Toy which simulates group behavior with plural range sensors

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Abstract
Due to recent technological changes, digital toys are becoming highly advanced. In particular, various operation methods have been developed for the radio-controlled car. However, not anyone may operate such toys easily. Therefore, we made a simple operation method for a toy via sound for small children. Our previous study focused on this operation method, but this time we are focusing on collective action where multiple toys move in the same direction. We produced a toy equipped with a range-finding sensor and let them run according to forward distance. In order to realize the collective action only from the sensor information without large-scale construction, we describe the actual device development from the simulation on the software.

Keywords: Flocking behavior, Toy, Boid algorithm

1 Introduction
In the present age, not only household electrical appliances but toys are also highly advanced due to technical development. As for the radio control car, new operation methods beyond using a lever controller have been introduced to the market. For example: using a smartphone or brain waves. However, not everyone can play with them. Therefore, we propose a radio control car device that even a small child can easily operate.

Previously, we produced a duck-shaped toy that was operated via a hand bell [1]. This toy estimates the direction of the sound source with two microphones equipped in right and left directions. It runs forward when the sound is of a specific frequency. In this study, the intention was to create a parent-child relationship of the duck between a toy and the user through a simple operation method of the toy. In the study we describe here, we are focusing on the collective action where multiple toys move in the same direction.

2 Prototype development
2.1 Simulation on the screen
When operating a figure with CG (Computer Graphic) animation, it is necessary to acquire the coordinate position of the figure. In addition, you must acquire a line and - where multiple figures exist - the position relative to other figures when you move the figure. When we manipulate a figure on a screen, we set the size of the screen to use and can get the coordinate of the figure from a numerical value. However, it is necessary to keep perspective of the space under control by a camera or ultrasonic waves to adopt the technique with a real toy.

The purpose of this study is not to command the group, but to avoid obstacles even if it is just one toy. Therefore, we put some sensors on the inside of some toys and assumed that each toy could measure the distance from itself to fellow toys and obstacles, and do group behavior. We chose to use an infrared sensor. We cold acquire one-way distance when using range sensors, but could not get the coordinate of the object exactly. Therefore, we examined a method to decide a path only by acquisition of distance.

One common example of simulating group behavior is the Boid algorithm [2]. This algorithm reproduces the movement of a school of birds or fish on a screen with CG animations. There are three constraints for this algorithm:
1. Do not get too close to fellow objects and things next to each other.
2. Merge the moving speed and direction with the group next to each other.
3. Advance towards the direction where there are a lot of fellow objects.

We simulated it on screen using openframeworks [3] and, in reference to "Nature of Code [4]" where the Boid algorithm was recorded, inspected necessary factors for reproducing group behavior with real-world objects (Figure 1).

Each figure generates a vector from each other's positions and speed and decides one's action. In the hardware configuration, we could not implement all three rules of the Boid algorithm. However, we judged that the results of the simulation seemed a reasonable approximation of group behavior.

This method includes one's rear in the detection range, but the line of sight is always in front. When applying it to a real toy,
it does not have to measure backward distance because that is measured when a fellow object comes from behind. In addition, by the distance that a sensor detected, we can set the speed. Based on this hypothesis, we did a test with the infrared sensor.

2.2 Verification using sensors

Firstly, we used one infrared sensor and inspected the obstacle avoidance with the value of the front. We made a first prototype that can move in all directions, and operated by using two geared motors (KM-16A030-26-06415) and two motor drivers (DRV8830 I2C). We put an infrared sensor (SHARP GP2Y1A21) on the base and controlled it with an Arduino UNO (Figure 2).

When a sensor gave a value within 25cm, it turned to the right and evaded obstacles and would run again. Also, there were variations of speed within the detection range of the sensor (5 ~ 80cm): accelerating as the obstacle is far away, and slowing down as the obstacle becomes close. Thus, through avoidance of collision with one sensor, it was possible to vary the speed toward the target.

Next, we reduced the number of motors to one, and produced a second prototype (Figure 3). When the sensor indicated the following distance to be 10cm, it would fall behind and stop, change the angle of the sensor with a servomotor (Micro Servo Digital 9g SG90), and look for a way out. It would look in left and right directions, measure the four directions of the distance together, and travel in a different direction where the direction indicated the farthest distance to an object. If it showed the same distance (in both left and right), it would travel in the left direction. Also, while detecting the distance of 10–20cm traveling at a constant speed, if a distance of 20–40cm it would travel faster, varying the speed according to the distance. However, as a result of testing this variation in speed, there was a range in which the sensor erroneously recognized the distance, and the toy collided with the wall and fellow toys. Also, because it did not check the distance while changing direction, there would sometimes be collisions.

Then, using an infrared sensor and a photo-reflector (RPR-220), it was to be able to do short-distance measurement that had a false recognition in the infrared sensor (Figure 4). Further, upon recognizing obstacles, instead of changing course in a wide direction, it changed angle to the left direction, and all individuals advanced in the same direction. Hereafter, we conducted the research using this prototype.

3 Conclusion and future work

In our present study, by using multiple range sensors, we conducted research with the goal of simulating collective action by the distance the sensor has measured. Without large-scale apparatus, and by utilizing control of the distance that the toy has measured, we consider it simple to run multiple toys. In the future, we are planning to not just reproduce collective action, but to create motions where various figures have individual characteristics. Then, by combining the collective behavior described here with the
operation method of controlling a toy by sound from our previous research, we want to create simple operation for a number of toys.

References