Pitching Form Evaluation Based on Elbow Position by a Monocular Camera

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ABSTRACT

Pitching in the correct form is essential for preventing injury and improving skills. It is not easy for athletes and instructors to check whether a pitcher is throwing in the correct form. In this study, we record a pitcher from the direction of the catcher by a monocular camera and estimate the skeleton pose of the pitcher by using OpenPose. We propose a new method to evaluate whether the pitcher can pitch in the correct form by examining the estimated pose. We use SSE(Shoulder, Shoulder, Elbow)-line as an evaluation index. When the upper body of the pitcher faces a batter, the SSE-line should be straight. To find the right frame at which the pitcher body turns squarely to the batter, the distance of the shoulders in a video frame is used. When it becomes the largest, the shape of SSE-line should be measured. Since the motion of the pitcher was fast, we use a 240 fps camera to investigate the relationship between the shape of SSE-line and the shoulder distance. The relationship between the shape of the SSE-line and the shoulder distance with the 240 fps camera was evaluated, and we discussed their pitching properties based on the evaluation.

Keywords: baseball, SSE-line, OpenPose, high speed camera

1. INTRODUCTION

In baseball, pitchers may have pain in the elbows and shoulders due to repeated pitching. They are called baseball elbows and baseball shoulders, respectively. Too much pitching is one of the causes of baseball elbow and baseball shoulders. If the pitching action is not correctly done, they may occur even when the number of pitches is small. Throwing in the correct form will help improve ball speed and control.

Thus, throwing in the correct form is important for avoiding injury and improving skills. However, it is not easy for players and coaches to find out whether a player is throwing in the correct form or not. They might not know the correct form itself.

We propose a new method to measure the correctness of the pitching form by examining the pose given by OpenPose[1]. We record a pitcher from the direction of the catcher by a monocular camera. Since our method needs only one camera which can be placed in the audience seat area. It can be applied not only to practice scenes but also to real games. We invent SSE(Shoulder, Shoulder, Elbow)-line as an evaluation index. When the upper body of the pitcher faces a batter, the SSE-line should be straight.

To find the right frame at which the pitcher body faces squarely to the batter, the distance of the shoulders in a video frame is used. When it becomes the largest, the shape of the SSE-line should be straight. Since the motion of the pitcher was fast, we use a 240 fps camera to investigate the relationship between the shape of the SSE-line and the shoulder distance. The relationship between the shape of the SSE-line and the shoulder distance with the 240 fps camera is examined through the experiment of four pitchers.

2. RELATED WORK

Hirayama et al. have reported that the ball speed decreases as the number of pitches increases in serious pitching practice. They also reported that the pitching form was not the same during the practice[2]. Since they used a motion capture system, it is not applicable to real games. Sensor-based approaches are getting popular in pitching analysis. The analysis

could be done in detail, but players are asked to put sensors on their bodies[3]. By using a smart ball such as Mizuno Inc.'s MAQ, it is possible to analyze the thrown ball. However, they cannot be used in real games.
As for pose and action analysis on the sport that utilizes human bone structure, Nakai et al. proposed the prediction method of free-throw shootings for basketball players [4]. Yagi et al. proposed the method to calculate the stride length and speed transition of 100-meter runners[5]. A fully video-based pitching analysis is expected to come for baseball players.

3. PITCHING FORM

One expression of the correct form is “throw the elbow above the shoulder height.” It is not very easy to objectively describe the goodness of the actual throwing form from this expression. Here we interpret the expression as follows. When the upper body of a pitcher faces the batter, two shoulder points and the elbow of the throwing arm should be placed in a line.
We call this SSE(shoulder-shoulder-elbow)-line.
It is desirable to let the SSE-line be straight. This can be applicable to all throwing methods; over slow, side throw, and under slow.
We aim to evaluate the SSE-line by computer vision method. When the elbow is below the line of both shoulders, the burden is concentrated inside the elbow, causing pain inside the elbow. If the elbow is above the line of the shoulders, this may be putting too much force on the shoulder to raise the elbow. As a result, there is a tendency to hurt the shoulder. Also, if the elbow is not in a straight line, the centrifugal force generated by the rotation of the body cannot be utilized, leading to a decrease in performance.

4. SSE-LINE AND THE SHOULDER DISTANCE

Upon evaluation of the shape of the SSE-line, we define SSE angle, which is formed by the elbow point, the shoulder point of the throwing arm, and the other shoulder point. The shape of the SSE-angle is shown in Figure 1. This can be calculated from the result of OpenPose. The SSE angle being 0° is equal to the SSE-line being straight.
The SSE-line evaluation should be performed when the pitcher’s upper body faces the batter. Since the camera is set behind a batter position, the SSE-line should be evaluated when the upper body of the pitcher is facing the camera. This means the distance of the two shoulders becomes the longest in video frames. We call this shoulder distance (shown in Figure 1).
If the frame rate of the video camera is not fast enough against pitching motion, it could be difficult to find the right frame on which the shoulder distance becomes the maximum.

