Proposal of a Real-time Position Measurement System for Curling Stones

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Abstract: The goal of our study is the design and implementation of a real-time position measurement system for use on curling stones. Often called 'chess on ice', curling requires a high level of strategy. Accordingly, how the stones move around the vast curling rink constitutes important data. However, in the unique environment of the icy and vast rink, it is difficult to monitor the position of the stones . In our research, we solve this problem by mounting an infrared LED control module onto each stone and the curling rink carrying out image processing using infrared cameras placed around the rink.

1. Introduction

Curling is a winter sport in which players slide stones across ice and compete to score points by getting more stones than their opponents close to the center of the target, which is called the house [1]. The ice on the surface of the rink is prepared by purposefully creating a surface of small bumps, called pebble. While the stones are sliding across the ice, the players use brooms to perform sweeping (scrubbing the surface of the ice), which pares away the pebble causing the direction and speed of the stone to change. Regarding the theory of the friction of the ice surface, many factors are intricately intertwined, such as the temperature of the rink, condition of the pebble, speed of the stones and variations of the stones themselves. For this reason, the mechanism of the behavior of the stones remains unclear [2], [3].

The curling rink has a total length of approximately 40m and there is a distance of approximately 30m from the hog line, at which players must release the stone when sliding, and the center of the house. The players control the behavior of the stone a based on their team's tactics. Known as 'chess on ice', curling requires a high level of strategy. Accordingly, how the stones move around the vast curling rink constitutes important data [4]. By accumulating data of the path of the stones, we can contribute to the construction of a curling stone behavior model [3], [5], [6], [7]. Furthermore, if stone position can be perceived in real-time, this can be applied to various aspects including in-game strategy support, teaching support and learning support. However, in the unique environment of the icy and vast rink, it is difficult to monitor the position of the stones by a simple method without hindering the players' game.

Therefore, the goal of our study is to construct a real-time position measurement system for curling stones.

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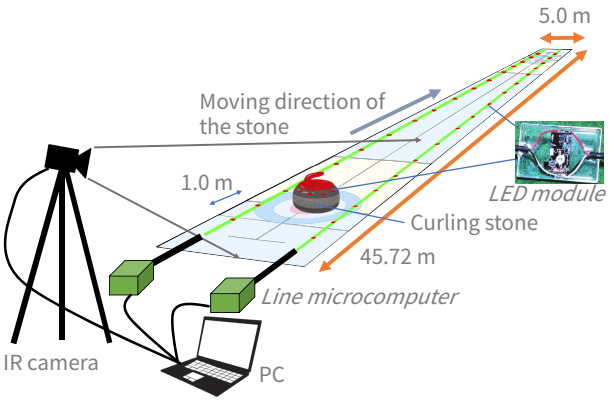

Fig. 1 System Structure

The proposed system solves the problem of the difficulty of measurement by mounting an infrared LED onto each stone and carrying out image processing using infrared cameras placed around the rink.

2. System Outline

2.1 System Structure

The system structure is presented in Figure 1. The proposed system is composed of an infrared camera, a PC, a microcomputer for the lines (hereafter, *line microcomputer*), a microcomputer for the stones (hereafter, *stone microcomputer*), an infrared LED line (hereafter, *LED line*) and an infrared LED light control module (hereafter, *LED module*).

The stone microcomputer controls the switching on and off, and intensity, of the *LED modules* on the stones. The *LED line* is constructed from *LED modules* connected in the style of a daisy chain. The line microcomputer independently controls the switching on and off, and intensity, of each *LED module* in the *LED line*.

