S.E.T. for socio-economic growth

National Science and Technology Forum (NSTF)

media release

Should we fear 4IR technologies, including artificial intelligence, or embrace them?

The National Science and Technology Forum (NSTF), in partnership with proSET (Professionals in Science, Engineering and Technology, a membership sector of the NSTF representing over 50 professional and learned societies) recently held a discussion forum with some of South Africa's (SA) leading experts to discuss this burning question from many varied perspectives.

One of the speakers pointed out that the concept of Global North and Global South has become obsolete. There is now only a *Global Majority* – those who have access to the internet and embrace artificial intelligence (AI), and the *Global Minority* – those who don't (Prof Habib Noorbhai).

Not surprisingly, SA, with is widening inequality gap, falls into both categories.

The NSTF provides neutral collaborative platforms where issues and sectors meet

- Feedback from these discussion forums is given to role players and stakeholders.
- Recommendations are circulated widely, which includes government, formal media, and the general public, as part of the SET community's (science, engineering and technology) efforts to make input into policies and implementation.
- The NSTF represents about 150 member organisations participating as key stakeholders of the SET and innovation community.
- These discussion forums allow for engagement, interaction and cooperation in a quadruple helix framework (higher education-business-government-civil-society).

In one way at least, SA is ahead of the Fourth Industrial Revolution (4IR) trend: Consider the MeerKAT, the South African part of the Square Kilometre Array (SKA), the world's largest radio telescope, situated in the dusty Karoo. This is where an international network of researchers have been probing the galaxy, studying pulsars, exploding stars, black holes and various kinds of science since 2018. According to **Prof Patrick Woudt,** Interim Director of the Inter-University Institute for Data Intensive Astronomy (IDIA), SA is at the forefront of technology-driven innovation.

Ten years ago, a number of universities came together to form the IDIA. Here, data-intensive cloud systems are being developed, as well as research pipelines and software tools. This is an environment of innovation and global collaboration with AI speeding up data processing and complex data sets are being analysed and visualised. The most recent are images of the centre of our galaxy as never seen before. It is an on-going challenge to store and analyse these extremely large and complex astronomical data (2.2 terabytes per second), generated by these state-of-the-art telescopes. The only way to cope with the volume is high performance cloud-based computing, data mining and fusing, and new visualisation tools. Since its inception, the Astrophysics and Science Programme has produced almost 700 graduates and continues to build capacity and expertise to open new windows to the universe.

While telescopes explore the macro cosmos, AI is used in nuclear medicine to diagnose and treat disease at a molecular level:
In his presentation, **Prof Mike Sathekge,** Head of Nuclear Medicine at the University of Pretoria (UP) and President of the newly established Nuclear Medicine Research Infrastructure (NuMeRI), explained how AI is revolutionising nuclear medicine as computer science fuses with clinical expertise.

Machine learning algorithms make disease classification more accurate and enable precise diagnosis. With enhanced image segmentation, as well as low-dose imaging, AI offers a short-cut in the detection and treatment of cardiovascular disease, tuberculosis (TB), dementia, HIV, Parkinson's disease and various types of cancer. AI algorithms also lead to more effective clinical trials and improves drug development. Prof Sathekge stressed that patient care must remain the central focus in nuclear medicine and if AI is going to be more meaningful, skills development is needed and some of the AI terminology must be standardised.

The role of laser technology in aerospace, manufacturing, infrastructure and human capital in SA:
Prof Claudia Polese is Head of the Aeronautical Engineering Stream at the University of the Witwatersrand (Wits) and the Advisory Aerospace Research Director at the National Aerospace Centre. Her most significant achievement has been the development of the Laser Shock Peening (LSP) technology. LSP is a surface engineering process that imparts beneficial residual stresses in materials. It increases the resistance of materials to surface related failures such as fatigue, stress corrosion and cracking. With the help of her Master's and PhD students and with the support from the Council for Scientific and Industrial Research (CSIR) and international partners over the years, Prof Polese secured funds to patent and develop the discovery that the quality of LSP processing can be monitored and assessed by the acoustic pressure produced when the laser hits the surface of the material through a thin film of water. She calls this *the heartbeat of LSP* because you can actually hear how the process works and ascertain its efficacy. The impact of bringing worn out components back to spec with LSP is huge. Her team of students and collaborators are currently working with Eskom to see how LSP can fix cracked or broken turbine blades and increase their lifespan. To cope with all the opportunities that laser technology offers, Prof Polese is developing new postgraduate courses and training younger colleagues to take laser technology forward.

