RESEARCH HIGHLIGHTS

Nanotechnology & Nanoscience 43
Security & Policy Issues 46
Environment, Water and Sustainability 47
Internet & Communications 54
Interactive and Digital Media 55
Aerospace Engineering 60
Energy 63
Info-Communication Technology 64
Microelectronics and Applications 65
Life Sciences 66
Interface of Biology & Engineering 71
Logistics 76
Social Sciences 78
Chemistry and Chemical Engineering 80
Civil and Environmental Engineering 81
Nanotechnology & Nanoscience

Nanotechnology, Catalysis and Reaction Engineering

Investigation on membranes to improve membrane performance for industrial usage

Various organic and inorganic nanomaterials and nanocomposites have been studied by the team consisting of Asst Prof Xu Rong, Asst Prof Yang Yanhui, Asst Prof Chen Yuan, Asst Prof Lai Zhiping and Asst Prof Leslie Loo Sun Sun from the School of Chemical and Biomedical Engineering (SCBE).

Some progress in carbon nanotube chirality control using metal incorporated MCM-41 catalysts has been made. Three CVD synthesis systems have been set up in the lab, which enable CVD growth studies from high pressure to vacuum conditions. Chirality control mechanisms will be explored through both experimental and theoretical approaches.

Inorganic membranes have diverse utility in key applications such as gas separations, fuel cells, and chemical sensors. The membrane research focuses on the following three areas: 1) Zeolite membranes and membrane reactors; 2) polymer/zeolite nanocomposite membranes; 3) multi-scale simulation of transport through complex porous structures. The ability to synthesize and control zeolite structures on nanometer scales has led to significant improvement in membrane performance, based on which further synthesis strategies to control the properties of zeolites will be developed.

Advanced Metrology and Non-Destructive Testing & Evaluation

Quest for micro-nano metrological capabilities and sub-100nm feature fabrication for semiconductors applications

Work to develop micro-nano metrological capabilities which are needed to meet current and future industry needs is being carried out in the School of Mechanical and Aerospace Engineering (MAE) and is focusing in the following areas: (i) conventional and non-contact whole field probe methodologies for semiconductor and bio-medical applications, (ii) novel sensing and fabrication techniques combining fundamental and applied concepts, (iii) multi-modal, in-situ NDT & E in semiconductor, petro-chemical, healthcare, aerospace and marine industries (iv) Metrology for 3D structures in meso-scale to micro scale region and (v) novel optical lithography and surface planarization techniques for semiconductor applications of the future.

Figure 1. Simulated cavity shear fringes under the influence of curvature
A novel concept of 3D feature fabrication using a four-beam counter propagating interferometric approach is one of the recent significant research endeavors being undertaken by Assoc Prof Murukeshan Vadakke Matham, Division of Manufacturing Engineering, School of Mechanical and Aerospace Engineering (MAE). Experimental research is going on to meet the target of sub-100nm features. Some of the projects in this area are funded by AcRF, A-STAR, NTU-RI CRPs and support from industry such as NTU-Chartered Semiconductor programs.

![Image](image1.png)
Figure 2. Optical non-contact NDT of composite panel: defects are the fringe locations

![Image](image2.png)
Figure 3. Simulated photo-resist features after exposure to multiple evanescent wave interference lithography.

![Image](image3.png)
Figure 4. Confocal microscope image of silicon surface removed by electrokinetic abrasion

![Image](image4.png)
Figure 5. Research student in the clean room doing optical lithography project.

**Nanocomposite Coatings**

**Development of hard yet tough nanocomposite coatings for industrial applications**

In real industrial applications, “superhard” coatings are rarely useful. Hard yet tough coatings are much sought after. In this project, Prof Sam Zhang of School of Mechanical and Aerospace Engineering (MAE) and his team dope amorphous phase with metallic phase to form a tough matrix, and meanwhile imbed nano-sized TiC or TiN crystals in this tough matrix to form nanocomposite coatings. Currently the team is synthesizing carbon nanotube (CNT) directly into nanocrystalline phase to from a composite coating. Preliminary results show that nc-TiC/a-C (CNT) nanocomposite coating is formed. The length of CNT can be a few up to tens of micron. The grain size of TiC is about 20 nm. Characterization and optimization work is on-going.
Droplet-Based Micro/Nanofluidics

Investigation on microdroplets promises new design for lab-on-a-chip devices

Droplet-based micro/nanofluidics is a new discipline of the emerging field of microfluidics. In a droplet-based platform, chemical and biochemical reactions are contained inside a small volume. The reactants as well as the reaction products are protected by an immiscible phase surrounding the droplet. Droplet-based micro/nano fluidics needs new concepts for generating, transport, merging, splitting, sorting and switching of the microdroplets.

In this A-STAR funded project, a research team consisting of Assoc Prof Nguyen Nam Trung, Assoc Prof Wong Teck Neng and Assoc Prof Chai Chee Kiong from the School of Mechanical and Aerospace Engineering (MAE) developed new concepts and devices for manipulating microdroplets and the flow field inside these droplets. The team also set up the experimental facilities for characterizing the flow fields inside a microdroplet. The technology pending a patent promises to lead to a paradigm shift in design lab-on-a-chip devices.
Security & Policy Issues

Through-The-Wall Passive Radar Detection

Breakthrough discovery for human motion detection

A team led by Prof Lu Yilong from the School of Electrical and Electronic Engineering (EEE) has made a significant breakthrough in passive radar through-the-wall detection. This novel passive radar technique allows the presence of living human beings and their motions on the other side of a non-metallic wall to be detected. The concept was validated in several initial trials using the ubiquitous Global System for Mobile Communications (GSM) and Digital Video Broadcasting signals for human motion detection. This technology has many applications in security surveillance and urban warfare.

Figure 1. Geometry configuration of the GSM based through-the-wall passive radar trial measurements.

Figure 2. Doppler frequency of a walking human inside an enclosed room using overlapping FFT Doppler processing technique.

Figure 3. Doppler frequency of a walking human inside an enclosed room for Doppler processing using only target echo signal.
Environment, Water and Sustainability

The National Weather Sensor Grid

Innovative Sensor Grid Design Enables Large-Scale Intelligent and Pervasive Environmental Monitoring

By Dr Lim Hock Beng, Dr Wang Wenqiang, Mr Mudasser Iqbal, Ms Yao Yuxia

In recent years, news and articles regarding global climate and environmental changes appear in the media more and more frequently. Scientists, government leaders and even ordinary citizens worldwide are increasingly concerned about global warming, El Niño, melting of polar ice caps, the rising sea level and other phenomena caused by global climate and environmental changes.

Large-scale environmental monitoring networks are important tools to study global climate change and its impact on ecosystems and civilizations. Some of these monitoring networks, such as the early Tsunami warning systems deployed in the Pacific and Indian oceans, can be crucial for saving human lives.

With rapid advancement in technology, building such networks has become easier than before. For example, environmental monitoring sensors are becoming smaller, cheaper and more powerful, and they can be deployed in the most hazardous environments on Earth. Long range real-time data transmission has become possible with emerging wireless technologies.

As an island country, Singapore is vulnerable to the hazardous consequences of global climate change. Environmental issues are rapidly coming to the forefront of national concerns and public consciousness.

Senoko Power, Singapore’s largest power generation company, initiated the National Weather Study Project (NWSP) in 2006. It is a community-based initiative that aims to promote the awareness about climate change, global warming and the environment among the youth population of Singapore. Senoko Power provided each participating school with a mini weather station for the school students to undertake various weather and environmental study projects. Figure 1 shows the deployment of weather stations in several schools.

Figure 1: Deployment of weather stations in schools throughout Singapore
A research team from the NTU Intelligent Systems Centre (IntelliSys) is building the National Weather Sensor Grid (NWSG) as the key infrastructure for the NWSP. The NWSG connects all of the school weather stations, so that the weather data can be automatically collected in real time and stored in a Central Data Depository (CDD) for subsequent data processing, analysis and sharing.

