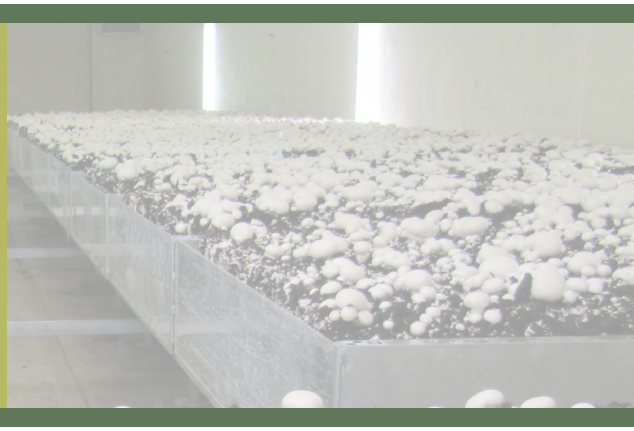
amr
Advanced Mushroom Research

# AMR Smart Harvest™

THE innovation in mushroom farming



## Increasing production and product quality using AMR Smart Harvest

## Production and quality improvement using AMR Smart Harvest

### What is AMR Smart Harvest?

Smart Harvest consists of multiple hardware and software modules that together significantly improve the process of harvesting mushrooms in several ways.

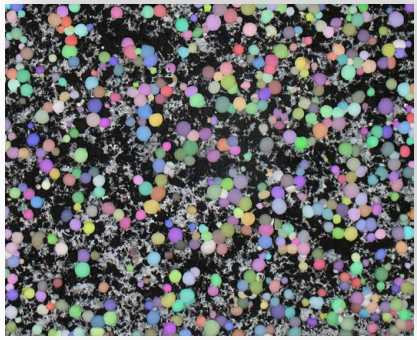
Central to the system is the visual analysis module in which mushrooms are captured with a high-resolution camera on the mushroom bed. In these images, mushrooms are found, measured and the texture and colour are assessed. By comparing current and previous images, the growth of each mushroom can be modelled precisely.

This analysis makes it possible to provide quantitative and qualitative information on the mushrooms currently in the harvest cycle, but Smart Harvest goes further than that. A picking advice -based on a massive number of calculations and optionally adjusted by an expert- can be projected directly on the bed. In addition, the entire harvest cycle can be planned and optimized by the system, making optimal use of available capacity and avoiding mushrooms getting picked too late or too early. All this results in a highly optimized harvest yield.

## Modules of Smart Harvest

### Visual analysis

Using proprietary algorithms developed by AMR, in which smart, self-learning techniques are used [1], it is possible to detect and model hundreds of mushrooms in a container within a few seconds. The colour and bulging of the mushrooms are part of this analysis as well.



Detection of mushrooms

### Picking advice

Using the values obtained by the visual analysis, the system then calculates dozens of secondary features for each mushroom which influence whether/when a certain mushroom should be picked. Think of the number of neighbours / contacts that a mushroom has, the number of mushrooms in a certain radius, or the average growth rate of the mushroom over the last few hours. A smart expert system [2] can, based on this information, provide the optimal picking strategy at any given moment.

### Projection of picking advice and sorting

Using a projector, the picking advice is projected directly onto the bed, where mushrooms to pick are for example coloured red.

Mushrooms can also be sorted based on qualitative characteristics such as diameter, weight, shape or colour. The various types can be given a different colour during the projection.

Projection of picking advice

### Growth prediction and management of the entire harvesting process

The decision to pick or leave behind a mushroom at a certain moment greatly depends on when the next harvest opportunity is. The decision also influences the growth and optimal picking moment of many of the remaining mushrooms in the container.

Smart Harvest uses historical data to accurately predict the weight, diameter and quality of a mushroom at any point in the future and can anticipate the influence of neighbouring mushrooms getting picked.

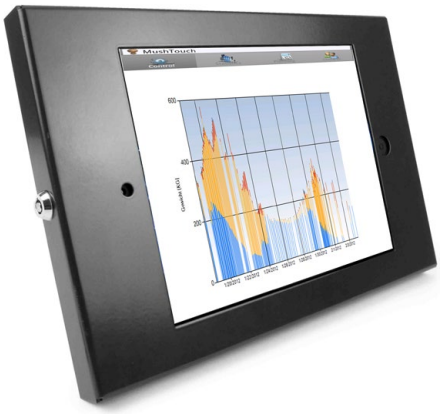
Smart Harvest is able to model the entire harvest cycle, including the physical infrastructure, which means that the system knows exactly when each container will arrive at the picking station and may even be used to control the velocity of containers in the mobile harvest system and to sort containers in different lanes in order to influence the picking moment. With these two features and a complex planning and optimization algorithm [3], Smart Harvest maximizes the yield and product quality of the entire harvest.

