

International Challenge: Autonomous greenhouses (2nd Edition) Boost greenhouse vegetable production by artificial intelligence

Criteria, rules & regulations

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Introduction

In this document we share criteria, rules and regulations for teams who want to participate in the 2nd International Challenge 'Boost greenhouse vegetable production by artificial intelligence', organised by WUR. We invite multidisciplinary teams to remotely grow cherry tomatoes in one of WUR's greenhouses. We invite teams to bring in their crop and AI expertise and passion and join the Challenge. All information can be found at www.autonomousgreenhouses.com.

Eligibility of teams

- The Challenge is open to students, experts, 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 and participate to the Challenge.
- Each team will appoint a team-captain who acts as contact person between the team and the WUR Challenge contact person.
- At least one team member must be a student.
- 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 before **15 July 2019 23:00 h GMT**.
 - 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 mail or a transfer link which must be put in the registration form.
- The registration form can be found on www.autonomousgreenhouses.com. The form must be filled in completely and uploaded to the registration in order to be eligible.
- The team should meet all eligibility criteria.

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:
 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, nationalities, gender).
 3. Extended abstract (Motivation, Methodology, planned A.I. approach) (An independent jury helps the organisers to select if needed).

- WUR will inform all duly registered teams whether they are eligible and have been admitted to the Challenge on **22 July 2019**. The organisers' and jury's decision will be final and will not be subject to debate.
- WUR retains the right to consider registrations after 15th July until 15th August 2019, if a minimum number of five teams has not been reached.
- All admitted teams need to participate in the pre-challenge Hackathon at WUR, The Netherlands on **12-13 September 2019**. During the pre-challenge 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 Challenge "Autonomous Greenhouse" growing experiment, taking place from December to May 2020. During the main Challenge the teams have to fulfil a predefined task for remotely growing a cherry tomato crop. 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 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 and 1-2 hours/day for daily data analysis, unexpected events, corrections and communication. Thus, by entering the competition the teams acknowledge of 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 **June 2020** (week 24) 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.

Pre-challenge Hackathon

- On **12-13 September 2019**, a Pre-challenge Hackathon will take place at WUR, Bleiswijk, The Netherlands.
- All admitted teams need to participate. At least the team leader has to be present on location.
- During the Pre-challenge, teams will grow a virtual cherry tomato 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 in order to fulfil the task of the Pre-challenge. By using the model, teams can learn how to grow a crop and how to control the greenhouse climate. The control strategy should result in an maximum pre-defined goal (e.g. crop yield, fruit quality, resource use for the yield realised). Teams will be able to use their own models or artificial intelligence algorithms to decide on the optimum growing strategy.
- Information in order to prepare the Hackathon will be sent to all eligible teams 2 weeks before the Pre-challenge. 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 open 1 week before the Hackathon event. This will allow the teams to implement their own algorithms and deal with any practical issues in advance.
- An international jury, consisting of well-known experts from science and industry in both fields, greenhouse horticulture and artificial intelligence, will judge the teams' performance on the virtual growing hackathon. The composition of the jury will be 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:
 - Team composition (20%)
 - Obtained results/reaching the goal in the pre-challenge (50%)
 - Strategy and approach for the main Challenge (30%)
- The five best teams will be selected. The jury's decision will be final and will not be subject to debate.

Challenge Autonomous greenhouse growing

- The main Challenge Autonomous greenhouse growing will take place between December 2019 and May 2020 (exact dates to be confirmed).
- A maximum of **five teams** will be admitted to participate.
- The goal of the Challenge is to produce a cherry tomato crop within 6 months with a pre-defined goal (e.g. high production, high fruit quality, high resource use efficiency). For that, selected teams will get the possibility to remotely operate a greenhouse compartment at the greenhouse facilities of WUR. Teams need to achieve the goal by growing the crop remotely, supported by measured values of greenhouse climate, water and nutrient supply and crop development and also webcam footage.
- Each team will be responsible for one greenhouse compartment. Each team has only access to the data of their own compartment, except for a selection of performance data which will be shared by WUR to the public periodically.

