
Perspectives*
CIVICA
Volume 03
{ Machine learning reloaded
Cracking the matrix for public services
Inspired by
CIVICA NorthStar*
Open >

Welcome to

Perspectives* Volume 03

I am delighted to introduce this volume of Perspectives* that looks at machine learning and its potential to transform public services.

The range of examples presented show how machine learning is already realising benefits and there is a clear opportunity to go much further. The University of Bath's ART-AI Centre shares Civica's interest in using machine learning to improve outcomes for citizens.

Our interdisciplinary research team is looking at how this technology can protect the most vulnerable in society. We are also developing models that reduce the presence, and impact of bias, as well as analysing emerging approaches to the regulation of AI. Now is the time to consider the implications of these applications for individuals, organisations and society.

These implications include not only robustness, reliability, safety and security, but also appropriate levels of transparency, intelligibility and acceptability for users who, very often, are not experts in the technology. Strong partnerships between academia and industry - such as the one we have with Civica - play a key role in embedding the latest thinking into application development.

I hope that this volume of Perspectives* inspires you, your customers and partners, to embrace machine learning as a technology to support enhanced outcomes for citizens. Please enjoy this volume and do share your reflections using #PerspectivesFromCivica

Eamonn O'Neill
Director, UKRI Centre for Doctoral Training in Accountable, Responsible and Transparent Artificial Intelligence (ART-AI), University of Bath

Perspectives* is exploring four themes throughout 2021:

1. Immersive technologies (download here)

2. Conversational AI (download here)

3. Machine learning (this volume)

Coming soon...

4. Augmenting our intelligence

Executive summary

Machine learning opens new possibilities to drive positive change; helping computers learn from data to create models humans wouldn't be able to build otherwise.

The need to explicitly programme devices limits our capacity for innovation. Machine Learning (ML), allows us to build models that, after being trained with large data sets, can help predict real-world outcomes and uncover fresh insights at speed and at scale.

Since the term 'machine learning' was coined in 1959, the technique has been used to build models that lie at the core of daily applications; from identifying a fraudulent credit card transaction, to recommending your next movie, or helping predict when maintenance is due. It can even create art, as Huawei fascinatingly demonstrated by completing Schubert's Unfinished Symphony.

In this third volume of Perspectives*, we take a look into the 'art' of ML and examine the positive impact it can bring to public services. From rapid diagnosis of disease, to assigning limited inspection resources, and suggesting early intervention, there are many potential benefits. However, the topic is not without controversy.

We observe that many organisations are not transparent about using the term 'machine learning', even when they use it. Terms such as 'predictive analytics' or 'behavioural insights' are often used instead. This is because, as with every new technology, people can be scared of what it can do. It is clear that done wrong, when fraught with bias (the 'dark side'), machine learning can damage reputation and erode trust. But done right, it can improve efficiency, help prioritise resources, and gain valuable insights we might have never known.

To help out, we identify four vital areas for consideration, the four key ingredients of ML: data, tools, skills, and accountability. Like with any formula, you need all the elements to get the right result. We hope that with more understanding of the benefits of ML and the proper application of data science skills, trust in this technology can be built further, and people's perspectives can shift.

As the well-known phrase goes, with great power comes great responsibility. **In the case of machine learning, the future is in our hands.**

$17bn

is the projected value of the machine learning market by 2027. Globe Newswire

{ Plug into the matrix

Before we get started, let's learn more about what machine learning is and, more importantly, what it's not.

Machine learning

Gives computers the ability to learn from data without being explicitly programmed.

What it is

All machine learning is AI

Machine learning is a subset of Artificial Intelligence (AI) using maths and statistics to learn from data and, sometimes, make predictions.

It identifies patterns in data

Machine learning is able to analyse massive quantities of data, and identify patterns in that data. In doing so, it provides new sources of inspiration and innovation.

And is overseen by humans

Humans play a vital role in machine learning, working as facilitators of the systems. Humans need to provide the data that computers can use, but also to correct and fine-tune the model.

What it's not

Not all AI is machine learning

AI systems can operate without needing to learn anything. If you already know the rules to apply to the data, then a model can be built.

It doesn't learn by itself

Unless you ensure models are re-trained, they will not evolve and become out of date. They could degrade and even become harmful, as what has been learned may no longer be applicable.

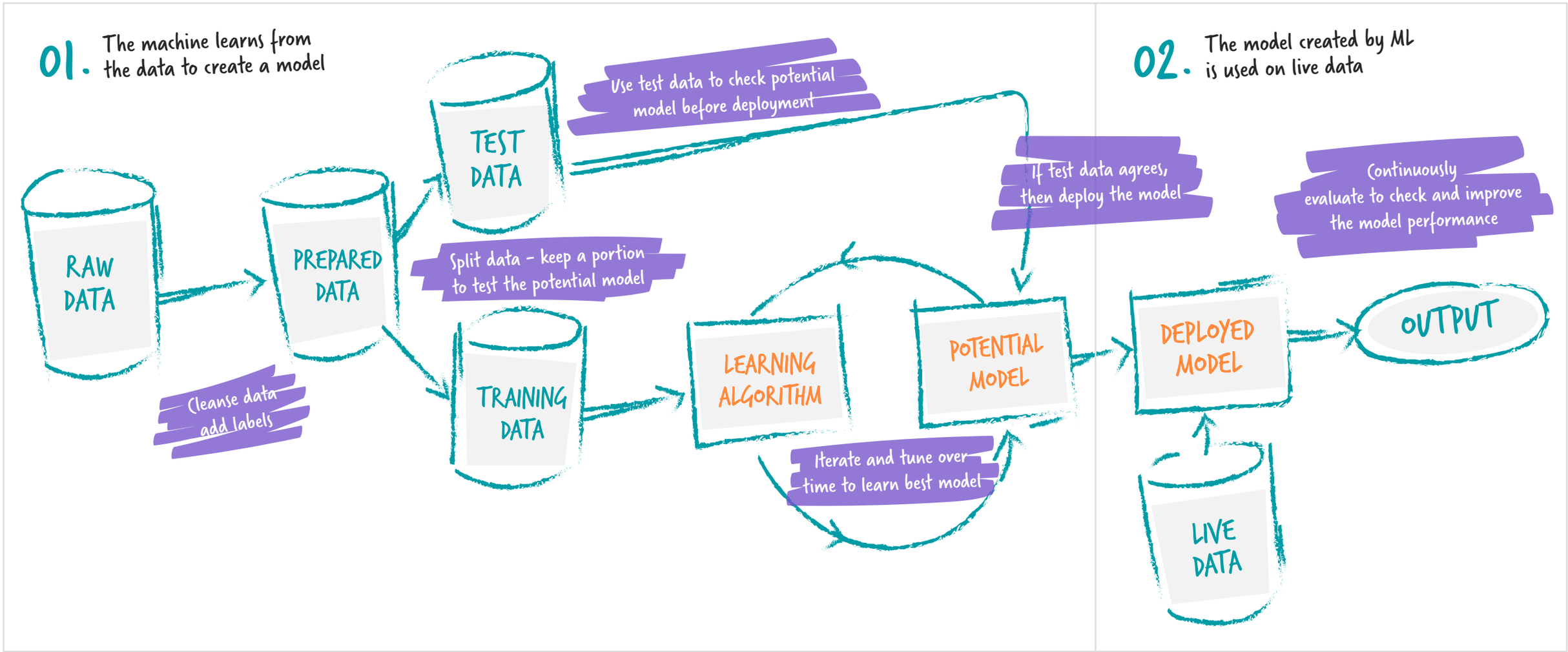
Or make decisions on its own

Machine learning systems generate insights. How you act on these is up to the person designing the resulting model. Machines take automatic actions only if they are programmed by a human to do so.

