ERCIM fellowship Programme
Final scientific report

Fellow	Amandeep **Cheema**

Host Organisation	Norwegian University of Science and Technology (NTNU)

Scientific coordinator	Marta **Molinas**

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The rising psychological stress levels are associated with mental disorders, cardiovascular diseases and cancers. Timely stress detection can improve quality of human life by preventing stress-induced behavioural and pathological consequences. Phonocardiography (PCG) signals are cost effective, easy-to-acquire mechanical heart activity signals and are useful in stress detection. These are suitable for telemedicine, rural areas, homecare and for low-to-middle income economies. The problem with PCG-based stress detection is the requirement of simultaneously acquired Electrocardiography (ECG) signals as reference signals. The simultaneously acquired ECG signals are used for heart sound segmentation in PCG signals. Therefore, the objective was to apply signal processing and machine learning techniques for designing a computer-aided PCG-based stress detection system alone that can eliminate the need of multi-modal signal acquisition. During the fellowship, I was involved in the following activities:

1. Stress detection using stand-alone PCG signals and reporting of identified most important frequency bands for stress detection
2. Grant proposal writing to get funding from the European Commission and the Research Council of Norway
3. Supervision of Masters' students in project and thesis work

The work of psychological stress detection was under Mental Health project at NTNU. In this project, data was acquired from twenty-eight health male and female adult students of NTNU and the stressor was institute examination and project deliveries. The duration of each recording of PCG signals was five minutes using Eko Duo device. The developed novel framework eliminated the need of ECG signals-based referencing of PCG signals for stress detection. This elimination of need of multi-modal signal acquisition made the framework cost effective and reduced computational complexity. This stand-alone asynchronously segmented PCG-based methodology used wavelet scattering approach. After the noise bands removal, the optimized segmentation length and the scattering network parameters namely- invariance scale and quality factor were utilized for computation of scattering features. These extracted scattering coefficients were fed to K-nearest neighbor (KNN) and Extreme Gradient Boosting (XGBoost) classifier and ten-fold cross validation performance metrics were- accuracy 94.30%, sensitivity 97.96%, specificity 88.01% and area under the curve (AUC) 0.9298 using XGBoost classifier for detecting stress. Another important contribution of this framework was identification of two important frequency bands in PCG signals for stress detection. These frequency bands are 270-290 Hz and 380-390 Hz. As per the best of our knowledge, the important frequency bands of PCG signals for stress detection were not reported in the literature. This study had gender-inclusive framework with male and female subjects, eliminated the need of multi-modal signal acquisition and paved a way for new research avenues to explore the features focusing on the identified frequency bands for developing a robust automated unimodal PCG-based stress detection system. In this study, I was involved in the idea formulation,

protocol and experiment design, discussions during data analysis and in reporting the findings of this study in a reputed journal (presently under revision).

I was involved in research proposal writing and submission to acquire funding from the European Commission and the Research Council of Norway, where the outcomes are awaited. We were involved in designing methodologies of amalgamating Electroencephalography, Electrocardiography and Phonocardiography to study the interactions in heart and brain during psychological stress. We have entered into collaborations with many institutes across the globe, working in this domain for knowledge sharing and research cooperation in these proposals. This experience gave me hands-on knowledge of various aspects of grant proposal writing. This also widened my own research and collaboration network and gave me opportunity to learn from the subject matter experts.

Additionally, I was also involved in co-supervision of Masters' students' thesis and project work. In particular, I was involved in co-supervision of Mental Health project, Cognitive Neuroscience project and Alcohol detection project.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Published work:

1. Anne Joo Marthinsen, Ivar Tesdal Galtung, **Amandeep Cheema**, Christian Moe Sletten, Ida Marie Andreassen, Øystein Sletta, Andres Soler and Marta Molinas, *Psychological stress detection with optimally selected EEG channel using Machine Learning techniques*, Proceedings in: Italian Workshop on Artificial Intelligence for Human-Machine Interaction (AIxHMI 2023) in 22nd International Conference of the Italian Association for Artificial Intelligence, November 06, 2023, Rome, Italy.

Under revision in SCI-indexed journal:

2. Øystein Sletta, **Amandeep Cheema**, Anne Joo Marthinsen Ida Marie Andreassen Christian Moe Sletten Ivar Tesdal Galtung Andres Soler Marta Molinas, *Newly identified Phonocardiography frequency bands for Psychological stress detection with Deep Wavelet Scattering Network*.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

I attended 22nd International Conference of the Italian Association for Artificial Intelligence, Rome, Italy from November 6 to November 9, 2023. There, I presented the paper: *Psychological stress detection with optimally selected EEG channel using Machine Learning techniques* in Italian Workshop on Artificial Intelligence for Human-Machine Interaction (AIxHMI 2023) on November 6, 2023.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

Place: INRIA Lab, Bordeaux, France
Duration: December 11, 2023 to December 15, 2023
Hosting Professor: Prof. Fabien Lotte

I visited INRIA Lab in Bordeaux, France. I had the opportunity to witness the cutting-edge research taking place in INRIA lab. On the first day, Prof Fabien gave a tour of all the labs showing the new EEG equipment, Virtual Reality (VR) equipment and the equipment related to acoustics, music instruments and art galleries-based research. On second day, we had a meeting where we discussed various entropy-based measures used by us and by the research fellows under Prof Fabien to find out the suitability of different entropy-parameters for the research applications. For the third day, Prof Fabien had arranged a research exchange workshop where everyone presented their research area and the findings. It was very useful and I delivered a talk on my research area and the outcomes. The next day, we had some interactions in the research group and I had a meeting with Prof Fabien where he gave some valuable insights and suggestions regarding my research. We also discussed possible future collaborations and he is now a scientific advisor in one of our grant applications. On the last day, I visited another lab of our collaborator Prof. Alexandre Surget in University of Tours and there also I delivered a talk on our research area and findings. We are now collaborating in a research grant proposal.