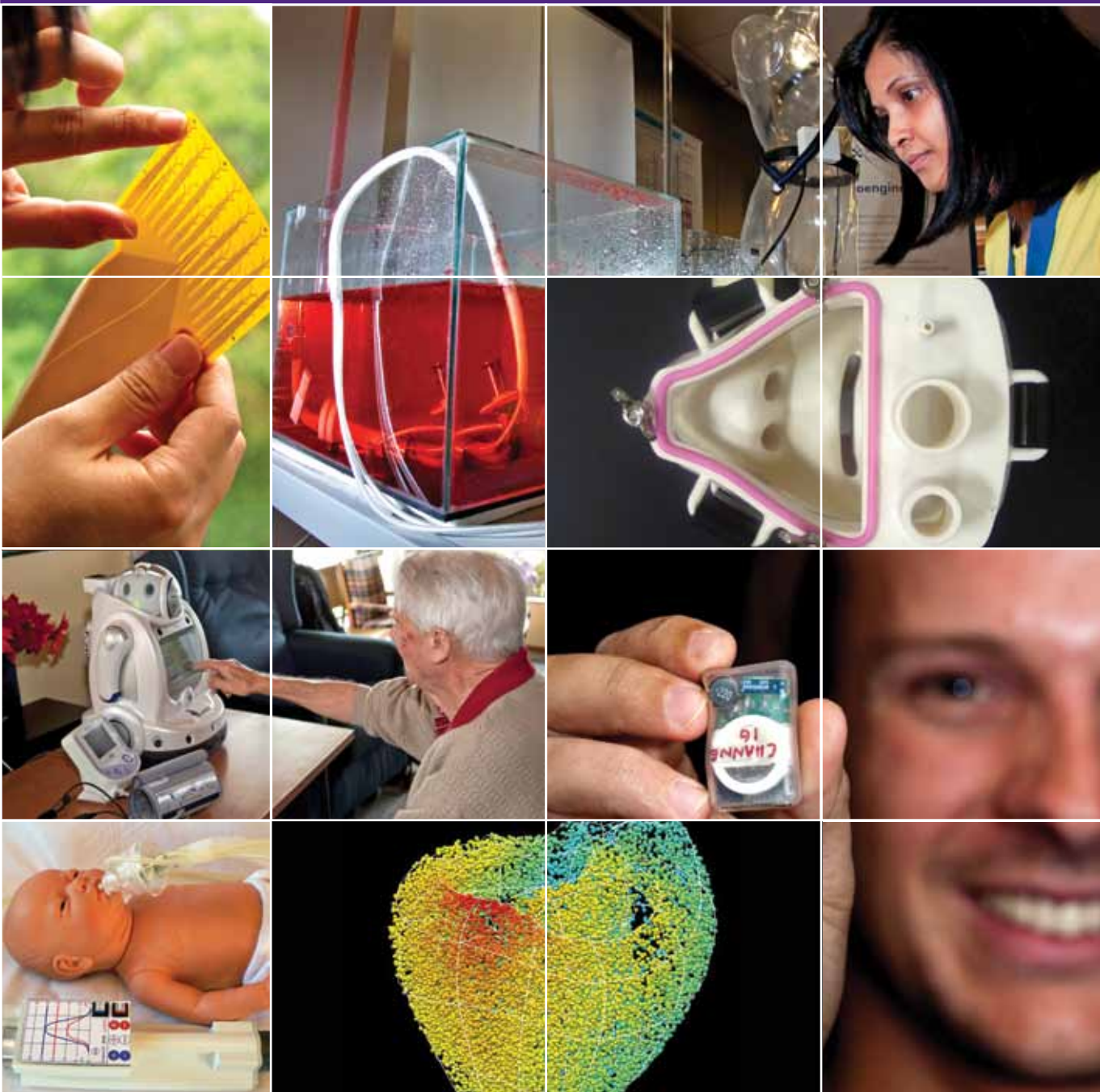


The University of Auckland Faculty of Engineering

Technologies for Health Research Theme



Introduction

- How can technology help the growing older population here and around the globe?
- What new technologies could help clinicians create new treatments, improve healthcare services, and ease the burden on healthcare systems?
- How can new technology help people to proactively manage their health needs?