{ Under the hood

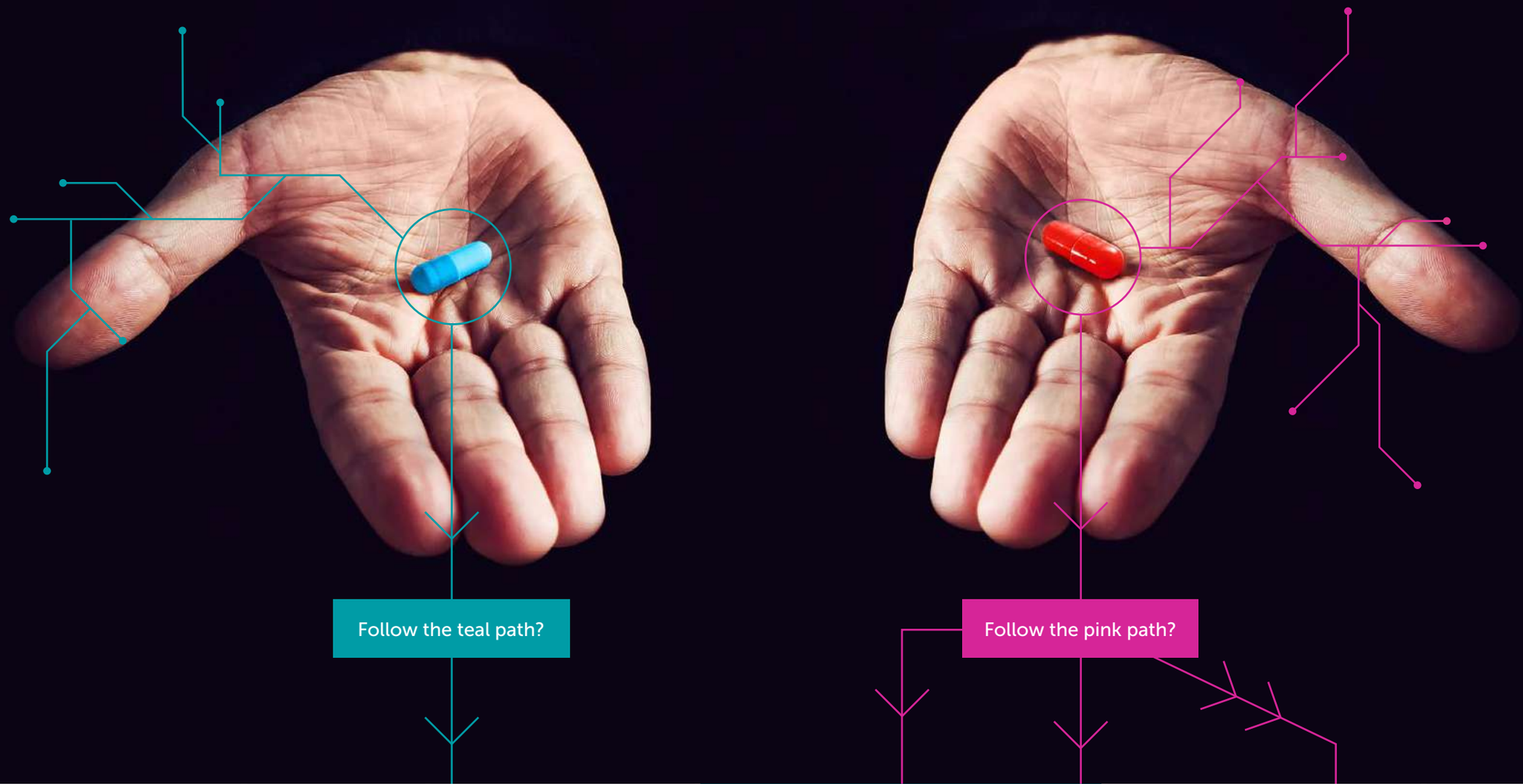
- How does machine learning work?
- What model should we choose?
- And how is it helping us?

How does it actually work?



Follow the white rabbit

There are two main types of machine learning. The path you choose depends on the problem to be solved and what you are trying to achieve. Which path would you take?



I want to build a model that can classify live data into existing categories

Labels

White rabbit | White rabbit | White rabbit | Not a white rabbit | Not a white rabbit

Supervised learning

Model that can find a white rabbit in any new data

If we can train a model to sort data into categories of interest, then we can use it to quickly find things we're looking for again in new live data.

Stay on a known path

I want the machine to identify clusters of similar data to find new categories

No Labels

Unsupervised learning

Category 1

Category 2

Category 3

Rather than develop a model, we learn how different variables interact. We've created new knowledge that can inspire innovation. *Note: These categories may also be used as inputs in further supervised systems.*

Imagine where this path could lead?

Still not sure?

Let the Royal Society explain a bit more...

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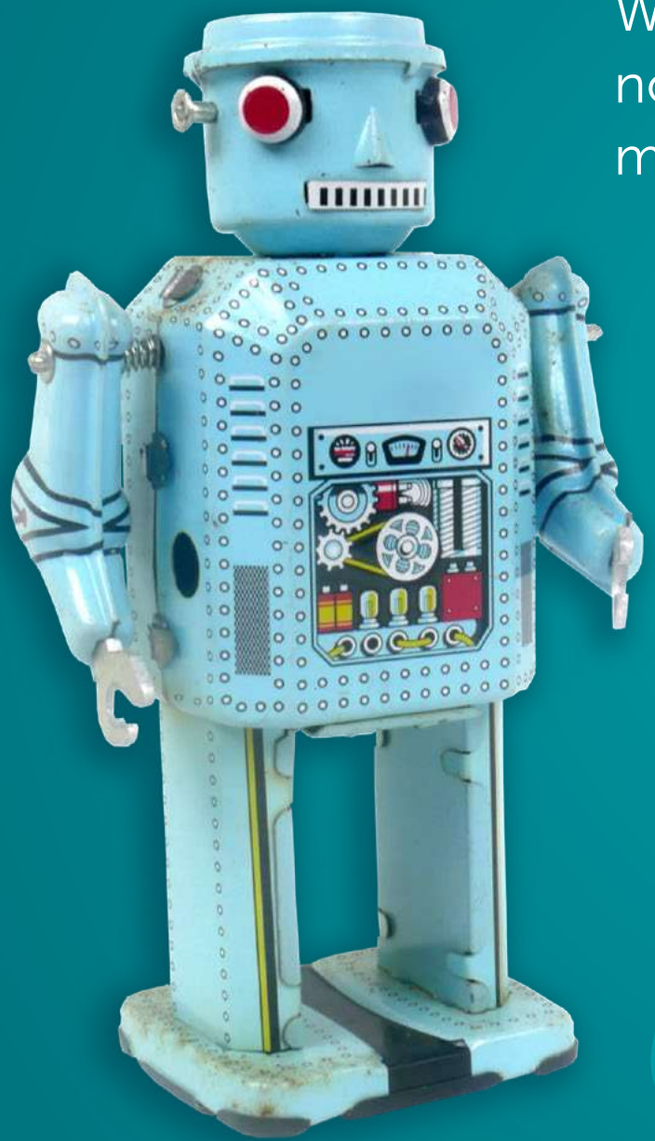

While you're here, why not cut through some more robotic jargon

Raw data
Data on which we want to perform exploratory analysis.

Prepared data
Data that has been cleansed and curated ready for processing.

Live data
Real life, current data that is put into the model so it can give an answer to the problem.

Learning algorithm
The type of mathematical algorithm used to help the system learn.

Training data
A significant portion of the prepared data that is used to help the machine learn.

Test data
A small portion of prepared data held back with which to test the model.

Neural network
A series of algorithms that mimic the operations of a human brain to recognise relationships in massive amounts of data.

Deployed model
A model that has been tested and found to be acceptable and useful.

Potential model
A trained model before its been tested.

Predictive analytics
Another term used in place of machine learning, especially when used to discover patterns and make predictions.

Deep learning
A term given to machines that learn in a layered form, much like our own brain.

Labels
Tags added to the data to help the system learn what it's looking at.

How is machine learning helping?

From fighting credit card fraud, to helping choose what to watch on TV, machine learning is being adopted across a wide range of sectors. We believe there are three main areas where it can add value.

