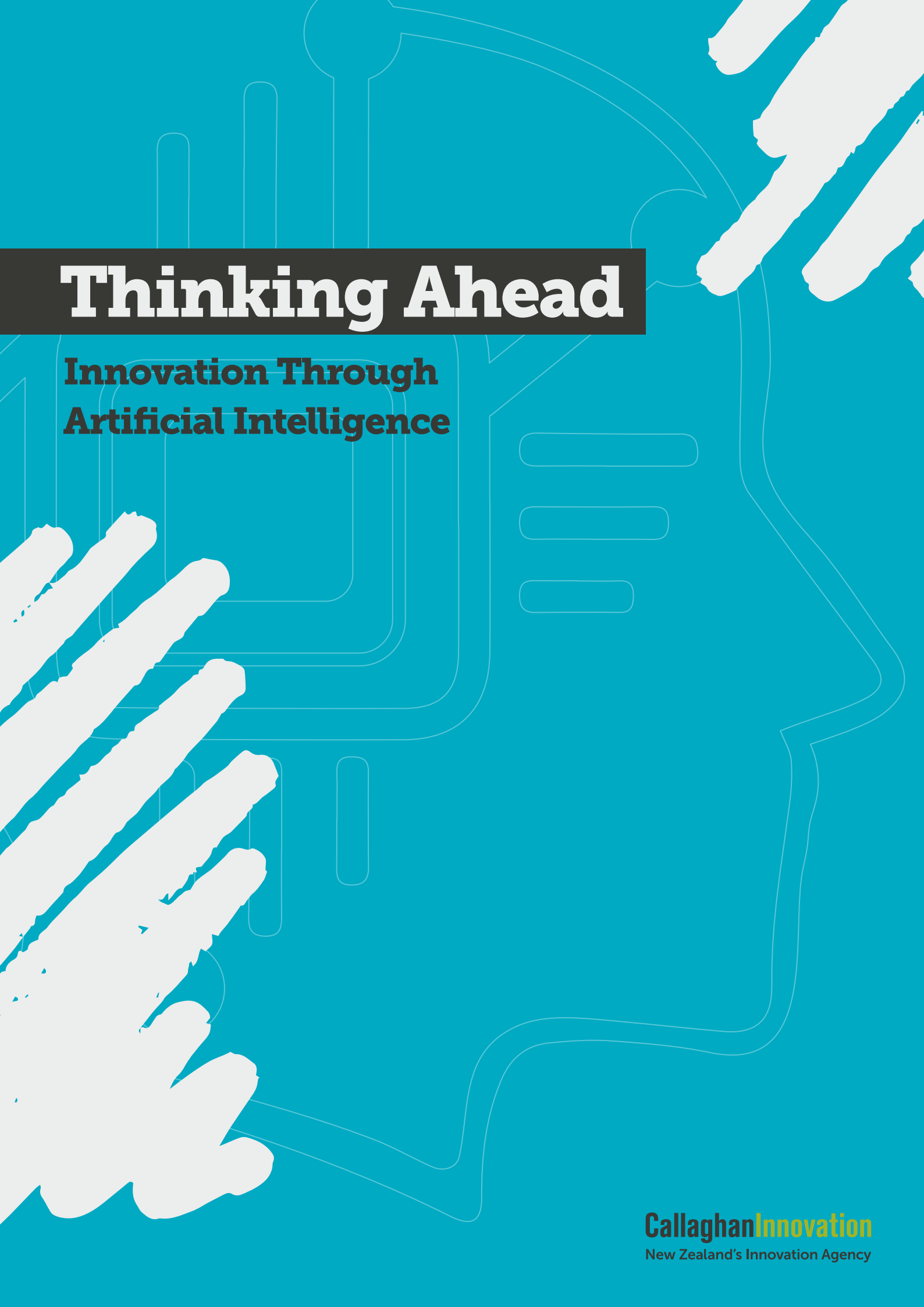
Thinking Ahead

Innovation Through Artificial Intelligence



CallaghanInnovation
New Zealand's Innovation Agency

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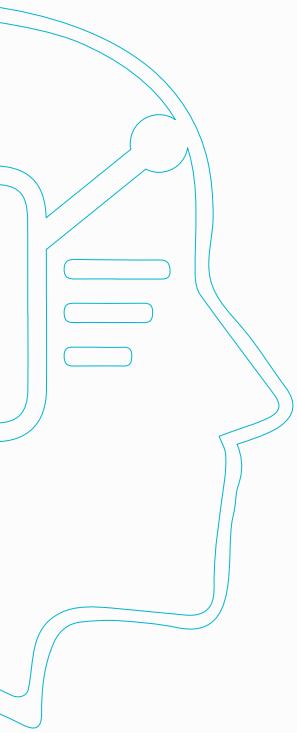
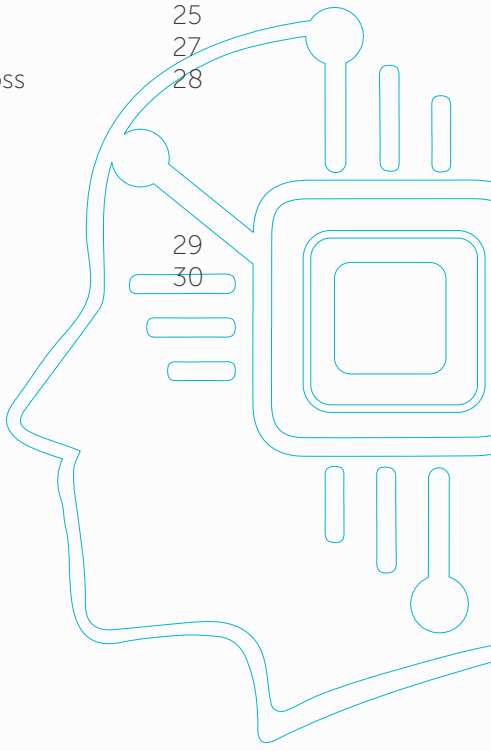




Executive Summary

In New Zealand the impact of artificial intelligence (AI) will come in waves across our sectors, as more firms find new ways to apply different types of AI.

Indeed, some Kiwi businesses are already using AI in smart ways, disrupting their sectors and creating competitive advantages.

Others, however, are struggling to get their heads around its practical uses.

The fact of the matter is businesses that are disengaged with the technology risk falling behind. Globally, companies using AI, big data and the Internet of Things to uncover new business insights are predicted to "steal $1.2 trillion from their less-informed peers by 2020"*. Seeing the potential, tech giants and other global players are investing billions in AI across a host of sectors, many of which they have never played in before.

This is why Callaghan Innovation has put together this much needed white paper looking at what AI means for four of our critical sectors: agriculture, digital, health and energy.

Trying to predict all the applications of AI will be impossible though, so businesses will need to be agile and switched-on to developments. The good news is that our Kiwi businesses have great access to information, government support, sector networks and partnerships to help them engage in AI opportunities that will benefit their business.

Forrester, 'Predictions 2017: Artificial Intelligence will Drive the Insights Revolution'

Agriculture Sector

We believe there will be an extreme impact in agriculture, with many tasks able to be automated and optimised. Presently we see the bulk of this impact occurring in the next two to five years but focused on efficiency and cost savings. Far more aggressive uptake and application right across the value chain is required if we want to sustain and advance our leadership in this space.

Digital Sector

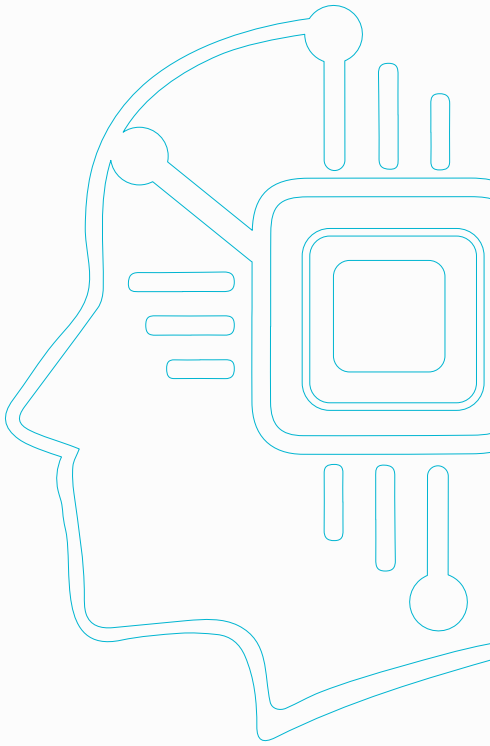
AI has well and truly arrived in the software-driven digital sector and its impact is being felt now. Companies in this industry should be well down the track of taking advantage of the technology.

Energy Sector

There is huge potential for AI to make far better use of complex systems in the energy sector. With the rich data available in New Zealand and a bold approach, this sector could adopt and adapt AI technology quickly. AI will allow more personalised energy management and the integration of a number of current and future renewable energy sources as well as appliances.

