Pickleball Analytics

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Agenda

- PROJECT OVERVIEW
- TRACK NET 2.0
- EDA
- MODEL PERFORMANCE
- FUTURE APPLICATIONS

What is Pickleball?

- Mix of tennis, badminton, and pingpong
- Can fit in a badminton court or a tennis court
- From 2019-2021, 40% increase of players in the US alone
- Estimated 4.8 million players in the US
- Industry expected to be worth ~$1.2 billion dollars in 2023

Sports Analytics: An Overview

- Sports Analytics industry is worth roughly $929 million globally
- Sports like tennis and baseball, utilize ball tracking metrics to obtain information
- Demand for such information expected to grow
- Currently no such offering exists for pickleball

What is our project?

- Project Sponsor is working on developing a pickleball analytics model
- Model is able to give detailed statistics on ball velocity, shot type, location
- Currently has identified a key issue with ball detection
- Goal: Achieve a 65% TP Rate

Literature Review

CNN Features off-the-shelf: an Astounding Baseline for Recognition (May 2014)

"The results strongly suggest that features obtained from deep learning with convolutional nets should be the primary candidate in most visual recognition tasks."

A. S. Razavian, H. Azizpour, J. Sullivan, and S. Carlsson, "CNN Features off-the-shelf: an Astounding Baseline for Recognition." arXiv, May 12, 2014. doi: 10.48550/arXiv.1403.6382.

A Study on CNN Transfer Learning for Image Classification (Aug. 2018)

"The CNN model used can be refined and fine-tuned further by stacking additional layers and adjusting weights."

M. Hussain, J. J. Bird, and D. R. Faria, "A Study on CNN Transfer Learning for Image Classification," in Advances in Computational Intelligence Systems, Cham, 2019, pp. 191–202. doi: 10.1007/978-3-319-97982-3_16.

A Study of Automatic and Real-Time Table Tennis Fault Serve Detection System (November 2018)

"…propose an image processing algorithm to locate the current position of a ball and predict its trajectory Zhao et al., also propose the use of convolutional neural network to find the position and center of mass of a ball"

Hung CH. A Study of Automatic and Real-Time Table Tennis Fault Serve Detection System. Sports (Basel). 2018 Nov 28;6(4):158. doi: 10.3390/sports6040158. PMID: 30487405; PMCID: PMC6316619.

TrackNet: A Deep Learning Network for Tracking High-speed and Tiny Objects in Sports Applications (July 2019)

"...develop a deep learning network, called TrackNet, to track the tennis ball from broadcast videos in which the ball images are small, blurry, and sometimes with afterimage tracks or even invisible.

Y. -C. Huang, I. -N. Liao, C. -H. Chen, T. -U. İk and W. -C. Peng, "TrackNet: A Deep Learning Network for Tracking High-speed and Tiny Objects in Sports Applications," 2019 16th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), Taipei, Taiwan, 2019, pp. 1-8, doi: 10.1109/AVSS.2019.8909871.

TrackNetV2: A Ball Tracking Solution

Who designed it?

Researchers from National Chiao Tung University in Taiwan. TrackNetV1 was created for tennis, but TrackNetV2 has been optimized for badminton.

How does it work?