5. PITCHING FORM EVALUATION

In this chapter, we analyze the time transition of the above-mentioned index to evaluate pitching form. The SSE angle and the shoulder distance are evaluated. The evaluation starts from the frame when the pitcher's shoulder starts to open. This means the pitcher's shoulder skeleton position can be visible at that frame. The evaluation ends at the frame where the pitcher releases the ball. The length of this section was based on the frame where each pitcher released the ball.
For each pitcher, the average and variance of the values of the SSE angle and the shoulder distance are calculated for each frame.

5.1 Summary of the photography

Subject pitchers are four male high school pitchers who belong to a baseball club. We call them Pitcher A, B, C, and D, respectively. They are experienced pitchers. Pitchers A and B are right-handed, and Pitcher C and D are left-handed. The shooting took place on August 2, 2019, and September 7, 2019. As shown in Figure 2, a monocular camera was installed using a tripod right behind the catcher to record them in normal throwing practice. The camera used was CASIO's EXILIM-ZR1800. The video size was 512 pixels by 384 pixels, and the frame rate was 240 fps. Figure 3 shows a frame of the captured videos.

5.2 Result and discussion

Figure 4-11 show the results of each pitcher. The orange value in each graph indicates the SSE angle, and the blue value indicates the shoulder distance. Pitcher A had 25 frames, Pitcher B had 19 frames, Pitcher C had 20 frames, and Pitcher

D had 22 frames for their throws. From the graphs, it can be said that the three pitchers, except Pitcher B, have the same shape even if they threw on another day. It can be seen that the time transition of the SSE angle changes largely through their pitch. The graph shape of the shoulder distance and the SSE angle seem to be unique to the individuals. It does not change even when the pitches are made on different days.
The two different graphs of Pitcher B on different days are considered. A continuous photograph of pitcher B's pitch form is shown in Figure 8 for a certain pitch on August 2 and in Figure 9 for a certain pitch on September 7.
From Figures 8 and 9, it can be considered that the left shoulder was lower in the second half of the pitch form on August 2, compared to the pitch form on September 7, and therefore the SSE angle was larger. The change in the shape of the graph was due to the change of the pitching form.

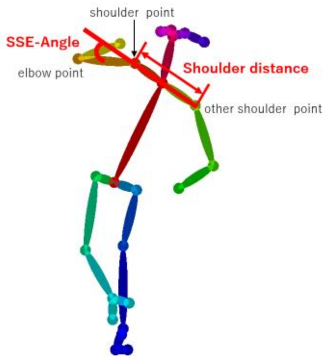

Figure 1. SSE-angle and the shoulder distance

Figure 2. Camera position

Figure 3. Input video frame

6. CONCLUSION

We proposed a new method that uses the video from the front of the pitcher to index the goodness of the pitching form, and that can be used to evaluate the pitching form for each pitcher. We invent the SSE line for that purpose. The time relationship between the SSE angle and the shoulder distance can describe the property of pitchers. Four pitchers were photographed at 240 fps, and the time transition of the SSE line for each pitcher was analyzed using the video taken on another day. According to the results of each pitcher, three pitchers except for Pitcher B show a graph with the same shape even if they were taken on a different day.
This research is partially supported by KAKENHI 19K22857.

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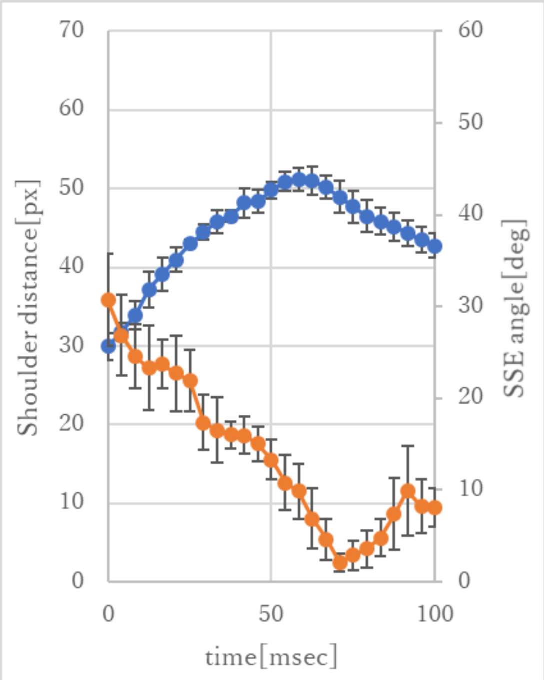