This system helps students and teachers to enhance the scope and depth of their weather study projects. More importantly, it provides a test bed for the development of large-scale environmental monitoring networks with significant research and industrial impact.

The Principal Investigator of this project is Dr Lim Hock Beng (Program Director, IntelliSys). The other team members are Dr Wang Wenqiang (Research Fellow), Mr Mudasser Iqbal (Research Engineer), Ms Yao Yuxia (Research Engineer) and several undergraduate research students and interns. The project is funded by Microsoft Research, IntelliSys and the NTU Research Support Office.

What is the National Weather Sensor Grid?

The National Weather Sensor Grid (NWSG) is a large-scale infrastructure for intelligent and pervasive environmental monitoring. It is based on two important and promising technologies; namely, sensor networks and grid computing.

Sensor networks are collections of sensor nodes connected via wired or wireless networks for sensing and measuring the physical environment. They present many challenging research issues and they have a wide range of important applications such as environmental and weather monitoring, military surveillance and homeland security, healthcare monitoring, tracking of manufacturing processes, smart homes and offices, etc. Thus, sensor networks have attracted a great deal of interest in the research community as well as within the industry.

Grid computing is an established standards-based approach for the coordinated sharing of distributed and heterogeneous resources. A compute grid provides distributed resources to meet the computational requirements of applications, while a data grid provides seamless access to large amounts of distributed data and storage resources.

For large-scale sensing applications, it is a major challenge to collect and share real-time data from heterogeneous sensor networks and sensor devices distributed over a wide area, and to process these data to make intelligent decisions. A promising approach is the integration of sensor networks with existing IT infrastructures such as the Internet to form cyber-sensor infrastructures for sensor data collection and management.
Sensor grids, which combine sensor networks with grid computing, are good building blocks for large-scale cyber-
sensor infrastructures. By integrating and sharing various sensor, computational and storage resources distributed
geographically, the sensor grid enables the collection, processing, sharing, visualization, archival and searching
of large amounts of real-time sensor data.

“To our knowledge, the NWSG is the first implementation of a large-scale sensor grid for environmental monitoring.
The novelty of the NWSG lies in its ability to integrate multiple sensor deployments, computational resources and
storage resources owned by different organizations across a wide geographical area, and to make the sensor
data seamlessly accessible for sharing, analysis, and decision making. These are the key elements for designing
large-scale intelligent and pervasive environmental monitoring systems,” says Dr Lim.

NWSG Architecture and Middleware Framework

The design of sensor grids requires a comprehensive framework to address challenges such as connectivity,
scalability, resource scheduling, data management, security, availability, quality of service, etc. We have developed
a sensor grid architecture framework called the Scalable Proxy-based aRchitecture for seNsor Grid (SPRING).
By using proxy nodes as interfaces between sensor networks and the grid fabric, the SPRING framework is
scalable and it can integrate heterogeneous sensor networks and devices with the grid.

The NWSG is built upon the SPRING framework and has several important features. First, it connects all the
weather stations via the Internet to automatically collect and aggregate weather data in real-time. Second, the
weather data are logically stored in the CDD, which uses distributed data storage resources. Third, the NWSG
integrates computational resources for the compute-intensive processing of weather data. Fourth, the weather
data can be conveniently accessed and shared via the web through mash-ups, blogs, and other user applications.

Figure 2 shows the system architecture and components of the NWSG. A Virtual Organization (VO) is a resource-
sharing participant of a sensor grid. In the NWSG, the schools and other organizations deploying the weather
stations and grid infrastructure hosting sites are considered as VOs. A VO may own one or more
resources such as sensor resources, computational data resources, grid-enabled devices, etc.

Figure 2. NWSG system architecture
Each VO can access and use resources in other VOIs through distributed resource brokerage and user authentication. The weather sensors are connected to the NWSG via wired or wireless proxy nodes. Users can schedule sensor data collection jobs on programmable weather sensors in any VO. Users and applications can also share and access archived or real-time weather data, and to run sophisticated weather data processing jobs using the necessary amount of sensor and computational resources in different VOIs.

![Diagram of NWSG software architecture]

The key enabling component of this distributed resource access is the sensor grid gateway. Since access to heterogeneous resources requires discovery, authentication, scheduling and execution of user requests, the sensor grid gateways maintain VO-level meta-information and implement the middleware needed to integrate sensor networks with the grid fabric. The user level, middleware and core services that form the NWSG software architecture are illustrated in Figure 3.

**NWSG Software and Web Services**

We are developing tools and services to efficiently publish, query, process, visualize, archive and search the vast amount of weather data. Web interfaces are provided to enable public access to the NWSG and its services. The public weather portal that hosts the NWSG services is accessible at http://nwsp.ntu.edu.sg.
We use geo-centric web interfaces to display and visualize the weather station information such as the geographical location, operational status, weather data sampling frequency and data snapshot, etc. The two interfaces developed so far are based on Microsoft SensorMap and Google Earth. Sample screen shots of the weather station map using the SensorMap and Google Earth interfaces are shown in Figures 4 and 5 respectively.

In particular, the Microsoft SensorMap is a specialized platform for sensor information publishing. We obtained a research award from Microsoft Research and started a collaboration project with them to develop tools for sensor data publishing and querying using the SensorMap platform. This project is led by Dr Lim Hock Beng (Principal Investigator, IntelliSys) and Dr Ling Keck Voon (co-Principal Investigator, School of Electrical and Electronics Engineering).

We have also developed a dynamic weather data display based on Macromedia Flash as shown in Figure 6. It is customizable since users can select the weather station to be displayed. In the spirit of Web 2.0, this display can be embedded within any web site, blog, or web-based application. This allows us to easily disseminate the weather data to users.

A data download service and interface has been developed to enable the users to download the weather data for research and educational purposes. Users can specify the desired weather station, time period, weather parameters and data format to download the data.

To visualize the temporal variations in weather conditions at a particular weather station, we provide a graphical plot service as shown in Figure 7. Users can select the weather station and the weather parameter, and a graphical plot will be displayed. In addition, various weather statistics such as the maximum, minimum and mean values of the selected parameter are computed via grid services and displayed.
We also developed several useful grid services based on the NWSG infrastructure. For example, a zone-based weather statistics grid service enables the user to query weather conditions over a geographical zone with multiple weather stations. After the user selects the zone of interest, the grid service then discovers the weather stations from which data must be acquired and analyzed to compute zone-based weather statistics for the user. A Weather Alerts grid service has been provided for users to receive notifications of specific weather events. For example, users can receive email notifications when it starts and stops raining at a location.

**Research and Industrial Impact**

Apart from weather stations, we can extend the NWSG infrastructure to manage a wide variety of sensors, such as water quality sensors, air quality sensors, seismic stations, GPS stations, traffic cameras, security cameras, etc. This enables the NWSG to support many important applications.

Environmental and water technologies are among the new growth sectors of the Singapore economy. One of the key research and development areas on water technologies is water quality management. At present, water quality sensors are already deployed in some of the catchments, rivers, canals, and reservoirs to monitor certain water quality parameters. The NWSG can be used to integrate such sensor deployments throughout Singapore so that extensive water quality data can be collected nationwide and managed on a unified platform. Apart from water quality monitoring, such a system can also enhance water security by supporting the detection of contaminants in the nation’s water supply and providing decision support to mitigate contamination events.

For countries to adhere to the Kyoto protocol, measuring and controlling the emission of greenhouse gases has become a critical issue world-wide. In Singapore, the bulk of the greenhouse gases, such as CO₂ and SO₂,
is emitted from power plants and industrial plants. Air quality and chemical sensors can be used to measure the gas emissions from such plants. The NWSG can integrate such sensors deployed throughout Singapore to enable automatic real-time monitoring and auditing of the gas emissions.

Clean energy is another important direction to address the climate change problem. Solar power and wind power are popular clean energy alternatives. In order to efficiently harness solar power in Singapore, it is necessary to analyze the distribution of solar energy locally. The NWSG can collect data from a large number of weather stations equipped with solar radiation sensors to generate a detailed spatial and temporal distribution of the solar intensities in Singapore. This can facilitate the selection of suitable sites for the installation of solar power plants.

