Rules of the IEEE Standard Educational Kit 2019

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1 Introduction

In a rough terrain land in the city of Big River there is a gas pipeline submerged in a toxic water channel. However, parts of the pipeline have been damaged due to a strong earthquake. Because of Big River's lands and waters are difficult to access, this scenario has become perfect for the testing new autonomous robots capable of solving this problem.

As many robots were introduced, the pipeline company ran a competition to see which robots would be best suited for this purpose.

2 General objective

Participants should construct **up to** two robots capable of identifying the parts of the missing gas pipeline and fetch the pipes that will be available on the surface to repair it.

3 The Robots

Teams that only have one robot, it should be hybrid, *i.e.* it will act both on the surface and submerged. Thus, the robot can move through all areas of the arena allowed to the team.

Teams that have two robots should act collaboratively, being one for the surface and one for the water only. The **only** area they both can attend is the *meeting area*. Thus, the robot acting on the surface **can not enter** the green area, even if it frequents the **pipe collection areas** and **white areas**. In the meantime, the robot for water **may not cross the black line**, only going to the white area, the green ramp and the water. The entrance to the pipe collection areas is prohibited for the robot for water.

The **maximum permissible size** of the robots is a cube with $27cm \times 27cm \times 27cm$ with them fully developed. They do not have a maximum number of parts, sensors or controllers for their robots. However, it is noteworthy that they can **only** have pieces of a single robotic kit.

For example, if the chosen kit is the LEGO® Kit, no part or accessory from any other manufacturer (Vex®, pETe® or FischerTechnik®) may be used.

Robots must be fully autonomous, and no external interference is permitted unless authorized by the referee.

4 The Pipes

The pipes are built with standard PVC pipes with diameter of $50mm$ (approximately 2 inches) and with three different lengths. They are arranged randomly on the surface. They are supported by two stands. The stands are built on MDF/MDP and glued to the pipe as shown in Figure 2, *i.e.* the pipe and the stands form a single piece. The thickness of the MDF/MDP are sufficient for the pipe to remain horizontal, suggestion are $15mm$ thickness MDF/MDP stands.

The colors of the pipes are irrelevant, *i.e.* they can be of any color. Marks on the inside may be placed to facilitate identification of which team came the given pipe. In the Figures herein, the pipe colors are merely illustrative. The **important** is the color of the surface where the pipe originally is, which defines the size of the pipe.

Each pipe is arranged on a base that identifies its length: the yellow base presents pieces of $10cm$ in length, the red base presents pieces of $15cm$ and the blue base presents pieces of $20cm$. In Figure 1, we can see an illustration of the pipe collection areas with a pipe of the corresponding size in each.

The maximum limit will be **five** pipes of each length, totaling up 15 pipes arranged in the arena per round.

It is worth mentioning that the pipe collection areas will be in random arrangement in each match. However, the relationship between the color of the base and the length of the pipe is fixed.

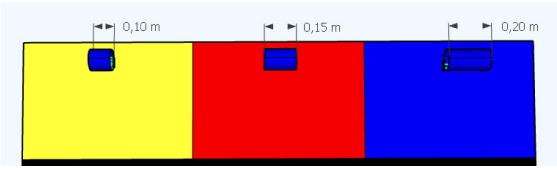

Figure 1: Pipe Collection Area - Colored bases identify the dimensions of the pipes, where they are randomly arranged.

5 The Arena

The arena consists of four main parts: pipe collection area (blue, red and yellow), interaction surface (white), water access ramp (green) and water (blue). The gas pipeline (Section 5.1) will necessarily be **"inside the water"**.

The surface are elevated of $10cm$ in relation to the water and the water are elevated of $10cm$ in relation to the ground. The access of the water to the

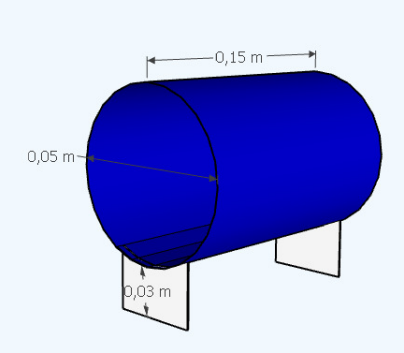

Figure 2: Example of 15cm long pipe. The colors of the pipes and the stands are irrelevant. The two MDF/MDP stands should be 3cm from the end of the pipe to the floor and glued.

surface are through a ramp with slope of approximately 15^0 identified in green color.

