EARTH OBSERVATORY OF SINGAPORE (EOS)

- **Tectonics: Earthquakes and Tsunamis**

Southeast Asia and the surrounding areas have many large, active faults, as well as a few major subduction zones that are responsible for some of the world’s most complex movements of tectonic plates. Earth Observatory’s broad research goal in this area is to increase fundamental knowledge of the region’s tectonic and seismic behaviour, as a basis for developing more reliable forecasting of earthquakes and tsunamis as well as preparation and education to reduce the potential risks and hazards. A host of integrated geologic, geomorphic, geodetic and seismologic studies are being done in collaboration with scientists in neighbouring countries.

- **Volcanoes**

Volcanic arcs in Southeast Asia are among the most active on earth. The volcano group within EOS conducts multidisciplinary studies to improve our understanding of volcanic activity that may or may not lead to eruptions. Mayon in the Philippines and Gede and Salak in Indonesia are key research sites because they represent contrasting patterns of degassing. The group is also expanding their mineable global database on volcanic unrest, known as WOVOdat. These and other projects are designed to produce knowledge and tools that will aid forecasting of volcanic eruptions, assessment of their environmental and societal impacts, and efforts to mitigate the hazards.

- **Climate Change**

This area of EOS research aims to fill a gap of much-needed information on climatic forces in Southeast Asia, which will allow better prediction of regional consequences that can be expected from global climate change. Several major drivers of global climate, including the Western Pacific Warm Pool and the Indian Ocean Dipole, are active in this tropical region, yet scientific knowledge about them has been relatively scarce. Our emerging program of climate research is concentrating initially on regional climate monitoring, paleoclimate studies and modelling of past and modern tropical climates.

ENERGY RESEARCH INSTITUTE @ NTU (ERI@N)

Established in June 2010, the Energy Research Institute at NTU (ERI@N) envisions to be a leading research institute for innovative energy solutions. The Institute distinguishes itself through excellence in basic research directed towards outcomes of high industry relevance. ERI@N integrates research across NTU as a whole in the context of the energy challenge, and then helps translate outcomes into practice.
ERI@N’s mission manifests itself into a comprehensive effort on Energy Generation, Conversion and Storage Systems, Grid Systems, and Urban Solutions, in a “Living Lab” environment with a particular focus on solutions for Megacities and for the Tropical Environment.

ERI@N has built up a critical mass of expertise along a three-pronged construct:

1. Interdisciplinary Research Programmes (IRPs) are the core of ERI@N’s applied research focus:
   i) Renewables and Low carbon generation,
   ii) Energy Storage & Fuel Cells,
   iii) Renewables’ Integration & Microgrids,
   iv) Multi-Energy Systems and Grids,
   v) Sustainable Building Technologies,
   vi) Future Mobility Solutions, and
   vii) Maritime Clean Energy Research.

2. Flagship Programmes deliver bold and significant outcomes in rational energy end-use and renewables integration:
   i) EcoCampus
   ii) Renewable Energy Integration Demonstrator -Singapore (REIDS)

3. ERI@N Accelerator Programme (EAP) takes the initiative to provide support and galvanize entrepreneurship to bring innovations from the lab to the real-world.

ERI@N works closely with Singapore public agencies (e.g. NRF, EDB, EMA) and private sector entities in support of on-going energy transitions, while also remaining sensitive to the diverse needs of South East Asia. It does so in close collaboration with both local and global industrial partners as well as with world-leading academic institutions and research laboratories.

Moreover, a large group of researchers and staff (more than 200 research staffs and 150 PhD students from 26 nations across the world) with their wide skillsets and expertise in Science, Engineering, Technology, Policy and Social Science makes a vibrant, multidisciplinary and collaborative research environment at ERI@N enabling it to achieve national sustainability goals and develop energy technologies with global relevance.

