

Implementation of an Impact Position Display System of Golf Ball using an Image Processing in an Indoor Golf Course

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Abstract—Recently, the people are commenced to learn how to play golf in an indoor golf course. The most difficult thing for beginners is the head-up that is frequently caused during their golf swing. Once the people hit their golf ball, they are wondering where it goes instinctively. Thus, they learn the wrong swing form that lift up their head. This paper presents the impact position display system to prevent this head-up when the beginners play the golf. The proposed approach uses a general web camera to shoot golf screen in an indoor golf course in real time. The captured video file is divided into the frame and each frame is divided into 16 blocks. We detect the changing motion block by calculating the variance of brightness of every block. Then, we estimate the impact positions in central, upper-left, upper-right, bottom left, bottom right, and display them on the screen using beam projector. The experimental results are obtained from separate experiments using iron and driver. The accuracy of the experiment is about 86%, 75%, and 60% for the central region, lower zone, and upper zone, respectively. Accuracy of this result significantly relies on the lighting effect. However, the proposed approach is good enough to use for the indoor screen golf course having limited lighting source. It can be useful to fix the bad habit that lifts up the head during the golf swing

Keywords—Object Tracking, Golf Simulator, Computer Vision, Image Processing, location control technology

I. INTRODUCTION

Recently, golf becomes one of the most popular sports. The recent developments in computing technology introduce the innovative products in which computing technology and the golf have been amalgamated and it pioneers a new market. For example, screen golf simulator, digital system for correcting the player's posture, and tracking device of golf ball are newly released in the market and they expand the market rapidly. Thus, the research related with these new computing systems have been proliferated. The sensors that are integrated

in screen golf simulator can be categorized into two types: full swing sensing technique and achieve sensing technique [1-2]. Both of them need to attach special sensing devices on the screen because they are optical sensors.

In general, the beginners who start to learn how to play golf lift up their head during their swing because they wonder where the ball goes instinctively. This paper presents the impact position display system, which can exactly display the point of the projected screen. It can be applicable for correcting the player's swing form by preventing the head-up.

The proposed system consists of three major components. The first component is a sensing part that is responsible for detecting the swing. The second component is on image processing part including the cameras. It is used to shoot the golf screen and to track the golf ball. The third component is a display system that is responsible for marking the hitting point on the screen. The sensing part detects the exact time of golf swing using infrared sensor. Then, it gives the control signal to the image processing component in order to indicate the starting time of input video frame that obtained from the video camera. The image processing tracks the movement of golf ball using the differences between the consecutive video frames. Then, it calculates the variance of trajectory and it determines the correct position of the ball on the projected screen. By considering the relative point from the projected screen, the exact position on the project screen is determined. Then,

the display system project an image onto a screen using the light source, the laser pointer.

The rest of this paper is organized as follows. Section 2 presents the proposed movement detection technique and the location recognition for impact positions. Section 3 describes the simulation method and the results. Section 4 includes concluding remarks.

II. THE PROPOSED MOVEMENT DETECTION AND IMPACT POSITION RECOGNITION

Figure 1 shows the whole procedure for the proposed movement detection and location recognition for impact position technique. It can be divided into two major parts: detecting the movement of golf ball and the location recognition of impact point. A detection of movement is achieved as follows. First of all, the image processing component determines the image that does not have any movement. Then, it monitors the brightness of following images since the movement of golf ball makes a change in brightness. It commences to trace the track of golf ball when the brightness is changed over the critical point. The proposed method divides the input video frames into the 16 blocks. It estimates the movement direction using the brightness variance of every block.

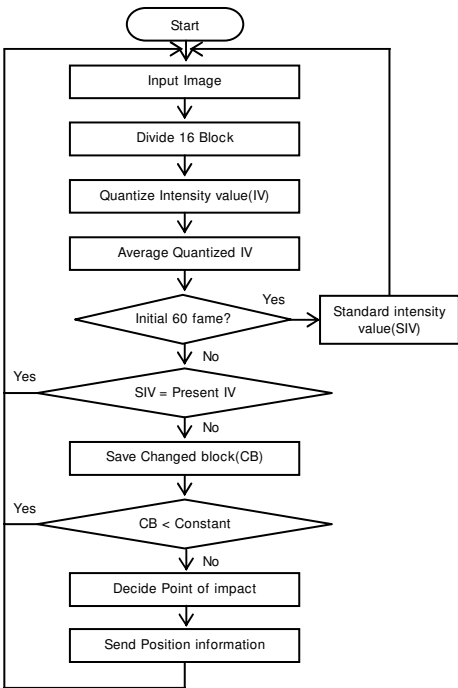


Figure 1. Flowchart of the proposed method

Figure 2 shows the implementation of program according to the proposed method. The image that is obtained from the video data is divided into 16 blocks (the left bottom). The intensity value according to the block is represented to the graph at the left side. We display it close to the red as the variance of brightness of the gray image that is obtained from the screen is big. In contrast, we represent it to the blue when the variance of brightness is small.