Prof Khumbulani Mpofu works in the manufacturing field where he holds two Research Chairs. He is also a professor of Industrial Engineering and Senior Lecturer. His presentation to the forum illustrated how the 4IR is reshaping industries worldwide with the fusion of technologies that blur the lines between physical and digital environments.

One major trend is the increasing integration of the Internet of Things (IoT) which allows for smart, more efficient transport systems that enable real-time data exchange between vehicles and manufacturers. This connectivity facilitates predictive maintenance, optimises performance and reduces downtime because it addresses potential problems before they arise. Automation with AI is another crucial development with robotic systems that can handle complex manufacturing tasks, optimise production processes and reduce costs. This is becoming increasingly important as the world shifts to electric and hybrid vehicles to minimize carbon footprints. Advanced battery technology and renewable energy are also key areas of innovation. In addition, additive manufacturing is revolutionising how components are designed and produced. Furthermore, the digitalisation of supply chains is transforming logistics and inventory management. In addition, the evolution of transportation manufacturing is influenced by human-machine interfaces like augmented reality (AR) and virtual reality (VR) that enhance training processes, improve design visualisations and a higher quality standard of production output.

Dr Kingsley O Ukoba, a Lecturer in the Department (Dept) of Mechanical Engineering at the University of Johannesburg (UJ) reported that the manufacturing sector contributes approximately 30% to the GDP of SA and employs more than 1.6 million people. And yet, between 2022 and 2023, there was a decline in output.

Instead of fearing 4IR, Dr Okuba believes AI will enhance productivity, innovation and sustained growth. The cost of energy is a case in point. With loadshedding a common occurrence in SA and Eskom battling an aging infrastructure, we might ask how more renewable energy can be implemented more effectively. In 2023, the renewable energy supply in SA made up 1% of the grid. By 2030, the target for renewable energy supply is 33%. Making use of 4IR tools like additive manufacturing (industrial 3-D printing), Dr Okuba predicts a future where every household will be able to print their own electricity in the form of 3D solar panels. SA has deposits of lithium and we should be producing batteries to store energy generated from solar and wind. Another research project of his focuses on the use of drone technology to aid farmers in smart agriculture.

4IR is the interaction between humans and machines and requires a radical change of mindset in SA:
Prof Riaan Stopforth runs the Scientific Multidisciplinary Advanced Research Technologies (SMART) Lab at the University of KwaZulu-Natal (UKZN). He reckons that the fear that AI and robots will replace humans and take over jobs is unfounded. Humanoid robots is a closed platform and human input is always needed to validate AI. In his SMART Lab research centre, Prof Stopforth explores 4IR with his students where they produce world-class technological inventions. They've used AI to make airplanes adapt to stability while flying, tested drones, designed remote controlled taxi's to determine the impact of a crash on commuters and built monitoring systems to track satellites. Despite these achievements, research in SA has stagnated because funding is limited and scientists often don't collaborate. To fully embrace the potential of 4IR, Prof Stopforth proposes open source research, remote learning and exposing scholars to AI platforms and experimentation.

Harnessing earth observation technology to transform water monitoring and management in Africa:
Prof Timothy Dube is a full professor of geospatial science, specialising in environmental and water sciences and serves as director of the Institute for Water Studies at the University of the Western Cape (UWC). In drought stricken Sub-Saharan Africa, it is imperative to know how much water is abstracted from river systems for agriculture, domestic or industrial use. The lack of a ground-based infrastructure has made collecting river system data extremely difficult. In the past, satellites only focused on small localised areas, but earth observation (EO) provides large-scale spatial data with a footprint that covers almost the entire globe. With this technology on hand, it is now possible to extract data specifically for African governments to understand how their water resources are doing. With the help of AI, this data can be harnessed to estimate rainfall patterns across Africa and calculate the risk of floods. This is essential information that farmers, cities and municipalities need for planning and policy making. Crop mapping is another research project that collects images from EO to identify active farming areas in Southern Africa. By integrating machine learning techniques and air-observation data, it is now possible to establish if crops are rain-fed or irrigated. Furthermore, in rural areas where drought and pressure on grazing lands are keenly felt, farmers are shifting agricultural activities towards wetlands. EO helps to identify these wetlands and determine their condition. The goal is to come up with conservation strategies and in collaboration with communities find ways to utilise water in a sustainable manner.