When you see a QR code, click it to learn more. Or why not immerse yourself by scanning it with the camera on your smart device.

Categorise data

Grouping and labelling data meaningfully to allow for further analysis.

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Freeing us from 100m spam emails

Google Gmail

SCAN ME

Combating credit card fraud

Mastercard

Provide insights

Using data to recommend actions that can be accepted or rejected by humans.

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Personalising your shopping experience

Amazon

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Saving $1bn by making the right TV shows

Netflix

Make predictions

Using historic data to better predict likely future events.

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Making air travel better and greener

Qantas

SCAN ME

Creating better autonomous cars

Tesla

{ Beware of the dark side... bias

Twitter taught Microsoft's AI chatbot to be racist in less than a day.
(2016)
Read more >

Amazon scraps secret AI recruiting tool that showed bias against women.
(2018)
Read more >

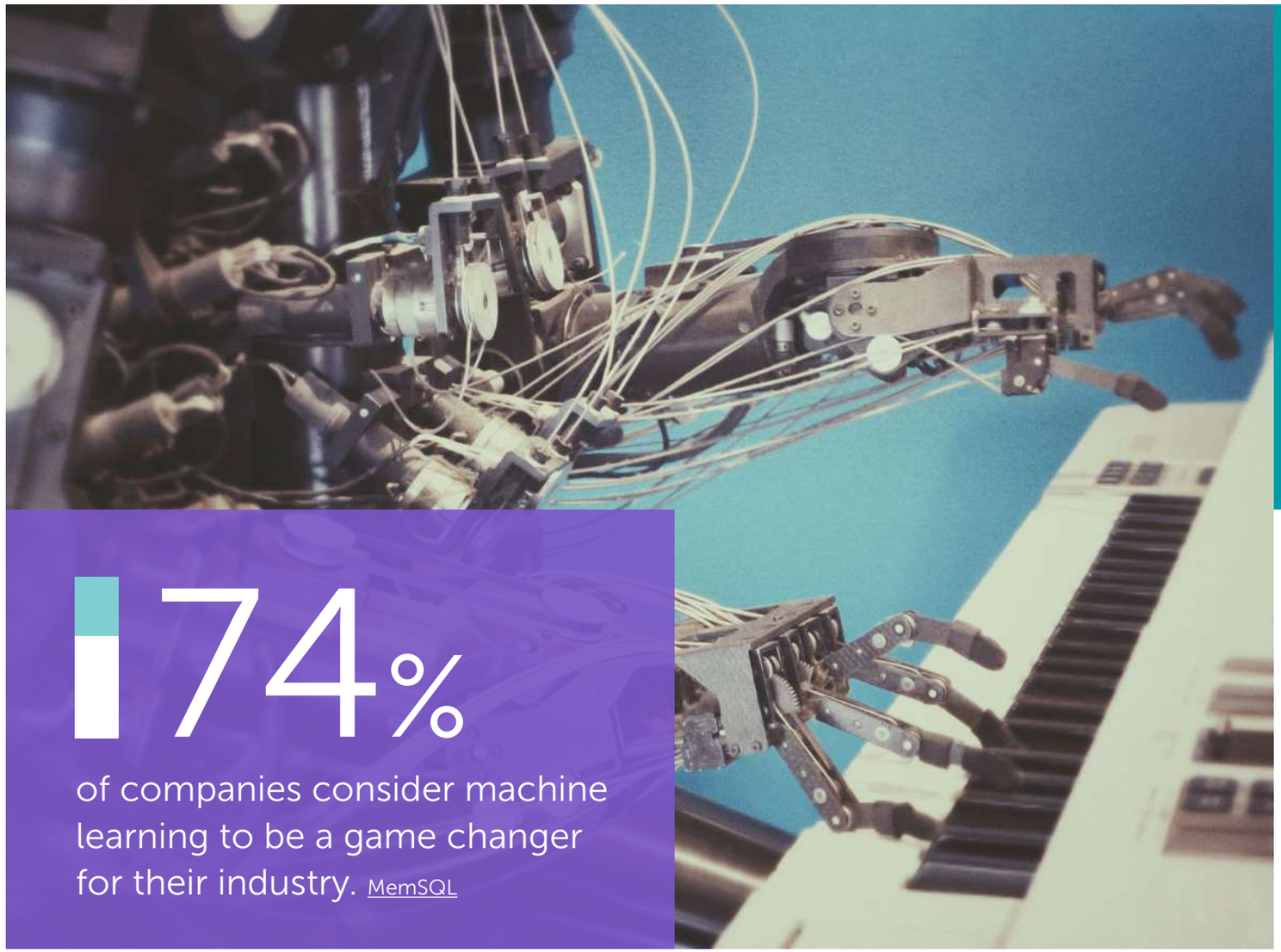
Racial bias found in a major health care risk algorithm.
(2019)
Read more >

If machine learning is not used carefully, and is fraught with bias, it can be useless or even harmful.

Used well, it can help tackle problems that can't be addressed any other way: it can make previously impossible problems solvable and bring about positive change. But it can also be damaging, even harmful. Machine learning's 'dark side' is bias.

Machine learning systems learn from data. This data can include conscious or unconscious biases and assumptions or reflect historical or social inequities. If trained with biased data, the resulting model can produce results that are systemically biased or prejudiced in their design. As our three examples show, the media is quick to highlight when this occurs.

Bias is a collective responsibility - from the system designer, to the person who interprets the results. In our media examples, each organisation is taking steps to recognise biases evident in their historical data and are working to improve. Machine learning can be an important technology for good. **Done right, machines may even help us to be better humans**.



Machine learning is not a new concept. In fact, we've been using it since the 1970s.

With the availability of more and more data, increased computing power, and easier access to ML tools, there has never been a better time to tap into this technology than today. To demonstrate why, we've examined its impact across five key public sectors, with the aim of inspiring further conversations.

74%

of companies consider machine learning to be a game changer for their industry. MemSQL

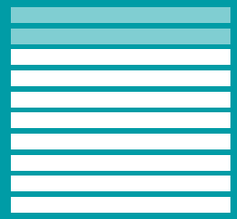
- > Local government
- > Health and care
- > Government and justice
- > Housing
- > Education

{ Local government

"The most important benefit to come from using predictive analytics [machine learning] is that it enables councils to deliver better outcomes."

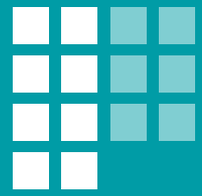
Local Government Association (LGA)

What's driving the opportunity?



75%

of local authorities have a reported 'funding gap' in terms of their forecast pressures. National Audit Office (NAO)



86%

of local government leaders confirmed machine learning has the potential to benefit their sector. Civica

Making a positive impact

We've hand-picked a few examples to show where machine learning is making an impact. But what else is possible? Continue the conversation and share your perspective.

Categorise data

Prioritise housing allocation ●

Machine learning algorithms may support categorisation of applicants enabling prioritisation based on eligibility as well as need. While many councils currently use a points-based system to categorise applications, machine learning could enable other factors relating to potential vulnerability to be considered, helping staff to focus efforts on those who have the greatest need.

Identifying welfare fraud ●

Machine learning models can support councils to assess whether claims for welfare support are valid. While these models can no doubt help officers target investigation into fraudulent claims, human oversight of the systems remains vital. The recent high-profile case in Australia highlights the vital importance of accountability and transparency in machine learning systems.

Provide insights

Enhance service delivery ●

A range of UK councils are considering the use of AI and machine learning to efficiently prioritise service delivery. From reviewing and recommending decisions on planning to managing energy strategy, dealing with fly tipping and optimising rates collection, machine learning offers opportunities to relieve administrative pressure and speed-up decision making.

Improve citizen engagement ●

Machine learning can support many applications designed to increase citizen engagement. From chatbots to sentiment analysis, machine learning can help councils better understand local trends and improve the citizen experience. Machine learning can also be used to engage citizens in election campaigns and help them be more informed about important local issues.

