Computational Analysis of Valence and Arousal in Virtual Reality Gaming using Lower Arm Electromyograms

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Research questions

- Is it possible to reliably capture and **recognize the affective state** of a person based on **EMG sensors** placed on their **lower arms**, while they interact with the virtual environment?
- Is **EMG signal from one arm** sufficient for detecting affect?

Motivations

- Facial **affect analysis in Virtual Reality** is challenging as the upper face is occluded by the headset.
- Currently in VR settings majority of the interaction takes place through the use of hand controllers. Therefore, we wanted to investigate if it is possible to capture affective state changes using **arm muscle activations**.

Figure 1: One of the participants interacting with the VR environment during the pilot study.

The Study

The study was conducted with 8 people(4 male and 4 female) wearing an Myo Armband on each arm. The participants played the following **VR games**:

- **Eggs time** –> positive and negative affect
- **Google Earth** –> neutral and negative affect
- **Spell Fighter** –> variety of negative affect
- **Museum of Fine Arts** –> low arousal, positive and negative emotions
- **Fruit Ninja** –> high arousal, positive and negative emotions.

Figure 2: Placement of the two Myo Armbands.

Annotation

Participants were asked to provide **self-reported arousal and valence** annotations using the scheme adapted from Grekow and Ras [1].

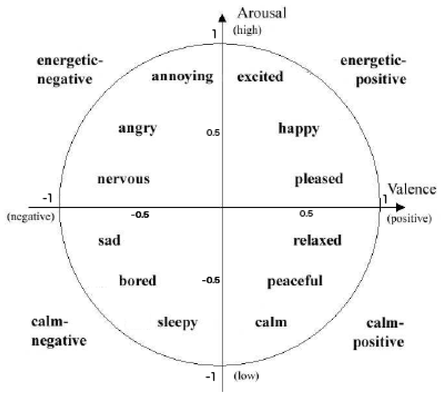

Figure 3: Annotation scheme provided to the participants. Adopted from Grekow and Ras [1]

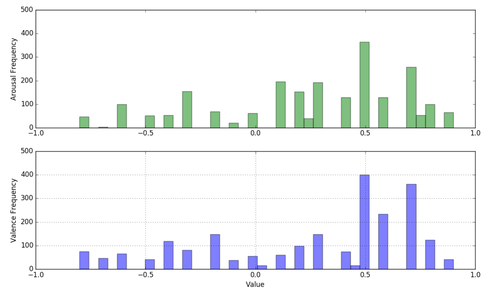

Figure 4: Distribution of data reported for Arousal and Valence.

Experimental Results

Table 1: SVM classification results for low/high arousal and negative/positive valence. The results are presented in terms of F1 values with subject-independent cross-validation over 7 subjects.

Sampling	Left		Right	
	Arousal	Valence	Arousal	Valence
None	0.91 ± 0.06	0.84 ± 0.07	0.91 ± 0.06	0.84 ± 0.08
CNN	0.91 ± 0.06	0.83 ± 0.06	0.90 ± 0.06	0.82 ± 0.07
SMOTE	0.89 ± 0.06	0.81 ± 0.06	0.88 ± 0.06	0.81 ± 0.06
SMOTE+CNN	$\mathbf{0.91 \pm 0.06}$	$\mathbf{0.85 \pm 0.07}$	$\mathbf{0.91 \pm 0.06}$	$\mathbf{0.84 \pm 0.08}$

EMG Feature Extraction

The listed features were extracted from the approximated signal (1-sec window) based on a discrete wavelet transform with a **db2** wavelet. Detailed definitions of these are available in Phinyomark et al. [2].

- Mean absolute value
- Mean absolute value slope
- Original signal zero crossing
- Original signal slope sign changes
- Waveform length
- Variance
- Root Mean Square
- Waveform Length
- Standard deviation of the amplitude of the signal

Conclusion

- EMG measures from both (lower) arms provide sufficient information to analyse the affect experienced by a player of a VR game;
- Comparable accuracy is obtained by using the EMG signal from one arm only.

References

[1] J. Grekow and Z. W. Raś.
Detecting emotions in classical music from midi files. 2009.

[2] A. Phinyomark, C. Limsakul, and P. Phukpattaranont.
A novel feature extraction for robust emg pattern recognition. 2009.

Acknowledgements

The work of H. Gunes is partially supported by the Innovate UK project Sensing Feeling (project no. 102547).