Figure 1: Sketch of track layout. The black lines are actually white tape. The grid is in meters. The numbers refer to the sections below. description.

Track description 2024

The Danish version has priority if there are contradictions.

1   Introduction

The course is located at DTU in the library building 101. The layout of the track will generally be as shown on the track sketch (figure 1), but minor variations may occur, the other figures do not all relate to the current track layout.

The track is designed on the basis that the vehicle can follow a tape line on the floor, and if you keep to the right of this line you will reach the goal, but in this way only achieve relatively few points.

1.1   The floor

The track is located on a plateau that is raised approximately 42 cm above floor level.

The floor below the track has two types of coating, a wood covering (oak) -

a.   b.

Figure 2: Start plate and guillotine, the two first and mandatory challenges.

see figure 2, which is the bright area on the track sketch, and a central area that is black. The black area (approximately 5.5 x 6.8 m in the middle of the area) is shown darker on the track sketch - see figure 3 (the area is usually at floor level, but is filled with black panels for the occasion). There may be small differences in level between the wood and the black panels - we have seen up to 5mm. The panels are framed with a narrow aluminium edge of approx. 5 mm, two aluminium edges thus give a transition of 10-15 mm, since there can also be a small distance between the panels (see also figure3).

1.2   Canvas tapes and power cables

The tape lines are made with 38 mm wide white tape (type Tesa-4651). The tape will be placed roughly as shown on the track sketch. No curve will be sharper than a circle with a radius of 50 cm. Electrical obstructions will be connected to cables. They will be taped to the floor (with black tape) and may be passed by the robot

1.3   Line sensor

The wooden floor is very bright with an infrared line sensor and can, therefore, be difficult to distinguish from the white canvas tape. It is therefore recommended to use visible light for the line sensor.

1.4   Navigation aid markers

At different places on the track, there will be ArUco markers. Each marker has a detectable unique code for the track. The markers can further be used to find own position relative to the marker.

ArUco codes can be detected by e.g. OpenCV, see e.g. https://docs.opencv.org/3.4.15/d5/dae/tutorial_aruco_detection.html and generated on-line by e.g. https://chev.me/arucogen/.

1.5   Other conditions

Except for the guillotine gate and goal, all the remaining challenge may be completed in any order. It is not a requirement that all challenges have to be completed. If the robot consists of several units, then all these units must pass the guillotine. Then, these units (satellite robots) can earn points independently.

CAD drawing of 3D printed parts can be found at Onshape DtuRobocup.

2   Gates

The gates are all 45 cm wide (+/- 2 cm) with 47-50 cm free height. The wall thickness of the gates is approx. 16 mm (this does not apply to the tunnel or the race track). The gates are shown as yellow lines in the sketch (figure 1).

Each correctly passed yellow gate gives 1 point.

3   The Start

The start is on a starting plate (figure 2 a). When the plate is left, a countdown of the guillotine gate starts (figure 2 b). Timing and distance to the guillotine are determined so that an average speed of 25 cm/s will be sufficient for passage. Passage of the gate gives 1 point.

4   The ramp

The ramp leads up to a platform at a height of approximately 55 cm (see figure 3). The ramp starts at least 3.5 m before the platform (horizontal distance) and with the same incline all the way. The width is 60 cm. The ramp is like the platform, staircase and descent made of wood and painted in a dark colour. The ramp also has a rough surface for increased friction during the run-up.

On the upper part of the ramp, there is mounted a seesaw. The normal position of the seesaw is horizontal and it is supported by the ramp. This means that the seesaw will remain horizontal when a vehicle moves from the ramp to the seesaw until the vehicle passes the support point. It will require approx. 200 g of load 20 cm from the support point before the seesaw tilts. A yellow gate is located at the outer end of the seesaw. When driving from ramp to the seesaw, there will be up to 6 cm height difference (the seesaw is lower than the ramp).

The gate at the seesaw must be passed by using the seesaw.

