Small Package Identification and Delivery Robot (SPIDeR)

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***Abstract*—This paper presents the development of an intelligent robotic system designed for automated miniature warehouse storage. Using the Yahboom Raspbot-based robot equipped with image recognition. The robot's primary function is to locate small items marked with AprilTags and transport them to designated locations within a warehouse environment. This alleviates navigational challenges for human workers. Utilizing computer vision for AprilTag recognition, the system effectively identifies and relocates items, enhancing operational safety and efficiency.**

***Index Terms*—Raspbot, Robot Intelligence, Path finding**

I. Introduction

Robots are continually being used to take on dangerous tasks. This protects human life and allows companies to be safer. According to the Bureau of Labor Statistics, the number one cause of injury is overexertion and bodily reaction. [1] The robotic solution presented in this paper is to help reduce this and other workplace related injuries. This is done by using the Yahboom Raspbot hardware. This small modular robot allows for a scalable approach to improving worker safety.

Warehouses are common places where people are lifting objects and must move them to a new location. By offloading this task of moving objects to the robots, employees are able to remain safe and perform other necessary tasks. The robots are able to reduce their load, and contribute to cost savings for the company as well.

In application, the robot will be able to identify objects that need to be moved. It will then identify the goal location and take the object to that location. This small scale application may then be scaled up for different sized objects depending on the needs of the users.

II. Related Work

In industry, large scale robots are used to streamline processes. These robots are used to do everything from creating the product, packaging, and loading the trucks. These systems are fully autonomous. These systems are also very expensive, which prices out most businesses.

Other research has been done by using small robots to assist workers in increasing productivity. This approach uses reinforcement learning to train the robot to work in diverse configurations and is more adaptable compared to other robotic applications. [2]

There are many options when it comes to automating a warehouse. Yet in the search for cost effective options that will leave the buyer with options, lower barrier of entry for using the robot, there are not many options. This is why this robot could provide another cost effective option to the above mentioned robots.

III. Methods

To solve the warehouse delivery problem, we identified the Yahboom Raspbot as a suitable robot. It has many of the necessary sensors and can easily be adapted to your needs. The problem with the Raspbot is it is only as powerful as the computer in it. We were donated a Raspberry Pi 3 for this task. Unfortunately, this did not have sufficient processing power to handle more complex tasks. As such, our desired solution had to be simplified.

Our initial requirements defined included using OrbSLAM and other libraries. It became clear very quickly that the Raspberry Pi did not have the capability to run this software. As such, we had to adjust our initial plan.

After making adjustments due to the mentioned limitations of the Raspberry Pi 3, we determined the methodology would be outlined as in Figure 2.

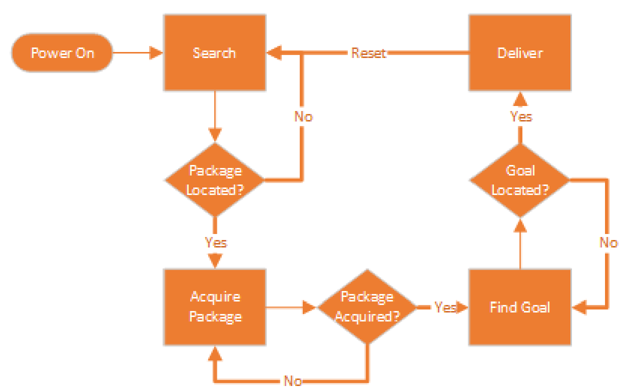

Fig. 1. Methodology for Robot

After powering on the robot, it would go through four main processes: Search, Acquire Package, Find Goal, and Deliver. Once complete, it would reset and start the process all over again. The SPIDeR was able to identify the AprilTags, acquire the package, and deliver it to the goal with the corresponding AprilTag.

As AprilTags look and function like QR codes, this uses something that people are used to seeing. The robot is also small. These qualities help lower the barrier of use for the consumer by appealing to familiar items. The resulting robot is able to deliver small goods across a smooth concrete warehouse environment.

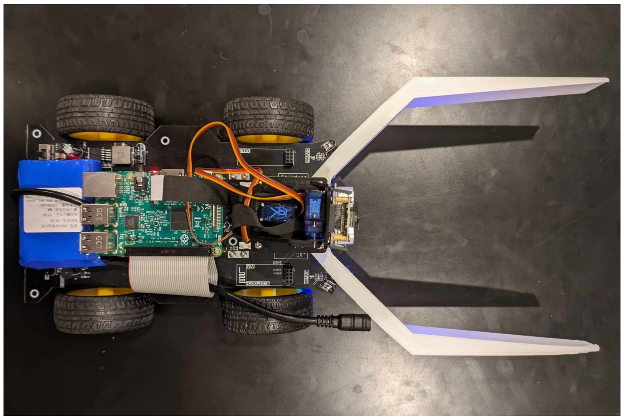

Fig. 2. 3D Printed "Mandibles" Enable SPIDeR to Move Objects with Ease

Additionally, SPIDeR utilizes it's four downward-facing infrared sensors located on the front to quickly detect whether it has reached it's destination. Package drop-off zones have a different level of reflectance compared to the rest of the warehouse for this purpose. A recent history of the sensor returns is maintained during operation - this allows the system to ignore false positives by only acting when a consistent change is detected.

SPIDeR is also equipped with a passive buzzer. This enables the system to audibly communicate its status to those working in the warehouse. In it's current version, it plays distinct sounds for when it has initialized, when a package is located, and when a package has been successfully delivered. By sharing its current state, SPIDeR promotes a safe, efficient, and efficient workplace.

IV. Results and Discussion

The SPIDeR solution demonstrated commendable performance in package handling within the simulated warehouse environment. It successfully identified and transported packages to the appropriate locations, showcasing its potential for operational efficiency. However, we observed occasional delays in package acquisition due to a number of different resource and mechanical constraints.

The biggest constraint we were faced with was the camera and getting a good quality image in order to identify the AprilTag. As soon as our Raspbot started moving, the camera would vibrate too much and our AprilTag detection library was not able to find the package or goal AprilTags. We would have liked to stabilize the camera feed by using a better camera or a stabilizing mechanism, such as a gimble, but we did not have any of that available to us. Instead, we settled on integrating a stop and go system where the Raspbot would drive for about 0.25 to 0.5 seconds then stop for the same amount of time to give the camera enough time to get a stable image and detect any AprilTags before continuing on.

The stop and go system successfully enabled our Raspbot to identify AprilTags during each phase of the process. The drawback to this approach, however, is that the Raspbot would take longer to accomplish the task in delivering a package. Part of the extra time added during execution occurred when trying to direct the Raspbot directly at the package or goal AprilTag. The Raspbot would move slightly left and right then stop and check where the AprilTag is. Often, the Raspbot would turn past the AprilTag during its 0.25 seconds of driving then have to turn back and forth until it was pointing enough towards the AprilTag to drive forwards before checking again.

V. Conclusion

Based on our materials and the results, we consider SPIDeR to be a resounding success. Our platform, while not as powerful or as intelligent as other available options, has been able to meet our expectations. Specifically, we have been able to implement a low-power, low-cost system that can be deployed in essentially any environment without major modifications to the warehouse.

Clearly, there are still further optimizations that could be made. Perhaps with just a little more budget, we would be able to implement a system that is more capable, and more adaptable. Even with just a minor increase in budget, we would be able to make great leaps in capability while also maintaining a large cost advantage over the competition. At the very least, with SPIDeR we have shown that implementing a warehouse assistant targeted towards smaller businesses is feasible, and still quite capable without the need for overly expensive hardware.

References

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