INSTITUTE FOR MEDIA INNOVATION (IMI)

Vision
The Institute for Media Innovation (IMI) at Nanyang Technological University (NTU), Singapore is a world-class research institute in Interactive New Media launched in April 2008 by Professor Bertil Andersson. It is directed by Professor Nadia Magnenat Thalmann, a world renowned authority on virtual reality research. IMI positions itself as an incubator of cutting edge and interdisciplinary new media-related research. The institute provides collaboration opportunities for researchers and experts on a wide array of multidisciplinary research projects, such as autonomous physical & virtual social robots, 3D medical simulations, 3D modelling, 3D fashion,
and virtual reality, etc. IMI collaborates with the Interdisciplinary Graduate School (IGS) by educating and training PhD students in New Media research areas.

Mission
• To develop cutting-edge new media research in its core research group.
• To lead the research and the international collaboration of the BeingThere Centre in 3D Telepresence.
• To create synergy and interactions with NTU schools to empower New Media interdisciplinary research through integrated projects and joint PhD supervisions.
• To promote and develop industrial applications in Singapore and elsewhere in the world.
• To organize or participate to local and international events such as conference, workshops, seminars and lectures.

Overview
The Institute for Media Innovation through its core research group has developed cutting-edge research in 3D Immersive situations, 3D interactive games, 3D fashion, 3D crowd simulation and 3D immersive medical applications in link with the LKC School of Medicine. IMI core group has created behavior for an innovative realistic female humanoid robot that is able to interact with people and recognize sound and gestures. Motion capture techniques have been also developed in order to analyze body motion. The core group in IMI has funded and facilitated collaborative multidisciplinary research projects in various fields of interactive digital media. 27 collaborative projects with the participation of NTU schools have been achieved. For example, we can cite the Virtual Pink Dolphin project, the faces segmentation and Expression for Autonomous Avatars, the Award winning film Unframed, and the interactive crowd. IMI core group has organized 5 international top conferences in the field of New Media and 12 workshops and 10 joint seminars with other schools. The IMI core group has welcome more than 134 visits so far and showed its latest demos. IMI core group interacts with more than 30 PhD students in New Media located in IMI and coming from different schools. Each student presents her latest research on the IMI Research Seminar that is held once a month in IMI. The core group together with the PhD students, has published more than 260 top publications so far.

The International Centre, BeingThere, on 3D Telepresence has been established since December 2010 at IMI with an overall funding of 23 Million Singapore dollars. It groups together key international partners - Swiss Federal Institute of Technology (ETH) at Zurich in Switzerland, the University of North Carolina (UNC) at Chapel Hill in the United States, and Nanyang Technological University (NTU) in Singapore. In this project, over 15 faculties in NTU have focused their research on various aspects of the Telepresence research and in particular, on virtual humans and social robots who can act as substitutes or additional human resources.

IGS PhD in New Media @ IMI
By enrolling in the Interdisciplinary Graduate School at NTU and selecting the Institute for Media Innovation (IMI) as research institute, students have the great opportunity to prepare a PhD in New Media in the dynamic environment of IMI. Playing a crucial part in ensuring the future of New Media in Singapore, IMI aims to educate the next generation of scientists and technologists and encourage them to share and benefit from their knowledge of engineering, business, design, educational and behavioral research.
IMI offers doctoral students vibrant multidisciplinary research capabilities. In particular, they will have an opportunity to work in the area of cutting-edge interactive 3D simulation with top
equipment as Immersive Room and real-time motion capture in a multidisciplinary team. Through their personal work, seminars, courses, and interaction with research experts, PhD candidates are prepared for research positions in leading academic institutions as well as private and public organizations.

Key Research Areas at IMI

1. **BeingThere Centre on 3D Telepresence**

The BeingThere Centre (BTC) was launched in December 2010 and has as its long-term goal the creation of a social interaction framework with a human-like robot or virtual human that would be autonomous, express emotions, and exhibit realistic behaviour. The Centre is composed of groups from the University of North Carolina (UNC), Eidgenössische Technische Hochschule (ETH) and NTU. Research into this technology focusses on four prototypes – a room-based telepresence system, mobile autostereoscopic 3D display and telepresence platform, mobile animatronics telepresence system, and autonomous Virtual Humans and Social Robots for 3D telepresence. To date, BTC research has led to 18 technical disclosures with licensing agreements under negotiation with the start-up Lythal Pte Ltd and the University of Central Florida. More than 137 persons including researchers and PhD/Master/Undergraduate students have been engaged in the Centre’s research. Totally 96 papers have been published in highly recognized international journals and conferences including IEEE Transactions on Pattern Analysis and Machine Intelligence, ACM Transactions on Graphics, IEEE Transactions on Image Processing, etc. The members of the Centre have received 15 international Awards and have 3 patents filed provisionally. 1 spin-off company has been created.
2. Virtual Humans and Social Robots