5   Golf Ball

On the seesaw 30 cm from the seesaw support point and on the ramp platform are placed golf balls (red circle in figure 1).

These balls must be placed in the hole on the platform (see figure 4) to obtain points. The diameter of the ball is standard 43 mm and the colour is orange. To ensure that the ball's position is uniform at each pass, a small metal ring (key

Figure 3: The figure shows the ramps, the see-saw and the stairs. The orange golf-balls and the yellow gates are visible too. Notice also the aluminium edge of the floor-plates.

Figure 4: Theplatform with golf ball and hole for the ball.

ring) is mounted under the tape in which the ball is placed. Each ball triggers one point (maximum 2 points). The hole diameter is 52mm.

6   Downhill from the plateau

The descent from the platform can take place via 2 alternative roads. The ramp is 60 cm wide and ends at least 2 m from the platform (horizontal distance). On the ramp, there is a gate that gives 1 point for passage.

7   Up and down the stairs

The second option for descent is the staircase (see figure 3), which has 4 steps and therefore 5 level jumps, each approximately 11 cm. The steps are 40 cm long and 60 cm wide. There are two gates on the stairs, each giving 1 point for passage.

Figure 5: The tunnel with doors at each end. The wide door is open.The doors are 1.5mm iron plates and both open outwards. The ArUco codes are not shown.

Passage for going up the stairs gives additional points for each passed gate (ie up to 4 points for going down and back up the stairs).

8   Closed Tunnel

The tunnel is mounted with an outward going door at each end. The doors are 25 cm high (see figure 5). The front door is the widest - so it can be pushed open from the outside. The doorways have the same dimensions as a gate, but they are not yellow. It gives 1 point to open and pass through each of the doorways. An additional 1 point per door is given if the doors are subsequently closed. The door is only considered closed if the opening is less than 2 cm (4 points in total). The tunnel is taped to the floor.

ArUco markers will be placed on the doors of size 100x100mm and type 4x4. Code 29 (outside) and 31 (inside) on the long door, and code 32 (outside) and 33 (inside) on the other door.

9   The racetrack

The race track starts and ends with an electronic gate. The gates are aluminium profiles, with internal dimensions similar to the other gates. When a light beam is broken in the starting gate, timing starts and it stops when a corresponding light beam is broken in the end gate. The light rays are located approx. 7.5 cm above floor level. 0, 1, 2 or 3 speed points are given. It will require an average speed of more than 1 m/s to achieve maximum points on this challenge. It must be the same (satellite) robot to activate the start and end gate.
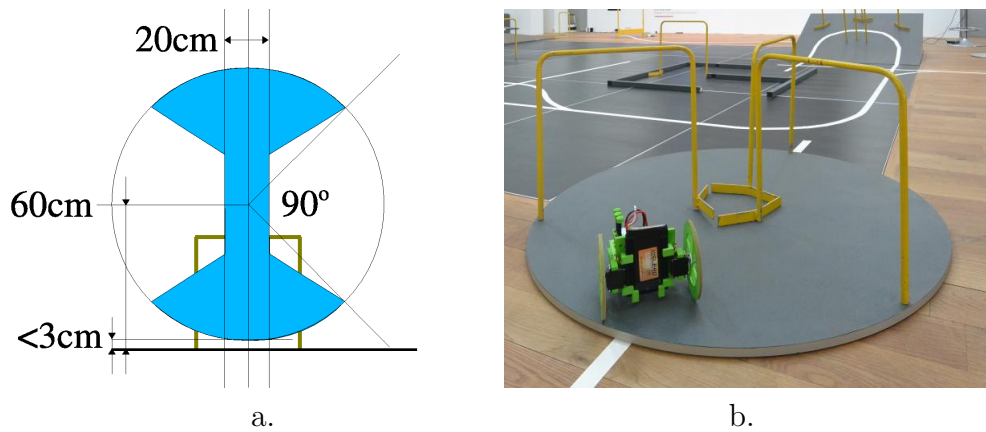
Figure 6: Axe gate (a.), with a gate shown beyond. The tree-gate (b.) is a circular 25 mm high disk with 3 gates and no tape lines.

