ANALYSIS OF PHYSICAL PHENOMENA IN GOLF SWING

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INTRODUCITION

- Using Matplotlib and Mediapipe to draw the trajectory of golf club, find the missing points and get its coordinate
- Using double pendulum system and the Lagrangian equation to explain the physical phenomena in the swing phase and then estimate the speed of the impact stage and top stage

METHODOLOGY

- **CRITICAL FEATURE EXTRACTION USING MEDIAPIPE**

- **SWING SPEED ESTIMATION**

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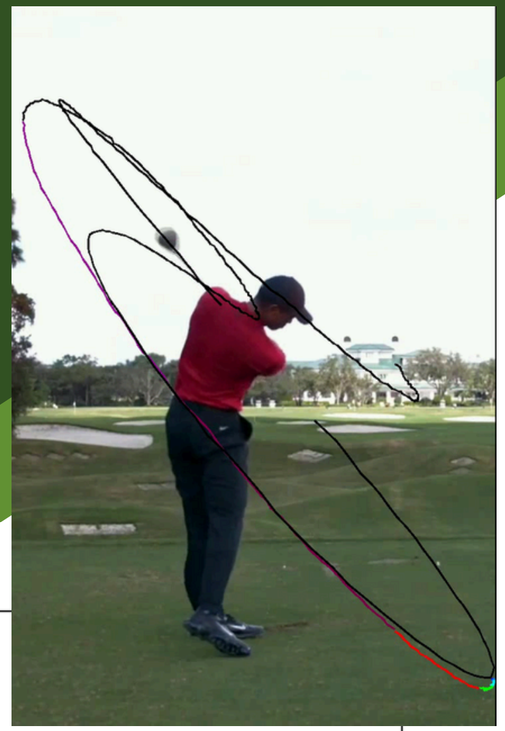
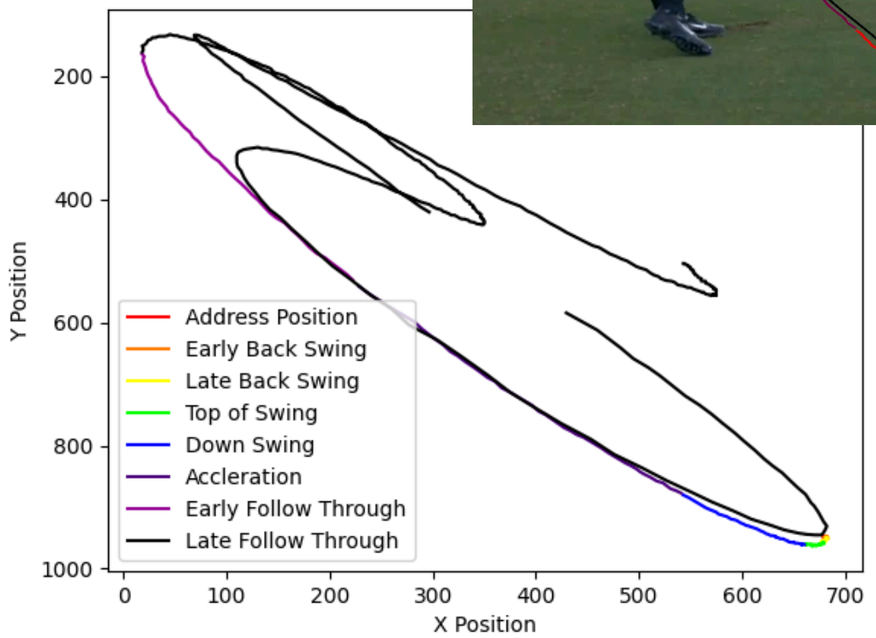
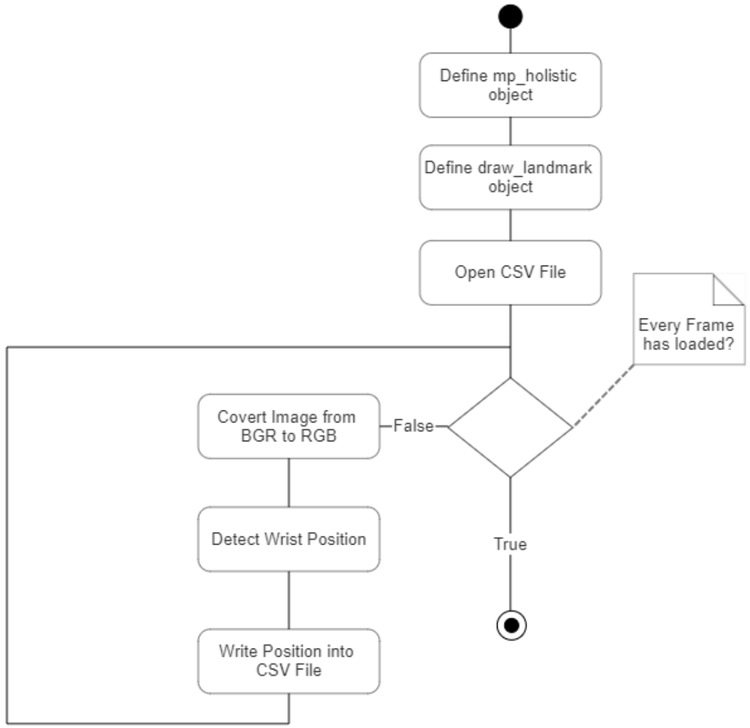
POSE ESTIMATION





