College of Engineering
NTU Singapore

A better world through creativity and technology
Research

Research is a vital building block of excellence at CoE. Through inter-disciplinary research and collaboration with peer universities, research institutes and companies locally and abroad, we have made our mark on the international scene with research output par excellence and impactful solutions.

Research Powerhouse

We are a global leader in research and technological inventions. Collaborating closely with other research institutes in the university such as Nanyang Environment and Water Research Institute (NEWRI), Energy Research Institute@NTU (ERI@N) and Singapore Centre for 3D Printing (SC3DP), the College further pushes research boundaries and milestones in research.

With research output ranked among the top three* universities in engineering globally, we have made our mark in innovation and technological leadership.

* Source: Essential Science Indicators 2015
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Research

NTU has invested heavily in research, establishing some of the best equipped laboratories and research centres in the world. We have acquired a global reputation in many research fields including advanced materials, biomedical engineering, clean energy, nanotechnology, water and environmental technology and wireless communication.

Urban Solutions

Explosive growth of cities, shifting demographics and ageing infrastructure combined with desire for improved liveability and protection from natural disasters or man-made events are creating strong demand for new urban solutions in areas of transportation, built environment and city management.

At CoE, our research is focused on developing innovative solutions and capabilities for land capacity, sustainable transportation and good quality living environment.

Transportation

- Enhanced efficiency and resilience in transportation, infrastructure, freight and logistics, road capacity and performance.
- Development of technologies, systems and facilities to support sustainable mobility modes.

Liveability

- Development of robust structures and design protection systems against potential threats from events.
- Simulate and test blast response and fire resistance.
- Advance smart solutions for emergency management.

Resilient Systems

- Creation and optimal utilisation of usable space.
- Management of mega-cities for comfortable and generative environment.
- Social, psychological, health and safety of underground living.

Future Healthcare

Ageing population has increased the demand for therapeutic treatments. Our research in medical technology is aligned with Singapore’s position as Asia’s bio-cluster.

Rehabilitation and Medical Robotics

- Medical robotics technology for faster patient recovery, less invasive and safer procedures.
- Neuron cognitive study of human movements.
- Wearable sensors and haptic devices for home and tele-rehabilitation.
- Techniques, technologies, and systems in medical informatics and systems to overcome the frailties of the human body.

Biotechnology

- Bioengineer healthcare treatments, including tissue/organ replacement, therapeutic medical devices, diagnostic solutions.
- Anti-microbial coatings.
- New technologies in genomics, microbial engineering, stem cell engineering, microscopy and measurement technology, manufacturing of biologics, and plant biotechnology.

Advanced Materials and Manufacturing

Singapore has the edge to be the advanced manufacturing hub of Asia and to tap opportunities from disruptive technologies such as additive manufacturing. The materials industry which cuts across multiple sectors will support the future of manufacturing.

Additive Manufacturing

- Lightweight materials.
- Fabricate and customise medical devices and implants.
- Novel printers, materials and issues related to certification and qualification.

Advanced Materials

- Tailor materials for medical applications.
- Functional defence materials and platforms for materials development, device design and system integration.
- Materials for renewable energy and environmental applications.
- Fabricate prototype devices from novel materials.
- Materials and technologies inspired by nature.

Engineering Digital Economy

The Infocomm Media (ICM) Masterplan 2025 is to establish Singapore as a Smart Nation that leads the world in tapping the potential of ICM to drive economic growth, social cohesion and better living. We conduct cutting-edge research on infocomm technology to respond to this new digital economy development.

