Biotechnology and Biological Sciences Research Council

Artificial intelligence in the biosciences

Introduction

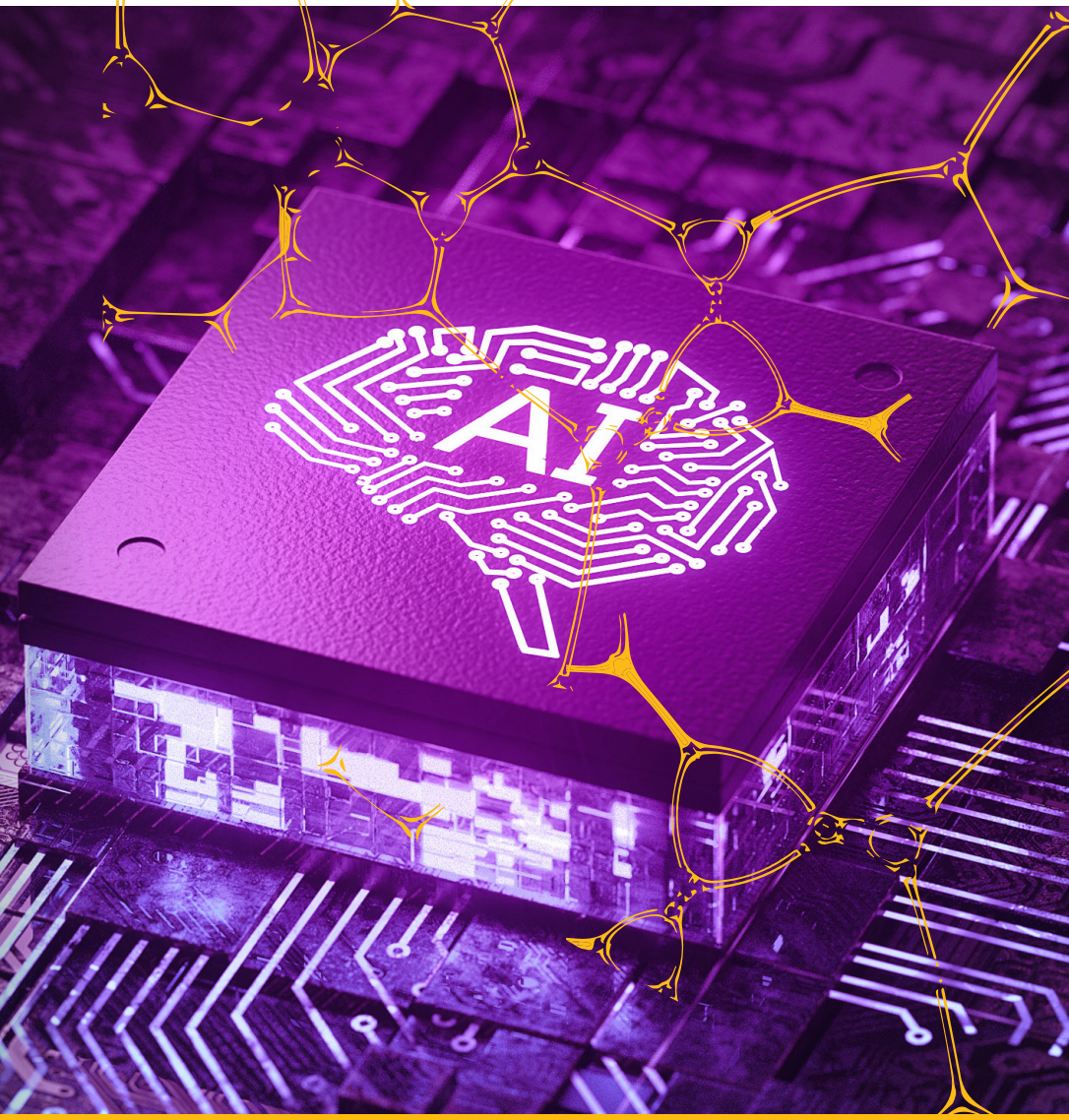
Artificial intelligence (AI) and its application is an area of growing importance within the bioscience research and innovation community.

This booklet provides a flavour of some of the varied and exciting AI research supported by UKRI-BBSRC. These case studies highlight the outcomes and impacts resulting from collaborative multidisciplinary partnerships between researchers and organisations.