- Import label annotations of the clubhead from the Pandas library
- Set it to eight golf swing stages.
- Draw the trajectory through matplotlib.
- Use OpenCV to input the video and ouput the video with trajectory

POSE ESTIMATION



- Define draw_landmarks function to draw the key points on the image
- Define and employ the Holistic model to detect position of the shoulder and wrist.
- If detected, write the date into the file.

RECOVERY OF THE OCCLUDED CLUBHEAD POSITIONS

- Some clubhead is invisible in frontal and side view of golf swing because of the body occlusion.
- These occluded clubhead can be estimated by wrist position, arm and shoulder angle, wrist and swing angle, and wrist and ground angle.
- First covert all angles to radians. Then use these angles to calculate the angle of between the swing and ground.
- Third the sum of the wrist horizontal position and the sine value of the angle between swing and ground is to obtain the horizontal annotation of the clubhead.

RECOVERY OF THE OCCLUDED CLUBHEAD POSITIONS

- Third the sum of the wrist horizontal position and the sine value of the angle between swing and ground is to obtain the horizontal annotation of the clubhead.
- Fourth the sum of the wrist vertical position and the cosine value of the angle between swing and ground is to obtain the vertical annotation of the clubhead.

- CRITICAL FEATURE EXTRACTION USING MEDIAPIPE

- **SWING SPEED ESTIMATION**

SWING SPEED ESTIMATION(1)

- the total length of the video was divided by the number of frames in the annotation to obtain the time of one grid.
- The interval between the three points was assumed to be the same
- the distance between two points divided by the time between the two points.
- the instantaneous speed at point B was obtained by taking the average.

SWING SPEED ESTIMATION(2)

- The interval between the three points was assumed to be the same
- the midpoint coordinates of point A and point B and those of point B and point C were calculated, which were points A' and C', respectively.
- the distance between two points divided by the time between the two points
- the instantaneous speed at point B was obtained.

