IFN712 Research Project Form

(Submitted to [y.feng@qut.edu.au](mailto:y.feng@qut.edu.au) by 30 June 2025)

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| Project agency (school, industry, ) | School of Computer Science/NRSAG project |
| Industry/project supervisor and contact emails |  |
| Academic Supervisor name(s) and contact emails | Yanming Feng [y.feng@qut.edu.au](mailto:y.feng@qut.edu.au),  Zhenguo Shi, [zhenguo.shi@qut.edu.au](mailto:zhenguo.shi@qut.edu.au) |
| Information Technology major(s) | Software Development, Computer Science and Data Science, Networks and cybersecurity |
| Project title | VitalID: Smartphone-Based Identity Authentication Using Heart Rate and Breathing Signals |
| Brief description of the research problem, aims, method and expected outputs (100~200 words) | **Background:** User authentication plays a critical role in mobile security and personalized device access. While fingerprint and facial recognition are widely adopted, they are not ideal in all scenarios—such as when a user’s hands are wet or face is covered. Furthermore, these modalities require explicit interaction and involve sensitive biometric data that cannot be changed once leaked.  Vital signs, including heart rate and breathing patterns, reflect physiological characteristics unique to each person and are difficult to forge. Photoplethysmography (PPG), obtainable through a smartphone camera and flashlight, allows measurement of heart rate and heart rate variability (HRV). Meanwhile, breathing sounds captured using the microphone contain frequency and rhythm patterns that can serve as auxiliary biometric signals. This project investigates the feasibility of combining PPG and breathing signals for identity verification in a non-intrusive and device-friendly way.  **Objectives:**   1. Vital Sign Data Acquisition: Develop a smartphone-based system to collect PPG signals using the camera and flashlight, and capture breathing sounds using the built-in microphone. 2. Signal Preprocessing and Feature Extraction: Process PPG data to extract heart rate and HRV features. Apply audio filtering and transform techniques to extract breathing-related features. 3. Model Design and Training: Construct and train a deep learning model (e.g., CNN or Siamese Network) that learns to identify individuals based on combined vital sign features. 4. Prototype Development: Build a functional Android prototype with an intuitive interface to perform real-time recording and authentication on-device. 5. Evaluation and Performance Analysis: Evaluate the system in terms of authentication accuracy, false acceptance/rejection rates, signal robustness under different user and environmental conditions, and usability.   **Expected Outcomes:**  The project will produce a complete prototype system that enables contactless identity authentication using smartphone-acquired physiological signals. It will include a mobile interface for data collection and real-time feedback, signal processing modules, and a trained deep learning model. The system will be tested on a small user dataset to assess accuracy and reliability. Results will inform future development of lightweight, privacy-conscious biometric systems for mobile and IoT platforms. |
| Key words | * Vital Signs Authentication * Smartphone Sensors * Photoplethysmography (PPG) * Heart Rate Variability (HRV) * Breathing Audio * Deep learning * Multimodal Biometrics |
| Answerable research questions for 3-5 students (desirable) | Research Questions:   * **How distinctive and stable are heart rate and HRV signals for individual identification across time and states?** * **Can breathing sounds serve as a complementary biometric feature in a smartphone-based system?** * **What preprocessing techniques are most effective for low-noise PPG and audio signal extraction using built-in smartphone sensors?** * **How do deep learning models perform on vital sign-based authentication tasks under varying conditions (e.g., lighting, background noise)?** * **What is the minimum recording duration required for reliable authentication?** |
| 3-5 key references (desirable) and website resources | 1. Hussain, S. et al. “BreathPrint: Breathing Acoustic Authentication Using Smartphones.” IEEE Access, 2020. 2. Zhang, Y. et al. “PPG-based Biometric Authentication for Mobile Devices.” ACM CCS, 2016. 3. Wang, T. et al. “Smartphone PPG and Deep Learning for Biometric Identification.” Sensors, 2022. 4. Hossain, M. et al. “Vital Signs Based Biometric Authentication: A Review.” Sensors, 2022. 5. Librosa: Audio Analysis in Python – https://librosa.org |
| Required major of studies, desirable skill sets, knowledge, and speciality | Software development and computer science majors. It is desirable if students have or willing to develop skills in the following areas:   * Android programming or collecting sensor data on smartphones * Digital signal processing for physiological signals such as PPG and audio * Machine learning using frameworks such as PyTorch or TensorFlow * Understanding of biometric authentication systems or vital sign analysis * Practical experience in mobile UI/UX design, system testing, and real-time integration |
| **Industry-based project: Student IP Agreement.** This is the IP model agreed between the parties. Please note that it is QUT policy that where possible students should be allowed to keep their IP. If students are asked to assign their work, then please **provide a brief rationale** as additional permissions are needed by QUT to approve. | Project IP vests in the student with a license back to Industry Partner **(licence)**  OR  Project IP vests in the Industry Partner/Project owner with a licence back to the student **(assignment)**  OR  Academic project (No IP agreement needed) |
| Number of students | 5 |
| The message from supervisor(s) about the acceptance for this project |  |
| Student name(s)  (Print your name and submit this form by the end of Week 2) |  |
| Date |  |
| Remarks on conditions of offer | This research is conducted as part of a government-funded project. Participating students will be required to sign an Intellectual Property (IP) agreement with the QUT project owners. The supervising team will shortlist candidates following the application process. |