The surface also have an area bounded by a line made of black tape approximately 19mm wide, leaving an area of 1.25m^2 in white, which will serve as a meeting point between the two robots, being the proper place to do the interaction, as shown in Figure 4.

The dimensions of the arena are shown in Figures 3 and4, and an isometric perspective of the arena is shown in Figure 5.

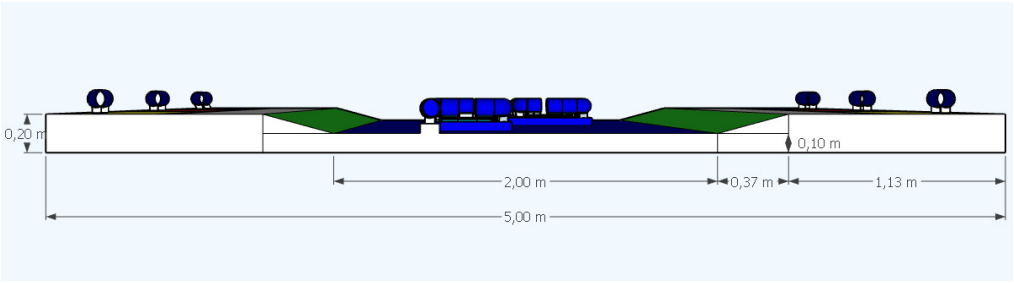

Figure 3: Front view of an arena example with its dimensions.

5.1 The Pipeline

The pipeline shall be represented on top of a platform with an elevation of 5cm from the base of the water. The pipes are mounted are described in Section 4. It is worth mentioning that the configuration of the pipeline is random, following the possibilities of the modular blocks defined in Section 5.2. When the robots are running, a robot can not invade the area of action of the opposing team.

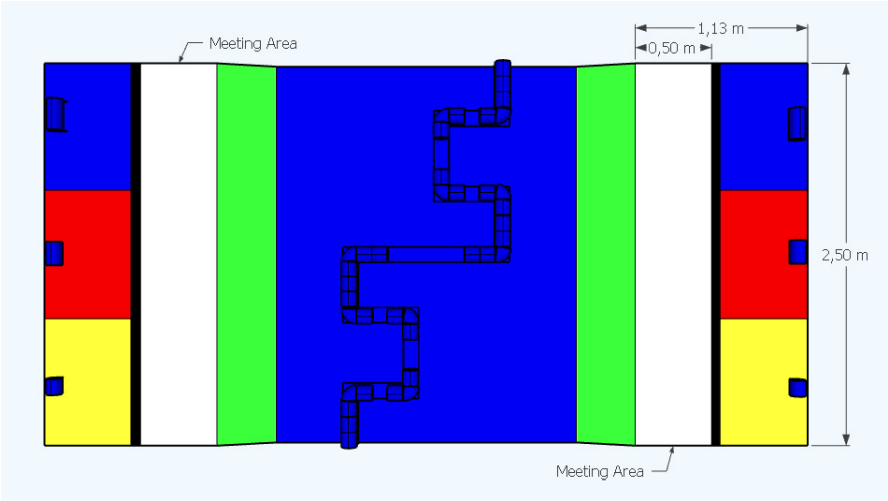

Figure 4: Top view of an arena example with its dimensions. The pipeline is merely illustrative and its layout is detailed in the next section.

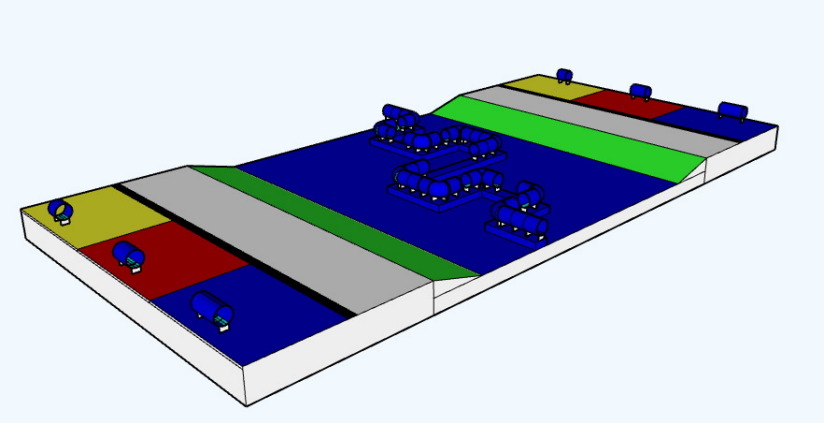

Figure 5: Isometric perspective of an arena example. The pipeline is merely illustrative and its layout is detailed in the next section.

