MODATRIS

Stress based adaptive difficulty for Tetris

VGIS 9

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Introduction

This project, called Modatris, is an expansion of the famous game Tetris, with two additional input modalities. These modalities are recorded using an eye tracker from Tobii and a skin conductance measurement device from Shimmer Research. Both devices are in this project used to measure the stress level of the user and will be fused together to give a final stress level between 0 and 10, meaning 11 different levels of stress. The game includes 11 difficulties, corresponding to the 11 stress levels measured from the user. The core concept is that the game is self-balancing; when the user is experiencing stress, the game will reduce the difficulty and vice versa. This will create a game which will not be too easy or too hard i.e. a balanced challenging experience.

Stress based Difficulty Balancing

A core assumption is that delivering an ever fitting level of difficulty will excite the user positively, balancing the level of stress/ hormones (Norepinephrine, cortisol, estrogen, testosterone, serotonin and epinephrine/adrenaline, …) and endorphins in the users bodily systems. The idea is to keep them engaged with challenges as to not get bored, while still remaining an enjoyable and fun experience by rewarding the user with extrinsic and intrinsic success. [12]

We can probe the users bodily systems to measure the levels of these particular hormones, but directly sampling these levels can prove to be extensive, by sampling blood of the user, lumbar punctures, or microdialysis of the brain. [5,6,7]

Instead we can go by proxies, using externally observable clues about the hormonal state of the users, that we know for studying human anatomy, physiology and responses to certain stimuli. An example of such a proxy indicator is sweat. The level of stress hormones in a human body covaries positively with bodily temperature, and thus also covaries positively with the activeness of the sweat glands. Finally, because the amount of water on the surface of the skin covaries positively with electric conductance through the skin, thus by electrifying the skin of the user we measure the stress-levels of the user by the proxy of the conductivity through sweat.[8,9]

Increased heart rate is another indicator of higher stress-levels[10,11]. However we choose not to include this as it is also an indicator of higher level of dopamine, which is also partly responsible for feelings of pleasure and well-being.

From studying the eyes we know that increased levels of adrenaline causes pupil dilation as a product of acute stress response, but can also be caused by many other hard-to-control factors like light intensity from the screen, sexual attraction, disease and medication, however these latter two applies to all other proxies as well.