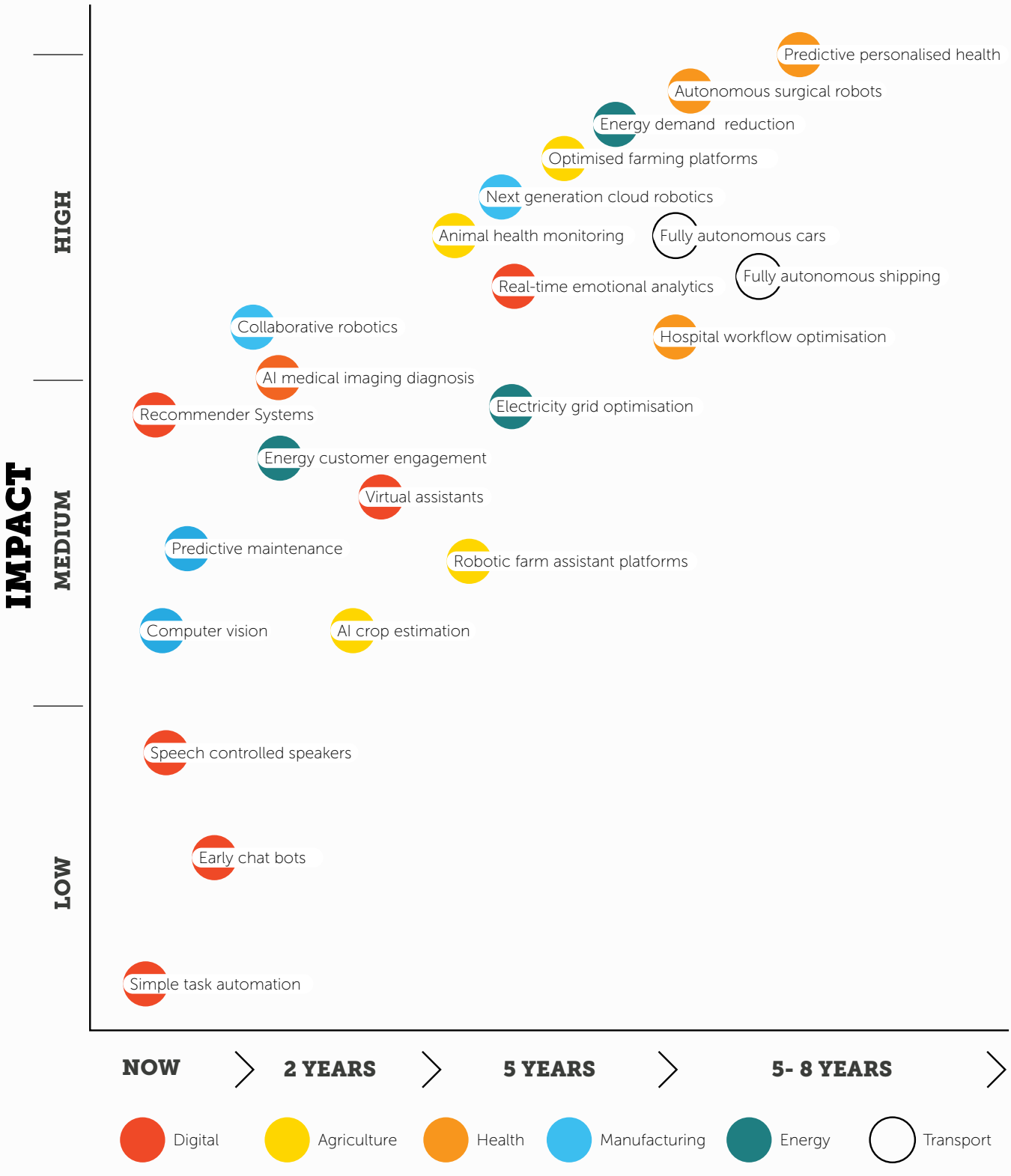
Health Sector

Health is also set to bear the brunt of extreme change. However, the promise of AI-optimised personalised medicine will be held back (for five to seven years) by the fundamental 'ambulance at the bottom of the cliff' structure of the health system. This is a global challenge but New Zealand can lead the way by turning that model on its head and finding ways to embrace innovations in personalised healthcare.



How AI will Impact the NZ Market

AI is set to transform sectors, similar to the effect of electricity when it was made available. Industries that were able to adapt and leverage electricity quickly thrived. This infographic takes a scan of many likely AI applications, their level of impact, and the timeframe within which they are likely to be deployed at scale. As New Zealand businesses undertake their strategic planning, they need to consider the impact these applications will have.



Enhancing the AI Conversation

Artificial Intelligence (AI) is one of the most talked-about technologies of our time. New possibilities for innovation based on AI technologies are emerging at a dizzying rate. In every sector of New Zealand industry, company leaders urgently need to get their heads around what these possibilities might look like for their businesses and embrace AI as a driver of future change.

The stakes are high, with Forrester Research predicting that globally, by 2020, businesses that are driven by the insights provided by AI, big data and the Internet of Things will "steal" $US1.2 trillion a year from competitors who don't embrace these opportunities.

In 2017, Callaghan Innovation released an infographic aimed at demystifying AI. This follow-up white paper goes deeper, closely analysing the impact of AI on several key sectors: agriculture, digital, energy, and health. We consider the types of AI that will have the greatest impact, and assess just how ready for innovation each of those sectors is.

As New Zealand's innovation agency, Callaghan Innovation sees first-hand the need to embrace new technologies such as AI and the consequences if we don't. The success of our sectors is critical to the prosperity of the Kiwi economy as a whole, and we are observing the need for a far more aggressive uptake of AI.

We hope this report will play a role in jolting businesses into action. They will not be on their own: we are focused on helping enterprises to accelerate their adoption of AI, and ensure they have the capability they will need to take advantage of these ground-breaking new technologies.

Vic Crone
Chief Executive, Callaghan Innovation

"The success of our sectors is critical to the prosperity of the Kiwi economy as a whole, and we are observing the need for a far more aggressive uptake of AI."

A Driver of Growth and Improvement

The rapid development of AI technologies presents major opportunities and challenges for our country. We need to actively engage with AI, in order to secure our future prosperity. And we need to hold a meaningful national conversation about the broader implications of AI for society.

The AI Forum is coordinating a large-scale research project – due to be published in the second quarter of 2018 – to explore the AI landscape both within New Zealand and internationally, and the potential for AI to help drive economic growth and social improvement in New Zealand. In the meantime, we welcome this white paper as adding a compelling voice to the national conversation.

Ben Reid
Exec Director, NZ AI Forum

forum NEW ZEALAND

Collaboration is New Zealand's Strength on the Global AI Stage

By Shaveer Mirpuri

The re-emergence of AI after a period of relative inactivity stems from major advances in complementary fields: computational power, cloud computing, the vast volumes of digitised data and cutting-edge approaches to algorithms and architectures. These technologies are now driving AI forward.

This rapid evolution means we need to have the discussion about AI right now. We're in an age where machines and humans can and do work together as professional colleagues, forming a "dream team" of sorts.

"We're in an age where machines and humans can and do work together as professional colleagues, forming a "dream team" of sorts."

Just as humans can choose to focus on selected fields of study, AI can be applied to specific industries. The combination of AI systems and human judgement produces a previously undreamed-of capability that enables companies and industries to innovate in faster and more dynamic ways.

That potential is what's motivating technology giants and large enterprises around the world to invest in AI, ahead of all other technologies.

In New Zealand, perhaps our biggest strength is our democratised landscape which makes it easy for corporates, innovators, academics and funders to join forces and collaborate on AI ventures. This type of co-operation is rare in larger markets so New Zealand should take advantage of the opportunities it offers.

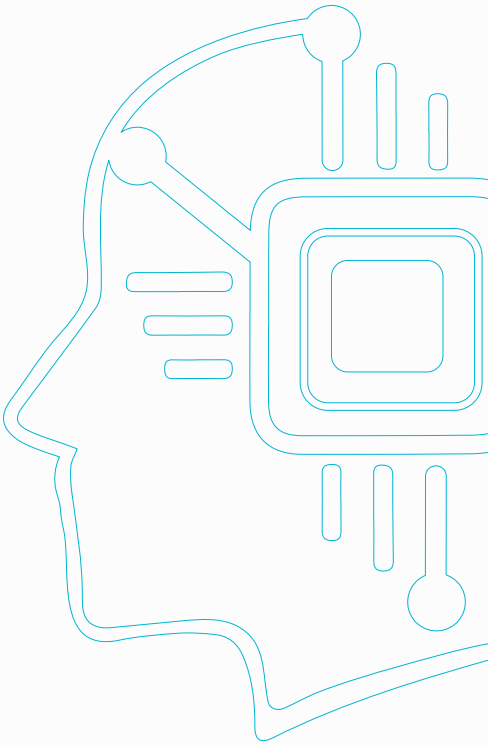
An example is Goat Ventures' joint venture with MinterEllisonRuddWatts, with the long-term vision of building the law firm of the future where the legal advice is provided by AI.