10 The axe gate

The axe gate is a rotating axe that periodically blocks the passage of 2 gates. The axe is made of plywood, with dimensions as shown in figure 6 a. The axe rotates with approx. 1 rotation in 10 seconds. There is a gate just before and one just after the axe, the distance between these gates is approx. 10 cm. The frame shown on the track drawing is a steel frame (90 x 60 cm), with one leg in each corner (a frame for an examination table - clearance height 67 cm). Each of the 2 gates gives 1 point.

11 The three gate

The 3-gate has 3 gates placed on a circular plate – see figure 6 b. The gates are placed readily on the plate and form an angle of 120 degrees. The plate is approximately 25mm thick and has a diameter of 120cm. The plate is painted on the top in a dark colour, the edge is (largely) vertical and in a lighter colour. Each passed gate gives 1 point.

12 Mini-golf

The mini-golf has a ball dispenser that releases 4 orange golf-balls, they are 43 mm in diameter an a weight of 46 g). These balls are to be placed in the blue target area.

The dispenser is activated by pushing the top of the container(see figure 7). The top of the container is approximately 18 cm above the ground.

The blue target area has a 12x12 cm opening with a height of 1 cm. The sides are sloped so that the balls can be pushed into the opening.

The dispenser base and the target area will be taped to the floor.

The green fence shown in the sketch around the mini-gold and package delivery area is a 10 cm high wooden fence that is painted green on the inside and taped
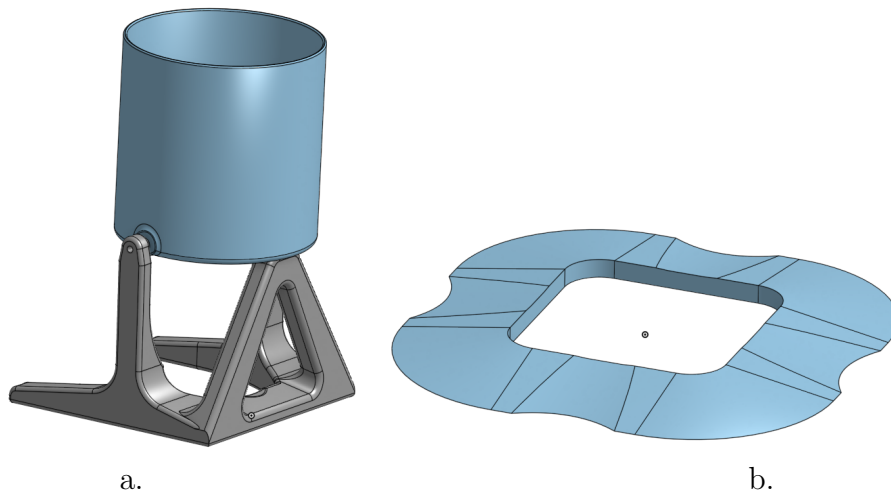
Figure 7: The mini-golf ball dispenser (a) height is 18 cm. The target (b) has an open area of 12x12 cm.

Figure 8: Package delivery trolleys. The trolleys are connected with magnets, they are marked with a delivery code. The magnets are oriented as shown in the right image.

to the floor.

Each ball placed gives 1 point.

For navigation aid, two ArUco code markers will be placed in the corner with the target area. The markers are of type 4x4 and will have a size of 100x100 mm. The code will be 18 and 19.

13 Package delivery

A set of four small trolleys hold four packages, three of which is to be delivered to three houses nearby. See figure 8. The starting position of the four trolleys will be as shown, but the order of the packages will be random.

