IEEE ROBOT@FARM COMPETITION

RULES BOOK

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LIST OF FIGURES

CONTENTS

1 VERSION CONTROL

0.0.0 - First Release.

2 INTRODUCTION

2.1 AGRICULTURAL ROBOTICS COMPETITION

Agriculture is fastly becoming a high-tech industry. The technology is developing rapidly, not only improving farmers' production capabilities, but also advancing robotics and automation technologies. The key reason for this is the requirement to dramatically increase production. According to the UN, the world's population will rise from 7.3 billion today to 9.7 billion by 2050. Farmers will need to keep up with demand as the world's population grows (ROBOTICS. . . , 2017).

Agricultural autonomous robots have been responsible for increasing production in the agriculture domain. The use of robots, such as drones, autonomous tractors, and robotic arms (ROBOTICS. . . , 2017), in conjunction with artificial intelligence approaches, has the potential to significantly boost farm production.

2.1.1 Objectives

The competition's main goal is to produce completely autonomous agricultural robots capable of performing tasks such as navigation, sensing, and mapping in the field.

2.2 RULES

The following section contains the rules for the competition, which were originally based on the Field Robot Event, 2021 edition (GRIEPENTROG et al., 2022).

3 RULES

3.1 COMPETITION DOMAINS

The tournament will be divided into two stages: the first will be entirely virtual, while the second will involve real robots for some selected teams.

3.2 VIRTUAL SETUP

The competition is conducted virtually using the Gazebo simulator[1], which is an open-source 3D robotics simulator. Gazebo supports codes for sensor simulation and actuator control. The simulator provides realistic rendering of environments including high-quality lighting, shadows, and textures. Virtual simulation environment can be found at: `https://github.com/Agricultural-Robotics-Competition`. Two models of robot (Terrasentia (EARTHSENSE. . . , 2021) and Jackal (CLEARPATH. . . , 2021)) are already available in this same link.

3.3 GENERAL RULES

3.3.1 Sensors

The focus for tasks in terms of localization shall be on positioning and sensor-based behavior. *Therefore, the use of any type of global localization (GNSS receivers) is not allowed on these tasks.*

3.3.2 Crop Plants

The crop plants for the task is yet to be determined. The appearance of the plants as well as its height depends on the location where the competition takes place.

3.3.3 Parc Fermé

During the contests, all robots have to wait in the parc fermé from the beginning on. No machine modification to change its performance is allowed during task runs. All PC connections (wired and wireless) have to be removed. This shall avoid having

[1] http://gazebosim.org/

an advantage of not being the first robot to conduct the task. The starting order will be random.

3.3.4 Navigation

The drive paths of the robot shall be between crop rows. Large robots or robots which probably partly damage the field or plants have to start after the other robots. However, damaged plants will be replaced by spare ones, to always ensure the same operation condition for the robots.

3.4 GENERAL REQUIREMENTS FOR ROBOTS

3.4.1 Autonomous Mode

All robots must act autonomously in all tasks, except for the freestyle. Any type of external control is not allowed during the performance of the tasks. This includes steering, motion and all features that produce movement or action at the robot. During start, the robot is placed at the beginning of the first row, as shown in Figure 1. The starting line is marked with a white cross line. The robot must be completely behind the line in the start. There will be an acoustic signal for the start of the task, and the robot must start its execution within one minute. If the robot does not start within this time, the attempt is flagged as complete and the robot receives no points for the attempt. The robot can be repaired between attempts, but must return as soon as possible into the parc fermé.

3.4.2 Start/Stop Command

All robots must be equipped with and connected to a wireless remote or a notebook that is able to start and stop the robot. It can only be used in controls with prior notice to the referees, and the only commands allowed are start and stop. Before the start of the tasks, the device must be placed on the table that is located at the edge of the field. The remote controller must be presented to the referee team before the run, and a jury member will watch the use of the START/STOP command during the task execution. In each task, the robot must be started remotely, not being allowed pressing any buttons on the robot itself.

3.4.3 Manual correction of the robot

The team member responsible of starting robot is allowed to enter the field after pressing the stop button on the external device and the robot has stopped completely. It is recommended to install some indicator onto the robot to see that the robot is in stop mode before entering the field in order to avoid any accidents. The start/stop member is also responsible for the eventually manual robot corrections. Due to the fact that it can be difficult to monitor robot's behavior from a large distance, another member is allowed to reach a maximum of 2 meters from the task area and give instructions to the operator. After leaving the remote control on the table, the operator is allowed to rotate (but not move) the robot in the field. The only exception for moving is when the robot may need to get back to the path if a wheel or track of the robot has collided the crop plants. Carrying the robot is only allowed after significant navigation errors in order to bring it back to the last correct position and orientation.

3.5 AWARDING AND PRIZES

Because this is the first edition, no awards will be given. Only participation certificates will be granted to teams.

3.6 TASK RULES

3.6.1 Basic Navigation

3.6.1.1 General Description

For this task, the robot should navigate autonomously through a maize field. Within three minutes, the robot has to navigate through curved rows (Figure 1). The aim is to cover as much distance as possible. On the headland, the robot has to turn and return in the adjacent row. This task is all about accuracy, smoothness and speed of the navigation operation between the rows.

