

# 3<sup>rd</sup> International Autonomous Greenhouse Challenge

## *Full autonomous control of a greenhouse lettuce production*

### Criteria, rules & regulations

#### Part 1: Online Challenge

Version: 2 April 2021

#### Introduction

In this document we share criteria, rules and regulations for teams who want to participate in the first part of the 3<sup>rd</sup> 'International Autonomous Greenhouses Challenge', the Online Challenge. It is organised by WUR and sponsored by Tencent. We invite machine learning and computer vision experts to participate in international teams to develop computer vision algorithms to characterise lettuce plants and to develop machine learning algorithms to control the growth of a virtual lettuce crop in a virtual greenhouse. The achievements of the teams in successful image recognition and smart climate control of a lettuce growth simulator will be ranked in the contest of the Online Challenge

This document describes the rules of this Online Challenge, which is part 1 of the 3<sup>rd</sup> International Autonomous Greenhouse Challenge. Part 2 consists of a Hackathon and Growing Challenge. It is not compulsory to participate in part 1 to participate in part 2.

All information can be found at [www.autonomousgreenhouses.com](http://www.autonomousgreenhouses.com).

#### Eligibility of teams

- The Online Challenge is open to students and researchers from universities and research centres and experts, from companies and start-ups.
- Teams of at least 2 real persons are eligible to subscribe.
- Team members must have the following expertise: 1. Machine learning 2. Computer vision. This expertise has to be demonstrated by professional or academic engagement.
- We encourage
- Each team will appoint a team-captain who acts as contact person.
- Each participant is only allowed to participate in one team and to subscribe to the Online Challenge once.
- Participants must subscribe via the official site with their professional or educational email account, thus company/start-up or university/research centre account.
- Names of participants and email addresses will not be disclosed by the organisers, only team names and number of teams will be public. If teams reach the top 5 ranking at the end of the Online Challenge, they automatically agree that the names of participants will be disclosed to honour them.
- We encourage teams from different countries and continents to participate. We encourage cooperation of different experts from different start-ups/companies with students and researchers from universities/research centres. We encourage to engage with experts in the field of horticulture but this is not mandatory.
- Good English language skills are required.
- The maximum number of teams accepted in the Online Challenge will be 200. In case of a higher number of subscriptions the organizers and jury will rank the subscriptions and select based on the criteria stated above. The jury's decision will be final and will not be subject to debate.

#### Registration

- To register, teams are required to submit the completed registration form available on the website from 15 April 2021 onwards.
- The submission must include detailed information on all individual team members.
- The team should meet all eligibility criteria (stated above).
- A link to the registration form can be found via a link on [www.autonomousgreenhouses.com](http://www.autonomousgreenhouses.com). The registration form 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 **20 May 2021 0:00 h GMT**.

## Confirmation of participation and participation process

- All duly registered teams will be informed whether they are eligible and have been admitted to this Online Challenge before **1 June 2021**. The organisers' and jury's decision will be final and will not be subject to debate.
- After being admitted to the Online Challenge, teams get ca. 6 weeks preparation time to develop their AI-algorithms before the actual Online Challenge event on 14 July.
- During the preparation phase teams will get access to a series of images of lettuce plants of different varieties and in different phases of development with measured plant traits (ground truth) to develop computer vision algorithms to identify the correct plant traits. The algorithm will have to identify the plant traits of a series of unseen lettuce plant images during the Online Challenge. Next to that, teams will get access to a simple greenhouse climate and lettuce production model (simple simulator) to develop machine learning algorithms to control the growth of a virtual lettuce crop in a virtual greenhouse and maximise (simulated) net profit. During the Online Challenge this algorithm should be suitable to control the growth of a virtual crop in a virtual greenhouse under conditions that are different than during the algorithm training phase.
- The result of the Online Challenge will be announced on **14 July 2021**.