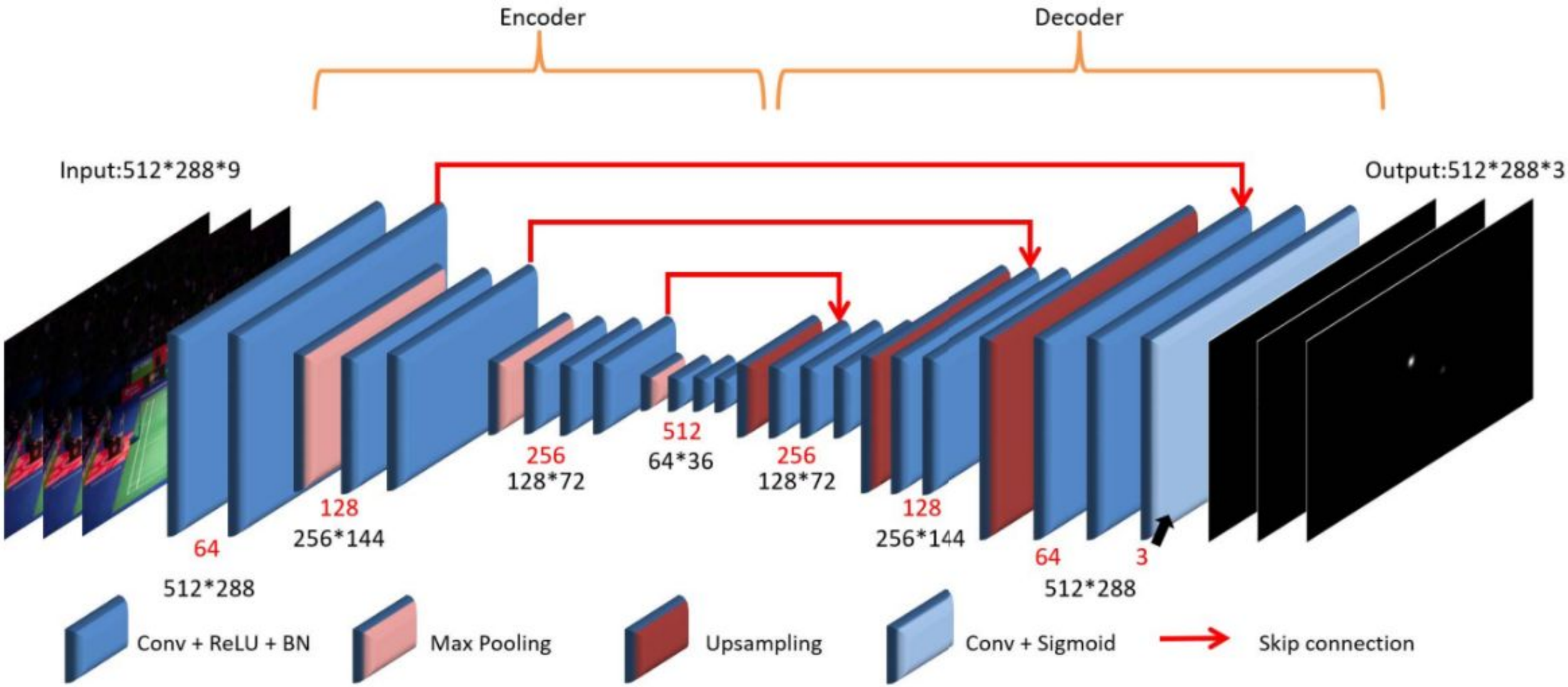
Uses Deep Learning to track the ball in video footage and draw a shot trajectory. It’s an Encoder-Decoder model.

What was it trained on?

55,563 frames of professional badminton games on different courts and camera angles.

N.-E. Sun et al., “TrackNetV2: Efficient Shuttlecock Tracking Network,” 2020 International Conference on Pervasive Artificial Intelligence (ICPAI), pp. 86–91, Dec. 2020, doi: 10.1109/ICPAI51961.2020.00023.

TrackNetV2: Efficient Shuttlecock Tracking Network



N.-E. Sun et al., “TrackNetV2: Efficient Shuttlecock Tracking Network,” 2020 International Conference on Pervasive Artificial Intelligence (ICPAI), pp. 86–91, Dec. 2020, doi: 10.1109/ICPAI51961.2020.00023.

Raw Dataset Statistics

Title	Pro Senior Mixed Doubles Gold Medal Match
Date	Sep, 2021
Dimension	1920×1080
FPS	60
Length	~ 54 mins