This project is exploring novel methods for real-time, human-robot and human-virtual human interactions. This includes:

- Multi-modal tracking and analysis of users’ behaviour in noisy environment
- Autonomous behaviour generation for interactions between users, robots and virtual humans in uncontrolled setups
- Advanced virtual and telepresence experience to support interaction among distant users, virtual humans and robots

3. Immersive Interaction

In this project, we develop first models of autonomy for virtual players in order to make them play in an autonomous way together without any human intervention. In a second phase of the project, we mix real and virtual players who should team up together to play a volleyball game. This research implies vision based techniques, real time analysis of who is doing what, being real and virtual, and how to cooperate together. We will then work on tele-presence with several real players playing on different devices such as Oculus Rift.
4. Augmented & Mixed Reality Seeing Through Project

The project “Seeing Through”: Immersive Real-time Display for Teaching Digital Rectal Examinations on a Bench-top Model, is a join cooperation between Imperial College London, NTU’s Institute for Media Innovation and Lee Kong Chian School of Medicine. Its goal is to create a real-world-augmented simulation of a “DRE” procedure by utilizing latest technologies in 3D scanning, positional tracking and VR-visualization. The project goal is to allow medical students to perceive the procedure with additional information and feedback, which are not available in regular teaching process.

5. Virtual Pink Dolphin-assisted Therapy for Children with Autism – Phase 2

We develop educational games for learning and training purpose with the aid of virtual tutors or virtual trainers. We work particularly to train autism children to interact with virtual dolphins.
6. Intelligent and Interactive Simulation for Industrial Heavy Lifting

In this project, we develop a simulation-enabled solution to interactively optimize the crane lifting and rigging operation in virtual plant environments. Virtual Reality (VR) technology will be developed to model the cranes and virtual plant environment in 3D, as well to simulate the crane dynamic movement in the virtual 3D environment. Efforts will be made on optimization focusing on 3D obstacle avoidance. IMI and PEC have entered a Research Collaborative Agreement for this project (Phase 1 and Phase 2).
7. **3D Fashion**

To experience a virtual fashion show, IMI has designed a dozen of real cloth models, and has simulated them on virtual models. In the immersive room, we can see these various virtual models wearing 3D clothes. The user can really feel the presence of these models walking along the 320 degrees screen.

8. **3D Crowd Simulation**

The research of crowd simulation in IMI focuses on the interaction and immersion of the virtual crowds. The immersive 3D display system has been successfully built, which has great potential for the training and evaluation of emergency evacuation and other real-time applications of crowd simulation with interaction.

**INSTITUTE OF CATASTROPHE RISK MANAGEMENT (ICRM)**

In recent years, we have witnessed massive increase of human and economic losses due to catastrophic events. These events are either natural or manmade. This increase of losses is due to globalization, urbanization, and global climatic change. As a result, the nature and effects of these disasters have also changed. The high level of economic activities and the inter-relationship of nations to such activities have brought out some unique and non-traditional risk management issues.

In Asia, where the risk awareness is low and the risk is high, the situation poses special problems and challenges. These include understanding and recognizing risk, risk quantification (monetary, social and human) as well as risk management. NTU’s Risk Research Agenda is driven by the
principle that catastrophic risk impacts the functioning and effectiveness of the whole fabric of society and businesses. Developing strategies for mitigating these risks will require a robust public-private partnership amongst government agencies, academia and industry players. ICRM is leading the charge at NTU through some of its current major research programs including:

