Australian
National
University

ROBOTIC HARVESTING: A POTENTIAL SOLUTION TO FARM LABOUR?

TECHNICAL SUMMARY

Invention snapshot

- Researchers from ANU are developing a robotic harvesting solution, for multiple crop types, under real-world conditions.
- Using a wide range of disciplines (machine vision, sensing, robotics, control, software architecture, etc.), our researchers are developing a multi-crop, selective-harvesting, robotic platform to help automate labour and reduce input costs for outdoor farms.

ANU Technology Transfer Office

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Background

The Australian horticultural industry remains heavily reliant on manual labour. Many horticultural tasks are short-term or seasonal. Often these arrangements are not attractive to local workers, who have ongoing financial commitments and longer term career aspirations. Local labour shortages regularly force growers/farmers to leave money on the ground (because there is no one to harvest their crops) or to shy away from planting their crops in first place. The Australian government has implemented several initiatives to help ease the labour shortage, such as the 'Seasonal Workers Program' (designed to allow growers/farmers to bring workers in from the Pacific and Timor Leste) and the 'Working Holiday Maker Program' that includes the working holiday visa which enables travellers to have an extended holiday and earn money through short-term employment. Despite these initiatives, the horticultural industry still faces uncertainty over the availability of labour. Recently, two new government schemes have been proposed. The first scheme is an unemployed farm work plan wherein jobseekers will be urged to take up work on farms or face losing their welfare payments. Under these arrangements, growers/farmers could register their job requirements, pay and conditions with the National Harvest Labour Information Service and job providers would then try to find local unemployed people to fill the positions. The second scheme is a new, specialised agricultural visa for foreign farm workers, which would allow growers/farmers to hire a dedicated overseas workforce on a temporary basis.

While these initiatives/schemes may address the issue of labour shortage, they do not address other labour-related problems (e.g. increased costs; managing, hiring and training of a large number of workers; dealing with personal issues; access to skilled and reliable workers), plus they introduce new risks (e.g. managing compliance and dealing with dishonest labour sourcing firms) and costs (e.g. accommodation facilities and other additional support services for foreign workers). As a result, the horticultural industry has seen an increased adoption of Mechanisation, Automation, Robotics and Sensing (MARS) technologies in an attempt to lower labour requirements and increase farming efficiency. Globally, growers/farmers are adopting technologies that help them better control their farm environments (e.g. software tools that provide meaningful crop data to inform decision-making; automated irrigation systems) and enable them to reduce labour requirements (e.g. packinghouse machines that can grade produce using technology rather than personnel).

Robotics and automation in horticulture is not a new phenomenon. However, with recent increases in computational power combined with reductions in cost, robotics applications are spreading. In horticulture, robots have been applied to the harvest of cherries, tomatoes, cucumbers, mushrooms, apples and other fruits[1]. So far, no harvesting robot has reached the stage of commercialisation, because of their low operational speeds, low success rates and high costs[1]. A recent survey (2016) revealed that (i) the development of robotic harvesting for tropical and subtropical horticulture crops was seen as THE priority across all growing regions of Australia, (ii) labour is by far the most important production/business cost for growers/farmers, and (iii) harvesting is the number one thing that Australian growers/farmers would like to automate on their farms[2]. Robotic harvesting offers an attractive potential solution to insufficient labour and enables more regular and selective harvesting (optimising crop quality and therefore profitability).

Technology description

The availability and quantity of sufficient labour for hand harvesting is a major concern of many growers/farmers. The shortage, instability and cost of labour for hand harvesting and increasing competition from lower cost world producers have been the driving forces behind the development of mechanised and automated harvesting. The global agricultural robotics market was valued at $2.8 billion (USD) in 2016 and is predicted to reach $12.8 billion by 2022[3]. Harvesting management is the most widely used application in agricultural robotic farming as it plays a vital role in high value crops and helps growers in maximising their yields[3]. Robotics for harvesting is a promising emerging type of farm tech and this market was valued at $5.5 billion (USD) in 2018[4]. The reality is that despite the rising cost of labour amidst unpredictability in farm profitability, farm robotics is still immature.