Although Singapore is lucky to be relatively free from major natural hazards like earthquakes, volcanic eruptions, tsunamis and extreme climate changes, we are still affected by the increasing occurrences of such hazards in Southeast Asia. For example, recent earthquakes in Sumatra can be felt in Singapore. Scientists are concerned that an extremely powerful earthquake could strike Sumatra in future, and this event may indirectly affect Singapore. The Earth Observatory of Singapore (EOS), a Research Centre of Excellence (RCE) in earth sciences at NTU, will deploy seismic sensors, Continuous GPS (cGPS) stations and other sensors to monitor the Sumatran fault. Such sensor deployments for earth sciences can be integrated by sensor grids to enable reliable and robust sensing, data acquisition, analysis, dissemination and visualization.

We anticipate that large-scale deployments of sensor grids will be carried out for various application domains in the coming years. The NWSG has the potential to be an important component of large-scale intelligent and pervasive sensing systems with significant research and industrial impact.

**For more information and to explore opportunities for collaboration, contact Dr Lim Hock Beng at limhb@ntu.edu.sg.**

**Water Treatment**

**Development of environmental friendly self-cleaning ‘flakes’ to treat water**

Using a combination of ultraviolet (UV) light and filters with atomic-sized pores, a team led by Assoc Prof Darren Sun from School of Civil and Environmental Engineering (CEE) and with scientists from Stanford University have developed self-cleaning membranes, a technology that saves almost 90 percent of the energy used in conventional water treatment methods.

The material, which is made up of nanofibers, will “stick” to existing water treatment membranes, where it attracts impurities in raw water. With its atomic sized nano pores, water is ultra-filtered before going on to further treatment. When UV light is passed over it, the film, which acts as a catalyst will destroy contaminants on its surface. These are then released as carbon dioxide and other harmless mineral products.
Internet & Communications

A Rule-Based System for Program Analysis

Development of language-independent approach to detect, analyse and report possible and/or potential vulnerabilities in web-based applications

This project led by Assoc Prof Loh Kok Keong Peter from the School of Computer Engineering (SCE), investigates an approach in developing a language-independent approach to detect, analyze and report possible and/or potential vulnerabilities in web-based applications. One of the design considerations is to have extensible system architecture to encompass future adaptiveness in rule generation for its work. This project was established in consultation with the Centre for Strategic Infocomm Technologies and is assisted by MINDEF.

Digital Repository (DR-NTU)

Development of an online system to sustain and manage NTU’s works and to allow users to browse and search for information

The Digital Repository (DR-NTU) project was developed by the project team consisting of Mr Jayan Chirayath Kurian, Assoc Prof Dion Goh from the Wee Kim Wee School of Communication and Information (WKWSCI) and Ms Joy Lynn Wheeler (Digital Resources Division, NTU Library) to create a digital repository to store and make accessible online works owned, published and created by NTU staff and students. The main stakeholders of this project are WKWSCI and the NTU Library. The DR-NTU project is divided into three phases. The initial phase of this project includes digitizing Asia Media Information and Communication Centre (AMIC)’s conference proceedings. In the second phase, a soft launch of DR-NTU will be conducted for evaluation and feedback. The third phase includes continued service development to accommodate feedback from users and the actual launch of DR-NTU to the NTU community. The software platform chosen is DSpace, an open source digital library software tool collaboratively developed by MIT and HP.
Interactive and Digital Media

Smart Suit

A wearable embedded body motion processing system for real time sensing and processing of anatomical motion data

This project is led by Assoc Prof Chen I-Ming from the School of Mechanical and Aerospace Engineering (MAE) under A*STAR Embedded Hybrid Systems Phase II Thematic Research Program. The objective of this project investigated by Assoc Prof Yeo Song Huat and Asst Prof Duh Been-Lin from the School of Mechanical and Aerospace Engineering (MAE) is to develop a high performance un-tethered wearable human motion processing system for real-time sensing and processing of anatomical motion data which will find their applications in the real-time control and manipulation of virtual figures in interactive media and games amongst others. In this project, a low-cost, miniature, flexible, low-component-count goniometer that uses optical linear encoders (OLE) packed in a small pliable casing mounted on a flexible substrate for measuring body joint angle was developed. A flexible steel wire guided by a Teflon tube is attached to the linear encoder to allow linear sliding movement due to the stretch of the skin surface as the body joint bends.

Shown in the figures are sensor pads, sewn with several OLEs, for detecting movements of different body joints. Based on the modularly design sensor pads, we will be able to develop a full body motion suit for digital animation as well as critical joint measurement tools for medical and sports applications. A US provisional patent has been filed in May 2007.
Using CoWord @ Courts

Deployment of CoWord in Singapore Subordinate Courts

CoWord is based on over 10 years internationally renowned R&D work by Prof Sun Chengzheng and his team, originally started at Griffith University, Australia, and currently located at Nanyang Technological University, Singapore (since July 1 2005). CoWord is the world-first and the most advanced real-time collaborative word processor, which allows multiple users to use Microsoft Word to concurrently and consistently edit the same documents over communication networks. CoWord has been tried by over 5000 users from all over the world. Since March 2005, the Information Technology Department at the Subordinate Courts in Singapore started exploring the use of CoWord in the courts. During 2006, several pilot trials have been carried out in real court room sessions in the Subordinate Courts in Singapore. An MOI (Memorandum of Intent) was signed between NTU and Singapore Government in May 2007 for establishment of a lab for both the Subordinate Courts and NTU to further evaluate the CoWord technology and explore opportunities for deployment of CoWord in the Subordinate Courts.

Computer-Assisted Cel Animation (CACAni)

Software with added functions to provide more options and flexibility for animators

During the past one year, with the help of Prof Seah Hock Soon from the School of Computer Engineering (SCE) and AIC Inc from Japan, CACAni has been improved further since the MoU was signed in June 2006, both in terms of functionality and performance. Auto-coloring has been enhanced with colour seed algorithm, faster, more accurate and robust. And for auto-inbetweening, faster tracing input algorithm has been developed to enhance vectorization process. Layering and stroke editing functionalities have been added to give animators more flexibility. Overall, CACAni is able to handle more complicated sequences or scenes, thus fitting well the requirement of animation production.

COSMOS: Crowd Simulation for Military Operations

Development of a system for use in civil-military operations for crowd control

SCE was recently awarded a research grant by the Defence Science Technology Agency (DSTA) to support a project, led by Assoc Prof Cai Wentong from the School of Computer Engineering (SCE), to create a 3D isometric, real-time strategy based simulation for handling and managing crowds in military operations. This generic crowd modeling and simulation system will integrate computer graphics and animation, game ‘Artificial Intelligence’ (AI) as well as distributed simulation technologies. The COSMOS system once developed can be used for military and Civil-Military Operations (CMO) in the areas of planning, training, and operational decision-making.
Web Archives of Singapore (WAS)

Creating the digital culture in Singapore

This is a MICA-funded joint R&D project with the National Library Board (NLB) in developing the strategy and system to sustain and manage Singapore’s Web collection called Web Archives of Singapore (WAS). WAS is successfully launched 18 October 2006. Second phase funding is expected in the next few weeks. In terms of e-social science, Dr Paul Wu from the Wee Kim Wee School of Communication and Information (WKWSCI) has secured MOE funding to develop towards a collaborative platform where the general public, joined with institutional professionals, will make sense of the digital culture in contemporary Singapore and beyond.