Baseline Performance

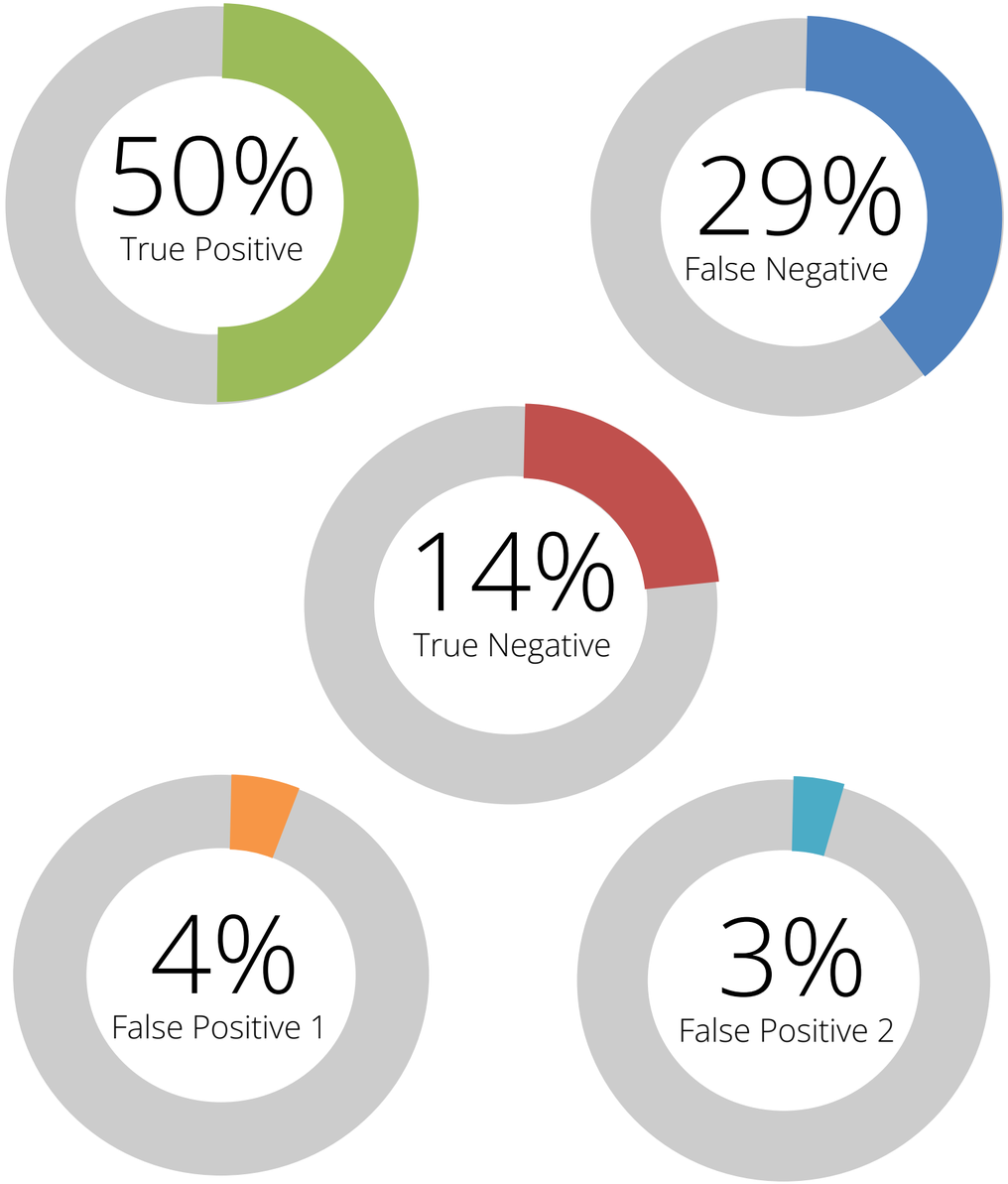
False Positive Distinctions

False Positive 1:

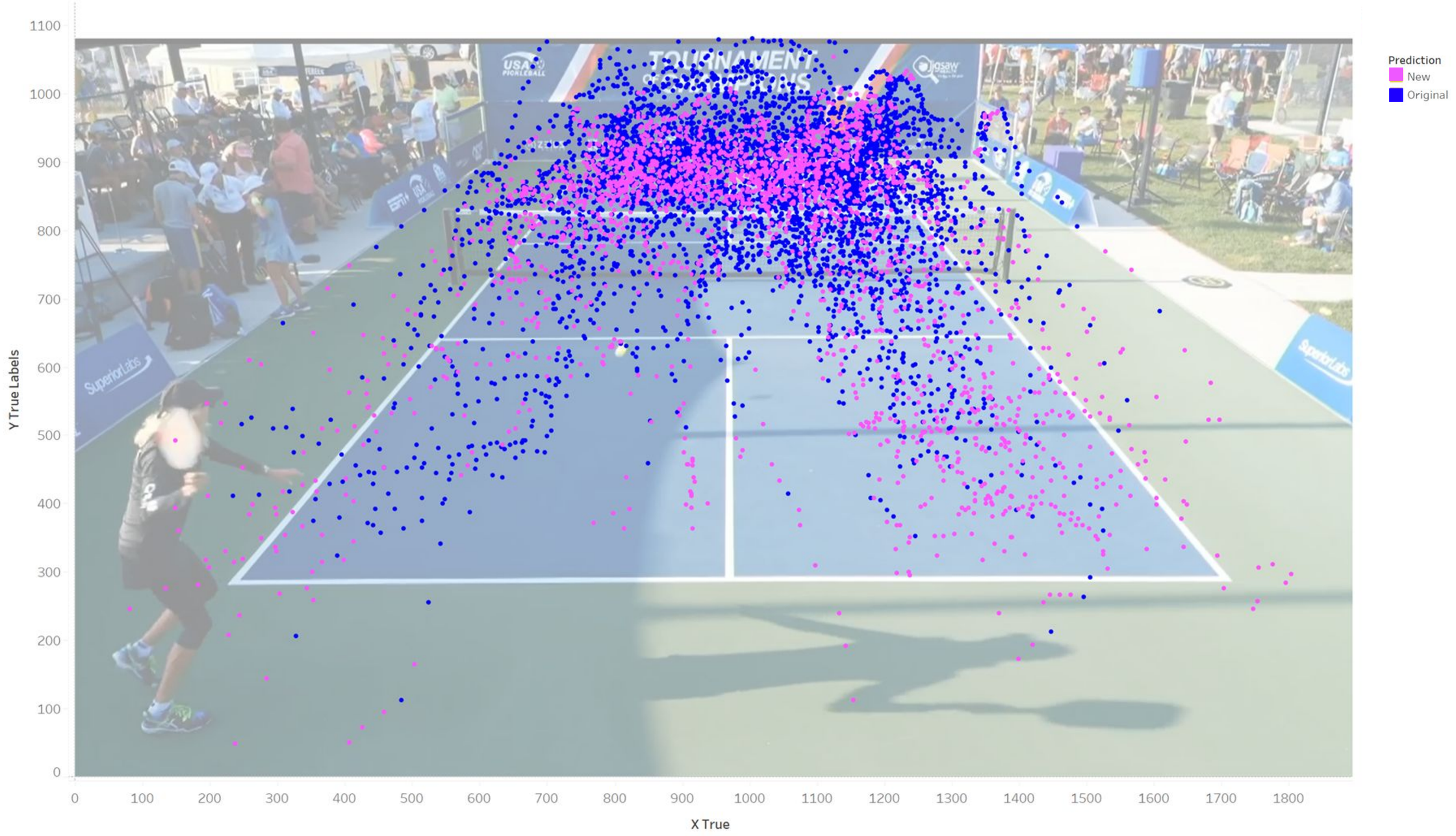
Prediction is too far from the ground truth location

