IEEE Latin American Robotics Competition for Student

RULES OF OPEN Category – 2020/2021

Version 1.0 – March, 2020

Supporting Robots for Warehouse Operations

Introduction

The competition context is aimed at automating an environment with a large number of packages to be organized, Figure 1. The essence of the competition is extracted from environments such as warehouse, product distribution center, store stock, etc.

Warehouses automation is already a reality in large companies like Amazon and Alibaba, but it should be a reality in midsize companies soon. Think of a possible solution. Participants must build an agile and fast robot to organize as many packages as possible in a limited time.

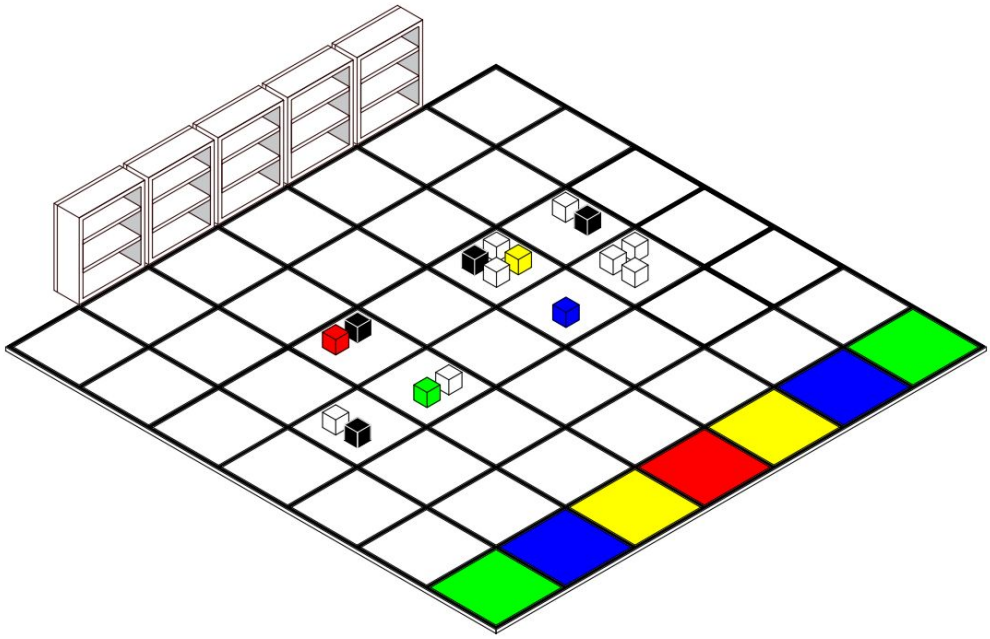

Figure 1 – general view of the contest

The goal

The robot can move freely in the scenario, but cannot collide or push a package out of the package's area. To reach the challenges of the competition, the robot has to take each package and take it to its destination. The objective is to take packages from a specific location and take them to predefined locations, so that, at the end, the packages are in a desired arrangement in the proposed scenario. The specific objectives are:

1. Take colored packages (yellow, red, green, blue) and take them to the unloading regions with equivalent colors.
2. Pick up packages containing bar codes and take them to their respective positions on the shelves.
3. Take the packages with numerical values and take them to their respective positions on the shelves.

Packages

Packages can be marked by color, barcode or numeric. The possible colors for the packages are: green, yellow, blue and red. The barcode is a simple representation containing only 16 possible combinations, in binary, from zero (0000) to 15 (1111). There is a specific region in the scenario where the packages are initially positioned, called the loading region. The numerical packages are white and the barcode packages are black.

Package Specifications

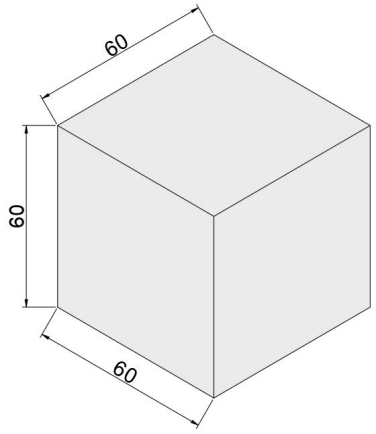

Figure 2 – Shape and dimensions of packages.

The packages are cubes measuring, approximately, 60mm x 60mm x 60mm, Figure 2, made by a 3D printer from the most common filaments on the market, ABS, PLA or PETG. The approximate settings for printing are 1 mm of thickness, 10% infill density, 1 mm thickness at the bottom and top. The approximate weight is 50 grams, which can vary 10 grams more or less.

