Robot Highways: the road to future food resilience?

How advanced robotics can solve major challenges that global agriculture is facing today

A challenging forecast for global agriculture

Global agriculture urgently needs innovative, industrial-scale solutions to increase its sustainability, efficiency and yield.

The world's population is set to reach 9.3 billion by 2050, and as a result, we'll need to increase global food production by 60%. Despite this challenge, global food waste at farming stages weighs in at around 1.2 billion tonnes each year. Accounting for over 15% of all food production and $370 million, most of this waste is lost in high- and middle-income countries like Europe, North America, and industrialised Asia.

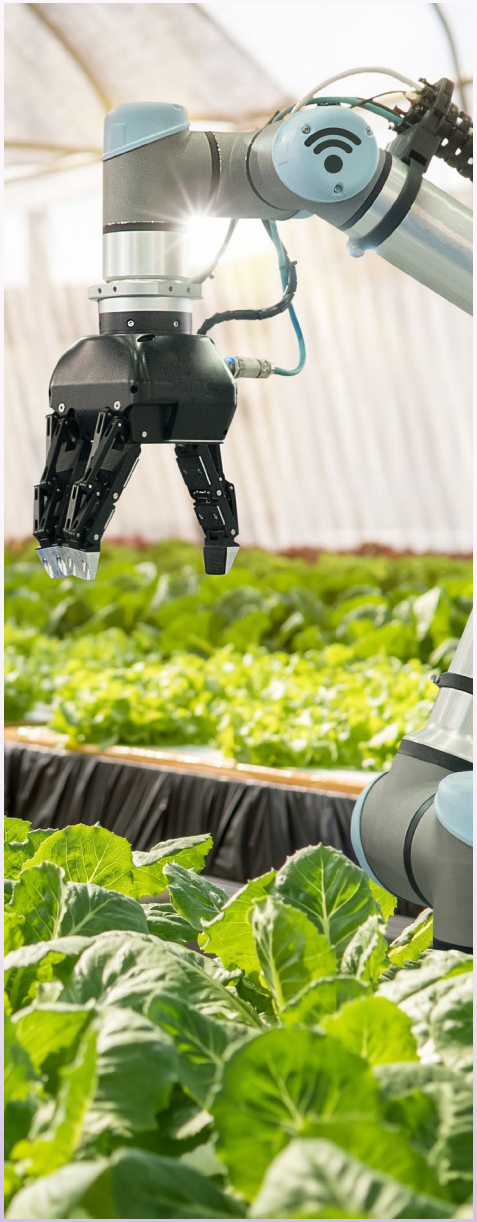
Despite population growth, the availability of seasonal workers across many economies is in decline, so labour shortages are intensifying the situation. In the UK alone, a shortfall of more than 500,000 farm workers means a significant number of crops are left to waste year-on-year. And these challenges are all playing out against the backdrop of extreme weather conditions caused by climate change. Globally, record-breaking temperatures, droughts and rainfall will decimate crops and make it even harder for farmers to predict labour needs relating to crop cycles, yield and soil conditions.

Countries in the developing world are already feeling the strain - with a further 50 set to become food insecure by 2030. To meet future demand, it's imperative the farming sector optimises operations by integrating new innovations like the Internet of Things (IoT), advanced automation, big data and edge computing. The agricultural technology or 'agritech' sector is already booming, and it's tipped to reach $22.5 billion by 2025. Powered by exciting new research developments and tech startups, it's leading an exciting revolution in agriculture.

Driving change with agricultural robotics

Funded by Innovate UK, Robot Highways is the world's first and largest trial of an entirely automated farming system. Based at Clock House Farm in Kent, the collaborative project has successfully demonstrated the ability of a fleet of robots to pick, pack, count and transport soft fruit as well as treat it for pests. What's more, the robots can be recharged from solar-powered charging points.

Through its success, the project displays an exciting vision for the future of agriculture. The industry is now increasingly recognising that IoT and robotic technology has many commercially viable and scalable applications that go beyond soft fruit farming to more complex food systems. By reducing our reliance on fossil fuels, human labour and decision-making, agritech is a powerful tool in the global effort to improve food resilience.



Innovation through collaboration

From September 2020, the Robot Highways project was led by Norway's SAGA Robotics and delivered alongside a consortium of academic, agricultural and technology partners.

These included the University of Lincoln, Clock House Farm, Berry Gardens, the University of Reading and the Manufacturing Technology Centre. Across their respective disciplines, each organisation was designated a specific role in supporting the delivery, research and development of the robotics trial.

Key targets for success

The project set out to achieve several key aims:

Improving forecasting and detection: to deliver 98% accuracy in autonomous detection of ripe fruit, fruit counting and gauging fruit size.

Increasing farm productivity: to achieve 10% productivity gains in picking operations.