Mobile Media

Developing mobile media applications to meet the growing demand in current media rich culture

With users consuming more and more media, and on the move for most of the time, it is no doubt that Mobile Media will become one of the key technologies of the future. Asst Prof Jiang Xudong, Asst Prof Yap Kim Hui, Assoc Prof Xue Ping, and Assoc Prof Tan Yap Peng from the Division of Information Engineering, School of Electrical and Electronic Engineering (EEE) have recently secured significant research funding to the tune of total $2.9 million under the Mobile Media Thematic Strategic Research Programme of the A*STAR’s SERC. They plan to realize the potential of mobile devices, to study and pioneer the growing trend of users, and to develop mobile media applications that are useful and convenient for the users to adopt in daily life. Further, biometric authentication technologies such as fingerprint, facial and voice, as well as digital watermarking and 2D barcode are being developed and employed with the purpose of securing mobile device access, mobile media download, and information exchange.
Virtual Singapura

Learning through virtual playing made possible

‘Virtual Singapura’ is a joint research project headed by Asst Prof Miao Chun Yan from the School of Computer Engineering (SCE) and Assoc Prof Michael Jacobson from the National Institute of Education (NIE). The study focuses on Agent-augmented Interactive Media and Situated Learning. It is the first immersive, situated, and virtualized learning environment in Singapore. The project is designed to enable students to learn through role playing in a virtual world.

The Culture 360 Project

A one-stop portal for cultural exchanges, networking and idea generation

The Culture 360 project conducted by Ms Khasfariyati Bte Razikin and Assoc Prof Dion Goh from the Wee Kim Wee School of Communication and Information (WKWSCI) is collaboration between NTU and the Asia-Europe Foundation. The project was initiated in response to gaps in information resources that exists in arts and culture portals of Asia and Europe. The project aims to address these gaps via a portal known as Culture 360. The portal also provides an avenue for collaboration via a suite of e-community tools such as wikis, blogs and expertise locators.

The Culture 360 portal disseminates information for projects, events, calls for participation, news and other relevant articles. Users are also able to exchange ideas and generate new content through the e-community tools. The portal engine is powered by DotNetNuke, an open source Web application framework. Work on this project started in WKWSCI in August 2006. A soft launch of the initial version of the portal is expected at the end of the year. The figure shows the home page of the portal which lists the latest contributions.
MobiTOP: A System for Mobile Tagging of Objects and People

System opens ups new opportunities for creative marketing, information sharing and real-time networking across various industries

The MobiTOP project which is carried out by the team consisting of Assoc Prof Dion Goh and Assoc Prof Theng Yin Leng from the Wee Kim Wee School of Communication and Information (WKWSCI), Assoc Prof Lim Ee Peng, Asst Prof Sun Aixin and Asst Prof Zhang Jun from the School of Computer Engineering (SCE), Asst Prof Chang Chew Hung and Assoc Prof Kalyani Chatterjea from the National Institute of Education (NIE), is an A*STAR funded initiative that aims to develop a flexible, reusable software platform for mobile tagging applications. Mobile tagging is an extension of Web-based social tagging, in which electronic annotations and/or metadata are assigned to physical objects in the real-world for the purposes of information sharing. In addition to tag creation and sharing, the project will also aim to offer state-of-the-art techniques for tag analysis and discovery to assist users in retrieving relevant tags generated by other users efficiently and effectively. User interface research for mobile devices will also be conducted to ensure that the mobile tagging applications are able to meet the needs of their users. Potential applications are varied and include education, accessibility information sharing, tourism, and social networking. The figure above shows a prototype mobile tagging application applied to the sharing of accessibility information in buildings along Orchard Road.
Aerospace Engineering

Micro Air Vehicles (MAV) and Nano Air Vehicles (NAV)

Concepts based on flapping wing propulsion and rotacrafts modeled after birds and insects

Investigation on Micro Air Vehicles (MAV) and Nano Air Vehicles (NAV) is currently worldwide studied in order to design a vehicle that can be used for reconnaissance, surveillance, and search-and-rescue missions in tight and enclosed areas. Research is focusing on aerodynamics and control on small scales, especially with regards to the examples that nature provides with birds and insects. Possible concepts for MAV and NAV are based on flapping wing propulsion and rotorcraft designs.

Work on experimental prototypes using rotorcrafts and flapping wing propulsion devices has been investigated as part of Undergraduate Research Experience on Campus (URECA) projects. Due to the hands-on nature of this project, the programme has proven to be very popular with students.

Figure 1. Rotorcraft MAV (URECA Project)
Figure 2. Design of a Flapping Wing Propulsion MAV (left hand side) and glider prototype (right hand side). (URECA Project)
Figure 3. Computational Fluid Dynamics of MAV prototype (URECA Project)
Figure 4. Design of a Flapping Wing propulsion device (URECA Project)
Design, Development and Analysis of Micro Air Vehicle

Design and development of a man-packable size MAV for surveillance in tight spaces and for future versatile MAV research testbed.

This project, funded by Defence Science Organisation (DSO) and conducted by Asst Prof Go Tiauw Hong with Asst Prof Jorg Schiuter from the School of Mechanical and Aerospace Engineering (MAE), aims to develop a man-packable size Micro Air Vehicle (MAV) satisfying certain flight requirements. Several possible designs will be looked at and further analysis will be conducted on the most promising design. The end goal is an autonomous MAV and to achieve this, many challenges need to be overcome, specifically in the flight control development and the hover-to-forward flight transition dynamics. A prototype will be developed and flight test will be performed to examine the validity of the concept and analysis, as well as for future development.

Autonomous Formation Flying of Multiple UAVs

Methods to allow collaborative sensing for coordinated flying of multiple UAVs

Coordination of multiple autonomous Unmanned Air Vehicles (UAVs) flying together is currently an area of active research in which Asst Prof Go Tiauw Hong in collaboration with Assoc Prof Eicher Low from the School of Mechanical and Aerospace Engineering (MAE) are venturing into, with the financial support from Academic Research Fund (AcRF). Such coordinated flying is pushed by the need for collaborative sensing. In this project, a simple coordination of multiple autonomous UAVs in the form of formation flying will be attempted.

The challenge here is to establish reliable communication among the UAVs and the development of a novel approach for precise localization of each UAV. Various techniques to achieve successful relative navigation and formation control schemes will be investigated. Several autonomous UAVs will be used as a test bed for implementing the methods developed and for flight testing.
Software to Automate the Detection of Defects in Radiographic Images

Digital imaging techniques reduces errors due to human subjectivity through automated interpretation of radiographic images

Radiographic non-destructive testing is often used for detecting defects in materials. Due to the degraded quality and the small size of the defects, X-ray films are sometimes difficult to inspect.

Based on a research conducted by Dr Wang Xin and Assoc Prof B Stephen Wong from the School of Mechanical and Aerospace Engineering (MAE), along with Mr. Tui Chen Guan from Republic of Singapore Air Force (RSAF) and Mr Frederick Foo from STA Travel, it was found that the interpretation of such images is often affected by a human operator’s subjectivity.

As such, the research team has developed a software which utilizes digital image processing techniques to allow the interpretation to be automated.

![Figure 2. Defect segmentation; (a) Image before processing (b) Image after segmentation](image)

The research team has received funding from the Republic of Singapore Air Force for the prototype software to be further modified to interpret radiographic images from an aircraft as part of a larger project to develop an automated radiographic system for aircraft inspection (Figure 3).

![Figure 3. Automated radiographic system for aircraft inspection](image)
Energy

Future Smart Power Distribution System

Intelligent energy metering, reading and billing system (IMRBS) allows for tracking of power generation and consumption for efficient power distribution

The project, featured on Channel News Asia (CNA), was selected to showcase renewable energy research in the Power Engineering Division of Nanyang Technological University (NTU). IMRBS, featured in the Straits Times reported that “NTU undergraduates have devised a two-way meter that accurately tracks power going in and out of homes. Project supervisor and undergraduates’ mentor, Assoc Prof Wang Peng from the School of Electrical and Electronic Engineering (EEE) says the innovation is poised for commercialization.” The aim of this project was to find solutions for the new requirements on energy metering initiated by the major restructuring of the electricity market and the rapid interfacing of green power producers to the previously centralized electricity grid. The objectives of the IMRBS are to automatically read monthly electricity consumption/selling of each customer/power producer in an island-wide local distribution network, and to forward the consolidated data to the relevant authority for processing and billing. Time-of-use meters for replacing existing electrical meters installed in Singapore are also developed. The system can also allow customers to sell back their clean energy to the future freely accessible power grid if they have solar panels installed within their vicinities.

