Development of Bowling Machine Using VEX IQ

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Abstract

VEX IQ is a kind of educational robotics platform focuses on semi-automatic and semi-remote. In this paper, a fully automatic bowling machine based on VEX IQ educational robotics platform has been developed. Since the brain of VEX IQ cannot communicate to other VEX IQ brains and the components of VEX IQ are made of plastic, it is necessary to overcome these problems to create mechanism similar to steel-made constructions and form an intelligent large system. We use sensors as communication interface for the brains of VEX IQ. Totally 3 brains and 10291 VEX IQ plastic components are used for the construction of the bowling machine. The overall size is about 252x93x90 in centimeters.

Keywords: Educational Robot, Bowling Game, VEX IQ, Robot C.

1. Introduction

Bowling is a well-known sport. The player tries to use the thrown ball to knock down the neatly arranged pins as many as possible. Usually there are three kind of indoor bowling games with 10 pins: tenpins, duckpins, and candlepins[1]. Fig.1 shows the relative sizes of bowling balls and pins for three popular variations of the bowling game[2]. Tenpins is the most popular one of the three variations. It is played everywhere except in the Canadian Maritimes.

It is quite challenging to make a bowling machine by using an educational robot host with plastic building blocks. Someone used LEGO to make a bowling machine with quite complete functions except scoring[3]. However, the pins in Ref. 2 are candlepins-like pins which are symmetrical up and down and have no distinct "top" or "bottom" end, unlike a tenpin. Unlike in tenpin bowling, fallen candlepins are not cleared away between balls within a player's turn [4].

VEX IQ is another kind of educational robotics platform which can be controlled in automatic and remote mode. Mr. Lin tried to use VEX IQ plastic building blocks to complete the implementation of an automatic bowling machine in his master thesis [5], but the functions in this work are independent of each other, and the system stability is insufficient.

Before making the VEX IQ bowling machine, the following issues must be considered:

1) The material of plastic parts is soft and low hardness.
2) VEX IQ host (brain) cannot communicate with each other.
3) The VEX IQ cable is limited in length.

In this paper, we will develop a bowling machine only with VEX IQ plastic building blocks and brains. The paper is organized as follows: Section 1 shows an introduction of this paper. Section 2 shows the hardware structure of the developed bowling machine. Section 3 shows the overall structure and some experiments. Finally, a conclusion and discussion is made in the section 4.

2. Hardware Structure

The VEX IQ bowling machine is composed of a pin-clamp mechanism, a pin-pressed and scoring mechanism, a host-communication mechanism, a pin-swiping mechanism, a pin sliding-track mechanism, a pin loader mechanism, a ball return mechanism, a rotary pin-elevator mechanism, and a pin conveyor-belt mechanism.

The current bowling machine arranges the pins in an equilateral triangle. However, due to the inherent limitations of VEX IQ building blocks, it is impossible to arrange an equilateral triangle. Therefore, we construct the pin-clamp mechanism in an isosceles triangle arrangement, as shown in Fig. 2. The function of the pin clamp mechanism is to clamp the unknocked pins and raise them, and then lower the pins to put the pins on the deck after the fallen pins are swept away.

Since the Vision Sensor of VEX V5 cannot fully match the VEX IQ to use, it cannot be used for scoring. So we used the touch sensor of VEX IQ to design a

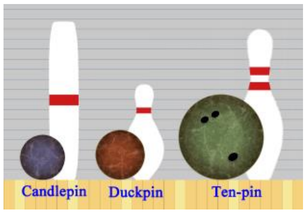

Fig. 1. Relative sizes of bowling balls and pins for three popular variations of the game[2].

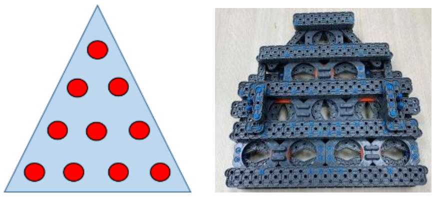

Fig. 2. The designed pin-clamp mechanism.

mechanism that can squeeze the pins. When the touch sensor is pressed, it will return a signal. So we can know the number of pins remaining on the deck, and the returned signal can be used for scoring. There is an ultrasonic sensor on the alley. When the ball is sensed to pass, the pin-pressed and scoring mechanism will be activated to perform the scoring process.

Since VEX IQ hosts (brains) cannot interconnect mutually and ultrasonic sensors will interfere with each other, two VEX motors with touch sensors and L-shaped beams are used to form a communication mechanism between the hosts. It is used for communication between host 1 (pin-pressed and sweeping) and host 2 (scoring).

The pin-swiping mechanism is used to sweep out the pins and the ball on the deck. It is made by combining the VEX IQ cross plates with the cross beams and the motor, and combining the rack and linear slider of the VEX IQ Gear Add-On Kit.

The pin sliding-track mechanism is used to make the pins transported by the pin conveyor belt slide down to the pin loader. Because the center of gravity of the pin is low, it is transported up to the highest point by the conveyor belt with the bottom facing up. The bottle sliding platform composed of the VEX IQ large plate has a slight downward slope to allow the bottle to slide downward due to the heavier bottom. The pin sliding track mechanism, composed of VEX IQ motor and rack, will move left and right to specify the position where the pin falls. A color sensor is installed above the end of the pin slide mechanism to detect whether a pin has slipped.

Whenever a pin slides down, the pin slide mechanism will move left and right to the top of the next designated drop position, waiting for the next pin to slide down.

