Boxes and Balls: Final Presentation

Owen Huang and Richie Zachariah

Agenda

- 1. Background
- 2. Data Generation
- 3. YOLO example
- 4. Spin Detection
- 5. Next steps

Background

Background: Spin in Table Tennis

- Very dynamic sport
- Players utilize the concept of spin to gain an advantage
- Spin caused by friction between ball and paddle
- Spin:
 - Changes path of ball
 - Changes how opponent must return ball



Background: Our Problem

We wanted to develop an algorithm that can predict what spin was applied to a ping pong ball after it has been hit.

Tasks:

- Train a neural network to recognize a ping pong ball
- Track ball using video
- Follow path of ball
- Classify the spin of the ball based on trajectory
 - Ex. top spin, back spin, side spin

Background: Project Applications

- Gathering statistics and information (Ex. Frequency of certain spins)
- Improving quality of replays
- Analyzing player playstyle
- Similar concept can be replicated in other sports
 - Tennis
 - Soccer
 - Pool
 - Baseball
 - Cricket

Data Generation

Data Generation: Recording Video



- iPhone camera
- Using 1080p at 60 FPS
- Around 20 minutes of footage
- Used different angles with varying distances

Data Generation: Extracting Frames from Video

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import os import glob	Name	Date	Туре	Size	Tags
<pre>vidcap = cv2.VideoCapture('IMG_3701.MOV') success,image = vidcap.read() count = 0 # Saves each frame in same directory as program while success: cv2.imwrite("image %d.jpg" % count, image) # save frame as JPEG file success,image = vidcap.read() </pre>	 image 382 image 383 image 384 image 385 image 386 image 387 image 388 	8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM	JPG File JPG File JPG File JPG File JPG File JPG File	150 KB 147 KB 149 KB 147 KB 149 KB 149 KB 147 KB 149 KB	
<pre>print('Read a new frame: ', success) count += 1 # Creates text file with image numbers and directories</pre>	image 389 image 390 image 391	8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM	JPG File JPG File JPG File IPG File	149 KB 149 KB 147 KB 149 KB	
<pre>imageFile = open("ImageFile.txt", "w") count2 = 0 for directory in glob.glob("C:/Workspace/updatedVideoToFrames/*.jpg"): # currentImage = os.listdir(name) str1 = ("image_%d.jpg, " % (count2))</pre>	 image 393 image 393 image 394 image 395 image 396 	8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM	JPG File JPG File JPG File JPG File	145 KB 146 KB 149 KB 144 KB 146 KB	
<pre>str1 = str1 + directory str1 = str1 + "\n" imageFile.write(str1) count2 += 1 imageFile.close()</pre>	 Image 396 image 397 image 398 image 399 ImageFile 	8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM 8/2/2021 1:56 PM	JPG File JPG File JPG File JPG File Text Document	146 KB 142 KB 145 KB 146 KB 48 KB	
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videoToFrames

- Converted video to individual frames
- Saved frames as JPG files in folder
- About 60 pictures per second of video -

Data Generation: Forming Training Data



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https://www.makesense.ai

- Manually placed bounding boxes around ball
- Exported boxes in .csv file
 - X-coordinate of center, Y-coordinate of center, width of box, height of box
- Values above used for machine learning

YOLO

YOLO: Example



Spin Detection

Spin Detection: Theory



Ball Trajectory

- Exploits flight path and Magnus Force
- Will use polynomial regression

Spin Detection: Extracting 3D Coordinates

- Very crude approximation (because of time constraints)
- Extracting 3d coordinates from 2 camera angles





Spin Detection: Magnus Force



Spin Detection: Regression and Linear Systems

Spin Detection: Results

```
def solveOmega():
    M = buildMatrix(0)
    acc = buildAcceleration(0)
    for i in range(1, len(times)):
        t = time_step * i
        M = np.concatenate((M,buildMatrix(t)),axis=0)
        acc = np.concatenate((acc,buildAcceleration(t)),axis=0)
    omega = np.linalg.solve(M.T@M, M.T@acc)
    print('Ball is spinning in the direction of ' + str(omega))
```

solveOmega()

Ball is spinning in the direction of [4.80489623e+06 5.58332166e+09 -2.92713315e+06]

Next Steps

Next Steps

- Program that can trace 2D path of ball from different angles
- Done using center of bounding box for each frame
- 2-d path important for detecting spin

Questions?