False Positive 2 :

It predicts a ball when there isn't one

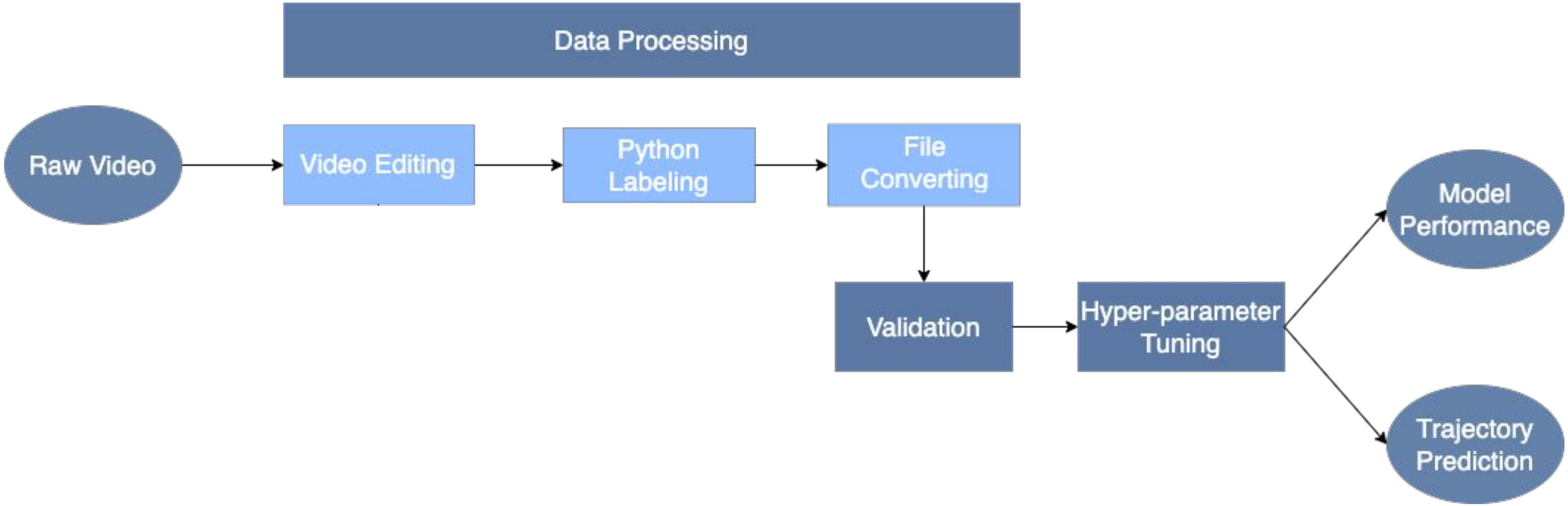


Ball Predictions



X True vs. Y True Labels. Color shows details about Visibility Predicted. The data is filtered on Visibility True, which ranges from 1 to 1.

Modeling Process



In-Play Clip Preprocessing

Step 1 - Video Editing

Use video editing to trim videos to moments after the ball is first hit until point ends

