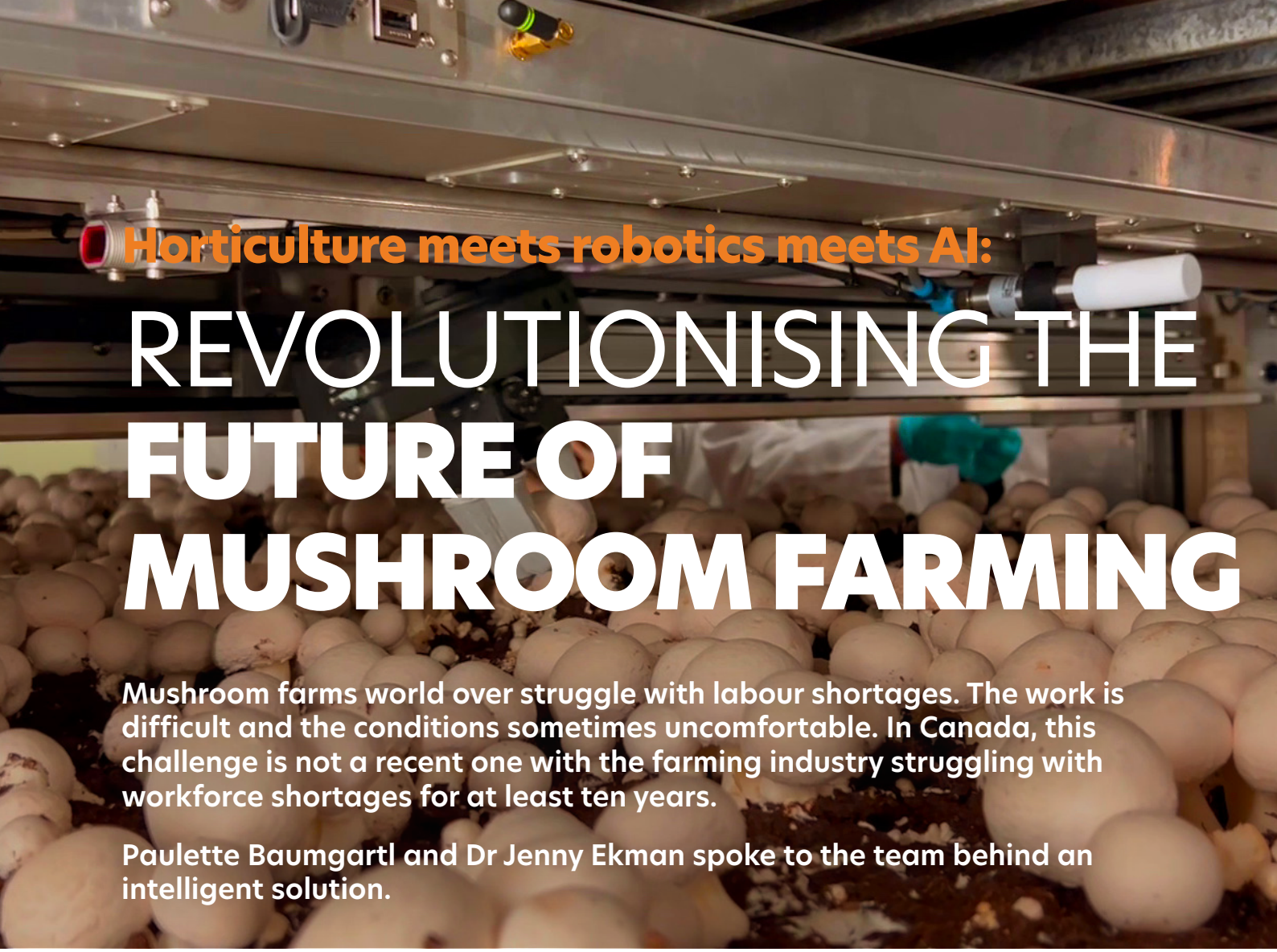


Horticulture meets robotics meets AI:

REVOLUTIONISING THE FUTURE OF MUSHROOM FARMING

Mushroom farms world over struggle with labour shortages. The work is difficult and the conditions sometimes uncomfortable. In Canada, this challenge is not a recent one with the farming industry struggling with workforce shortages for at least ten years.

Paulette Baumgartl and Dr Jenny Ekman spoke to the team behind an intelligent solution.

Thanks to the revolutionary advances in technology, automation has emerged as a very real and viable solution. Canadian grower Murray Good took his frustrations to the University of Western Ontario in 2012. Two research theses and a decade of hard work later, Mycioncs Inc has emerged as a fresh mushroom picking and packing system that combines mechanical engineering, robotics, and mushroom picking know-how with artificial intelligence.

