Notice of Request for Proposal

Project: Autonomous Product Retrieval System

Buy More, a home entertainment, computer and gaming store will accept proposals for an autonomous robot to be used to retrieve boxes from a warehouse (Autonomous Product Retriever, APR). This RFP covers a scaled prototype for the system to retrieve packages from the warehouse and drop them off at an order fulfillment area. Proposal submitters will be required to attend a prototype demonstration and also give a presentation to the Buy More distribution management and technical team.

Background information:

Buy More's strategic decision to close their brick and mortar stores and turn their focus to online sales has ultimately created high volume in their distribution center. Buy More's guiding principle for the next decade is *Buy more of less* versus the old principle of *Buy more of more.* As a result, the company will reduce the number of SKUs (stock keeping units) they carry. This will allow them to work with their suppliers on volume discounts and special packaging. Due to labor issues in the past, the company made the strategic decision to reduce the number of employees at their distribution center and plan to install an Autonomous Product Retrieval (APR) system.

Order processing

The APR will eventually interface with the current inventory system, Where's the Ware (WTW). Currently when items are received, the forklift driver scans the barcode on the box and then places the item in a location based on the instructions from WTW. WTW stores the item number and the location, along with other information.

When an order is placed, WTW produces a pick list. The pick list includes the product barcode, box location and order fulfillment area. The APR will receive this information, go to the box location, and verify the correct product is in the location (using a barcode on the box). If the product is correct, the APR brings the product to the correct order fulfillment area. If the product is not correct, the APR sends a message including the actual barcode and box location to WTW so the information can be updated. WTW will then send the APR to another location.

Since submitters will not be given access to WTW for this RFP, if you experience an incorrect product in a location, please display the location and the barcode of the item in the location on the screen of the APR and then return to the starting position.

Description of the Scaled Facility for Proof of Concept

The scaled facility has no physical walls and is approximately ten feet by nine feet (see Figure 1). The facility has five horizontal aisles and three vertical aisles, each aisle being one-foot wide, in which to maneuver. The boxes are stored on shelving at ground level, with each shelf holding up to six boxes that are accessible from one aisle and a different set of six boxes on an adjacent aisle. (Note: while a shelving area may hold a maximum of 12 boxes (6 in each of 2 rows), there may be some boxes missing.) The warehouse locations are equally spaced across the shelves and each location is 6" wide. The boxes are placed on the shelf based on the center of the 6" location. (The center of the box should be in the center of the location). The first location center is 3" from the edge of the shelf.

There are a total of eight shelves in the scaled facility, each being 3 feet long and one foot wide. A rough sketch of the facility is provided in Figure 1. Home A is the starting point for all retrievals while Home B, C, and D are the order fulfillment areas. After dropping off at Home B, C or D, the APR will return to Home A for the next pick list.