EXPERIMENTS AND EVALUATIONS

THE RESULT OF POSE ESTIMATION

MOMENTUM DURING DOWNSWING AND IMPACT INSTANT

EVALUATION RESULTS

THE RESULT OF POSE ESTIMATION

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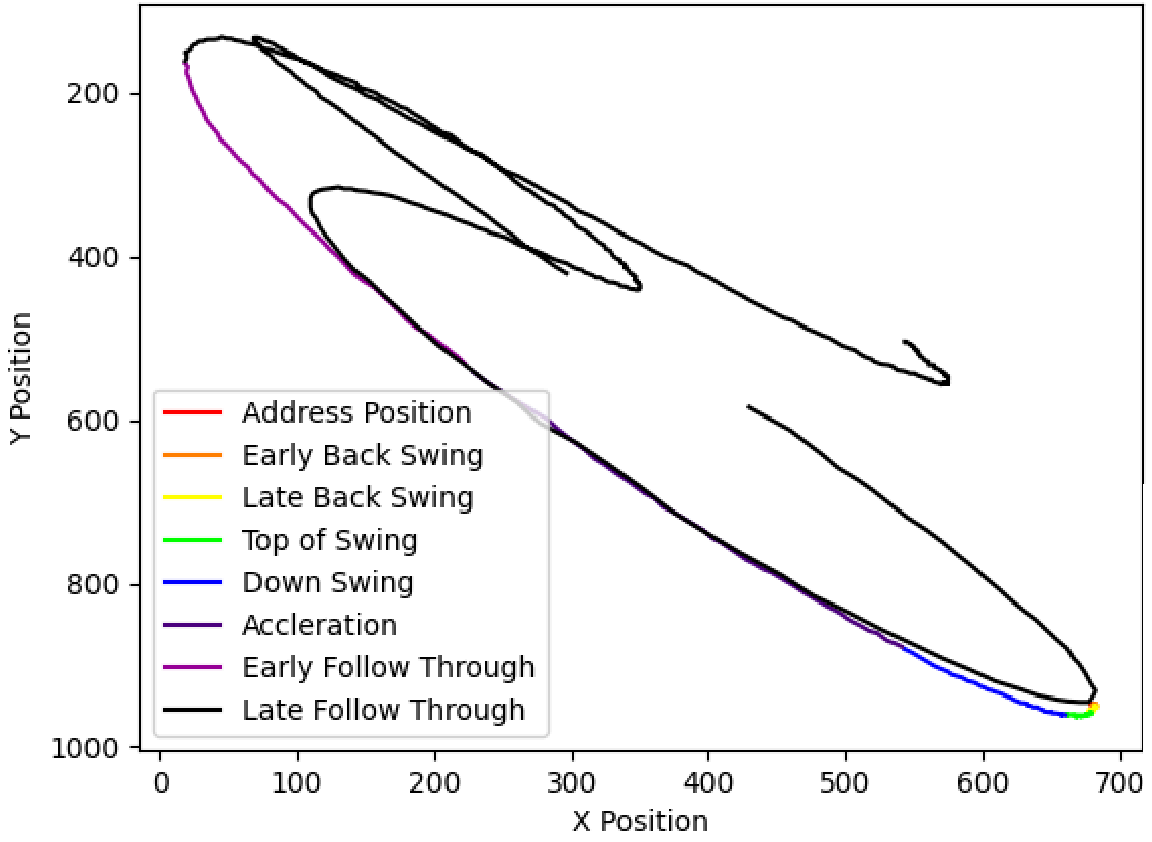
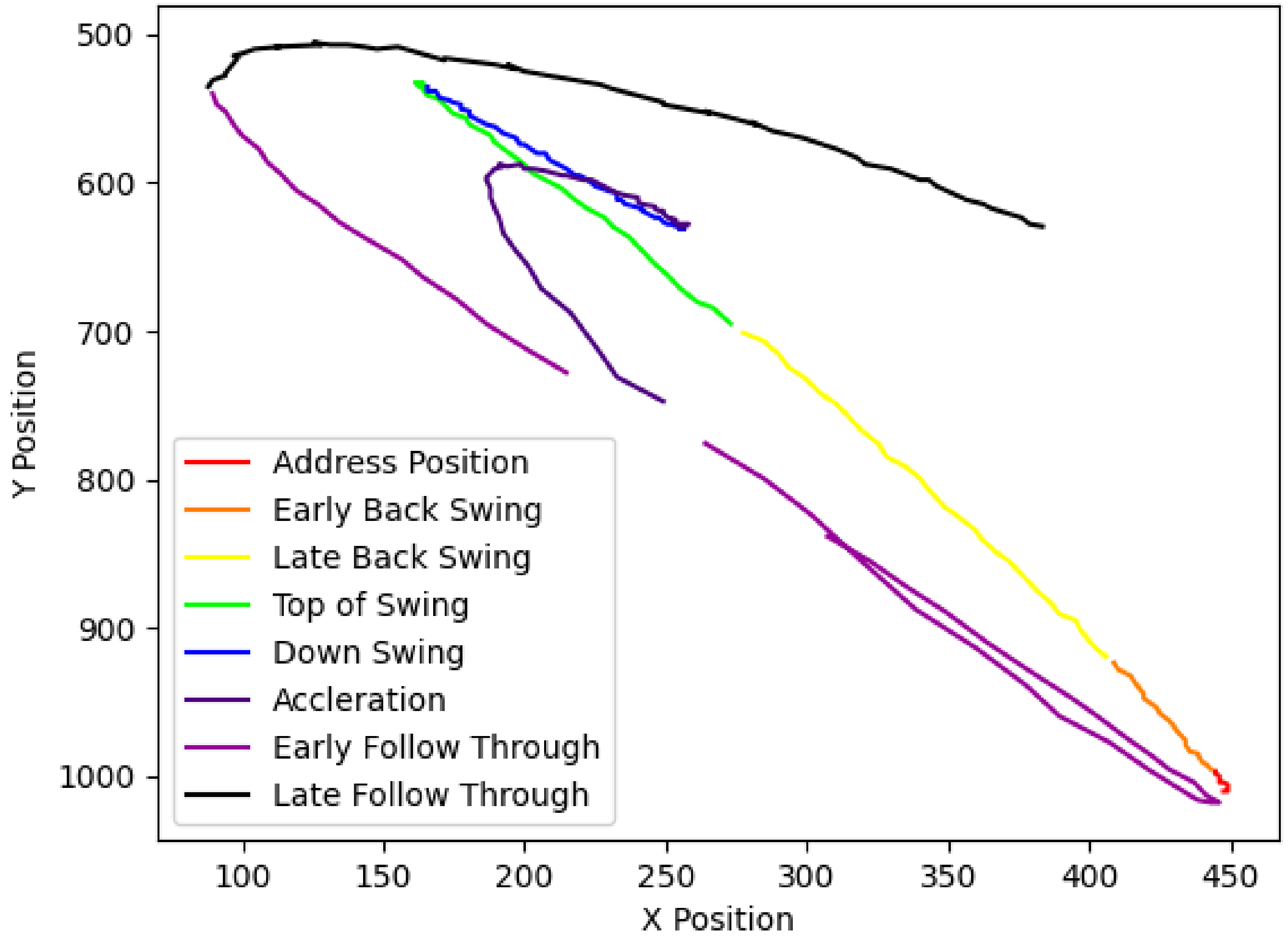
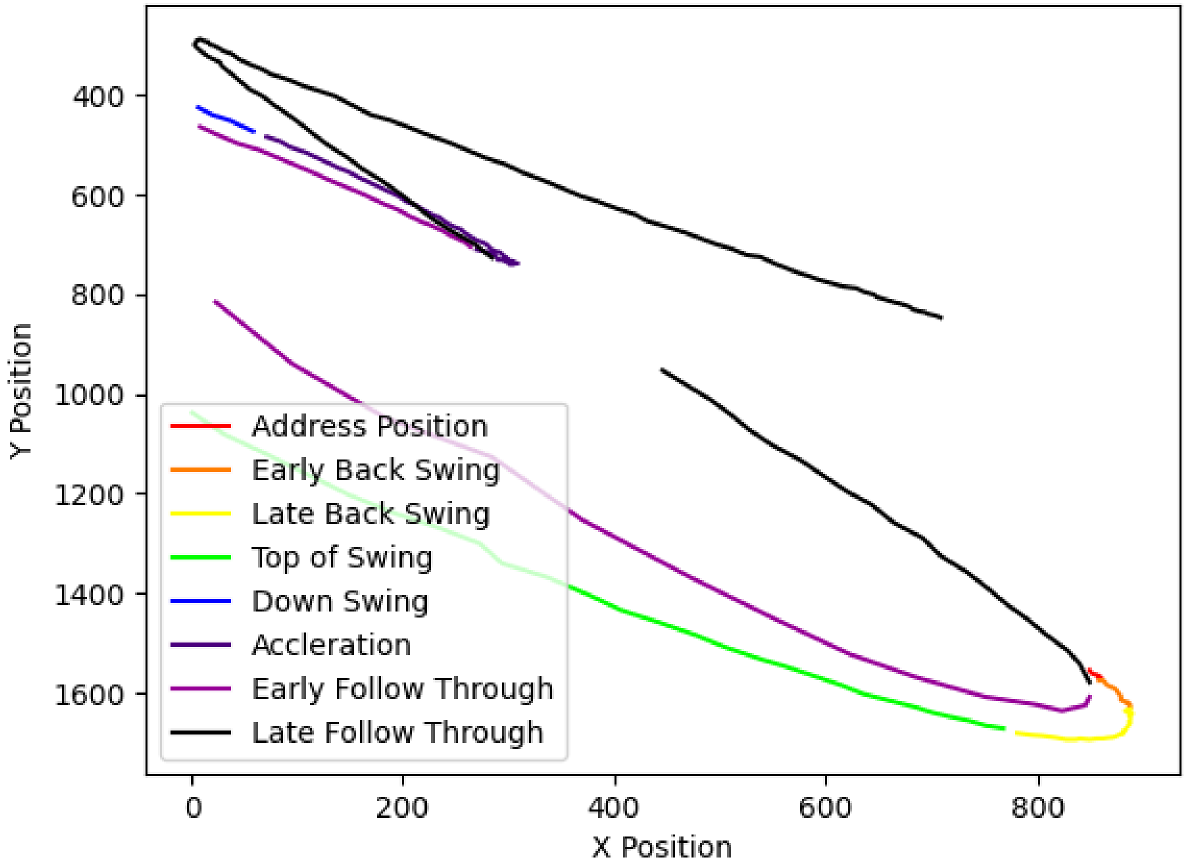
THE RESULT OF POSE ESTIMATION