Reducing reliance on farm labour: to reach 85% of a human labourer's fruit picking speed autonomously.

Reducing the use of fungicides: to reduce mildew by 85% reduction through autonomous ultraviolet disease control as a fungicide alternative.

Reducing waste and conserving resources: to achieve a 20% reduction in fruit waste.

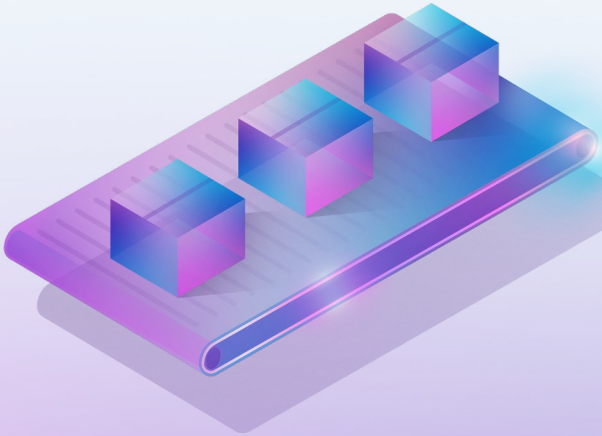
Reducing fossil fuel usage: to create a 100% rechargeable, solar powered robot fleet.

Supporting advanced robotic farming

As part of this collaborative project, our main role was to deliver a cyber-physical platform capable of supporting all of the robot fleet's operations. Farmers needed a single interface that enabled them to control the entire fleet, access device data, real-time diagnostics and reporting capabilities. For speed and efficiency, we also had to determine the optimal positioning for data and computation on the network, whether that was at the network edge or in the cloud. Fortunately, our previous experience in delivering network-based platforms, edge computing infrastructure and cloud architecture meant we were well positioned to lead these areas of the project.

Starting small on the farm

The project was broken down into a series of smaller pilot projects, which tested the viability of each use case. One pilot focused on robotic fruit detection and forecasting, another on automated ultraviolet disease control and others on spraying, picking, packing and fleet control. Once each trial was successful, each pilot system was then connected into a full-scale farming model that illustrated how all the systems could effectively operate together in an actual agricultural setting.



Delivering next-generation robot farming infrastructure

At the start, we focused on understanding what network capabilities and services would be needed to support all the use cases across the project.

Through our initial surveys, it was clear we would need to develop a flexible edge and cloud-based architecture to support the high level requirements of the robot fleets, smart devices and data processing taking place. Then, across the farm's operations, we would be able to decide where computing power would be best placed to support each individual use case.

Giving farm robots the edge

For the farm's robots to be commercially viable, they needed to be able to carry out tasks effectively at speed. This meant, for certain jobs, it was essential to bring computing power closer to where they were operating to significantly reduce latency and accelerate decision making. When fruit picking, for example, low-latency processing at the network edge enabled devices to rapidly process visual data and then turn it into decisions and actions. It also helped them to respond in real-time to any remote commands sent from the control interface.

Taking full advantage of the cloud

The farm robots also required constant connection to sufficient data storage in the cloud to store the enormous volumes of information they were generating.

At the same time, we recognised this as an opportunity for any less latency or time sensitive data to be analysed using cloud compute power. This wider data analysis would then support the project by identifying potential trends and anomalies that could enable more strategic planning.

Use case: fruit counting and forecasting
During the Robot Highways trial, our edge computing system successfully delivered:

- 99% accuracy in counting
- 2,400 bounding boxes per second on a high-spec Graphics Processing Unit.

Our bespoke robotics platform and farm management system

To coordinate and automate a fleet of round-the-clock robots, we built a cloud-based farm management platform where all of the different components across the entire project could be integrated to interact with each other seamlessly.

From a single interface, farm managers could then oversee all of the operations taking place simultaneously, schedule multiple or individual robots, as well as have instant access to a whole range of real-time information about each device's performance, efficiency and productivity.

The end result was our bespoke Farm Operations Dashboard, providing Robot Highways farmers with a range of highly valuable features including:

- **Real-time monitoring:** up-to-date location information on each robot, right down to its exact coordinates and availability – for example, what task it's doing or whether it's charging.
- **Live operations window:** a live overview of each device's schedule including current and pending tasks and the percentage progress completed.
- **Detailed task logs:** a full itinerary of previous tasks and historical data including when they were completed as well as details and statistics on the time it took.
- **Live weather updates:** up-to-the-minute forecasting and alerts, incorporating a range of weather and crop data.
- **Full fleet control:** multi-task scheduling options, with the ability to specify start and finish times and locations to each device.
- **Health and safety features:** mandatory compliance checklists and prompts before tasks can be scheduled, as well as pop-up notifications for any potential issues.
- **Emergency override function:** in case of emergency, a remote shut down and reboot function.
- **Maintenance scheduling:** the ability to orchestrate routine updates, repairs or charging alongside operations from the dashboard, as well as to receive regular status updates and alerts on device battery life.

