Emerging use-cases for Frontier technologies

What might be possible in the near future?

In the 2023 Futures exploration cycle we're asking ourselves the question:

Between now and 2030, what are the most exciting frontier technologies from a development perspective and how might the next seven years of technological change impact the way we do development?

As part of our initial research we conducted some high level speculation. Combining data with tech trends to create this set of **18 emerging use-cases for frontier technologies**.

Our hope is that they inspire you to see what the possible benefits of artificial intelligence, biotechnology, big data, quantum computing, sensors, and extended reality might be in the future.

4 Examples of Artificial Intelligence

1 Vertical farms

Traditional farming relies on long supply chains from farms to consumers, high volumes of water and significant areas of land.

46% of the world's habitable land is already used for agriculture (Our World in Data, 2019). With populations set to grow to 9.7 billion by 2050, there will be increasing demand for an already limited area of habitable land.

Vertical farms can be fitted into towers, skyscrapers and shipping containers within cities to produce food, using sensors and AI; increasing crop yields, proximity to users and requiring less water and carbon for transport.

(ref. GIZ Tech Detector)

The global cost of cyber crime is expected to rise to $10.5tr by 2025 . A number of trends in technology are contributing to a rise in potential cyber attacks: more devices are connected to the internet (through IoT, 5G, WiFi access), organisations are increasingly relying on third party applications and an increase in remote working is establishing new ways for cyber criminals to access digital assets.

With a rapidly increasing potential for cybercrime, technologists are recognising and acting on the need to develop more sophisticated ways of dealing with cyber attacks. AI can be used to monitor significant data sets, and seek out abnormalities to flag potential attacks. It can also be used to proactively identify potential vulnerabilities, allowing security teams to build more resilient networks.

(ref. Deloitte, 2021)

2 Artificially intelligent cyber defence

3 Personalised medication

The uniqueness and immense complexity of human bodies has held us back from developing treatments that are tailored to specific people's illness. As such, medical professionals have to rely on the data we have to hand about people, and their illnesses to assess which treatments are most likely to be effective.

As we develop new ways of sourcing large quantities of data on people's genetic makeup, this presents an opportunity to use AI to identify patterns in the data and make better informed decisions about what treatments will be effective. With a clearer idea of the specificities of someone's genetic makeup, doctors will be able to use AI to identify which health conditions someone is likely to face, and proactively identify treatments to prevent them.

(ref. TechRadar, 2020)

Increasingly governments across the world have recognised and addressed the need to integrate evidence-based decision making into policy development. However, this can be a complex process: data may be incomplete, expensive to gather and time consuming to analyse. Further, it can be difficult to create policy that is tailored and responsive to the needs of large, diverse populations.

AI has the potential to support governments at various points in the policymaking cycle. It can be used to scan the web and social media to identify needs within populations, help policymakers build accurate forecasts of the impact of policies on various metrics, and speed up implementation through automation and iterative improvement.

(ref. BCG, 2021)

4 Decision making support for policy makers

3 Examples of Biotechnology

Currently only 2Mgt of carbon are captured each year, whereas the Net Zero by 2050 scenario requires that this number rise to 250Mgt per year (IEA, 2022).

When biomass is converted into different forms of bioenergy (heat, light, electricity), carbon is produced and sequestered in geological formations or embedded in long lasting-products.

As the climate crisis worsens, and more funds, effort and expertise are devoted to finding new energy sources, and reducing the impact of existing one's, we might see a rapid uptake of carbon capture through bioenergy production.

(ref. GIZ Tech Detector)

1 Bio energy with carbon capture

The world could face a $15tn infrastructure gap between planned investment in infrastructure and what's needed to support trade, transport and development (WEF, 2019)

As more people move into urban areas, there is going to be increased strain on cities' infrastructure to support these changes. The number of people expected to live in urban areas could be 68% of the world population by 2050 (Cleantech 100, 2021).

Self-healing concrete contains bacillus spores and starch. These can stay dormant in a concrete mixture until exposed to water and air (a crack appears), then they react to produce calcium carbonate which bonds to the concrete fixing the crack. Could this reduce the cost of infrastructure repair in growing cities, and help close the infrastructure gap?