The numerical cubes are white and have the same number on the 4 side faces. Values are two Arabic numerals. The area occupied by each number is in a rectangle shape 18 mm wide and 40 mm high. The first number is 10 mm away from the left edge and 10 mm away from the top edge. The second number is aligned at the same height as the first and aligned right with a distance of 10 mm from the left edge. The values that can appear in the cubes are 00, 01, up to 15.

The barcode consists in only 4 vertical bars filled with black or white centered on the side faces of the cube. Each bar with height 60 mm and width 12 mm. Thus, the free area on each side is two rectangles 6 mm wide and 60 mm high on the left and right sides. The white bars are of value 1 and the black bars are of value 0 and can form up to 16 combinations of zero (0000), one (0001) to 15 (1111). In Figure 3 you can see all these possible combinations.

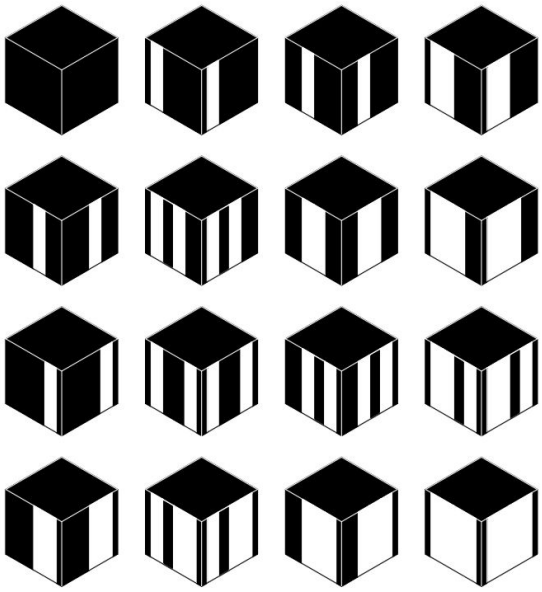

Figure 3 – Cubes with barcode from 0 (top left) to 15 (bottom right).

Scenario

Each package has a tag that identifies it and, consequently, its destination or destination region. The scenario basically contains three types of regions: transit region, package loading region and package unloading region.

The scenario is formed by 49 (7x7) squares, see Table I, for free circulation of the robot, for loading and unloading packages. The package loading region consists in two areas centralized in the scenario. Each area consists of four squares. Table I shows the two loading areas marked in gray and indicated by the squares {(3,2), (3,3), (4,2), (4,3)} and {(3,5), (3,6), (4,5), (4,6)}. This

numerical and gray marking will not be present in the real scenario and serves as a guide to better explain some details of the scenario. The white background squares, as shown in Table I, are aimed to allow the free circulation of the robot. There are two unloading regions: one for numerical packages and one for colored packages.

Tabela I: Arrangement of squares.

1,1	1,2	1,3	1,4	1,5	1,6	1,7
2,1	2,2	2,3	2,4	2,5	2,6	2,7
3,1	3,2	3,3	3,4	3,5	3,6	3,7
4,1	4,2	4,3	4,4	4,5	4,6	4,7
5,1	5,2	5,3	5,4	5,5	5,6	5,7
6,1	6,2	6,3	6,4	6,5	6,6	6,7
7,1	7,2	7,3	7,4	7,5	7,6	7,7

Arena Settings

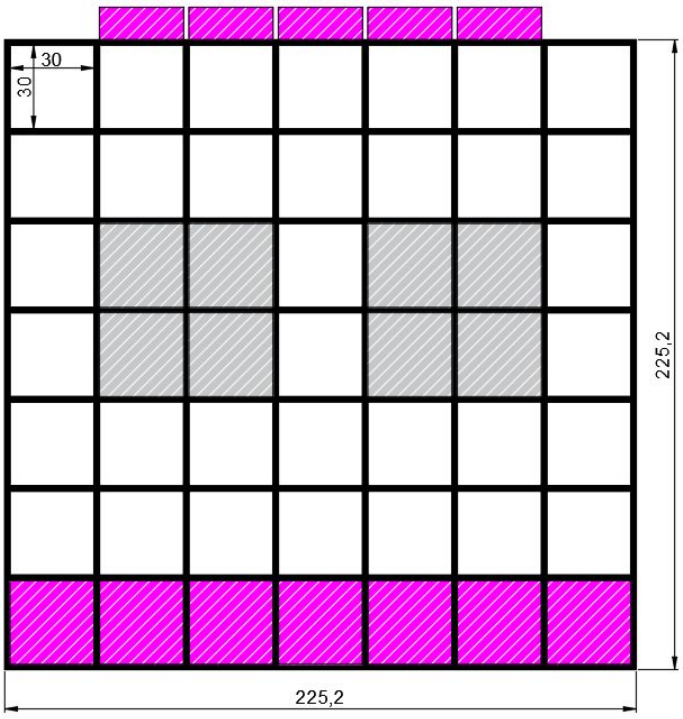

Figura 4 - Dimensions of the competition arena with loading and unloading regions hatched in gray and purple, respectively.