Step 2 - Python Labeling

Using adapted TrackNet labeling tool to label first 12000 in-play frames

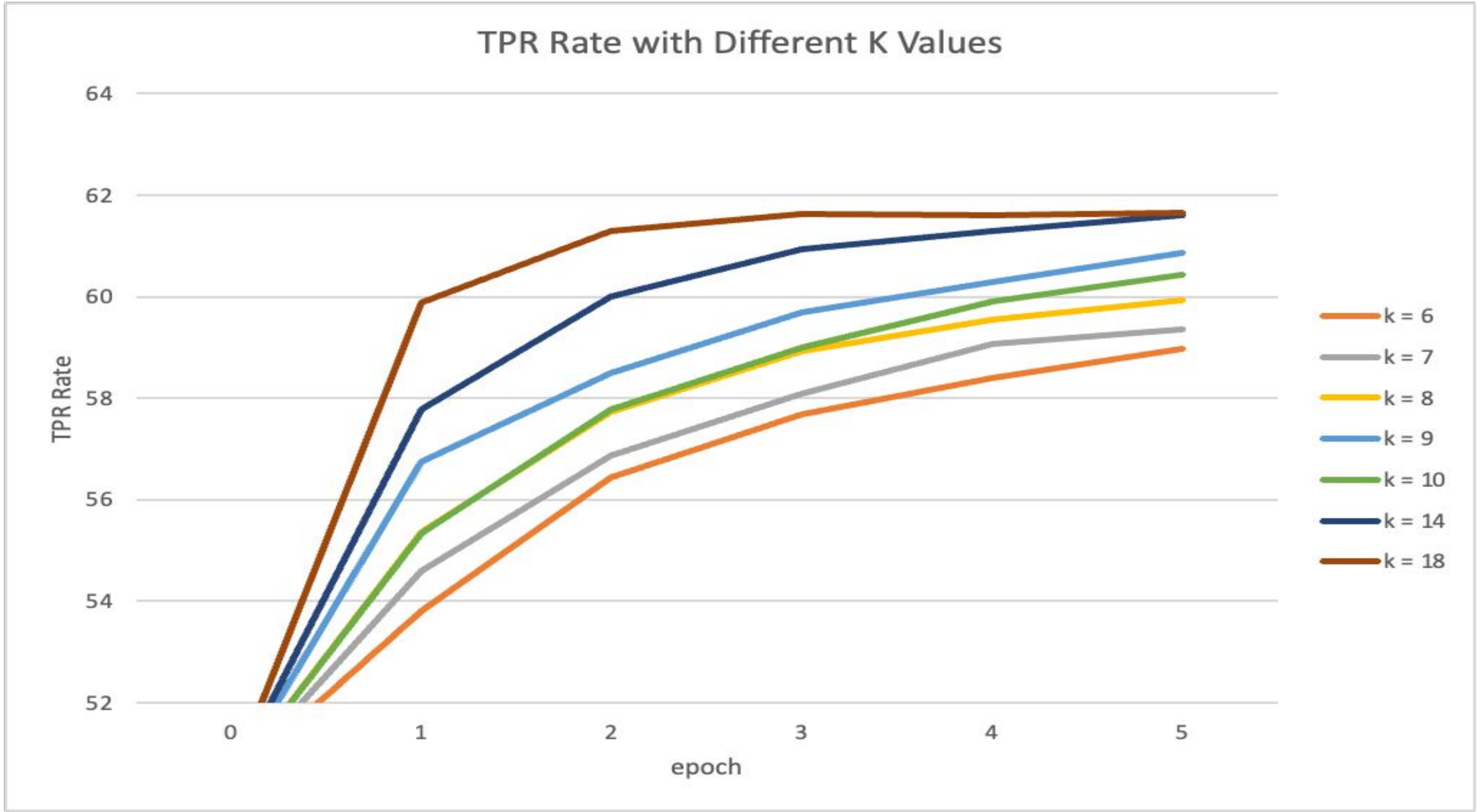
Step 3 - Dataset Diversification

Capture shorter clips from other vantage points to prevent overfitting of model to one video