The pipeline is shared by both teams who must not remove or change the pipes in their initial configuration. It is allowed only to add pipes to the pipeline. An example of a pipeline is shown in Figure 5.

5.2 Arena Assembling

The entire arena is assembled with parts made of MDF/MDP, separated into 5 large blocks: a modular block that represents the water and the base of the

pipeline, two blocks for the surface access ramps and the other two blocks to the surfaces.

The blocks are covered with colored adhesive in the colors indicated in Figure 4.

The water block is $2,0m \times 2,5m$, as described in the Figures 4 and 3. MDF/MDP pieces compose this part of the arena with heights of $0.1m$ for the robot's displacement in the water and $0.15m$ in which the pipeline will be above. Figure 3 helps to illustrate. Six different types of MDF/MDP pieces are required to build this part of the arena and they are shown in Figures 6 and 7. The types are:

1. 2 pieces with blue top of $0.64m \times 2.5m$, height of $0.1m$ responsible for the sides;
2. 8 pieces with blue top of $0.08m \times 0.32m$, height of $0.1m$ responsible for the composition of the moving area near the pipelines;
3. 16 pieces with blue top of $0.27m \times 0.32m$, height of $0.1m$ responsible for the composition of the moving area near the pipelines;
4. 8 completely blue pieces of $0.08m \times 0.27m$, with a height of $0.15m$, responsible for the composition of the pipeline support;
5. 4 completely blue pieces of $0.08m \times 0.32m$, with a height of $0.15m$, responsible for the composition of the pipeline support;
6. 4 completely blue pieces of $0.08m \times 0.40m$, with a height of $0.15m$, responsible for the composition of the pipeline support;

The pipeline support parts will have pipes over them (pipeline), with missing pipes to be filled by the teams.

6 The Matches

Each team competes on one side of the pipeline, aiming to relocate as many pipes with the correct dimensions, into the possible free spaces. The team with the highest score (scores available in the Section 7) is the winner.

Each match will have a referee that will determine the team's score, arrange the arena's colors and the management of the pieces and colors in the dispute.

All robots start in a random position on the meeting area, placed by the referee, always aiming for symmetry between the teams.

The layout of the pipeline shall be defined by the referee before the start of each round. Furthermore, the referee defines the number and position of missing pipes to be replaced.

During the match, if the robot accidentally moves or fall the pipes through the pipeline, the team may request repositioning to the referee. However, this operation presents a penalty described in the score (scores available in Section 7).

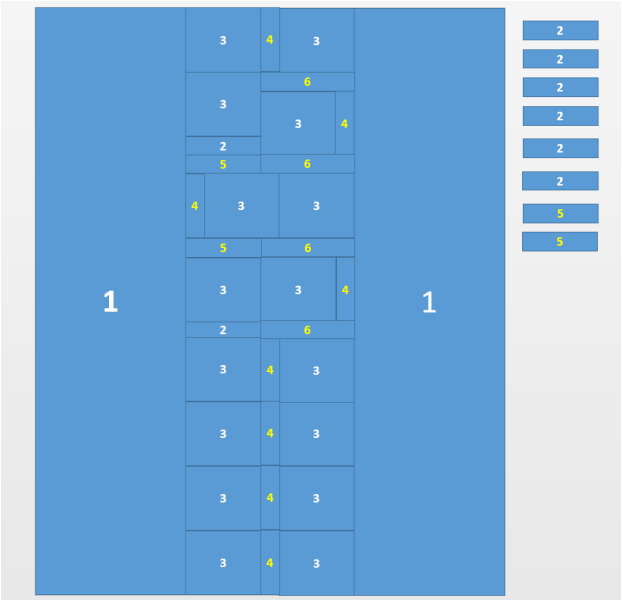

Figure 6: Example of modular block assembly with the water and the pipeline support. The numbering represents the size of the blocks and the color of the numbers are their height, white numbers are blocks of $0.1m$ and yellow numbers are blocks of $0.15m$. The remaining blocks in this assembly are on the right.