Make predictions

Improve food standards ●

The UK Food Standards Agency is using machine learning to identify risky imported food and feed products coming into the country as well as providing insights to councils on which food establishments are most likely to present a risk. This helps local authorities prioritise the inspections they undertake.

Supporting vulnerable citizens ●

Machine learning models can be used to predict potential future concerns and identify opportunities for early intervention. Real use cases include supporting social workers to identify the need for preventative steps; alerting authorities to at risk children, finding families that need additional support, and creating alerts of potential failing health in older adults in care.

● **Established:** already making an impact ● **Emerging:** starting to make an impact

"We have used the insight generated to recommission domestic abuse services, inform Ofsted assessments; and guide the review of domestic abuse service providers; all transforming public services to achieve more with less and create great places to grow, live and work."

Essex Partnership

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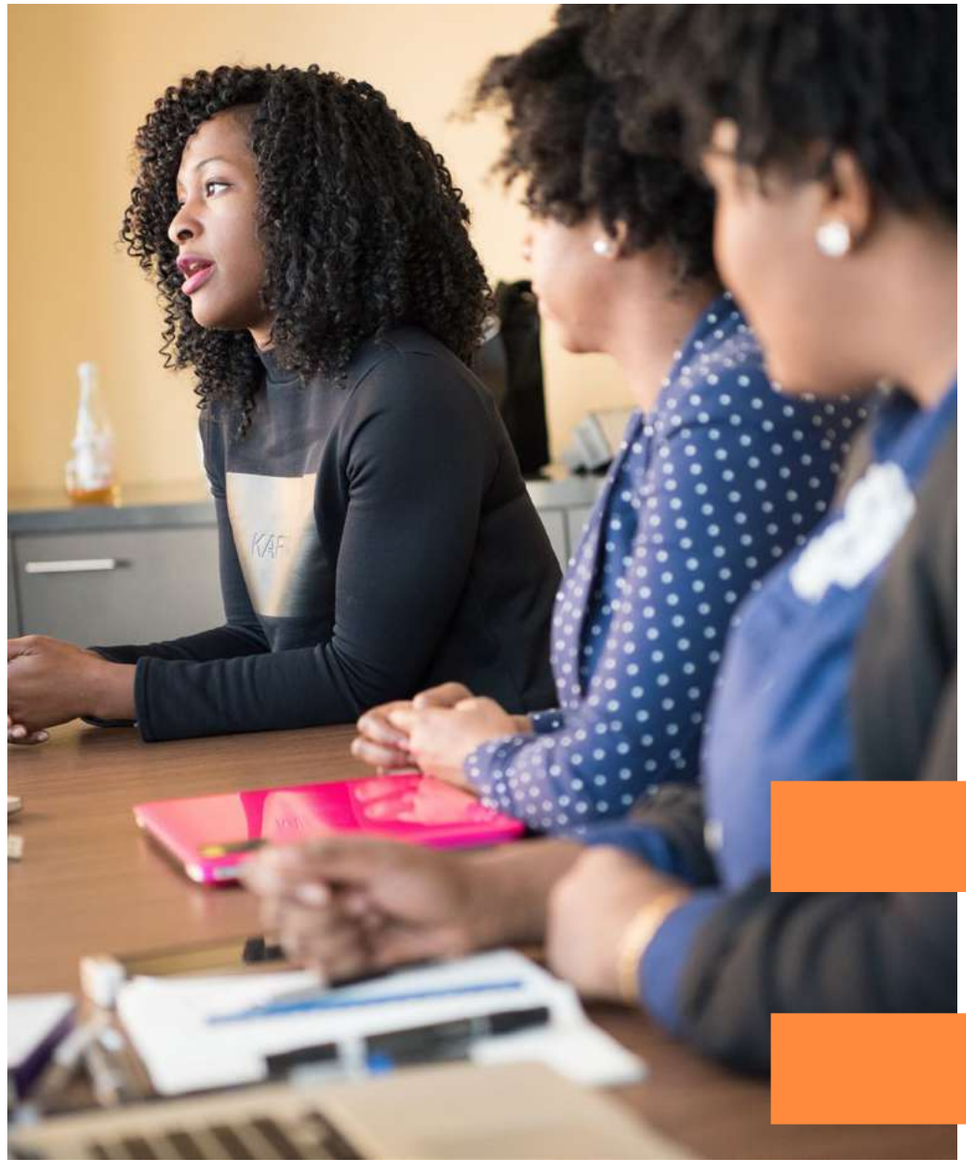
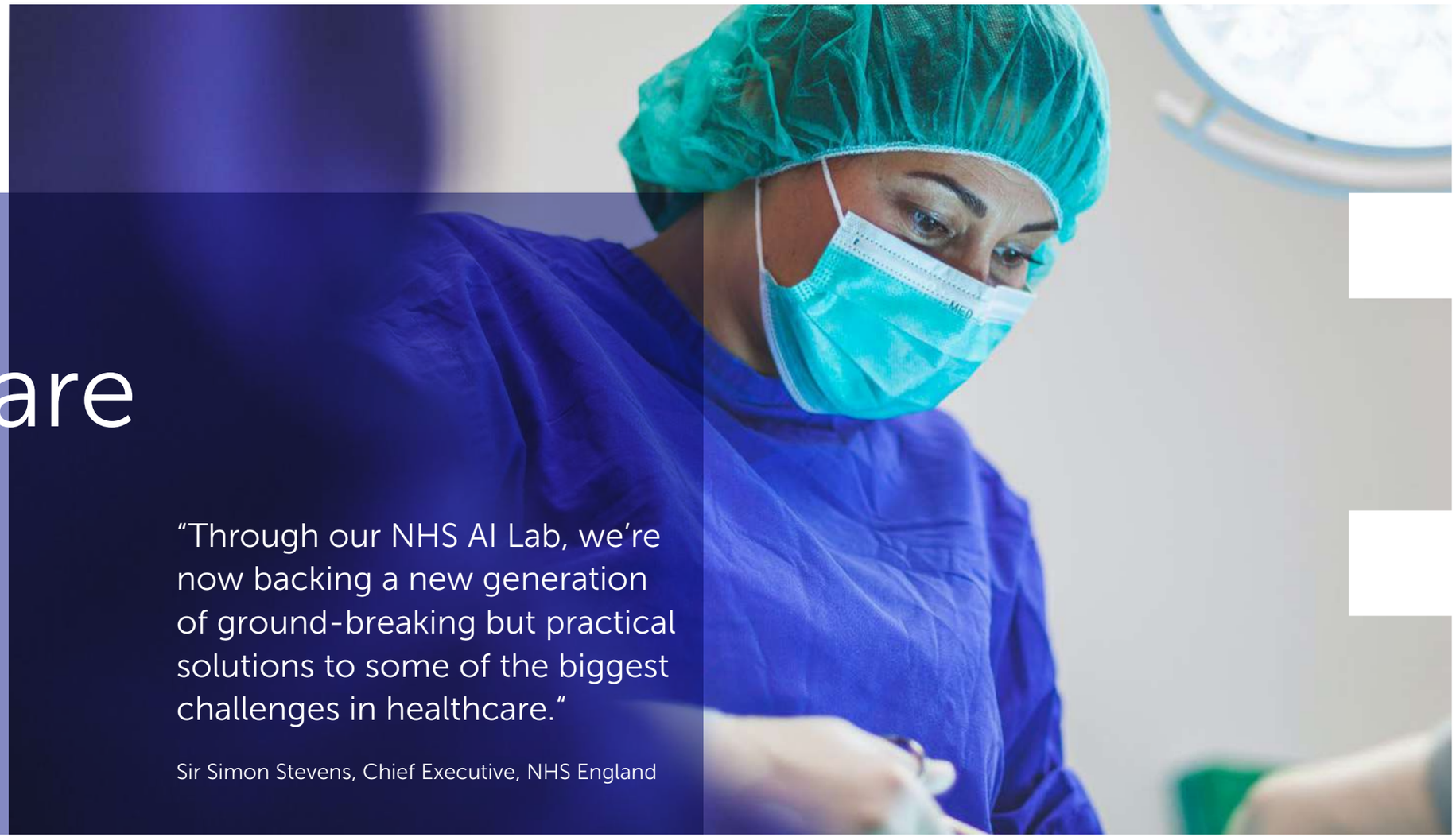
Tackling domestic issues earlier



{Health and care



"Through our NHS AI Lab, we're now backing a new generation of ground-breaking but practical solutions to some of the biggest challenges in healthcare."