Figure 4. Pitcher A on August 2, 2019

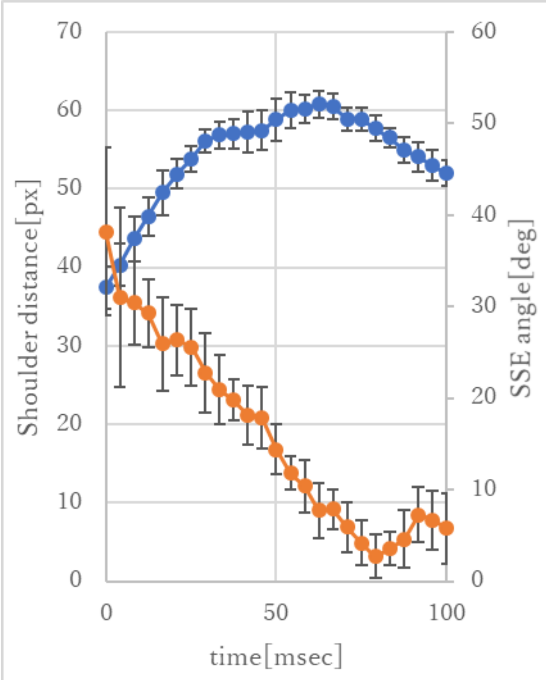

Figure 5. Pitcher A on September 7, 2019

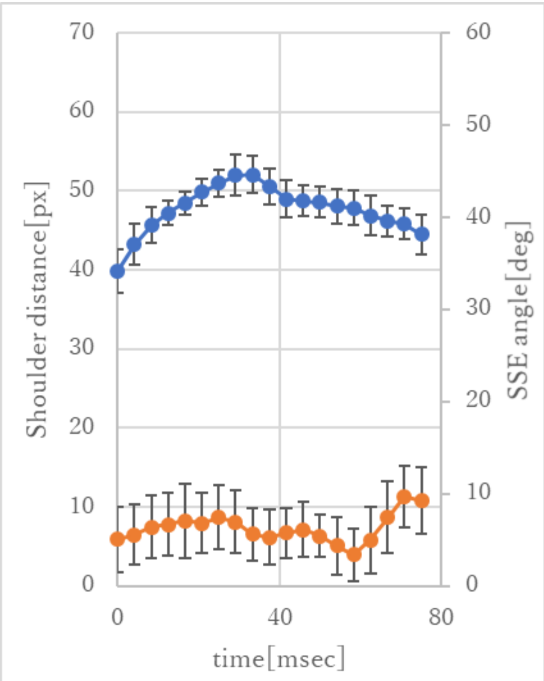

Figure 6. Pitcher B on August 2, 2019

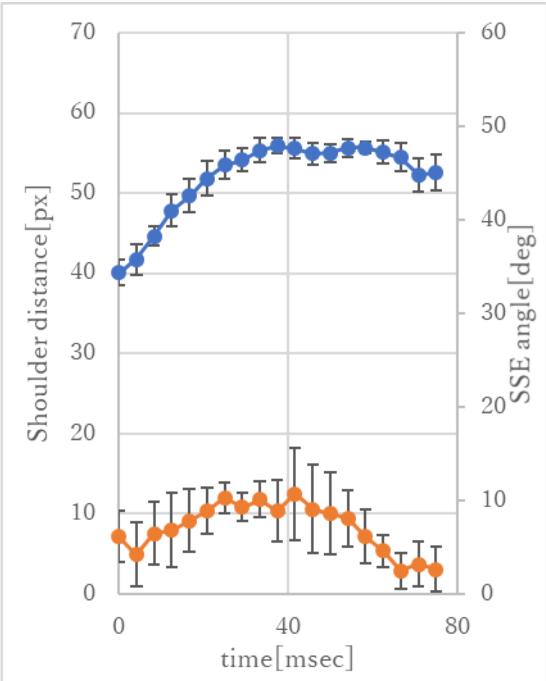

Figure 7. Pitcher B on September 7, 2019

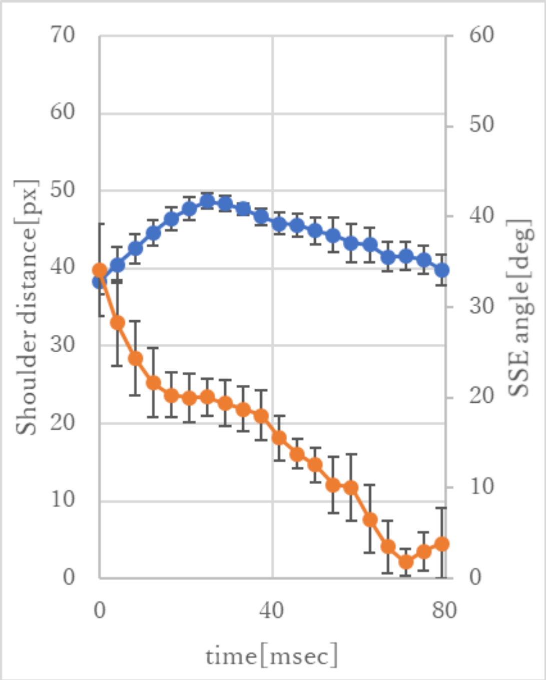

Figure 8. Pitcher C on August 2, 2019

