Safe-tech Hackathon

Enhancing the safety and security of autonomous agricultural vehicles

AGRIEPICENTRE
Engineering • Precision • Innovation

"Robotics and Autonomous Systems (RAS) are set to transform global industries. These technologies will have greatest impact on large sectors of the economy with relatively low productivity such as Agri-Food. The UK Agri-Food chain, from primary farming through to retail, generates over £108bn p.a., with 3.7 million employees in a truly international industry yielding £20bn of exports in 2016."

Quoted from "Agricultural Robotics: The Future of Robotic Agriculture" A white paper produced by the UK Robotics and Autonomous Systems Network (UK-RAS, 2018).

Executive Summary

This is an industry paper produced by Agri-EPI Centre in collaboration with Innovate UK funded project Hands Free Farm.

The paper offers recommendations around the future development of autonomous agricultural solutions. The key messages and recommendations in this paper are based on collaborations with key stakeholders and end-users which took place as part of the 2021 Agri-EPI Agricultural Technology Hackathon.

The Hackathon challenge was based on Hands Free Farm a 35ha testbed for autonomous farm machinery and drones. One of the challenges in scaling up the Hands Free approach, is that, like many farms, the 35ha plot includes footpaths and roads with public access. Safety and security of the operation of autonomous machinery is therefore of paramount importance. Members of the Hands Free Farm project team, Kit Franklin, Senior Agricultural Engineer, Harper Adams University and Head of Business Development Map of Ag, Clive Blacker provided the key challenge areas for our hackers to address.

The paper considers on-farm safety, connectivity and cyber security in relation to the use of autonomous agricultural vehicles. It raises a series of considerations around agriculture's readiness for large scale adoption of autonomous vehicles.

Hands Free Farm Autonomous tractor spraying

1. Autonomous vehicles – driving the future of farming?

The development of autonomous vehicles and artificial intelligence to grow and harvest food is gathering pace, and it is now commonly accepted that automation is becoming a critical element in sustainable food production.

Robots and AI are now advanced enough to be used for non-standardised tasks such as weeding, crop sensing, and fruit picking, and many jobs can be augmented, if not replaced by robots. AI is likely to grow in its applications in agricultural production support. This is reinforced by one market analyst's prediction of a current market of about $600M in 2018, rising by >38% compound per annum over the coming years.

The huge tractors and harvesters that are a common sight on farms today have increased productivity in the face of challenges including climate change, tight working windows and a reduced workforce. But the size and weight of these machines have also caused issues, particularly reduced soil health through compaction, which hinders plant growth, and challenges around the precision application of inputs, as sprayer and harvesting widths have increased.

The development of automated agricultural vehicles is opening up a new world where large machinery may be replaced by multiple smaller, lighter machines that advance precision farming, by monitoring and treating every plant separately. Rather than driving the machines, humans will manage the fleet, maintain the robots and closely monitor and analyse plant and crop development.

2. Reducing hurdles to the development of autonomous vehicles

Robots are complex systems which must be synchronised and able to operate to the same standards as current systems in unstructured agricultural environments, where there are constantly changing conditions and variability.

This requires intelligent systems which are cost-effective, safe and reliable for humans, crops and the environment.

Farming is complex and stakeholders across the industry can impact the day to day running's of the farm business. When developing any technology, innovators should think holistically about how the technology will be used on-farm, and by whom. This robot-human collaboration clearly creates ethical, legislative and social impacts.

If we don't consider the future stakeholders early on, autonomous technologies will be adopted more slowly due to barriers from policy makers, the public, and insurers.

As part of its 2021 Agri-Tech Hackathon, Agri-EPI engaged with a range of stakeholders to explore three key areas:

- Public safety
- Connectivity
- Cyber-security threats

Public access and safety

Agri-EPI engaged with industry stakeholders including NFU Mutual and Country Land and Business Association, a 27,000 strong membership organisation for landowners and farmers, to explore the risks and challenges posed by autonomous farm vehicles to users of the countryside.

Key challenges:

The biggest area of potential risk is the threat of collision with humans or other vehicles who are using the countryside. This could include local residents, livestock, wildlife, and utility providers, who may become potential random obstacles in the path of unmanned machinery.

Recommendations:

Artificial intelligence and machine vision should be used to identify and avoid collision with certain objects, as well as to recognise the difference between static and moving objects. For static obstacles such as pylons and trees, these can be taken into account through a pre-route survey of the field. Machine vision and supervision could additionally be used to identify and distinguish between objects in the field-- for example a 6 ft tall maize plant versus a 6 ft tall human. Building a mechanism to distinguish between a deliberate collision versus an accident into the machine technology is key to ensuring safety to users of the countryside.

There is still work to be done in terms of communicating and raising awareness of farming practices to the general public and how to safely navigate the countryside. At present there are issues around livestock worrying and damaging crops from trespasses. Discussion of appropriate signage would be necessary to highlight the operation of autonomous agricultural vehicles being used to produce food for the public. This could include signage indicating 'do not enter' or 'stay away' zones. There is also the consideration of whether the UK Government's statutory guidance Countryside Code would need to be reviewed to reference technology and autonomous systems.