These important questions are being addressed by our research which aims to develop practical technologies for the prevention, treatment and management of illness, and the preservation of mental and physical wellbeing.

The world faces an increasing challenge in providing healthcare and New Zealand's expertise in medical technology has the potential both to improve the quality of life and to provide economic growth for an export market in medical technologies.

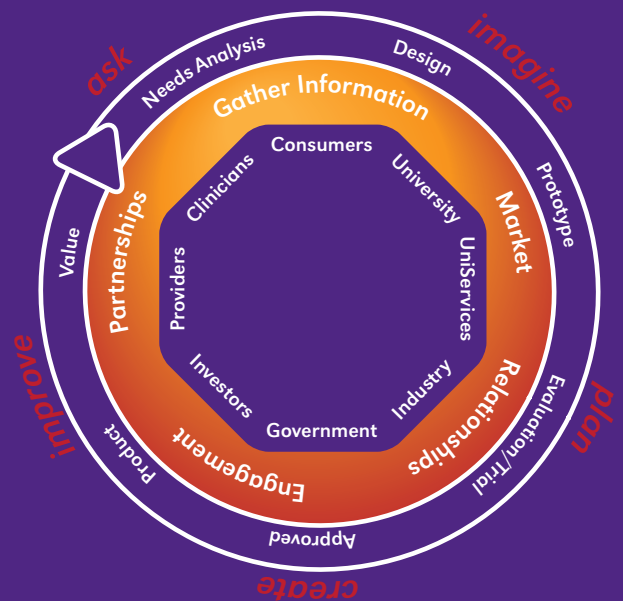
Meeting the challenge

The Faculty of Engineering at The University of Auckland focuses strongly on developing healthcare technologies, and has strong links with the Faculty of Science, the Faculty of Medical and Health Sciences, the Auckland Bioengineering Institute, the Liggins Institute, local clinicians and district health boards, New Zealand and international companies. This focus brings technology researchers, developers, clinicians and users of medical technology together, to develop more practical technology that addresses both current and emerging needs.

How we can work together

Combining the expertise of our researchers and the management skills of UniServices enables us to help clients in a number of ways. We can:

- act as consultants where specific expertise is needed
- work together with clients on projects funded either directly by them, or jointly with the help of government or other funding
- manage medium and large scale research projects and programmes on behalf of clients
- help create new companies to commercialise new technologies
- work collaboratively across New Zealand and internationally, delivering the expertise needed to develop new technologies
- carry out professional trial programmes, including clinical trials.
- carry out fundamental research and publish the results internationally



What we do

Our areas of expertise are outlined here along with a selection of current projects.

Automation and robotics

We are developing automated devices that address healthcare issues, including physical manipulation and rehabilitation (eg, for joint injuries), cognitive assistance (eg, reminding people to take medication, or brain training for maintaining cognitive abilities) and decision support (eg, recording, retrieving and analysing health data). The development of telemedicine devices and techniques is a particular focus across the University with both technical and medical researchers involved. The University offers consulting and capabilities in the microfabrication of devices such as sensors, lab-on-a-chip technologies, micro-electro-mechanical systems, and material patterning for prototyping novel medical devices.



Robot assisted neurorehabilitation

Rehabilitation robots are being developed to help patients re-learn the activities of daily life following stroke, spinal cord and other neurological injuries. This project will enhance current rehabilitation by providing more consistent, repetitive and targeted therapy for each individual patient. The robots will use objective measurements to assess patient's progress in real-time and adjust therapy accordingly. Brain and neuromuscular control is also being investigated so the robots can be operated by the patients' natural biological signals.

Research areas include:

- robotic assistants to help clinicians, carers and patients
- devices for physical manipulation and rehabilitation
- robots to aid alignments in surgical procedures such as bone setting
- advanced implants, in-body actuators and sensors, wearable devices
- trials of equipment for patient use at home
- mobile phone based interventions
- sensing and automated tube feeding system
- optimisation of treatment, eg, radiotherapy
- smart surgical tools for minimally invasive surgeries
- soft robots as patients for medical diagnosis and training.