Every time a team has problems with the robot(s) and needs to touch it, reposition it, restart the program, reassemble some loose piece or just gave a bug, it will be considered a restart.

Whenever a round of matches is started, all robots must be within reach of the referee. Moreover, no team can make any changes to any of the robots.

The maximum time of each match is *10 minutes*. In the event of a tie, the following tiebreaker criteria will define the winning team in order of importance:

1. Number of 20cm pipes successfully placed in the pipeline;
2. Number of 15cm pipes successfully placed in the pipeline;
3. Number of 10cm pipes successfully placed in the pipeline;
4. Lowest number of restarts;
5. Less number of pipe lost (see Section 8);
6. Fewer pipes knocked over top of the pipeline;
7. Lowest number of inactivity penalties;
8. Coin Toss.

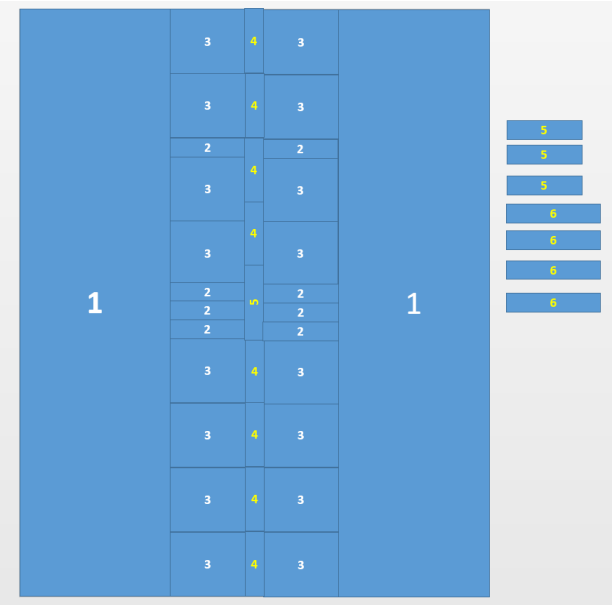

Figure 7: Another example of modular block assembly with the water and the pipeline support.

6.1 End of a Match

There are three ways to be decreed the end of a match:

- **Time-out**: the time of 10 minutes ends. Thus, the team with the highest score at the end of time will be the winner.
- **Give-up**: one of the teams gives up the game. Thus, the opposing team is immediately the winner.
- **Finished the task**: when the pipeline is completely repaired. Therefore, the team with the highest score at the end of the match is the winner.

7 The Scores

- Each 10cm pipe successfully placed in the pipeline: 170 points.
- Each 15cm pipe successfully placed in the pipeline: 210 points.
- Each 20cm pipe successfully placed in the pipeline: 250 points.
- Each pipe lost (see Section 8): -25 points.

- Each time a robot exceeds its permitted delimited area or leaves the lane: -20 points and the robot will be re-located in the meeting area at the place established by the match referee.
- Each restart of a robot: -25 points.
- Each pipe dropped from the pipeline that had been placed by the opposing team or that were in the same since the beginning of the match: -30 points and the pipe will be repositioned by the referee.
- Each repositioning of the pipes in the pipe collection area during the match: -15 points.
- Each pipe, of smaller length, placed in some larger space, will be counted the score referring to the size of the pipe, minus fifty points for having put in the wrong place. Example: 10cm pipe (170-50 = 120 points) and 15cm pipe (210-50 = 160 points).
- For every 30 seconds with the inactive robot: -20 points.

8 Important Comments

- A pipe is considered delivered successfully when it is static in the horizontal position on the support of the pipeline.
- A smaller pipe may be placed in place of a larger one.
- If a team "A" during the match moves or knocks down a pipe correctly positioned by team "B", the score achieved by team "B" will not be affected, only team "A" will be penalized.
- A pipe is considered lost when one of the robots removes it from its initial location (pipe collection area) and this pipe is misplaced in another place that is not the support to the pipeline.
- A robot is considered inactive when stopped or making any other movement that is not related with pipeline inspection, pipe collection, pipeline repair, or robot interaction with the same team (case of two robots).
- A pipe can be moved from one robot to another in the meeting area and the ground robot is allowed to discharge the pipe onto the ground for the other robot to pick up. If this pipe remains in the ground in the end of the match, this fact is a penalty.