## User interaction - Providing harvest data insights

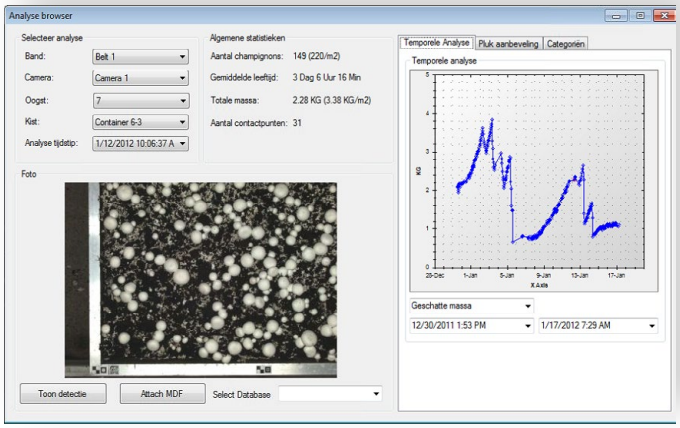
Smart Harvest provides several ways of viewing the harvest results and controlling the system. On a touch screen / tablet, the main results can be seen and the main components can be controlled.

A desktop (Windows) application provides access to more extensive analysis results, such as comparisons of multiple harvests or different containers. Using the desktop application the user can inspect the results for an individual container or even an individual mushroom.

Finally, all main statistics can be accessed through a website from a remote location or on a mobile device.



Harvest yield and system operation on a touch screen device




Detailed analysis using a desktop application

## Additional components

A number of optional modules may be linked to the Smart Harvest system to make it even more powerful. Pickers can check in and out using an RFID system linked to the touch screen interface and picker availability for the next few days can be entered.

The Smart Harvest system can also be connected to most climate control and measurement systems. This way the influence of climate variations on the growth of mushrooms can be displayed immediately and, for instance, a watering system can be operated automatically.

## What are the benefits?

Together, the different modules of the Smart Harvest will lead to:

- Increased production: more kilograms per square meter through picking recommendations and harvest cycle management.
- Better picking performance: more pieces and pounds per minute thanks to a more uniform distribution of mushrooms and speed control of the container at the picking station, giving pickers a constant, manageable load.
- Increased product quality: mushrooms will be picked before they become deformed by contact with neighbours and before they start to discolour.
- Better insights: detailed charts and statistics show the user what is happening in the current harvest cycle and allows the user to easily compare the effectiveness of different strategies or source products.

## Who can benefit from Smart Harvest?

Currently, Smart Harvest is only suitable for growers using a mobile harvest system and partially for growers who cultivate on a single layer. In traditional cultivation on multiple layers or in natural settings it is not possible to move a camera system over the mushroom beds. We believe that the future lies with mobile cultivation and will happily advise and guide you in the implementation process so that your company can also benefit from using AMR Smart Harvest.

Additionally, AMR offers consultancy services to growers and other organizations who wish to use the analysis capabilities of Smart Harvest to answer specific questions such as “How does the growth of strand X compare to strand Y?” or “How does the air humidity level affect the growth and mushroom count?”. Our consultancy services include the use of a mobile harvest system in a climate controlled room and of course a fully optimized Smart Harvest setup.

## Packaging robot

AMR has collaborated with ROBA Engineering to develop a packaging robot which combines perfectly with the Smart Harvest system. Mushrooms are manually picked and placed on a conveyor belt, where picture are taken of each mushroom from multiple angles. From this the 3D shape and the texture of the mushroom are derived, after which the weight and quality can be accurately estimated. A robotic arm with a double gripper then gently picks up the mushrooms and fills different types of boxes, exactly up to the desired weight. Low quality mushrooms can be discharged automatically. Finally, all results are fed back to the Smart Harvest, where they are made accessible.

## More information

For more information about Smart Harvest please contact:

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Footnotes:

1. The algorithms used include artificial neural networks (http://en.wikipedia.org/wiki/Artificial_neural_network) and a proprietary variation on active shape models (http://en.wikipedia.org/wiki/Active_shape_model).
2. The basis of the expert system is a Fuzzy Inference System (http://en.wikipedia.org/wiki/Fuzzy_control_system). By defining so called ‘fuzzy rules’, it becomes possible to tell Smart Harvest that ‘bigger’, ‘yellowish’ mushrooms, or mushrooms with ‘many’ neighbours should get a higher picking score, without the need to define exactly what ‘big’, ‘yellow’ or ‘many’ means.
3. The planning and optimization algorithm consists of proprietary techniques. Smart Harvest continuously updates the overall harvest strategy by analysing millions of different scenarios based on the latest available measurements and pre-set expert knowledge.