Industrial Chemistry & Green Technology

Developing technologies relating to green chemistry

Prof Ng Siu Choon together with Asst Prof Wang Xin, Assoc Prof Li Changming, Asst Prof Timothy Tan, and Asst Prof Arvind Rajendran from the School of Chemical and Biomedical Engineering (SCBE) have been developing more efficient fuel cells, ionic liquids, supercritical fluid chromatography and solar cells.

Nanocomposites that are photocatalytic, superhydrophilic and antibacterial have also been synthesized. These materials can be coated to surfaces inside or outside buildings and structures for self-cleaning and self-sterilization. Current work includes exploring various synthesis methods (including atomic deposition, sonication and sol-gel) that will give the most efficient materials.
Info-Communication Technology

Wireless Chip Area Network (WCAN)

Wireless networks shrink their coverage to support higher data rates for multimedia applications

The WCAN project seeks to develop a wireless network whose coverage is shrunk to centimeter range to deliver data at Gbps rates. The WCAN can deliver data at the current Gbps levels among the cores within a SoC (a complete system on a chip), or among different SoCs within a module via electromagnetic waves using on-chip radios, if successfully developed. At the same time, it can overcome the current SoC interconnect challenges. Adopting ultra wide band or impulse radio technology as its physical layer, the WCAN can greatly save not only power consumption, but also circuitry overheads. Hence WCAN offers an alternative solution to the on-chip interconnect problems faced by current SoCs.

Development of Sputtered SBT Thin Films for Nonvolatile Random Access Memory Application

Improving the performance of random access memory applications

Utilization of ferroelectric thin films for nonvolatile random access memory (NvRAM) applications is under intensive investigation. Layered perovskite structure SrBi$_2$Ta$_2$O$_9$ (SBT) thin film has attracted ever increasing attention because it exhibits fatigue-free property up to $10^{12}$ cycles, excellent retention characteristics, and low leakage current density. However, two obstacles exist that hinder commercial application of SBT thin films: low remnant polarization and high annealing temperature (> 800°C).

In this project led by Prof Sam Zhang of the School of Mechanical and Aerospace Engineering (MAE), the relationship among deposition parameters, microstructure and polarization properties of Sr-deficient or Nd-doped SBT thin films are studied to obtain pure SBT phase (without pyrochlore “intoxication”). The polarization properties are improved through doping of Nd, and at the same time, the crystallization temperature of the Aurivillius phase is reduced. The bias applied on substrate during deposition further reduces the crystallization temperature to as low as 670°C.
Microelectronics and Applications

Compound Semiconductor and Device

Technology paves the way for high speed photodetectors at long wavelength on GaAs substrates to potentially replace the incumbent and more expensive InP-based technology.

The Compound Semiconductor and Device Group from the School of Electrical and Electronic Engineering (EEE) has demonstrated for the first time pico-second (ps) pulsed response from dilute-nitride (antimonide) semiconductors. This technology paves the way for high speed photo-detectors at long wavelength on GaAs substrates to potentially replace the incumbent and more expensive InP-based technology. This work is funded by the EC-ISIS program in collaboration with Dr Andreas Stohr of the University of Duisburg Germany. In addition, the group has successfully achieved for the first time the growth of III-V compound semiconductor quantum dots on SiGe/Si substrates using a technique called migration enhanced epitaxy (MEE). High DC gain of 100 was obtained on large-area devices and microwave characterizations will be next targeted. This work is funded by the SMA program in collaboration with Prof Gene Fitzgerald of MIT.

Breakdown of Metal Gate/High-K Nanoscale Gate Stack

Finding has significant impact on the reliability of nanoscale gate stacks

The Silicon Research Group from the School of Electrical and Electronic Engineering (EEE) has reported the first time ultrafast transient during the breakdown of metal gate/high-k (EOT < 1.5nm) nanoscale gate stack at 2006 IEEE Electron Device Meeting in San Francisco, USA. The ultrafast transient, only happened during substrate injection of carriers from the Si substrate to the gate, gives rise to very small reliability margin of the post-breakdown. The finding has significant impact on the reliability of nanoscale gate stacks of sub-45nm CMOS technologies since metal gate/high-k technology will be used by Intel and IBM for volume production soon. This project is a joint collaboration with Dr Guido Groseneken of IMEC, Belgium and Mr Tung Chih Hang of Institute of Microelectronics.
Life Sciences

Cystic Fibrosis (CF)

Genetic engineering to increase the efficacy of gene replacement therapy for treating cystic fibrosis

Cystic fibrosis (CF) is the most common autosomal recessive disorder in Caucasian population, with a frequency of about 1 in 2500 live births. Discovery of the mutated gene encoding a defective chloride channel (loss of function) in epithelial cells, named cystic fibrosis transmembrane conductance regulator (CFTR), has improved our understanding of the disorder’s pathophysiology and has aided diagnosis. However, the gene replacement therapy, one of the most promising treatments, is still far from being used in patients with cystic fibrosis, mostly because of low efficiency in targeting the appropriate cells. To overcome this problem, some gain of function CFTR mutants are in the development stage by genetic engineering to maximize the efficiency of CF gene therapy, using a combination of electrophysiological and molecular techniques. This is a potential new line of treatment that would offer renewed hope to CF sufferers throughout the world. This is a collaborative project between Asst Prof Alex Gong from the School of Biological Sciences (SBS) and his former mentor Dr Paul Linsdell from Department of Physiology and Biophysics, Dalhousie University, Canada.

Neurodegeneration Disorders

Discovery of Traditional Chinese Medicine (TCM) compounds effective for combating Alzheimer’s Disease

Neurodegeneration disorders are one of urgent social problems in coming elderly society, it is critical to accomplish better strategies for managing this social problem. Consequently, one direction toward this goal that was proposed is to sort out active chemical compounds from TCMs with a wealth of long-held knowledge and experiences and to characterize the effects of synthesized toxin, such as conantokin for development of potential drugs. In particular, the focus has been placed on three categories of therapies for: (1) fear and depression, (2) memory and recognition impairments, and (3) pain. As this consequence, immediate action has been taken since 2005 to seek compounds from Traditional Chinese Medicines that specifically affect glutamate or GABAergic neurotransmission at synapses.

Alzheimer’s disease (AD) is the most common neurodegenerative disorder worldwide. It is characterized by loss of neurons and synapses resulting in cognitive impairment and a gradual loss of memory, language skills, and reasoning, leading to dementia and finally death. Recent studies indicate that loss of synaptic function resulting in cognitive impairment may actually precede the more obvious brain pathology – the two most striking pathological features of AD, i.e. the extracellular deposits of β-amyloid (Aβ) plagues in the cerebral cortex and intracellular neurofibrillary tangles of hyperphosphorylated tau proteins. Synapses seem to be particularly susceptible to the effects of soluble oligomers as indicated by impaired function of synaptic ion permeation. Because Aβ-induced NMDA receptor mediated glutamate excitotoxicity is involved in neuronal death in Alzheimer’s disease, NMDA antagonists from the traditional Chinese medicines and synthetic peptides have been investigated as treatment in the lab. Although NMDA antagonist drugs do not block Aβ formation, hope that such drugs can help prevent further neurodegeneration is held.
The team has already proposed promising putative lead compounds for treatment of memory loss. Using patch-clamp techniques, screening has so far indicated that three TCMs used for treating stroke in the oriental medicine exhibit profound actions on NMDA receptor activity. Furthermore we found that conantokin-G selectively blocks NMDA receptors. This is a collaborative project between Asst Prof Alex Gong and Assoc Prof Liu Chuanfa from the School of Biological Sciences (SBS) and Prof Shiro Konishi at the Faculty of Pharmaceutical Sciences, Tokushima Bunri University, Japan.