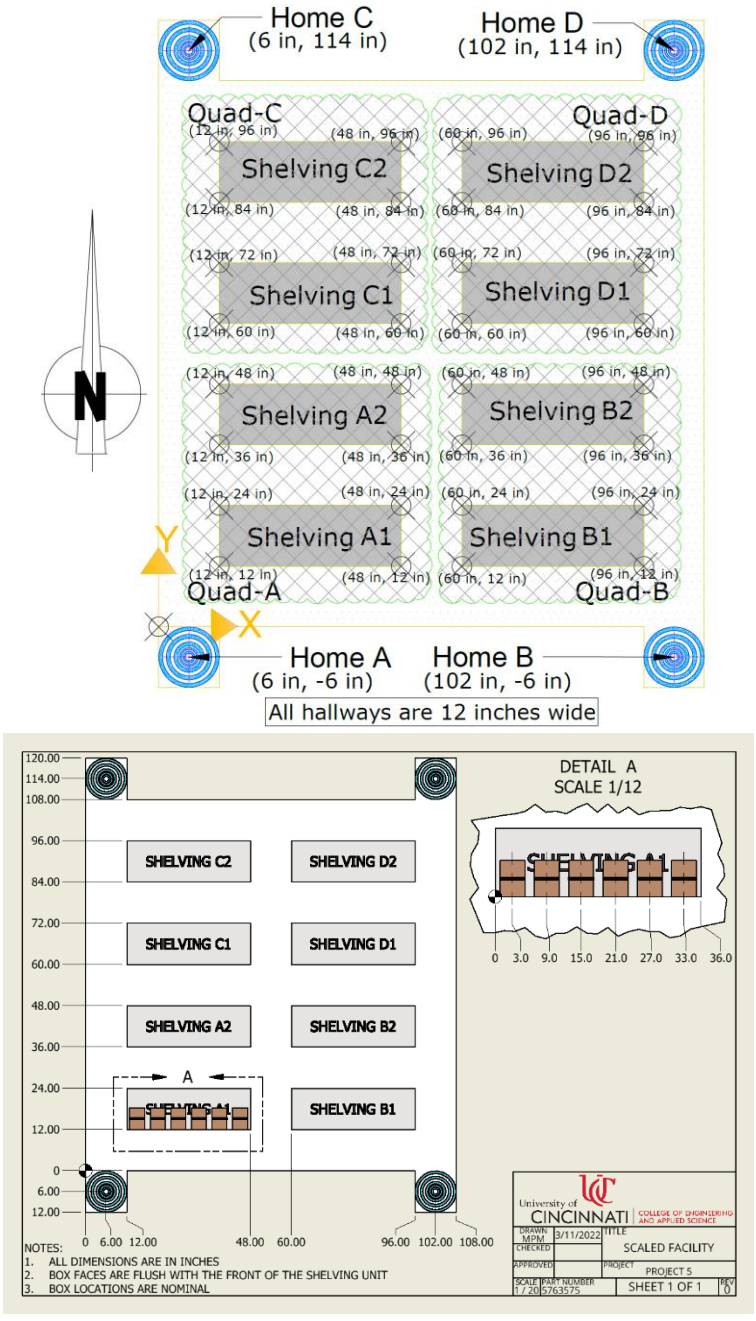

Figure 1. Schematic of the scaled facility showing x, y coordinates

Figure 2 shows a pictorial representation of box locations in the shelving area. All boxes are on the ground level. **This figure is only an example representation**; boxes can be located in any of the storage locations

