Machine learning:

the power and promise of computers that learn by example

AN INTRODUCTION

"Machine learning can drive advances in healthcare, teaching, transport, and more, supporting better public services and boosting the economy. We have the opportunity now, as a society, to ensure that machine learning can bring the maximum benefit to the greatest number of people."

Professor Peter Donnelly FMedSci FRS,
Chair of the Royal Society Working Group
on Machine Learning.

THE ROYAL SOCIETY

Machine learning is already a part of our everyday lives

Machine learning is a branch of AI that allows computer systems to learn directly from examples, data and experience.

Rather than following pre-programmed rules to perform a task, machine learning allows a system to learn how to carry out that task.

This technology is developing at a rapid pace, due to the growing availability of data, increased computing power to analyse this data, and technical advances in the field.

Scientists have been publishing papers on areas of machine learning for **over 60 years**

The direct value of public sector data has been estimated at

£1.8 billion

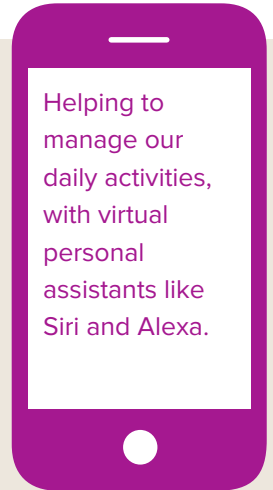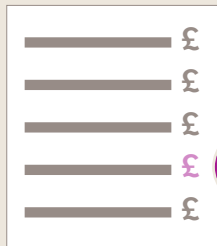with the wider social and economic benefits from this totalling

£6.8 billion

Everyday examples of machine learning

Tagging pictures on social media, through image recognition systems.

Protecting against fraud, by detecting unusual financial transactions.

Helping to manage our daily activities, with virtual personal assistants like Siri and Alexa.

Translating text into different languages, via machine translation services.

Making recommendations for books, films or other products, by analysing your preferences.

What might machine learning do in the next five or ten years?

More efficient use of energy, transport, and logistics.

Improved drug development in the pharmaceutical industry.

Support doctors in providing faster, more accurate diagnoses.

Help teachers create personalised learning plans for each pupil.

In business

Expand our scientific knowledge about ourselves and the world around us.

In society

Speed up some legal processes, and reduce their costs.

Allow companies to create personalised services and products for customers.

Identify those most in need of support from public services.

Make driving safer and easier, including enabling driverless cars.

Improve emergency responses to incidents such as flooding.

Google DeepMind reduced the amount of energy needed for cooling its data centres by 40% through using machine learning to optimise heating and cooling.

What happens next?

As machine learning is put to use in an increasing range of applications, it generates new questions or debates, which in turn open up further opportunities.

Public dialogue shows that people welcome many of the benefits that machine learning has already brought and are extremely interested in its wide-ranging potential. As with most new technologies, the public also have concerns that need to be addressed.

Machine learning has the potential to be a disruptive technology, and it could play a central role in helping to address the UK's productivity gap. Now is the time to shape how this technology develops, so that the changes it brings benefit us all.

New research areas

Confidence in the robustness of the decisions taken by machines and in the security of the systems within which they operate is important, especially in safety-critical systems, or where decisions made by machine learning have a significant effect on individuals.

For some applications, being able to understand how a machine learning system works may be important. Improving the transparency and interpretability of machine learning is a technically exciting area, which can also help expand the range of potential applications.

The success of machine learning will depend on a successful interaction between people and computers, and this is an area that will require research and testing.

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Real world biases and 'messiness' will be reflected in the data used by machine learning; systems need to be able to cope with, or adapt to, this.

"**There's such an information overload that it's becoming difficult for even the smartest humans to master it in their lifetimes. How do we sift through this deluge of data to find the right insights and turn that into actionable knowledge? Machine learning and AI can help us tackle really complex problems in areas like cancer, climate change, energy, genomics, macroeconomics, financial systems, robotics, and physics.**"

Sabine Hauert, Assistant Professor, University of Bristol.

So much data is being created that nobody really knows how much there is but IBM estimate that

90%

of the world's data has been created within the last five years.

New debates

Improvements in medical diagnoses, the development of new treatments, efficient energy systems, and driverless cars all involve uses of data, including personal information, which may at times become sensitive. The Royal Society and British Academy are examining new uses of data and their implications and will be making proposals about the future data governance landscape.

Like other major new technologies, machine learning will affect many types of work. It can perform well at specific tasks and in many cases this can be used to support human roles. The nature and extent of the impact is not clear, but is already being widely debated. It will have implications for education and skills and will raise questions about how best to distribute the benefits.

How can the UK maintain its position as a leader in machine learning?

23%

of the UK population lack basic digital skills

By supporting the development of skills at every level.

- Build digital skills and understanding at every level from schools, to universities, and into the workplace, and ensure that opportunities are not limited by gender, ethnicity, or socio-economic background.

- Support advanced studies in machine learning.

By helping create opportunities to use machine learning.

- Integrate machine learning into the UK's industrial strategy, to help businesses make the most of its potential.

- Support a new wave of research in machine learning, including in areas that can address social or ethical concerns.

By creating a data environment that supports machine learning.

- Continue to build on the UK's track record of open data.

- Ensure as much data as possible is of the quality that can be easily handled by machines.

Through an enabling governance environment.

- Support an informed public debate about what we want machine learning to do, and how the benefits are distributed.

- Develop a framework for data governance – one that can keep pace with the challenge of data use in the 21st century.

For more information on the Society's machine learning project and to view the full report, visit **royalsociety.org/machine-learning**

"There are exciting opportunities for machine learning in business, and it will be an important tool to help organisations make use of their – and other – data. To achieve these potentially significant economic benefits, businesses will need to be able to access the right skills at different levels."

Hermann Hauser KBE FREng FRS,
co-founder, Amadeus Capital Partners

The Royal Society

The Royal Society is a self-governing Fellowship of many of the world's most distinguished scientists drawn from all areas of science, engineering, and medicine. The Society's fundamental purpose, as it has been since its foundation in 1660, is to recognise, promote, and support excellence in science and to encourage the development and use of science for the benefit of humanity.

The Society's strategic priorities are:

• Promoting excellence in science

• Supporting international collaboration

• Demonstrating the importance of science to everyone