## Online Challenge procedure

- Teams are subscribed and received a notification that they are eligible.
- Teams get a 6 weeks of preparation phase for the two parts of the Online Challenge. The computer vision challenge and the machine learning challenge.

### Part A computer vision challenge

- For the computer vision challenge teams will get access to a series of ca. 300 images of lettuce plants during the preparation phase.
- Images are taken with a RealSense camera under defined conditions and contain images of individual lettuce plants of different varieties in different growth stage and grown in different growing conditions. Each image is connected with information on the ground truth plant traits, such as plant diameter, plant height, plant fresh weight, plant dry weight, and leaf area.
- Teams use the images to develop a computer vision algorithm. This algorithm will have to be able to estimate the plant traits of a series of ca. 50 unseen lettuce plant images provided after the preparation phase under limited time and memory constraints. The computer vision algorithms have to detect the plant parameters described above.
- For each picture and plant trait the absolute difference between estimated value (teams' computer vision algorithm) and real value (WUR ground truth measurement) will be calculated and normalised. The total sum of absolute normalised difference will be calculated per team. The team with the lowest difference will be ranked first for this part of the Online Challenge.

There will two ranking boards available:

- The first is the public ranking board, which will be visible during the preparation phase of the Online Challenge. On 1 June 2021 00:00 GMT, teams will be provided with batches of images (out of the ca. 300 total images). After viewing each batch of images, the team can upload at most one new submission of the image prediction results. After every new submission, the public ranking board will show the scores of the latest submission, as well as the ranking list of all participating teams. On July 11<sup>th</sup> 2021 23:00 GMT, the public board will be closed and no new submission will be accepted anymore.
- On July 13<sup>th</sup> 12:00 GMT, a private ranking board will be opened and a new set of 50 unseen lettuce plant images will be provided to the teams. Teams must submit the image prediction on this image set within 5 minutes. After 12:05 GMT the submitting will be rejected. Teams can only see their own scores in the private board before the announcement of the final results on July 14<sup>th</sup>.
- A total ranking of teams will be made based on the private board score. The team with the highest score will be ranked first on the ranking board.

### Part B machine learning challenge

- For the machine learning challenge, teams will get access to a simple greenhouse climate and lettuce production model (simple simulator) during the preparation phase.
- The simple simulator consists of a given set of outside climate conditions, a given greenhouse type and given greenhouse actuators (ventilation, heating, lighting, screening). It needs to be provided with a series of climate setpoints (ventilation strategy, heating strategy, lighting strategy, screening strategy per timestep) as inputs. The input climate setpoints will activate the available actuators, which will control the inside greenhouse climate. The realised inside climate parameters will be provided as a feed back value. Crop management consists of defining

plant density (number of plants  $m^{-2}$ ) over time. Since the crop growth in the simulator is determined by the realised greenhouse climate, also the crop growth parameters (fresh weight, height, diameter) over time will be provided as output.

- The climate control strategy will determine the use of resources, mainly energy (for heating, for electricity for artificial light) and therefore creates costs.
- Fresh weight, height and diameter of the average lettuce plant are provided as the main output. These determine product price and therefore create income.
- Teams will have to develop machine learning algorithms to feed the simple simulator with the optimised control parameters in order to maximise net profit.
- Technical information on the working principle and an access key will be sent to all eligible teams at the start of the preparation phase.
- During the preparation phase teams can interact with the simple simulator for algorithm development. During the Online Challenge this algorithm should be suitable to control the growth of a virtual crop in a virtual greenhouse under changed conditions (e.g. other weather conditions, different greenhouse type, different lettuce type) and limited time constraints.
- There will be different versions of the simulators (A-D) with slightly different simulation parameters (e.g. other weather conditions, different greenhouse type, different lettuce type):
  - Simulator A will be available during the preparation phase of the Online Challenge from 1 June 0:00 GMT to 11 July 23:00 GMT, with limited access (typically 1000 times per day), to train the algorithms of the teams.
  - Simulator B will be available once every day from 12:00-13:00 GMT, to test the trained model, with limited access (typically 200 times per day). A public ranking board will be generated according to the net profit on simulator B. On July 11<sup>th</sup> 2021 23:00 GMT Simulator A and B will be closed.
  - On July 12<sup>th</sup> 00:00 GMT, Simulator C will be available for a period of 24 h, with limited access (typically 1000 times), to re-train the model.
  - On July 13<sup>th</sup> 12:00 GMT a private ranking board will be opened and simulator D will be provided to the teams with limited access (typically 200 times). Teams must submit the optimised control parameters in this new simulator version based on their developed algorithms in order to maximise net profit. After July 13<sup>th</sup> 13:00 the submitting will be rejected. Teams can only see their own scores in the private board before the announcement of the final results realised in simulator D on July 14<sup>th</sup>.
- The teams with the highest net profit will be ranked first for this part of the Online Challenge. A total ranking will be made according to the private ranking board.