Milliseconds matter – athletes and the 4IR:
Prof Habib Noorbhai is the Director of Biomedical Engineering and Healthcare Technology Research Centre at UJ. His research confirms that AI systems improve the performance of professional athletes.

Athletes today continue to perform at higher levels than in the past. Usain Bolt, the eight-time Olympic gold medallist ran the 100 meters in 9.58 seconds. The runner up crossed the finish line in 9.71 seconds and the third place clocked in at 9.84 seconds. The difference between a gold and a bronze medal is a mere 0.13 seconds.

Back in the day, athletes were taken into expensive laboratories to analyse their performance. With AI technology, this landscape is becoming incredibly competitive. World-class athletes now use Extended Realities (XR) which merges virtual reality, mixed reality and augmented reality that facilitates coaching feedback while they are training in simulated environments. Some of the new apps include 3D motion capture, force plates, accelerometery, the gyroscope, heart rate monitoring, and electromyography that evaluates the electric activity of muscles and the nerves that control them. Instead of just looking at one particular data item, it is now possible to employ a more holistic data approach to really understand how we can measure and understand the capabilities of athletes. The goal is to apply XR validation frameworks to other sports, like baseball, football, or tennis, and include different athlete levels and game scenarios. Prof Noorbhai aims to deepen neurocognitive integration, merge electroencephalography, EMG, and eye tracking with XR to map real-time decision-making and brain-body performance dynamics. With these high-tech integrations, it is now possible to gain insight into brain activity and assist athletes in improving their performance.

Using AI to explore and analyse the dynamics of ideas and innovation:
Prof Sara Grobbelaar is a professor in the Dept of Industrial Engineering at Stellenbosch University (SU) and a research associate at the University's Centre for Research on Evaluation, Science and Technology (CREST).

Prof Grobbelaar believes that the 4IR presents a grand social experiment in SA. Can AI be leveraged to uplift people and give them access to services and goods that they need? One has to try and improve the living conditions and create employment opportunities for poorer individuals through the development of new products, services, processes, and business models.

Entrepreneurial activity is a potential growth point and Prof Grobbelaar has designed a framework to map the biographies of innovation projects to understand why some initiatives succeed while others fail. It's about understanding the whole evolution of an innovation project through event history analysis and process tracing. Models of innovation systems are also being developed to do 'what-if' analysis, scenario analysis, and model performing functions of innovation systems. The idea is to create a world-leading innovation analysis platform that combines extensive empirical evidence through case studies to track the success and failure of ideas. This research project offers practical tools for practitioners and policymakers to understand innovation dynamics better. It is also a vital support mechanism especially for smaller companies, individuals, university systems, and accelerators, to look at how they can support innovation projects.

Recycling indigenous agricultural knowledge in the age of 4IR:
Dr Thizwilondi Joanbeth Madima is a lecturer and researcher in the Dept of Indigenous Knowledge and Heritage Studies at the University of Venda (UNIVEN). Her research focuses on digitising indigenous heritage and promoting circular economy approaches in agriculture, particularly the use of liquified livestock manure to address food security and climate change in indigenous communities. In her presentation, she pointed to the fact that food insecurity today affects 14 million people in SA. In rural areas, AI has little impact because internet access is not available. Instead, the notion is to recycle indigenous knowledge. This includes using livestock manure to revitalise the soil and using spoilt food to make compost.

The future of 4IR in SA cannot be left to chance – it must be deliberately inclusive, empowering and focused on bridging the digital divide:
Prof Upasana Singh is an academic leader in information systems and technology at the UKZN. She pointed out that the pipeline for 4IR innovators is thin unless participation is broadened. Currently, only 20% of graduates in SA study science, technology and engineering and most rural schools do not have access to the internet. Data costs still remain a barrier and women remain underrepresented in these fields. Her recommendations include the scaling up of successful programmes like GIRLCODE, an organisation that empowers young woman to code, build Apps and enter the ICT space, integrate 4IR into school curricula and support educators as digital champions.