Mycionics Inc began as the research thesis of Master's student Stefan Glibetic, who now serves as the Chief Technology Officer. Stefan, a mechatronics engineer, oversees the ongoing technology integrations, ensuring it meets the ever-changing needs of the mushroom industry. Importantly, the ongoing development has all occurred 'on farm', so the materials, processes and machinery are 'growing room proof'.

Stefan and his team designed the system from scratch, overcoming significant challenges, including harvesting in narrow spaces, and integrating high tech robotics into dark, damp, dirty spaces.

Taking the regular 'critical' feedback from farmers on board, each element has been tried, tested and improved over many years. According to the company, the result is robotic system than can run for extended periods and achieve impressive pick rates.

For Stefan the R&D journey continues as he refines software and AI capabilities for next generation systems.

The Mycionics system has been successfully trialed in a number of mushroom farms in Ontario, where it combines several machines on a growing stack to scan, pick, and pack the mushrooms. The system follows a graze harvest approach designed to overcome challenges associated with robotic picking, such as overcrowded beds and bruising during harvest.

One of the key advantages is its ability to integrate artificial intelligence (AI) and machine learning into the automation process. The system uses data from sensors and cameras to learn from its environment and make real-time decisions to optimise harvesting. This allows

The complete system with harvester, packer and lift - Mycionics

The robotic arm with the picking finger - Mycionics

the system to identify which mushrooms are ready for picking and which ones should be left to mature.

So, how does it work and what do the numbers say? MushroomLink sat down for a chat with CTO Stefan Glibetic and CEO Michael Curry to learn more and explore the opportunities and implications for Australian growers.

ML: What does the system consist of exactly?

MY: Each system consists of three separate machines, the harvester, the packer, and the lift. Together, they act as a mushroom scanner, picker, packer and importantly, a 'decision maker'. The harvester's scanner scans the beds and collects data on the microclimate, mushroom size and location. The harvester's gripper fingers pick the mushrooms, and the packer trims and packs them into boxes or tills

The harvester is battery operated (avoids cords running over the beds) with a running time of 16-18 hours on a single charge. The system can collectively determine which harvester needs a re-charge, and for how long to ensure units are picking continuously. The other machines are hard wired.

The system fits onto Dutch aluminium beds, the standard found in most Canadian mushroom farms.

ML: Can you tell us more about the harvester's gripper fingers? It looks like it has a fair amount of dexterity for a robot, and a light touch.

MY: The finger is a bit of a game-changer for our system. We have designed it to have multiple forms of motion to mimic a human picker, including push, pull, pivot and twist, depending on the mushroom and how it sits in the bed (for example, if it is part of a cluster, or stand-alone). The harvester uses the scanned data to intelligently decide which gripper action is best and will be most gentle to the cap. At all times, touching the top of the cap is avoided.

The materials used are part of our intellectual property, but suffice to say they have been extensively tested for suitability and we are pretty proud of the end product.

ML: Okay, so the million-dollar question is how does the harvester's gripper cope with the first flush beds, when all mushrooms are clumped together? This is what has defeated previous attempts at robotic harvesting.

MY: Firstly, we try to understand why the first flush emerged in such dense clusters and optimise operations accordingly. Is the problem with pin set? Are the harvesters too late? Or is there an issue with the compost.

Additionally, as our harvesters can work 24/7, they operate a system of graze harvesting, i.e., they can

A box of robotically picked and packed mushrooms - Mycionics

spend more time on the beds, conducting multiple passes - an approach that would be expensive with a human work force.

Essentially the harvester thins out the first flush before clustering becomes problematic. Using multiple harvesters, the system can divide and conquer the bed intelligently and stay on top of the mushrooms. This way we achieve better stagger, reduce impact of tight clustering, and increase yield and quality.

ML: Once the mushroom is trimmed, it's then dropped into the punnet or box. Is cap up an option?

MY: The packer is designed to fill three different packing vessels: punnets, multi crates, and cardboard boxes.

Using intelligent algorithms and filling strategies, punnets, for example, are evenly filled, with the top layer ideally cap up. To achieve this, boxes are filled from the bottom up in such a way as to increase the chances of the top layer staying cap side up. With this method of harvesting, the mushroom cap is only touched once on the underside. The top of the cap is not touched at all. Our tests have shown that even after one week in a cooler (for both white and brown mushrooms), no bruising has occurred, a measure that exceeds quality outcomes of human harvesters.

ML: How does the packer know when it's reached the top layer?

MY: Using data from the harvester's scanner, the packer knows the weight and size of each mushroom as well as the weight it needs to fill in each punnet. Logically, the systems also know which mushrooms have not been picked, and so can intelligently decide which mushroom to put next in the punnet (or box) to minimise overfill percentage. Currently we are achieving 1% overfill compared to 3-5% industry standard, but admittedly we've been only focusing on creminis (Swiss Browns).

ML: How quickly can this machine pick mushrooms?