1) Future Resilient Systems (FRS)
Through the Singapore-ETH Centre (SEC), ICRM is leading the NTU-side effort in partnering with ETH, NUS and SMU on the CREATE program on Future Resilient Systems (FRS). Asia is undergoing massive growth of its urban areas along with corresponding growth of its critical infrastructure systems such as for water, transport, communications and power. The resilience of these infrastructure systems to hazards or shocks is critical for ensuring the health and safety of the population. Developing an understanding of the resiliency of infrastructure systems is complex, in that the infrastructure systems are individually themselves large and inter-linked and can exhibit totally unexpected system responses which can even result in cascading failures across the entire system of systems. Specifically ICRM will examine the risk to a city’s critical infrastructure and particularly power networks under present and future configurations. The goal is to address challenges faced with interwoven infrastructure networks by developing frameworks, concepts and tools to make interconnected infrastructure systems more robust and resilient.

2) Natural Catastrophe Data Analytics Exchange (NatCatDAX) Initiative
Data necessary for catastrophe risk quantification in Asia and Southeast Asia are generally poor in terms of availability, accessibility and quality. In an environment of low insurance penetration and fragmented markets, this contributes to: (i) lack of modelling input for “blind” spots, (ii) lack of data standards, and (iii) lack of robust and updated catastrophe models which are dependent on both exposure data and loss data for validation. Application of innovative insurance and reinsurance products and risk transfer instruments based on parametric triggers is thus practically impossible, in the absence of quality underlying data. Headquartered in ICRM, the NatCatDAX Alliance will be set up as an association of academia, government and industry group to address the above mentioned data and modelling gaps, through catastrophe data and analytics platform for Asia Pacific and starting with Southeast Asia. The Alliance has the objectives of: (i) increasing availability of quality data through fusion of remotely sensed data and national data, (ii) enhancing underwriting process, (iii) spurring collective market analytics and product innovation, and (iv) underpinning needed catastrophe research.

LILY RESEARCH CENTRE

The LILY Research Centre (Joint NTU-UBC Research Centre of Excellence in Active Living for the Elderly) was jointly established by NTU and The University of British Columbia (UBC), Canada. It is funded by the National Research Foundation, Prime Minister’s Office, Singapore under its IDM Futures Funding Initiative administered by the Interactive and Digital Media Programme Office. Major research directions being conducted by the LILY Research Centre include but are not limited to: artificial intelligence, data analytics, machine learning, crowd sourcing, affective computing, trustworthy computing, human-agent interaction, personal informatics, unobtrusive sensing, social cognitive processing, etc.
MULTI-PLATFORM GAME INNOVATION CENTRE (MAGIC)

Game System & Infrastructure
Interactivity, consistency, and scalability are three essential requirements for MMOGs. The research in System & Infrastructure will be focusing on problems related to the above mentioned requirements and develop corresponding infrastructure and system support solutions, including (1) consistency requirement and interactivity analysis; (2) resource provisioning; (3) MMOG on the Cloud; and (4) mobile gaming support.

Game AI
Since MMORPGs are normally resource-intensive, having to handle the vast number of players and the time synchronization among these players in a large-scale persistent game world, MMORPG companies have traditionally devoted most of the technical and research effort on database engine, graphics and networking, but place little attention to explore and harness the potential of Artificial Intelligence (AI) research. As a result, the present capacity of AI technologies that have been incorporated within commercial MMORPGs remains low in comparison. However, it is envisaged that games with strong AI content will likely make a significance in future commercial games. The AI research in MAGIC will focus on the modeling of high-order domain intelligence and embedding the developed technologies as programmable entities in AI-controlled characters for MMORPGs, using a gene-meme coevolution multi-A-Life framework. The gene-meme coevolution A-Life paradigm shall increase the game entertainment value by eventually blurring the line between Player vs. Environment (PvE) and Player vs. Player (PvP) games in their subtlety, complexity and ferocity within the MMORPG game world.