Dengue Fever

**Breakthrough findings for development of anti-viral compounds against dengue virus**

Dengue fever, a neglected emerging disease for which no vaccine or antiviral agents exist at present, is caused by Dengue virus, a member of the flavivirus genus which includes several important human pathogens such as Yellow fever and West Nile viruses. The NS5 protein from Dengue virus contains 900 amino acids. Viral replication begins with the synthesis of minus-strand RNA from the dengue virus positive strand RNA genome. This essential function for the production of new viral particles is catalyzed by the NS5 RdRp. The research led by Assoc Prof Julien Lescar from School of Biological Sciences (SBS) has solved the crystallographic structure of an enzymatically active fragment of the Dengue virus RdRp and refined it at 1.85 Å resolutions. The NS5 nuclear localization sequences (NLS), previously thought to fold into a separate domain, form an integral part of the polymerase sub domains. The structure also reveals the presence of two zinc ion binding motifs. The results should inform and accelerate the structure-based design of antiviral compounds against dengue virus.

Hematopoietic Stem Cells (HSC)

**Research opens up possibility of building a supply of stem cells for therapeautical purposes**

All the cells of the blood and immune system are derived ultimately from hematopoietic stem cells (HSC). Therefore, understanding of the rules that govern the maintenance and turn over of HSC is the key to the whole hematopoietic system and especially important to the further improvement of the efficiency of bone marrow (BM) and cord blood transplantations in clinics. Using in vitro culture systems and genetically modified BM and stromal cells, a team led by Prof Klaus Erik Karjalainen from the School of Biological Sciences (SBS) attempts to build a niche that can support HSC self-renewal and hence provide us unlimited source of HSC for therapeutical purposes. T lymphocytes are the main players in adaptive immunity and the deficiency in their production or function can lead e.g. to dramatic immunodeficiencies as exemplified by AIDS and to increasingly more prevalent immune dysfunctions associated in aging. Since T lymphocytes are generated in thymus we have started to characterize novel genes that are induced and expressed in developing thymocytes. Cell biological, genetical, and biochemical approaches in order to understand their roles in T cell development will be used.
The Genetic Characterisation of Human Metapneumovirus Isolated from Pediatric Patients in Singapore

Findings confirm cause of lower tract infection and leads to investigation on diagnostic test for detection

The Genetic Characterisation of Human Metapneumovirus Isolated Human respiratory syncytial virus (RSV) has become acknowledged globally as one of the most important causes of severe respiratory tract infection in paediatric patients. The symptoms that are exhibited by these individuals are due mainly to the induction of specific classes of cytokine that occurs during RSV infection, and this is an important facet of the RSV disease. In 2001 another paramyxovirus closely related to RSV was identified in the Netherlands. The virus, called human metapneumovirus (HMPV), was found in hospitalized children and produces symptoms in patients that are similar to that of RSV.

Assoc Prof Richard J Sugrue from the School of Biological Sciences (SBS), in collaboration with colleagues at KK hospital, NUH and DSO has undertaken the first study to examine the importance of HMPV infection in paediatric patients in Singapore. The work involves the isolation of hMPV from a cohort of paediatric patients at KK hospital, and the subsequent characterization of these virus isolates at the genetic level. The findings were recently published which showed HMPV to be a significant cause of lower respiratory tract infection among children in Singapore. The genomic RNA has been isolated from these HMPV isolates (Figure 1.) and is currently being used to express recombinant virus proteins. These proteins will be eventually used to prepare diagnostic reagents for the routine detection of HMPV in the microbiology laboratory.

Chiral and Pharmaceutical Sciences

Understanding chiral compounds for important pharmaceutical activities

It is now known that the enantiomers of a racemic drug have different pharmacological activities, as well as different pharmacokinetic and pharmacodynamic effects. The focus of this project will be mostly on chiral separation, chiral support material synthesis and nanoparticle synthesis. The purification of the enantiomers of chiral drugs by the Simulated Moving Bed (SMB), Crystallization and Supercritical Fluid Chromatography (SFC) methods have been done and unambiguous characterization techniques for different racemic species for chiral compounds have been developed. A systematic approach of preferential crystallization of chiral compounds combining thermodynamics, optimal operation and in-situ monitoring has also been developed. The HPLC/SFC and preferential crystallization were coupled for separating chiral compounds, resulting in green and higher yield separations.
Nano-sized achiral and chiral packing materials for Super-critical fluid Chromatography (SFC), Capillary Electrophoresis (CE) and Capillary Electrochromatography (CEC) are also being developed by Prof Ching Chi Bun, Asst Prof Kunn Hadinoto Ong, Prof Ng Siu Choon, Asst Prof Arvind Rajendran and Asst Prof Timothy Tan from the School of Chemical and Biomedical Engineering (SCBE). There are, to date, no known published studies on the application of chiral-nanomaterials. The reduction in size of packing materials is anticipated to lead to a huge increase in chromatographic resolution.

Biosensors and Bioelectronics

Integration of fundamental sciences and emerging technologies resulting in the doubling of performance for lab-on-chip system

A team consisting of Assoc Prof Li Changming, Asst Prof Chen Peng and Asst Prof Julian Chan Chi Chiu from the School of Chemical and Biomedical Engineering (SCBE) has developed a flow-through ELISA lab-on-chip system. Its great potential in various diagnostic applications has attracted the interest of prestigious companies, such as BD and BIORAD, for commercialization. A novel microbial fuel cell, which boosts the power output by two-fold compared with the best performance reported to date has also been devised. Research on nanoparticle based nanomedicines is also actively undertaken with joint efforts with Singapore National Heart Center and School of Biological Science. In another line of research, techniques for single molecule detection and single cell assays based on novel nanostructures such as nanopores, silicon nanowires, carbon nanotubes, and nano-electrochemical-electrodes are being developed. Optical sensing or imaging at both cellular and molecular levels is another aspect of the research endeavors.

Therapeutic Engineering and Regenerative Medicine

Utilizing computing techniques to develop better therapeutic procedures

Tissue engineering, a relatively new multidisciplinary field involving engineering and life sciences principles, offers the hope of organ replacement without long organ transplant waiting time.

Understanding the biophysical properties of cells on biomaterials is essential for designing new tissue regeneration processes and for developing new biomedical devices. Therefore, integrative bio-analytics are critical to the research. Using functional microscopy, optical tweezers and atomic force microscopy, the biophysical dynamics of cell regeneration, biomechanics of membranes and dynamic adhesion of bacteria are examined.

The research team consisting of Assoc Prof Chan Bee Eng Mary, Asst Prof Wang Dongan, Asst Prof Chew Sing Yian, Asst Prof Chong Chuh Khiun, Assoc Prof Vincent Chan, Assoc Prof Liao Kin, Assoc Philip Cheang Hong Ning and Asst Prof Ooi Chui Ping from the School of Chemical and Biomedical Engineering (SCBE) has used computational techniques to correlate intimal thickening in coronary artery bypass grafts and the dominating hemodynamic parameters. These parameters are being used to develop better therapeutic procedures, e.g. surgical bypass, vascular implants and tissue engineered alternatives.
Nanoparticles

Nanoparticles developed by NTU used in anti-cancer gene therapy

Led by Assoc Prof Philip Cheang Hong Ning, a research team from School of Chemical and Biomedical Engineering and National Cancer Centre (NCC) has engineered nanoparticles for use in anti-cancer gene therapy. Tests have shown that the nanoparticles can carry and transfer pieces of DNA, or genetic material, to the spleen, causing it to produce immune cells that recognize and destroy cancer cells. The tests also show that such gene therapy can prevent a cancer relapse and the result is a more targeted and effective cancer treatment with fewer side effects.