Sir Simon Stevens, Chief Executive, NHS England

What's driving the opportunity?

4.6M

people currently on the NHS waiting lists for surgery and 300,000 people have been on hold for more than 12 months - 100 times higher than before the pandemic. NHS Digital

91%

of health and care leaders confirmed that machine learning has the potential to benefit their sector. Civica

Making a positive impact

We've hand-picked a few examples to show where machine learning is making an impact. But what else is possible? Continue the conversation and share your perspective.

Categorise data

Drug discovery ●

By identifying factors contributing to diseases and finding alternative paths for therapy machine learning can help discover new drugs and open opportunities for precision medicine. The use of AI and machine learning was instrumental in the race to find a vaccine for the COID-19 pandemic.

Identifying diseases and diagnosis ●

From cancers to genetic diseases, machine learning plays an important role in identification and diagnosis. Models based on multiple sources of historic and current data can present recommendations to medical professionals. This can improve accuracy and speed of detection.

Provide insights

Population health insights ●

By collecting data about specific populations and combining it with insights from satellites and real-time social media updates, machine learning algorithms can help monitor the health of a population and provide early insight into potential health issues. This is of particular benefit to third-world countries that lack proper healthcare infrastructure. Population health analytics have recently been used in the fight against COVID-19.

Personalised treatment ●

By analysing patient medical history, machine learning models can recommend customised treatments that can target specific diseases in individual patients. The University Hospital in Geneva is using machine learning to deliver personalised treatment to cancer patients based on their medical history.

Make predictions

Enabling robotics ●

Machine learning is a foundational technology for robotics. Robots are routinely being used to help surgeons conduct precision procedures where machine learning and computer vision help the system to operate. Robots are beginning to be piloted for companionship in care settings, and machine learning helps the system to make decisions and respond to interactions in real-time.

Predicting demand for care ●

In order for patients to receive high quality care, it's important to manage demand and optimise hospital resources. Machine learning can help predict emergency department patient arrivals, their medical urgency, admissions, and likely discharge times. This helps hospitals run more efficiently and enhances the patient experience.

● **Established:** already making an impact ● **Emerging:** starting to make an impact

"A lot of the work we do is using AI approaches to identify subtle changes in patients which might help us to understand why one group of patients behave in a certain way... [this] will give us crucial information which is needed to help clinicians treat patients in the best possible way and improve patient outcomes."

Dr Richard Lee, Consultant Physician in Respiratory Medicine and Early Diagnosis, The Royal Marsden Hospital London

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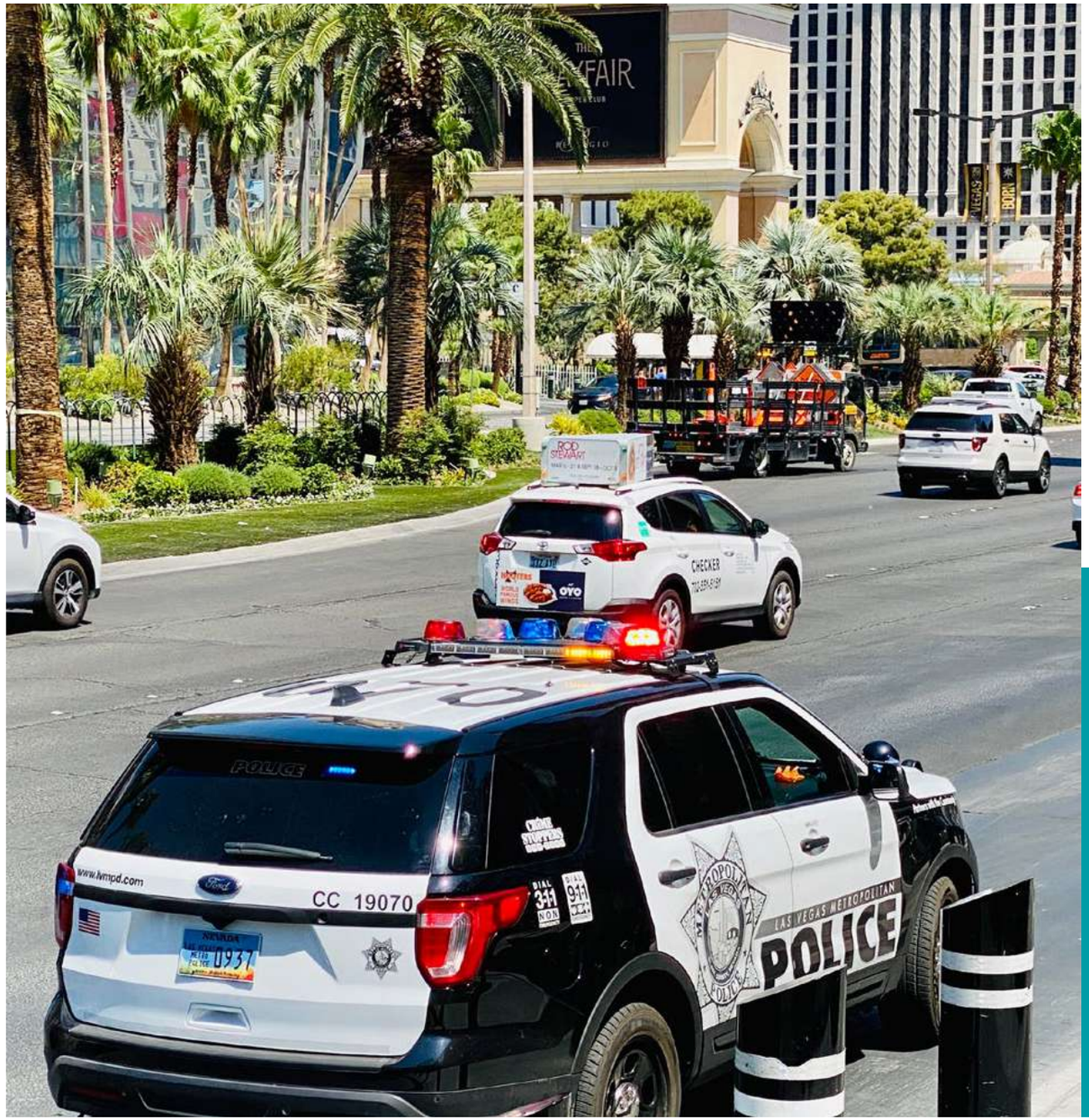
Early diagnosis of lung cancer in patients



{Government and justice

"There are not enough humans to hire that you could afford to do all the work. You're going to have to start entrusting machines to assist. AI and machine learning are the way of the future."

Michael Lee Sherwood, Director of Information Technologies, City of Las Vegas

What's driving the opportunity?

$30M

committed by the Australian government to strengthen their AI and machine learning capabilities. Australian Government

92%

of central government leaders confirmed that machine learning has the potential to benefit their sector. Civica

Making a positive impact

We've hand-picked a few examples to show where machine learning is making an impact. But what else is possible? Continue the conversation and share your perspective.

Categorise data

Improving MOT testing ●

The UK's Driver and Vehicle Standards Agency (DVSA) use machine learning to target their resources and ensure MOT standards remain high. The algorithm groups MOT centres based on the behaviour they show when conducting MOT tests and identifies those requiring inspection. By identifying areas of concern in advance, examiners' preparation time for enforcement visits has fallen by 50%.

Making citizen information accessible ●

The UK's Government Digital Service (GDS) used machine learning to categorise and tag 100,000 pages of information on the government website. Using the technique shortened a task that would have taken six years to under six months.