Each package hold a colored golf ball (red, yellow, green and white or orange) and the red, yellow and green ball are to be delivered to the red, yellow and green
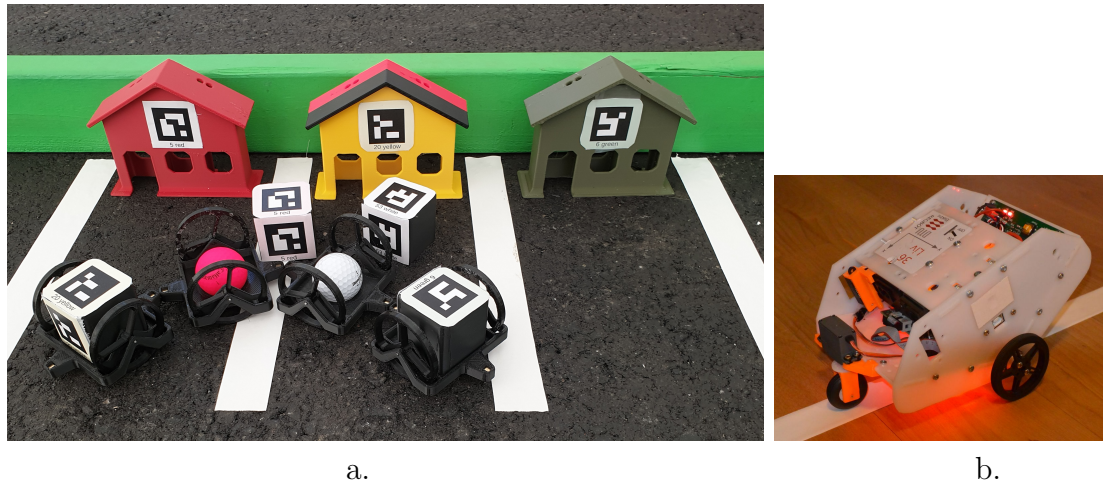
a.   b.

Figure 9: Package delivery is to be at the right house. In (a.) the delivery of the package with the red ball is correct, and would give 2 points, none of the others are correctly delivered. To the right (b.) is the autonomous circling robot.

house respectively. The fourth ball is not to be delivered.

Each package has a delivery marker, an ArUco code, and the same code is on the corresponding house. The ArUco markers are the 4x4 type and is printed as a 35 mm square, the embedded code is 5 for red, 6 for green, 20 for yellow and 53 for the fourth package.

The trolleys are connected using (super)magnets (a cube of 5x5x5 mm type W-05-G from supermagnete.de). The trolleys can be pulled or tipped by the magnet, but are fairly easy to detach as the magnets are embedded in 2 mm plastic. The package is open at the bottom, and the ball may roll out if the trolley is tipped. The package is 5x5x5 cm and the trolley is 10.5 cm long.

The houses has a front-yard that is 20 cm wide and 30 cm deep and marked with white tape (see figure 9a. The package is delivered if the center of the golf-ball is inside the front yard (the yard stops at the center of marking tape). A correct delivered golf-ball (with or without the package and/or the trolley) gives 2 points.

14   Autonomous robot at roundabout

A robot is trapped in a roundabout. It runs right (clockwise). The robot is approx. 17cm wide and 25cm long (see figure 9b).

The robot must not be touched and it gives -1 point for each touch (up to a maximum of -2 points). The speed will not be constant but be within the range of 0 to 50 cm/sec with an average speed of approximately 30 cm/sec over 20 seconds. If the robot is pushed, or for some reason loses the line, it will stop, but still, it should not be touched.

Placement of an obstacle or other actions that prevent the robot from driving counts as a touch.

15   The siren

The goal siren is activated by pressing the front plate (which mechanically activates a switch). The front plate is approx. 15 cm wide, 10 cm high and recessed approx. 1 cm in relation to the frame. 2 points are scored to get to the goal (and activate the siren). When the goal is activated, the run is over.

There will be AuUco markers on the front and back of the siren. Size 100x100mm and 4x4 code 25 (front) and 33 (back).

16   Reliability

There is two runs on the track, and if the score is 5 or above and the same score is achieved in both runs, one extra point is given.