**Requirements Document**

**Project:**
**Task:** To collect blocks and build a tower.
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**Revision History:**

**V1.0:** Initial upload of document (Jastaj Virdee, Harley Wiltzer, Jenny Zhao, Juliette Regimbal)
**V2.0:** Added constraints in sections 2.3.3 and 2.3.5 to cooperate with the revised Project Specifications (Harley Wiltzer)
**V3.0:** Revised sound constraint in 2.3.5 and performance constraint in 2.6 due to revised Project Specifications (Harley Wiltzer)
**V4.0:** Added target zone size restriction in 2.5.2 to cooperate with the revised Project Specifications (Harley Wiltzer)

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## 2.0 CAPABILITIES

## 2.1 PURPOSE

The purpose of this project is to create an autonomous robot that competes against another robot in manipulating styrofoam blocks according to its designated role. The robot must start in its designated corner and localize within 30 seconds before starting its task. The roles are defined as follows:

### 2.1.1 BUILDER

The Builder must identify and gather styrofoam blocks from the playing field and attempt to stack them in a designated green zone. Moreover, the Builder is forbidden from entering any of the starting corners and the red zone. The goal of the Builder is to build the tallest structure of styrofoam blocks, where the entire structure must lie within the green zone.

### 2.1.2 GARBAGE COLLECTOR

The Garbage Collector must identify styrofoam blocks from the playing field and displace them to the red zone, effectively stealing potential building blocks from the Builder. Furthermore, the Garbage Collector is forbidden from going to any of the four starting corners and cannot enter the green zone.

Regardless of the robot's designated role, it must complete its task within 5 minutes from the starting time (including localization). Furthermore, the robot is forbidden from colliding with another robot or any obstacle (including walls and wooden blocks), and the penalty for such an event is immediate disqualification.

Ultimately, the robot wins if it score more points than its opponent. Points are awarded as follows: 1 point for moving a block into the appropriate zone (green zone for the Builder or red zone for the Garbage Collector) and extra points are awarded for stacked blocks for the Builder. Each stacked block is worth the same amount of points as its stacked level – that is to say, a block that is stacked on top of two other blocks is worth three points.

## 2.2 SCOPE

The robot must be constructed using parts provided in 4 project kits and other parts that may be approved for use. Parts and components should be as inexpensive as possible without significantly impeding the robot's ability to perform the task.

Operation must occur on a 12' by 12' hardwood field with black grid lines marked at 1' increments. Two special zones - red and green - exist for scoring and are defined as rectangles from points (0,5) to (2,9) and (6,3) to (8,4) respectively. If designated a builder, the robot moves blocks and constructs a tower in the green zone. If designated a garbage collector, the robot moves as many blocks as possible to the red zone. The robot cannot enter a zone that does not match its designation, nor can it enter the 1' by 1' corners of the field that serve solely as starting zones.

All tasks must be completed within 5 minutes, during which the robot must localize, perform the assigned task, and return to its starting corner. Localization must occur within the first 30 seconds and the robot's center of rotation must remain in the tile. Robots are not permitted to directly interfere with its competitor during competition.

Collisions must be avoided with wooden blocks placed at random positions and orientations on the field, but not in the red or green zones. Collisions with the opposing robot must also be avoided.

Execution and the 5 minute duration begins when the robot receives parameters via WiFi that include the Builder Team Number, Builder Starting Corner, Collector Team Number, Collector Starting Corner, and the *x* and *y* coordinates of the lower left and upper right corners of the red and green zones in that order.

## 2.3 CONSTRAINTS

The robot must be built using only the materials provided in four Lego Mindstorms kits. This includes four EV3 bricks, 32 mid-sized servo motors and 4 smaller servo motors, 4 ultrasonic sensors, 4 light sensors, 4 color sensors, 4 gyroscopic sensors and an abundance of building blocks and structural pieces.

### 2.3.1 HARDWARE LIMITATIONS

Up to four EV3 bricks may be used in the construction of the robot. Each brick can be connected to up to four motors and four sensors. An EV3 brick is powered by a 300MHz ARM9 processor, and has 64MB of RAM, 16MB of Flash memory, and a microSDHC slot. The brick also has a 178x128 pixel monochrome LCD character display, and 6 buttons (exit, enter, arrow keys). Furthermore, the brick includes WiFi and Bluetooth support, which can be used to send data to the brick wirelessly. Finally, programs may be uploaded to the brick via its microUSB port.

### 2.3.2 SOFTWARE LIMITATIONS

The robot must use the leJOS EV3 firmware, which includes a Java Virtual Machine (JVM) . Software for the robot must be written in Java, code must be uploaded to the robot as a JAR archive.

### 2.3.3 MECHANICAL LIMITATIONS

The structure of the robot must be made entirely out of Lego Mindstorms plastic parts. These parts are light and are prone to flexing or cracking if large loads are applied to them. Furthermore, the resilience of the mechanical devices will affect the performance of the robot: tire deformation, for example, can cause drastic error in odometry calculations.

The performance of the motors and sensors may vary. Some servo motors, for example, may be capable of very precisely reporting tachometer values while others struggle to do so. Likewise, some sensors may pick up significantly more noise than others. Software filters may be designed to reduce these effects.

Furthermore, there is a constraint on how the robot may go about dragging or lifting blocks. The robot may not stab or pierce the styrofoam block in any way, meaning it must be ensured that the robot's method of manipulating styrofoam blocks does not damage the block.

#### 2.3.4 TIME LIMITATIONS

Robot must be complete by November 29th, 2016. All documentation must be finalized by December 2nd, 2016.

The robot itself has some time constraints as well. Notably, it has five minutes to complete the following tasks:

- Localization (must take 30 seconds or less)
- Build tower or collect garbage (depending on given role)
- Return to its starting corner

By the 5 minute mark, the robot must be back at its starting corner to be awarded any points.