3.6.1.2 Task Environment

The starting is on the right side (first turn is left). This is not a choice of the team but of the officials. A headland width of 2 meters free of obstacles (bare soil) will be available for turning operations. The headland will be indicated by a fence or ditch or similar (3D object). The first stage of the test is without intra-row gaps to make it easy to robots to start localizing themselves, the next stages have intra-row gaps along the track. On the second stage, the robot has to follow a particular given turning and row pattern. This pattern is available in the 'driving_pattern.txt' file in the 'map' folder of the 'virtual_maize_field' package of the robot container. The content of this file may look as an example like:

$\boxed{\text{S - 1L - 1R - 3L - 2R - F}}$

Random stones and pebbles are placed along the path. Therefore, machine ground clearance is required. There will be no gaps at the row entries and exits. The ends or beginnings of the row may not be in the same line.

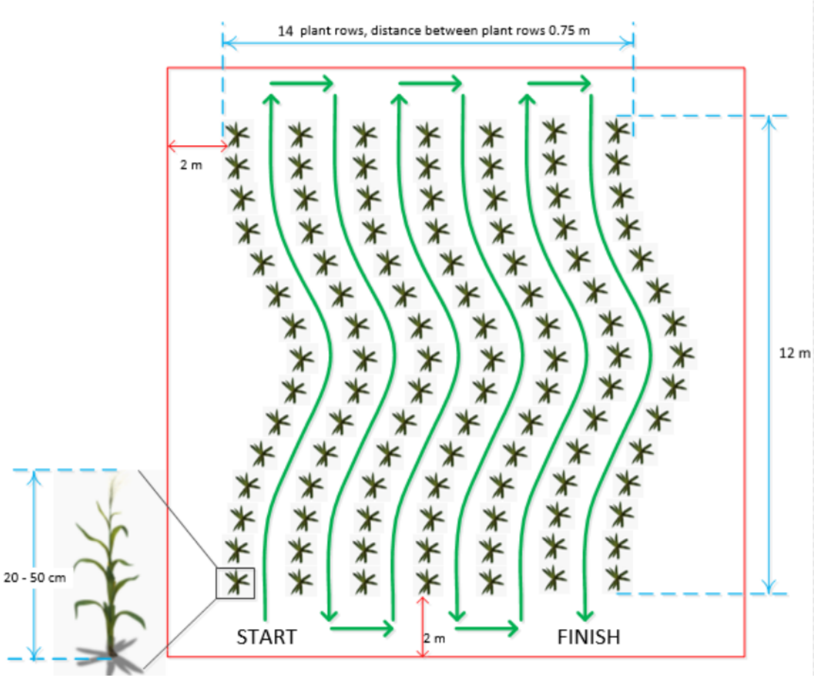
3.6.1.3 Assessment

The distance traveled following the given path during task duration is measured. The final distance will be calculated including especially a bonus factor when the end of the field is reached in less time than 3 min. The final distance including a bonus factor is calculated as:

S_{final} [m] = $S_{corrected}$ [m] * 3 [min] / $t_{measured}$ [min]

The corrected distance includes travelled distance and the penalty values. Travelled distance, penalty values and performance time are measured by the referee team. Crop plant damage by the robot will result in a penalty of 2% of total row length distance in meter per damaged plant.

Figure 1 – Concept of field structure for navigation task



Source: (GRIEPENTROG et al., 2022)

3.6.2 Detecting Objects and Mapping

3.6.2.1 General Description

The robots shall detect objects as weeds and cans and map or geo-reference them. For this task, good row navigation is required. There will be ten objects in total distributed across the field. The robot has to generate a file (pred_map.csv) with the coordinates of the objects relative to the given reference points. The reference point of the coordinate system (0,0) is in the **center of the field**. Each line in the file must represent a single object, with the coordinates x and y in meters. Extra points can be obtained for object classification also indicated in the file. After the run, the file should be saved in the 'map' folder of the 'virtual_maize_field' package in the robot container.

3.6.2.2 Task Environment

Objects are realistic weeds and cans. The objects are placed randomly across the field, with no objects in the headlands. The reference point of the relative coordinate system will be in the center of the field, in pillars with a QR code with the name of the pillar. The relative coordinates of the pillars will be provided to the teams in the 'markers.csv' file in the map folder of the 'virtual_maize_field' package. When the robot detects an object, it should publish the object type to the '/detection' topic. This will spawn a marker in the simulation above the robot position.

3.6.2.3 Assessment

The jury calculates and assesses the accuracy of the provided and mapped objects:

Detected object and right category	5 points
Detected object and wrong category	-5 points
Mapped object position to true position	points = f (distance error)

$$Points = f(x_{\text{error}}) = \begin{cases} 15 \text{ if } x \leq 2cm \\ 15.56 - 0.2817x \text{ if } x \leq 37.5cm \\ -5 \text{ if } x > 37.5cm \end{cases} \tag{1}$$

with x_{error}: distance error or Euclidean distance.
Crop plant damage by the robot will result in a penalty of 4 points per plant.

The robot is allowed to push the object to the headland, but will only earn points for the delivery. The total travelled distance will not be assessed.

3.6.3 Real Robot

3.6.3.1 General Description

Teams are invited to let the virtual environment and to use a real robot to perform simplified versions of tasks described in sections 3.6.1 and 3.6.2.

3.6.3.2 Assessment

The jury calculates and assesses using the same criteria described in sections sections 3.6.1.3 and 3.6.2.3.

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