National Supercomputing Centre
SINGAPORE

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New public-private partnership in supercomputing to support advanced healthcare research, and more, in Singapore

- *NSCC, SingHealth and NVIDIA have collaborated to develop a research ecosystem of hardware and software tools to support healthcare and medical research at Singapore's largest public healthcare cluster. These include a new supercomputer and access to advanced software, training and high-performance computing (HPC)-enabled pre-trained AI models to significantly accelerate large-scale and complex healthcare research.*
- *The collaboration reflects the theme of the SupercomputingAsia 2022 (SCA22) conference, "Towards Supercomputing for All", which highlights the growing ubiquity of advanced supercomputing resources in an increasing number of fields.*
- *With the gradual re-opening of global economies, including that of Singapore, the SCA22 conference returns as a hybrid event with in-person participation for the first time since 2019, with over 800 international attendees from some 65 different organisations, including 22 companies from the HPC industry.*

Singapore, 01 March 2022 – Three collaborations were signed between the National Supercomputing Centre (NSCC) Singapore, SingHealth and NVIDIA at the Opening Ceremony of the annual international SupercomputingAsia 2022 (SCA22) conference. The collaborations work hand-in-hand to build a complete innovation environment that combines supercomputing infrastructure capabilities, the operating software and AI tools to power advanced research, and healthcare use cases for applying these capabilities and tools. Beyond healthcare, these tools will also support a variety of research in other fields like climate science and data centre operations.

SingHealth and NSCC will develop and deploy a supercomputer that will be placed at SingHealth's Singapore General Hospital (SGH) Campus to support medical research and innovation efforts for the cluster and healthcare researchers from across Singapore. NVIDIA will provide access to its software tools and pre-trained AI models. Partners can further leverage NSCC's Supercomputing Digital Sandbox environment, which makes it easier for researchers not trained in HPC to use NSCC's supercomputer. SingHealth will leverage the supercomputing infrastructure and digital tools provided to advance a number of its ongoing medical research and innovation projects, so as to benefit patient care and improve clinical outcomes (*Refer to Annexes for information on the projects*).

"These Public-private partnerships linking the entire value chain of infrastructure, software, digital tools and researchers will accelerate scientific outcomes, and in this case support Singapore's healthcare and medical services," said Dr Janil Puthucheary, Senior Minister of State for Communications and Information & Health, and Minister-in-Charge of GovTech who is also the Guest-of-Honour at SCA22 conference. "The NSCC, SingHealth and NVIDIA agreements serve to deepen collaboration and will open up many more possibilities in other fields of medicine, beyond the initial use cases."

"Supercomputing power is a very critical national resource that is crucial in enabling many research projects that impact the economy and society, now and for the future," said Mr Peter Ho, Chairman of the NSCC Steering Committee. "NSCC is excited to work with partners like SingHealth and NVIDIA to benefit local researchers in an important field like healthcare. We also hope that this will spur the many local and international organisations attending SCA22 to do likewise and find mutually beneficial partnerships that will help advance Singapore's HPC community, and its related research fields."

Apart from the development of the new NSCC-SingHealth supercomputer, SingHealth will also be able to leverage NSCC's wider national HPC infrastructure and the new Supercomputing Digital Sandbox, which is designed to make the experience of using HPC resources much easier and simpler for

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researchers who may not possess in-depth HPC knowledge.

“The adoption of emerging technologies is a game-changer in helping us enhance care delivery and optimise healthcare resources with the goal to improve clinical outcomes and the experience for patients,” said Professor Kenneth Kwek, Deputy Group CEO (Innovation & Informatics), SingHealth. “Through this exciting collaboration with NSCC and NVIDIA, supercomputers and software specialised for AI and deep learning will be made readily available and accessible to our colleagues, to aid them in doing breakthrough research and developing new innovations that will transform and shape the future of healthcare.”

One of the healthcare projects that the tripartite partnership will support is SingHealth’s Artificial Intelligence for Transformation of Medicine Programme (AIMx), which aims to develop AI algorithms for the smart triaging of patients with cardiovascular disease. Using big data comprising clinical data, chest x-rays and retinal images of patients with symptoms of cardiovascular disease, the AI algorithms are designed to predict a patient’s risk of adverse cardiac events and perform a suitable triage. The tool could help clinicians prioritise patients with serious cardiac issues for urgent medical attention in emergency settings or identify patients with a higher risk of coronary artery disease in outpatient settings. The benefits of the research include greater efficiency and improved accuracy in the identification of high-risk patients, facilitating timely and life-saving clinical intervention, as well as optimising the use of precious healthcare resources.

