

3rd International Autonomous Greenhouse Challenge

Full autonomous control of a greenhouse lettuce production

Criteria, rules & regulations

Part 2: Hackathon and Greenhouse Challenge

Version: 15 June 2021

Introduction

In this document we share criteria, rules and regulations for teams who want to participate in the 3rd 'International Autonomous Greenhouses Challenge', organised by WUR and sponsored by Tencent. We invite multidisciplinary teams to fully autonomously grow a hydroponic lettuce crop in one of WUR's high-tech greenhouses. We invite teams to bring in their crop and AI expertise and passion and join the Challenge.

This document describes the rules of part 2 of the challenge, the Hackathon and Greenhouse Challenge. Part 1 consists of an Online Challenge. It is not compulsory to participate in part 1 for participating in part 2.

All information can be found at www.autonomousgreenhouses.com.

Eligibility of teams

- The Challenge is open to students and researchers from universities and research centres, experts from start-ups and companies.
- Teams are multi-disciplinary, combining the following expertise: 1. artificial intelligence/sensors technology 2. "green thumb"/crop physiology/crop management/horticulture production. This expertise has to be demonstrated by professional or academic engagement.
- Teams have at least 3 individual members. Individual members are members of the team and subscribe to and participate in the Challenge.
- At least one team member must be a student.
- Each team will appoint a team-captain who acts as contact person between the team and the WUR Challenge contact person.
- We encourage teams from different countries and continents to participate. We encourage cooperation of different experts from different start-ups and companies.
- Good English language skills are required.

Registration

- To register, teams are required to submit the completed registration form available on the website from 15 July 2021 onwards.
- The submission must include:
 - detailed information on all individual team members;
 - description of motivation of the team, methodology and planned A.I. approach ("*extended abstract*", to be filled in directly in the registration form);
 - a short smartphone video of the team. It must be sent to us via a transfer link which must be put in the registration form.
- The team should meet all eligibility criteria (stated above).
- The registration form can be found on www.autonomousgreenhouses.com and must be filled in completely. Follow the instructions on the website in order to submit it.
- The registration form must be completed and submitted before **1 September 2021 23:00 h GMT**.

Confirmation of participation and participation process

- A maximum number of **20 teams** will be admitted to the pre-Challenge Hackathon. The selection is made based on:

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1. Eligibility criteria (stated above). A team must meet all eligibility criteria.
 2. Team composition (An independent jury helps the organisers to select based on variety on expertise/skills, companies/start-ups/organisations, variety on nationalities, variety in gender).
 3. Extended abstract (An independent jury helps the organisers to select on motivation, methodology and planned A.I. approach).
- WUR will inform all duly registered teams whether they are eligible and have been admitted to the Challenge on **1 September 2021**. The organisers' and jury's decision will be final and will not be subject to debate.
 - WUR retains the right to consider registrations after 1 September until 1 October 2021, if a minimum number of five teams has not been reached.
 - All admitted teams need to participate in the Hackathon at WUR on **4-5 November 2021**. During the Hackathon the teams have to show their skills and present their approach in front of a jury. The five best teams will be selected.
 - A maximum of five teams will be admitted to the Growing Challenge, the fully autonomous hydroponic lettuce production experiment, taking place from February to June 2022. During the main Growing Challenge the teams have to fulfil a predefined task for fully autonomously growing a hydroponic lettuce. The team performing best according to predefined criteria (see hereafter) will win the Challenge.
 - Due to the size and complexity of the competition, teams should consider that funds for travel and a substantial amount of time as well as dedication are required. Following the experience of the previous edition, an estimation of the dedicated time is given: 2 months for preparation of A.I. algorithms and strategy before the first crop cycle plus 1 months for data analysis and preparation before the second crop cycle plus time for communication. Thus, by entering the competition the teams acknowledge the above and commit to adequately preparing for the competition and conducting the greenhouse experiment for its entire duration.
 - A Final Event will be organised in **July 2022** at which the teams look back and share their experience and at which the winning team will be announced by an international jury of experts.