Gamification & Society
Gamification usually applies game design techniques and mechanics to solve problems and engage audiences for non-game applications and processes. One flagship project in MAGIC is to use humans to “compute” solutions to public policy issues and in so doing concurrently gauge public reactions to these solutions. A large-scale multilevel social game will be developed, with 5,000 to 10,000 players being presented with complex public policy issues in a living simulated Singapore. By asking players to propose, pitch, and rate solutions and their proponents, this game serves as a tool for public policy planning and adoption. The objective of this social policy game will be primarily for analysis and understanding of how certain aspects of social policy are impacted by social interaction and social networks. The analysis will focus on mining the vast activity logs generated by the social game, to determine what in-game information participants processed before deciding which proposed solutions they favor. As a concept, this game will present a unique case study which applies serious MMORPG in the context of solving real world problems. The research achievements will also be applied to solve other problems outside the entertainment game industry.

Game Analytics
Although the application of game analytics is expanding for social and mobile games, not much has been focused on the MMO. Yet it is important to detect and analyze player behavior and reaction based on a variety of indicators, e.g. time engagement, consumption preferences and patterns, etc. so that game developers can design better game experience resulting in longer playtime, increased purchases, and more targeted in-game advertisement. MAGIC will be
collecting and analyze the above-mentioned data, targeting at providing game developers guidance for creating better games.

MAGIC will also conduct research on user attention tracking. A system is to be developed to track the key facial points of the user in real-time, in order to identify the attention centre. To achieve this goal, the key challenge is to robustly and precisely track the key facial points of the user. In this research, we first plan to use the existing multi-view face detection techniques to detect faces. We also plan to investigate how to integrate the information from both color and depth images for robust multi-view face alignment. We will study new classification algorithm based on boosting for this application. We will also investigate other face analysis technologies for blink detection and mouth tracking to further improve the effectiveness of human-computer interaction. By analyzing the recorded information about user attention during a period of time, user behavior analysis can be conducted to better understand the user’s interests. Such analysis is also crucial for game developers to further improve the players’ gaming experience.

**Game Security**
Cheating reportedly exists in most multiplayer online games, but it is difficult to measure. The Internet and darknets (any private, distributed P2P file sharing network, where connections are made only between trusted peers using non-standard protocols and ports) can provide players with the methodology necessary to cheat in online games, and there are many facets of cheating in online games which make the creation of a system to stop cheating very difficult. Server-side game code makes a trade-off between calculating and sending results for display on a just-in-time basis or trusting the client to calculate and display the results in appropriate sequence as a player progresses. It can do this by sending the parts of the world state needed for immediate display, which can result in client lag under bandwidth constraints, or sending the player the entire world state, which results in faster display for the player under the same bandwidth constraints, but exposes that data to interception or manipulation—a trade-off between security and efficiency. MAGIC will look into the trade-off described above, investigating on anti-cheating / anti-hacking techniques related to network security, game files integrity etc.

**Network Optimization**
Network latency is a measure of how fast a network is running. The term refers to the time elapsed between the sending of a message to a router and the return of that message (even if the process only takes milliseconds, slowdowns can be very apparent over multi-user networks). Latency problems can signal network-wide slowdowns, and must be treated seriously, as latency issues cause not only slow service but data losses as well. At the user level, latency issues may come from software malfunctions; at the network level, such slowdowns may be a result of network overextension or bottleneeking, or DoS or DDoS activity. Considering the current status of networking infrastructure in South East Asia, network optimization is quite an important research topic for MAGIC. The main research focus will be how to reduce latency, spike, and reduce bandwidth requirement etc.

**Game Physics & Graphics**
Game physics involves the introduction of the laws of physics into a simulation or game engine, particularly in 3D computer graphics, for the purpose of making the effects appear more real to the observer. Typically, simulation physics is only a close approximation to real physics, and computation is performed using discrete values. In most computer games, speed of simulation is
more important than accuracy of simulation. This leads to designs for physics engines that produce results in real-time but that replicate real world physics only for simple cases and typically with some approximation. More often than not, the simulation is geared towards providing a "perceptually correct" approximation rather than a real simulation. The research on game physics & graphics in MAGIC will focus on achieving high simulation accuracy while preserving high simulation speed to further enhance players’ gaming experience.

