Construction of a Robot for Sorting Balls

Report on the project of the LEGO Mindstorms seminar

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***Abstract*—Nowadays, the technology development is unprecedentedly fast. The development of technology leads to a trend in many of the industries: automation. Automation has a lot of advantages for the industry, such as avoiding manual errors, lowering the running costs and extending the production time. The robotic arm plays an important role in automation, it has a wide range of uses in different industries. This LEGO robotic arm is inspired by the garbage sorting claw, so this LEGO robotic arm is designed for sorting. The preliminary idea is a robotic arm that can sort some object by its color, in this case is sorting the balls to the corresponding basket according to its color.**

I. INTRODUCTION

A robotic arm is a very popular tool in many industries, such as logistics, recycling industry and manufacturing. Because of this trend, it was decided to build a robotic arm with LEGO NXT.

The goal of this project is to build a robot that can sort balls to different baskets according to its color. It is challenging to construct a robotic arm, because a functional robotic arm involve a lot of concepts from mechanics. All movement of the arm and the claw must work with the gear wheels.

At the end, the goal of sorting balls is achieved. The following will be status of technology, the detail of the construction process, the possible improvement of the robot, the result and conclusion. This is a photo of the final product:

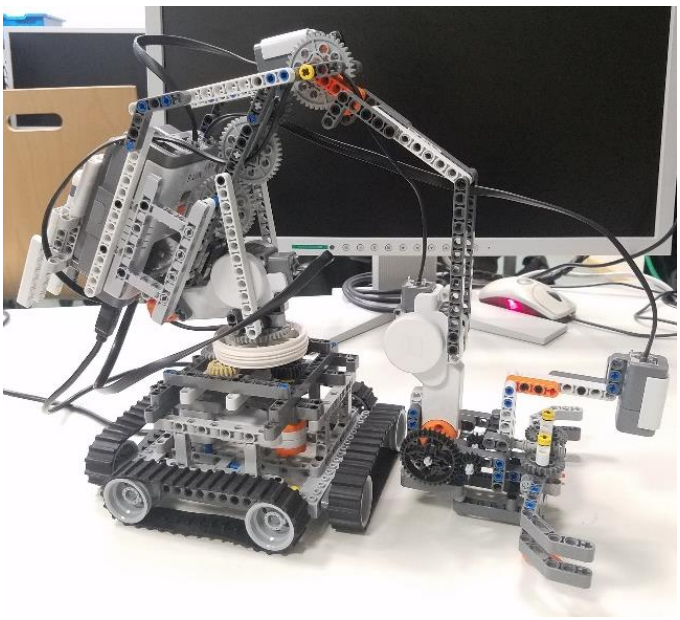

Figure 1: The finished LEGO robotic arm

II. STATUS OF TECHNOLOGY

A. *The earliest robotic arm*

The earliest robotic arm was built in 1937, the history of the “industrial robot” is long and it has been so well developed.

B. *The robotic arm nowadays*

For example in the container port, the robotic arm sorts the containers and loads them to different trucks or cargo ships. In the recycling industry, there is a robotic system called “ZenRobotics Recycler”[2], this system is using robotic arm to separate the construction material according to the type of material.

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Figure 2: The ZenRobotics Recycler
https://zenrobotics.com/wp-content/uploads/ZenRobotics-Recycler-overview2-1.jpg

III. THE CONSTRUCTION

A. The robotic arm is assembled from three parts: the base, the arm and the claw. The claw is a relatively easy part to build. There is a motor and a color sensor in the claw. The motor controls the movement of the claw so that it can open and close. The function of the light sensor is to detect the color of the balls and the color of the baskets. The reason to set the color sensor above the claw, but not at the side or under the claw, is to reduce the error of the color detection. Due to the limitation of the color sensor, that the brightness can affect the result a lot, setting the sensor above can ensure that there is enough light source for the object, then the result can be more accurate.

B. The second part of the robot is the arm, which connect the base and the claw. Only a motor is used in this part at the beginning, after several tries of experiment a touch sensor is added for the user input. The motor is connected to a set of gear wheels, when the motor spins, it can drive the gear wheels and it can lift up or put down the front part of the arm, which is connected to the claw. The touch sensor is used to detect the user input. If the touch sensor is pressed by the user, then the balls sorting program will start, otherwise it will just wait for the input by the user. The reason to add the touch sensor is to prevent the situation, where the balls sorting program is still running even there is no ball to sort or the ball has not yet been given.

C. The base is the hardest part of the whole robotic arm. The main component is the motor, which controls the rotation of the whole robotic arm and claw. The base is static, so four continuous tracks are used, which are made of rubber in order to increase the friction between the base and the ground. The biggest problem of the base is the balancing and the weight of the upper arm. There are 2 motors, 2 sensors, a lot of gear wheels and other components in the upper arm. When the upper robotic arm was lifted up, it will fall down immediately due to the weight of the claw. So the NXT block and some LEGO bricks are added to the back of the arm to balance the whole upper arm. But after this modification, another problem comes out. There is only one axis for the rotation and it is hard to rotate when the upper arm is too heavy. The solution of the rotation problem is to add a large wheel between the rotation axis and the arm and a set of gear wheels underneath. The wheel and the gear wheels can distribute the weight of the arm and reduce the friction when it rotates.