Fusion of the GSR and Gaze Modalities

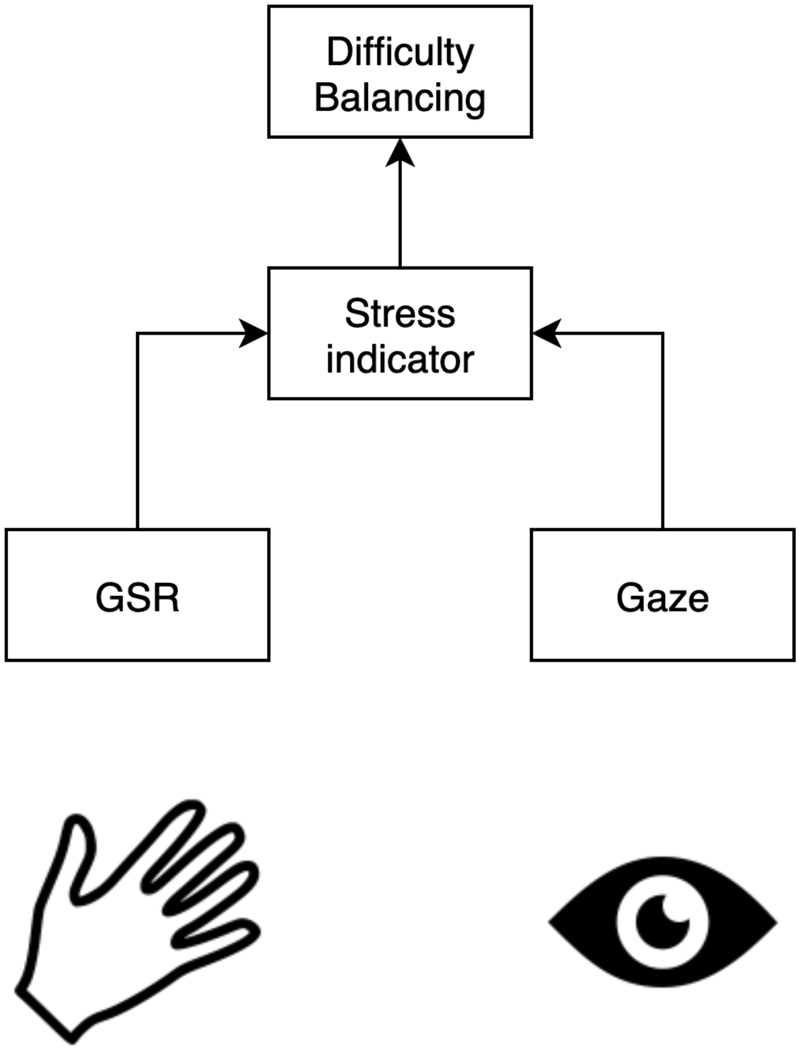

Figure 1. Fusion of modalities

The fusion of the two modalities, eye tracker and skin conductance, is done by keeping a global mean over the last 5000 samples where there eye tracker is sampling at 30hz and the GSR is sampling at 50hz. We do late fusion based on a logical AND over increases and a logical OR over decreases of the measurement compared to a running mean, respectively we then decrease and increase the difficulty of the game.

The current direction for the eye tracker is analogous to concentration, if the person is intently staring at a point, the score is lower and higher if the eyes are bouncing all over the place. We assume that if the users gaze is constantly jittering all other that place that it is an indicator of stress.

Gaze indicator

This is calculated using the distance from the global eyetracker mean and a newer local mean only done over the last 10 samples.

GSR indicator

The current direction of the GSR sensor is analogous to stress increase, if the person is getting a stress response from playing the game, compared to the global mean stress response.

Fused stress indicator

The difficulty is reevaluated each time a new block is generated; It is increased by 1 if either the user's current GSR or Gaze Stress Indicator is going down compared to their last values last time a block was generated. This is because if the values are going down the current level is not challenging to the user.

Difficulty is decreased by 1 if the Gaze and the GSR modalities both indicate an increase in stress-level, this way only if both are increasing do decrease the level of difficulty, otherwise the two adjustments negate each other by disagreement.
This helps keep the level of difficulty biased towards consistency and only change if it both indicators agree on an increase in stress-level of the user.

Following is a code snippet of the late fusion logic:

```
# if the user was more stressed on eye and gsr reduce by 1
if curr_diff_gsr > last_diff_gsr and curr_gaze_var > last_gaze_var:
     if measurement != 1:
          measurement = measurement -1

#if user was calm on eye and gsr increase by 1
if curr_diff_gsr < last_diff_gsr or curr_gaze_var < last_gaze_var:
     if measurement != 0 and measurement < 9:
          measurement = measurement +1
```

Sensors

Tobii X2-30 Compact

Figure1. Tobii X2-30 sensor

The Tobii X2-30 Compact eye tracker from Tobii[1] is a small device that can be placed under the screen on a laptop. After it has been calibrated it tracks, in 30 [Hz], where on the screen the user is looking.

Shimmer3 GSR+ Unit

Figure 2. The Shimmer3 GSR+ Unit

The Shimmer3 GSR+ Unit from Shimmer Technologies[2] is a small bluetooth device with 3 attachable sensors for the fingers. It records skin conductance, or galvanic skin response (GSR) at customizable frequencies, normally 15.9[Hz].
GSR is a powerful tool for recording stress or excitement caused by a variety of stimuli in people. GSR responses can be seen when people are subjected to visual, auditory and even olfactory stimuli[3].
GSR responses can also be measured when a subject is not exposed to environmental stimuli. The Shimmer User Guide[3] says: "*Thinking about something exciting or stressful, or carrying out a task that requires concentration, will also cause a noticeable response*."

Implementation

Shimmer3 GSR+ implementation

The Shimmer3 GSR+ is interfaced directly with python 3.6 without the use of Shimmer software. The device is connected to a pc over bluetooth, and the raw data is streamed in.

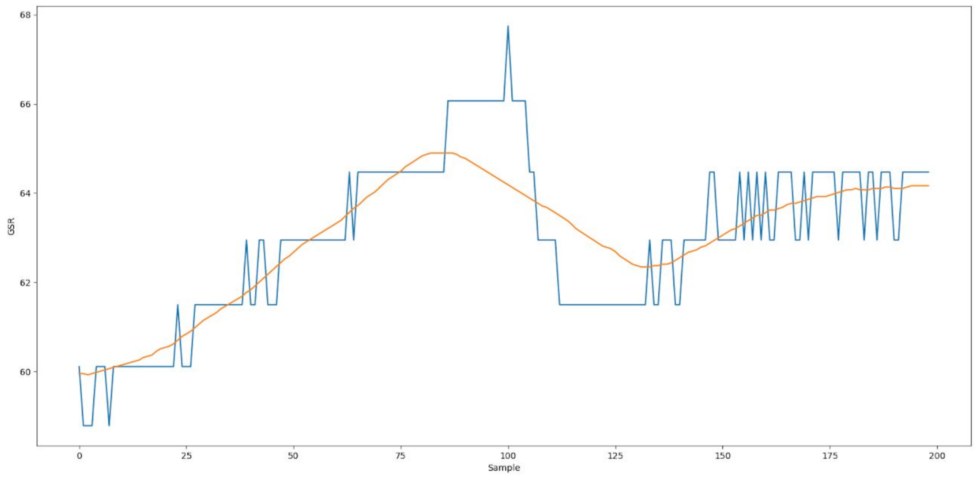

Figure 3. The filtered data with a uniform average filter with size 50. We use sample rate 50hz so the image shows 4 seconds of data