The volume and complexity of biological data is ever growing thanks to transformative technologies such as DNA sequencing and high-resolution imaging. Bioscientists are also increasingly benefitting from the ability to access and re-use data to accelerate discovery.

Artificial intelligence, including techniques such as deep learning and machine learning, is providing new opportunities to extract knowledge from this rich and varied data, and will help unlock future waves of bioscience innovation to benefit our economy and society.

Read more on AI in the UKRI Statement of Opportunity ‘Transforming our world with AI’.



Case Studies

#1 Big brother: using artificial intelligence to improve pig health and welfare

#2 KnetMiner: Rothamsted Research answers White House call for coronavirus data help

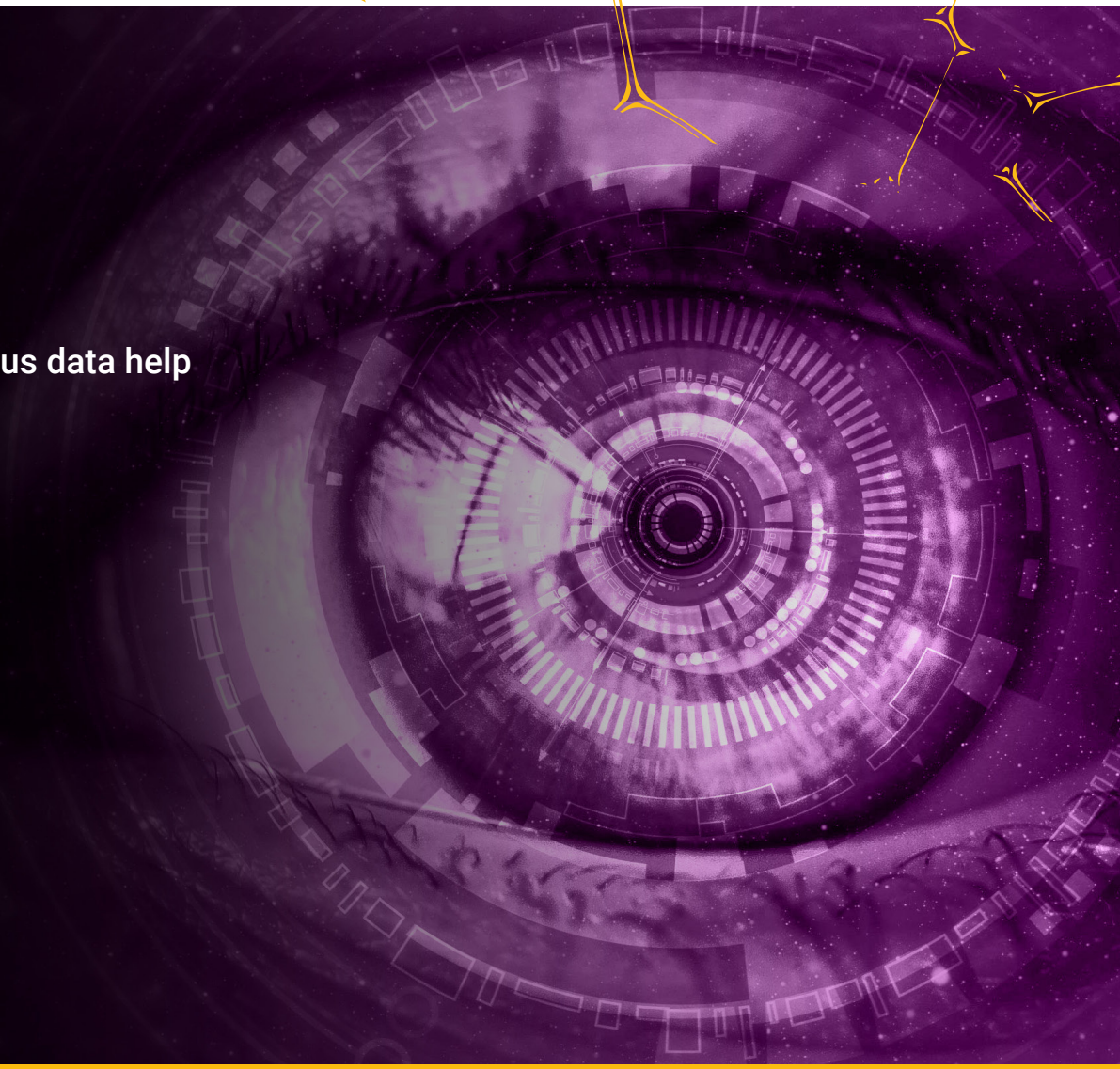
#3 Deep machine learning to capture the performance of plants

