



Grower Summary

HNS PO 194

GROWBOT: A Grower-
Reprogrammable Robot for
Ornamental Plant Production
Tasks.

Annual 2017

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AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

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Project leader: Aran Sena, King's College London

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Previous report: -

Key staff: Academic Supervisor (1st): Dr. Matthew J. Howard
Academic Supervisor (2nd): Dr. Elizabeth Sklar
AHDB Research Manager: Dr. Jim Dimmock

Location of project: King's College London

Industry Representative: Bruce Harnett (Kernock Park Plants), Jamie Dewhurst (J&A Growers) and Mike Mann (Winchester Growers).

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(or expected completion date):

GROWER SUMMARY

Headline

Horticulture businesses face a significant labour security issue; however businesses which currently rely on manual labour struggle to achieve a high-level of automation due to the dexterity skills required. Advances in robot programming by demonstration may help provide a flexible automation solution which can be put directly into growers' hands.

Background

Horticulture, as an industry, faces significant labour challenges. These challenges are present both in the near term, with the current uncertain political climate, and in the long term, with a general downward trend of people entering the industry^{1, 2}.

GROWBOT is attempting to address these labour challenges by reducing the dependency on human labour for horticultural businesses, through robotic automation. In addition to the business-focused reasons for pursuing robotic automation, many tasks in horticultural production are physically demanding and often in difficult environmental conditions. By developing automation systems which can be deployed directly by the grower, when and where it is required, this technology offers benefits to both workers and businesses.

Summary

Labour security represents a significant risk to the long-term success of the U.K. horticultural industry, between reduced levels of people entering the industry and a heavy dependence on a migratory workforce. These long-term risks have been further highlighted by the current political uncertainty.

Robotics presents horticulture with many possible solutions to these labour issues; however horticulture presents Robotics many significant challenges. Robots are used extensively in conventional settings, such as in the automotive industry, due to their speed, accuracy and strength; however taking advantage of these traits requires the workspace of the robot being highly controlled (i.e. the positions and locations of all objects around the robot are known to high degree of accuracy). This level workspace control, or *structure*, is not possible in horticulture, as the robot must interact with organic material.

Organic material presents many uncertainties. The same varieties of a plant will all have different geometries, and plant material is flexible, making grasping the plant an uncertain

¹ <https://www.theguardian.com/society/2015/jul/01/sue-biggs-rhs-horticultural-timebomb>

² <https://www.rhs.org.uk/education-learning/careers-horticulture/horticulture-matters/>

process for the robot. Additionally, plant material is fragile, limiting how the robot can interact with it. These properties result in a highly challenging grasping task for the robot. This is arguably a more challenging task than that presented by the Amazon Picking Challenge³, seen by many as a benchmark in industrial grasping, where participating teams had to use a robot to pick items from a bin and place them into a basket order with objects ranging from defined shapes, such as boxes of cereal, to flexible objects, such as sponges or gloves.

To date, agricultural robotics research addressing handling has focused on the handling of relatively well-defined fruits and vegetables, such as sweet peppers or strawberries. Autonomous harvesting of fruit and vegetable crop is supported by two features, (i) readily defined and identified features (e.g. red ripe strawberries, or bright waxy surface of peppers which are clearly visible under a bright light against a leafy background, (ii) structured growing environments. For point (i) in horticulture, the plant varieties being grown will often have obstacles in the way of grasping points, and for point (ii), unlike peppers or strawberries which can be grown in configurations easier for grasping (e.g. on a trellis structure), ornamental flowers must be grown in aesthetically natural formations. GROWBOT seeks to push robotics capabilities further toward directly handling plant material for horticulture.

Given that much of the growing which takes place in the U.K. is carried out by small and medium enterprises (SMEs), and focused on providing high-quality variety in small batches, traditional automation often cannot address their needs due to cost and flexibility issues. These challenges result in growers needing large teams of people to keep up with demand as they will often lack the volume and associated production data to justify the deployment of expensive traditional automation systems, or even the technical means to do so.

Collaborative robots (a.k.a. *cobots*) offer a possible solution to the rising need for automation; however the challenges of handling plant material, and having these systems deployable by non-experts, currently limits the extent to which cobots can help. GROWBOT aims to address these challenges by developing robotic systems which could be used directly by non-experts for horticultural tasks, so that growers can be empowered to use their horticultural knowledge more easily and reduce the amount of repetitive labour-intensive tasks that must now be done by hand.

When considering the research direction for this project, I first spent a few weeks visiting my project industry advisers around the U.K. to help get a better grasp of what horticultural tasks are currently being done, and how the people working there do them. I visited J&A Growers in Coventry, producers of young tree stalks for forestry and landscaping companies, and

³ <https://www.amazonrobotics.com/#/roboticschallenge>

Kernock Park Plants, producers of a wide variety (3000+) of plants and flowers for commercial businesses.

These visits highlighted both the task diversity present in the horticulture industry, and the challenges faced by businesses in implementing further automation. A common challenge observed in both growing sites preventing wider use of automation was that the actual handling of plant material required complex dexterous handling, as seen in the grading processes shown in Fig. 1.



Figure 1: Examples of manual handling tasks during grading in hardy nursery stock (left) and protected ornamentals (right).