Each square in the scenario is determined by a black border, with an internal size of 30 cm x 30 cm and with an internal white color. The width of the border line is approximately 1.9 cm. The size of the scenario is approximately 225.2 cm x 225.2 cm. At the bottom, the 7 squares are colored and represent the region for unloading the colored packages (Figure 4).

The upper region, adjacent to the external boundary of the arena, has 5 centralized and aligned shelves between the second and the sixth square. The shelves are arranged next to each other and together they have 15 compartments. The compartments are numbered between 1 and 15. The compartment in the lower left corner has a value of 1, the second in the lower left corner has a value of 2, the highest compartment on the right has a value of 15, (Figure 5).

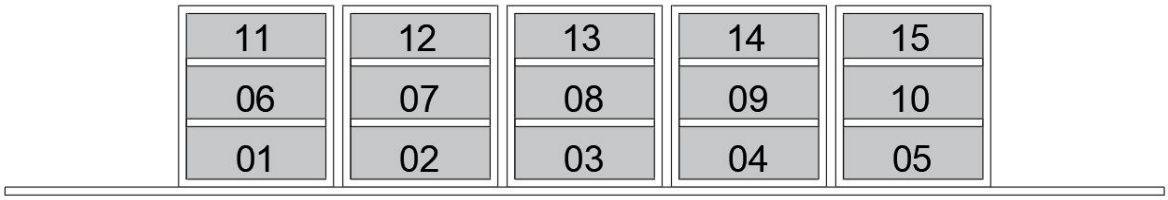

Figura 5 - Front view of the shelf compartments numbered 1 to 15.

Each shelf measures approximately 30 cm wide, with 3 parts, 10 cm high and 10 cm depth. Thus, since the shelves are made of 1.5 cm thick MDF, their total dimensions will be approximately 36 cm high, 30 cm wide and 11.5 cm depth (Figure 6).

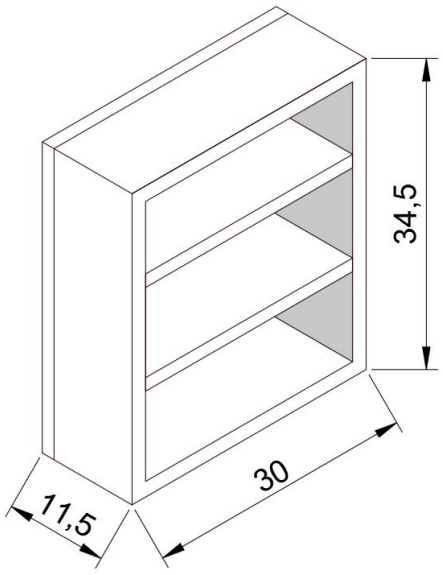

Figura 6 - Dimensions of unloading shelves.

Lighting Conditions

The local committee will try to provide uniform lighting throughout the arena. However, teams should be prepared to calibrate their robots based on the lighting conditions of the venue. The local committee will take actions to minimize the effects of shadows and natural light, however these factors cannot be completely eliminated. Therefore, it is highly recommended that competitors design their robots to be immune to the variations of lighting that can be presented in the venue during the competition. From the start of competitions, the teams will "play" under existing lighting conditions without discussion or claims.

The Competition Rules

For each team in each round, the positions of the packages will be defined by draw. After that, the team will not be able to modify their robot in any way. Changes and re-scheduling are allowed only after the round has ended.

When the robot starts its round no intervention can occur, otherwise it will be considered as a restart. The robot starts the race at the starting point and will be transferred to this position on each restart. Each robot will have a maximum of three attempts per round, therefore, 2 authorized restarts. For each restart, all moved packages are placed back in the initial position of the first attempt, but without stopping time. The organizing team will be responsible for re-arrange the packages.

If the robot presents an obvious mechanical problem, if the judge allows, the participating team can make an intervention at the robot. They can start again (it does not count as a restart) and the time does not stop. As a clear example of a mechanical problem, we can cite the detachment of a wheel, motor, sensor, battery without power, or any difficulty not associated with a bad design that prevents its normal operation and can be repaired within the framework of the form fast. The team, in this case, and only after authorization of the judge, can go to his bench and fix the robot. If the judge does not understand that there was a mechanical problem, it will not authorize the maintenance of the robot. Time does not stop at all.

A round is declared finished in three ways:

- If the round´s time is finished (5 minutes).
- If the team decides to terminate its participation, even if all goals have not been met. It is worth the score obtained and the time spent until the moment of closure.
- The robot has already used the 2 authorized restarts.
- When all packages are positioned in an appropriate location.
- If the robot leaves the arena four times.