Hackathon

- On **4-5 November 2021**, a Hackathon will take place (hopefully physically) at WUR, Bleiswijk, The Netherlands.
- For the pre-Challenge Hackathon a maximum number of 20 teams will be allowed to take part (for organizational reasons).
- Due to the current COVID-19 situation it might be necessary to choose for a different organizational form in case of remaining restrictions. If there are more subscriptions or if we have to deal with restrictions due to COVID-19, a pre-selection will be made by the jury based on information provided by the teams during their subscription and/or a different organizational set-up will be chosen. We might need to choose for a hybrid event, partly physically, partly online. Teams will be judged based on, for example: team composition + curriculum + video of the teams + fixed amount of teams/country allowed (according to a proportional factor) + sketch of their A.I. approach. The exact form of the Hackathon will be announced prior to the event.
- Participation in the Hackathon is mandatory prior to further participation in the Greenhouse Growing Experiment.
- All admitted teams need to participate. At least the team leader has to be present on location, unless we have to deal with restrictions due to COVID-19.
- During the Hackathon, teams will grow a virtual lettuce crop in a virtual greenhouse environment. They will need to reach a pre-defined goal. Teams can earn points based on pre-defined criteria.
- WUR will provide a combined virtual greenhouse climate and crop simulation model for lettuce production in order to fulfil the task of the Hackathon. The simulator used in the Hackathon will be more refined than the one used in the Online Challenge. By using the model, teams can learn how to grow a lettuce crop and how to control the greenhouse climate. The control strategy should result in a pre-defined goal (e.g. maximum crop yield, minimum resource use, maximum net profit). Teams will be able to use their own algorithms to decide on the optimum production strategy.
- Information in order to prepare the Hackathon will be sent to all eligible teams ca. 4-6 weeks before the pre-Challenge Hackathon event. The goal and detailed rules of the pre-Challenge will be provided to the teams on the day of the Hackathon in order to give all teams the same information at the same time.
- The virtual greenhouse-crop simulation model will be opened before the Hackathon event. This will allow the teams to implement their own algorithms and deal with any practical issues in advance. More detailed information will be provided to the teams.
- An international jury, consisting of experts from science and industry in both fields, greenhouse horticulture and artificial intelligence, will judge the teams' performance during the Hackathon. The composition of the jury is announced via the Challenge website.
- Additionally, the teams will have to motivate and explain their strategy and planned approach for the main Challenge in front of the jury. Each team will give individually a short presentation (ca. 10 min.) in front of the jury.
- Teams can get points for:
 - Obtained results/reaching the goal in the pre-Challenge Hackathon (60%)
 - Strategy and A.I. approach (40%)

- Strategy and A.I. approach will contain the following elements of judgement:
 - Novelty with respect to overall scientific community, application on horticultural domain (**novelty**)
 - Capacity to operate without manual interventions, thus fully autonomously (**functionality**)
 - Capacity to operate with only the standard sensors applied in lettuce greenhouses (temperature, humidity, light, CO₂, water supply and camera images) (**robustness**)
 - Easiness of implementation on large scale (**scalability**)
- The five best teams will be selected. The jury's decision will be final and will not be subject to debate.

A wild-card for teams from previous edition "2nd Autonomous Greenhouse Challenge" in Hackathon of "3rd Autonomous Greenhouse Challenge"

- The teams' experience and outcomes obtained during the growing experiment of the previous edition of the 2nd Autonomous Greenhouse Challenge are a valuable contribution to the combined field of AI and greenhouse horticulture.
- The aim of the *wild-card* is to give a follow up to the gained knowledge and experience by encouraging teams that participated in the 2nd Challenge to join the competition and challenge themselves again.
- The jury will have *one wild-card* available to give to that 2nd-edition team which is best performing in the this-edition Hackathon among all participating last-edition teams. The wild-card can be used by the jury in case 2nd-edition teams subscribe but none of them qualifies in the Hackathon.
- If one or more 2nd-edition teams qualify in the Hackathon the wild-card will not be used.
- The total number of teams selected for the Growing Challenge is five, whether or not the wild-card is used.
- As 2nd-edition teams we define a team who has participated in the previous greenhouse growing experiment and in which at least 50% of the members of the previous edition are participating again.