#### 2.3.5 LIMITATIONS ON USER INTERACTION

The user may not have any contact (physical or electrical) with the robot once the game has begun. However, the robot may provide feedback to the user by means of sound or visual information via its LCD screen. In fact, the robot must make a beeping sound after it has finished localization, so that the judges can verify that it has localized in time. Failure to do so will result in disqualification. Furthermore, the robot may only one sound during localization, and that must be when the robot has finished localizing.

### 2.4 USER FUNCTIONS

The user interacts with the device in two phases: before operations begin (disabled state) and during operations (enabled state). During the disabled state, the user has access to a menu to select different modes of operation and diagnostics, with basic feedback given depending on which mode is selected. Feedback is given via the LCD screen built into the EV3 brick, while user inputs are received using the directional and enter buttons on the brick.

During operation the robot cannot take feedback from the user other than a signal to halt. This is due to the constraints in section **2.3**. However the robot can can provide the user with audio and visual feedback. The LCD displays the current $x$, $y$ and $\theta$ coordinates as measured by the odometer. Below the coordinate display, the current robot state is displayed as well as other information specific to the task being performed. Signals during operation such as detecting a block or scoring are signaled by the EV3 emitting a beep or series of beeps. The user should have documentation to explain the different audio signals the robot may or may not produce during different stages of execution.

At any time the user can halt the robot using the escape button in the upper left corner of the EV3. The robot state will switch to disabled and all processes will stop, but the LCD will continue to display previous information for diagnostic purposes. Pressing any button at this point will fully terminate the program.

## 2.5 OPERATING ENVIRONMENT

### 2.5.1 LOCATION

The competition will take place on the 2nd floor of Trottier building. The robots will operate in a maze-like configuration, with obstacles (wooden blocks) and target objects (blue Styrofoam block) scattered at random orientation and random location.

### 2.5.2 COMPETITION SURFACE

The competition surface is composed of nine 4x4 hardwood panels. Each panel marked with black gridlines that is 3mm in width and 30.48cm apart. The gridlines are to assist with the robot odometry correction. The competition floor is surrounded by 30 cm tall wooden boards that act as a fence, to prevent the robot from falling off the edge and to assist robot localization.

Two target zones, the red zone and the green zone, will be designated on the playing surface in tile coordinates. It is assured that these zones will never be smaller than one square by two squares, and will never be larger than two squares by four squares.

### 2.5.3 AMBIENT LIGHTING

The light source for the competition environment is natural sunlight and indoor lighting. This lighting environment forms an operating basis for the robot's light sensors to detect color of objects, which is related to performing tasks such as odometry correction and object identifying. There may be other ambient lighting, such as a projector, that acts as interference to the light sensor.

### 2.5.4 EXTERNAL SOUNDS

The competition environment will be noisy, with people talking, and possible construction noise outside the building. All of this would not affect the robot's ultrasonic sensor. However, the robot will be subject to ultrasonic interference from the other robot's ultrasonic sensor in the playfield.

### 2.5.5 TEMPERATURE

The operating temperature is ideally room temperature 21C. It is expected to go up slightly as time passes, as the room will always be occupied by people. This will not affect any of the robot's sensors. However, temperature change could cause the robot's rubber tires to deform, leading to slight deviation in odometry.

### 2.5.6 RESTRICTIONS

Several restrictions have been discussed in previous sections. (to be updated)

## 2.6 PERFORMANCE

Once the robot is placed in the starting position (one of the four corner tiles), the code will be executed in the usual manner by pressing the Enter button on the EV3. From this point on there may be no physical or electronic contact with the robot. After establishing a connection to the competition server, the robot will only be allowed to move once it receives the parameters for the current run (see 2.2 for list of parameters).

As seen in 2.3.4, once the parameters are received, the robot will have 5 minutes of playing time. During this time interval the robot must first localize, build a tower or collect garbage (depending on the given role), and return to its starting position, which will be one of the four corners. It should be noted that localization must occur in the first 30 seconds of the 5 minute interval. Furthermore, the initial orientation and starting corner of the robot will be determined by a referee before localization occurs.

It is difficult to determine how far the robot will travel seeing as there are too many unknown variables. These include the robot's starting corner, the positions of the wooden and Styrofoam blocks, and how our robot will interact with the other. However what is known as seen in 2.2, is that "operation must occur on a 12' by 12' hardwood field with black grid lines marked at 1' increments".

The EV3 requires either AA batteries or the rechargeable battery pack to function. For the competition, either new batteries should be used or the battery pack should be charged completely to enable the EV3 to function to its maximum capacity.

## 3.0 COMPATIBILITY

### 3.1 COMPONENT REUSE

As mentioned in **2.3**, the robot must be built using the components from up to 4 Mindstorms kits. Therefore some of the components used throughout the five labs will in fact be reused. It is important to test all four of some of the components (such as the motors and sensors) so that the ones that function the best can be used. This will minimize error, enhancing our robot's functionality.

Part of the goal of the weekly labs was to prepare us for the project, which means it is expected that some of the code that was written will be reused. For example our robot will need to localize and navigate, as well as keep track of where it is located on the grid, all of which was accomplished at some point in the labs. Like the physical components, it is important to test the code from the four groups, and use the code that works the best for the specified task. However any code that is being reused will likely have to be modified to match the specifications of the project.

### 3.2 COMPATIBILITY WITH THIRD PARTY PRODUCTS

In terms of physical components, the robot will mostly be made from the parts in the Mindstorms kits. However it is possible to use other products, but the approval from the professor(s) is needed. The system must also be able to work with Eclipse and LeJOS so that the code (written in Eclipse) can successfully be uploaded to the EV3 as a LeJOS program.