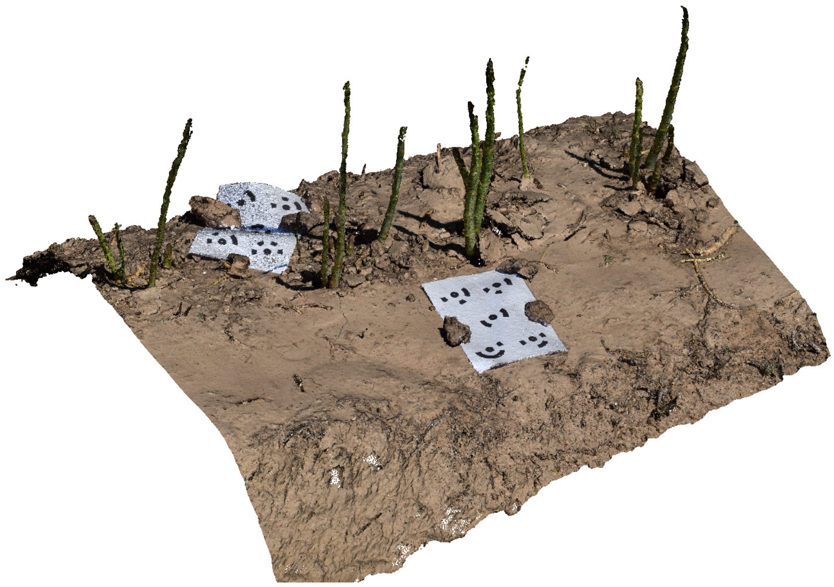

Figure 1: Image of a 3D reconstructed green asparagus bed (created by Tao Hu)

To address this need researchers from The Australian National University (ANU) are engineering a robotic platform capable of selectively harvesting multiple horticulture crop types. The platform consists of three main systems: a perception system – tasked with the identification and location of the crop targets (fruit or vegetable); a manipulator system – tasked with the harvesting action (i.e. cutting and manipulation); and a transportation system – tasked with moving the platform along the crop bed/row. The focus over the next 12 months is further development of the perception system, which requires the implementation of 3D modelling experiments (Figures 1 & 2) at several farm locations. Once complete, this information will be used to optimise the design of the manipulator and transportation systems. The transportation system consists of a custom-designed enclosure (which houses and integrates the perception and manipulator systems together) that can be potentially mounted/hitched to the back of a standardised tractor. This will enable the harvester to be operated by one person, using existing farm equipment, and effectively means that the harvester can access all farm areas currently accessible by a tractor.

Advantages

- Involving members of the horticultural industry early will help to ensure that ANU provides a solution that meets current needs and returns value back to growers and farmers.
- Supporting innovation that advances and grows the Australian horticultural industry – development of a multi-crop selective-harvesting robotic platform will provide steps towards the goal of fully autonomous and reliable crop picking systems.

- Our robotic platform will stand out from other designs in two key areas: it will be fast (improving its economic viability) and it will target multiple crops (enabling differently designed robots to be substituted by a single platform).
- Our novel robotic platform will be multi-purpose and adaptable, enabling the technology to be transferrable to many horticulture crop types.
- Unlike other harvesting robots, our perception system will provide information fast enough, with enough resolution, to allow for complex interactive applications such as harvesting[5]. As such, our system will be capable of detecting and localising crop targets with a high degree of accuracy (providing fast, accurate harvesting).
- Other potentially achievable advantages include minimal crop handling, minimal crop damage, low electro-mechanical complexity (improving reliability and durability), and multiple angle harvesting capability.

Applications and time to market

Robotic harvesting has the potential to revolutionise harvesting methods for a range of selectively harvested crops. Using an assortment of crop, technical and market attributes, a systematic comparison approach was used to determine which crops to concentrate on first. Capsicum, chilli and green asparagus have been chosen as the first series of crop types to consider. Of these three, capsicums and chillies are more difficult for a robotic harvester, given the dense foliage surrounding the fruit, which often obscures it from view. As such, green asparagus will be targeted first, as it poses a simpler perception problem due to the relative lack of foliage. Pursing green asparagus first will enable our researchers to develop and refine the robotic platform to a level that will enable it to harvest more difficult crops, whilst also facilitating the testing of the platform in real-world, on-farm conditions. Further crops will be investigated following the successful harvesting of capsicum, chilli and green asparagus. All three of these crops require selective harvesting, with each requiring differing ripeness conditions for optimal harvesting. Horticultural crops that do not require selective harvesting are better suited to mechanical (once-over) rather than robotic (selective) harvesting and as such are not ideal horticultural crop types for our robotic platform.

Figure 2: The ACRV team performing 3D perception modelling experiments at a near-by asparagus farm (taken by Alex Martin)

3D perception modelling, on-farm experiments are already underway for green asparagus (Figures 1 & 2). The goal is to perform the first on-farm harvesting trials on a single crop during the 2019 harvest season. Then following platform refinement and optimisation, the aim to perform on-farm harvesting trials, for multiple crops, from 2020-2022. Our platform is at an early stage of development, but the objective is to have commercially viable units available in 2023.

Opportunity

ANU is driven to deliver a robotic platform that will be of practical use to the Australian horticulture community. As such, we are seeking to involve members of the horticultural industry, throughout the life of project, to ensure that we provide a solution that meets current needs and returns value back to growers and farmers.