THE RESULT OF POSE ESTIMATION

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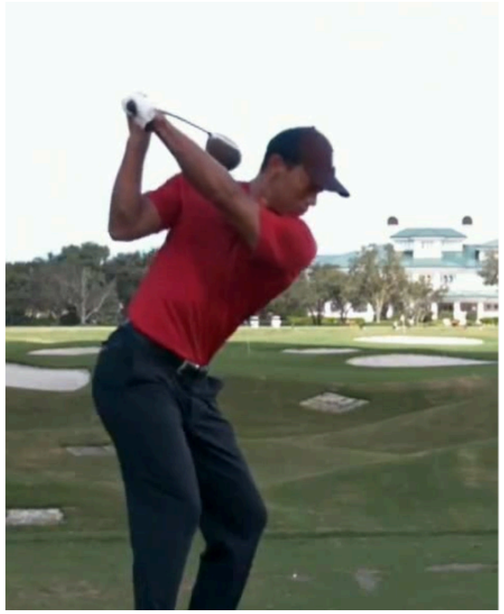
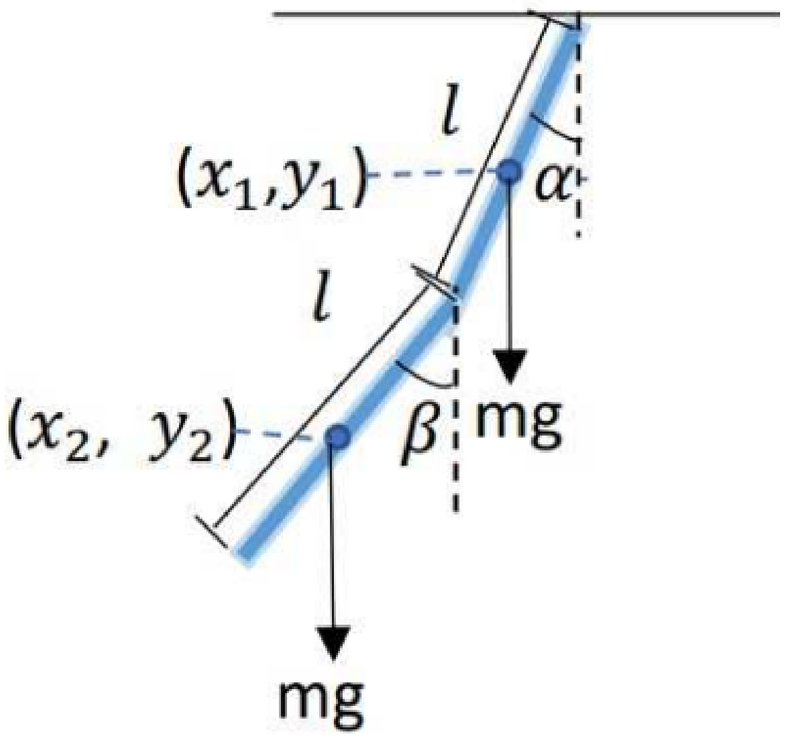
EVALUATION RESULTS