In both sites, the production managers were content with the current performance of their workers; however they saw the value in advancing automation for their companies in the future and for the industry in general. Top motivators for furthering automation included wanting to help their employees make better use of their time by automating the more repetitive "simple" tasks (that still require a great deal of dexterous skill from a robotics point of view), and more fundamental concerns over the long-term success of their company and industry due to the previously mentioned labour security issue.

Given the objective of developing robot systems which can be readily deployed for a variety of tasks in the horticulture industry, a primary direction for my research lies in human-robot skill transfer when the user of the robot system is not a robotics expert, i.e. a non-expert. Understanding and improving how non-expert users interact with and respond to adaptive learning systems is critical for GROWBOT, as the performance of an adaptive learning system is dependent on the data it is provided - if the data is provided by the non-expert user, the quality of teaching provided by the user is therefore a critical factor.



Figure 2: Rethink Robotics Sawyer
Robot with AR10 Hand

The first stage of research in addressing the challenge set by GROWBOT has focused on improving the communication between robot systems and human teachers, to help non-experts better understand the learning process of a robot.

Moving forward, it is hoped that the techniques developed in this first stage of research will help the robot use the insight of a human teacher for more complicated tasks. While it may be difficult to explicitly program how to interact with plant material (even for a robotics expert), it is hoped that by combining machine learning with the adaptive problem solving of a human teacher the robot will be able to learn effective control policies for plant handling.

This next stage of research will be carried out with a current generation collaborative robot; a Rethink Robotics Sawyer robot as shown in Fig. 2, along with an Active Robotics AR10 manipulator. It is intended that by using current generation industrial equipment and manipulators, this research will take direct steps towards transferring the technology developed in GROWBOT to industry at the end of the project.

Financial Benefits

As the project is still in early stages, it is difficult to provide exact figures. To help understand the *potential* financial benefits of robotic automation, a basic cost analysis is provided in the table below.

N.B. All numbers provided here are rough estimates based on currently available data - no guarantees are given. Actual costs and return on investment may differ. In-depth process analysis is required to determine viability of automation, and the real-world potential savings that automation can offer for your business.

Assumptions:

1. Salary numbers used here are assumed based on current government information⁴.
2. The working week for an agricultural labourer is ~40 hours.
3. Robot cost based on estimate of £30,000 for a collaborative robot plus £10,000 for accessories (grippers, sensors, etc.)⁵. Operational life of robot based on total lifetime of 35,000 hours for Rethink Robotics Sawyer robot⁶.

	Human	Robot 40 hrs/wk	Robot 24/7	Robot 60% utilisation
Hours /week	40	40	168	100
Weeks /year	46.4	52	52	52
Cost	-	£40,000	£40,000	£40,000
Cost /hour	£7.66 ⁷	£19.23	£4.58	£7.69
Cost /year	~£14,217 ⁸	-	-	-
Operational Life	-	~16.8 years	~4 years	~6.7 years

While this shows in numbers why you might want to use a robot, the main question that remains is ‘*what is the return on investment*’. This can be difficult to estimate, and depends on the processes being automated. Taking a naïve view, if we compare the £40,000 fixed cost of the robot against the recurring £14,217 cost of the human labourer, this represents a ~2.8 year break-even period; however this is not a truly informative view on the financial benefit of robotic automation.

As the robot represents a fixed asset investment, key factors for estimating the benefit of automation are what *rate, r*, it can perform a task compared to a human, and the *utilisation, u*, per day/week compared to the human (i.e. for a human labourer we assume 40 hours per week in the above table). Looking purely at the financial benefits, ideally:

$$r_{human} * u_{human} \leq r_{robot} * u_{robot}$$

In this case, a robot might work at a slower rate compared to the human worker, but it can perform for longer duration, consistently.

In addition to potential financial benefits, additional benefits to robotic automation include: consistent performance (addressing quality issues relating to worker fatigue), eliminating lengthy training cycles (addressing issues in getting a new human labourer ‘up to speed’),

⁴ <https://www.gov.uk/agricultural-workers-rights/pay-and-overtime>

⁵ <http://blog.robotiq.com/what-is-the-price-of-collaborative-robots>

⁶ <http://www.rethinkrobotics.com/news-item/rethink-robotics-sawyer-robot-set-for-global-deployment/>

⁷ Assuming Agricultural Minimum Wage (Grade 3, Hourly): £7.66

⁸ This doesn’t account for overtime, night work, or tied-accommodation.

availability (i.e. replacing a robot at the end of its life, or in the event of a breakdown, or if you must purchase additional robots to expand capacity), and allowing growers to redeploy human labourers to more value-adding work.

Ultimately, it does not make sense to try consider return on investment unless the automation is actually *capable* of performing the required tasks. Current industrial systems generally lack the capabilities required for horticultural automation involving direct plant handling, where there is low volume and high variety. GROWBOT is therefore primarily focused on addressing this capability issue, to (hopefully soon) make the decision of whether to automate or not easier for growers.

Action Points

Given the early stage of this research, there are no explicit action points.

From observations made during industry site visits, it can be seen that there are often processes which are possible to automate using current technology; however a lack of awareness can result in missed automation opportunities. It is worthwhile to review currently available automation options, such as collaborative robots, and to consider what processes are currently labour intensive that could be adapted to better suit automation.