(ref. GIZ Tech Detector)

2 Self healing concrete

Between 1950 and 2015, plastic production grew from 2.3m to 448m tonnes, and is expected to double by 2050 (National Geographic, 2019). Waste plastic is responsible for the deaths of millions of animals each year, and causes severe damage to our natural ecosystems.

Enzymes can be used to catalyse the process of decomposing polymers to monomers in bioreactors, producing a mixture which can be combined with enzymatic additives to create PLA (one of the most common materials for 3D printers). These technologies are showing promise as an effective way to reduce the energy required to recycle plastic, and to reduce the toxicity of waste produced through the process. Machine learning algorithms can be used to both find, and genetically engineer the most effective enzymes for the process.

(ref. GIZ Tech Detector)

3 Enzymatic plastic recycling factory

3 Examples of Big Data

Across social media and the web, users are increasingly being exposed to content that matches up with their pre-existing preferences and views. Users interact with content they agree with, which in turn exposes them to more content that aligns with their views, which proliferates echo chambers ('bubbles'), and inhibits users interacting with content they disagree with.

Data can be gathered from users' interaction with the web to map out their 'filter bubbles' and expose them to different content. This could be used to help facilitate the idea of the internet as a marketplace of ideas, where users have access to and interact with a range of views, articles and entertainment sources.

(ref. GIZ Tech Detector)

1 Anti filter-bubble algorithm

2 In-silico farming

As the climate crisis leads to increasingly volatile weather conditions, farmers across the globe are going to face uncertain crop yields.

Data can be gathered in real-time using sensors placed in fields to build complex models of farming ecosystems. By applying machine learning algorithms to the data set, the models will be able to more accurately and responsively predict future crop yields, providing information to farmers on how to optimise outputs. Further, the responsiveness of the models to real-time data inputs from the field will allow increased preparedness to potential climate shocks.

(ref. GIZ Tech Detector)

Between 1970 and 2019 there have been 2 million deaths from natural disasters, with 91% occuring in low-income countries (UN, 2021). Within this period the economic cost of disasters has increased from $49 million to $383 million per day, globally (Ibid). With climate change increasing the frequency and severity of disasters, the need to proactively support affected communities has become a global priority.

Big data generated from de-identified mobile location data can be used to track population movements before and after disasters, allowing governments and humanitarian organisations to more efficiently allocate resources before and after disasters.

ref. Flowminder

3 Big data for proactive humanitarian support

3 Examples of Quantum computing

Storage is one of the major challenges with building cost-effective renewable energy infrastructure. Improving the energy density of batteries allows us to store energy at a lower cost, but between 2020 and 2025 it is only expected to improve by 17%.

Given quantum computers' greatly expanded potential to calculate, they can be used to simulate different models for the chemistry within a battery, and different potential materials they could be made up of. This optimisation could increase energy density by 50%.

This could allow batteries to serve as a grid scale storage solution for solar, which could potentially increase solar use by 60% by 2050. This could lead to a reduction of 1.4 gigatons of carbon in the atmosphere by 2035.

(ref. McKinsey, 2022)

1 High energy density batteries

2 Sustainable cement

Two thirds of cement emissions are produced during the calcination process needed to make clinker, a powder put into cement mixtures. So far, no cost-effective alternative has been found for clinker, and the process of trial and error needed to develop them is costly and time consuming.

Quantum computers can be used to simulate theoretical material combinations of alternative clinkers to find an alternative that maintains the durability of the clinker, while reducing CO2 emissions. It's expected that this could reduce carbon emissions by 1 gigaton by 2035.

(ref. McKinsey, 2022)

3 Drug development

Drug development involves developing and exploring different molecular formations, which might be able to combat deadly diseases and health issues. Given that these molecular formations themselves have a quantum structure, quantum computers are much better suited to simulate their potential behaviour than classical computing can.

Currently the simulations needed to predict molecule behaviour accurately would require years if done on a classical computer. This leads to a heavier reliance on active experimentation which greatly increases the costs of drug development. The computing power of quantum computers could facilitate accurate simulation of behaviour.

This could greatly increase the speed and reduce the cost of drug development, making the pharmaceutical industry more responsive to emerging health problems and accessible in low-income contexts.

(ref. McKinsey, 2022)

3 Examples of Sensors

According to the World Economic Forum at least half the world lacks access to reliable healthcare, within sub-saharan Africa the number of people without access to any kind of healthcare is roughly 408.8 million (WEF, 2019).