Under this JV, experienced funders, PhD-level experts and industry practitioners with terabytes of relevant data have combined to develop an AI engine that can be used by any firm delivering legal services.

Through initiatives like this New Zealand has the potential to make its mark in the game-changing AI arena.

With research firm Gartner predicting that globally in 2021 AI augmentation will generate $US2.9 trillion in business value and recover 6.2 billon hours of worker productivity, it's an arena well worth playing in.

Shaveer Mirpuri is CEO of Goat Ventures, and one of the leaders of a $2M joint venture with MinterEllisonRuddWatt to apply AI in legal services.



The AI Technology Landscape

It's important businesses have confidence to engage with the topic of AI and to incorporate it into their R&D strategy. Last year Callaghan Innovation released an infographic aiming to demystify AI. It highlights the different types ready to be used right now, versus AI technologies approaching in the future.

The AI Technology Landscape

AI is computer systems that exhibit human like intelligence. It is a group of science fields and technologies concerned with creating machines that take intelligent actions based on inputs.

Deep learning

A high powered type of machine learning algorithm that uses a cascade of many computing layers. Each layer uses the input from the previous layer as input.

Enabled by neural networks and given big data sets, deep learning algorithms are great at pattern recognition, and enable things like speech recognition, image recognition and natural language processing.

The combination of neural networks (enabled by the cloud), machine learning technology, and massive data sets (the internet), has made deep learning one of the most exciting AI sub-fields recently.
Examples: Google's DeepMind beating the best human at the game "Go".

Thought controlled gaming

The application of AI, wearable technology, and brain computing interface technology to enable seamless interaction with social gaming environments in real-time, through avatars without the need for joystick-type devices.
Examples: Emotiv, Games Research Lab (Columbia Uni).

Real-time universal translation

The application of natural language processing to enable two humans (with no common language) to understand each other in real-time.
Examples: Microsoft Translator.

Neuromorphic computing

Future generation computing hardware that mimics the function of the human brain in silicon chips.
Examples: The Human Brain Project/IBM's TrueNorth processor chip/NZ's Professor Simon Brown at University of Canterbury.

Machine Learning

Algorithms that can learn from and make predictions on data. Overlaps with computational and Bayesian statistics. Underpins predictive analytics and data-mining.
Examples:
Recommender systems like NZ's own Movio which recommends movies.
Xero uses machine learning for automated processes (like automated cost-coding).
JV between Goat Ventures and Minter Ellison for legal AI.

Next gen cloud robotics

Convergence of AI, big data, cloud and the as-a-service model will enable a cloud-based robotic brain that robots can use for high powered intelligent and intuitive collaboration with humans.
Examples: Cloud Minds.

Robotic personal assistants

Cloud-based AI learns from big data to enable human-like social robots that can perform usefully as personal assistants.
Examples: Kuka Robotics.

Real-time emotion analytics

The application of AI to analyse brain signals, voice and facial expression to detect human emotions.
Examples: Emotiv.

Autonomous systems

Autonomous robots, self-driving vehicles, drones, all enabled by AI.
Examples: HMI Technologies (trialed at Christchurch Airport).

Natural language processing

Technologies that enable computer systems to interact seamlessly with human languages.
Includes:
Written language and speech recognition, sentiment analysis, translation, understanding meaning within text/speech, language generation.
Examples: Siri, Alexa, Cortana. New Zealander Mark Sagar's company Soul Machines.

Cognitive cyber security

Cloud-based AI systems trained on historical cyber threat data, capable of mitigating real-time cyber threats.
Examples: Deep Instinct.

Autonomous surgical robotics

Cloud-based AI platforms can help robotic surgeons to perform precise surgeries by learning from large historical surgical data sets (like video).
Examples: Imperial College of London, MIT.

Patttern recognition

A branch of machine learning and deep learning which focuses on recognition of patterns in data.
Examples: DeepFace, (Facial recognition system by Facebook).

Virtual companions

Cloud-connected, virtual reality-based avatars powered by AI engines that can behave and interact just as a human would.
Examples: Digital companions that provide caregiving companionship for the elderly.

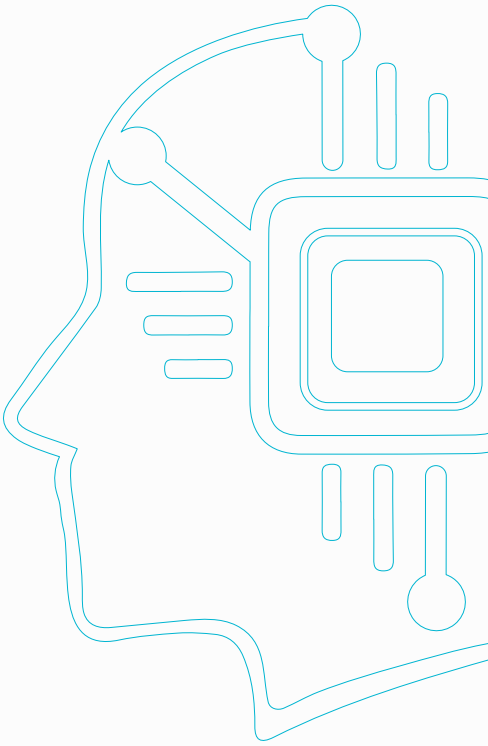
Chatbots

A software robot that interacts with humans online, receiving and sending conversational text with the aim of emulating the way a human communicates. An example of natural language processing.
Examples: Kiwi start-up Jude.ai (an AI-based financial advisor). Kiwi company Wine Searcher.

Neural networks

Computing systems that organise the computing elements in a layered way that is loosely modelled on the human brain. Enables deep learning.
Examples: The computing system that sits behind Baby X at Auckland University.New Zealand's Professor Kasabov at AUT (Neucube).

Sources:
Frost & Sullivan "Artificial Intelligence- R&D and Applications Road Map" (Dec 2016), Harvard Business Review- The competitive landscape for Machine Intelligence (Nov 2016),
Shivon Zilis and James Chan "The State of Machine Intelligence, 2016" (2016), Stanford University.
"Artificial Intelligence and Life in 2030" (2016), https://en.wikipedia.org/wiki/Artificial intelligence (2017)



Section 02: Overview

Machine Learning

By Shaveer Mirpuri

Machine learning is a field of AI focused on training systems with data. Unlike programming, which involves coding a system to do something, this approach teaches machines to think, based on their training. This means they can decide what actions to take, and in some cases adapt their decision models based on the results of those actions. In this way, something approaching human intelligence can be delivered at scale.

"In this way, something approaching human intelligence can be delivered at scale."

The techniques for developing machine learning will continuously improve over time and will inevitably be extremely complex. Small, medium and large businesses cannot expect their technical specialists to be across this technology by default. They may understand learning and training methods, or classification and pattern recognition, or information retrieval or prediction. But the real commercial magic will come from the specialist machine learning engineers.

These engineers combine the experience gained in their PhD research with commercial savvy. They're pairing business goals with seriously cutting-edge approaches. Already, they're working at the limits of machine learning potential, implementing things like natural language generation, reinforcement learning and generative adversarial networks.

The opportunity to lead in this space is thrilling. Machine learning has been consistently proven to solve a vast array of problems in numerous applied industries. Advances in deep learning (machine learning applied to neural networks modelled on interconnected nodes like those found in the human brain), natural language processing (NLP, the ability to interpret text and/or speech), and computer vision (CV, the ability to interpret images and/or video) are already driving developments in major sectors such as digital, health, agriculture and energy.

Section 02: Overview

Natural Language Processing

By Alyona Medalyan

Natural language processing (NLP) is what computers and smartphones use to understand our spoken and written language. Because we've long used language to interact with our devices NLP has become an integral part of our lives, even without us noticing it happening. Here are just a few of the everyday uses of NLP that affect us all:

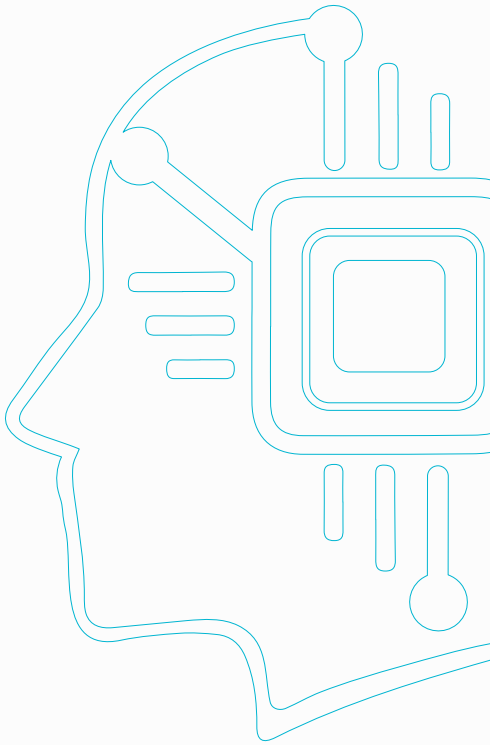
- Any time you type a message or a search query, NLP helps you type faster.
- When you compose an email, a blog post or any document in Word or Google Docs, NLP helps you to write more accurately (with spelling and grammar checkers, including a product called Grammarly that uses both and automatically adds a helpful explanation).
- When you search on Google, many different NLP algorithms are triggered to help you find things faster.
- NLP enables productive emailing by supporting email clients that can continuously defend you from spam.