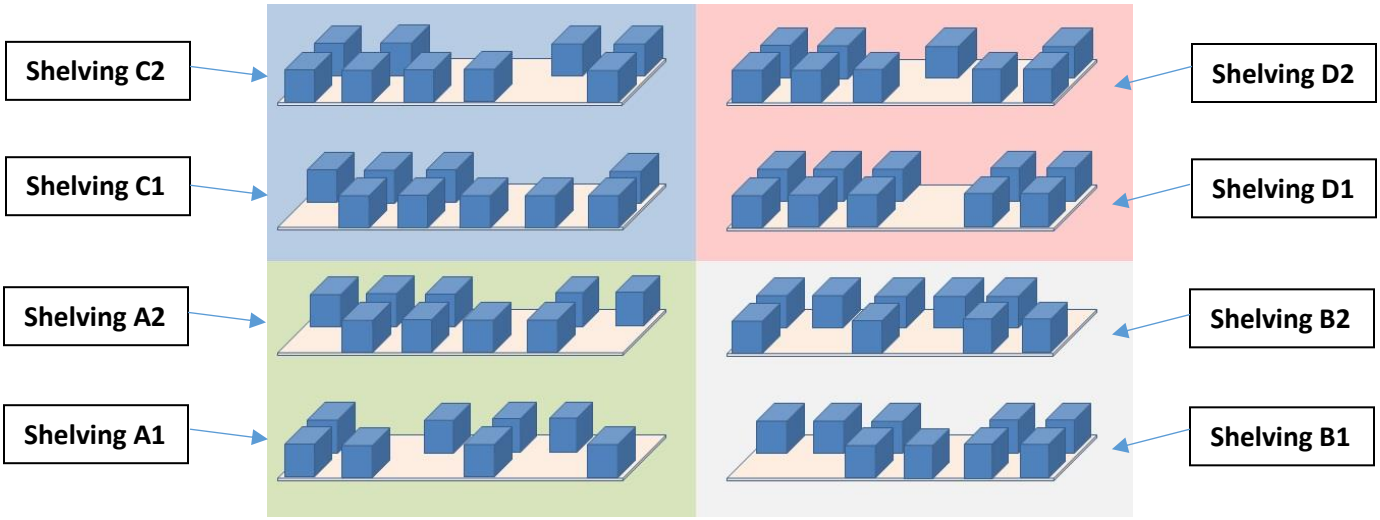

Figure 2. A pictorial representation of box locations in the shelving area.

Inventory location

The inventory location consist of the shelving unit (A1, A2, B1, B2, C1, etc.), and the location on the shelves. Below is a sample of how the locations are numbered on a single shelving unit. All shelving units will be numbered 1 to 12, with location 1 being in the Southwest corner of the shelving unit and location 12 being in the Northeast location. In Figure 3 there is no box in location 1. An example of a location is A2_3.

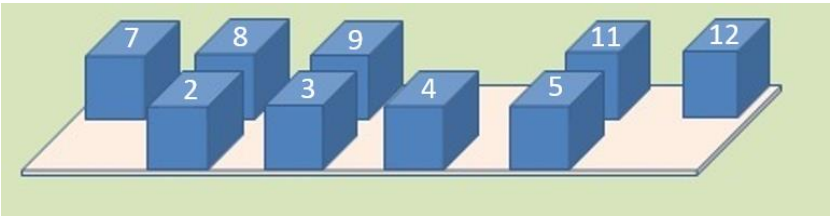

Figure 3. A pictorial representation of location numbering in the shelving area.

Box Specification for Scaled Prototype

See posted drawing *PrototypeBoxR2* for more details and the manufacturer of the box.

Dimension (inches):

- Height: 6 5/8 + ½ / - 0, Width: 4 3/8 ± 1/8, Depth: 6 3/8 ± 1/8
- Lifting Handle: A rigid handle approximately ½ ± 1/8 in. wide is located approximately ½ ± 1/8 in inch above the box, centered and spanning the box width.
- Weight: < 200 grams
- The boxes are cardboard and the handle on each box is metal.

Description of the Barcodes

Box verification can be performed using a crude barcode scanning technique. Each box will have both a horizontal and vertical barcode. Your robot needs to scan either a horizontal or a vertical barcode, but not both. Figure 4 shows the four different barcodes that will be used in tesing the prototype. See Figures 5 and 6 for the placement of the barcode on the box.

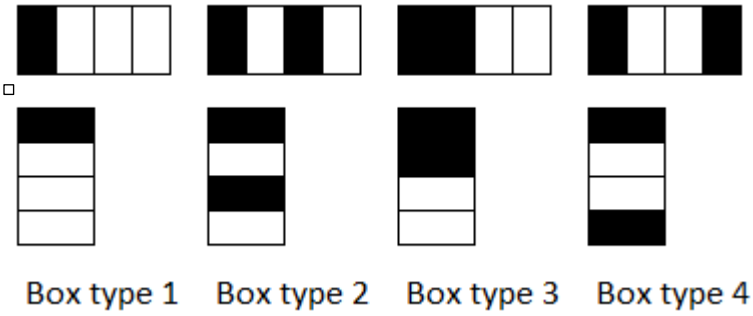

Figure 4. Example of barcodes in horizontal and vertical directions

- The horizontal barcode is one inch tall and has 4 – 0.5 inch segments; the vertical barcode is two inches tall and has 4 – 0.5 inch segments as shown in Figure 5.
- The horizontal barcode should always be scanned from left to right and the vertical barcode scanned from top to bottom.