Provide insights

Supporting justice ●

Parole boards in the United States use a controversial machine learning model to support decisions on the early release of prisoners. The model considers a range of inputs including demographic and survey information, to provide insights on the likelihood of re-offending. The Ministry of Justice in the UK extracts actionable insights from huge amounts of different prison reports to better inform decisions about inspections.

Strengthening safety and security ●

Machine learning underpins many technologies used to protect citizens, including cyber security and video surveillance. Belfast Council is using the technology to support monitoring of parks and open spaces. Machine learning can help human operators to make sense of the vast piles of data produced, alerting officers to suspicious activities.

Make predictions

Environmental disaster risk management ●

The impact of natural disasters may be reduced if it is possible to predict their occurrence. Machine learning offers opportunities to develop models based on a range of climate and human data to help predict events.

Public infrastructure ●

Routine maintenance of public infrastructure is an absolute must to avoid any untoward incidents. Machine learning can be used to proactively monitor infrastructure health. This helps in the accurate prediction of maintenance. Detroit, USA uses machine learning to target road maintenance measures by classifying images of roads according to status.

● **Established:** already making an impact ● **Emerging:** starting to make an impact

"We are investigating further how we can use the data from multiple satellites and local sensor networks to create algorithms that will help detect fires earlier, predict fire behaviour, and help emergency services respond more effectively to protect homes, people and nature."

John Barilaro, Deputy Premier, New South Wales

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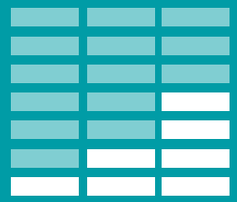
Protecting homes, people and nature

{Housing

"Artificial intelligence and machine learning have moved from being very niche, embryonic technologies only considered by a very small number of far-sighted UK social housing providers, to becoming much more widespread."

Housing Technology

What's driving the opportunity?



46bn

connected devices around the world today – up 200% since 2016. Juniper Research

96%

of housing leaders confirmed that machine learning has the potential to benefit their sector. Civica

Making a positive impact

We've hand-picked a few examples to show where machine learning is making an impact. But what else is possible? Continue the conversation and share your perspective.

Categorise data

Early intervention for at-risk tenants ●

Clustering of data can identify patterns that lead to non-payment of rent. This would enable early intervention and wrap-around services being provided to prevent escalating arrears.

Raising property standards ●

Councils may not have full information on whether social housing properties are privately rented or owner-occupied. The London Borough of Hackney is using machine learning to identify potentially any unlicensed House in Multiple Occupation (HMO). This enables the council to work with landlords and tenants and ensure they are fit for purpose.

Provide insights

Safer, healthier homes ●

Combined with IoT sensors, machine learning can help detect and monitor health and safety risk factors. Continuous monitoring of data to identify anomalies, enables preventative action to protect tenants and property assets.

Improving operational efficiency ●

Using machine learning models to analyse internal data alongside open data can help with strategy development in areas such as managing demand, maximising assets and improving procurement and contract management.

Make predictions

Predictive maintenance ●

IoT data and customer reports can be used to help predict when equipment may fail and identify the optimal repair schedule. Housing association's such as LiveWest and Housing Solutions are investigating using machine learning to aid in diagnostics as well as predicting where to take action before breakdowns occur.

Predicting energy efficiency ●

Machine learning techniques could be used to predict energy performance scores for domestic properties that may not have Energy Performance Certificates (EPCs). Models being developed by the Office for National Statistics (ONS), may improve the energy efficiency data required to underpin carbon reduction strategies for housing stock.

● **Established:** already making an impact ● **Emerging:** starting to make an impact

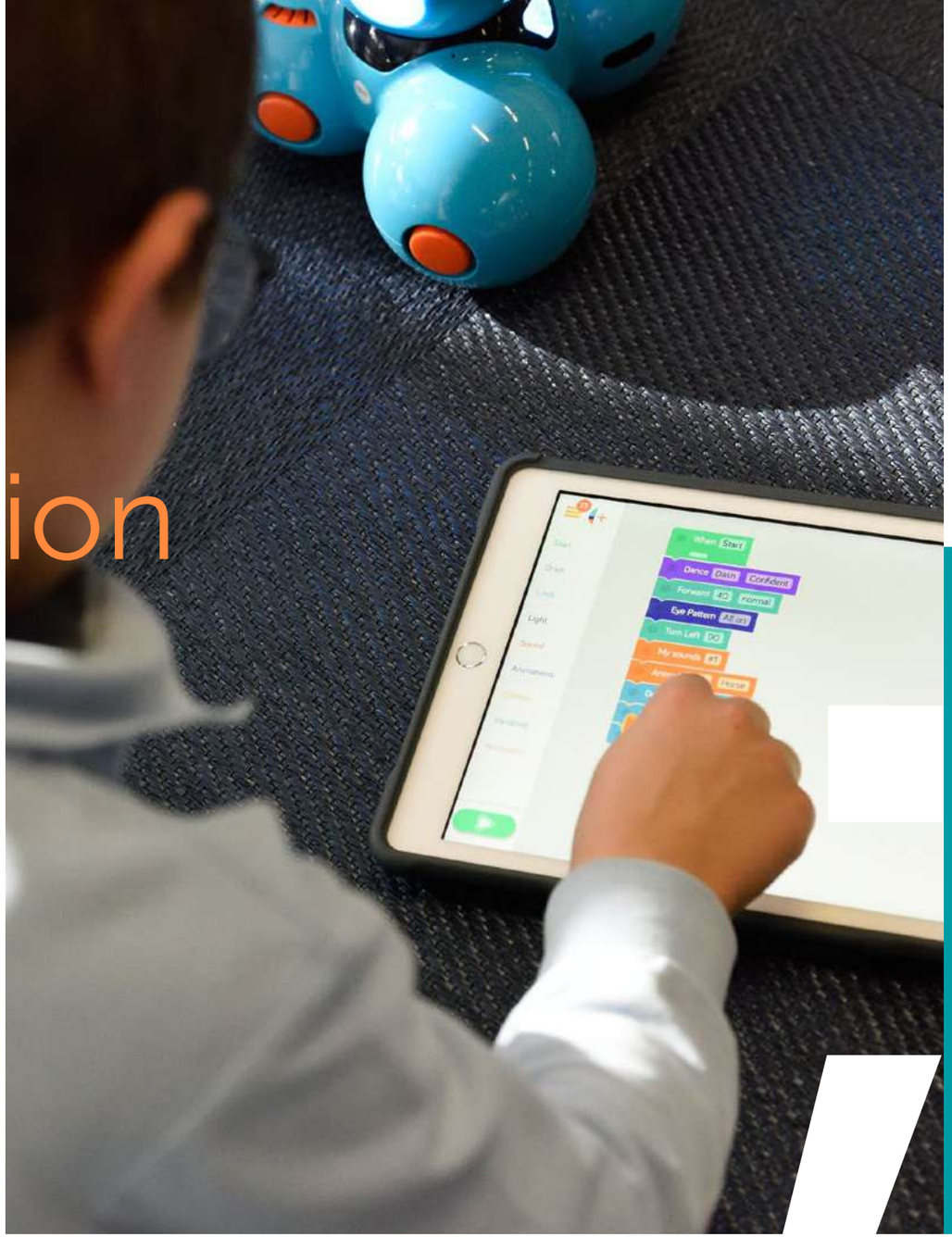
"The health of our tenants is of paramount concern. It [machine learning] will help us take preventative action, where necessary, to protect, manage, or even improve our homes."

David Amos, Head of Policy and Commissioning, Renfrewshire Council

SCAN ME

Tackling fuel poverty in social housing

{ Education



"The ability to ingest data from multiple data sources, interrogate that data, and to derive insights – using tools such as predictive analytics and machine learning – is what makes AI such an exciting advancement in education technology."

Tao Zhan, Director, UNESCO Institute for Information Technologies in Education

What's driving the opportunity?