Transgenic Mice

Making New 'Mice' to Use as Disease Busters

Prof Klaus Karjalainen of the School of Biological Sciences (SBS) is working to create a new variant of mouse with an immune system resembling that of humans, in the hope of speeding up the process of drug discovery. This will allow researchers working on vaccines for immune diseases like HIV and bird flu to try them first on these mice, without the need to test on primates, which have a similar immune system to human. Source of Funding: Singapore Immunology Network.
Interface of Biology & Engineering

Biomedical-Optics

Development of diagnostic methods for early colon cancer detection with the use of fiber optics

With the deployment of fiber optics for non invasive healthcare management combined with nano-technology, sensitive optical biosensors exploiting the phase, intensity and wavelength of visible light can examine the interaction of bio-molecules in real time in early colon cancer diagnosis. Funded by Academic Research Fund (AcRF) and A*Star, the ultimate aim of this research done by Assoc Prof Murukeshan Vadakke Matham, Division of Manufacturing Engineering, School of Mechanical and Aerospace Engineering (MAE) is to develop a diagnostic method that eliminates the need for current biopsy. The recently reported endo-speckle fluoroscope is an encouraging first step in this direction.
Haemocompatibility of Amorphous Carbon Doped with Silicon

Silicon concentration influences platelet adhesion

In this study led by Prof Sam Zhang of the School of Mechanical and Aerospace Engineering (MAE), the influence of silicon concentration on the surface energy of the coatings, and the resulting blood compatibility are determined due to reduced intrinsic stress of the amorphous carbon in the fields.

![Graph](image)

Figure 1. The number of adherent platelets with increasing Si concentration.

The incorporation of silicon not only decreased the sp2-hybridized carbon bonding configurations, the static evaluation of the films incubated in human platelet-rich-plasma also showed a decrease in platelet adhesion. After some testing, the result showed that haemocompatibility is improved also at high Si concentration.

![Micrographs](image)

Figure 2. SEM micrographs of the adherent platelets on: a) uncoated Si wafer, b) a-C(Si37.6at.%) film.

Development of High Performance Fluoridated Hydroxyapatite Coatings for Biological Applications

Increasing the success rate of biological implants

Pure Hydroxyapatite, which is used in biomedical applications, has a long-term stability problem: the high rate of its bioresorption results in loosening and implant failure. In view of the fact that fluorine ions existed in human bones and teeth serve as an essential element against dissolution, a research team led by Prof Sam Zhang of the School of Mechanical and Aerospace Engineering (MAE) has developed the promising fluoridated
hydroxyapatite (FHA) coatings on titanium alloy substrates by the sol-gel dip-coating method. The FHA coatings showed similar cell morphologies and good cell viability (Figure 1.). The coatings fluoridated had a strong stimulating effect on cell proliferation and differentiation activities. Moreover, incorporation of fluorine significantly improves the adhesion strength between the coating and the substrates (Figure 2). This research is supported by a grant from the Agency for Science Technology and Research (A*STAR) and Singapore Institute of Manufacturing Technology (SIMTech).

Cells Separation Using Microdevices

A novel methodology to separate cells based on their electrical properties

The recent interest in bio-technology has seen a boom in the labs-on-a-chip micro devices. These micro devices leverage on the physical phenomena that occur at the micron scale. Among others, dielectrophoresis has been used as the enabling technology to separate different cells. A research team led by Prof Lam Yee Cheong together with Assoc Prof Yang Chun from the School of Mechanical and Aerospace Engineering (MAE), Prof Kamal Youcef-Toumi from the Massachusetts Institute of Technology, Dr Isabel Rodriguez from the Institute of Materials Research and Engineering, and doctoral candidate Kua Chin Hock, have developed a novel methodology to separate cells based on the differences in their electrical properties. The technique which they named as Moving Dielectrophoresis can simultaneously separate and transport the cells, without the necessity of any fluid flow. The work has been accepted for publication in Analytical Chemistry, a leading journal in chemistry.
BioMEMS

Faster, cheaper and better microchips for cell characterization

This project, funded by A*STAR, officially ended on 31 Aug 2006. The research has been continuing, particularly in the design and implementation of new microchips for impedance-based measurements of cells. The current research focuses on the monolithic integration of polydimethylsiloxane (PDMS) waveguides with microfluidics on the same chip, in order to provide a compact low-cost optical detection in a lab-on-a-chip platform. In this project, an inexpensive light-emitting diode was used as the light source, and a standard CCD camera captured the optical output signal. Therefore, such an integrated approach together with fast prototyping in PDMS offers a cheap and convenient solution for more complex disposable lab-on-a-chip microsystems.

![Waveguide and Fluorescein Solution](image1)

*Figure 1. Photomicrographs of the waveguide-channel coupling under no external illumination and when the excitation is sent through: a) A straight waveguide and b) 90° curved waveguides.*

Imaging The Brain

3D visualization provides insights to human brain activities

A multi-disciplinary team effort by Assoc Prof Alexei Sourin from the School of Computer Engineering (SCE), Assoc Prof Vladimir Kulish from the School of Mechanical and Aerospace Engineering (MAE), and Asst Prof Olga Sourina from the School of Electrical and Electronic Engineering (EEE), have resulted in the development of a revolutionary new software that enables 3D visualization in living colours and data processing of human brain activities. A concept of a dynamic 3D volumetric shape was employed for illustrating how the electrical signal changes through time. Its size and appearance visually reflect the brain activity.

The software developed is an interactive program, which visualizes one or several signals by modeling the respective time-dependent 3D surfaces around the 3D human head. The locations of electrodes and the surfaces of the moving EEG shapes are visualized with different colors. Two different semi-opaque moving shapes corresponding to two different EEG signals can be displayed concurrently to visually analyze the difference between the respective brain activities. The software has the ability to translate data from the standard test that measures brain activity within minutes and then processes the information, revealing additional data that cannot be determined from conventional electroencephalogram (EEG) data.
Besides just a visual comparison, one can apply set-theoretic (“Boolean”) operations to the moving shapes to isolate activities common for both of them, as well as those that are unique for either one. Furthermore, the group set-theoretic operations applied to the individual frames of the moving shape allow for isolating idle parts of the brain as well as for estimating an average level of the brain activity. This could mean that doctors now are able to forecast charges that forecast neurological events such as epileptic seizures. This new found technology can also be used to study the behaviour of the brain.

A good comprehension of the human brain is an essential area of research as neurological disorders ranging from epilepsy to Alzheimer disease affect up to 1 billion people globally, with as many as 6.8 million resulting deaths.

**Medical Imaging**

*Accurate, sensitive, and non-invasive techniques for early diagnosis of mucosal cancers*

At team of researchers which include Prof Seah Hock Soon and Assoc Prof Lin Feng at the School of Computer Engineering (SCE) are investigating a new imaging tool that can be adapted to a state-of-the-art clinic setting to provide accurate, sensitive, and non-invasive techniques for early diagnosis of mucosal cancers. The system will allow doctors to accurately diagnose cancer through images, without having to collect tissue samples. This study, conducted with a number of local hospitals, has a system that can rapidly combine images taken by an endoscope into three-dimensional diagrams that doctors can decipher easily. This collaborative work stemmed from researchers at NTU and the National Cancer Centre Singapore. The team has expanded to include researchers from Princeton University. The project is funded by SingHealth Foundation, Academic Research Fund for Research Manpower, and A*Star Biomedical Research Council.
Logistics

Simulating Staffing Needs for Surgical Instrument Distribution in Hospitals

More efficient and effective logistic and manpower management through computer simulation

![Diagram of surgical instrument distribution process](image)

Figure 1. New process of surgical instrument distribution on ad hoc orders

A research team led by Assoc Prof Arun Kumar from the School of Mechanical and Aerospace Engineering (MAE) in collaboration with Singapore General Hospital, worked in the area of manpower planning at the local hospital. Timely and accurate delivery of surgical instruments to operating rooms is critical for success in surgical operations in hospitals. Due to several problems being faced in the process of surgical instrument distribution on ad hoc orders from operating rooms, the Hospital management considered adopting a new process of surgical instrument distribution on ad hoc orders that involves staffing new healthcare assistants for delivery of surgical instruments to operating rooms. Using computer simulation, this study assessed the efficiency of the new process and recommended the optimal number of healthcare assistants needed for delivery of surgical instruments on ad hoc orders, at which healthcare assistants as well as surgical instruments could be most efficiently utilized. The results show that computer simulation is an effective tool supporting decisions on staffing needs for surgical instrument distribution in hospitals.
Ant Colony Optimization for Disaster Relief Operations