### Online Challenge event

- The Online Challenge Event will take place on 14 July 2021.
- The goal of the Online Challenge Event is to scout talents, to identify the best AI experts on the field of computer vision and machine learning, and to determine the winning team.
- An international jury, consisting of experts from science and industry in both fields, greenhouse horticulture and artificial intelligence, will oversee the Online Challenge and the teams' performance during the Online Challenge. The composition of the jury will be announced via the Challenge website.
- The total ranking of both parts of the challenge will be translated into points per rank with the highest number of points for the first in ranking. The points of both parts of the challenge will be added. The team with the highest number of points will win the Online Challenge.
- The jury will announce the final ranking.
- Teams are encouraged to publish their algorithms on a public GitHub server. Teams who have published their algorithms make a chance for a prize money and for a wild-card for direct participation in the Growing Challenge of the "3rd Autonomous Greenhouse Challenge". The wild-card qualifies for participating as (part of) one of the 5 selected teams for the real greenhouse experiment growing a hydroponic lettuce crop in a real greenhouse compartment at WUR.

### Important dates

- 15 April – 20 May 2021 0:00 GMT: Subscription open for teams via a link on [www.autonomousgreenhouses.com](http://www.autonomousgreenhouses.com)
- 20 May - 1 June 2021: Confirmation of admission of teams, links to images and simulator will be provided incl. more detailed information.
- 1 June 2021: Teams will get technical information for the Online Challenge and access to the lettuce images including ground truth plant traits and access to the simple greenhouse-crop simulation model (simple

- simulator)
- 1 June 0:00 GMT– 11 July 2021 23:00 GMT: Preparation time for teams to develop their computer vision and machine learning algorithms
  - 12 July 2021 0:00 GMT: Possibility of re-training machine learning algorithm during 24 h
  - 13 July 2021 12:00-12:05 GMT: Online Challenge computer vision – teams have to provide results on unseen images
  - 13 July 2021 12:00-13:00 GMT: Online Challenge machine learning – teams have to provide results on unseen lettuce simulator
  - 14 July 2021: Online Challenge event incl. winning ceremony
  - *For other important dates of the 3<sup>rd</sup> Autonomous Greenhouse Challenge, see the separate rules document for the Hackathon and Growing Challenge.*

## Media, ownership & IP

- Each team will remain entitled to the intellectual property of the information 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 for publicity and marketing purposes. This includes also WUR's right to publish teams' and participant names, additional photos and videos taken during the Online Challenge event. This excludes WUR's right to publish teams' algorithms. Publishing teams' algorithms is a free decision taken by the teams themselves.
- By entering the competition, each team automatically agrees to grant WUR the right to overall analyse and publish created data (foreground) of the Online 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 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 algorithms:
  - 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 or try to manipulate the Online Challenge by any means.
- WUR assumes no responsibility for incorrect or inaccurate information regarding the Online 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 Online Challenge.
- Participation is at each participant's own risk and expense.
- 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](mailto:autonomousgreenhouses@wur.nl) only.