"When you search on Google, many different NLP algorithms are triggered to help you find things faster."

While consumers are already benefitting from NLP, businesses are starting to realise the gains as well. Any company that collects customer feedback in free-form, such as complaints, social media posts or survey results, can use NLP to find useful insights in the data that they can then act on.

At Thematic, we do feedback analysis (such as survey responses and reviews) to help businesses understand their customers' priorities for product and service improvements.

Demand is growing for bigger and better NLP solutions, even as rapid advances are made in the area of voice recognition using deep learning algorithms. Once the voice is converted to text, the next step is to figure out the user's intent. The two biggest challenges for NLP right now are being able to resolve ambiguity and to teach algorithms about context.
For example, when someone says "turn off the lights", they may want to switch off the lights, or they may be referring to a song title – and there are at least two songs with this title!



** Alyona Medelyan, PhD, is CEO of Thematic, which uses natural language processing to provide customer feedback analysis. She also runs the New Zealand Natural Language Processing meetup.*

Deep Learning

By Geoff Holmes and Eibe Frank

One of the big changes in the IT industry over the past decade has been the emergence of several extremely wealthy companies whose research capabilities and computational resources exceed those of the leading universities.

Not only do they have more computing power, they have access to more data, and this provides the perfect platform for building effective machine learning-based technology. This technology has become commonplace and extends to all the devices we use on a regular basis. It's used to perform many tasks, but the areas where we're seeing the greatest impact is in image processing and computer vision.
This is not a new application for machine learning, but the latest results are staggeringly better than previous ones, due to developments over the past decade in the area of neural networks. The new branch of machine learning is called deep learning.

"It's used to perform many tasks, but the areas where we're seeing the greatest impact is in image processing and computer vision."

The machine learning group at the University of Waikato is investigating deep learning in a number of ways. We are integrating several state-of-the-art deep learning approaches into the well-known WEKA machine learning software produced by the group. The aim is to make deep learning possible without requiring the user to write programs.

The group is also looking at the use of transfer learning in several deep learning applications. Transfer learning is the idea of adding training data that is specific to a certain task to a pre-existing learned model. For example, if the task is identifying an object in an image there are publicly available models trained on vast libraries of pictures. In the New Zealand context they can be adapted for use in agriculture, such as estimating yield in grape production.

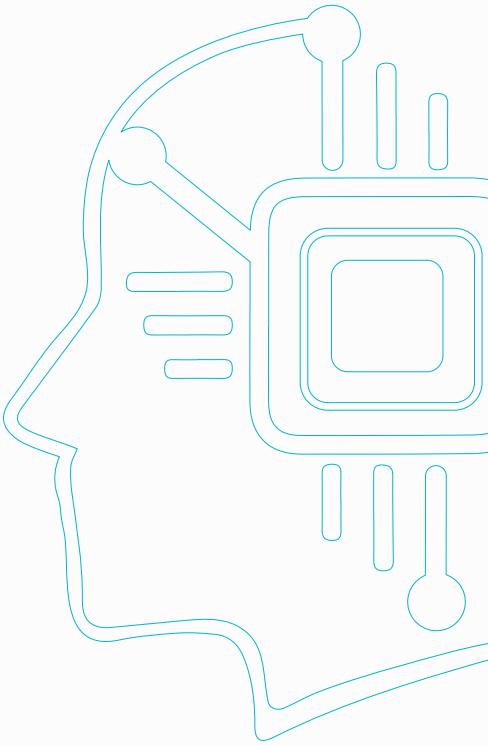
The idea is that the pre-existing network has already learned to extract useful features from general images, such as edges, textures and shapes, etc. By additional training of the model using images of grapes and surrounding vegetation, it becomes possible to learn higher-level features that are specific to grapes.

It is then relatively straightforward to count individual grapes and estimate yield. The advantage of this approach is that the grape data set can be significantly smaller than the one used to establish the pre-existing model.

** Geoff Holmes and Eibe Frank are researchers at the University of Waikato's Machine Learning Group. The group has been researching machine learning for decades and has had international success with its WEKA machine learning work-bench software.*

Sector Analysis

AI will have a significant impact on a number of key industries in New Zealand and globally.
Here we take a look at present and future developments in the agriculture, digital, energy and health sectors.



Section 03: Sector Analysis

Agriculture

AI will enable significant and valuable new solutions in agriculture.

The Internet of Things (IoT) will converge with AI in future intelligent agricultural systems, fuelled by large volumes of data acquired from images, videos and IoT sensors.

Smart Application of Water and Sprays

Technological strides in AI are smoothing the way for new levels of optimisation on our farms and across all horticultural activities.

Automated irrigation systems are getting better and better thanks to constant monitoring of individual plots and the transporting of water to specific places, based on the real-time needs of plants.

Techniques using IoT and sensors to analyse what's happening across thousands of hectares of land in real-time will enable improvements in predictive modelling. Farmers will be able to check the advantages of specific phenotypes, or traits, in certain growing cycles over time. Predictive modelling will also help them forcast pest resurgences, dramatically preventing yield losses and reducing farmers' dependence on chemical pesticides.

At the University of Waikato, researchers are applying machine learning to near-infra-red images of soil samples, meaning the soil does not have to be sent to the lab. This will enable farmers to apply fertilisers much more efficiently.

Robots will be developed to roam between growing plots, collecting data and eliminating known strains of weeds. These bots are light enough that they do not damage the soil, and because they release herbicides only onto the weeds, they're also more environmentally sustainable. Many uses of AI in agriculture are focused on reducing the biological and ecological damage caused by inefficient use of pesticides.

Animal Health Monitoring

AI can also be used to improve efficiencies in livestock management by optimising feeding and dispensing of medication.

The technology can constantly monitor stock movements, eating patterns and health, and immediately flag animals that are showing unusual behaviour or reduced wellbeing. They can then be treated quickly before they spread infection. Farmers benefit from cost reduction through more targeted use of antibiotics, while also improving the treatment of stock.

The main technology driving all of this is computer vision. In the simplest terms, images are constantly captured and pre-processed (through edge detection), filtered for frequency and density, then classified using other techniques (with machine learning boosting the accuracy), and the results are merged.

"Robots will be developed to roam between growing plots, collecting data and eliminating known strains of weeds."

Crop Estimation

Machine learning can predict crop yields well ahead of scheduled harvests. Until now, kiwifruit growers have had to manually count fruit over certain areas and then extrapolate those numbers over the whole orchard. The sector would not know until the product hit the supermarket shelves whether its spot sampling had been correct. Any miscalculation could result in tens of millions of dollars in losses.

"Any miscalculation could result in tens of millions of dollars in losses."

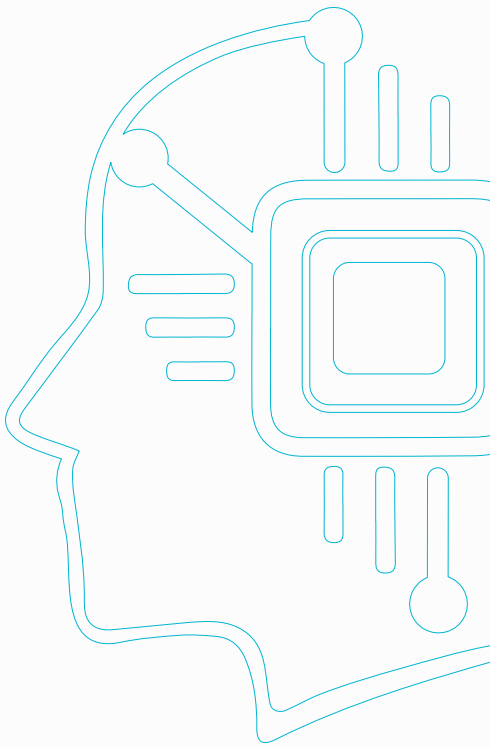
AI-enabled drones can resolve these sorts of issues. Even stabilising a device as simple as a smartphone to ride along on trailers can help provide better estimates. The device videos the orchard on-the-go and can then geo stitch a map. From there, video-based machine learning systems can detect, and therefore count, seeds and fruit months in advance.

