and respiration sensors were connected to one Human++ UniNode and integrated into a chest belt (Chest node), while the skin conductance and skin temperature sensors were connected to a second Human++ UniNode and integrated into a wrist band (Wrist node). The integrated platform is shown in Figure 2. The sensors communicate with the computer via the Real-Time Arousal monitor software interface. [15]

1.2. The Real-Time Arousal Monitor

The user interface of the Real-Time Arousal monitor is shown in Figure 3. The ECG signal is displayed, together with the detected beats and the instantaneous heart rate. Skin conductance is shown as raw data and the instantaneous estimation of arousal is shown in a big red bar. A graph shows the arousal level over time. Analysis and visualization of the respiration signal are implemented for future exploration. Data is acquired, and stored both in memory and on disc on a regular basis, with linear interpolation implemented whenever data is lost due to communication flaws. [16]
2. Ideas

In order to relax, people need distraction, social support, express emotions, stimulate positive thoughts or relaxing exercises. The device is going to be office related, this means that the feedback needs to be subtle, calm technology. Then it will not be noticed by the other employees in the office.

The three main ideas generated out of the research conclusions information are: photo frame, bounce ball and text coach.

2.1. Photo Frame

This concept in Figure 4 is about a photo frame which lightens up when the user gets stressed. The intensity of the light is based on the stress level of the user. The light attracts the attention of the user and the picture of his child makes him decrease his stress. The user is distracted and calms down again.
2.2. **Text Coach**

The “text coach” concept is shown in Figure 5. When someone is stressed he receives a subtle text message, e.g. a joke or weather forecast and then ‘btw your stress level is now 10’. The text message creates relaxing thoughts and distraction. Especially in this era people immediately check their cell phone when they hear something. The only problem is that when someone is stressed all the time he will continue receiving text messages. This will make the user crazy and the thus when a person remains stressed he will receive a three text messages within the first five minutes and after half an hour another one.
2.3. **Bounce Ball**

Figure 6 presents the “Bounce ball” concept. The ball is a light-ball, and will light up in red when the user is stressed. He or she needs to throw away the bounce ball, this way the user can express his angry emotions. After throwing it a few times the red light slowly disappears. The playful interaction distracts the user and the changing body movement makes the muscle less tensed.

![Figure 6. Bounce ball](image)

2.4. **Idea Selection**

Because of the personal value and the idea of an integrated desk object, the photo frame has most potential. The huge personal value of the frame helps people to remind the happy relaxing days and therefore it cannot be seen as a useless gadget. This means that people will use it anyway, also when it is not connected to the sensors (ordinary photo frame).

The feedback of the other two concepts is less subtle than the photo frame. The big red light of the bounce ball and text message sound can become annoying. This kind of distraction is too obvious and instead it needs to fit in the environment. The light of the photo frame on the other hand is visible but does not distract in a wrong way, it emphasizes the picture in the frame in a discreet way (there are already lighting photo frames in the market which are used in everyday surrounding and thus not annoying.) and therefore could not be seen as an annoying feedback.

In short, the photo frame is the final concept, because it is simple, subtle, useful and contains personal value (stimulates positive thoughts), which makes it user friendly in order to be effective and decrease the stress level.
3. Prototype

Before the final prototype was made, first a test prototype was designed in order to find out what needs to be developed.

3.1. Test Prototype

In this prototype as shown in Figure 7, an ordinary photo frame is used and amber colored LED’s are added. A pot meter at the back of the framed is used to fade the light and to see the effect.

![Figure 7. Test prototype](image)

During the building process it became clear that the LEDs did not spread the light intensity equally over the total frame, little orange dots were visible. Next to that the placement of the LEDs around the picture made the picture look yellowish, ugly. This is not good and there should be thought of a different placement of the LEDs. The light increases when stress increases, but is the light change noticeable by the user who focuses on his work and what light color should be used?

3.2. User Test

In order to find out what light pattern and color indication needed to be used to makes the user aware of his stress level, a small user test was conducted.

A small light ball was made with white, red, blue, green and amber colored LED lights. The test prototype was not used, the bad light division and the tarnished picture could influence the user’s interpretation. In order to increase the stress level of the user, the user had to do the snake game. During the gaming the light bulb went on and the
different colored lights were shown. The white light was used to show the three different light patterns, see Figure 8.