Innovative logistic management methodology for enabling faster and better relief operations

This research project is led by Assoc Prof Arun Kumar from the School of Mechanical and Aerospace Engineering (MAE) and his former graduate student Dr Yi Wei. The findings describe a solution methodology for the dynamic multi-commodity and vehicle dispatch problem arising in disaster relief activities. The logistics planning involves dispatching commodities (such as medical materials and personnel, specialized rescue equipment and rescue teams, food, and so on) to distribution centers in affected areas and evacuation and transfer of wounded people to medical relief centers. A meta-heuristic method of ant colony optimization (ACO) was proposed for the solution of the problem. The ACO meta-heuristic decomposes the original emergency logistics problem into two levels of decision making, i.e. the vehicle routes construction, and the multi-commodity dispatch. The sub-problems are solved in a sequential and iterative manner. The results indicate that this method performs well in terms of solution quality and run time consumed.

Cross Docking Planning and Dynamic Scheduling for FMCG Supply Chain

Dynamic scheduling algorithm will enable effective supply chain management in cross docking

Cross docking is an operation strategy that moves items through flow consolidation centers or cross docks without putting them into storage. A trend toward smaller and fewer warehouses will transfer many warehouse operations into cross docking operations in the 21st century. And due to the high requirement of timing and accuracy, operational performance in cross docking greatly depends on good planning and dynamic scheduling, for example, there is currently a shortage of planning policies for cross-docking operation which receives product from multiple vendors and sorts onto outbound trucks for different stores. Adding to this is the requirement to handle uncertainties such as trucks arriving late and material mismatching at the cross docking point. The objective of this project carried out by Asst Prof Malcolm Low from the School of Computer Engineering (SCE) in association with A*STAR SIMTech is to develop cross docking planning and dynamic scheduling algorithm and solution with optimal material mixing policies and RFID supported technologies for supply chain.
Social Sciences

Predictive Utility of the Protection Motivation Theory (PMT) Model for Myopia Prevention Amongst Children

Studies look at motivation factors to prevent myopia amongst children

This research project headed by Asst Prof May O’Lwin from the Wee Kim Wee School of Communication and Information (WKWSCI) examined the predictive utility of the protection motivation theory (PMT) model for myopia prevention amongst children. An integrative model for myopia prevention behavior of parents was first developed in the context of theory and survey instruments then refined using information gathered from two focus groups. Empirical data then was collected from parents of primary school children in Singapore, a country with one of the highest rates of myopia in the world, and analyzed using structural equation modeling (SEM). The research revealed that coping appraisal variables were more significantly associated with protection motivation, relative to threat appraisal variables. In particular, perceived self-efficacy was the strongest predictor of parental intention to enforce good visual health behaviors, while perceived severity was relatively weak. Health marketing communications and public policy implications are discussed. This research project was also successful due to the overseas collaboration with Jerome D Williams from University of Texas at Austin, Aradhna Krishna from University of Michigan, Maria Hoy from University of Tennessee, Ross D. King from University of Wales and local collaboration with Saw Seang Mei, Jochen Wirtz and Susanna Leong from National University of Singapore.

NTU Economists Forecast China’s 2007 Macroeconomic Performance

Economists from NTU’s Asia Research Centre (ARC) and Xiamen University’s Macroeconomic Research Centre give an assessment of China’s economic outlook, using a quarterly macroeconometric model jointly developed by the two universities. The NTU team comprised Assoc Prof Chen Kang, Assoc Prof Tan Khee Giap and ARC Director Prof Tan Kong Yam, a group of academics who have developed a global reputation for their work.
NTU's MBA Ranked Best in Singapore and Top 3 in Asia Pacific

Nanyang Business School (NBS)'s MBA programme has been ranked the best in Singapore and third in the Asia Pacific region in the Financial Times’ listing of the top MBAs in the world. NBS is placed in the 67th position, above local universities and well-known global names like Washington University's Olin School, the University of British Columbia’s Sauder School of Business and Melbourne Business School of the University of Melbourne. On average, NBS’ MBA graduates chalk up an increase of 110% in salary three years after graduation. Full-time MBAs have the benefit of cross-cultural learning from a diverse international population of participants and teaching faculty.

Launch of IPS-NTU Report on Competitiveness Ranking and Simulations of 79 Asian Economies

Findings of a ranking by NTU and IPS of 79 Asian economies, comprising 10 ASEAN nations, 34 Greater China economies and 35 Indian states, indicate that six out of 10 ASEAN countries made it to the top 15 competitive economies, with Singapore placed third behind Hong Kong and Taiwan. The NTU economists behind the ranking were Assoc Prof Tan Khee Giap, Assoc Prof Chen Kang and Prof Tan Kong Yam.
Chemistry and Chemical Engineering

A Magnet-Driven PCR Reactor for DNA Amplification

New efficient and effective technique for chemical and biochemical analysis

Microfluidic is an enabling technology for chemical and biochemical analysis. New microfluidic technologies allow designing better tools for many applications including forensic investigation at crime scenes. DNA can be rapidly and reliably replicated by polymerase chain reaction (PCR). DNA samples are driven by a liquid magnet in a circular closed loop through three different temperature zones.

Completing one loop doubles the amount of DNA in the sample. The miniature PCR device designed by Assoc Prof Nguyen Nam Trung from the School of Mechanical and Aerospace Engineering (MAE) and Asst Prof Kwok Yien Chian from the National Institute of Education (NIE) is simpler and more reliable than existing methods because there is no need of micro pumps and other mechanical parts. In this system, the DNA sample is driven by a ferrofluid plug controlled by an external permanent magnet. Successful PCR was achieved in less than 4 minutes. The external magnet is a good way to drive the system as it is low cost, has small power consumption. Current designs commercially available on the market face problems of temperature control, high driving pressures and leakage. The development of the device was funded by NTU and NIE. The work was published in the journal “Lab on a Chip” and highlighted in the magazine “Chemical Technology” in July 2007.
Civil and Environmental Engineering

Membrane Technology

A novel ceramic membrane technology for recycling used oil

Waste oil reprocessing is a market worth $S2 billion in Asia annually, and the Institute of Environmental Science & Engineering (IESE) at NTU is making sure Singapore gets a fair share.

Used lubricating oil is commonly recycled using re-refining technology, which is expensive and difficult to employ. IESE, however, has developed a new method using a ceramic membrane-based technology that will greatly reduce the cost. Such recycled engine oil from PSA Corporation, after blending with fresh engine oil, has been tested on small-scale equipment without a hitch.

A joint venture company is also being formed with a private environmental company.

Reinforced Walls

Wall-reinforcement technique may save lives in earthquakes

Researchers at NTU’s Lien Institute for the Environment (LIFE) have come up with a simple technique to strengthen brick walls against abrupt collapse during an earthquake.

The technique consists of sticking criss-crossing canvas strips across the brick wall to provide the restraint against abrupt collapse. They found that the reinforced walls can withstand twice as much shaking. This translates to more escape time and less chance of injuries from falling bricks. The Institute is already working with two aid groups in Indonesia to reinforce homes and schools using this technique.

Underwater Robot

An underwater robot that mimics an amoeba for purpose of underwater inspection or observation

NTU’s scientists led by Assoc Prof Chen I-Ming, Director of Intelligent Systems Centre (IntelliSys), have created an underwater robot that could save precious marine life. Called the Amoebot, this underwater robot swims by changing its shape, just like an amoeba. Amoebot is not only able to move against a current and navigate among obstacles; it also leaves surrounding marine ecology and environment undisturbed, making it perfect for underwater inspection or observation of the type undertaken by marine and coastal engineering and the underwater leisure industry.