The points identified around safety link to the need for cross sector learning between the automotive industry and the agriculture sector. This collaboration would help to maximise preparedness through rigorous testing of autonomous models. Companies who brought their experience from the automotive sector included Continental Engineering and Epitomical who have experience in developing and testing autonomous highway vehicles. The Transport Research Laboratory also attended the workshop and highlighted the need for rigorous testing and training to be included.

Another key area of focus is on improving the understanding of the integration of human operators with robots for increased performance and reliability. One example area of responsibility would be ensuring rights of way are maintained for the public to use while utilising autonomous vehicles or machines. This may involve hosting electricity pylons and ensuring public footpaths are accessible.

There was a strong view amongst stakeholder that there should be an agricultural vehicles autonomous code of practice put forward. It is encouraging that this is already being explored by Harper Adams University and BSI.

Connectivity

Key challenges:

Farms are remote and often located in rural areas with poor connectivity-- traditional telco services are not commonly deployed to all parts of the farm. Traditional "over the air" technologies, such as satellite, provide flaky performance or can often have expensive usage limits. More and more "things" are being connected to the internet, where performance and reliability of connectivity are major challenges. Current technologies on farm have usage limits, and a move toward the Internet of Things means that more devices are using connectivity which leads to performance issues and poor connectivity.

Recommendations:

Farms need increased connectivity to support the streamlined adoption of autonomous systems in the future. It is necessary for information systems infrastructure to be developed apace of new autonomous technologies if we are to support the rapid adoption of technology such as autonomous agricultural vehicles on farm.

An example is the Hands Free Farm which uses LoRaWAN, 4G, Zigbee, RTK and drones which are all connected devices in order to operate efficiently.

The case for using 5G in farming shows promise, although the superfast networking technology is only beginning to be applied in the agriculture world. 5G is currently being rolled out through the 5G Rural First project. Improving connectivity on farm will also support the livestock and dairy sectors who are collecting data from sensors and multiple sources on farm.

Cyber security on-farm threat

Key challenges:
The agricultural industry has for a long time been viewed as low risk from potential cyber-attacks. However, with more and more farms and food processing plants adopting new technologies to streamline production and integrate with supply chain services, cyber-crime is becoming an increasingly severe threat to agri-businesses. The number of attacks is on the rise and important areas to address this include anti-fraud and anti-theft systems.

More machines and devices connecting to the internet widens the threat landscape and increases potential vectors. Many attacks start by a device being compromised or laying dormant, by lateral movement within the environment. Organisations commonly do not know what is connected to their network and cannot spot anomalous or malicious behaviour. The problem is only becoming exacerbated as Operational Technology (OT) such as manufacturing and production environments are being attacked, which ultimately compromises the future of food production. The ability to take over or glean data from these systems may be a national threat to food supply chains.

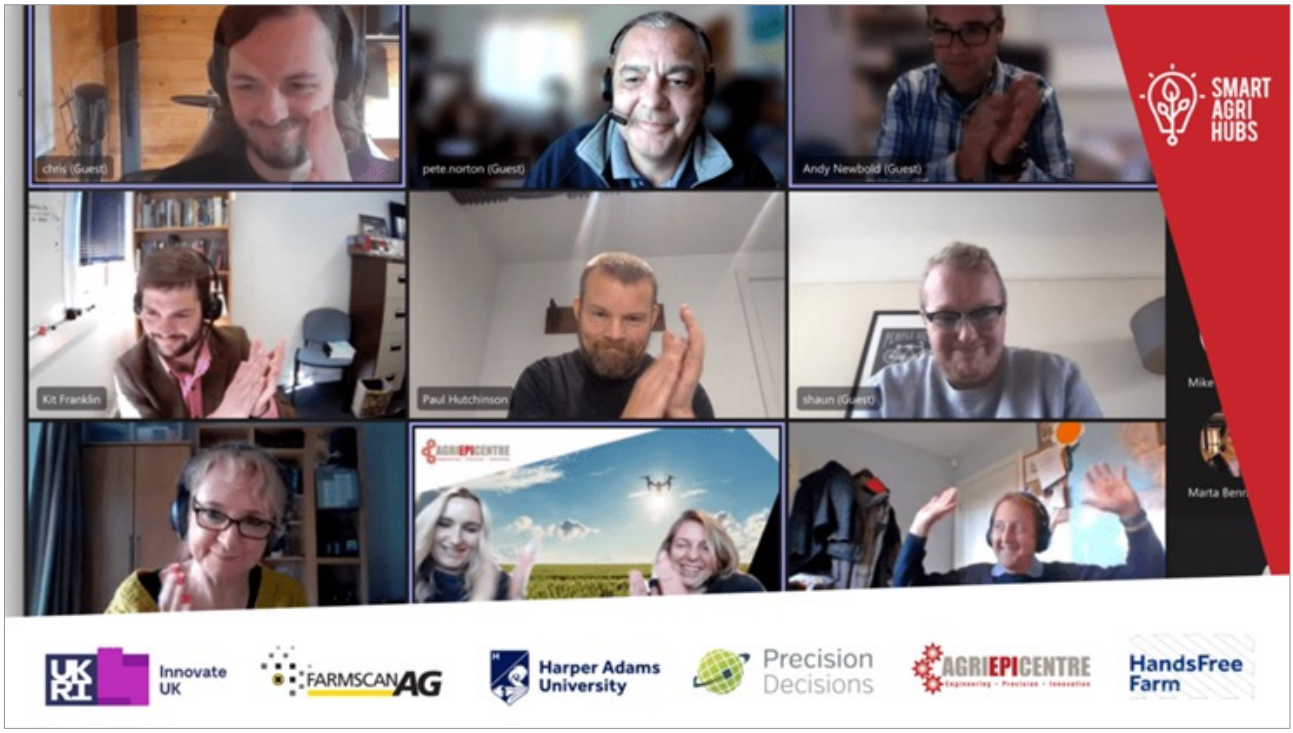
In addition, we have seen an increase in farm thefts relating to high value GPS equipment. Current global positioning systems (GPS) equipment on tractors can cost up to £10,000 apiece. These systems help farmers map their acreage and make the most efficient use of their land.