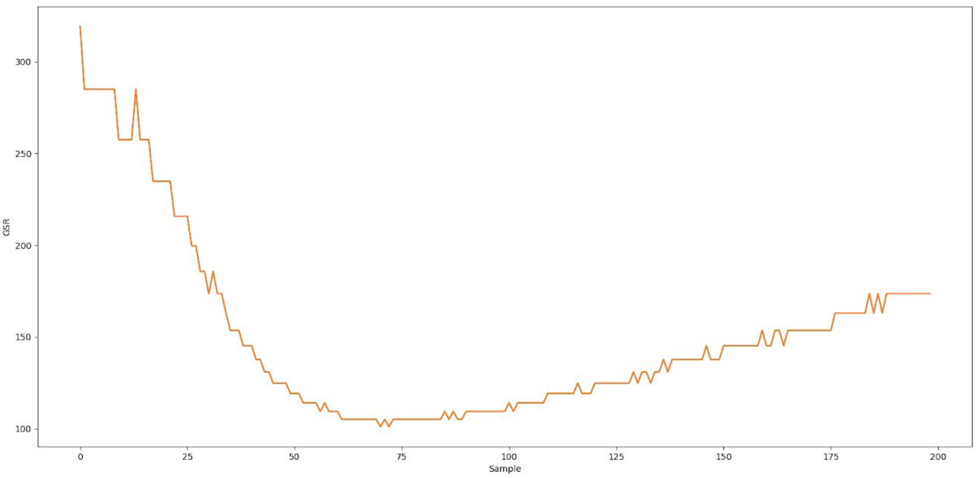

Figure 4.If there is no large discontinuities there is no effect(the blue is directly under the red)

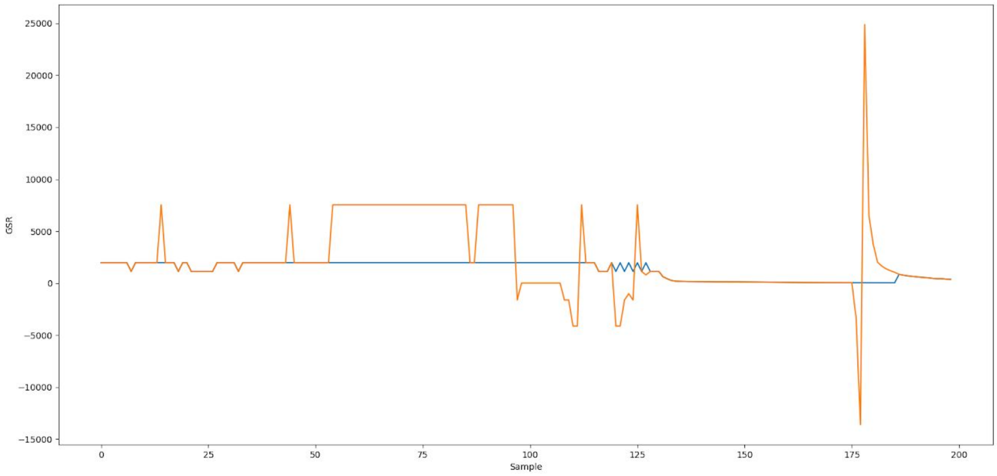

Figure 5. But if the sensor receives large noise it prevents by using last sample we use 1000 as measure for hen this happen.

