**Bibliography**

[1] Md. A. Ahamed, Md. A.-U. Ahad, Md. H. A. Sohag, and M. Ahmad, “Development of low cost wireless biosignal acquisition system for ECG EMG and EOG,” in *2015 2nd International Conference on Electrical Information and Communication Technologies (EICT)*, Dec. 2015, pp. 195–199, doi: 10.1109/EICT.2015.7391945.

This research paper aims to demonstrate that three biosignals (EEG, EMG, and EOG) can be monitored using a device which is wireless, portable, and battery powered. This is an extremely useful technology to consider as it is in alignment with our priority of minimal and non-invasive hardware. The team found that their device transmitted effectively up to 9 meters away from the receiver using a Bluetooth connection and was able to function continuously for about 22 hours. If a rechargeable power source were to be used instead, this could prove an efficient wearable technology for the purposes of live monitoring.

[2] P. Arpaia, N. Moccaldi, R. Prevete, I. Sannino, and A. Tedesco, “A wearable EEG instrument for real-time frontal asymmetry monitoring in worker stress analysis,” *IEEE Transactions on Instrumentation and Measurement*, pp. 1–1, 2020, doi: 10.1109/TIM.2020.2988744.

Using only three points of contact with dry EEG electrodes, this team was able to identify stress responses in the subject with 98% accuracy. The wearable device used transmitted the collected data via wireless internet connection to a local Raspberry Pi unit, which then forwarded the data to their server for analysis. This is a very similar method to that which we are using, and for the same reasons. This paper was able to effectively demonstrate that accurate EEG data could be collected while imposing fewer movement restrictions than traditional methods.

[3] E. Bak, G.-H. Choi, and S. B. Pan, “ECG-Based Human Identification System by Temporal-Amplitude Combined Feature Vectors,” *IEEE Access*, vol. 8, pp. 42217–42230, 2020, doi: 10.1109/ACCESS.2020.2976688.

The goal of this work was to evaluate the efficacy of differentiating individuals based solely on ECG sensor data. The team tested a wide variety of feature vectors, mainly focusing on the relative temporal positions of the fiducial points in the ECG. Achieving an identification accuracy of 94%, this research shows string indication of unique and identifiable characteristics within subject’s ECG. While this is not of great importance with regard to current space missions where identity is not a concern, this could prove useful technology as we enter into the age of commercial spaceflight.

[4] O. Bazgir, Z. Mohammadi, and S. A. H. Habibi, “Emotion Recognition with Machine Learning Using EEG Signals,” in *2018 25th National and 3rd International Iranian Conference on Biomedical Engineering (ICBME)*, Nov. 2018, pp. 1–5, doi: 10.1109/ICBME.2018.8703559.

This study trained three different classification models (SVM, KNN, and ANN) on EEG data of 32 participants being subjected to 40 different music videos invoking an emotional response, according to the arousal-valence emotive model. The sampling frequency of EEG data was 512Hz, and 10 channels were used: F3-F4, F7-F8, FC1-FC2, FC5-FC6, and FP1-FP2. The study concluded that the SVM had the highest predictive accuracy of 91% with the F3-F4 channels in the Beta frequency band (13-30Hz). The authors suggest that further study into other classifiers such as random forest, deep neural network, or recurrent neural network may be required.

[5] J. M. Eklund and N. Khan, “A bio-signal computing platform for real-time online health analytics for manned space missions,” in *2018 IEEE Aerospace Conference*, Mar. 2018, pp. 1–8, doi: 10.1109/AERO.2018.8396819.

This study aims to test a non-invasive method of determining blood pressure of subjects by using a PPG, an ECG, and the PTT calculated between them. The team used an intravenous BP monitor as a reference, and was able to produce a correlation coefficient of 0.90 for systolic BP and 0.81 for diastolic BP using linear regression methods. While this is promising with regard to non-invasive and continual BP monitoring, it is important to note that the PTT measurement necessary to compute BP required an ECG that cannot be replaced with a second PPG (as may be suggested by the results from Q. Zhu et. al. [12]). This is because the ECG information must be taken close to the heart in order to ensure measurable and accurate PTT.

[6] M. Elgendi and C. Menon, “Machine Learning Ranks ECG as an Optimal Wearable Biosignal for Assessing Driving Stress,” *IEEE Access*, vol. 8, pp. 34362–34374, 2020, doi: 10.1109/ACCESS.2020.2974933.

Similar to the paper by P. Arpaia et al. [2], the main focus of this research was on monitoring the stress levels of subject. In contrast, however, their goal was to identify what individual biosignal produced the highest correlation with subject stress using interaction principal component analysis. They concluded that, in identifying stress during a time period in which a subject is driving, ECG data was the most accurate, followed by GSR. During their analysis, they also noted a significant correlation between heart rate and EMG data. The main limitation in this study was the small sample size, which was taken from a database of stress recognition in drivers.

[7] D. Jia and W. Yin, “Continuous blood pressure prediction based on hierarchical adaptive algorithm,” in *2020 IEEE 4th Information Technology, Networking, Electronic and Automation Control Conference (ITNEC)*, Jun. 2020, vol. 1, pp. 934–938, doi: 10.1109/ITNEC48623.2020.9084725.