Recommendations:
Network connectivity is wide and varied and will continue to evolve. A way to combat future technology threats is to include more ingress/egress points and IT/OT networks which need to be secured. Compromised systems or devices can cause loss of revenue, reputational damage, and loss of intellectual property. Utilising built-in cyber and anti-theft systems as part of the agri-tech development process will link in as well to the adoption of better technology on farm as farmers will be able to deploy this technology safely and securely.

3. The Agri-EPI Agri-Tech Hackathon

Hackathon Outcomes – the winners

Agri-EPI Centre's 2021 Agri-Tech Hackathon sought to identify solutions to enhance the safety and security of autonomous farm machines. Agri-EPI ran the initiative with Innovate-UK funded Hands Free Farm, a testbed for autonomous farm machinery and drones.



One of the challenges in scaling up the Hands Free approach is that, like many typical farms, the 35ha plot includes footpaths and tracks with public access. Safety and security of the operation of autonomous machinery is therefore of paramount importance. We proposed our Hackathon to address the following challenges

- Detecting people entering and exiting an operational area
- Communicating that unmanned vehicles are operating in the area
- Providing safety and other information and advice
- Managing human-machine interaction

The teams which took part came from a range of disciplines, such as robotics, artificial intelligence, machine learning, Internet of Things, drones and computer vision. They were Agribot; Epitomical Limited; Continental Industry; NextGenAgri Limited; GMV NSL; and MNB Networks Ltd. The teams covered a range of areas relating to on-farm safety and security.

The hackathon was supported by funding from the European Union's Horizon 2020 Research and Innovation Programme, through an Open Call issued and executed under the project SmartAgriHubs.

The winner: Agribot

The Hackathon winner was UK company Agribot, which provides accessible precision farming on a global scale through a ground-breaking and patent pending AI and satellite technology.

The Agribot early warning system provides farmers with an understanding of crop health and empowers them to make treatment decisions that are environmentally and economically advantageous. This product combines the power of AI with a wide variety of different types of satellite data to give customers early insights and information to make the decisions that will benefit the future of the planet. Agribot works with growers, businesses, NGO's & governments to drive economic and environmental change.

Agribot's winning Hackathon concept brought together cutting-edge AI and vision technology to provide a cost-effective, anonymised human and animal detection system that could work with notoriously patchy rural connectivity.

Legacy

Agribot is now in conversation with the Hands Free Farm (HFF) team to develop and implement their technology on the HFF site.

The runner-up: NextGenAgri

NextGenAgri provides a range of solutions that couple innovation with the critical challenges of the UK agricultural community.

These include increasing field and farm yield; asset and farm security and worker safety.

4. Summary

Takeaways include:

- Early stakeholder engagement is key to identify risks and challenges
- Safety and security should be considered in the design process
- Cross sector input is needed
- Security & safety solutions for autonomous vehicles must be designed with farmer useability in mind
- Farms need increased connectivity & networks to support better adoption of autonomous systems
- The ethicality of collecting public data should be considered in the regulation of AI
- Cyber security is an increasing on-farm threat

This Project has received funding from the European Union's Horizon 2020 research and innovation programme, through an Open Call issued and executed under the project SmartAgriHubs (Grant Agreement No. 818 182)

Event partners

HandsFree Farm

AGRIEPICENTRE Engineering • Precision • Innovation

Industry stakeholders

TRL THE FUTURE OF TRANSPORT

CLA

HSE

NFU Mutual

bsi.

Hackathon participants

epitomical®

agribot

NextGenAgri

MNB Networks SIMPLY CONNECT

gmv NSL

Continental Engineering Services

Funders

SMART AGRI HUBS