

An Indian-Australian research partnership

Project Title: **A unified healthcare system for monitoring patients vital parameters in hospitals**

Project Number **IMURA0698**

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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? <i>(Please nominate JUST one. For more information, see www.iitbmonash.org)</i>		Highlight which of the Academy's Theme(s) this project will address? <i>(Feel free to nominate more than one. For more information, see www.iitbmonash.org)</i>	
1	Material Science/Engineering (including Nano, Metallurgy)	1	Advanced computational engineering, simulation and manufacture
2	Energy, Green Chem, Chemistry, Catalysis, Reaction Eng	2	Infrastructure Engineering
3	Math, CFD, Modelling, Manufacturing	3	Clean Energy
4	CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control	4	Water
5	Earth Sciences and Civil Engineering (Geo, Water, Climate)	5	Nanotechnology
6	Bio, Stem Cells, Bio Chem, Pharma, Food	6	Biotechnology and Stem Cell Research
7	Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng		
8	HSS, Design, Management		

The research problem

Define the problem

Currently, in most of the cases, while patients are being monitored in the hospitals, they are attached to several different cables which are connected to the CPU and the monitor. The monitoring of various physiological parameters such as heart rate, temperature and blood pressure (BP) is individually implemented through wired cables which are then connected to the monitor. This makes it very uncomfortable for the patient to move and restricts any movement of hands/feet or even the body of the patient as it affects the accuracy of monitoring the parameters. The patient cannot sleep in a comfortable manner in the hospital which leads to other issues. Moreover, particularly for children and senior citizens such conditions sometimes lead to sadness, depression and other side effects.

Project aims

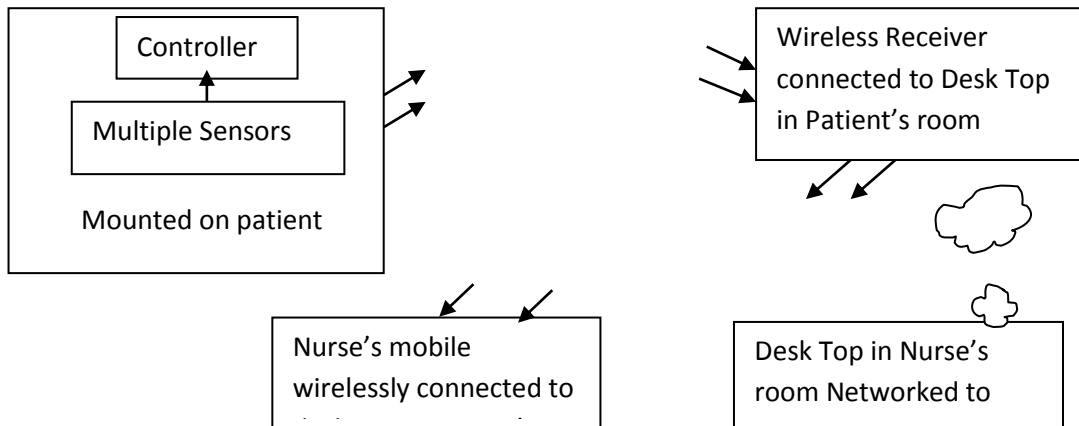
Define the aims of the project

The study would involve use wireless sensors, to transmit the vital signals to a single device with a microcontroller which will be worn by the patient or simply kept in her/his pocket. This unit will then transmit all the sensor data wirelessly to the receiver connected to a desktop computer in the patient's room. The desktop in the patient room will be networked wirelessly to the nurse's room. In case of any abnormal readings being recorded, and then an alert signal will be sent to the nurse's desktop and/or mobile phone.