Having these insights in advance would also enable harvesters to undertake section-based optimisations, improve food safety, and direct fertiliser to specific locations. Suppliers can better manage their pricing and revenue forecasting with retailers, accurately book shipping logistics and storage, and reducing waste.

Looking Ahead

New Zealand's agriculture sector is primed to start innovating with AI. We see AI having an extreme impact in this sector with the ability to automate and optimise many tasks. AI is likely to drive substantial gains through controlling costs, automating physical processes, accurately predicting results, reducing wastage and optimising resource allocation. As a country, far more agressive uptake and application is needed if we want to sustain our leadership in this space.

Sector	Impact	Key AI Technologies
Agriculture	Extreme	Machine learning NLP Drones Computer vision IoT Robotics Satellite data



Grape Expectations: Putting AI to Work in the Vineyard

Lincoln Agritech, a research and development company owned by Lincoln University, is developing an AI solution which can make early-season predictions of vineyard harvests.

"Grape growers and wineries spend a lot of money trying to predict their grape yield each year," says Lincoln Agritech optics and image processing team leader Jaco Fourie.

"This currently involves hiring a large number of workers to manually sample grape bunches."

Through a project funded by the Ministry of Business, Innovation and Employment and NZ Winegrowers, Lincoln Agritech is working on creating a system that instead uses electronic sensors to accurately count grapes.

"The sensors will capture and analyse grape bunches within individual rows, and assess the number, sizes and distribution," says Dr Fourie.

"We'll then feed this data into computer algorithms, which have been designed by the University of Canterbury, to predict grape yield at harvest time."

New data will be added to the system each year, leading to continuous improvements in the model's accuracy as more information is gathered under different conditions.

Lincoln Agritech CEO Peter Barrowclough says "the game-changing innovation will enable growers to accurately assess differences in yield not only between regions or vineyards but also blocks and rows."

"Over the long term, site-specific yield prediction will help reduce costs by enabling better planning both in the vineyard and in market."

NZ Winegrowers' general manager of research and innovation, Dr Simon Hooker, says the technology will benefit the industry by supporting better crop management, smoother processing and market forecasting based on capacity to supply.

Collaborating partners on the project include Plant and Food Research, Lincoln University, the University of Canterbury, CSIRO (Adelaide), NZ Winegrowers and local winegrowers in the Marlborough region.

"The sensors will capture and analyse grape bunches within individual rows, and assess the number, sizes and distribution."

Machine Learning to Boost Sustainable Farming Apps

A New Zealand cloud-based software developer providing irrigation advice to farmers plans to strengthen its capabilities using machine learning.

Regen uses on-farm sensors and other data to provide farmers with daily recommendations around nitrogen application and water and effluent irrigation.

The company's solutions, which can be accessed via smartphone, take the guess-work out of interpreting the large amounts of data farmers need to consider before making an irrigation decision.

It launched its first solution, Regen Effluent, in 2010 and has subsequently expanded into nitrogen application management and water irrigation scheduling. It was a finalist in the 2016 Innovation Awards.

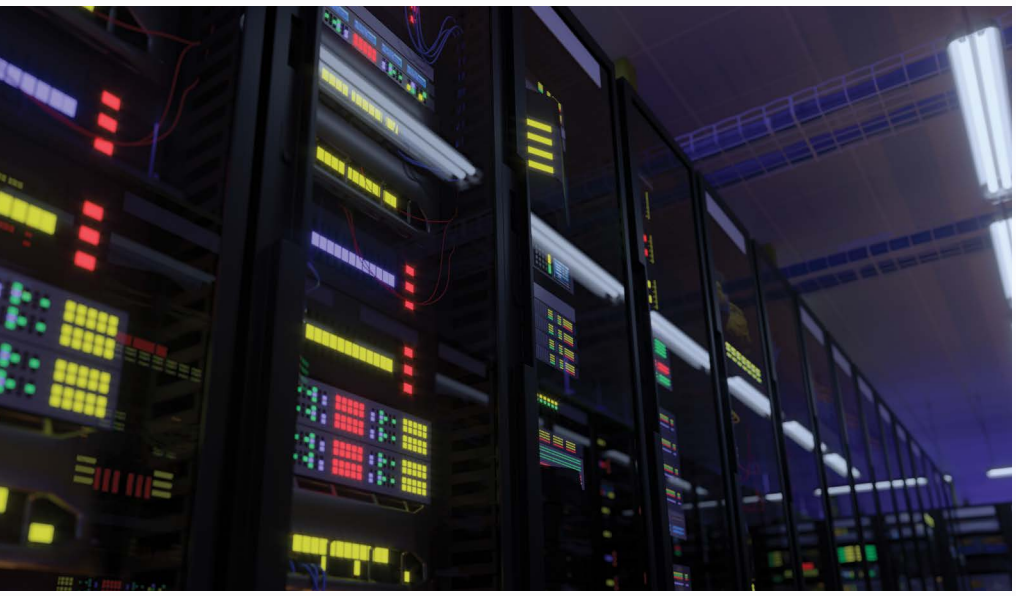
Optimising the amount, and timing, of effluent and water irrigation, and nitrogen application, are key components of ensuring farm sustainability and resource consent compliance, minimising leaching, and optimising pasture growth.

Chief executive Bridgit Hawkins says Regen now plans to incorporate machine learning into the modelling, giving its solutions more powerful predictive capabilities.

Several years of data collected from sites around the country will enable the company to tap into valuable insights.

"By using the time series data we have across many sites and putting two different methods of measuring the same feature together – along with some of the known factors that influence the strengths and weaknesses of each method – we can develop a new, superior measure," she says.

"Using that new measure we plan to strengthen the predictive component of our solutions."



"The company's solutions... take the guess-work out of interpreting the large amounts of data farmers need to consider before making an irrigation decision."

Section 03: Sector Analysis

Digital

AI has already created a tsunami of innovation, and a significant amount of that has occurred in the software-driven digital sector. AI algorithms are being incorporated into all types of applications from search engines to online photo storage tools.

"Their vision is to create a law firm of the future where legal advice is provided by AI."

Finance and Accounting

Accounting systems are using a combination of data mining, supervised learning (where inputted data is labelled), fuzzy logic and other statistical methods. They can be quickly deployed to shadow financial transactions and generate recommendations to support business decision-making.

"Robo advice" is used to forecast the benefits or consequences of different levels of capital expenditure. Financial firms are even offering such tools to their customers. Self-sufficient algorithms can evaluate a borrower's credit standing and tailor loan products to suit. Instead of relying on regulation and sampling methods to identify and predict suspicious trading, government agencies and payments companies can use mass machine learning for fraud detection.

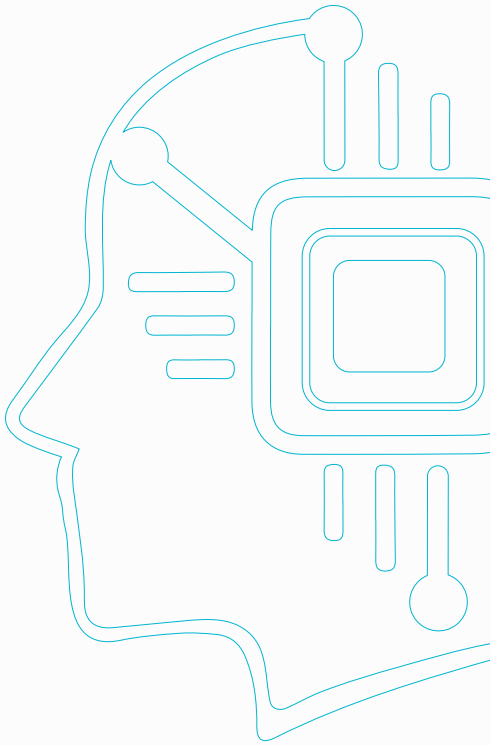
Legal

Technologies such as advanced natural language processing (NLP), self-organising maps, deep neural networks and unsupervised learning (where inputted data is unlabelled) will be able to analyse thousands of legal documents within seconds.

Soon AI systems will be able to understand a customer's objective or query about a contract, extract the relevant information and solve the problem much more precisely than a human expert can. Then the system will be able to explain its advice by automatically deriving and interpreting the rules from legislation.

This first layer of advice would be followed by problem-solving and analysis using legal hierarchies in different jurisdictions or fields of law – in much the same way as a human subject matter expert would, but more quickly and without the costly hourly rate.

In New Zealand this is what the Goat Ventures and MinterEllisonRuddWatts joint venture aims to do. Their vision is to create a law firm of the future where legal advice is provided by AI.



