UGV: Image Data Collection Test

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Purpose

The purpose of this test is to evaluate the ability of an unmanned ground vehicle (UGV) to capture usable top-down visual data of crops, for example, cauliflower or similar-sized horticultural plants. The test is intended to validate whether the UGV's onboard vision system can collect consistent image data along the crop canopy for further use in AI-based plant monitoring, detection or classification tasks when the UGV is operating autonomously or being manipulated.

Test Facility

The test shall be conducted in an experimental plot with two (or more) rows of cauliflower (or equivalent crops) planted with a clear path between the rows and clear separation between plants (e.g. standard commercial field vegetable spacing could be used). The setup for this test is shown in Figure 1. The following field layout properties should hold:

- Plot width: approximately 1 meter.
- Plot length: approximately 10 meters.
- Plant spacing: approximately 50 cm between plants (in both X and Y directions)
- No artificial lighting or smoothing shall be introduced; natural field conditions apply with a slope of no more than 10 degrees.
- The test area must be clearly bounded and marked for consistency.
- No obstacles (rocks, holes, etc.) shall be intentionally introduced, but natural surface irregularities shall remain in data collection path.

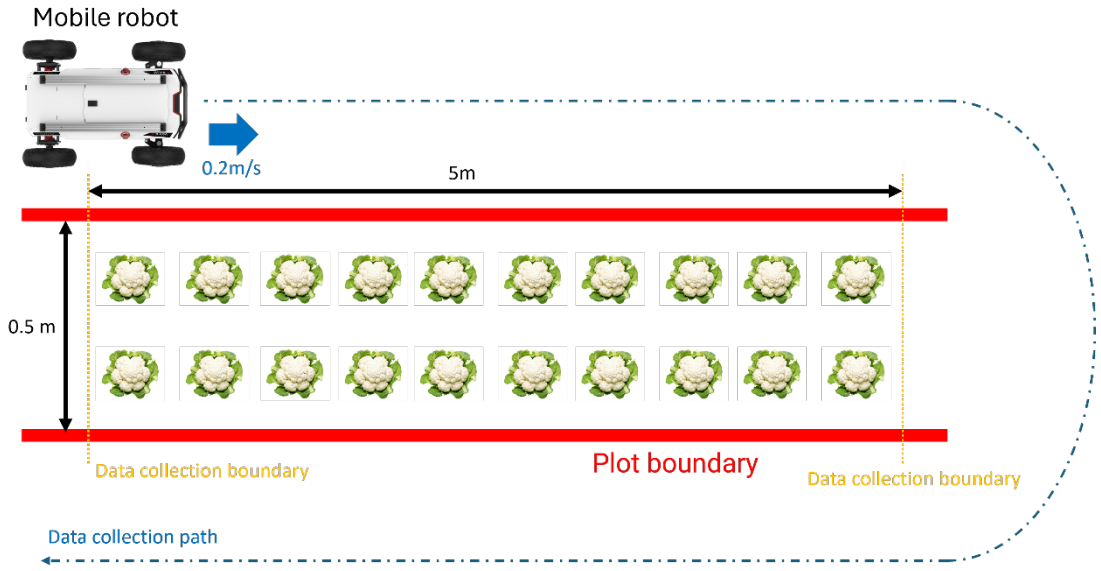

Figure 1. Test area for UGV.

Test Procedure

Each test trial shall follow the steps below:

1. The UGV is placed at the start of the data collection path. Trial start time is marked.
2. The UGV moves forward along the data collection path at a constant speed of 0.2 m/s.
3. The robot's vision system begins capturing overhead images of the plant canopy while the robot moves between the 2 data collection boundaries. In total, there will be two passes through the plot, each collecting 50 images for a total of 100 images. Each pass-through will collect data of a single row of plants that are closest to the robot.
4. The robot exits the data collection boundary and stops. Trial end time is marked.
5. The collected image data is downloaded and inspected for coverage, clarity and consistency.
6. The trial will be repeated at least 3 times for statistical consistency, e.g. due to different light or soil conditions (e.g. wet or dry). Iterations can be repeated at different times of day and/or on different days, to allow for variations in weather conditions. Note that weather conditions must be recorded.

Evaluation Criteria and Error Conditions

Trials are evaluated according to number of images captured, as well as image sharpness and exposure ratings for all captured images, plus duration of each image capture trial.

A trial is evaluated as “successful” if all the following criteria are satisfied:

- The captured images will be tested by an image assessment script. The script contains two evaluation criteria: *sharpness* and *exposure*. There are 3 levels of sharpness: *Blurry, Acceptable, Sharp*. There are 2 levels of exposure: *Normal, Overexposed.* When the sharpness of an image is between Acceptable and Sharp while the overexposure value is normal, it will pass the script test.

- Across 3 continuous test repetitions, each resulting dataset (6 datasets in total: 3 repetitions × 2 directions) contains at least 50 captured images. In each dataset, at least 90% of the images pass the test of the image assessment script.

Conditions

The following test conditions shall be recorded and included in the test report:

- Field layout dimensions and crop type.
- Robot sizes.
- Observed behavior in each segment (stability, wheel/track slippage, yaw drift).
- Terrain conditions (soil softness, grass cover density, moisture if relevant).
- Terrain gradient (%).
- Weather conditions.
- Robot configuration and payload details.
- Vision system specifications (camera type, resolution, mounting height).
- Sample captured images.
- Trial start and end times.

Test Result

The following shall be recorded and included in the test report:

- Number of successful trials.
- Duration of each trial (in seconds).
- Average duration and standard deviation over all trials conducted (in seconds).
- Percentage of images that pass the image assessment script test (i.e. meeting sharpness and exposure criteria).