$3.7bn

is the projected size of the global machine learning education market by 2023. Forbes

94%

of education leaders confirmed that machine learning has the potential to benefit their sector. Civica

Making a positive impact

We've hand-picked a few examples to show where machine learning is making an impact. But what else is possible? Continue the conversation and share your perspective.

Categorise data

Evaluating assessments ●

Machine learning can be used to help grade student assignments and exams. This can free up educators to focus more on interactions with students. However, while assistants like Grammarly can help individuals self-correct, other models have been subject to controversy, such as the one used by the UK's OFQUAL in 2020 to grade student exams.

Early intervention ●

By finding patterns within student data, it is possible to identify clusters of students who need additional support in order to reach their full potential. A 2017 study using machine learning identified a group of students who needed additional scholarship funding, increasing retention from 64% to 90%.

Provide insights

Adaptive learning ●

Machine learning can be used to analyse a student's performance in real-time, providing insights that can be used to suggest learning paths for students or to modify teaching methods and content. Brazil's Ministry of Education has accredited a machine-learning-based platform, now used by over 5,000 schools to provide customised learning experiences for students.

Contactless and cashless ●

Machine learning algorithms, as part of facial recognition systems, can be used to enable students to experience a completely contactless method of purchasing school meals.

Make predictions

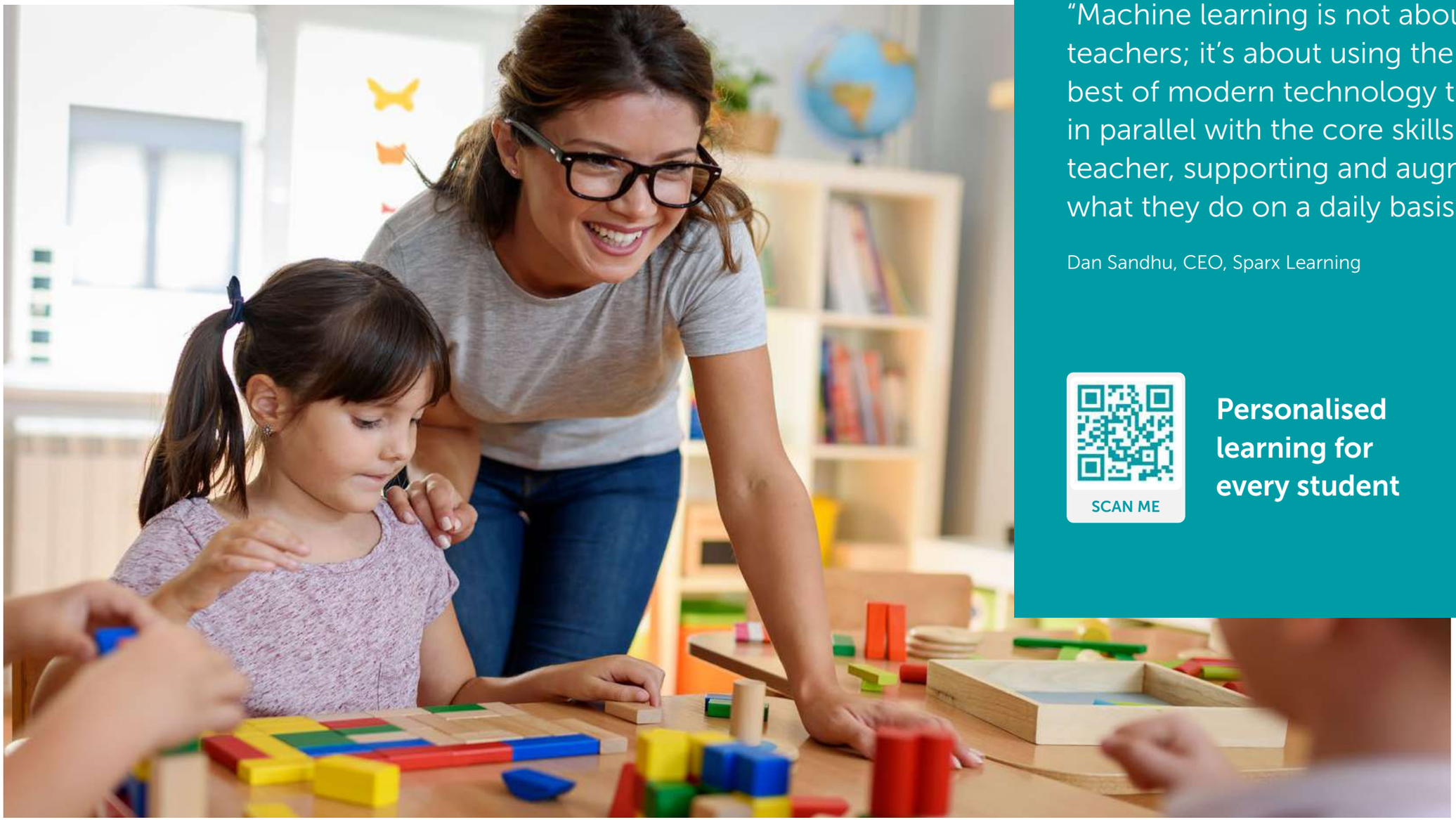
Prioritising inspection ●

The UK's schools inspection agency, Ofsted, uses machine learning to determine when a school should be inspected. Models have been trained using historic inspection data and can be used to predict the likely outcome of an inspection, helping to put human inspection resources into schools where they are most needed.

Behavioural intent ●

By detecting specific patterns in a student's behaviour, machine learning can discover and prevent problems even before they occur. In 2020, a study showed that machine learning could identify clusters of students who were likely to drop-out with a 94% accuracy.

● **Established:** already making an impact ● **Emerging:** starting to make an impact



"Machine learning is not about replacing teachers; it's about using the very best of modern technology to work in parallel with the core skills of the teacher, supporting and augmenting what they do on a daily basis."

Dan Sandhu, CEO, Sparx Learning

SCAN ME

Personalised learning for every student

{ Ideas into action

Now you understand how machine learning works, and where it's already having an impact, we present four key elements to help you maximise its value.

As with any multiplication equation, if any of the variables is 0, then the overall answer is 0

01. Understand your data

Data is the core ingredient, helping the machine to learn.

In an ideal world, you would first define the problem you are trying to tackle, and then gather the right data that would allow you to solve it. In reality, gathering new data can take months, sometimes years.