Mr Alan Knott-Craig is a successful entrepreneur, author, and founder of Fibertime – a company that aims to bring affordable internet to townships. According to him, only 5 million South Africans (out of a pool of 60 million) are currently internet subscribers. The irony is that 95% of South Africans do have access to the internet because they've got mobile phones with 5G or 4G or 3G on it, and there are base stations everywhere, but poorer people in townships don't trust the technology and can't afford the data charges nor the upfront installation cost and monthly subscription fees. To overcome this barrier to entry, Mr Knott-Craig developed a ground-breaking business model and launched a pilot project in the township of Kayamandi near Stellenbosch in the Cape. Fibertime connected 10,000 homes to the internet which meant planting poles and stringing fiber to every shack or brick home. Routers were installed for free. There are no subscription fees and residents buy R5 vouchers that give them unlimited 100 megs per second internet access for 24 hours. The monthly cost is R150 for unlimited, fast and uncapped access.

The SU's Bureau of Economic Research studied the exponential impact of fast and affordable internet access in this township. In one case study, a mother living in Kayamandi spent 4 hours a day commuting to work and back and paid R900 a month on taxi fare. With uncapped internet access, she convinced her employer that she could work from home and with the savings on transport costs, she had extra cash to enrol for an online secretarial course and was grateful that her children preferred to stay safely at home surfing the internet. Fibertime is already in 30 townships across 6 cities and 5 provinces. At the moment, Alan and his team are connecting 1,200 homes every day and can connect up to 30,000 homes a month. By March 2026, he envisages that 400,000 homes in townships across the country will be connected to the internet. If one considers that there are on average, 5 people living in every home, it is not inconceivable to say that in less than a year, more than 2 million South Africans in poorer communities will be on very affordable, world-class, unlimited, super-fast fibre. This is an enormous audience of people who have been locked out of the digital economy who can now access on-line education and business opportunities.

Human rights, cybersecurity and legislation in the 4IR:
Ms Emerentia Morape Is a governance specialist and researcher with a strong focus on cybersecurity, data privacy, and governance. In her presentation, Ms Morape highlighted two main pieces of legislation that protect human rights in cyberspace. The first is the Protection of Personal Information Act (POPIA) which came into full effect in 2021. At its core, it is a law designed to give individuals greater control over their personal information, and to affirm privacy as a fundamental right. The second piece of legislation is the Cyber Crimes Act. This Act criminalises cyber fraud, forgery and extortion or exploitation in digital platforms for financial gain. Causing reputational harm is also criminalised under this Act. The sharing of intimate images or information without consent, (a.k.a. revenge porn) has serious social and psychological consequence for victims. SA is still very new to the cyberspace and we do not yet have the cybersecurity infrastructure and policies in place. Human-centric cybersecurity should recognise that true security can only be achieved when grounded in respect for human dignity and fundamental freedoms.

Dr Jabu Mtsweni is the Head of Information and Cyber Security Centre and Chief Researcher at the CSIR and reported that while SA ranks 1st in Africa on the International Monetary Fund (IMF) AI Readiness Index, we fall behind when it comes to cyber security. (SA is 59th out of 93 countries.) We still do not have enough capacity to handle various incidences, such as data breaches and the hijacking of digital ecosystems. Over 150 South African organisations report cyber incidents every month, with 47% of fraud happening on banking apps. Alarmingly, between April 2023 and April 2024, there has been a 400% increase in digital identity theft. AI, inasmuch as it can be used for good, can also be used for bad. Fake news, scams, and even ransomware are common. It is important to strike a balance between the benefits of the technology and the risks it entails. We need to invest in people, build their skills and make sure that as a country, we are implementing new technologies with guidelines and policies in place.

Ms Sibahle Ngwenya is a Machine Learning Research Engineer with a background in mineral processing and industrial engineering. Her experience at Mintek, one of SA's leading research organisations, has contributed in the design of numerous projects looking at process optimisation, technology development, and mineral extraction. In her presentation, she noted that innovation is constrained by slow and linear regulatory systems. The Presidential Commission on 4IR provided a strategic roadmap to guide the adoption of an AI policy. The roadmap looks at 4 strategic pillars: Investment in Human Capital; the establishment of a national AI Institute; building 4IR infrastructure; and creating a conducive police and legislative environment.