MOMENTUM DURING DOWNSWING AND IMPACT INSTANT





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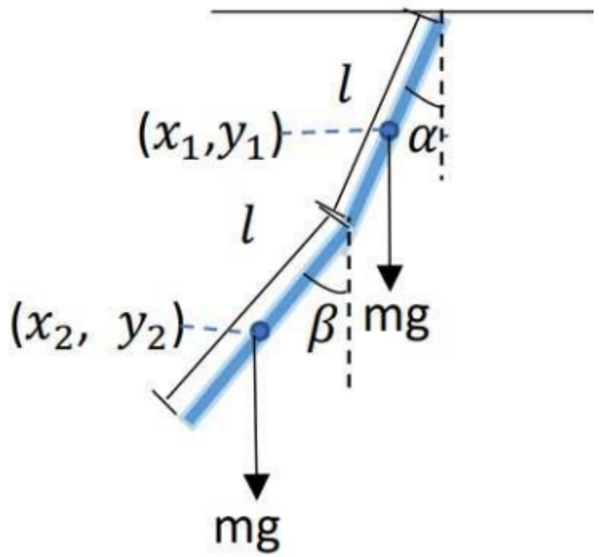


$$L = \frac{1}{6}ml^2\left(\dot{\beta}^2 + 4\dot{\alpha}^2 + 3\dot{\alpha}\dot{\beta}\cos(\alpha - \beta)\right) + \frac{1}{2}mgl(3cos\alpha + cos\beta)$$

$$P_\alpha = \frac{1}{6}ml^2(8\dot{\alpha} + 3\dot{\beta}\cos(\alpha - \beta))$$

$$P_\beta = \frac{1}{6}ml^2\left(2\dot{\beta} + 3\dot{\alpha}\cos(\alpha - \beta)\right)$$

Table I Physical parameters of the top stage and impact instant in the DP system

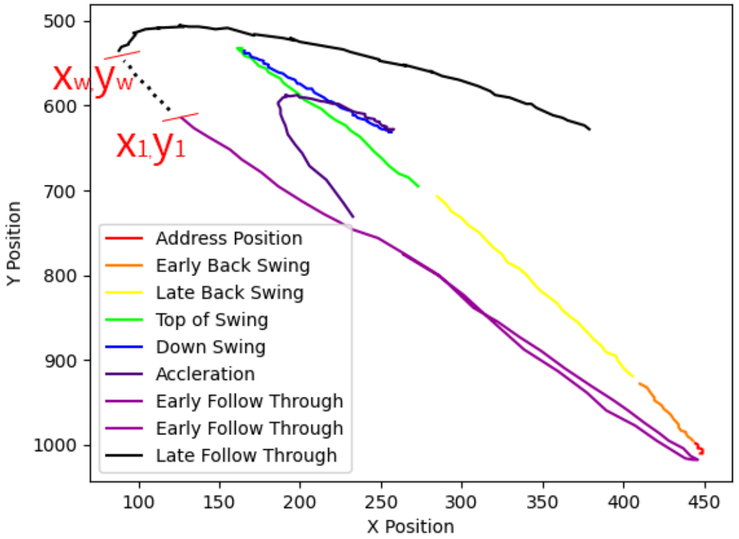
Top	x_1	y_1	x_2	y_2	α	β	$\dot{\alpha}$	$\dot{\beta}$	P_α	P_β	F(N)	m	l
	295.92	442.36	305.13	424.53	172.23	58.47	4.16	-11.86	0.03	0.08	40.85	1	1
Impact	x_1	y_1	x_2	y_2	α	β	$\dot{\alpha}$	$\dot{\beta}$	P_α	P_β	F(N)	m	l
	379.53	575.51	551.06	800.93	78.19	70.18	-4.13	-39.88	-0.09	-0.15	45.18	1	1