**Game Content Creation, Publishing, and Management**
The virtual worlds of games are purified reflection of our real world. This reflection is usually honest so that players can quickly immerse into the virtual worlds. Measuring the real world and map it to virtual worlds becomes a very important approach. MAGIC aims to develop dynamic 3D profile sensing technology and system to truly record the interesting part of our world, which greatly eases the content creation. In terms of publishing and management, MAGIC will be conducting R&D to develop a publishing and management platform, linking hybrid distribution channels in South East Asia, and encapsulate them with a payment module which supports micro-payment, and provide the platform to all game developers. The platform can be easily integrated for online game purchasing or in-game transactions, and help game developers to publish their games more efficiently and widely.
NEWRI develops technology and engineering solutions. Solutions are based on transdisciplinary and in-depth scientific know-how and application experiences. We are ranked among the top research organisations in the environment & water domain. NEWRI is part of the Nanyang Technological University, Singapore.

NEWRI has teamed with industries worldwide as a technology and solutions provider in the domain of environmental engineering. We are at the forefront of fundamental scientific research which provides the basis for our innovations. Our 400-strong scientific research and engineering manpower are led by globally ranked thought leaders in the domain. NEWRI does not stop at research but continues into de-risking its IPs and technologies to better meet the needs of industry, guided by our Research-Engineering-Deployment (RED) philosophy.

NEWRI is structured to create engineering innovations relevant to the community and industry. As cities grow, emerging challenges include aged waste treatment infrastructure, space constraints for waste management, changing wastes load and characteristics, and the need for tailored solutions. Our people and know-how have been deployed to solve problems in the real setting and at full-scale, through our 5 Centres of Excellence:

<table>
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<tr>
<th>Centre Name</th>
<th>Research Focus</th>
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<tr>
<td>Advanced Environmental Biotechnology Centre (AEB – NEWRI)</td>
<td>AEBC has the capability of addressing scientific and industrial challenges arising from the entire value chain of wastewater reclamation and biosolid management. Their strong fundamental and applied environmental microbiology research platforms address complex wastewater-energy-greenhouse gas nexus by building foundations on mechanisms of flocculation and deflocculation, membrane biofouling, spatial distribution and interaction of functional species in a bioprocess and energy and resource recovery from wastewater and biosolid.</td>
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<td>Environmental Process Modelling Centre (EPMC – NEWRI)</td>
<td>EPMC (DHI-NTU repositioned) focuses on the development of state-of-the-art capability in high performance hydrodynamic / hydro-environmental system modelling and simulations. The research in the Centre addresses complex infrastructural issues in urban environments subject to climate changes, as well as multi-scale and multi-objective projects in the region. EPMC is rooted firmly on the development of expert modelling tools for engineering applications, as well as collaborative partnerships in the environmental and water industry.</td>
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<tr>
<td>Residues and Resource Reclamation Centre (R3C – NEWRI)</td>
<td>R3C focuses on solution-oriented integration of waste management such as thermal, bio, physical / chemical upcycling as well as on-site pol lutants detection in its waste-to-energy, waste-to-resource and contaminated site remediation endeavours. It looks at customized waste management solutions from various sectors with cutting edge research such as gasification, IBA resource recovery and remediation, strengthening Singapore environmental industry’s capability in the area of waste resource management.</td>
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<tr>
<td>Singapore Membrane Technology Centre (SMTC – NEWRI)</td>
<td>SMTC is entrenched in a cross-disciplinary research area of membrane technology for the environment, water, energy and cleaner production through membrane applications for bio-pharmaceutical, food, petrochemical, electronic industries. SMTC’s efforts in research, engineering and deployment has resulted in many collaborations with other universities and industry partners.</td>
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<tr>
<td>Environment Chemistry and Materials Centre (ECMC – NEWRI)</td>
<td>ECMC has world class capabilities in environmental catalysis and catalytically-driven AOP processes for waste water treatment, as well as assessment of green and smart adsorbents and environment sensing. ECMC’s research, innovation and industrial applications extend to Water Chemistry and Technology to Environmental Chemistry to Environmental Materials. Highlights include dual-functional materials for separation-catalysis, novel electrode for efficient EC degradation of phenols, hierarchically porous catalytic ceramic membrane and rapid drinking water disinfection.</td>
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Research interests include:

- Energy-efficient biological processes for wastewater reclamation
- Industrial wastewater management with the focus on mitigation of inhibitory and toxic materials
- Biosolid management and energy/resource recovery
- Modeling and system control of biological processes
- Microbial community analysis and bioaugmentation of biological processes

Research interests include:

- Surface, coastal and ground water management
- Hydrologic and hydro-environmental modelling with field measurements
- Industrial water management
- Process modelling and control
- Environmental Impact assessment
- Decision support modelling

Research interests include:

- Waste to Materials – Converting wastes into new and useful materials
- Waste to Energy – Harnessing energy from urban biomass, sewage sludge, agricultural residues.
- Contaminated Site Remediation – Developing solutions and technologies for remediating contaminated sites
- Thermal upcycling / Physical /Chemical upcycling
- Tar reforming and desulfurization for syngas upgrading
- Leachate-route-receptors relationship
- Bottom/Fly ash geo-polymerization with marine sediment
- On-site detection methodology
- Role of humic substances in landfill stabilization

Research interests include:

- Novel membranes (based on biometric, forward osmosis (FO), pressure retarded osmosis (PRO), low pressure nanofiltration (NF) and membrane distillation (MD) membranes
- Enhanced module and system design through hydrodynamic modelling and design optimization via 3D printing technology
- Membrane and process characterization non-invasive, online sensors (smart membrane system)
- Fouling control via anti-fouling surfaces and novel cleaning strategies
- Energy harvesting from brines by pressure retarded osmosis (PRO) technology
- Novel membrane bioreactors (MBR) including forward osmosis MBR, membrane distillation MBR, anaerobic MBR, extractive MBR and fluidized bed MBR
- CO2 separation with membrane contactor for biogas upgrade and greenhouse gas (GHG) capture

Research interests include:

- Physico-chemical wastewater treatment
- Chemistry enabled ‘mining’ of biomasses and emerging wastes
- Advanced oxidation processes
- Sustainable adsorbents and absorbents
- Water disinfection devices
- Specialty product water
- Catalysts and catalytic processes
- Advanced environmental analysis / Atmospheric chemistry
- Green and smart adsorbents & draw solutes
- New materials for non-conventional membrane filtration
- Green and smart adsorbents & draw solutes

Highlights include dual-functional materials for separation-catalysis, novel electrode for efficient EC degradation of phenols, hierarchically porous catalytic ceramic membrane and rapid drinking water disinfection.
With **Research-Engineering-Deployment (RED)** as a guiding philosophy, we are in a unique position to bridge research innovation with engineered solutions to be deployed in a commercial setting. NEWRI’s know-how and innovation stem from fundamental research that is industry-driven. To ready our innovation for the uptake by our industry partners and spinoffs, we have engineered solutions to tackle challenging issues that have brought Lab scale to Pilot Scale and eventually Full Scale. NEWRI is structured to create Engineering Innovations that continues to derisk, monetise IPs and Technology. Our Innovation Cluster (ART) de-risk our technology development from applied research (prototype level - TRL 2 - 4) to pre-commercial scale (TRL 6 - 8).

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<tr>
<th>Applied Research</th>
<th>NEWRI&lt;br&gt;Technology (NEWRITech)</th>
<th>NEWRI&lt;br&gt;Comm (NEWRIComm)</th>
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<td><strong>One of the challenges for commercialisation of IP-protected novel technologies, is the translation and bridging the gap between laboratory processes, results and testing, and full-scale final product. This comprises several key challenges, including scaling up component materials and equipment, system level thinking, and testing at pilot scale in an actual application setting.</strong> NEWRI’s ART (Applied Research and Translation) leads and facilitates the bridging process in three-fold - ST-ART, WW-ART and WIE-ART.</td>
<td><strong>NEWRI’s know-how has impacted the environment for the better through successful delivery of both industrial and community projects in the Asian region. Our contiguous value chain commits our people and innovations to deliver real benefit and have made a difference in the water and environment industry.</strong> NEWRITech leads the business of research connecting industry to our research, leveraging on our innovations and expertise. This has evolved into spinoff companies, integrated with the industry and addressing real challenges in commercial projects.</td>
<td><strong>NEWRI’s community development arm, NEWRIComm, was set up to apply the institute’s research and engineering capabilities to make a meaningful impact on the lives of people, especially those unable to access clean water.</strong> The organisation partners philanthropists, foundations, global institutions and corporate entities to develop water and sanitation-related development work to make social investments for a better shared future.</td>
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Please visit [http://www.ntu.edu.sg/newri](http://www.ntu.edu.sg/newri) for more information.
RAPID-RICH OBJECT SEARCH (ROSE) LAB