The current reality however is that policy implementation is fragmented across multiple government departments. Ms Ngwenya proposes smarter, evidence-based AI regulation that allows regulators to learn about new technologies and develop rules that are fit-for-purpose. This is the "Sandbox" approach. A flagship success is the collaboration of key financial regulators who successfully tested innovations in digital payment systems and guided companies to market. To secure the economic future of SA, it is imperative that we move from policy to action. Agile regulation is the key to unlocking our 4IR potential.

Mr Dumisani Sondlo is the National AI Policy & Governance Lead, at the Department of Communications and Digital Technologies (DCDT) in SA. He has the responsibility of ensuring the development of the country's policy on AI.

AI is growing fast and could enable whole economies to be transformed in a short space of time. 'The entire world is sitting around a table to take a slice of the AI pie, but is our country SA at the table?' Mr Sondlo asked. It is a risky landscape and there are concerns that AI could get out control. We're already seeing the proliferation of fake news that can pose a threat to democracy. AI can be weaponised and used for criminal activity, but AI also presents opportunities for economic growth, job creation and developing Africa. In consultation with stakeholders, the DCDT is currently developing enabling policies to promote the responsible use of AI in SA.

This policy will aim to build capacity, develop talent and expand the provision of broadband. The policy framework also includes making more energy available to power AI, support AI start-ups as well as establishing research centres to test ideas. Regulation must address data security, intellectual property (IP) and the protection of citizens. It is also important to ensure that human oversight over AI is maintained. The National AI Policy Framework has recently been submitted to Cabinet and will be presented to various industry sectors to develop their own strategies once it is approved.

Conclusion: In some ways, SA is employing 4IR technologies to good effect, similar to further afield in the developed world, and even able to get ahead of the curve in specialised areas. Examples are radioastronomy, nuclear medicine, advanced manufacturing, and earth observation data for water management. Sports science is also developing apace to keep up with the best in the world. Some people in the national system of innovation are also working very hard to build the skills pipeline related to all of these fields.

However, for 4IR technologies to benefit the majority of the population and open up opportunities in an inclusive manner, wide-spread connectivity is required. Although the DCDT is concerned about limited access to broadband and working on legislation, it is a private sector initiative, Fibertime, that is making substantial progress in this space and providing connectivity to millions of South Africans in townships.

4IR technologies need to be regulated to ensure safety, security and human rights such as privacy and dignity. On this front, also, SA is making progress as lawyers, academics and government study the requirements and attempt to fast-track legal and policy development. The Presidential Commission on 4IR provided a strategic roadmap to guide the adoption of an AI policy, and the DCDT reports that the National AI Policy Framework has been submitted to Cabinet. As with research and innovation skills, there is concern about the human capital needed to implement government policy.

In the meantime, SU is studying innovation processes with the aim of informing government policies that aim to stimulate innovation and move the 4IR along in a positive direction.

To return to the question at the top of this article: we should embrace 4IR technologies wholeheartedly and explore their full potential to advance science, engineering, technology and innovation. At the same time, legislative processes should be fast-tracked to ensure safety, security and protection of human rights.

Read about previous NSTF Discussion Forums and articles on related topics:

- UNGA78 Science Summit Panel: Pitfalls of AI (15 September 2023)
- Pitfalls of AI (18-19 May 2023)
- Advanced manufacturing and automation: potential and challenges (11-13 September 2019)
- Implications of the 4IR for SET, industry, society, and education (11-13 September 2018)
- Light-based Technologies Innovation Forum (14-15 March 2016)
- Digital Wellness workshop for policy design towards Digital Security, Cyber Crime and Cyber Crime Prevention (21 August 2015)
- ICT Security and Privacy Issues (15 May 2015)

About the NSTF

The National Science and Technology Forum (NSTF), established in 1995:

- is a broadly-representative stakeholder body for all science, engineering and technology (SET) and innovation organisations in South Africa
- gathers stakeholders around burning issues of national and global interest, across the public and private sectors, including matters of public policy
- includes a network of professional societies in SET and STEM education (STEM = science, technology, engineering and mathematics) - the NSTF pro*SET* membership sector.
- recognises, awards and profiles the outstanding contributions of individuals and groups to SET and innovation through the prestigious NSTF Awards
- runs and supports collaborative projects and youth outreach, including recognition of top performance in mathematics and science, role modelling, bursary and STEM career information
- runs and supports the STEMulator.org which attracts youth and educators to Explore>Discover>Learn the world of STEM including careers. (Established by NSTF pro*SET)*

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