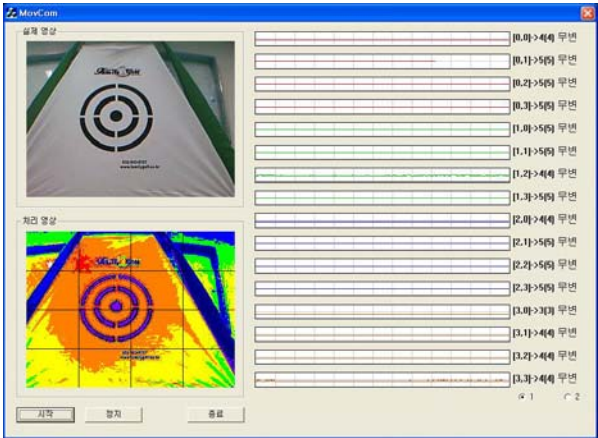


Figure 2. Motion detection program

A. Movement Detection

For detecting movement, we divide the obtained image into 16 blocks. The intensity value of every block will be quantizing into 10 steps. Average of intensity value for each block should be the representative value. The SIV (standard intensity value) is determined by the average value of 60 frames, so the average BIV (block intensity value) is represented to the background image have no movement. After the SIV is set, the comparison between the SIV and the intensity value of input image is continuously performed. If both of them are equal, it notes that there is no movement in input image. If there is any change, it needs to calculate the track of the golf ball. Thus, the imaging processing component save the differences between the SIV and intensity value of current image to the changed block (CB) information.

If the CB information is smaller than the invariable of movement decision among the entire block, this movement detection process will be pass to the next frame. However, it starts to the location recognition of impact position if CB information is larger than the invariable of movement decision.

B. Location Recognition of Impact Position

This process is commenced by monitoring the real-time variance of intensity values for 16 blocks. Once the golf ball hits the screen, the block including the impact point has big. Thus, the impact position is successfully captured by calculating the changed block information that is obtained from the previous movement detection part. We estimate the impact position in central, upper-left, upper-right, bottom left, and bottom right.

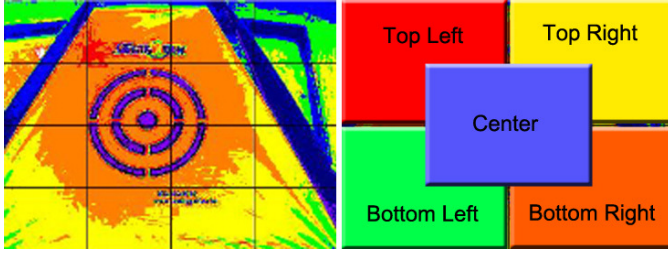


Figure 3. Block segmentation and five impact region

This process is performed by the following two steps. In the first step, we estimate the impact position in central, left-side, and right-side. The sums of changed block information for left and right 8 blocks are separately calculated. When both of them has similar ratio, we treat that the impact position is in central region. Otherwise, we estimate the impact position will be left or right using Eq. (1).

$$\begin{aligned} \text{Center, } & \text{if } \alpha_{\text{low}} < \frac{B_{\text{left}}}{B_{\text{right}}} < \alpha_{\text{high}} \\ \text{Left, } & \text{if } B_{\text{left}} > B_{\text{right}} \\ \text{Right, } & \text{else } (B_{\text{left}} < B_{\text{right}}) \end{aligned} \quad (1)$$

Here, B_{left} represents the sum of changed block information in left 8 blocks. B_{right} is the sum of changed block information in the right 8 blocks. α_{low} and α_{high} represent the minimum constant and maximum constant for estimating central position, respectively.

In the next step, we estimate the position in top and bottom for both the left and right side. Four blocks included in the bottom of left and right side except the central region have the biggest movement by nature of screen golf simulator itself. In this case, we estimate the impact position is in bottom. Then, we calculate the ratio of 4 upper blocks and the other 4 lower blocks in order to

judge the impact position to either low or high as shown in Eq. (2).

$$\begin{aligned} \text{Bottom, } & \text{if } B_{\text{imp}} > \beta_{\text{imp}} \\ \text{Top, } & \text{if } \frac{B_{\text{top}}}{B_{\text{bot}}} > \beta_{\text{high}} \\ \text{Bottom, } & \text{else } \left(\frac{B_{\text{top}}}{B_{\text{bot}}} \leq \beta_{\text{high}} \right) \end{aligned} \quad (2)$$

Here, B_{imp} is the sum of block information of 4 blocks in the lowest part. B_{top} is the sum of block information of 4 blocks in upper-left and upper-right side. B_{bot} is the sum of block information of 4 blocks in bottom left and bottom right side. B_{imp} and β_{high} represent the distinction constant for the lowest bottom and the distinction constant for upper side, respectively.

After estimating the impact position by the proposed algorithm, we display the point on the screen. It is achieved by controlling two motors and beam pointer as shown in Fig. 4. Two mirrors are connected to different motors. The laser beam is reflected by these mirrors and it is projected on the screen by changing the angle of two mirrors.