E-commerce

In parts of the digital sector use of AI is already business as usual. Online retailers, for example, use the data they have on their customers to make personalised pitches and display relevant content. E-commerce search engines can already be empowered by NLP, and programming techniques can allow customers to search for products expressively and conversationally, rather than using specific terms. More accurate product recommendations increase average revenue per user, conversion to sales and retention rates.

Wholesale businesses can use predictive toolkits to dynamically price products on the basis of forecasted demand. That same forecasting power allows larger retailers and wholesalers to better manage their inventory and distribution.

Looking Ahead

The capability to capitalise on the benefits of AI in the digital sector are at a more advanced stage than in other industries. For those specialising in or relying on advanced human intelligence (such as professional advisory services), or large corporates looking to leap into adjacent fields, however there is no time like the present to adapt.

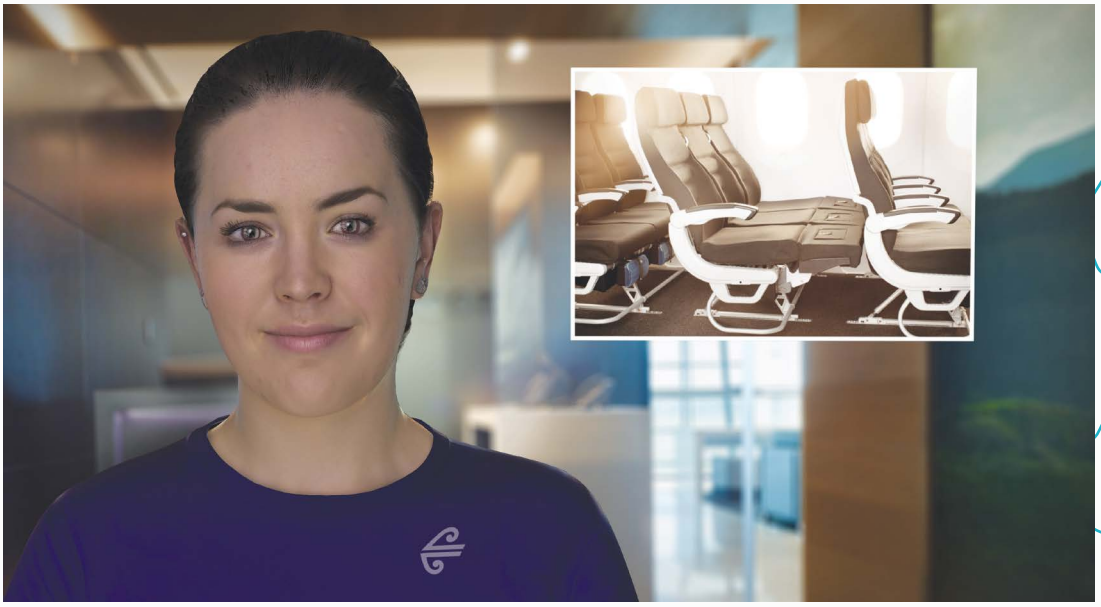
For many New Zealand digital companies it makes sense to use existing off-the-shelf solutions rather than making a significant investment in developing their own intellectual property.

We believe opportunities in AI for New Zealand's digital sector are in partnerships with corporates. Startups can target a partner in the relevant space and use their data to full effect while planning their expansion to a larger market.

Sector	Impact	Key AI Technologies
Digital	Medium	Machine learning Deep learning Natural Language Programming (NLP)

"We believe opportunities in AI for New Zealand's digital sector are in partnerships with corporates."

‘Sophie’ Impresses Travel Crowd



Even ‘digital humans’ need to prepare ahead of a public engagement.

‘Sophie’, the creation of human computing company Soul Machines, had to have her accent tweaked, her facial expressions perfected, and learn about the country, before fronting at a launch of a new global Air New Zealand campaign.

That put her in good stead to showcase her advanced emotional intelligence and responsiveness as she answered questions about New Zealand as a tourist destination and the airline’s products and services.

The technology behind Sophie uses neural networks and brain models to bring its digital humans to life from their cloud-based human computing engine, which sits on top of an artificial intelligence platform powered by IBM Watson.

Soul Machines was founded by Dr Mark Sagar, the director of the Laboratory for Animate Technologies based at The University of Auckland’s Auckland Bioengineering Institute, and Greg Cross, serial entrepreneur and co-founder of PowerbyProxi, which was sold to Apple in 2017.

Air New Zealand says working with Sophie underscores its commitment to harnessing technology to improve customer experience.

“We’re always looking for new ways to improve the travel experience and solve pain points with digital innovation,” says Jodi Williams, the airline’s general manager of global brand and content marketing.

While there are no current plans to employ Sophie on a permanent basis, experimenting with digital human technology is just one of the airline’s many forays into the innovation space.

Soul Machines work is attracting more and more international attention with major corporations including Autodesk, Royal Bank of Scotland, Daimler Benz joining IBM and Sony now customers of their world leading Human Computing technology.

> *“The technology behind Sophie uses neural networks and brain models to bring its digital humans to life.”*

Solving the Data Entry Headache for Small Business

Entering the wrong account code into accounting software may seem like a trivial problem, but repeated hundreds of times by thousands of businesses it becomes a major financial headache for SMEs and their financial advisors. Xero has declared itself to be on a "journey towards code-free accounting", and is using machine learning to help reach its goal.

The company says with more than 10.1 million unique account codes, and over 800,000 invoices entered into its online software by users every day, the automation of account codes is set to transform accounting practices, ensuring greater accuracy and reducing the time small businesses spend on unpaid admin.

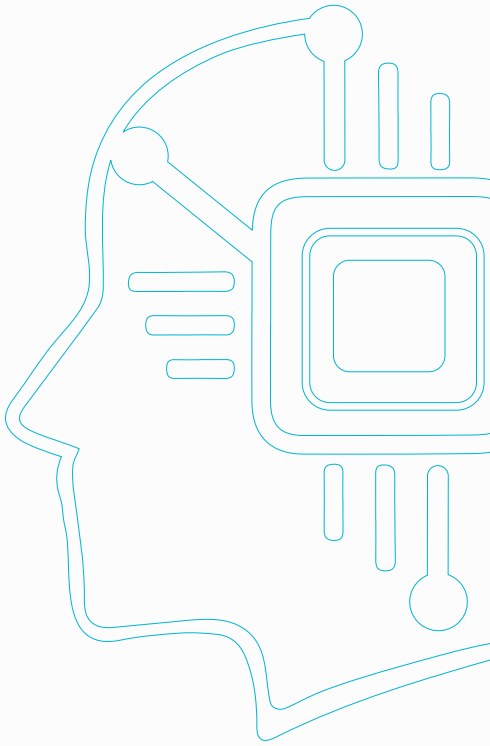
Xero now has the AI smarts to consider each individual business's characteristics, then recommend account codes based on what it has learned.

"We set out to further develop our machine learning program to reduce the number of mistakes being made when creating bills," says Andy Neale, Xero's head of data science and automation.

"In doing so, we've created a system that not only learns from the individual needs of our customers, but can also make objective decisions about which account their transactions should be coded to," he says.

"Account codes can be a time-intensive task for small businesses. We are using machine learning to simplify the system overall, so that more time is spent growing the business, rather than on low-value, administrative tasks."

"We've created a system that not only learns from the individual needs of our customers, but can also make objective decisions about which account their transactions should be coded to."



Section 03: Sector Analysis

Energy

The more quality training data a sector has access to, the better the AI that can be integrated into its everyday operations. The energy sector is one of those industries with a wealth of data that is ripe for machine learning and its companion technologies.

The commercial opportunities from using AI in this industry come from the technology's real-time optimisation, predictive analysis and forecasting power. A number of New Zealand energy distribution companies are working with postgraduate students in big data and machine learning to analyse information gathered from both their networks and smart meters.

Optimising Costs

Between 75 and 85 per cent of data in this sector is unstructured, and machine learning can be used to analyse it. Platforms using unsupervised learning techniques are well-suited for anomaly detection, which can boost the efficiency of utility operations.

Machine learning algorithms are being used to understand vast amounts of data to predict mining, drilling and power generation failures, and then to recommend tailored maintenance based on the potential issue. AI systems can monitor the emission of nitrogen oxides from gas turbines and vary the distribution of fuel to maintain the required levels of energy generation. Scaled across the network, this is a genuine opportunity to better control costs.

"Machine learning algorithms are being used to understand vast amounts of data to predict mining, drilling and power generation failures, and then to recommend tailored maintenance based on the potential issue."

Machine learning can also manage energy use within complex systems. For example, Google's DeepMind AI achieved a 40 per cent reduction in energy used to cool the company's data centres, even after human engineers had supposedly optimised the facility's energy use. On a bigger scale, machine learning can be employed to manage the use of resources such as water in 'smart cities'.