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\begin{itemize}
  \item Multi-user test beds to measure and evaluate new communication technologies.
  \item Digital information processing, inter-operability and wireless/quantum communications, and terabit optical transmission technologies.
  \item Heterogeneous networks, large scale MIMO (multiple-input multiple-output), cognitive radio, optical fibre networks, wireless sensor networks, mesh networking, software-defined networking and 4/5G networks to reshape the communication industry.
  \item 5G HetNets and TV White Spaces communications.
\end{itemize}

**Achievement**

\begin{itemize}
  \item Built a no-line-of-sight localisation test-bed to support applications for police, fire service and search and rescue operation.
\end{itemize}

**Satellite Engineering**

\begin{itemize}
  \item Satellites for communications, weather study, observation of climatic changes and natural disasters.
  \item New satellite technology for future generations of satellites flying in formation and constellation.
  \item Create versatile nano-satellite mission for in-orbit technology demonstration.
\end{itemize}

**Achievements**

\begin{itemize}
  \item Completed and launched the first four Singapore-built satellites (X-SAT, VELOX-I, VELOX-II & VELOX-PII) between April 2011 to June 2014.
  \item To launch a climate monitoring satellite named VELOX-CI and a communication satellite named VELOX-II in 2015/16. An electric propulsion demonstration satellite named VELOX-III will be built by 2016.
\end{itemize}

**Environment and Water**

\begin{itemize}
  \item Low carbon technology through development of catalysts, green solvents, new chemical processes, control strategies and system modelling and optimisation.
  \item Advanced environmental and water technologies, such as novel membranes and bioprocesses, for high performance water reclamation, solid wastes and water resource management as well as energy recovery.
\end{itemize}

**Energy**

\begin{itemize}
  \item Conversion of solar energy to clean fuels, improved storage, transport and consumption techniques.
  \item Convert natural resources and bio-feedstock into value-added chemicals and fuels.
  \item Research on energy optimisation for smart buildings.
  \item Intelligent power distribution and energy optimisation for built environment, aerospace and marine applications.
\end{itemize}

**Food Science and Technology**

\begin{itemize}
  \item Food products/ingredients and their effects on health.
  \item Sustainable production and ingredient production through process engineering and biotechnology (bio-refinery).
\end{itemize}

**Big Data**

Singapore continues to expand its capabilities in data and analytics. The knowledge created enables us to deal with priority issues such as healthcare and underpin our development towards being a Smart Nation and a regional analytics hub.

**Internet of Things (IoT)**

\begin{itemize}
  \item Pervasive, low-power, self-sustainable sensing, networks, actuating technologies, and applications for smart city, buildings and transportation.
  \item Internet for serving general public, but with special emphasis on people with special needs (e.g., elderly, minors, and disabilities).
  \item Research in real-time big data and multimedia analytics.
  \item Cyber-physical system security.
  \item Vehicular technologies or smart transportation.
  \item Physical analytics beyond big data.
\end{itemize}

**Cloud Computing**

\begin{itemize}
  \item New approaches and technologies for fast and rich mobile object search with constrained network and computational resources, compact and innovative feature coding, scalable indexing and search algorithms.
  \item Large-scale image/video classification and search.
  \item Large-scale 3D scene understanding and search.
  \item Face recognition and retrieval, especially in social media contexts.
  \item Deep learning for large-scale image recognition and search.
  \item Semantic image segmentation and co-segmentation.
  \item Large-scale image/multi-object search.
  \item Cloud-based solution, fine-grained classification and retrieval.
\end{itemize}

**Visual Analytics**

\begin{itemize}
  \item Emerging applications and use cases over cloud platform.
  \item Cloud resource management and service orchestration via advanced optimisation algorithms.
  \item Critical infrastructure (e.g. green data centre) for cloud computing and its enabling technologies (software-defined systems, new hardware, etc).
  \item Real-time data analytics in the cloud.
  \item Hardware accelerated heterogeneous cloud infrastructure.
  \item Energy efficient cloud infrastructure.
\end{itemize}

**Achievements**

\begin{itemize}
  \item HPC cloud and its support for scientific computing: developed transformation-based monetary cost optimisations for scientific workflows.
  \item Energy saving: leveraged smart power management and renewable energy to reduce the carbon footprint of cloud computing.
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Resource Resilience

Singapore has finite space, limited water supplies, and no natural resources. The government has made sustainable development, the use of renewable energy, and the efficient use of resources, primary considerations in all its future planning efforts.