Specifically we are looking to engage on three levels:

- **Feedback and advice:** surveys and discussions with growers and farmers around current farming conditions, practices and harvesting procedures (to reveal key factors into the successful deployment of a robotic harvester for specific crops).
- **Farm visits:** visiting of farms to witness harvesting first-hand and to discuss harvesting techniques, costs and components of most value. What are the current harvesting efficiency issues and how can a robotic harvester address these? We want to develop a shared understanding of the role that robotic systems can play in the harvesting process.
- **Farm trials:** conducting on-farm 3D perception modelling experiments and prototype harvesting trials. We would like to collaborate with growers/farmers, utilising their knowledge and abilities, to perform real-world demonstrations of our robotic platform.

If you are interested in providing feedback or advice, or would consider a farm visit or trial, or would like to learn more about our robotic harvesting solution, please get in touch.

Organisational capacity

The **Computer Vision and Robotics Group** at ANU is leading Australia's innovative research into the use of robotics in creating intelligent systems that function in complex and dynamic environments. The group focuses on the robotic sciences, in particular the underpinning scientific theories behind the functionality of robots. One key strength of the group is that the 'robotics', 'computer vision' and 'networked systems' research areas are co-located, creating a dynamic environment that supports breakthrough interdisciplinary research. The group's mission is to marry fundamental engineering principles and scientific development with real-world applications. The group conducts innovative and fundamental research focused on multi-view geometry, 3D modelling, dynamic-scene understanding, machine learning and pattern recognition.

ANU hosts a node of the **Australian Centre for Robotic Vision** (ACRV). The centre brings a critical mass of researchers and technical support together to make substantive advances in applying computer vision to robotics problems, and includes the leading national laboratory in vision-based control of robotic systems. The ANU node leads the 'fast vision and motion control' research program and is heavily engaged in the 'robotic manipulation' research program. Globally the ANU node is amongst the leading centres of excellence for robotic perception and autonomous navigation.

Scientific team

All team members work within the ANU node of ACRV and the Research School of Engineering (RSE) (Figure 3). Collectively, the team has over 50 years' experience in robotic perception, manipulation and control.

Professor Rob Mahony leads the robotics group and robotic sciences laboratory at ANU. Rob's expertise is in non-linear systems theory and optimisation with applications in robotics, geometric optimisation techniques and computer vision.

Dr Viorela Ila is a senior lecturer at ANU and a senior research fellow with the ACRV. Viorela has over 17 years' experience in robotics and computer vision and has been leading the development of the perception system.

Dr Tao Hu is a technical officer with the RSE with expertise in the areas of computer vision and robotics. Tao has been assisting with the software engineering components of the perception system.

Mr Gerard Kennedy is a research assistant for the ACRV with qualifications in mechatronic systems. Gerard has been assisting with perception algorithm development.

Mr Brock Holland is an ANU student undertaking a Bachelors of Engineering with majors in mechatronics and mechanics. Brock has been assisting with manipulator design and control system development.

Mr Alex Martin is a technical officer with the RSE. He works on numerous ACRV projects, manages the administration of the robotic sciences laboratory and facilitates in-house manufacturing and testing of robotic systems.

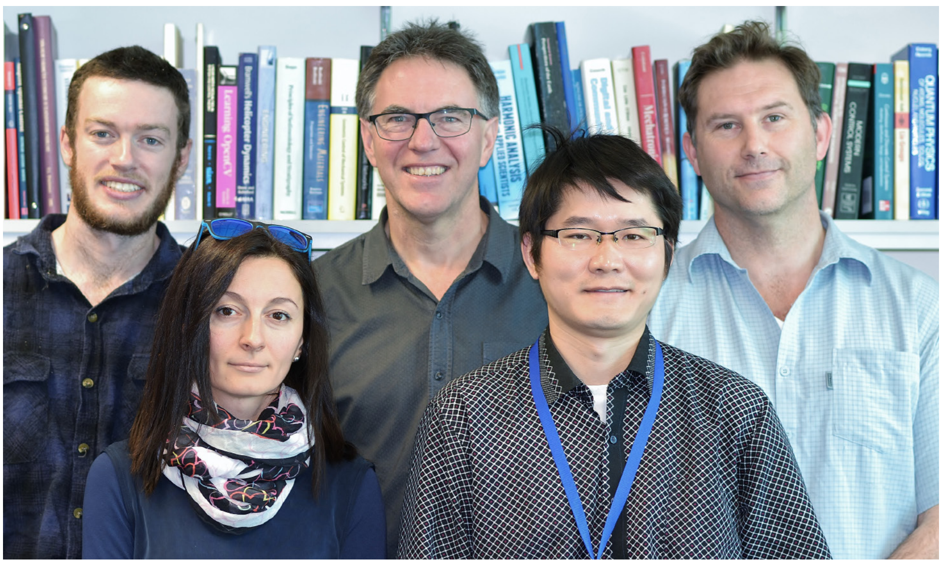

Figure 3: ACRV Team photo (Left-to-right: Gerard Kennedy, Viorela Ila, Rob Mahony, Tao Hu, Alex Martin)

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[3]MarketsandMarkets Report (2017). Agricultural robots by market type, offering, application and geography – global forecast to 2022 (205 pp.).

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