D. For the programming part, MATLAB is used as the programming language. When the program starts, the robotic arm will rotate to three default positions, where the baskets are, and scan the color of them. Then it will return to the start position and wait for user input by pressing the touch sensor. After that the program will go to a clause. If there is a signal from the touch sensor, then the claw will close and detect the color of the ball. It will compare the color of the ball and the colors of the baskets, which was scanned and recorded in three variables at the beginning. If the colors are matched, the arm will rotate to the corresponding position and drop the ball into the basket. If the color sensor cannot detect the color of the ball or the colors do not match, the claw will release the ball and wait for new signal from the touch sensor. The following is the flowchart of the whole balls sorting program:

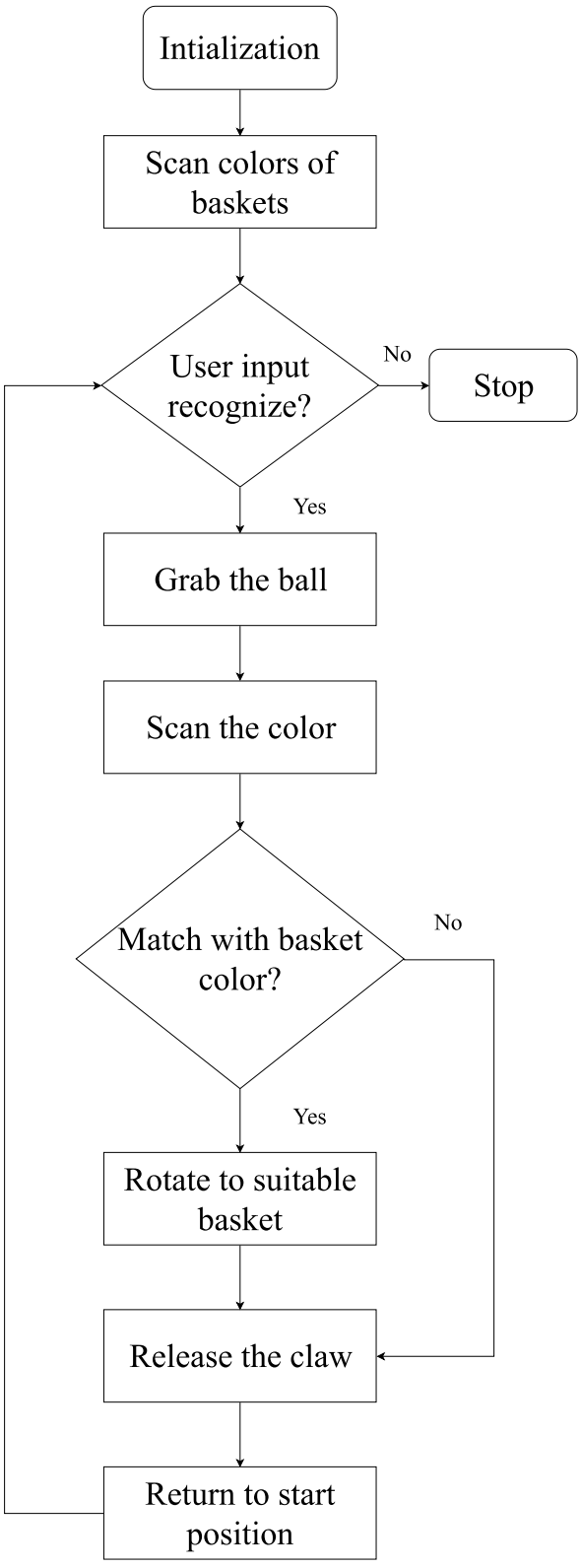

Figure 3: Flow chart of the program

E. Some problems of this robotic arm have not been solved, one of the biggest problem is the accuracy of the robot. As mentioned before, the result of the color sensor heavily depends on the brightness of the environment. So sometimes the robot cannot detect the correct color because of the limitation of the color sensor. Another problem is the rotation angle of the motor in the base part. This is also a problem of the hardware, the motor cannot turn to the same angle every time with the same program. So sometimes the robotic arm cannot deliver the ball to the basket because of the inaccuracy of the motor rotation. The program for the rotation part has adjusted for many times, to make the rotation as accurate as possible, but it can still have error.

F. The LEGO robot has a huge potential to be developed further. One of the possible developments is to be even more automated. It is possible to add a ramp, which deliver the balls to the claw automatically. The touch sensor can be used as a detector for the ball, when the ball come from the ramp and trigger the touch sensor, then the sorting part of the program starts. Due to the limitation of time, this automation has not been made but it is a possible enhancement for the robotic arm.

IV. RESULT

In this stage, the LEGO robotic arm can deliver three balls with different colors into three corresponding basket most of the time. When there is failure of the ball sorting part, the main reason is about the error of the color sensor or the inaccuracy of the motor rotation. Although there is some error because of the hardware, but the result is also satisfying. The GUI of the robot is simple, there is only a start button. Because the robotic arm is designed to use the touch sensor as the user input. This robotic arm model can apply for garbage classification, container sorting, package sorting and so on.

V. CONCLUSION

The LEGO robotic arm can achieve the goal of sorting the balls according to the color, so it is a successful project.

When the robotic arm is used in logistic industry, another possible development in the future is sorting by other criteria, not only by the color. For example sort the containers by its weight, destination to be delivered, types of product and so on. Compared with the robotic arm in the industry, the functions are similar. So it is a satisfying result to build a robotic arm with LEGO that can compare with the existed industrial robot. But this robot also has some limitations, such as the inaccuracy of the sensor and motor, it can only sort the balls by color and the upper arm is still not very stable. In summary, this robot has its limitation, but it can achieve the goal. So it is a successful project.

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