The function of the pin loader mechanism is to place the pins dropped from the pin-sliding mechanism on the designated 10 positions, and move to the bottom of the pin-clamp mechanism to wait for the pin to be picked up after placing the pins. The pin-loader is composed of VEX IQ's horizontal plate, beam and thrust bearing housing. The isosceles triangle formed by the bearing housing on the front of the loader is just suitable for the arrangement of the pins. There are four gears on the back, two of which are unpowered, and the other two gears are combined with a motor as a power output to drive the loader to move horizontally back and forth with a fixed rack on the left and right sides. Fig. 3 shows the front and rear sides of the pin-loader mechanism.

The ball return mechanism consists of three parts: the guiding track, the ball-lifting mechanism, and the return slope. The thrown ball will be returned to ball rack via the three parts to wait for the next throw. The designed ball-lifting mechanism is similar to a windmill in order to actually lift the ball from low to high. Hence the ball can roll on the return slope to the ball rack naturally.

The most important design of the automatic bowling machine is how to make the 10 pins in the same direction during transportation, and the pins are placed in the same direction on the pin loader. Due to the special shape of the pins and the inconsistent falling directions of the pins, it is not easy to meet the previous requirements. Different from the common pin elevator mechanism, large plates and gears of VEX IQ, and the tank chain (reverse application) were used to create a mechanism for lifting pins in a rotating manner, as shown in Fig. 4. The operation of this mechanism can transport the pins in sequence and guide the pins to the same direction. The pins will slide down to the pin conveyor belt due to the wider and heavier side of the bottom, so the pin directions on the pin conveyor belt will be consistent, as shown in Fig. 5.

3. Overall Structure and Experiments

Considering the structural robustness of the entire structure, the VEX IQ bowling machine is designed with the support like steel structure. For example, the column is composed of a horizontal plate and a corner connector, so that the structural rigidity of the column can be improved and not easily bend, and it can be more stable during the operation of the machine.

Three VEX IQ hosts are used in the designed bowling machine. The functions are respectively pressing the pin and sweeping the ball (host 1), scoring (host 2), placing and delivering the pins (host 3). The relationship between each host and the hardware block is shown in Fig. 6.

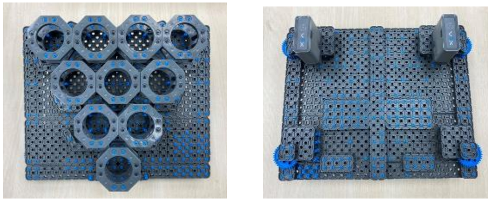

Fig. 3. Front and rear sides of the pin-loader mechanism.

Fig. 4. Pin elevator mechanism.

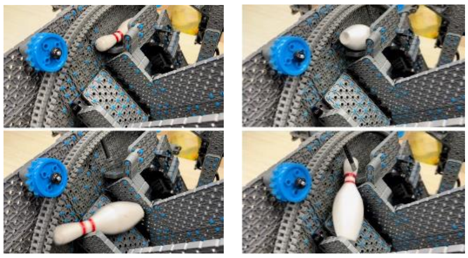

Fig.5. The pin directions will be consistent eventually.

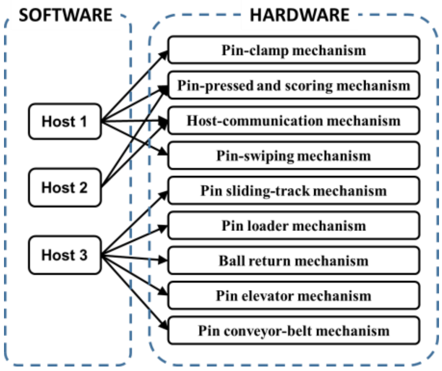

Fig. 6. Relationship of each host and each hardware block.

The completed bowling machine is shown in Fig. 7. Totally 10291 VEX IQ plastic components are used for the construction of the bowling machine. The overall size is about 252x93x90 in centimeters. Fig. 8 shows an actual operation of the bowling machine. In experiments, except for the pin-clamp mechanism, the operation success rate of the other mechanisms can almost reach 100%. The main reason for the failure of the pinning mechanism is that some pins are displaced due to the collision of the ball or other fallen pins, which will cause the mechanism to get stuck on the pins and fail to smoothly clamp. This will also cause subsequent scoring problems.

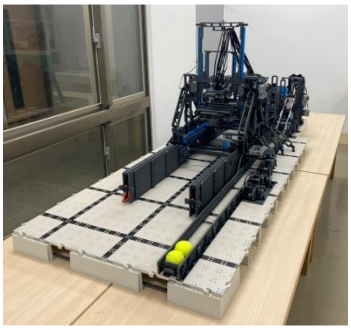

Fig. 7. The completed bowling machine.

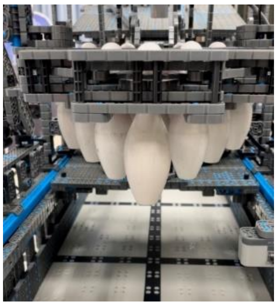

Fig. 8. The completed bowling machine.

4. Conclusions

In this paper, we introduce a bowling machine developed using only VEX IQ plastic building blocks. It is proved by actual operation that our organization can provide the entertainment of bowling game completely automatically. Since VEX's Vision Sensor does not yet support VEX IQ, the visual sensor cannot be used for scoring. The inability of direct communication between VEX IQ hosts also necessitates the use of additional sensing devices as a medium for message transmission. If these two problems are solved in the future, it will be expected that the entire system can be completed with fewer building blocks and parts.

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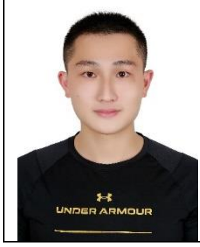

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