Added Value for End-Users

Based on real-time usage data, machine learning algorithms and supervised learning can improve energy management even in power plants. This in turn optimises total pricing for consumers and provides opportunities to offer promotions based on customer demographics.

Already today generator-retailers, or 'gentailers', offer their customers products that break down electricity bills by appliance type – for example Bidgely, offered by Contact Energy, and Genesis Energy's partnership with Ecotagious.

Machine learning is used in some of these products as part of a deeper effort to provide customers with more choices about how to produce, consume and store energy and encourage them to do so in many ways, including gamification.

Smart Grids

AI has the ability to transform resource distribution and compensate for drastic fluctuations in demand.

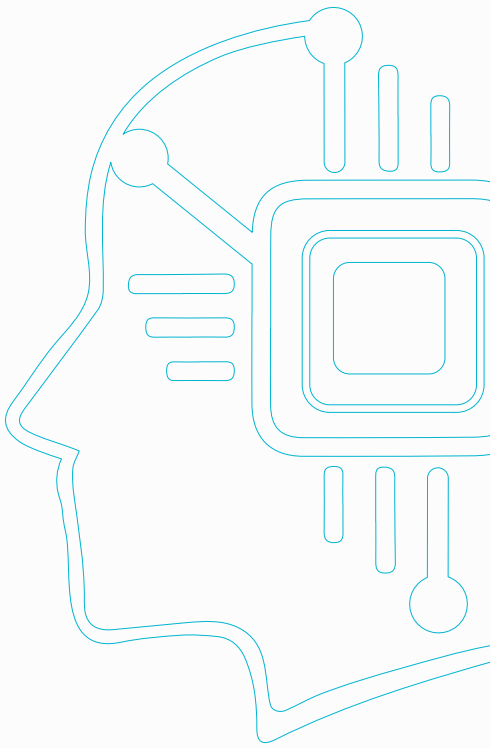
The technology will also move far beyond just pricing and distribution to respond directly to the dynamic needs for energy, water and waste management. Through an ecosystem of 'smart grids', electricity and water can be distributed from many small producers and be personalised to specific regions and timeframes. Each producer could use techniques which are particularly suited to time-series data. This network would take in and and learn user behaviour, and use the information to manage the energy or water supply. A producer can then sell their excess capacity back to the grid, maximising efficiency and reducing wastage.

Looking Ahead

While machine learning applications in energy are transformative, they're also realistic. With the rich volume of data available, New Zealand energy businesses can readily continue developing their AI technologies.
Better resource allocation, improved customer satisfaction, lower costs and greater energy conservation are obvious benefits.

Sector	Impact	Key AI Technologies
Energy	High	Machine learning Natural Language Programming (NLP) Chatbots

"Through an ecosystem of 'smart grids', electricity and water can be distributed from many small producers and be personalised to specific regions and timeframes."



Driving Change and Sustainability in the Transport Sector

New Zealand company Ohmio Automotion wants to revolutionise urban and hyper-local transport with its self-driving electric shuttles which uses artificial intelligence to navigate.

Ohmio's focus is related to the technology ecosystem that autonomous vehicles require to operate. This technology ecosystem provides an infrastructure framework for vehicles to optimise important aspects of autonomy such as navigation and obstacle detection, as well as providing some degree of control by transport authorities.

Ohmio Automotion has evolved from HMI Technologies, a world leader in custom-built intelligent transport systems. Having developed world class self-driving technology, Ohmio™ successfully demonstrated this with the launch of the ohmio HOP in September, 2017.

The electric ohmio HOP shuttles are self-driving, connected, autonomous vehicles, meaning that not only are they driverless, but they share information with each other. Unlike similar vehicles being produced elsewhere around the world, they can move more efficiently and safely in a convoy or "platooning" formation. This makes Ohmio vehicles a scalable solution, responding to demand to operate as an efficient and safe virtual tram running on virtual tracks, the company says.

An innovative mapping capability and sensors allow Ohmio vehicles to be deployed quickly on selected routes.

These self-driving shuttles will help people connect from mass transit hubs and parking facilities to their final destination, as well as providing efficient transport around commercial facilities such as airports, retirement villages and university campuses.

With technological advancements, the first commercially built vehicle, a 20 person shuttle, ohmio LIFT, will be premiered in the next few months. It has been purchased by Christchurch Airport with a view to have it operating before the end of 2018. Other flexible options, including ohmio MOVE, a freight carrier, will also soon be revealed. Ohmio technology will also have wider applications in other sectors such as agriculture, transport and logistics.

The technology is a key component of Mobility as a Service [MaaS] where transport networks involving shared mobility and public transport are so convenient that there is less need for private transport.

"We are committed to developing technologies which deliver a safer, more efficient and sustainable transport future and electric self-driving vehicles have amazing potential in that regard," says Ohmio Automotion Chairman, Mohammed Hikmet.

"Self-driving, connected, autonomous vehicles, meaning that not only are they driverless they share information with each other."

Technology Partnership Puts Smarts into Auckland's Power Grid

A partnership between power company Vector and Israeli technology firm mPrest is being used to develop and apply a machine learning and AI system to better manage Auckland's changing energy demands.

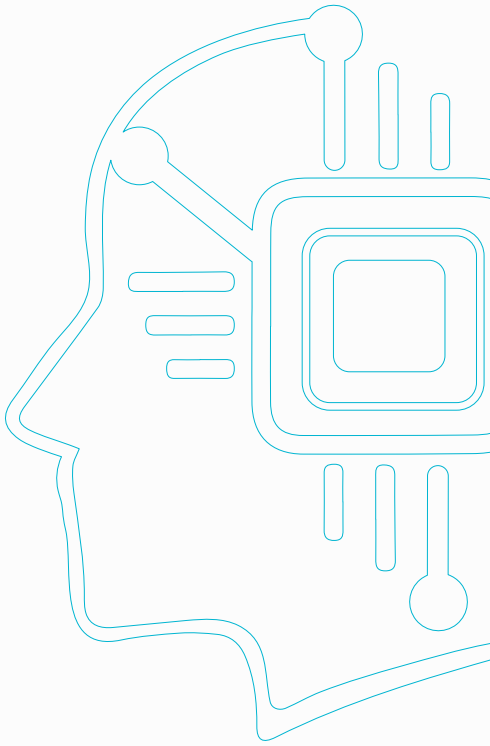
The mDERMS programme, developed by Vector and mPrest engineers, uses the latest technology to better monitor, analyse, and control Auckland's energy network, which connects traditional infrastructure like electricity lines and substations with new technology like solar and battery energy solutions, or distributed energy resources (DERs), to power more than half a million homes and businesses.

With customer energy needs and expectations rapidly changing, mDERMS is an overlaying "system of systems" that can integrate, oversee, manage, and make use of these DERs and their controlling systems on Vector's electricity network.

Sometimes referred to as the "internet of energy," mDERMS gathers and analyses DERs like solar panels, energy batteries, electric vehicles, and integrates them onto one platform that can be managed by Vector to optimise this complex energy system for the end-consumers.

The smart grid of the future will be less like an "electron corridor", and more like a vibrant energy marketplace. mDERMS will enable this marketplace to exist, allowing communities and business access to different sources of energy when and where they need it, and at the cheapest price possible.

> *"The smart grid of the future will be less like an "electron corridor", and more like a vibrant energy marketplace."*



Section 03: Sector Analysis

Health

In the health sector, data and analytics are set to transform drug research and development and provide radically personalised care for patients.

Augmented (Intelligent) Diagnoses

Machine learning is already being used to detect known diseases by performing low-level diagnoses on scans, biopsies and other patient data. The next evolution for this technology will involve using other types of streaming data to predict medical problems, rather than analysing them afterwards.

Techniques developed at Auckland University of Technology by the Knowledge Engineering Discovery Research Institute (KEDRI) have predicted strokes in individual patients with astonishing accuracy - 95 per cent for one day ahead, and 70 per cent for seven and 11 days ahead of a stroke occurring.

It's clear that these research studies will have a profound effect beyond reducing the cost of diagnosis. Stroke, for example, is the leading cause of long-term disability and the third most common cause of death in the United States.

Faster and more accurate diagnosis of a patient's health status will lead to real and significant cost reductions for the government, and for the insurance and healthcare industries that step in when a condition becomes acute.

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Personalised Healthcare

Personalisation will eventually be at the heart of innovation in the pharmaceutical industry. Today we're seeing medical platforms based on regulation being paired with some AI techniques. Although not strictly machine learning, these systems help doctors identify the right drug at the correct dosage. In turn, this reduces the cost of human errors and adverse drug interactions, and in drastic cases even saves lives.

Over the next decade, radical personalisation of healthcare may spell the end of blanket costs for treatment and care, leading to price transparency and specific care for individuals. Patients could be continuously monitored through intelligence algorithms and have tailored treatments automatically prescribed to them exactly when needed.