#4 Intelligent automated cell-based imaging microscopy

#5 GrassVision: automated precision application to reduce herbicide use

#6 RoboChick: an autonomous platform monitoring poultry welfare

#7 LabGenius: Autonomising the discovery of protein therapeutics



Case study #1

Big brother: using artificial intelligence to improve pig health and welfare

At a glance

- AI enables automation of pig performance monitoring.
- First steps towards an early warning system.
- AI improving animal health and welfare, advancing agriculture and food security.

- Subclinical and clinical disease in pigs is the main factor responsible for reductions in both welfare and productivity. Changes in pig behaviour are a useful indicator for early signs of compromised health and welfare, with early detection of issues required for timely intervention, mitigation of losses and improvement of well-being.

- Professor Ilias Kyriazakis and Dr Ali Alameer at Queen's University Belfast and Dr Jaume Bacardit at Newcastle University have exploited the potential of computer vision, machine learning and convolutional neural networks - a type of artificial neural network used in image recognition - to automatically monitor pig performance and behaviour using low cost cameras and relate any changes to pig health and welfare.

- The work continues as part of the EU H2020 project Healthy Livestock, with the ultimate goal to provide an early warning system to farmers and veterinarians that links behavioural changes to their underlying cause(s).

£1.3bn
Pig meat value in the UK in 2019

~£3.00
Cost per pig of digestive diseases affecting pigs in early stages of their life

~£3.80
Cost per pig of respiratory disease affecting pigs at latter stages of their production

£587k
Value of UKRI Agri-Tech Catalyst award (BBSRC and IUK) to kickstart the research

Case study #2

KnetMiner: Rothamsted Research answers White House call for coronavirus data help

At a glance

- AI enables easy access to broad range of complex information.
- Supporting international COVID-19 research by facilitating knowledge discovery and hypothesis generation.
- Collaborative application-driven research and innovation, unlocking new knowledge from health data assets.

- In March 2020, the White House, Microsoft, the Chan Zuckerberg Initiative and others launched a call to action to the world's artificial intelligence experts to develop new text and data mining techniques that could help the scientific community answer high-priority research questions related to COVID-19.
- A team from Rothamsted Research led by Dr Keywan Hassani-Pak with Joseph Hearnshaw, Dr Marco Brandizi and Ajit Singh took up this challenge and successfully repurposed KnetMiner, a tool they originally developed to help crop scientists.
- COVID-19 KnetMiner provides medical researchers with quick and intuitive access to all documented linkages between genes, medicines, and the virus. Medical researchers can now search for genes and keywords, visualise connections between biological concepts and explore knowledge relating to COVID-19.