Both the *line microcomputer* and *stone microcomputer* correspond with the PC. The PC sends control commands to each type of microcomputer, based on the results of image

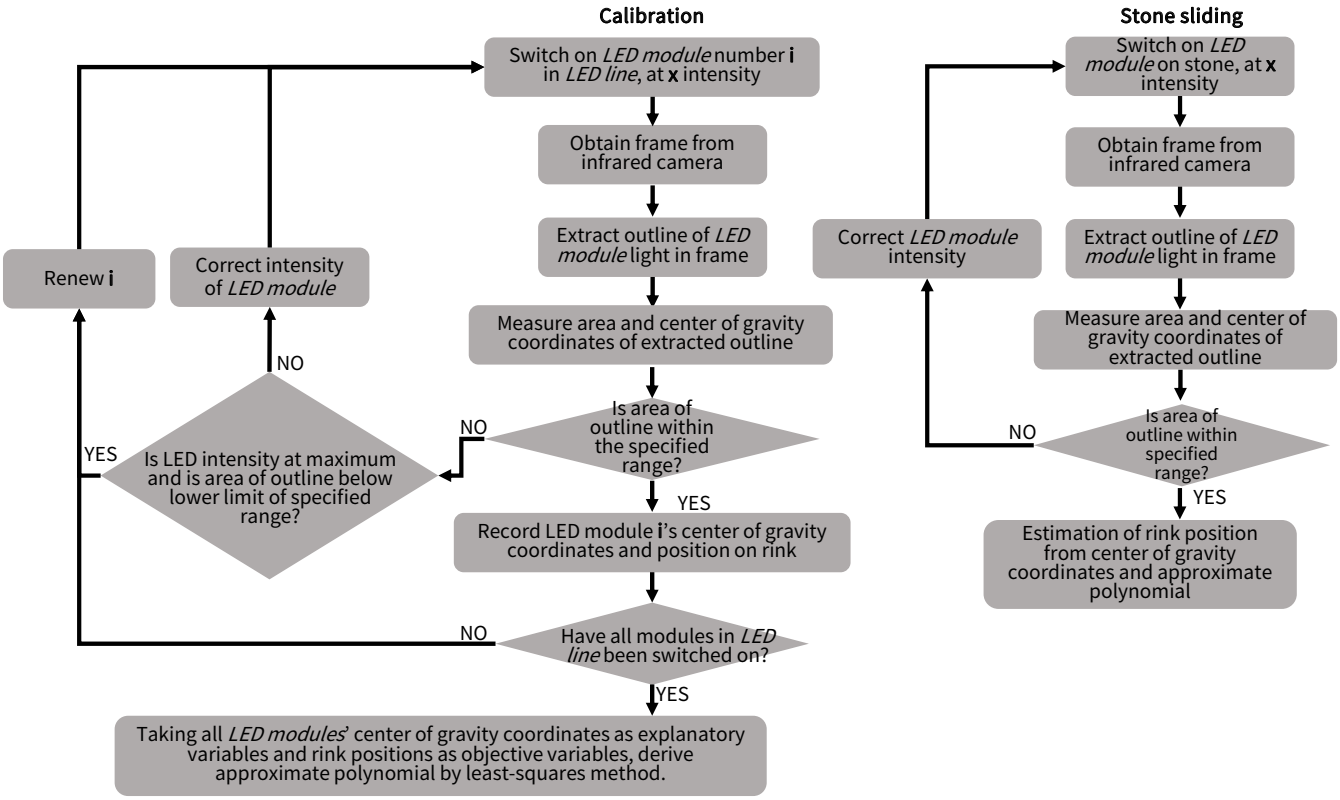

Fig. 2 Flowchart

processing of the infrared camera footage. Infrared cameras can be placed freely around the rink, but because sweepers will be to the left and right, or in front, of the stone, it is desirable to position the cameras opposite the direction in which the stone travels, as shown in Figure 1. In addition, it is necessary to attach light removal filters to the infrared cameras to be used.

2.2 Measurement Method

We carry out calibration to establish the correspondence relationship between each picture element in the camera footage and the position of the stones on the rink. After calibration, the system estimates stone position in real-time from the camera footage. Flowcharts of calibration and the instance of stone sliding are given in Figure 2.

3. Evaluation

We conducted a performance evaluation experiment to investigate the usability of the proposed system. Due to space limitations, we give only the result, which was an average measurement error of 50.2mm (standard deviation 20.1mm). Also, the average time taken to process one frame was 0.044 sec/frame, and the standard deviation was 0.002 sec. These results demonstrate that the proposed system can measure the position of curling stones in real-time and with a high degree of accuracy.

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