Growing Challenge, fully autonomous hydroponic lettuce production

- The main Growing Challenge, fully autonomous hydroponic lettuce production, will take place in two growth cycles between 1 February and 30 June 2022.
- A maximum of **five teams** will be admitted participating. The selection is done during the Hackathon.
- The goal of the Growing Challenge is to produce a fully autonomous hydroponic lettuce crop within 6-8 weeks with a maximum net profit.
- For that, selected teams will have to develop a fully autonomous algorithm and submit it to the organizers before the start of the experiment in order to control a hydroponic lettuce crop in their own assigned greenhouse compartment.
- Each team will be responsible for one greenhouse compartment. Each team has only access to their own algorithm and to the detailed data of their own compartment.
- The greenhouse compartments are located at WUR, Violierenweg 1, 2665 MV Bleiswijk, The Netherlands. All compartments have the same size and equipment.
- The greenhouse compartments are designated to the teams in a random manner.
- All greenhouse compartments are equipped with actuators to control inside growing conditions. The actuators are: ventilation windows, heating systems, screening system, artificial lighting, fogging, hydroponic growing gutters with irrigation with a team-defined nutrient mixture, and CO₂ dosing. All compartments are equipped with sensors to control the actuators through a standard greenhouse climate computer, also available on site. Main sensors are to measure: temperature, humidity, CO₂, PAR light, pH, EC, amount of irrigation and energy consumption. The teams will be fully responsible for own crop observation during the growth cycle, and data will be provided via a Intel [RealSense](#) camera system and a [Sigrow Stomata](#) camera system. All data measured and all control actions taken are available through a digital data interface for each team and must automatically interact with the submitted algorithm. Final harvest data (e.g., fresh weight, crop height and diameter) will be measured by WUR and made available to the teams.
- Each team will be allowed to install their own additional sensors and cameras to monitor additional climate, irrigation and crop parameters in order to get additional information if they think this would improve their performance. Before the start of the first crop cycle, teams will get physical access to their own greenhouse compartment in order to install their additional sensors (if any), to test the connection and to test the principle functioning of their algorithms.
- Teams will grow two cycles of a hydroponic lettuce crop during two periods of 6-8 weeks in a designated greenhouse compartment. The first crop cycle will be for training purposes, the second crop cycle will count for the Growing Challenge. The best performing team in terms of net profit during the second crop cycle will win the Challenge.
- Each team needs to develop and submit their own algorithms and submit it to the organizers before the start of the first crop cycle of the Growing Challenge experiment.
- The teams will receive a training dataset/s of a lettuce production under different growing conditions in the same

greenhouse compartments before the start of the experiment (well in advance), which they might use to train their algorithms. The teams will get access to the parameterised virtual greenhouse climate and crop growth model (simulator) of WUR to obtain artificial training data if desired. Further information will be provided at a later stage.

- Teams will implement their algorithm interacting with the digital data interface and perform initial tests 2 weeks before the start of the experiment. Team will submit the algorithm to the WUR organizers (e.g. as executable), the algorithm takes the control of their greenhouse compartment from the day 1 of growing experiment (= transplanting date). WUR organizers will treat the algorithms confidential, the ownership remains with the teams. The algorithms will be fully deleted after the challenge. Submission is only needed to avoid changes made by teams manually.
- The fully autonomous algorithm of the teams will have to make choices with respect to the control settings in order to control the crop production fully autonomously. Each team will be able to extract necessary data from the greenhouse compartment and couple it to their own artificial intelligent algorithms in order to fully autonomously decide on the control settings for the next day/period. The algorithm will send the control settings automatically back to the system (the greenhouse climate computer) in order to control the actuators automatically and steer the crop. WUR will continuously obtain performance criteria per compartment and share them with each team during the first crop cycle and share them with the public during the second cycle.
- Each team will get a predetermined amount of time for consultancy and supervision by the WUR organisers. This time can be used to physically check own sensors, carry out additional handlings or ask for advice.
- WUR will provide a greenhouse compartment for each team with the equipment described above. WUR will provide each team with a list of digital information they get. WUR will provide each team with information on the possibilities and limitations of the control equipment.
- More detailed rules of the Growing Challenge will be provided to the teams directly after the Hackathon in order to prepare for the Growing Challenge in time.
- During the second cycle, any intervention with the control software by the teams will be registered, as it proofs the algorithm to be less autonomous. More interventions will yield a lower ranking of the team.
- An international jury, consisting of experts from science and industry in both fields, greenhouse horticulture and artificial intelligence, will monitor the Growing Challenge. Teams will need to reach the pre-defined goal of the Growing Challenge. The team with the highest net profit in the second crop cycle will win the Challenge. The jury will announce the winner during the Final Event.
- The net profit will be determined by the following elements:
 - Production ($\text{kg m}^{-2} \text{ cycle}^{-1}$) and price of product ($\text{€}/\text{kg}$ product), taking into account quality aspects (e.g. weight, size, presence of defects)
 - Energy use (MJ kg^{-1}) and price of energy ($\text{€}/\text{MJ}$)
 - CO_2 use (kg kg^{-1}) and price of CO_2 ($\text{€}/\text{kg}$)
 - Water and nutrient use (l kg^{-1}) and price of water and nutrients ($\text{€}/\text{l}$)
 - CAPEX sensors???

The Final Event

- The Final Event will take place in July 2022 at WUR in Bleiswijk, The Netherlands. The exact date will be announced at a later stage. In case of restrictions due to COVID-19 an alternative form will be chosen.
- At least the team captains' presence at the Final Event is required, otherwise the jury is entitled to disqualify the team.
- The goal of the Final Event is sharing knowledge and experience among participants and making new multi-disciplinary and international connections among each other and with members of the international jury and the WUR experts. All teams will present their approach and results during the Growing Challenge, including an explanation of the artificial intelligent algorithms used.
- The jury will announce the winner. The team with the highest ranked net profit during the second crop cycle of the Growing Challenge, corrected for the number of interventions needed in this second cycle, will win the Challenge.
- We aim for organising an international public symposium and/or a series of online webinars to present the results to everyone interested. Teams will then be provided the opportunity to present themselves and their approach and future vision to a relevant international audience (e.g. academic, technologists, investors). The form of such a symposium and/or series of webinars is unclear at the current stage and will also depend on eventual restrictions due to COVID-19. More detailed information will follow.

