Advanced Science and Technology Letters
Vol.120 (GST 2015), pp.554-557
http://dx.doi.org/10.14257/astl.2015.120.111

Development of High Speed Vision System to Calculate the Velocity Vector of Golf Ball

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Abstract. In this paper, we propose a high speed vision system to calculate 6 degree of golf ball velocity vector for a golf simulator. Firstly, a high speed vision system and its algorithm is presented to find ball position and its initial linear velocity on the golf court, and secondly, golf ball spin is calculated. These ball parameters are critical for simulator in order to simulate a real golf environment. Finally, these algorithms have been implemented with the acceptable result.

Keywords: Golf Simulator, Spin Detection, Stereo Vision, Camera Trigger

1 Introduction

Nowadays, the golf simulations including indoor golf screens have been popular not only as a game, but also as trainer for beginner golf players. Because golf ball usually has high launching velocity up to 80km/h, in order to measure initial angle and velocity of shoot, high speed capturing image and algorithm analyses are required. On the other hand, as any fan of golf sport knows, ball spin plays an important role in estimating the trajectory of the ball after being shoot. We propose a hybrid vision based golf simulator system, in order to find and calculate initial parameters for golf simulators. This simulator takes advantage of a top camera and computer based application to determine the initial position, and additional stereo vision system for determination of ball linear velocity and spin.

2 Vision System for initial position of Ball

Since initial position of the ball is important for the simulator to generate real path trajectory of the ball, a top camera system, installed on the ceiling is used to detect the initial position of the ball. This detection algorithm is shown in Fig.1. In this algorithm first of all, frames are captured from the golf course and then, based on background subtraction and image segmentation, objects are detected in each frame. Then, up on golf ball features and object classification, non-ball shapes are ignored

ISSN: 2287-1233 ASTL

and finally by using camera calibration, ball position in the world coordinate is determined. The result of ball detection has been shown in Fig.1.

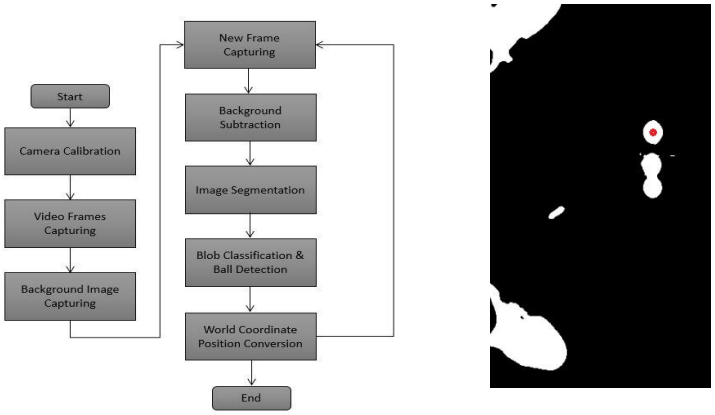

Fig. 1. Golf ball detection algorithm and detection result

3 Golf Ball Spin detection

Our proposed vision system, as shown in Fig.2, consists of four cameras with 100 mm pitch distance to cover more FOV (Field of View). A photo sensor is located in front of the ball tee to detect the shoot. This sensor can generate a pulse when the player strikes the ball. This pulse is the trigger pulse of the cameras and light. These four cameras are sequentially triggered and their trigger signals is the 100 Hz frequency. So each camera has 100fps, but their sequences can make a capturing system with overall 400fps.

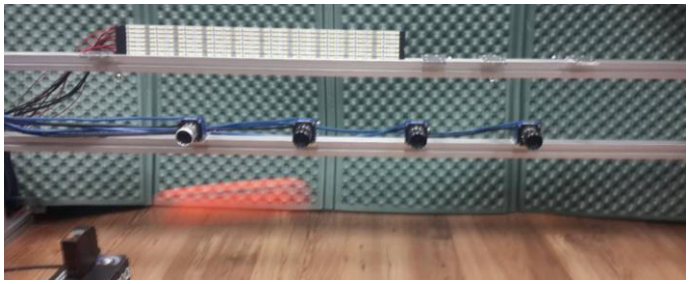

Fig. 2. Vision based system

3.1 Golf Ball Spin detection algorithms

In this section the spin detection of golf ball is described in Fig.3. Pitch angle can be calculated by finding α angle. On the other hands, roll angle is determined by finding

the length of line, passing from the ball's and black line's centers. By division of this line length per ball radius, β will be resulted. Algorithm for finding α and β is shown in Fig.4.