Big Data

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Internet of Things (IoT)

- Pervasive, low-power, self-sustainable sensing, networks, actuating technologies, and applications for smart city, buildings and transportation.
- Internet for serving general public, but with special emphasis on people with special needs (e.g., elderly, minors, and disabilities).
- Research in real-time big data and multimedia analytics.
- Cyber-physical system security.
- Vehicular technologies or smart transportation.
- Physical analytics beyond big data.

Achievements

- Developed a non-GPS localisation technique to identify object’s locations for urban environments.
- Developed indoor localisation service.
- Implemented indoor energy harvesting for supporting sensing, networking, and actuating.
- Successfully developed co-existence mechanisms for massive wireless devices.
- Implemented crowd-sensing system development from both technological and social aspects.
- Launched environmental monitoring with low cost sensing infrastructure.

Visual Analytics

- Emerging applications and use cases over cloud platform.
- Cloud resource management and service orchestration via advanced optimisation algorithms.
- Critical infrastructure (e.g., green data centre) for cloud computing and its enabling technologies (software-defined systems, new hardware, etc).
- Real-time data analytics in the cloud.
- Hardware accelerated heterogeneous cloud infrastructure.
- Energy efficient cloud infrastructure.

Achievements

- HPC cloud and its support for scientific computing: developed transformation-based monetary cost optimisations for scientific workflows.
- Energy saving: leveraged smart power management and renewable energy to reduce the carbon footprint of cloud computing.
Infocomm technology is one of Singapore’s most significant service sectors, so the use of secure, resilient and robust technologies are critical to ensure our national reputation as a trustworthy and secure business hub. The global cyber security market which is expected to grow to about US$120.1 billion by 2017 at a compound annual growth rate of 11.3% from 2012 to 2017, spells exciting opportunities for our investment in this area.

Cyber Security

- Trustworthy systems: develop new approaches for risk assessment, vulnerability detection and security enhancement in complex cyber-physical systems.
- Cyber situational awareness: build scientific foundation for a theoretically-grounded and empirically-validated algebraic model of data that supports a wide range of scalable analytical techniques to enhance cyber situational assessment and awareness.
- Insider threats: multi-disciplinary study for detecting and tracking insider threats.
- Cyber-physical systems security: modeling cyber-physical attacks in perspective of novel computing devices and architectures.
- Scalable malware and vulnerability detection using programming analysis for binary, source code and JavaScripts.

Achievements

- Hardware security: identifying security flaws in the testing phase of integrated circuits.
- Security verification for security protocols, runtime security policy, mobile computing, trust platform and cloud computing.

Research in numbers*

120 Industrial partners

100 Academic and research organisations

2,300 Research publications

2 Engineering disciplines in top 10 of QS World Rankings by Subject 2015

7.8 citations per publication on SCI

178m Research grants

54 books and chapters and presented

280 Patents/licences filed/signed

1000 papers at conferences

35 Research Centres and Institutes

*All figures are correct as at July 2014. QS World University Rankings by Subject 2015 are correct as at April 2015.
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- Industrial partners 120
- Academic and research organisations 100
- Research publications 2,300
- Engineering disciplines in top 10 of QS World Rankings by Subject 2015
- Citations per publication on SCI 7.8
- Published books and chapters and presented 54
- Research grants 178m
- Papers at conferences 1000
- Patents/licences filed/signed 280
- Research Centres and Institutes 35

*All figures are correct as at July 2014. QS World University Rankings by Subject 2015 are correct as at April 2015.
Faculty

CoE is home to more than 500 academics from many countries around the world. Our provision of world class research facilities, resources and opportunities have attracted top researchers to join the faculty. We don’t just stop at recruiting the best minds, we provide them with the environment and culture to excel. The diversity of knowledge, expertise, experience, and culture inherent in the faculty is an immense asset that will propel the College into the next epoch of technological wonders.

Brightest Talents

Our faculty members are recipients of the prestigious President’s Science and Technology Awards, the World’s Most Influential Scientific Minds and Regional TR35.