The robot cannot leave the arena. Each time you leave the area, you will be punished with **- 100 points** and the **fourth time** that this occurs the round will be finished. Exiting the arena means when any part of the robot comes in contact with the floor out of the arena. If the robot gets

stuck or loses its balance, team members can make an intervention in their robot, but it will be considered a restart, and time measurement will not stop.

Punctuation

The score is counted in two phases. The first phase indicates the attempt to take the first package to the correct position. In the second phase, the score is assigned to each attempt to pick up and take the package to the destination position.

In the first phase, the scores are given as follows:

- 10 points for positioning yourself in front of a package;
- 20 points for picking up the package;
- 50 points per walk in the correct direction of the destination area of the package;

After reaching the 80 points of this first moment, no more points will be counted for this phase.

In the second phase, the robot will be able to take any package to its respective position. The following scores are possible:

- Colored Cubes:
    - 100 points for each color cube delivered in the correct region;
    - Maximum 400 points for 4 correct attempts.
- Barcode cubes:
    - 500 points for each barcode cube delivered in the right position;
    - 2000 points maximum for 4 attempts.
- Cubes with Arabic numbers:
    - 1000 points for each cube with numerical value delivered;
    - Maximum 8000 points for 8 correct attempts.

The scores for phase two will only be valid if the robot completely solves each task. Organize each package in its respective position.

If any team reaches the maximum score of the match an extra challenge will be launched. The robot enters the arena in a random position to pick up a package from one of the shelves in a random position. The robot must deliver the package to one of the loading regions. The score for the extra challenge is 4000 points. The competition judge is completely free to define the details of the extra challenge.

If the robot touches the package, it can only be removed from the loading area if the package is lifted. In this context, if the robot drags the package out of its area, the team will be penalized with a negative score relative to the score value associated with the package.

General rules:

- For each restart, the score is reset, the time is kept and the packages return to the starting position. Each round has a maximum of two restarts. It is up to the team to

decide whether to keep the score so far and to end the participation or if they will try a restart, with a new score returned to zero. It will ALWAYS BE CONSIDERED as the team's score for the round, the score of the last try.

- The first and main criterion for determining the winner is the highest score. If there is a tie the second criterion will be the shortest time. In the case of a tie in both criteria, an extra round for tie-break will be held. During the final rounds, when there is a tie in the score, there will be an extra round immediately to determine the 1st, 2nd and 3rd places

Any consideration or exception is at the discretion of judges and organizers.

The execution of the rounds

Before starting the rounds, if the team finds it is necessary to do a color or lighting calibration, an extra minute will be given to each team before its round.There are two types of rounds, qualifying and final:

Qualifying rounds:

- All registered teams in the IEEE Open category must participate.
- Consists of 04 rounds per team. This number may vary, at the discretion of the judges / organization of the event.
- The maximum time per team to perform the round is 5 minutes with 1 extra minute of initial calibration.
- Each team can restart their robot twice per round. For each restart the score will be zero and the time will not stop (time running).
- The best score of the four rounds will be taken into account to decide which teams will advance to the final rounds. The four best teams will be qualified to finals.
- If there is a tie, it will be chosen who got the score in the shortest time. If the tie persists, a new round between the tied teams should occur.
- Each team has 1 minute to appear in the arena, after that period, the time of the competition begins to run.

Final Round:

- The top four teams in the qualifying rounds are in attendance.
- It consists of 03 rounds.
- Maximum time per team to perform the test is 5 minutes + 1 minute of calibration.
- Each team can restart their robot twice per round. For each restart the score will be zero and the time will not stop (time running).
- The best score of the 03 rounds will be taken into account to determine the champions.
- If a tie occurs, a fourth round will be played between teams tied to define their place.
- Each team has 1 minute to appear in the arena, after that period, the time of the competition begins to run.

Requirements to Participate

Those interested in participating in the Latin American Robotics Competition LARC IEEE OPEN category must form teams of undergraduate or graduate students in any educational institution in any country. Nevertheless, high school students will also be allowed to participate. To register, teams must submit a document describing the development and operation of the robot (TDP) in IEEE format. This TDP will be used for the winners to make a brief report to the other competitors. Please, verify the deadlines on the event website.

The Jury

The JURY is composed by a member of organizing chairs, an auxiliary of the organization and a member of another team that is not competing in the match, chosen before the match starts.

Extraordinary Situations During the Competition

If there is any situation not covered under the above mentioned rules, or any doubt about the score, it will be up to the judges and the organizers of the competition to consider the case in the greatest possible impartiality and make a decision. It is important to mention that any fact that it is not explicit in the rules cannot be automatically considered as allowable in the competition. Missing facts will always be treated as **extraordinary situation** and it must be judged as allowable or not by the judges and organization