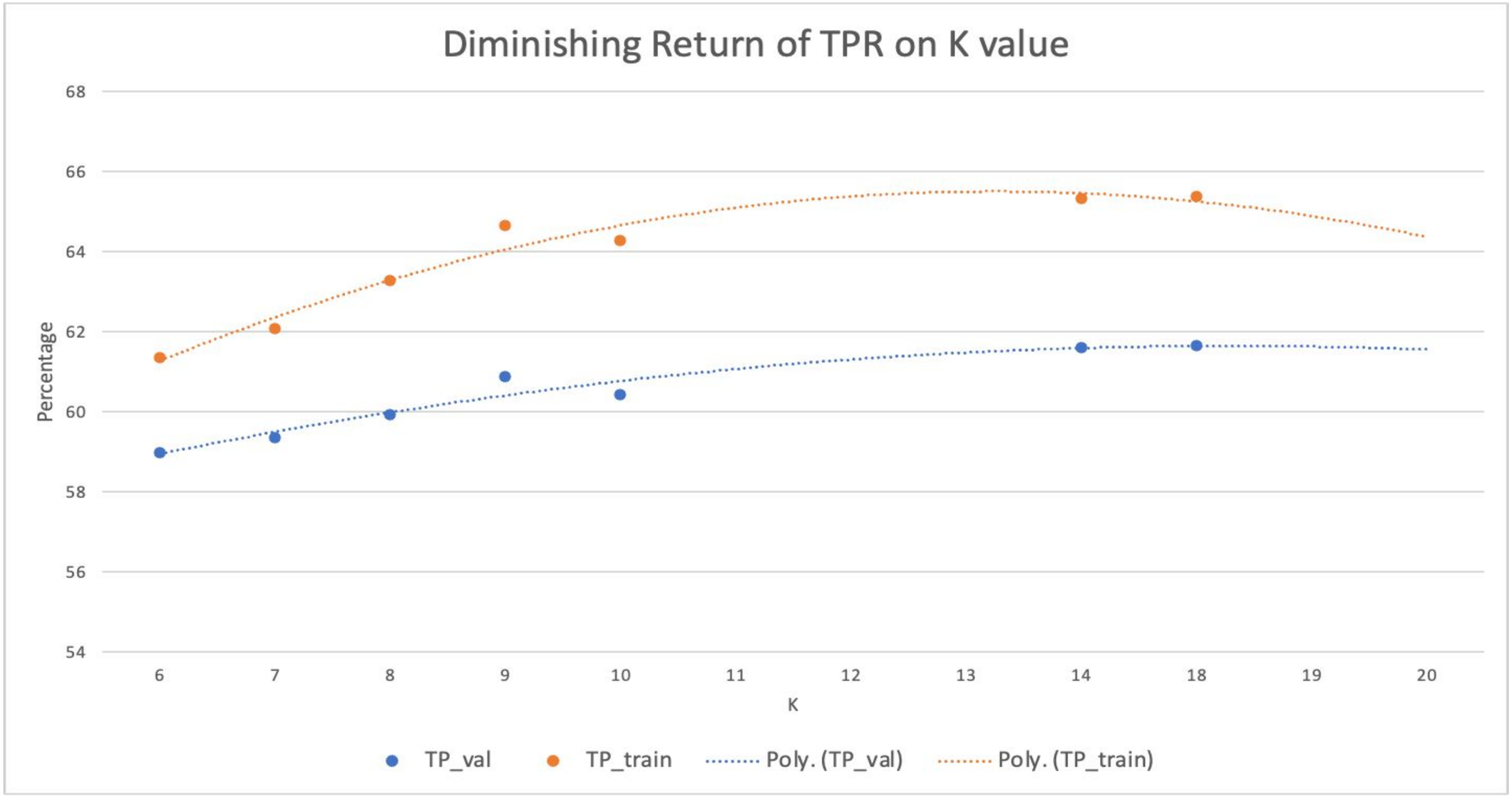
Hyperparameter Tuning

1. Used 5 epochs because it allows us to see a trend
2. Found a learning rate using 5 epochs
   a. Tried k=.00001, .0001, .001, .003, .01
   b. We decided on .01
3. Found optimal k using learning rate = .01 and 5 epochs
   a. Tried k = 6,7,8,9,10,14,18
   b. Decided on k=14
4. Used k=14, lr=.01, for 20 epochs to get results