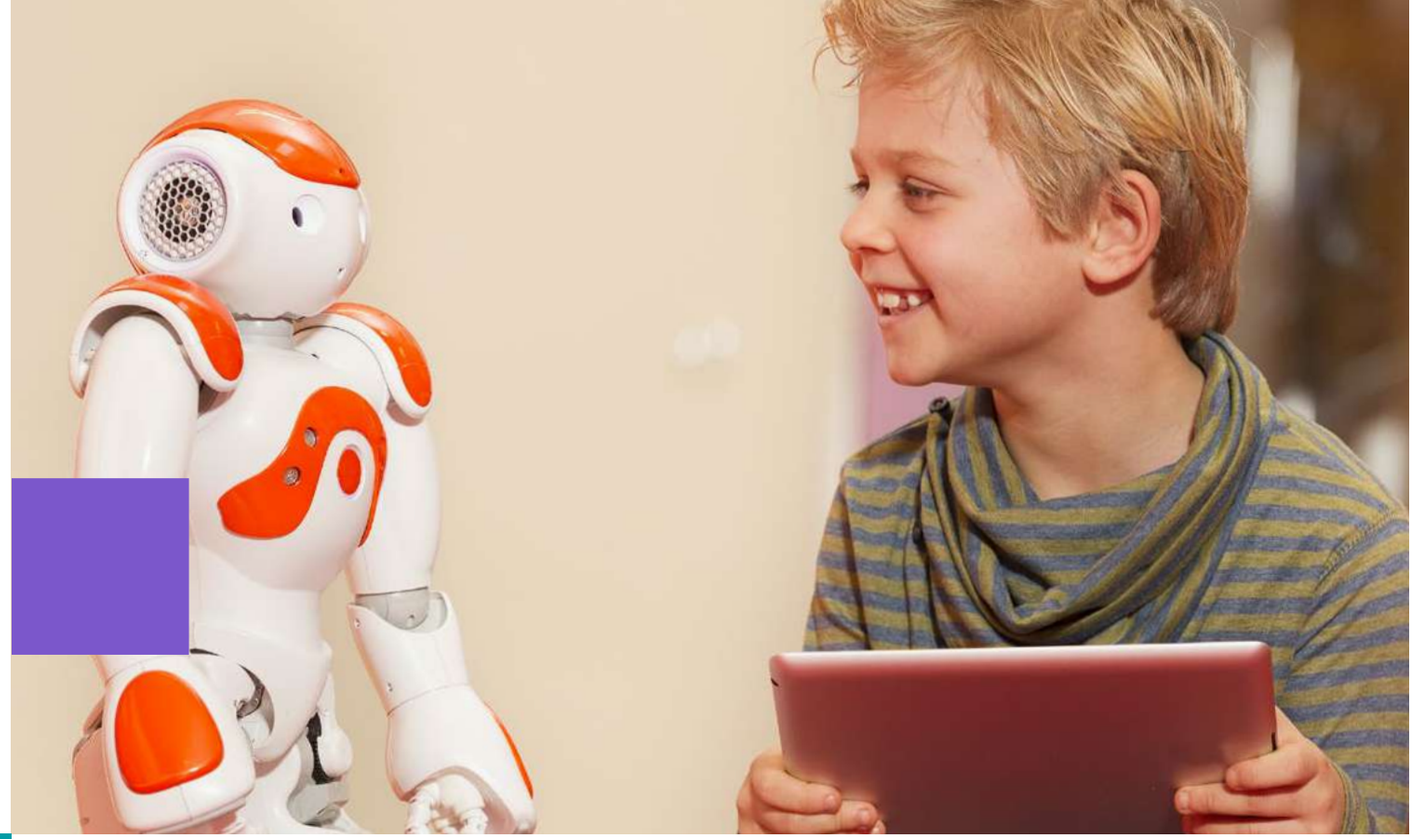
So we recommend starting with the data you already have. If you begin small, remember to allow the system time to learn as you gather the data - it needs many cycles of iteration to output a good model.

Be wary of a model generated with insufficient data, or data that has blind spots or sources of bias - it's probably not right and will likely lead to wrong and dangerous conclusions.

22.5 quintillion

bytes of data are produced every day (that's 2.5 followed by a staggering 18 zeros). Techjury

02. Use the tools



Machine learning uses large amounts of data to identify patterns in the data and provide insight. Because of this, it requires a lot of computing power that historically has been out of reach for many organisations.

Thanks to the cloud, computing power is now easily and cheaply available. Moreover, major cloud platforms now offer tools to build machine learning systems.

This has democratised access and opens the opportunity to bring machine learning into public services software and organisations.

$305bn

spent by end-users on public cloud services in 2021. Gartner

03. Choose your experts

Based on our experience, the best machine learning models are developed when subject matter experts work hand in hand with data experts. This ensures that the ‘problem to be solved’ is well defined and the right learning algorithms are used to build the best model.

48%

of UK businesses are recruiting for roles that require hard data skills. UK Government

Data scientists play a key role in designing the process for training and testing the model. But only subject matter experts can determine if the model created actually makes sense and adds value.

As few public services organisations have access to data scientists, we recommend collaboration between academia, the public, and the private sector to drive positive outcomes.

04. Act responsibly

The world around us is complex and never ceases to change. Even if you get the science right, you should consider the following and be prepared to be accountable:

Sense: is the insight adding any value? Does it make sense? Is it actionable? Is it meaningful?

Bias: is the insight provided fraught with bias? (both the data and method used to analyse the output can contain bias).

Ethics: can I explain the output? Is the insight helpful or harmful?

Relevance: has the world changed since I trained the model I am using? Are my assumptions still correct? Does my model need to be updated?

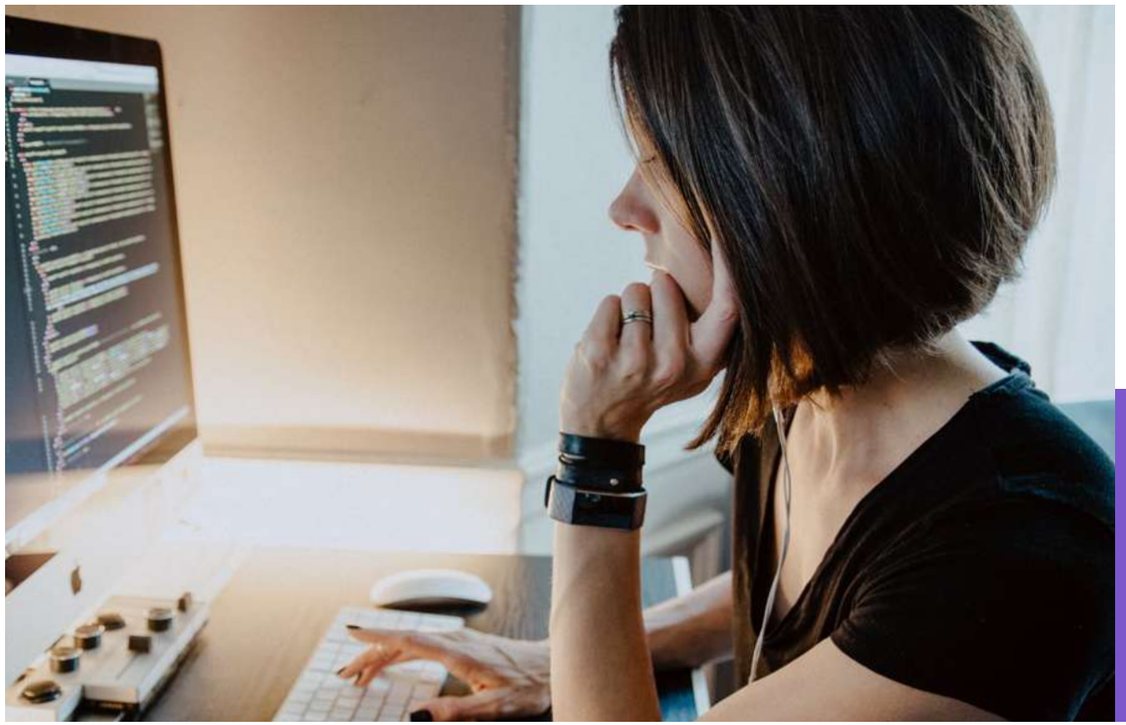
If you cannot comfortably answer yes to any of these areas, you should stop using your model, and retrain it.

70%

of Australian citizens would be more willing to use AI systems if assurance mechanisms were in place. KPMG

Continue the conversation

Are you an innovator, a thinker or a leader driving change in public services? If so, we'd love to hear your thoughts. Learn more and get involved at **civica.com/perspectives**



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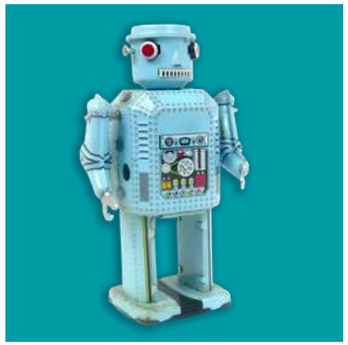

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About us

Civica is one of the UK's largest software companies, with over 30 years of proven expertise in delivering improved outcomes for public services around the world.

Through our commitment to turning ideas into action, we help over 2.5 million professionals deliver the public services of the future, every day.

At Civica, innovation is in our DNA. We take great pride in putting together exceptional teams and a genuine, purpose-driven culture to help everyone be an innovator.

Our innovation lab, Civica NorthStar, is focused on creating enhanced outcomes for public services by applying fresh ideas around data, automation and new technologies.

Working with our customers, we harness new thinking and innovative technologies to create enhanced outcomes for our communities.

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