Digital twins for enhanced visualisation

To enhance the remote monitoring capabilities and fleet control system inside our dashboard, we also integrated it with Open Remote's Digital Twin technology. This used the continuous live data feeds and status information going into the platform to create a virtual replica or 'twin' of each robot that realistically simulated it performing jobs on the farm in real-time. Then if problems were identified on the device, like a low battery or an obstruction in the field, alerts would be sent to the digital twin where operators could then accurately visualise problems to solve them more effectively.

What's next for Robot Highways?

The Robot Highways project officially came to an end in February 2023. However, many of the collaborators and funders are now determined to explore new opportunities that'll enable them to investigate these findings further.

Demonstrating the results

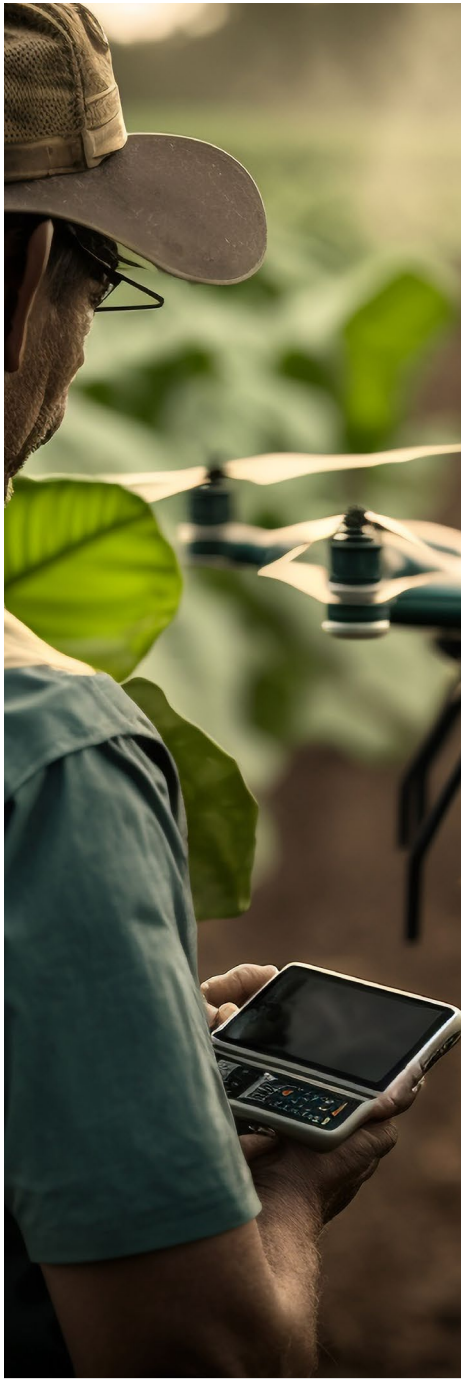
Since the trials, the Robot Highways project has carried out several major demonstration events across the UK to showcase its capabilities. These events included an exhibition at our very own annual Robotics Festival in November 2022, a demonstration at our Research and Development Headquarters at Adastral Park and an open day at Clock House Farm. So far, the project has received wide-ranging interest from many different industries and professions – from farmers and supermarkets to national and international media outlets and politicians.

Exploring future applications

Many of the partners are committed to using the project to develop more commercially viable applications that can support the wider agricultural sector. Beyond farming, there are also many potentially exciting use cases that the findings of this project could support. For a start, the ability to seamlessly orchestrate multiple smart devices alongside edge infrastructure could assist drone fleet coordination, large-scale construction, manufacturing and many other complex industrial settings.

Rural 5G: the future?

Connectivity plays a key role in delivering the advanced automation capabilities that the Robot Highways project relies on. Because of this, deployment of a higher bandwidth and lower latency 5G network onsite would be the logical next step in enhancing the capabilities of the project. This will create a foundation for large scale deployment of rural 5G to significantly amplify the productivity of automated farming and precision-based agriculture.



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We're a trusted partner for the agricultural sector as it embarks on a transformation journey to create a more sustainable future. Our strong track record across network and IT security means we have a comprehensive portfolio of best-in-class security controls, and detection and response solutions that can be applied to an OT environment. And because we have expertise across network, security and compute, customers don't have to source numerous specialist OT vendors.

Wherever you're at on your agritech journey, our skilled professionals can help create the secure, innovative solutions you need. To find out more about how our services can help progress your transformation, visit our Digital Industries Innovation Hub or contact a specialist.

Offices Worldwide

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