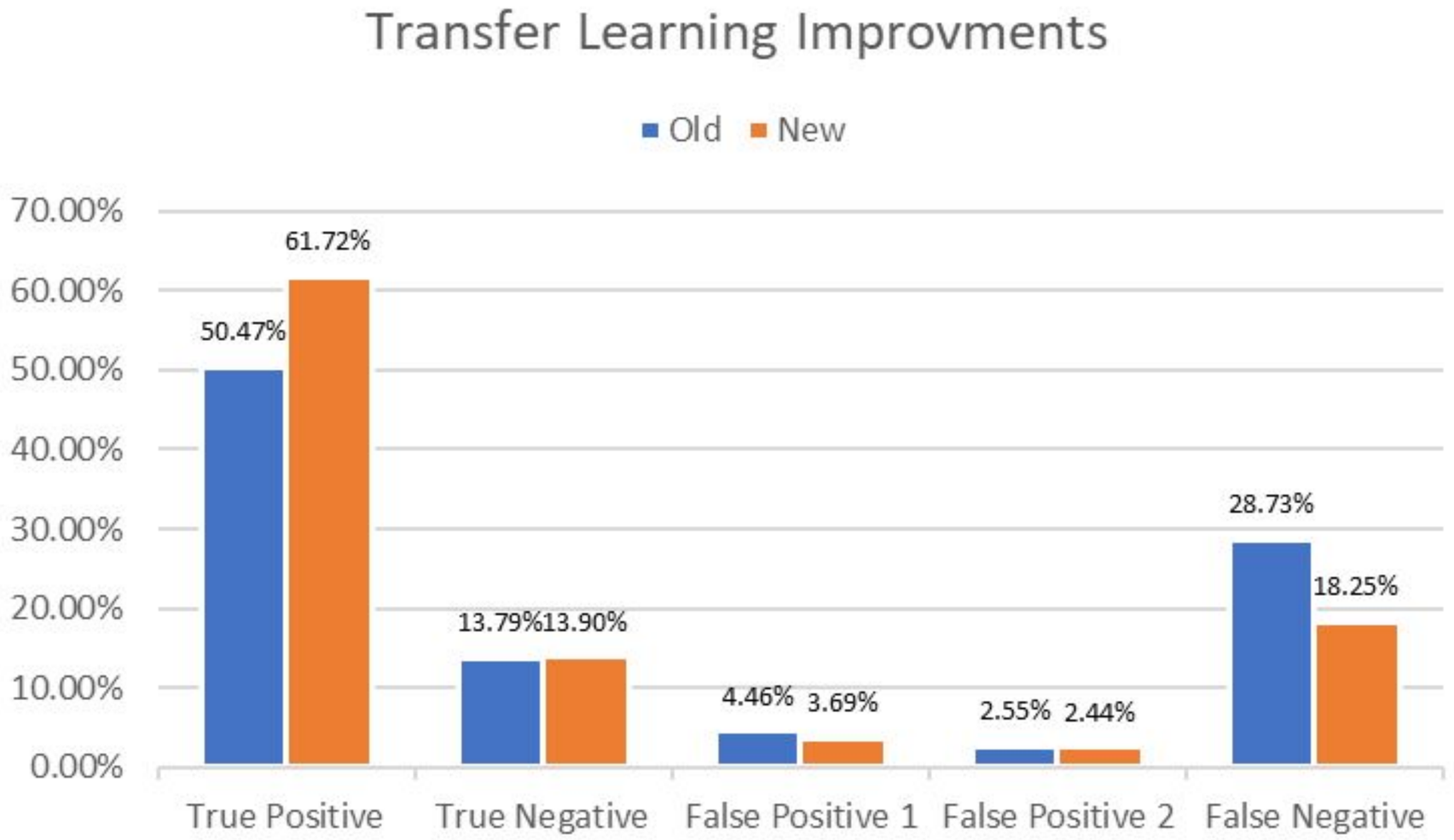
TPR Rate: Training on k Layers



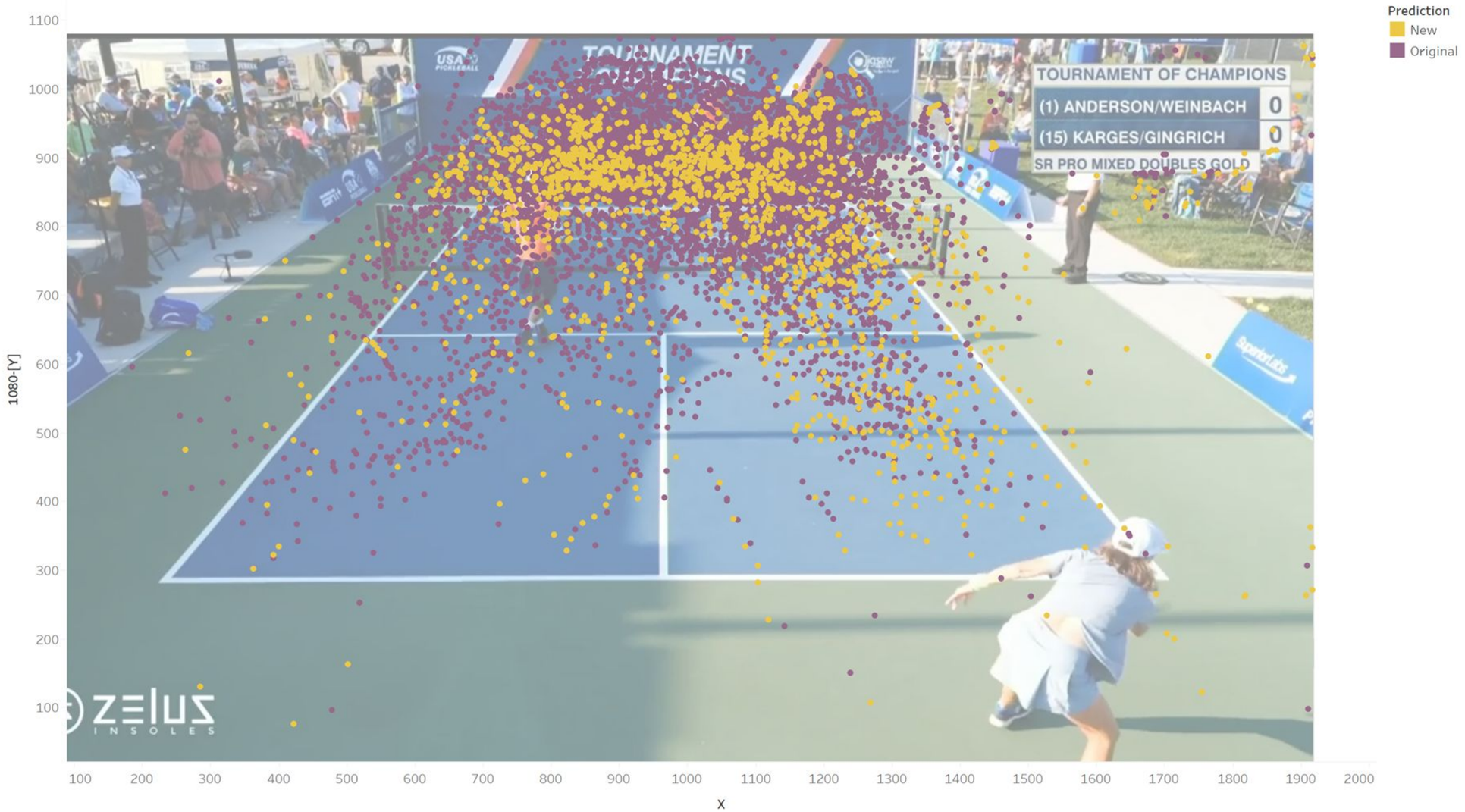
Optimal k Layer Values



Model Performance

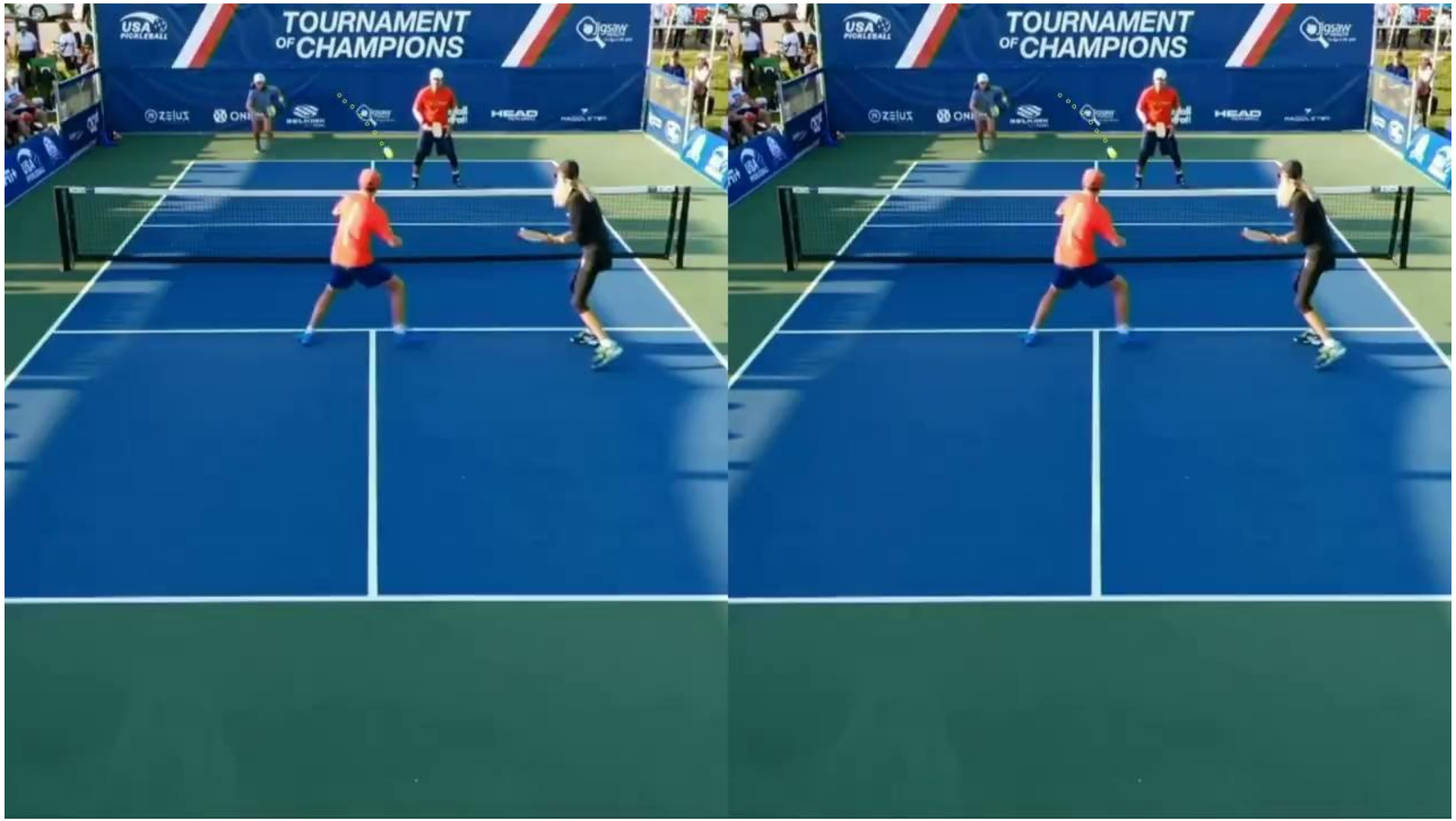


Data about Performance



X vs. 1080-[Y]. Color shows details about Prediction. The data is filtered on Visibility, Y and Model. The Visibility filter includes values greater than or equal to 1. The Y filter includes values less than or equal to 1070. The Model filter keeps New. The view is filtered on X and Prediction. The X filter includes values greater than or equal to 10. The Prediction filter keeps New and Original.

Sanity Check



Before

After

Challenges/Future Work

Challenges:

- Limited knowledge regarding both pickleball and computer vision
- Difficulties dealing with machine learning softwares and platform

Future Work:

- Conduct research paper on the whole project
- Provide github codes and readme to project sponsor
- Train the model with multiple videos with different angles and dimensions

thanks for watching

Thank you especially to Fritz, our sponsor, for being so responsive and helpful, Professor Cantay and Anand, for being great advisors, as well as the rest of the class and data science department for their continued support.