100m
Coronavirus cases worldwide

2m
Deaths since the COVID-19 outbreak

425k
Scholarly articles about COVID-19, SARS-CoV-2, and related coronaviruses

Data from Jan 2021

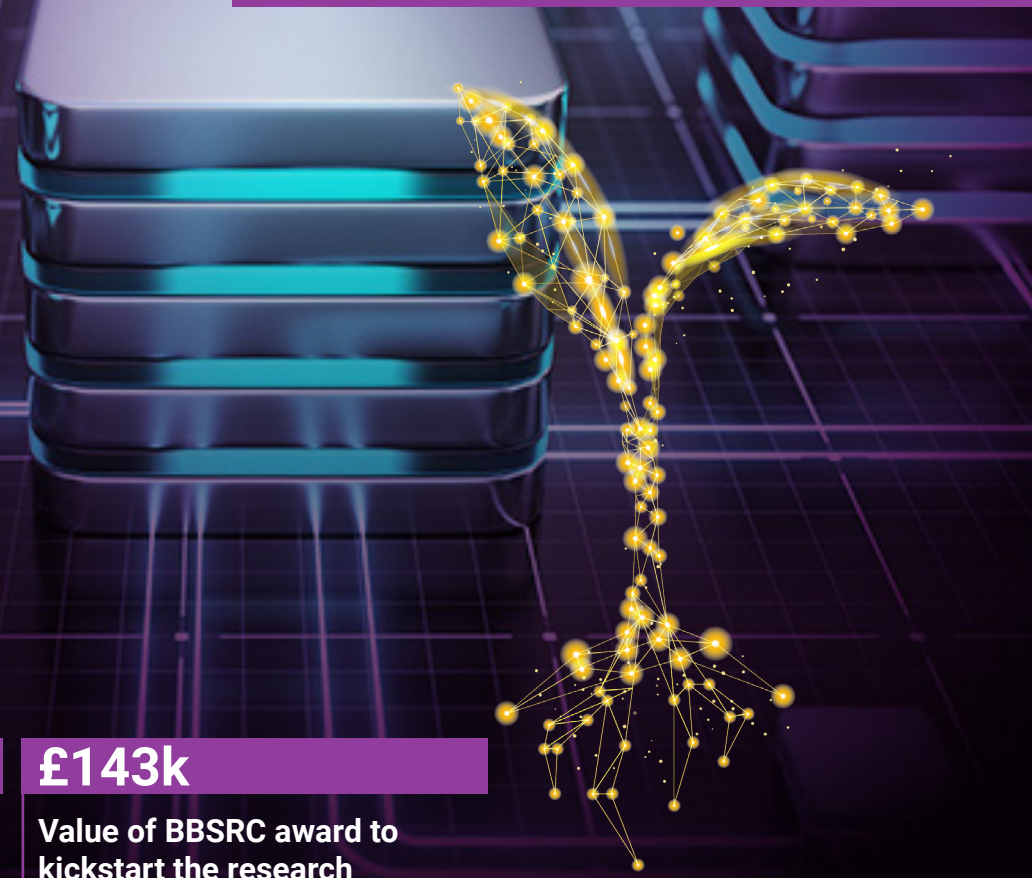
Case study #3

Deep machine learning to capture the performance of plants

At a glance

- AI enables increased accuracy and objectivity in counting tasks.
- Significant time and cost savings for researchers in plant sciences
- More efficient and reliable decision-making for crop breeders.

- Crop phenotyping performs a crucial role in identifying higher-yielding plants, in itself one solution to the continuing challenge of global food security. The current challenge for the field lies in capturing sufficient information to help determine how a plant is performing.
- Professor Tony Pridmore at the University of Nottingham together with Dr Andrew French, Dr Michael Pound and Dr Aaron Jackson, in collaboration with Syngenta, explored the use of convolutional neural nets (CNN), a type of artificial deep neural network used in image analysis and computer vision.
- CNNs are used for plant feature extraction to aid improvement of products and processes in the agricultural and food industries.
- Exploratory projects currently focus on detection and counting of biological objects, e.g. counting of seeds on sunflower heads or insects on leaves to look for signs of pathogens or pests.
- Access to a library of annotated images is a limiting factor for many researchers looking to deploy AI, an issue the Annotated Crop Image Database is looking to help address.



0.5-2 minutes
Time for human to count insects on a single leaf

5 seconds
Time for CNN to count insects on a single leaf

2.5 person weeks
Saving in effort to assess spread of single insect species

£143k
Value of BBSRC award to kickstart the research

Case study #4

Intelligent automated cell-based imaging microscopy

At a glance

- Cell-based imaging microscopy more accessible to a wider audience.
- AI enabling automation of tasks and minimising need for human guidance.
- Transferability of hardware and software approaches from unrelated fields.

- Researchers looking to understand cells and cellular components will often need to spend a lot of time manually seeking out the position of cells of interest in their sample before they can image them.

- Dr Dominic Waithe (UKRI Innovation Fellow) and Professor Christian Eggeling at the University of Oxford have now developed a microscope system that is tightly integrated with state-of-the-art machine learning algorithms, enabling it to autonomously perform imaging experiments and making the process more productive, objective and less time consuming for the user. The system is also designed to run on affordable and compact Nvidia Jetson Development boards as opposed to larger and more expensive desktop computers.

- The team also developed a simple and effective Augmented Reality (AR) system for fluorescence microscopy systems, allowing relatively non-skilled users to visualise the cell localisations in real time, helping to integrate the image acquisition phase with the analysis of the sample.