“From weather forecasting to life sciences, NVIDIA’s accelerated computing and software are powering many of the world’s fastest supercomputers and HPC systems, giving researchers the power they need for scientific breakthroughs,” said Dennis Ang, Senior Director, Enterprise Business, ASEAN and ANZ Region at NVIDIA. “Our collaboration with NSCC and SingHealth will help to grow research and innovation in healthcare, as well as other key fields related to climate research and digital twin simulation in Singapore.”

NVIDIA will provide access to its software development kits and open-source pre-trained AI models. NVIDIA will also be working with NSCC to provide access to its unique software tools and training to support large-scale and complex HPC-enabled AI research.

Co-organised with partners from Japan, Australia and Singapore, the SCA22 Conference is an annual international event that gathers HPC practitioners and companies. With the theme “*Towards Supercomputing for All”,* the conference covers a wide array of topics such as the latest trends in supercomputing, HPC-enabled research, data centre technologies, collaborations in areas of HPC and quantum computing. The event also brought new focus on talent development and inclusivity in the realm of HPC with new tracks on “Accelerating HPC Upskilling without Borders” and “Inclusivity and Diversity, the path to supercomputing for all”.

NSCC also launched the first HPC Innovation Challenge for the Environment at SCA22 to encourage local teams to submit potential solutions and proposals in areas like creating smart city ecosystems, greener buildings, enhancing the quality of urban living and solutions to tackle climate change. Teams from Singapore government agencies, local enterprises and students from Institutes of Higher Learning will be invited to vie for Challenge Prizes totaling S$18,000.

The international conference will also welcome the ThaiSC supercomputing centre of the National Science and Technology Development Agency, Thailand as a co-organiser in the next iteration of the event, SupercomputingAsia 2023 (SCA23).

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Chinese Translations

- National Supercomputing Centre (NSCC) Singapore - **新加坡国立超级电脑中心**
- SingHealth – 新加坡保健服务集团 (新保集团)
- Professor Kenneth Kwek, Deputy Group Chief Executive Officer (Innovation & Informatics), SingHealth - 郭永强教授,新保集团副总裁 (创新与信息学)
- Singapore General Hospital - 新加坡中央医院
- Mr Dennis Ang (洪闻禧), Senior Director, Enterprise Business ASEAN and ANZ Region, NVIDIA Corp

About the SupercomputingAsia 2022 (SCA22) Conference

Co-organised by HPC centres from Singapore, Japan and Australia, SupercomputingAsia 2022 (SCA22) is an annual conference that encompasses an umbrella of notable supercomputing and allied events in Asia. SCA22 will be held as a hybrid conference from 1 to 3 March 2022. The key objective of the SupercomputingAsia conference is to promote a vibrant and relevant HPC ecosystem in Asia. Delegates will be able to gain access to visionary insights from thought leaders in academia and industry, optimum networking opportunities and the supercomputing community in Asia. The conference co-organisers include the National Supercomputing Centre (NSCC) Singapore, RIKEN Center for Computational Science (R-CCS), Research Organization for Information Science and Technology (RIST), Pawsey Supercomputing Centre and the National Computational Infrastructure (NCI) Australia. Since 2018, the SCA conference series has quickly grown to become a key meeting and networking platform for the HPC and supercomputing value chain for Asia and internationally. Partners share new insights, discuss trends and present the latest advances in the development of HPC. The conference attracts international delegates including mid- and C-level executives, principal researchers and HPC professionals from academia, industry and the public sector.

MEDIA FACT SHEET

SingHealth's collaboration with the National Supercomputing Centre (NSCC) and NVIDIA will provide clinicians and researchers with access to supercomputers as well as software with specific expertise in Artificial Intelligence (AI) and deep learning to accelerate and catalyse high-value research that will transform clinical care for patients.

The SingHealth-NSCC-NVIDIA collaboration will advance medical research and innovation projects such as the following:

Diagnosing Cardiovascular Disease through Artificial Intelligence

Cardiovascular disease (CVD) is the leading cause of death globally, causing 20% of deaths in Singapore and 33% of deaths globally. As the prevalence of CVD is higher among older adults, Singapore is likely to see a rise in the number of patients with CVD as the population ages.