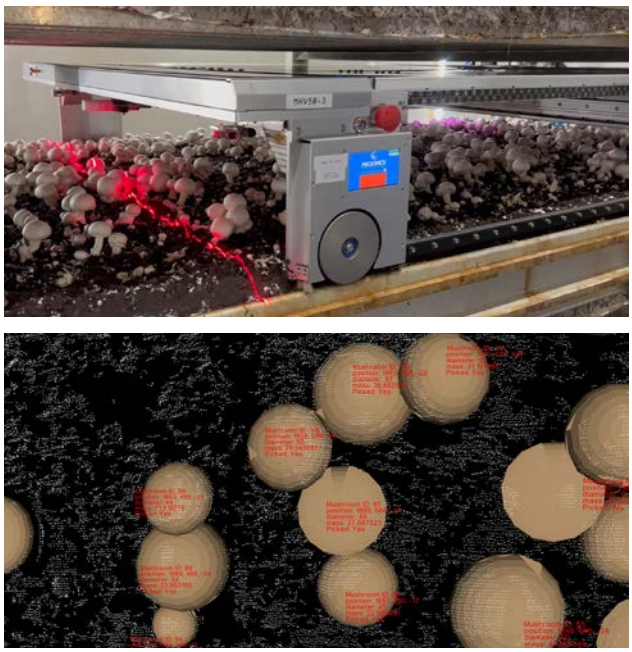
MY: This is an interesting and complicated question. As the system is modular, up to four systems can harvest in parallel, acting as a 'team'. Essentially this mimics human harvesters, where you have a few people. Four systems can operate across seven vertical beds of any length.

Depending on the number of systems, harvest ranges from 350-1500kg/day of average size of mushrooms of 25-75mm in diameter.

ML: Can you tell us more about the harvester's scanner and the data it produces?

MY: The harvester's vision system is a custom-built 3D scanner and is considered the 'brains' of the system. It scans 750m^2 per hour, which equates to around 30 minutes for a bed, which is sufficient to match the growing rate of mushrooms.

As well as data on the mushrooms themselves, the scanner also logs climate information including CO_2 concentration, relative humidity, temperature, and pressure. Air flow to come soon.



Top, the harvester's scanning unit; bottom, visualisation of the mushroom bed - Mycionics

The harvesters report to a central server, systems are initialised, and picking begins. Once the machines are attached to the bed, they intelligently decide what to next pick based on the information they have. If they don't have enough information, they scan the bed again before they start.

ML: How relevant is all the extra data that is being collected? For example, the climate data?

MY: Currently growers only collect data from a few points in the room, which doesn't give an accurate picture of what is happening on the beds. The harvester's scanner gives feedback on the entire surface area. This detailed picture gives growers the opportunity to react and respond to various problems like CO_2 pocketing; growers can adjust air flows and ventilation in the room accordingly.

While many growers have the intuition, they rarely had the opportunity to observe the internal climatic factors in real time. With this system they can make informed decisions and optimise room and bed management based on real data.

We have also created a model which uses historical micro-climate data (last 5 hrs) to predict (next 5 hours) future growth, which can be a powerful planning tool.

Down the track we have a few extra ideas, for example adding robotic irrigators to the system, so when a dry spot is detected, the right amount of water can be added exactly where and when it is needed.

Digital representation of the seven mushroom beds, with a top-down view of the level 1 - Mycionics

ML: Are human workers part of the equation at all?

Yes, our systems require one runner to attach systems to the beds. The systems are mobile and can be moved from bed to bed or room to room in minutes. The primary job of a runner is to unload and load the packer. On average, one person can operate eight systems spread across several beds or rooms.

ML: When will Australian farmers have access to the Mycionics system?

To lower the entry barrier into robotics, we offer a picking service, whereby Mycionics is compensated for every kilo harvested that meets market standards. In essence, we become part of the farm's workforce (our picking service is comparable to the cost of human labour).

This business model means that farms can try before they buy, without any large upfront investments, allowing any size farm the opportunity to embrace the technology. And as we earn per successful kilogram, we are invested in making sure it works.

We do envisage selling our systems down the track, including in Australia. Currently we have plenty of work to do here in Canada. However, with the right partner, we could also imagine bringing our picking service down under.

Canadian mushroom industry:

- CAD $1 billion industry (AUD $1.1b)
- 100 farms, main company Highline Mushrooms grows over 50% of mushrooms
- Dominant mushroom is *Agaricus*, however speciality mushrooms are the fastest growing
- Most retail mushrooms are sold in punnets, wholesale in cardboard boxes
- Multilevel aluminium shelves are the standard growing infrastructure in Canadian growing rooms

Watch the Mycionics Harvesters in Action Here

MYCIONICS
INTELLIGENT HARVESTING SOLUTIONS

For more information: www.mycionics.com