- The greenhouse compartments are located at WUR, Violierenweg 1, Bleiswijk, The Netherlands. All compartments have the same size and equipment.
- The greenhouse compartments are designated 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, drip irrigation, nutrient mixture, CO₂ input. 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, energy consumption, pH, EC and amount of irrigation and drain. The teams will be partly responsible for own crop observations (e.g. fruit set, pest presence); details on this will follow. All data measured and all control actions taken are available through a digital data interface for each team.
- Each team will be allowed to install their own additional sensors/camera's (to monitor additional climate, irrigation and crop parameters) in order to get additional information if they think this would improve their performance.
- The teams will have to make choices with respect to the control settings in order to control the crop growth remotely. 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 decide on the control settings for the next day/period. They will send the control settings back to the system (the greenhouse climate computer) in order to control the actuators automatically or send instructions for crop handling in order to reach the goal. WUR will continuously obtain performance criteria per compartment and share them with each team. A small subset of performance data (energy, CO₂ and water use and the cumulative production) will be shared with the public.
- Teams will grow a cherry tomato crop during 6 months in a designated greenhouse compartment. Teams will have to communicate to WUR in advance the number of stems per seedling plants. The day 1 of the experiment corresponds to the transplanting date (plants will be transplanted with first truss flowering).
- Each team needs to develop their own algorithms before the start of the growing experiment.
- The teams will receive training dataset/s before the start of the experiment (well in advance), in order to train their algorithms. Further information will be provided at a later stage.
- Teams will implement the digital data interface and perform initial tests 2 weeks before the start of the experiment. Team will take the control of their greenhouse compartment from the day 1 of growing experiment (= transplanting date). In the same week teams will get physical access to their compartment in order to install additional sensors (if needed), further test their data interface connection and principle functioning of their algorithms.
- 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.
- Teams will need to reach a pre-defined goal. Teams can earn points based on pre-defined criteria (see hereafter).
- 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 continuously or regularly (e.g., data on crop development and harvest will be shared weekly). WUR will provide each team with information on the possibilities and limitations of the control equipment. Teams will use their own models or artificial intelligence algorithms to define the control strategy. The control strategy will result in a crop yield and in a resource use for the realised production.
- Goal, criteria and detailed rules of the main Challenge will be provided to the teams directly after the Pre-challenge in order to prepare for the Challenge in time.
- An international jury, consisting of well-known experts from science and industry in both fields, greenhouse horticulture and artificial intelligence, will monitor the teams' performance during the Challenge based on the set criteria. Teams will get points for different criteria. The team with most points collected will win the Challenge. The jury will give points for all teams at the Final Event and announce the winner.

The Final Event

- The Final Event will take place in week 24 (June 2020) at WUR in Bleiswijk, The Netherlands. The exact date will be announced at a later stage.
- The team's presence at the Final Event is required, otherwise the jury is entitled to disqualify the team.
- During the Final Event, all teams will present their results obtained during the growing Challenge, their resources (e.g. sensors, personal capacity) used, and their strategy followed. The presentation also should explain the artificial intelligent algorithms/models used. The presentation should take ca. 20 minutes and will be given in front of an international jury. The presentation is part of the final judgement.
- Next to that, the teams will share their experience with each other.
- The jury will announce the winner. Jury members will be selected from companies and academia and will be experts in the fields of greenhouse horticulture, automation and artificial intelligence. Members of the jury will be published on the Challenge website. Each jury member will score the teams based on the results achieved during the greenhouse growing experiment, as well as on their presentation of their strategy used. The score of each jury member will be added to a final score. The team with the highest score is the overall winner. The decision of the jury will be final.
- All teams participating will benefit from the Challenge by making new multi-disciplinary and international

connections among each other and with members of the international jury and the WUR experts.

- The winning team will be provided the opportunity to present themselves and their approach and future vision to a relevant international audience (e.g. academic, technologists, investors).

Predefined criteria

Points can be obtained for (preliminary list):

1. Reaching the predefined goal of the greenhouse growing Challenge: e.g. grow cherry tomatoes with the least input of resources. Teams get points for e.g.:
 - Production ($\text{kg m}^{-2} \text{ season}^{-1}$).
 - Stability of production over time or correlation between the in advance projected production with the actual production (is the crop growing according to plan made on beforehand by the team).
 - Product quality (fruit weight, colour, taste – we will provide the teams with preferences).
 - Energy use efficiency (MJ kg^{-1}).
 - Water use efficiency (l kg^{-1}).
 - Nutrient use efficiency (g kg^{-1}).
2. Presentation of artificial intelligent algorithms and/or models used. Judgement by experts in the field. Teams get points for:
 - Novelty with respect to overall scientific community, application on horticultural domain (**novelty**)
 - Capacity to operate without manual interventions (**functionality**)
 - Capacity to operate without additional sensors or information (**robustness**)
 - Easiness of implementation on large scale (**scalability**)

Important dates

- 22 May-15 July 2019: Subscription of teams via this site: www.autonomousgreenhouses.com
- 22 July 2019: Confirmation of admission of teams, matching incomplete teams.
- September 2019 (Week 35-36): Teams will get preparation materials for the Pre-challenge and access to the virtual greenhouse-crop simulation model.
- 12-13 September 2019: Pre-challenge Hackathon at WUR, The Netherlands, selection of 5 teams for growing challenge.
- October 2019: Sowing plants.
- November 2019 (Week 47-48): Implementation of digital data interface and some testing.
- December 2019 (Week 49): Transplanting, teams will get access to their greenhouse compartment for installation of additional sensors (if needed), teams take the control of their compartment.
- December 2019- May 2020: Challenge Autonomous Greenhouse growing.
- June 2020 (Week 24): Final event at WUR, The Netherlands

Media, ownership & IP

- Each team will remain entitled to the intellectual property of the information, documents, videos and other items submitted 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 and materials for publicity and marketing purposes. This includes WUR's right to publish teams' and participant names, photos and videos taken during the Pre-challenge, Challenge and Final Event.
- By entering the competition, each team automatically agrees to share data from own additional sensors/camera's installed in the compartment, with WUR. All data have to be shared no later than 1 week before last crop harvest.
- By entering the competition, each team automatically agrees to grant WUR the right to overall analyse and publish created data of the challenge.
- Participants acknowledge that the Challenge is public in nature and that information will be shared on a non-confidential basis, except when this concerns 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 thereto.
- 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.