Healthbots

This project delivers an advanced, customised robotic healthcare platform for the elderly. Trials are being conducted with our partner, The Selwyn Foundation, around medication management, vital signs monitoring and fall detection. The robot links wirelessly to a computer network via a central server which delivers much of the IT support needed for its function. This is a joint project between UniServices, The University of Auckland, the Electronics and Telecommunications Research Institute in Korea (ETRI) and Yujin Robot in Korea.



Heart pump

Smart implantable medical devices are in development to enable chronic treatment therapies. Here, energy is supplied to a heart pump wirelessly from an external source to reduce the infection risk and improve the patient's quality of life.



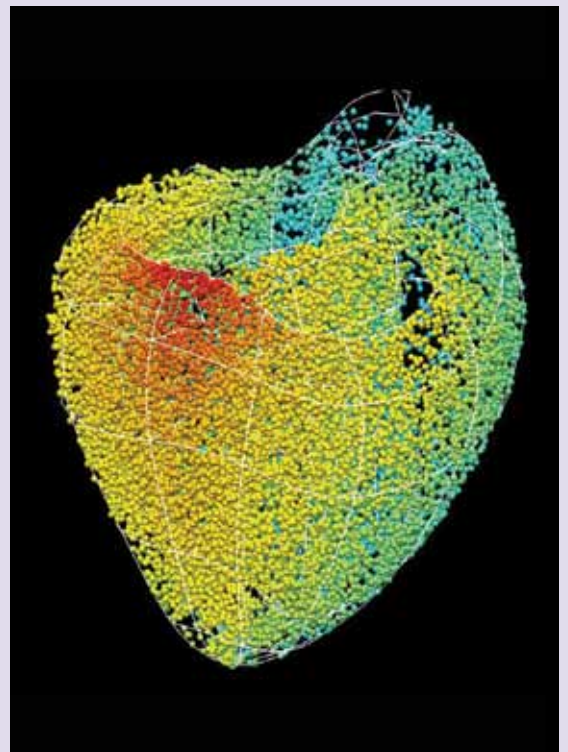
Optiflow Junior

A team of University researchers have worked with Fisher & Paykel Healthcare on their award winning Optiflow Junior, a respiratory device for neonates. Their research has focused on Computational Fluid Dynamics analysis of the infant airway in order to help identify flow patterns and pressure changes during respiration and during treatment to help create more effective nasal high-flow interfaces.

Modelling

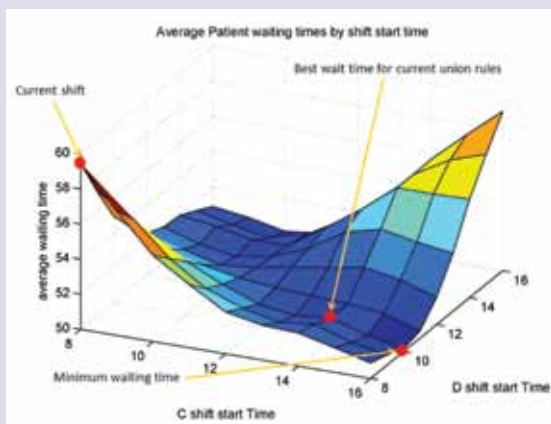
Human organ and structure modelling is a particular strength within the University. Techniques and expertise cover biomechanical, physical, functional, and cognitive function modelling using computer, mathematical, biological, and cell modelling systems. Strengths include modelling of:

- all major organs
- bones and joints
- blood flow
- respiratory system and vocal tract
- neuromuscular/skeletal systems
- ergonomic factors
- simulation and optimisation of movement patterns
- cell growth/activation
- prostheses and implant design
- behaviour modelling, eg, vehicle drivers
- optimising hospital processes.



Electrical activation of the heart

Certain heart defects and diseases can be corrected with artificial pacemakers, providing electrical impulses to the heart via electrodes. Positioning of electrodes on the heart is critical for optimal function, but the appropriate position is unique to each individual. We are developing tools to enable rapid and cheap patient-specific modelling of the heart to optimise electrode placement for pacemakers.



Reducing hospital waiting times

Researchers are working closely with departments within Auckland District Health Board to simulate and optimise a number of hospital processes including rosters, workloads for doctors and nurses, patient length of stay and patient transit. The modelling techniques used can include both restrictions on resources (eg, limitations on staff numbers) and requirements that must be met (eg, demand for patient transits). The models are then used to investigate and optimise hospital processes for increased efficiency.