Harnessing the power of AI, SingHealth clinicians are working with various healthcare and research institutions to come up with solutions to improve the care and management of CVD. AI will be a powerful tool that can help clinicians assess patients' test results more efficiently and accurately, reducing the time required for diagnosis and allowing patients to receive the appropriate care in a timely manner.

1. APOLLO (AI-driven national Platform for CT cOronary angiography for clinicaL and industriaL applicatiOns)

APOLLO is a collaboration between the National Heart Centre Singapore, Duke-NUS Medical School, Agency for Science, Technology and Research (A*STAR), National University Hospital and Tan Tock Seng Hospital.

It is an AI-driven platform for computed tomography coronary angiography (CTCA) for clinical, research and industrial applications. CTCA is the most comprehensive 3D non-invasive imaging to diagnose cardiovascular disease.

The system consists of four modules which can perform different AI analyses on CTCA images, and provide detailed AI-generated reports on patients' conditions and their risk of cardiovascular disease. The four modules identify and report the following parameters that determine the risk of cardiovascular disease:

- Calcium Score
- Epicardial Adipose Tissue

- Stenosis (narrowing of blood vessels)
- Type, Volume and Characteristics of Plaque (cholesterol, fatty substances, waste products, etc. that can clog or damage arteries)

Refer to Annex A for samples of APOLLO's AI-generated CTCA Reports

Key Benefits

- **Reduced variability in reporting**
  - The AI-generated reports will assist clinicians in accurately interpreting the CTCA results, helping them to maintain a consistent standard in reporting.
- **Shorter processing time**
  - A radiologist typically takes two to four hours to interpret a CTCA scan, while the AI-driven platform can complete the analysis within ten minutes, which is more than 100 times faster.
  - This relieves clinicians of the burden of performing the full analysis manually, allowing them to work more efficiently and be able focus on other important areas of clinical work, such as caring for patients. This improves productivity and optimises healthcare manpower and resources.
- **Greater detail in reporting**
  - The AI-generated reports go into a deep level of detail, providing clinicians with in-depth insight into patients' conditions and how to manage it.
  - Such details be used to track the progression of disease, as well as the benefits and effects of medication, such as cholesterol-lowering medication.
  - E.g. A clinician usually interprets a CTCA result to diagnose a patients' stenosis (how narrow a blood vessel is as a result of plaque buildup). In addition to stenosis, the APOLLO platform also gives insight into the type, volume and character of the plaque, and predicts the risk of future heart attacks.
- **Specific to Asian population**
  - As it is based on local CVD data, the AI-platform is trained to recognise Asian patterns of disease. Its data warehouse also lays a foundation for the creation of more AI solutions which are customised for Asian populations.
  - This is important as there are currently more global studies on CVD for the Western population. With Asians having a different genetic make-up and demographics, clinical solutions that are specific to the Asian population are needful, and are important for personalised medicine.

Large Data Warehouse and AI Toolkit

The project also aims to build a **large, shareable, and anonymised pool of CTCA real-world data**, consisting of 1.5 million CT slices, or cross-sectional images – of the heart, from over 5,000 patients across three hospitals in Singapore, to further refine and train the AI model. As of December 2021, over 3,200 patients have been recruited to contribute their CT slices for the project. With this data warehouse, clinicians and healthcare innovators can create and test more AI models to better predict, diagnose and manage CVD.

In addition, the team aims to create an **integrated platform for the development of AI Toolkits** for anonymisation, reporting and scoring of data. Such toolkits will facilitate the implementation and integration of potential AI solutions into clinical workflows within a shorter amount of time. This will support clinicians and innovators as they bring their budding AI solutions to life, and from bench to bedside to benefit patients.

2. Artificial Intelligence for Transformation of Medicine Program (AIMx)

The Artificial Intelligence for Transformation of Medicine Programme (AIMx) is a collaboration between SingHealth, Duke-NUS Medical School, A*STAR's Institute of High Performance Computing (IHPC), and NSCC, which aims to develop AI algorithms for the smart triaging of cardiovascular disease (CVD) patients in the emergency and elective settings.

Using big data comprising clinical data, chest x-rays and retinal images of patients with symptoms of CVD, the AI algorithms will only require a few seconds to predict individuals' risk of adverse cardiac events and perform a suitable triage. In the emergency setting, this will help clinicians prioritise patients with serious cardiac issues for urgent medical attention, and in the elective setting, this will identify patients with coronary artery disease. This allows for a **more accurate identification of high-risk patients, facilitate timely and life-saving clinical interventions, and optimises the use of healthcare resources**.