The Rapid-Rich Object Search (ROSE) Lab was conceived in view of the proliferation of mobile internet devices and the growing need to expand search beyond text’s limited capability in describing real-world objects. The Lab is a joint collaboration between NTU and Peking University (PKU), one of China’s top universities. The Lab aims to build one of the largest databases of structured domain objects in Asia, and to develop innovative visual object search technology.

Since 2012, the ROSE Lab has secured 19 industry partners, including Tencent (one of the largest Internet companies in Asia), NVIDIA (the world’s leading visual computing company), Accenture (one of the world’s leading management consulting companies), OMRON (a leading Japanese industry automation company), and Nielsen (one of the world’s leading market research and measurement companies).

The lab’s research focuses on mobile object search platform upon cloud services, and the research topics include:

- Large-scale Object Database and Analytics
  - Media object database design
  - Semi-supervised and unsupervised data collection
  - Database indexing and maintenance
  - Database optimization for search

- Scalable Visual Object Search
  - Visual object representation and understanding
  - Fast object retrieval and recognition
  - Deep Learning and unsupervised learning
  - Face spoofing detection and aging prediction
  - Object and human tracking
  - Visual anomaly detection
  - Action and gait recognition
  - Person re-identification with multiple non-overlapping cameras
  - Scene understanding and reconstruction
  - Mining persons of interest

- Media Cloud Platform
  - Cloud platform optimization for search and media services
  - GPU architecture design and optimization for machine learning

- Media Processing
  - Video analytics
  - Image and video coding
  - Image Quality measures
SINGAPORE CENTRE FOR ENVIRONMENTAL LIFE SCIENCES ENGINEERING (SCELSE)

The Singapore Centre for Environmental Life Sciences Engineering (SCELSE) is a unique interdisciplinary Research Centre of Excellence (RCE) and global leader exploring microbial biofilms to discover, control, and direct their behaviour for sustainable environmental, engineering, public health and medical applications.

SCELSE is funded by Singapore’s National Research Foundation, Singapore Ministry of Education, Nanyang Technological University (NTU) and National University of Singapore (NUS), and is hosted by NTU in partnership with NUS.

SCELSE research focuses on the universality of microbial biofilm communities, employing high resolution ‘omics tools (genomics, proteomics, and metabolomics), computational biology, state-of-the-art biofilm imaging and laboratory-to-pilot scale bioreactors to investigate microbial biodiversity and function in complex systems.

SCELSE has well-established links with several biomedical, life sciences and engineering schools/departments at NTU and NUS, together with industry, government and academic partners in Singapore and abroad. These provide a unique and diverse platform for addressing cutting-edge biofilm research questions. SCELSE’s research model ensures all facets of biofilm research are rigorously investigated, employing ecological theories to link processes at difference scales to evaluate and predict biofilm community behaviour under varying conditions, such as environmental stress.

The exploratory power available to SCELSE researchers, combined with a singular level of interdisciplinary expertise presents a unique opportunity for delivering comprehensive understanding microbial systems and developing the translational approaches that will deliver technological benefits and biofilm control applications, based on rapid advances made in life sciences research.

SCELSE’s key research areas and projects include:

- Experimental defined multispecies biofilm
- Emergent properties of biofilm matrix
- Biofilm-driven bioprocesses
- Host-microbiome (holobiont) interactions
- Urban water cycle microbiomes and microbial processes
- Air microbiomes: genomics, connectivity and adaptive responses
- Pathogen detection and control
- Antimicrobials and antibiofilm drugs
- High resolution biofilm imaging
- Genomics and bioinformatics
- Systems biology of microbial biofilms