£506

Cost of one Nvidia TX2 development board used to control this microscope

£142k

Value of pump priming award, jointly funded by BBSRC and EPSRC

Case study #5

GrassVision: automated precision application to reduce herbicide use

At a glance

- AI used to explore potential for increased productivity of pasture.
- Reduction of environmental impact and threat to livestock health.
- AI advancing sustainable agriculture and food security.

- Weed infestation in managed grassland has a significant impact on forage quality and animal performance, resulting in reduced yield and palatability. The most common control strategy is extensive use of herbicides, but there is growing concern regarding water contamination and calls to restrict herbicide use.

- To address this issue, Associate Professor Mark Hansen and Professor Melvyn Smith, at the Centre for Machine Vision at the University of the West of England, worked with SoilEssentials Ltd to develop a novel artificial intelligence-driven spray apparatus. This device enables precision application of herbicides to broad-leaf weeds in grass crops, allowing for potential reductions in herbicide use in excess of 90%.

- The SKAi project, supported by Innovate UK, exploits the commercialisation potential of the original project, building a smart camera and artificial intelligence platform for use by beef and dairy farmers, agronomists and agrochemical applicators that differentiates between crop and weed species and enables precision targeting of agro-chemicals in a commercial setting.

18.3m ha

Size of the UK total agricultural area, with grass covering ~67%

£120m

Cost per year to the UK to remove herbicides from public water supplies

£181k

Value of BBSRC-Industry Partnering Award to support the research

Case study #6

RoboChick: an autonomous platform monitoring poultry welfare

At a glance

- AI enables continuous poultry health and environment monitoring.
- Robotic system enabling data collection and analysis beyond what existing farm staff monitoring can deliver.
- Improved welfare and climate conditions, advancing agriculture and food security.

- Poultry requires careful husbandry, but current commercial monitoring technologies largely provide insight at flock level and require significant human intervention. This makes the approach imprecise, labour intensive and expensive while not providing sufficient insight at the level of individual animals for efficient poultry production.

- Dr Theo Demmers, Senior Research Fellow at the Royal Veterinary College, assembled an interdisciplinary team from Ross Robotics Ltd, Harper Adams University and Applied Poultry, with expertise in engineering and robotics, animal welfare and behaviour, and commercial poultry management to develop a multi-functional robotic system to address this need.

- RoboChick is an animal welfare-friendly robotic system, which can autonomously navigate through a growing flock of broilers and collect a range of data on animal behaviour, physical condition and environmental microclimate.

- It paves the way for a commercial autonomous and artificial intelligence-driven device for targeted monitoring and intervention, reducing reliance on manual labour and improving animal welfare.

106.5m	~100k	£550k
Broilers produced in UK per month	Average number of broilers per shed	Industrial Strategy Challenge Fund Early Stage Feasibility funding for “RoboChick”

Case study #7

LabGenius: Autonomising the discovery of protein therapeutics

- LabGenius evolves novel therapeutic proteins using EVA, a next-generation protein engineering platform, at the forefront of engineering biology, that integrates several bleeding-edge technologies from the fields of synthetic biology, robotics and machine learning.
- Dr James Field and a group of fellow Imperial College PhD students founded LabGenius in 2012 to commercialise their protein engineering technology. The company has gone on to raise around $29 million in private investment.
- An EPSRC-funded PhD and funding from the BBSRC and Innovate UK helped establish LabGenius.
- James was named BBSRC Innovator of the Year in 2017 and has been listed in the Forbes 30 Under 30 Europe list of the most impressive young entrepreneurs that are reshaping Europe for the better. James is also a fellow of the prestigious Synthetic Biology Leadership Excellence Accelerator Program (LEAP).

$29m
Private investment secured by LabGenius

50
People employed by LabGenius

£102k
BBSRC investment to support the research

At a glance

- Use of AI in conjunction with proprietary experimental data to model and predict the relationship between a protein's sequence and its function.
- Increasing the efficiency with which researchers can identify high-performing protein variants.
- Important role of businesses in developing and deploying cutting-edge AI to increase business productivity, resilience and competitiveness.

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UKRI Statement of Opportunity 'Transforming our world with AI':
ukri.org/about-us/what-we-do/strategies-and-reviews/ai-review-transforming-our-world-with-ai/

UKRI-BBSRC Review of Data Intensive Bioscience:
ukri.org/news/bbsrc-publishes-review-of-data-intensive-bioscience/

UKRI Funding Finder:
ukri.org/opportunity/

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