Heatmap of Players on a Padel Court

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September 18, 2023

Abstract

A video of the so called "best point in padel's history" was the object of a computer vision application able to compute the motion of the players during a Paddle match. A Yolo detection model was used on each frame of the video to detect the relevant classes and a homographic transformation was applied to transform the image coordinates in real world coordinates, mapping the players and objects with respect to the ground. Also, finally "heatmap" of the players was computed.

1 Introduction

Padel, also known as "padel tennis" or "platform tennis," is a racquet sport played on a smaller, enclosed 10m x 20m court. Players use solid padels and a rubber ball with limited bounce. The objective is to score points by hitting the ball over the net and into the opponent's court, with the added challenge of using the walls. It's popular in cold climates due to heated courts and is known for its fast-paced, strategic gameplay.

Heatmap is a concept largely used in sports in general. The map shows the relative frequency of the position of the players and is one of the elements of the sports data benchmark, useful on performance analysis.

The World Padel Tour of 2020 was the context for the point defined by the Argentinian player Juani Mieres as the best in his career. He and his fellow contryman Miguel Lamperti played Brazilian Marcello Jardim and Argentinian Lucho Capra. Because it is a decent representative piece of a regular Padel match, the record of the point was the object of the analysis of this study.

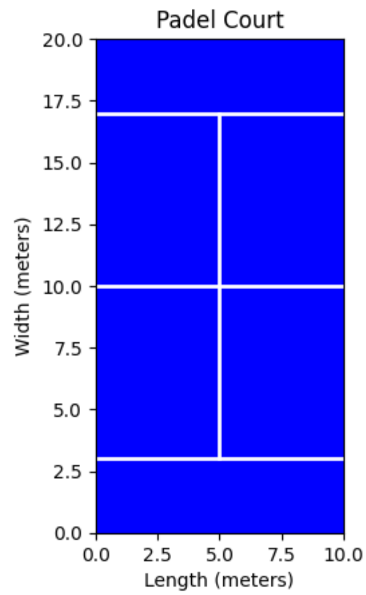

Figure 1: Paddle Court Real-World Coordinates

2 Methodology

The first step of the data processing pipeline was to separate the downloaded video in jpg files of the frames of the record. The video is 1 min and 17s long and the total number of frames is 1834. So, the interval between each frame is approximately 42 ms.

YOLO (You Only Look Once) is a fast and accurate object detection algorithm in computer vision.

It predicts bounding boxes and class labels for objects in a single pass through a neural network, making it suitable for real-time applications. It divides the image into a grid, predicts multiple bounding boxes for each grid cell, and uses anchor boxes to handle objects of different sizes and shapes. YOLO is widely used in various fields, such as surveillance, autonomous driving, and more, due to its speed and accuracy.

Figure 2: Yolo applied to one of the frames

YOLO (version yolov7) was applied to the frames of the video, and it was able to pinpoint the position of the players on the image. For some frames, as the one depicted in Figure 2, yolo also detected the the padel rackets as the class "tennis racket", and the ball of the game, as the class "sports ball". A car that is parked on the up-left corner of the image was detected in every frame. For an initial analysis, the focus of this work will be on the players and their bounding boxes. The numbers in the up-left corner of the bounding boxes represent the probability of a correct classification. Yolo, when run by the detct.py script, is able to output a text file informing the classes of the object detected and its bounding boxes coordinates. The text output associated with the frame of Figure 2 is as follows:

```
32 0.91875 0.566667 0.0109375 0.0166667
38 0.354688 0.327083 0.01875 0.0347222
38 0.230469 0.663194 0.0265625 0.0541667
0 0.387109 0.311111 0.0523437 0.188889
0 0.469141 0.226389 0.0429688 0.152778
2 0.0648438 0.140972 0.129688 0.140278
0 0.207031 0.619444 0.0546875 0.25
0 0.678906 0.638889 0.0828125 0.233333
```

Each line corresponds to one object detected, the integer is the label of the object. The labels found were 2, 38, 0 and 32, that represent cars, tennis rackets, people and sports balls, respectively.