AI Sandbox

AIMx also aims to develop a digital solution platform, an AI sandbox, which will provide healthcare innovators and technology developers access to anonymised clinical data sets for model validation of the AI algorithms, and a simulated, real-world clinical environment to test their AI models. SingHealth innovators, healthcare partners, industry players and commercial developers will all be able to utilise this Sandbox for their potential solutions.

The AI Sandbox consists of two components:

- **Clinical Data Sandbox** – testing of trained algorithms for system robustness
    - The anonymised clinical data within the sandbox will be run through the AI algorithms to test its clinical data performance and ability to handle the input of new data
    - If the outcome is successful, the algorithm can proceed to go through technical sandbox to test its readiness for clinical implementation

- **Technical Sandbox** – for algorithms that have been approved by the US Food & Drug Administration (FDA) or Singapore's Health Science Authority (HSA), or have obtained successful outcomes from the AIMx Clinical Data Sandbox
    - The AI algorithms will be tested for system compatibility within a digitally simulated environment, to ensure it is ready to be deployed for clinical use

Starting with the AI cardiovascular disease algorithm and its accumulated pool of images and data, the AI sandbox will subsequently be expanded to include other clinical specialties. This will play an important role in catalysing the development and deployment of potential AI solutions, and ensuring their relevance and viability in addressing care gaps.

Developing Personalised Cancer Therapies Quickly and Accurately with Artificial Intelligence

3. Using AI to Identify Neoantigens from Cancer Mutations for Precision Immunotherapy

In building a strategy for precision immunotherapy, cancer vaccines can now be much more personalised to direct each patient's own immune system to destroy cancer cells by identifying new mutations as targets. Known as neoantigens, these new cancer mutations are specific to each individual patient and are not present on normal cells. At initial stages, cancer is able to disguise itself and evade the body's immune system. As cancer grows, it forms new mutation proteins which the immune system is able to recognise, and can be potential targets which are vulnerable to specific immunotherapy. For example, custom-manufacturing neoantigen-specific vaccines can activate and boost neoantigen-specific T cells, which are cells in the immune system that can directly destroy cancer cells with minimal to no side effects.

One of the key challenges in producing neoantigen-specific vaccines is identifying the correct neoantigens which can be effectively recognised by the body's immune system, a very complex and time-consuming process due to the vast amount of genetic information to sieve through. Cancer cells possess a huge amount of peptides but not all form good targets. Computational analyses using AI and machine learning has recently made it possible for effective neoantigens to be discovered, identified and harnessed as targets to design powerful cancer immunotherapy against human cancers.

A team of clinicians and scientists from the National Cancer Centre Singapore (NCCS) is leveraging the power of such AI to **enhance and shorten the neoantigen identification process**, with the aim of producing improved neoantigen-specific vaccines for patients with primary liver cancer and liver metastasis from metastatic colorectal cancer – where their cancers have been surgically removed. The team's AI algorithm is trained on vast biological data sets that contain information about potential neoantigens found on the surface of cancer cells, and uses the patterns and information from the data to quickly and accurately predict neoantigens from genetic information.

The team is currently conducting a clinical trial involving 60 patients – 30 with primary liver cancer and 30 with liver metastasis from advanced colorectal cancer who have already had all their cancers removed. In both cancers, the relapse of cancer at two years after surgery is 50 percent or more.

This AI-driven platform is seeking to identify up to 10 neoantigens per patient, with an aim to activate and expand neoantigen-specific T cells in the patients with the injection of the 10-neoantigen carrying cancer vaccines. The cancer vaccine will be combined with a well-established antibody (immune checkpoint inhibitor) that can activate cancer-specific T cells – thus providing a further immune boost as a combination.

This treatment combination is aimed at reducing the chance of cancer returning after the cancerous masses have been surgically removed from the patient.

Clinical Trial Process and the Role of AI

- Cancer is surgically removed from patient and tissue sample is collected.
- Whole genome sequencing and RNA sequencing (for confirmation of mutation in the tumour) is performed on the tissue sample.
- HLA (human leukocyte antigen)-typing is performed to predict if a mutation is immunogenic in the patient.
- **AI with machine learning is used accelerate the prediction of neoantigens from comprehensive genetic information.**
- Identified neoantigen as targets on cancer cells is used to produce neoantigen-specific vaccine.
- Neoantigen-specific vaccine with an antibody as a combination is used to treat patient for up to a year.
- Clinical and analytic data will be fed back for further process development and machine learning to facilitate improvement in vaccine potency and even more precise neoantigen prediction hit rate

The whole process of neoantigen identification and vaccine production and readiness can take up to three months from surgery to vaccinating the cancer patient.