Pharmaceutical companies are already using predictive modelling and machine learning for biological processes, although the unstructured and unlabelled nature of data makes this difficult. However the technology has the potential to provide an alternative to expensive experimental trials, accelerating drug development and dramatically decreasing production costs through more efficient resource allocation.

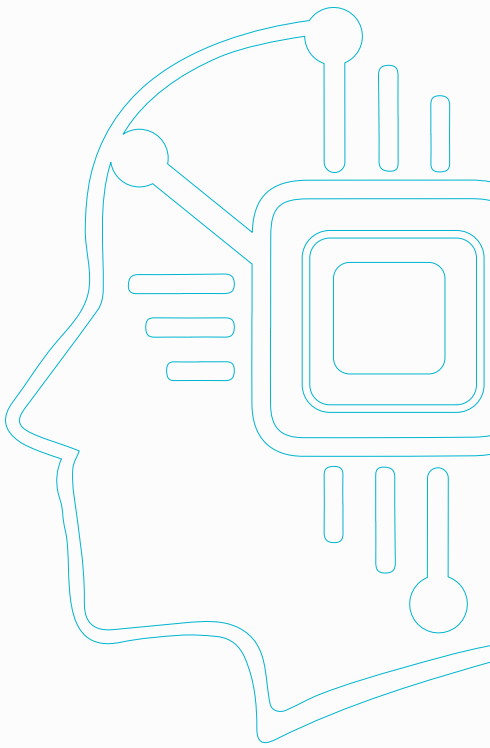
"Patients could be continuously monitored through intelligence algorithms and have tailored treatments automatically prescribed to them exactly when needed."

Pharmaceutical companies also want to use predictive modelling to optimise the design of patient clinical trials for new applications of existing drugs. Predictive modelling offers a way to identify subgroups of individuals who may not even be diagnosed yet, but who may respond to a new type of treatment.

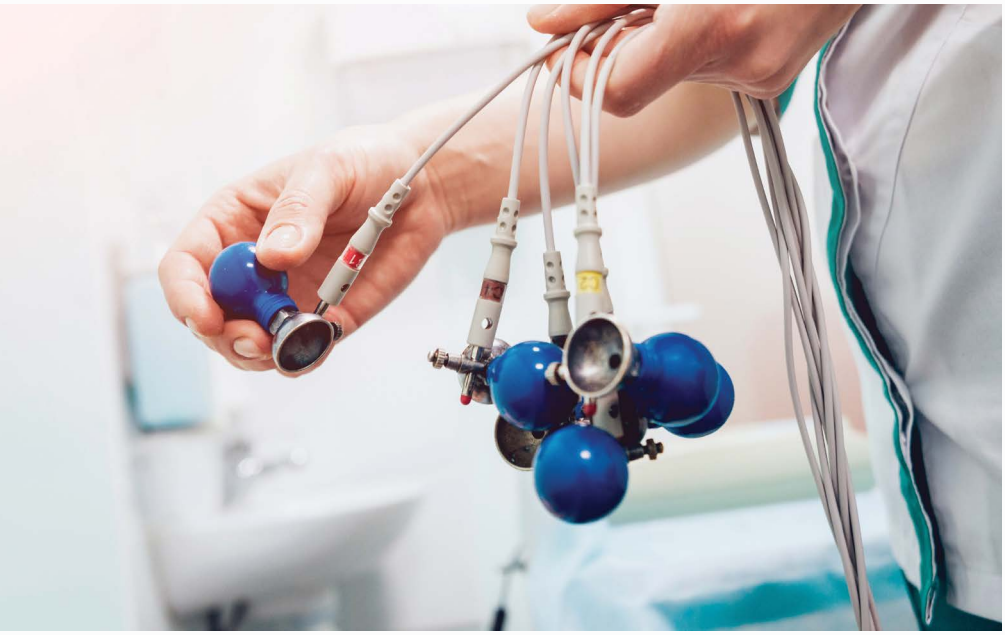
Looking Ahead

AI clearly has significant potential for health and medical treatment, particularly through AI-optimisation and personalised medicine. Benefits would include earlier diagnosis, widely available detection tools, as well as tailored medical treatment. However, this will require turning the 'ambulance at the bottom of the cliff' model on its head.

Sector	Impact	Key AI Technologies
Health	Extreme	Machine learning Deep learning NLP



Kiwi Hospital at the Heart of AI Trial



The healthcare division of global technology giant Samsung chose a New Zealand hospital for a trial of an electrocardiogram monitoring device linked to AI-based data monitoring.

Samsung Healthcare trialled its S-Patch electrocardiogram (ECG) monitoring devise at South Auckland's Middlemore Hospital in 2017.

The small 8-gram wearable S-Patch monitor is used to assess arrhythmia, with AI employed to translate and assess the mass of data collected by the device.

The S-Patch attaches to the chest via two electrode stickers, and the information is sent to the S-Patch's built-in bio-processor which is able to measure a patient's ECG skin temperature, GSR, and body fat. This data is then sent to the patient's phone, tablet or computer.

Arrhythmia is a heart condition where beats are irregular, meaning that they are often either too common or missed. Linked with alcohol and a bad diet it can lead to more serious issues such as heart failure and heart attacks if it's not carefully managed.

With a 200-patient long waiting list to access Middlemore's present Holter monitors used for arrhythmia monitoring, the S-Patch allowed more people access to a key piece of healthcare technology.

Combining wearable sensors with AI diagnostic capabilities is a growing research focus aimed at improving health outcomes.

"Combining wearable sensors with AI diagnostic capabilities is a growing research focus aimed at improving health outcomes."

Spearheading AI and Data-Driven Change Across the Health Sector

Precision Driven Health, one of the largest data science research initiatives to be undertaken in New Zealand, is aimed at providing world-leading research into the emerging area of precision medicine and personalised care.

Precision medicine is the growing body of international research that is identifying and enabling the capture of data that is vital for the practice of precision medicine. This includes genetic data, device data, social and diet data. With its focus on keeping people healthy and out of hospital for as long as possible, precision medicine makes good economic sense.

Established in 2016, the seven-year, $38 million Precision Driven Health (PDH) research programme is a major public-private venture between industry, government and academia. The founding participants are Orion Health, Waitemata District Health Board and the University of Auckland, with support from the Ministry of Business Innovation and Employment.

"Healthcare as we know it is tremendously wasteful. For example, of the $2.2 trillion annual healthcare spend in the United States, up to $1.2 trillion is wastage. This is largely because healthcare professionals don't have access to, or a way to digest, comprehensive patient records that contain genetic, environmental and social information," says PDH General Manager Dr Kevin Ross.

"PDH's research programme harnesses New Zealand's unique combination of existing electronic healthcare data and world-class research capability to enable the development of data-driven healthcare solutions that are applied globally," he says.

To date, PDH has supported at least 24 academics, 31 industry researchers and 19 students across over 40 projects. The project is already producing peer-reviewed, commercially-viable research, including 5 research articles and 17 conference presentation.

Commercial use of the initiatives research is already underway, with results from a project now influencing care at Waitemata District Health Board.

> *"Existing electronic healthcare data and world-class research capability to enable the development of data-driven healthcare solutions that are applied globally."*

Section 4: Callaghan Innovation Support

Grow Your Business with AI

At Callaghan Innovation we want to encourage New Zealand businesses to think about AI technology, and take steps to understand how it might impact their sector, and how it could be an important piece of their ongoing R&D strategy.

We offer a range of services for innovation, including access to AI and other dedicated specialists, technology and product development, innovation skills building, business collaborations and R&D grants.

Several of the companies profiled in this paper have benefited from Callaghan Innovation's technical and business expertise.

If you want to talk about how to grow your company with AI, get in touch.

No reira. E ai ki te whakatauākī ō Callaghan Innovation: Rukuhia te wāhi ngaro, hei maunga tātai whetū. Tēnā tātou katoa.

Jonathan Miller is the National Tech Network Manager for Data and IoT at Callaghan Innovation.

> *We offer a range of services for innovation, including access to AI and other dedicated specialists, technology and product development, innovation skills building, business collaborations and R&D grants.*

Section 4: Callaghan Innovation Support

About Callaghan Innovation

Callaghan Innovation is New Zealand's innovation agency, challenging and helping Kiwi businesses to step up to the opportunity of technological change.

We play a lead role in the country's innovation ecosystem, connecting businesses to the networks, capability and co-funding they need to make their ideas happen and thrive.

Our 400 staff include more than 200 of New Zealand's leading scientists and engineers, who are dedicated to solving tough technical problems for our customers.

We operate from five urban offices and a regional partner network of a further 12 locations across New Zealand. Our work is supported by critical relationships with top research and innovation facilities both locally and globally.

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New Zealand's Innovation Agency

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hei maunga tātai whetū.

Dive into the unknown, reach for excellence.