The second and the third element of each row are the normalized x horizontal and y vertical coordinates of the center of the bounding box with respect to the upper left corner of the image as the origin point (0,0). The third and the forth coordinates are the normalized width and height of the bounding box, the 2d box that enclosures the detected object. In the case of a person, the lower line of the box contains the point of contact with the floor (if it exists). This work models the position of the players on the court as the center of the lower limit of the bounding box, in image coordinates:

$$x_{floor} = x \tag{1}$$

$$y_{floor} = y + \frac{boxwidth}{2} \tag{2}$$

Because only points on the floor are being considered, mapping the image coordinates into real world coordinates in this case is a 2D x 2D transformation. A homographic transform, often referred to as a homography or homographic transformation, is a mathematical transformation used in computer vision and image processing to map points from one two-dimensional plane to another. It describes the relationship between points in two different images or scenes that are related by a projective transformation. A quasi-parallelogram that forms the court in the image is mapped into a rectangle that has the dimensions of a regular padel court, as in Figure 1, using a homography matrix.

The fact that the camera remains static during the scene simplifies the problem because the homography matrix is the same for all the frames and needs to be computed only once. The python library OpenCV can compute the homography matrix if at least 4 points correspondences in the two 2D spaces are given. To find the points that form the court, lines were plotted over one frame and their coefficients were adjusted until they visually matched the edges of the parallelogram, like displayed in Figure 3. Figure 4 shows only the lines that delimit the court on a 2D clean plane. Later, the intersection points of those line were computed, and some were excluded because they were not part of the distorted court. These 6 points, showed in Figure 5, were the ones chosen to match the real world points in the new system of coordinates, according to Figure 1. The following homography matrix was found:

$$\begin{bmatrix} 1.00573521e+01 & -3.33475888e+00 & 6.20128376e-02 \\ 3.40240542e-02 & 1.33613688e+01 & 3.22180200e-02 \\ 2.11447369e-03 & -6.47405088e-01 & 1.00000000e+00 \end{bmatrix}$$

The homography transformation requires a first step of homogenization of coordinates, a z coordinate with value 1 is added to the 2D point.

To find the real-world coordinates $\mathbf{X} = [x, y]^T$, you apply the inverse homography transformation to $\mathbf{X}_h$:

$$\mathbf{X} = \mathbf{H}^{-1} \cdot \mathbf{X}_h$$

Here, $\mathbf{H}^{-1}$ is the inverse of the homography matrix.

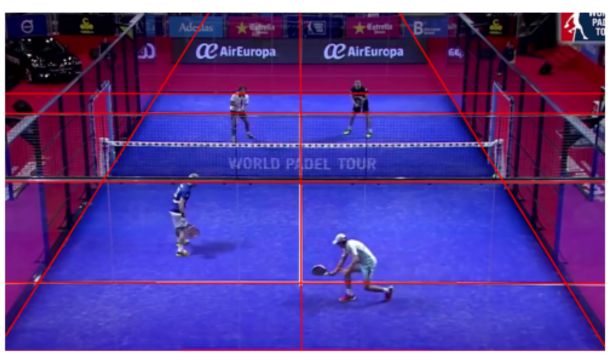

Figure 3: Detection of Court Edges

The homography transformation was applied to all the points labeled as persons (the others were filtered out) for all the frames. The Real World Coordinates of the frame of Figure 2 are represented on the Figure

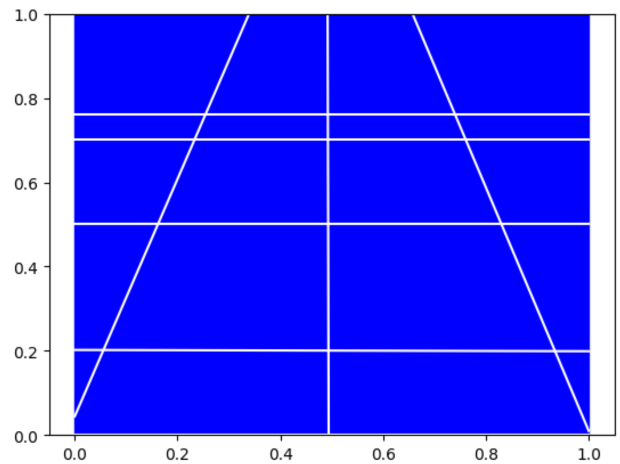

Figure 4: Court Edges Representation

3 Results

Having mapped the positions of the players with respect to the court in real world coordinates, the computation of the heatmap of the players was performed, simply by coarse-graining the points coordinates to establish a 80x40 map of frequencies. The result is showed in Figure 7.