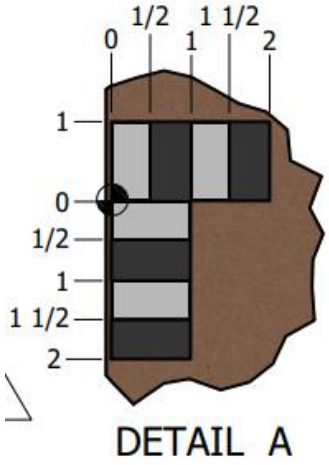

Figure 5. Dimensions of the barcode

All units in inches

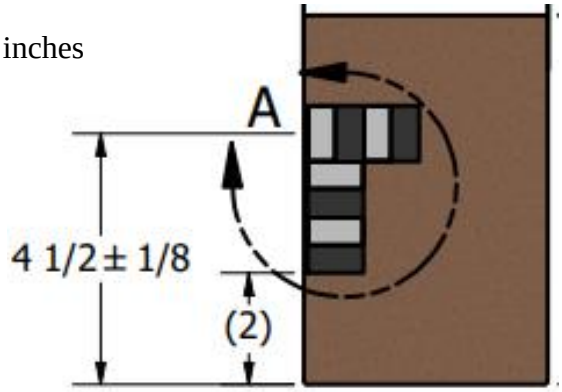

Figure 6. Placement of barcode on the box

- The horizontal barcode will be positioned on the left edge of box with its vertical center located 4 1/2 ± 1/8 inches from the bottom of the box. The vertical barcode will be positioned directly below the horizontal barcode with its left side running down the left edge of box (see Figures 6 and 7).

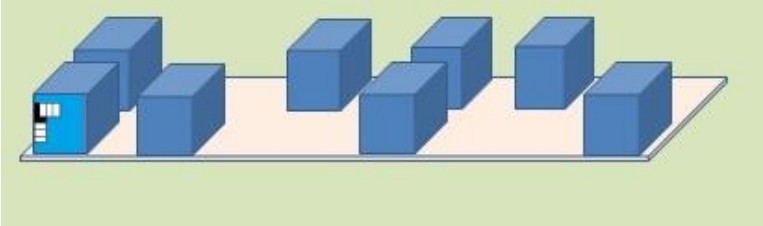

Figure 7. Location of barcode on box (larger view)

General requirements of the autonomous record retriever (ARR):

1. After receiving an inventory location, barcode and fulfillment area, the APR will travel to the box. Format of pick list is shelving unit_, location on shelf, barcode, fulfillment area (ex. [A1_3, 1 , C])
2. Use barcode scanning techniques to determine the product and check it matches the product asked to retrieve.
3. If the barcode matches, pick up the product and bring it to the correct order fulfillment area (B, C or D) as specified in the pick list.
4. If it is the incorrect product, display the location and barcode in the location.
5. Operate autonomously in a timely fashion as entries will be evaluated based on time to complete a retrieval and distance traveled.
6. Navigate indoors without the aid of GPS (Global Positioning Satellites) or other more traditional forms of indoor navigational aids (e.g., walls, lines, markers). At all times the ARR must know its location in the facility.
7. Avoid collisions with humans and other objects in its path (including another robot).
8. Not come in contact with boxes other than the box being retrieved.
9. After it has dropped off the product, or identified the wrong product, return to Home A, align itself to be ready to retrieve the next box.

Constraints

- Must be programmed in LabVIEW or Python
- Limited to parts in the LEGO kits supplied or 3D printed parts

Evaluation

The proof of concepts will be evaluated based on the following:

- Ability to get to the correct location
- Ability to verify the product is the correct product
- Ability to pick up the box and drop it off at the correct order fulfillment area
- Ability to return to Home A and receive another order request.
- Speed (travel time from home to order fulfillment area)
- Efficiency (minimize distance traveled)
- Safety (avoidance of obstacles)

Request for Additional Information (RFAI)

There will be opportunities for teams to ask questions about required functions to have a better understanding of the problems and tasks. Questions will be presented and answered in a Frequently Asked Question section in the Project 4 Page on the CANVAS Community Page.

Demonstration

During the demonstration, teams will have the opportunity to show the functionality of their ARR. Each team will be given 2 locations and product barcodes. They will be expected to go to the location, check if the correct product is stored there. If it is the correct product, pick up the product and bring it to the correct order fulfillment area. If it is not the correct product, display the location and the actual bar code on the box at that the location.