Benefits of Precision Immunotherapy

- Potentially applicable to all types of cancer, thus benefitting many more cancer patients
- Tailor-made and personalised to be highly effective in fighting each patient's cancer
- Does not involve off-target toxicities, where therapies unintentionally affect other proteins or molecules in the body that it was not meant to target. This reduces unexpected side effects of therapy for patients.

- In this clinical strategy, the objective is to prevent cancer from returning in patients with liver cancer and colorectal cancer spread to the liver. These are some of the commonest cancers in Singapore and in the world.

Future Applications

Moving ahead, the same cutting edge technology can potentially be used for the much more precise prediction of viral peptides for target identification and vaccine development against diseases such as influenza and coronaviruses. This is an important capability for pandemic preparedness.

Interviews with Principal Investigators of the above projects are available. For media queries and interviews, please contact:

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SingHealth DukeNUS
ACADEMIC MEDICAL CENTRE

ANNEX A: APOLLO AI-generated CTCA Reports

National Heart Centre Singapore
SingHealth

Patient Name: Sample | **NRIC: S0000000A** | **Gender: Male**
DOB: 06/06/1800 | **Study Date: 08/08/1800** | **Referring Doctor: Dr. Lee**
Performing: Dr. Ada | **Case ID: APOLLO-001** | **Institution: NHCS**
Procedure: CT Coronary Angiogram

Text report | Table report

Coronary artery branch \ Items		Calcium score	Calcified plaque	Noncalcified plaque	Mixed plaque	Stenosis grade					
						Normal (0%)	Minimal (0 - <25%)	Mild (25 - <50%)	Moderate (50 - <70%)	Severe (>70%)	Occluded (100%)
LM		50			✓				✓		
LAD	Proximal	1096	✓						✓		
	Mid				✓				✓		
	Distal					✓					
	Ramus										
	D1										
	D2										
LCX	Proximal	23	✓					✓			
	Distal					✓					
	OM1										
	OM2										
	L-PLB										
	L-PDA										
RCA	Proximal	713			✓				✓		
	Mid		✓						✓		
	Distal		✓					✓			
	R-PLB										
	R-PDA										
Total Agatston score		1882									

CONCLUSION
Coronary artery disease.
Moderate luminal stenosis in the proximal to mid LAD, proximal and mid RCA.
Mild luminal stenosis in the proximal LCX and distal RCA.
Suggest correlation with clinical symptoms and invasive coronary angiography of functional imaging if appropriate.
Report Indicators: May need further action.
Reported by: XXX
Reported Date/Time: XXX
Finalized by: XXX
Finalized Date/Time: XXX

Text report | Table report

Scan Quality: Good
Calcium Score: Agaston 1882, LM 50, RCA 173, LAD 1096, LCX 23, Volume Score 1641 mm^3.
The calcium score is between 90th and 100th percentile for men between the age of 60 and 64.
Coronary Arteries:
Left Main (LM):
The left main artery has moderate luminal stenosis caused by mixed plaque.
Left Anterior Descending (LAD):
The proximal LAD has moderate luminal stenosis caused by calcified plaque.
The mid LAD has moderate luminal stenosis caused by mixed plaque.
The distal LAD is widely patent with no obvious stenosis.
Left Circumflex (LCX):
The proximal LCX has mild luminal stenosis caused by calcified plaque.
The distal LCX is widely patent with no obvious stenosis.
Right Coronary Artery (RCA):
The proximal RCA has moderate luminal stenosis caused by mixed plaque.
The mid RCA has moderate luminal stenosis caused by calcified plaque.
The distal RCA has mild luminal stenosis caused by calcified plaque.

CONCLUSION
Coronary artery disease.
Moderate luminal stenosis in the proximal to mid LAD, proximal and mid RCA.
Mild luminal stenosis in the proximal LCX and distal RCA.
Suggest correlation with clinical symptoms and invasive coronary angiography of functional imaging if appropriate.
Report Indicators: May need further action.
Reported by: XXX
Reported Date/Time: XXX
Finalized by: XXX
Finalized Date/Time: XXX

Note: SCCT grading scale for stenosis severity:
No-stenosis – 0%
Minimal stenosis – 1% to 24%
Mild stenosis – 25% to 49%
Moderate stenosis – 50% to 69%
Severe stenosis – 70% to 99%
Occluded – 100%