4 Conclusion

The data processing leading to the homography transformation worked in a satisfactory way and as a consequence, the mapping to the court was well performed as well as the computation of the heatmap. Modelling players as one point in such a small court might be one factor that causes imprecision. Nonetheless, the choice for the central point of the lower limit of the bounding box seems to reflect good results. Yolo had some problems when players were in unusual positions for example "diving" to save a point, and some frames simply lack one or two labeled objects, A further good work to develop in this framework could try to increase the generality capacity of this project. A corner detector could calculate the edges of the court and its correspondences with the padel court points, that way computing dif-

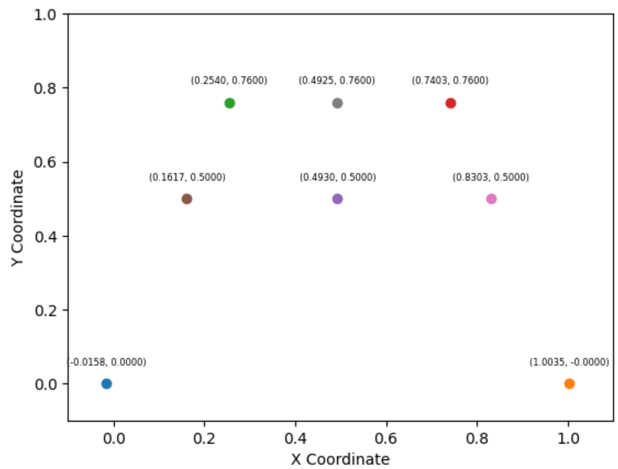

Figure 5: Corner Points of the Court

ferent homography matrix and the transformation in real world coordinates

article hyperref

5 References

References

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[2] Lee, S. H.,(2022). Understanding Homography (a.k.a Perspective Transformation) *Conference Proceedings*, 567-580.

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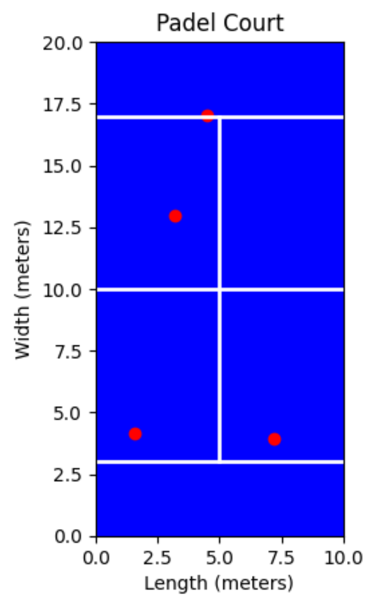

Figure 6: Real World Coordinates

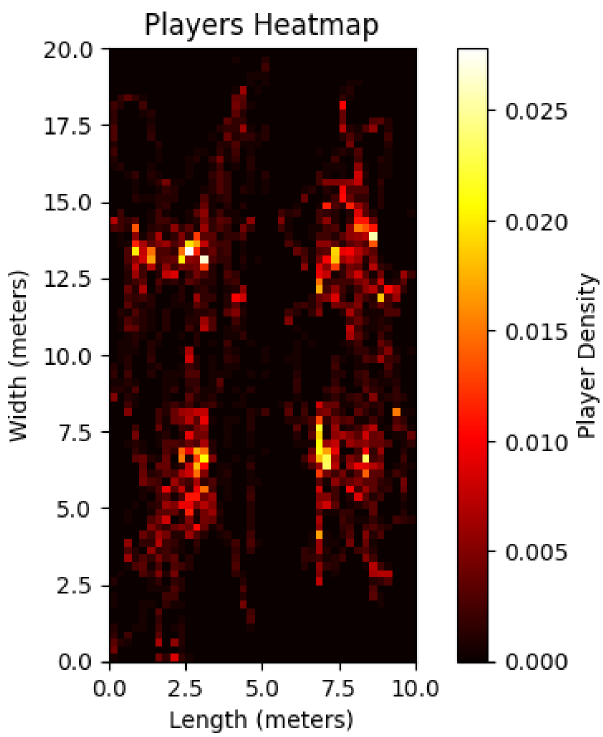

Figure 7: Heatmap of the Players