Important dates

- 15 July – 1 September 2021: Subscription open for teams via www.autonomousgreenhouses.com
- 1 September 2021: Confirmation of admission of teams.
- September 2021: Teams will get technical information for the Hackathon
- October 2021: Teams will get access to the virtual greenhouse-crop simulation model
- 4-5 November 2021: Hackathon at WUR, The Netherlands (if possible), selection of 5 teams for the Growing

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Challenge

- November 2021 – January 2022: Preparation time for teams to develop their algorithms, teams get training datasets, access to virtual greenhouse-crop simulation model, technical information for Growing Challenge and experimental conditions
- January 2022 (week 3/4): Teams will get access to their greenhouse compartment, installation of additional sensors (if needed), implementation of digital data interface and testing and submission of algorithm, PR activities
- 1 February 2022: Transplanting small lettuce plants, algorithms of teams take over control of their compartment
- 1 February 2022 – 31 March 2022: First crop cycle Growing Challenge, fully autonomous hydroponic lettuce production, collect data, test-run algorithms
- March 2022: Public webinar
- April 2022: Preparation time for teams to finetune their algorithms, re-submit improved algorithm
- 1 May 2022 – 30 June 2022: Second crop cycle Growing Challenge, fully autonomous hydroponic lettuce production, the real Challenge, best performing team wins
- May 2022: Public webinar
- July (week 27/28): Final event at WUR, The Netherlands; public symposium incl. winning ceremony

Media, ownership & IP

- Each team will remain entitled to the intellectual property of the information, documents, videos and algorithms submitted by themselves in connection with the Challenge (background);
- By entering into the competition, each participant automatically agrees to grant WUR the right to reproduce, disclose or use the submitted information, documents and videos for publicity and marketing purposes. This includes also WUR's right to publish teams' and participant names, additional photos and videos taken during the pre-Challenge, Growing Challenge and Final Event. This excludes WUR's right to publish teams' algorithms.
- By entering the competition, each team automatically agrees to share all collected data (foreground) from their own compartment including data from additional sensors and cameras installed in the compartment, with WUR.
- By entering the competition, each team automatically agrees to grant WUR the right to overall analyse and publish created data (foreground) of the Challenge. This excludes WUR's right to publish teams' algorithms.
- Teams algorithms will be treated confidential by WUR organisers and not be shared with third parties. Teams are asked to submit algorithms (e.g. as executable) only with the goal of ensuring autonomous control during the Growing Experiment. WUR organisers will delete all algorithms after the execution of the challenge. Note: If teams want to publish their algorithms and approach they are free to do so on their own decision.
- Participants acknowledge that the Challenge is public in nature and that information will be shared on a non-confidential basis, except when this concerns by teams developed algorithms and information or materials agreed beforehand to be confidential of nature. Participants acknowledge that this dissemination may preclude obtaining intellectual property protection. WUR excludes any liability in respect hereto.
- By submitting to the Challenge, each participant ensures that the submitted information and materials:
 - is the participant's own and original work;
 - does not infringe copyrights, trademarks or other intellectual property or other rights of any person or entity (such as rights of privacy, publicity);
- Any team found to have committed plagiarism, infringement of intellectual property rights and/or unlawful use of information will be disqualified.

General

- WUR reserves the right to modify any aspect of the competition. All teams will be informed about modifications in due time.
- WUR reserves the right to disqualify a team, if WUR deems the team or team member's behaviour in violation of the rules and regulations of the competition, or in case they have provided misinformation.
- WUR assumes no responsibility for incorrect or inaccurate information regarding the Challenge, or any late, lost or misdirected entries, whether caused by any of the equipment or programming associated with or utilized in this Challenge or by any human error which may occur in the processing of the registration in this Challenge.
- Participation is at each participant's own risk and expense. In order to cover expenses, teams are encouraged to search for sponsorships. Sponsors of teams get the possibility to be mentioned on our Challenge website www.autonomousgreenhouses.com.
- Participants are not allowed to use the WUR or the Tencent logo, unless it is part of means provided by WUR, such as flyers or other documents produced by WUR.

Contact

- Autonomous Greenhouse Challenge organizers can be contacted via: autonomousgreenhouses@wur.nl only.