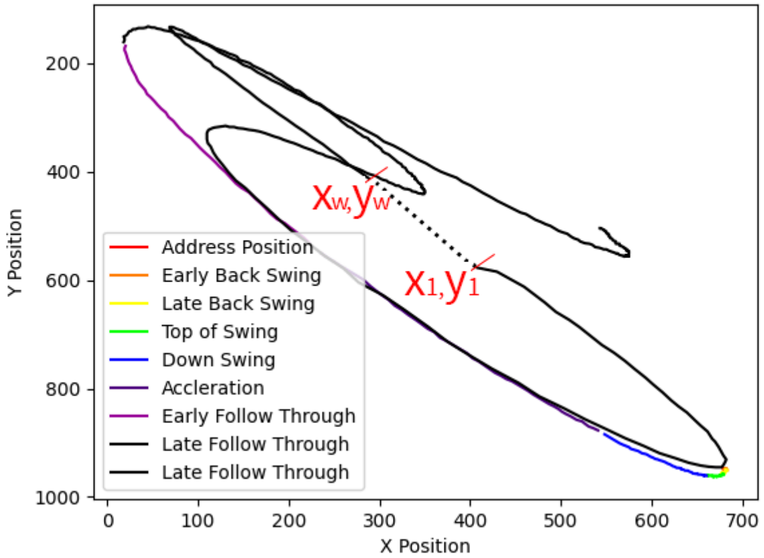
THE RESULT OF POSE ESTIMATION

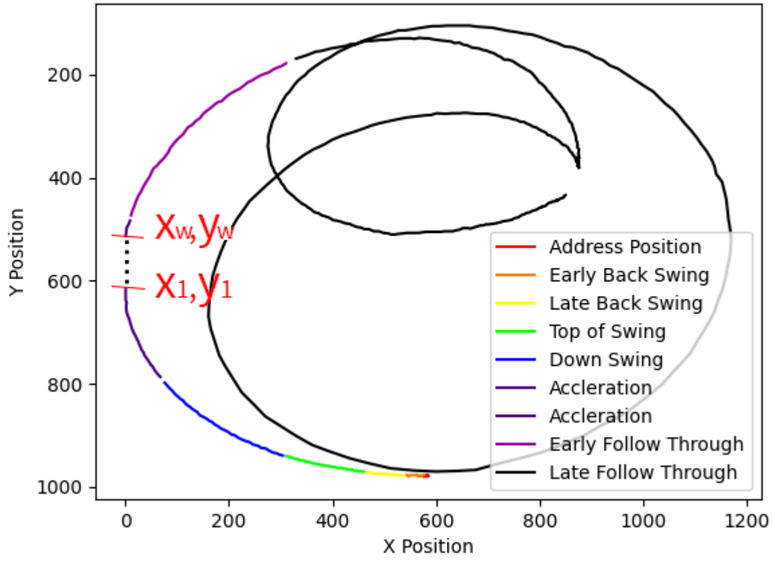
MOMENTUM DURING DOWNSWING AND IMPACT INSTANT

EVALUATION RESULTS

RECOVERY OF MISSING ANNOTATIONS







THE SPEED ESTIMATION

84.47 (cm/s)

CONCLUSION

- some problems in the players' hitting skills, such as incorrect posture and incorrect swing path, could be detected.

- The discovery and resolution of these problems can help players improve their swing skills and competitive level.

THANK YOU