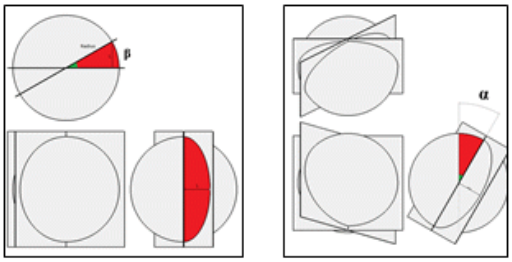

Fig. 3. Ball roll and pitch angles model

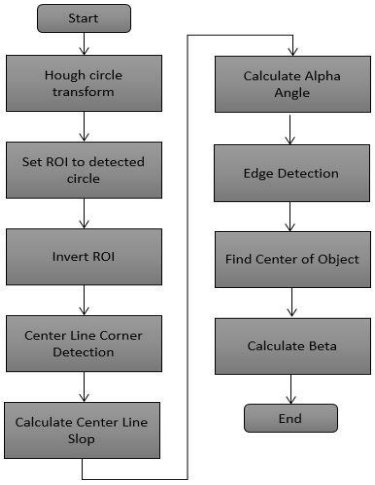

Fig. 4. Algorithm of ball roll and pitch calculation

In Fig.5. (a) Typical captured frame has been shown. Fig.5. (b) shows the inverted ball ROI. In Fig.7. (c), green line and red line are corresponding line for roll and pitch angle calculation respectively. The difference of angles between sequential captured frames is used to determine of angular velocity as well ball spin velocity.

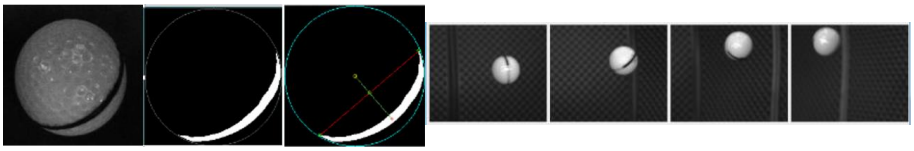

Fig. 5. (a) Typical captured frame (b) Inverted ball ROI (c) Extracted information

Fig.6 shows the schematic of stereo vision. By stereo vision equation all freedoms of ball linear velocity vector can be determined as follow:

$$\vec{V} = [(X_{i+1}, Y_{i+1}, Z_{i+1}) - (X_i, Y_i, Z_i)]/\Delta t \quad (1)$$

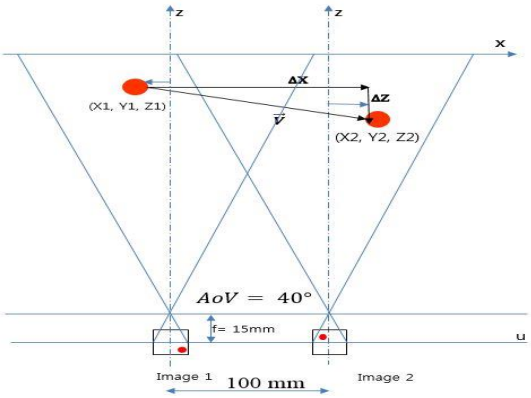

Fig. 6. Stereo vision schematic

4 Conclusion

In conclusion, introduced golf ball detection algorithm in this paper, has been implemented by visual C++ MFC environment. So, its initial position and velocity is measured, and final ball position can be estimated by simulator program. Also, this system uses vision based system to find the in-flight ball spin velocity. Acceptable results demonstrate that this program is able to be used in commercial screen golf.

Acknowledgments. This research was financially supported by the 2014 Ministry of Education (MOE) and National Research Foundation of Korea (NRF) through the Human Resource Training Project for Regional Innovation and Creativity (NRF-2014H1C1A10669 98) and by 2014 Business for Cooperative R&D between Industry Academy (No. C0250963).

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