Swallow safe foods

Soft robotic techniques are being used to model the contractions of the oesophagus during swallowing. Using a biologically-inspired artificial oesophagus it is possible to investigate how foods interact with it's surface as they are swallowed. This enables analysis of flow and deformation of current and new food formulations to facilitate the development of swallow-safe foods.

Hardware and software design

We design and manufacture complex digital systems to support a range of technologies used in healthcare, including hardware, low level software, high level algorithms, low power and high performance devices. Areas of expertise include:

- design of mobile medical technologies requiring minimal power usage
- networking of componentry and systems

- safety critical/real time systems, eg, for remote surgery
- wireless power transfer for implanted medical devices
- electromagnetic standards compliance
- complex control systems, eg, nonlinear and nonstandard controllers
- signal processing, analysis and modelling
- health IT systems.



Seamless telemedicine

Odin is a smartphone middleware platform which can be used to support real-time communication and information exchange among diverse stakeholders in telemedicine. Applications have been developed which transmit data from biometric sensors in real time via 3G, wireless or Bluetooth, switching seamlessly between systems with no loss of data, and sending alerts should a patients readings go outside pre-set limits. It converts a smartphone into a very powerful tool for telemedicine.



Next Step Neonatal Resuscitator

This new, patented resuscitator and transport ventilator for neonates uses a miniature linear DC-Servomotor to control tidal volume, airway pressure and respiratory rate.

This reduces the risks associated with both excessive pressure and excessive volume in the lungs. This compact, lightweight, portable device was invented by KM Medical Ltd (Auckland) and the prototype was developed by the Faculty of Engineering's Mechatronics Engineering Group.



Developing better breathing masks

Individuals with obstructive sleep apnoea often use a device to provide them with pressurised air while sleeping. A facial mask allows easy flow of air in and carbon dioxide out of the patient. Leon Evans, an employee of Fisher & Paykel Healthcare, developed the mould above to test various mask designs as part of the project undertaken while completing his Master of Engineering Studies in Medical Devices and Technologies.



Movement modelling and analysis

Small, robust motion sensors can help us better understand how the body moves. A hermetically sealed device capable of rapidly measuring dynamic 3D acceleration, rotation rate and orientation which can be used, for example, to diagnose gait abnormalities or assess movement during injury and subsequent recovery. It is charged using inductive power transfer and sends information wirelessly to a computer using digital telemetry.

Imaging

Imaging is a broad and growing area of research across different faculties with applications including:

- magnetic resonance imaging (including functional MRI)
- conversion of images to 3D models
- computerised tomography (including micro CT)
- body composition scanning
- *in vivo* high resolution imaging of skin and other diffuse tissues.

Advanced materials

The University is well placed to develop advanced, innovative materials for medical applications with specialist expertise in light metals, plastics and advanced composite materials including:

- new materials for prosthetics or to encourage cell growth, enable healing or improve bioactivity
- implantable materials (including biodegradable materials)
- nano and micro materials
- 'smart' polymers that respond to changes in their environment
- processing methods for biomaterials.



Gastric electrical system mapping

Sterilised, high-resolution electrode arrays, flexible enough to conform to the anatomy of the stomach or small intestine, enable us to obtain electrical measurements from the human stomach and small intestine. Each array contains 128 electrodes at a precise spacing of 5.2 mm and allows us to capture information about the propagation patterns and velocity of the electrical waves controlling peristalsis (wave like the muscle contractions of the digestive system). This technology is currently used at Auckland City Hospital and in overseas universities and hospitals.



Acoustic noise reduction

Acoustic noise is now so prevalent in modern society it has become a health and social hazard. We are developing algorithms which introduce anti-noise signals to reduced unwanted acoustic noise.

Sensing and measurement techniques

Across the University a wide variety of sensor development work is underway, including:

- devices based on enzymes, antibodies, and nucleotides
- detection of trace gases
- direct and label free sensing of biological molecules
- *in vivo* monitoring of life function
- spectroscopy to assess real-time behaviour of biomolecules.



Distributed ambient intelligence system (DAIS)

Researchers within the Electrical and Computer Engineering Department have developed a fully digitised laboratory that can determine the status of the occupants, sense user interactions, and monitor and automatically adjust ambient conditions.