- This project will avoid most of the cables which are currently used in patient monitoring due to which the patient cannot move or sleep in a comfortable manner in the hospital.
- This project will primarily focus on the design and development of smart compact wireless remote monitoring techniques in order to monitor the heart rate, BP, SpO₂, respiration rate (RR), body temperature and blood glucose levels using smart compact systems & sensors.
- The compact system will integrate different types of sensors to sense, these parameters, such as the signal conditioning circuits and a microcontroller to extract and de-noise large amount of data produced by these sensors and then transmit it,. Developing novel and innovative efficient & effective algorithms to preliminary de-noise the signal, remove the artefact and compress the data imposes a lot of challenge.
- Each patient will have a separate device. The device will be a rechargeable, low power, pocket device with soft and light connections to the electrodes as compared to the traditional connections. Hence, choice of material, design of cables and configuration of connections will be complex and a part of research. Minimising the power requirement will be another challenge in this study.
- Wearable medical devices have got certain frequency bands and standards. As these frequency bands are freely available, using them in the hospital wards should not impose any issues of interference on the other existing devices. Managing the channels across number of beds will be necessary.
- The sensor data will be analysed and displayed on the monitor in the patient's room which in turn will be wirelessly networked to the nurse's room. Further signal processing will be carried out on the sensor signals on the desktop in the patient's room to determine the severity of the condition. Novel algorithms will be implemented to distinguish normal and abnormal readings. In case of abnormal readings an alert signal will be sent to the desktop in patient's & nurse's room to indicate the severity of the condition. In case if the feedback gets neglected an alert signal will be generated and transmitted to the handheld device or mobile of the nurse. We also aim to explore possibility of involving patient's close relatives in the alert signal network.
- The system will then be evaluated based on the results. Results include number of physiological parameters to be monitored, number and type of sensors which will be used, signal conditioning, & noise removal, signal processing, transmission techniques & protocols, receiver design and decoding, GUI and further processing on the computer in patient's & nurse's room.

Block Diagram:

Compact System with wireless transmitter



Phase 1: Design the compact system with the wireless interface between the compact system and a handheld device and the laptop which provides an alert signal to the nurse (India, 12 months)
Hardware Development:

Design & develop the compact system (microcontroller with transmitter) connected to various sensors/electrodes through thin wires/cables and placed in the patient's bed or could be somewhere on patient's body. This module will be low power battery operated module. This compact system could be a pocket device with soft and light connections to the electrodes/sensors as compared to the traditional connections. Choice of material, design of cables and configuration of connections, etc will be looked at. The device can be easily put on (or fixed to) the bed (patient's choice).

The wireless receiver will be attached to the computer in the patient's room which will process the information received & send the required information to the nurses room and/or alert signal to the nurse's room or mobile if required. There are recent standards and frequency bands for wearable medical devices. These frequency bands are freely available and hence using them in the ward should not impose any issue of interference on other devices/equipment. Management of channels across various beds is necessary.

Few other points researched will be as follows;

- The protocols and standards for safety levels, will be followed in the design
- Other challenges including processing power, memory, efficiency of the algorithms with respect to the available memory and similar aspects will be looked at.

Phase 2: Develop novel signal processing algorithms to analyse and process the data from multiple sensors and transmit wirelessly to mobile devices (Melbourne + India, 6+6 months)

There are various levels of signal processing. First level (noise removal and data compression) will be implemented in the module A. Second level (further cleaning and marking for display) will be implemented in the desktop computer in the patient's room. This could be a challenging task as data from multiple sensors will be sampled onto a single processor. Accuracy of the algorithms developed has to be high. Third level, e.g. data processing and alarm generation, will be implemented in the desktop computer in the nurse's room, where data from various rooms is also coming. This will be a good feature to alert the staff if something goes wrong with the patient. Alert signal can also be sent to the mobile phone.

Phase 3: Test the compact system in the laboratory on control subjects (India 6-8months)

Phase 4: Evaluate and test the system remotely on controlled subjects (India, 6 months)

Phase 5: : Modify the design based on the results obtained (India, 6 months)

Phase 7: Thesis Completion (India, 3 months)

Expected outcomes

Highlight the expected outcomes of the project

This research will lead to the following outcomes:

1. Design and development of a compact flexible system which integrates number of wireless sensors used to assess and monitor various physiological parameters in patients (mainly recovering patients)

2. Wirelessly transmit the processed sensor signals to the computer and alert if the readings are not normal.
3. Develop novel & innovative algorithms to analyse the sensor signals
4. Evaluate the compact system and finalise the design.
5. Develop the wireless interface between the compact system and a handheld device or a laptop/computer.
6. Develop the network between the laptop at the user and the laptop at the clinic in order to transmit an alert signal.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

The theme relevant to this project is “**Advanced computational engineering, simulation and manufacture**”.

The first part of the project is to develop a unified compact system using sensors, microcontrollers and wireless IC's. This will require extensive hardware manufacturing skills. In order to develop algorithms for signal processing part of the project advanced computations and software simulations can be used.

Once these algorithms are tested for accuracy, they will then be implemented on the system developed.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

Candidate should have an MEng degree with an expertise in Wireless Sensor networks, Embedded System Design, C, C++ Programming, and Matlab. The student should have knowledge in microprocessor hardware and software programming techniques.

Potential Collaborators

Please provide a few key words relating to this project to make it easier for the students to apply.