With Africa's population expected to double by 2050, there is going to be increased demand for healthcare infrastructure.

Flexible skin patches packed with silicon-based biosensors can be used to gather data on people's vitals in real time, transferring information across wireless sensors to people's smartphones and a network of hospitals. Tech startups are exploring whether this technology can be used in conjunction with blockchain to securely manage the data, and protect patients privacy (Taralunga and Forea, 2021). This could greatly reduce the need for on site visits, and allow doctors to better monitor patients wellbeing without the need for point of care interaction.

(ref. GIZ Tech Detector)

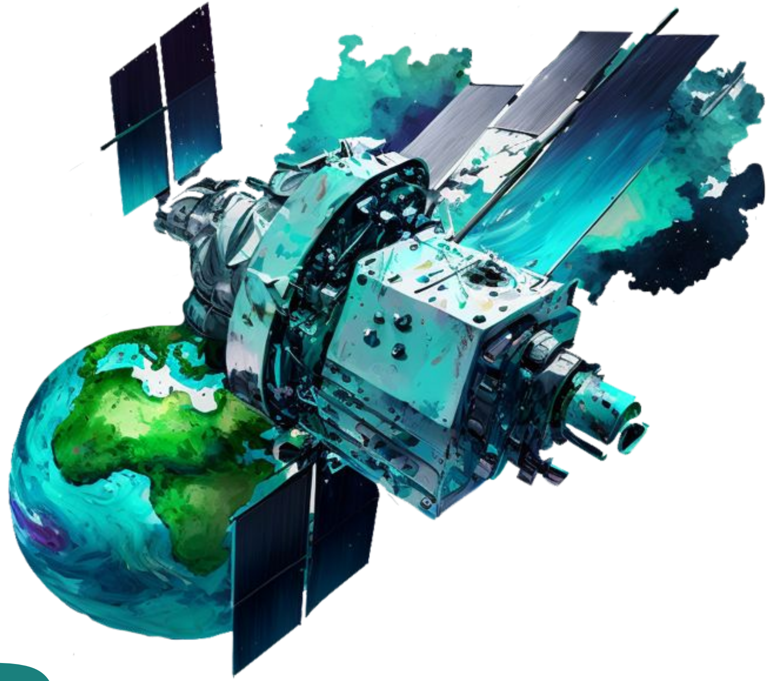
1 Wireless skin patch sensors

Only 74% of the world have access to safe water (OurWorldinData, 2020). As we work to improve access to clean water across the globe, there will be an increasing need to ensure that transport systems are resilient, clean and safe.

Sensors distributed throughout different parts of the water system, to gather real-time data on potential contaminations, floods or droughts giving city planners, farmers and engineers time to respond to problems before they affect populations.

(ref. GIZ Tech Detector)

2 Integrated water management platform



Harmful algal blooms (HABs) in marine environments, caused by water pollution, can pose serious risks to animal and human health. A HAB event in 2019 killed eight-million salmon.

Satellite sensors combined with AI can be used to directly estimate water health status, allowing for accurate predictions of when events such as this can occur. The technology could be used to monitor key environmental indicators at a high scale, with increased frequency to facilitate pro-active management of marine ecosystems.

(ref. ScienceDaily)

3 Satellite sensors to monitor pollution in marine environments

2 Examples of Extended reality

AR-enabled headsets and AR software allow surgeons to view 3D images as true 3D objects in space. This allows them to more naturally interact with content.

For example, the surgeon would be able to tilt their head or walk around an actual 3D reconstruction of the patient's anatomical structures, reducing the need for cumbersome manipulations on a monitor, enabling quicker and more intuitive understanding of potential surgical plans and procedures, and more generally reducing the cognitive load required to process the visual information.

(ref. Forbes)

1 AR enabled headsets to support healthcare

Veative Labs in India, is a provider of VR education and learning simulations for schools and industry. The Veative Labs STEM library contains over 500 educational modules, and a portion of its content library is open-sourced and accessible via WebXr (an alternative method of accessing content directly via the web and thus facilitating distribution).

With 58.4 million children of primary school age not attending school, and rapidly increasing youth populations in LMIC countries, this technology could help more children access educational resources (Our World in Data, 2021).

(ref. UNICEF)

2 VR learning tools to increase access to education