Modatris.py implementation

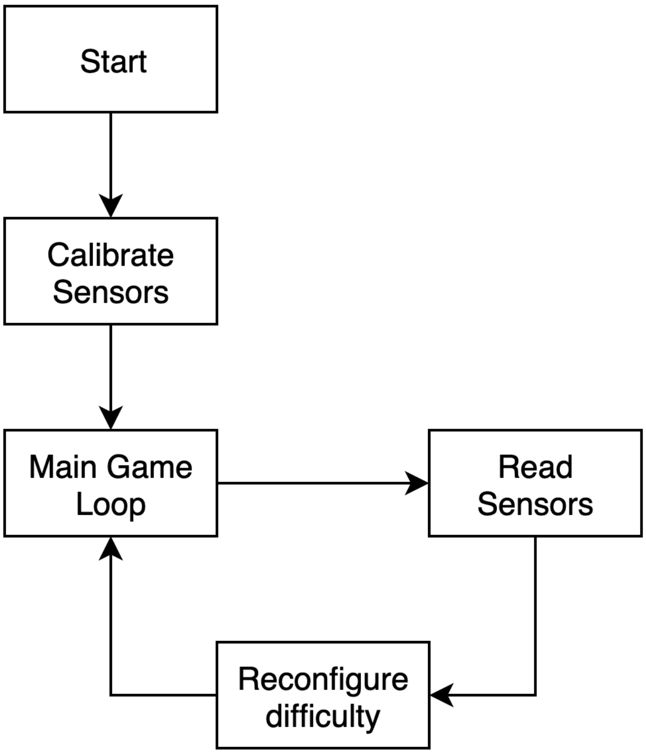

Figure 6) Block diagram of Modatris.py

Modatris is written for Python 3.6+ and downloaded from this Github repository[4]. It uses the Pygame asset to render the visuals of the game. When the game is launched it has a calibration phase, as seen in Figure 6. During this phase the Tobii X2-30 Compact and Shimmer3 GSR+ will be calibrated for the user. When the devices have been calibrated, Modatris enters the main game loop. This is where the game is run, initially on the lowest difficulty.

There are 11 levels of difficulty in the game, and they automatically update according to measurements from the sensors. The levels of difficulty are given by the shapes of the tetris blocks. There are two initial sets with 10 blocks each, labelled easy and advanced blocks. These are Level 1 and Level 11 in difficulty, all the intermediary levels are built on combinations between the two initial sets. For example, Level 2 contains eight easy blocks and two advanced blocks, and so on. The blocks in each level are randomized and so the user gets them in a non-predictable order.

Future work

As future work, a color palette implementation is to be considered. Because the gaze tracker sensor is part of the system, and highly dependent on light, the color intensities in the game have to be adjusted accordingly. The reason for this is that the pupils dilate when looking at a dark screen and retract when looking at a bright screen to allow light to shape images on the retina. The challenge here is to find colors that balance this aspect as much as possible to reduce noise given by screen light for the measurements of the gaze tracker.

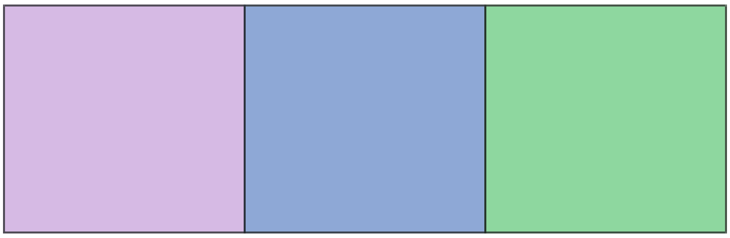

Figure 7) Color palette used in Modatris

Figure 7 showcases the color palette that could be used in the game. The colors are chosen because they have similar intensities. The RGB values for the palette are in order, the following:

[214, 186, 228]
[142, 168, 214]
[142, 214, 159]

In future versions, the Modatris will also alter the speed that the blocks fall with to alter difficulty.

Test

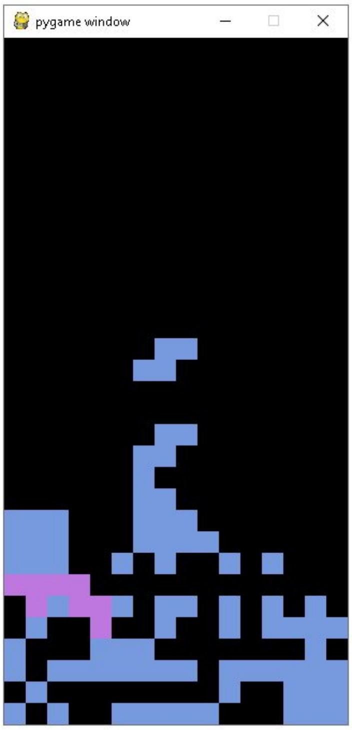

Figure 8) The values seen in the image to the right is difficulty level , current gsr, last block gsr, current gaze value, mean gaze value

Discussion

As a prototype, Modatris works as intended, but could benefit from more work. In particular the GSR sensing could use more extensive testing and better filtering. Future work could also include, as mentioned, the use of pupil dilation to measure stress, however there is a need for another eye tracking device to do this.

Bibliography

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