I pursuit of continual and non-invasive blood pressure monitoring (as in J. M. Eklund et. al. [5] and O. Viunytskyi et. al. [10]), this paper utilizes a linear model in combination with a neural network consisting of 5 neurons in the input layer, 16 neurons in the hidden layer, and 2 neurons in the output layer (systolic and diastolic BP). This implementation was able to identify abnormal BP readings with up to 95% accuracy, with an error over 15mmHg less than 5% of the time. Most significantly, this study uses RF radar sensors to obtain PPG data at two locations, resulting in an excellent, non-intrusive method of obtaining PTT measurements without the use of an ECG.

[8] J.-H. Lee, J. M. Hwang, D. H. Choi, and S.-O. Park, “Noninvasive Biosignal Detection Radar System Using Circular Polarization,” *IEEE Transactions on Information Technology in Biomedicine*, vol. 13, no. 3, pp. 400–404, May 2009, doi: 10.1109/TITB.2009.2018623.

This paper discusses and verifies the efficacy of measuring an individual's heart and respiration rate through clothing and without direct contact. While this technology has existed for some time, they improved upon the methodology by using a small circular polarity antenna, roughly the size of a deck of cards (100mm x 50mm x 13 mm). This research takes a large step in the direction of non-invasive health monitoring systems and could be used as part of a more extensive data collection and monitoring system for our project. The only caveat is that their experiment required that the subject be motionless for the duration, but this could still be utilized in a less frequent, more comprehensive examination.

[9] G. Retsinas, P. P. Filntisis, N. Efthymiou, E. Theodosis, A. Zlatintsi, and P. Maragos, “Person Identification Using Deep Convolutional Neural Networks on Short-Term Signals from Wearable Sensors,” in *ICASSP 2020 - 2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, May 2020, pp. 3657–3661, doi: 10.1109/ICASSP40776.2020.9053910.

Similar to the work done by E. Bak et. al. [3], this paper focuses on identification of individuals using hear rate data. In contrast, however, these researchers also incorporated accelerometric and gyroscopic data captured from smartwatch worn by the subjects. They found that a great deal of device-specific noise from the accelerometer and gyroscope was affecting their data, causing the neural networks to identify subject based on the devices they wore rather than the intended data set. This is certainly a factor that future endeavors must account for, especially considering the application to a weightless environment where the orientation and acceleration of subject is much less predictable.

[10] O. Viunytskyi, V. Shulgin, V. Sharonov, and A. Totsky, “Non-invasive Cuff-less Measurement of Blood Pressure Based on Machine Learning,” in *2020 IEEE 15th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET)*, Feb. 2020, pp. 203–206, doi: 10.1109/TCSET49122.2020.235423.

Continuing the work of J. M. Eklund et. al. [5], this study aimed to predict BP measurements of patients using PPG, ECG, and PTT. In contrast, however this study trained machine learning algorithms on the data in question, using a separate neural network for systolic and diastolic BP and allowing for continual prediction rather than sparse data-point analysis. Each network comprised seven inputs, one output, and three internal hidden layers with 256 neurons. This endeavor resulted in RMSE values of “… ± 2.43 mmHg and ± 2.12 mmHg for systolic and diastolic pressure, respectively” for patients used to train the neural networks, and “… ± 3.59 mmHg for systolic pressure and ± 2.92 mmHg for diastolic pressure” for patience not used to train the neural networks.

[11] H.-Y. Wu, M. Rubinstein, E. Shih, J. Guttag, F. Durand, and W. T. Freeman, “Eulerian Video Magnification for Revealing Subtle Changes in the World,” p. 8.

This study demonstrates the applications and efficacy of motion and color amplification of video. The team uses special and temporal analysis algorithms to detect minute changes in motion or color and amplifies those chances into macroscopic and visually noticeable exaggerations. This is applicable to medical monitoring of respiration and heart rate via video. The implication of this work is that information previously undetectable by the human eye can be rendered easily comprehensible and provides yet another option for non-invasive monitoring of human vital signs. Additionally, this would allow for specific feature sets to be manually selected by humans in order to be amplified for a neural network.

[12] Q. Zhu, X. Tian, C.-W. Wong, and M. Wu, “ECG Reconstruction via PPG: A Pilot Study,” in *2019 IEEE EMBS International Conference on Biomedical Health Informatics (BHI)*, May 2019, pp. 1–4, doi: 10.1109/BHI.2019.8834612.

This team of researchers used a dataset of 42 patients monitored with simultaneous 8-minute PPG and ECG readings sampled at 300 Hz to train a linear transform on the relationship between the two methods. Using their algorithms, they were able to precisely determine the ECG readings from the PPG. The motivation behind this type of reconstruction is that ECG equipment is cumbersome and uncomfortable. The electrodes used can cause irritation and cannot be worn for long periods of time, especially while the subject is active. PPG is simple in comparison, requiring only a pulse oximeter affixed to the fingertips or toes. This is much less intrusive and provides as much information; an idea candidate to minimize hardware for continual monitoring.