![Figure 8. Light patterns](image)

What can be concluded is that the red light was noticed immediately, this one had the highest intensity. Besides that the colors did not have a big influence on the emotions of the users. The users did not feel more stress when seeing a certain color. As for the light patterns, the fade light was too subtle. People who were caught up in the game did not notice the fading and they found the blinking light annoying.

This means that the fading, which is used in the scenario of the photo frame is not going to work. The light change is too small. In order to get noticed the light change should become more intense, a subtle blinking (otherwise it becomes annoying). The colors did not have a big impact on the users. According to expert Jacob Alkema, from TU/e, this is because the light surface is too small. The photo frame uses a tiny small area of the desk and thus cannot create a big impact. This means that I need to keep the light and pattern indication simple for the user to understand.

### 3.3. Final Concept

According to the conclusion of the user test the feedback needs to be simple in order to make sense to the user, this means that obvious color indications need to be used. The two light colors that will be used in the improved concept are amber and red. Amber represents the vibe of candle light (calm technology, it fits in the environment), but also a subtle warning impact of a traffic light. It means watch out. If you continue like this, you will become in the danger zone. This give the user the opportunity to changes its behavior. Red represents stop right now. When the stress level of the user is max, the photo frame will light up red and the user knows that he needs to quit his wrong behavior immediately. Otherwise health issues will occur.
It is generally known that a little bit of stress is healthy, it keeps you alert. The light of the photo frame will start working when the stress level reaches 50%. In Figure 9 you can see an abstract scenario of how the device responds to the certain stress levels.

- **50% - 75%**: amber light fades on and stays on at full intensity.
- **75% - 85%**: user needs to watch out and thus the orange light should get more attention by the user. Out of the user test was clear that the blinking light was obvious, but annoying. Therefore the amber light will start blinking with a fading in the rhythm of a slow, relaxing breathing.
- **85% - 100%**: this is the danger zone for the user’s health. The red light fades on and the user knows that he needs to quit what he is doing, otherwise it will go wrong.

### 3.4. Material Use

Hardwood is used for the frame, because the texture of this hardwood symbolizes nature, serenity and calmness. Nature and trees represent slow growing, take your time. It is in contrast to the fast changing technology society we live in. Therefore the frame is not a digital frame with dissolving pictures.

In the test prototype the light dots were not good. Therefore the LEDs need to be placed at the side of the Plexiglas and sand beaming the Plexiglas increase also the light infraction of the material.
3.5. Final Prototype

The final Prototype in Figure 10 shows in essence the effect, which means that the final product can be adapted. When the right machines are available the electronics will compacter and smaller. Then the frame could be thinner and the picture space will be bigger, but also the light will be more intense. Also hardwood will be used instead of MDF.

Figure 10. Final prototype

4. Future Development

The final prototype is not the final design. In the future several things need to be adapted.

- Wireless: the connection of the photo frame and the computer is going to be wireless. Right now an Arduino is connected to the computer and Photo frame.
- Real Wood: instead of MDF, Hardwood will be used
• Better light division: instead of normal LED’s small RGB LED’s need to be used. Then more LED’s for one color can be used and thus more light.

• Stress level: right now the photo frame reacts on the arousal level of the user. When imec has made sensors which measure the stress level, the frame will respond to the stress level of the user.

• Final user test: when there is enough light and the right material is used, the design can be tested. Then it will become clear if the user interprets the light indication and patterns the right way.

5. Conclusion

It is expected that in the next decade, technology will enable people to carry their personal body area network (BAN) that provides medical, lifestyle, wellness, assisted living, sports and entertainment functions for the user. With this system the employee is able to control his own health. This is necessary, because of the fast economy, fast technology development, companies who are trying to survive in competitive market and the economic crisis of 2009, more and more top work performance from the employees is demanded.

In this paper we present our process and demonstrate a design of a wireless arousal monitoring feedback system. A prototype, the Smart Photo Frame has been made and was connected to the computer and the wireless emotion monitoring sensors of IMEC NL. This prototype needs to be improved a bit more in order to be ready for a further user tests. The electronics should be smaller and more LED’s need to be integrated. Next to that in the future the device needs to respond to the stress level of the employees instead of the arousal level.
References