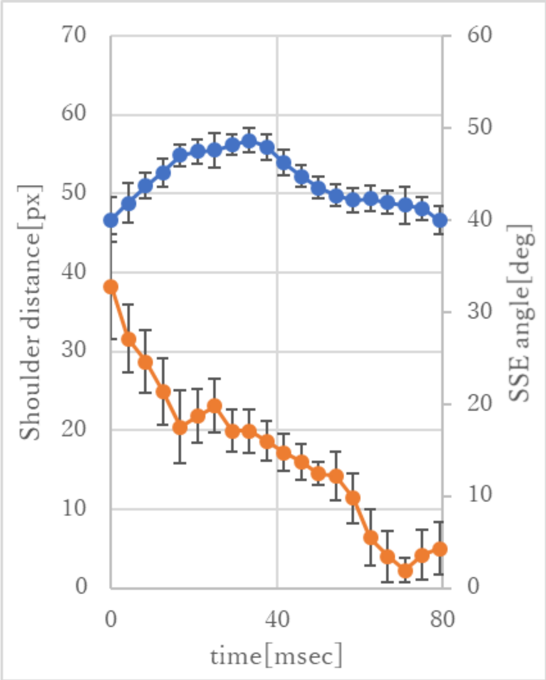

Figure 9. Pitcher C on September 7, 2019

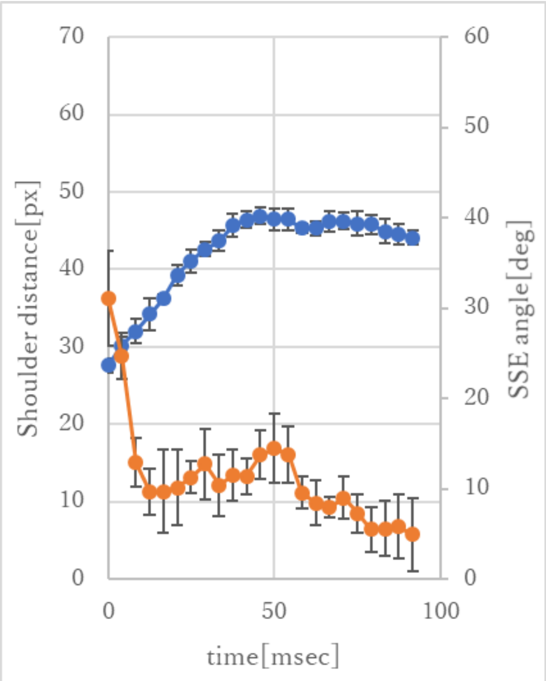

Figure 12. Pitcher D on August 2, 2019

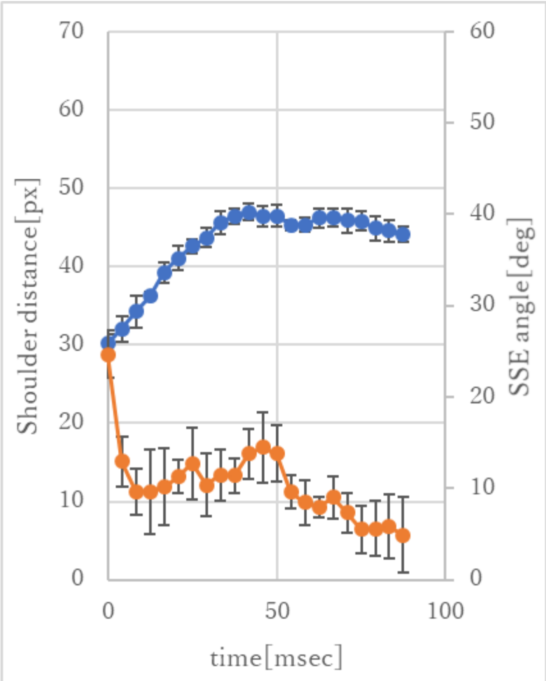

Figure 11. Pitcher D on September 7, 2019


Figure 12. An image sequence of a pitcher A’s pitching form on August 2


Figure 13. An image sequence of a pitcher A’s pitching form on September 7