Applications include:

- *Miniaturised wireless sensor nodes for remote patient vital signs monitoring*
- *Internet-enabled devices for large scale pervasive and intelligent healthcare services*
- *Real-time and reactive remote patient monitoring and diagnosis*
- *Natural and intelligent interactions for elderly and disabled patients.*

Technology evaluation and testing

The University of Auckland is the only university in New Zealand where the Faculties of Engineering, Science and Medical and Health Sciences can combine development, testing and clinical trials on the same site. This generates a very efficient iterative process which allows validation of technologies for:

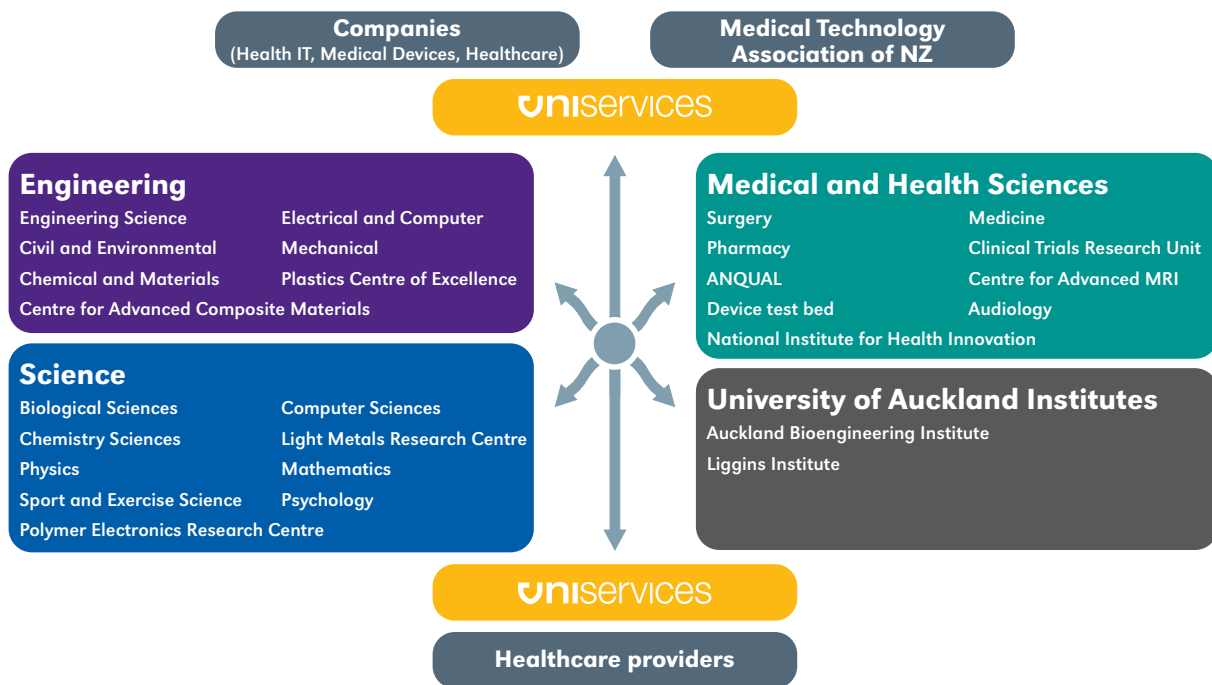
- fitness for purpose
- risks and benefits
- safety, eg, volatile materials, contaminants and emissions
- software safety and reliability.



Creating new technologies

Engineering teams draw together expertise from across the University and the wider community, and integrate research and commercial interests across engineers, medical experts, healthcare companies, health information technology (IT), medical devices and a mature and collaborative software industry.

This results in high functioning multi-disciplinary teams with skills ranging from medical health and sciences, robotics, psychology and modelling, through to bioengineering, health IT platforms, sociological research, clinical trials, health informatics, statistics and economics.



UniServices

UniServices commercialises intellectual property and manages contract research between the University and its clients. The company has all-important access to funding, supports testing and enables delivery to market through management, licensing and marketing expertise. UniServices has clients in 36 countries and collaborative partnerships in health IT, medical devices, robotics, software development, and diagnostics across the globe.



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