Greenhouse challenge v2

A major development in the agricultural domain is the transition to “precision agriculture”, in which crops are monitored and taken care of at the plant-level. Precision agriculture requires a high level of automation, to obtain measurements, interpret data, and take fine-scaled actions. Drones have the potential to play a significant role in precision agriculture, as they can move in three dimensions, observing places that are normally hard to access.

In this competition, we want to push the state of the art for drones that navigate autonomously in greenhouses. Specifically, we want teams to develop a solution with one or more autonomous drones that need to inspect a tomato greenhouse as quickly as possible. The goal is to monitor the tomato crop and find a plant with a disease (simulated for the competition). The teams are free to develop any flying solution, if the take-off weight is lighter than 1 kg. This said, the scoring system stimulates the development of drones that are as light-weight as possible.

Goal

The competition will take place at "Tomatoworld", a greenhouse dedicated to research on innovative technologies for the growing of tomatoes. It is a greenhouse of ~1200m2, with 18 aisles on the right (17.4 meters deep) and 16 aisles on the left (16.7 meters deep) of the greenhouse – see the floor plan further below in the document. There is approximately ~1 m space between two rows of tomatoes. The tomatoes are grown using a high-wire production system, meaning that the plants are attached with strings to a frame. The greenhouse uses fans for ventilation creating some (local) draft.

The **goal** is to “monitor” as many tomato plants in the greenhouse as possible within a fixed time slot of 10 minutes.

Monitoring the plants means providing images of the plants and tomatoes in the different rows (on the left and right side of the isle). Tomatoworld grows about 50 varieties of tomatoes, ranging from beef tomatoes to cherry tomatoes. The quality of the images will be evaluated by judges that are experts in the field. Extra points can be gained as well by providing a map with the measured temperature and CO2 concentration at different spots in the greenhouse. Finally, additional points are awarded for locating a tomato plant that will be painted to have some brown spots, indicative of a disease (see example paint and image below). Solutions that do not require the installation of external infrastructure are preferred, which is reflected in the scoring system. As is common in IMAV, the smaller and lighter the individual drones are, the higher the score. In a greenhouse, small and lightweight drones are important for the safety of workers and plants.

View of the aisles.

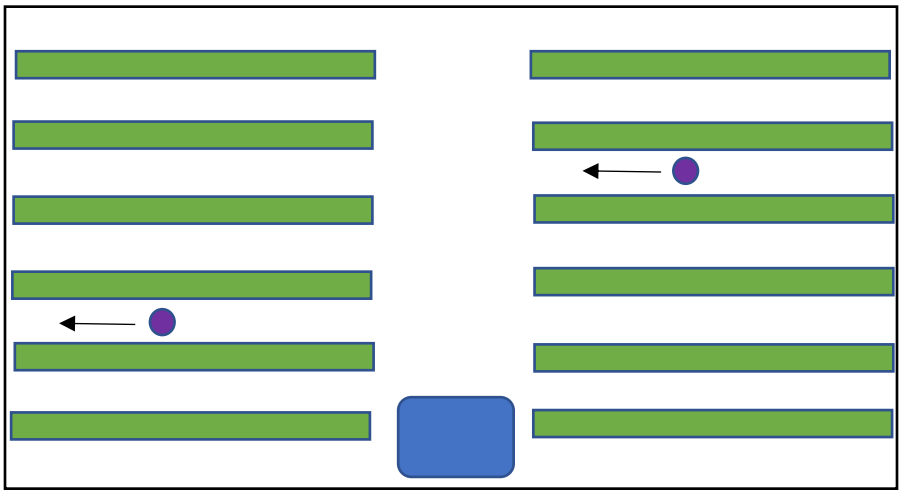
Paint and example of a painted leaf. Note: this is not a tomato plant leaf!

Rules

During the run

Each team's slot is 20 minutes consisting of 5 minutes for setup, 10 minutes of flight, and 5 minutes of wrapping up. After the flight, each team has *one hour* for processing images, making maps of CO2, etc.

Below we show a very coarse schematic of the flight arena. The team can install the ground station in the blue area, and all drones need to start and take off in that area. The drones (purple circles in the schematic) then need to navigate through as many aisles as possible. Below the coarse map is a more carefully measured map of the arena, indicating all aisles in green.



East South

16.70 meter	4m	17.40 meter
18L		18R
17L		17R
16L		16R
15L		15R
14L		14R
13L		13R
12L		12R
11L		11R
10L		10R
9L		9R
8L		8R
7L		7R
6L		6R
5L		5R
4L		4R
3L		3R
Office /		2R
Office /		1R

North Toilets Meeting room West

Score

The score is determined by the following formula:

$$s = \left(R_f + R_I + 5D + 2C + 2T\right)WAIS$$

Where:

- Rf = the number of full rows flown.
- RI = the number of full rows for which there are images of all plants left and right
- D = 1 if the team has located the sick plant
- C = 1 if for the flown region, the drone also tracked CO2 for mapping
- T = 1 if for the flown region, the drone also tracked temperature for mapping
- W is the weighing factor: *W = 1000 / m*, with *m* the takeoff weight of the drone in grams
- A is the autonomy factor: A = 1 when external infrastructure is used (beacons, markers, etc.), A = 5 if offboard processing is used, and A = 10 if a fully onboard solution is presented.
- *I* is the image quality, judged as 0.5 (very bad images like QVGA resolution), 1 (VGA-like quality), 2 (HD-like quality)
- S is a safety factor, which is default 1, but can be determined to be max 2 if extra measures are taken to protect the plants

Safety

Safety for the plants

Please note that before entering the arena, each team needs to put on special protective clothing and disinfect hands and all equipment that will be brought into the arena. Disinfecting equipment can be done by spraying the disinfectant on a cloth and cleaning the equipment with it. Moreover, teams are not allowed to bring any tomato or tomato-based products to the Tomatoworld site, nor to touch the tomatoes present to avoid introducing diseases. If even one plant is affected by a disease, all plants in the facility will have to be actively removed and incinerated.


Left: Disinfecting equipment, Right: blue suits for being able to enter tomato ranges (e.g., to recover a drone), white jackets for operators that do not need to enter the tomato aisles.

Also note that we are fully aware that during the competition an autonomous drone may fly into the plants and possibly damage them with the propellers. Still, try to design the system such that this type of accident and damage is minimized.

Safety during flight

Safety of the developed system will be evaluated by the judges before practice runs and before the competition. The drones should have a safety procedure when they start to fly above 3m height. They should then descend and land. This is to prevent them from flying into the ceiling windows. Avoidance of the glass at end of each aisle is part of the task. The judges will check with the team before flight whether such glass / the end of the aisle is detected by the sensing system. Moreover, one safety pilot per drone is recommended, and obligatory for drones >= 250 grams.

Practice

We realize how important it is for teams to test out their solutions at the competition site. Hence, the teams are allowed to practice in the Tomatoworld greenhouse for two days, September 12 and 13. The competition takes place on the 14th. The precise practice rules will be communicated on site on Monday, September 12, 9:00 am. Please note that lunch will be provided by us during the practice days.