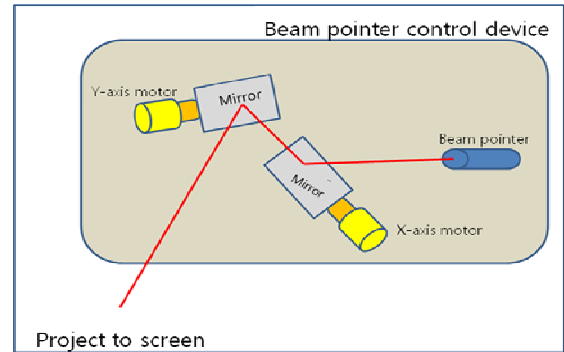


Figure 4. Beam pointer control device

III. EXPERIMENTAL RESULTS

A. Simulation Environment

The simulation environment is constructed based on the real screen golf simulator. It consists of golf swing mat, screen, the prototype of the proposed impact position display system including a camera and PC. The critical value is adjusted by the verification program of the proposed image processing algorithms. The direction of beam pointer is determined by controlling motors that represent X and Y axis. We use ATmega128 chipset

to control these motors and the number of rotations is decided by calculating the angle according to the distance. Figure 5 shows the implementation of beam pointer and motor controlling system.



Figure 5. Beam pointer projection device

B. Experiments

After we construct the simulation environment, we demonstrate the proposed system by conducting irons and drivers, separately. Since the movement of screen depends on the swing speed, we make the critical value to the variable. Figure 6 shows the results of different frames by a shot with an iron.

In addition, the impact position is displayed as red in the last frame after the golf ball hit the screen. From the simulation, the average value is obtained during 300 swings. Figure 7 shows the amount of movement of each block when we the golf ball is hit. The accuracy of the experiment is about 86% for the central region. In addition, the accuracies for lower zone and upper zone are about 75% and 60%, respectively.

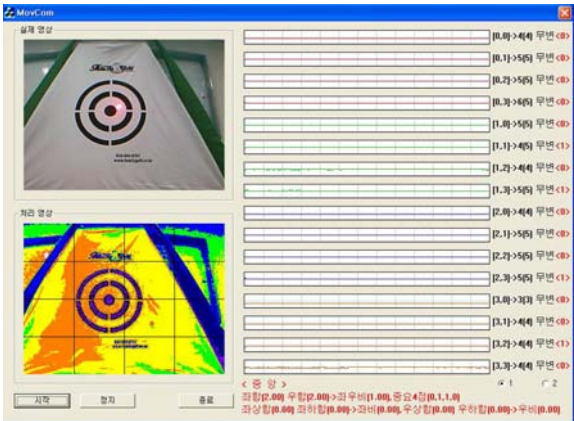


Figure 7. The experimental result of moving detection

IV. CONCLUSIONS

The basic aim of this paper is to display the impact position of golf ball on using the image processing algorithm. Even though the proposed

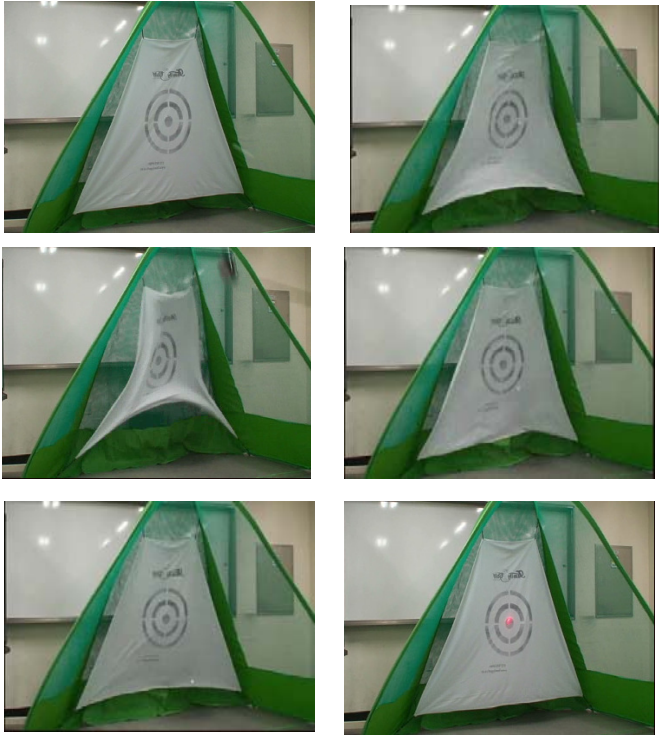


Figure 6. The experimental result of each frames

system can be implemented with low-cost using a web camera and a control board connected into the PC, it is efficient to correct the head-up, which is the biggest problem for a beginner. The proposed system can be useful in the indoor golf course because it is convenient to place this equipment in front of the mat and it exactly displays the impact position on the screen. In the future, we will improve the accuracy by using the infrared filter, not intensity value and employing the grid technique.

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