

How To Build Fast and Reliable Football Tracking System



Start Point.

Recorded video:
Arsenal vs West
Ham United



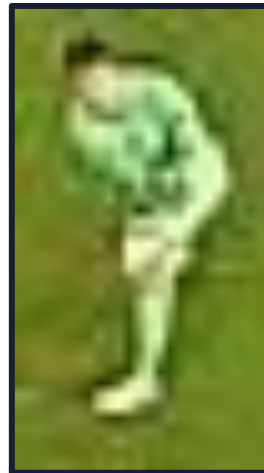
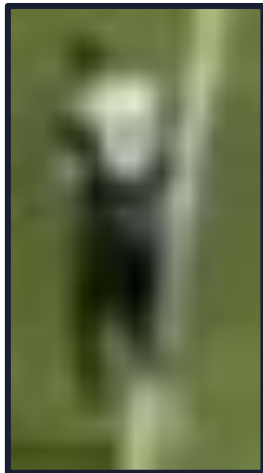
Our Challenges

Panoramic 8K
video with
small objects

Accuracy and
real-time

Short R&D
period
(including
hardware)

“Zero”
operator



Yup. We got really small objects



Fast Introduction



I am **Dmytro Fedyukov**

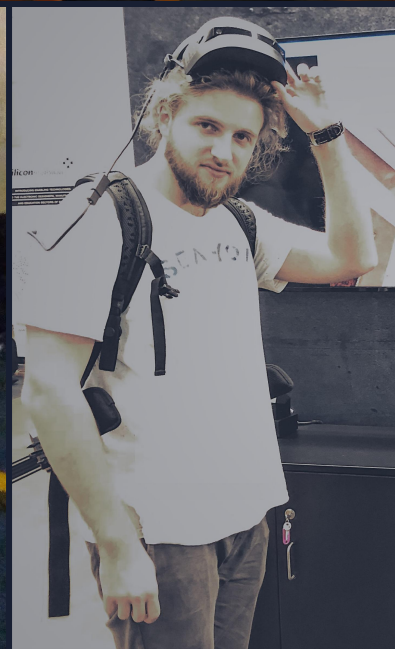
Head of Data Science @
SoftConstruct team, Kyiv.

SoftConstruct is a leader in developing and providing sports betting and gaming solutions and services for both online and land-based brands.



We are all around the world



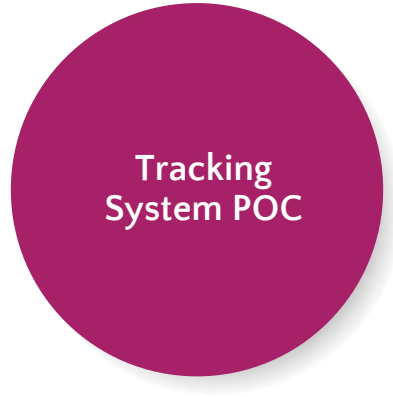


Jan '18



Pipeline start point

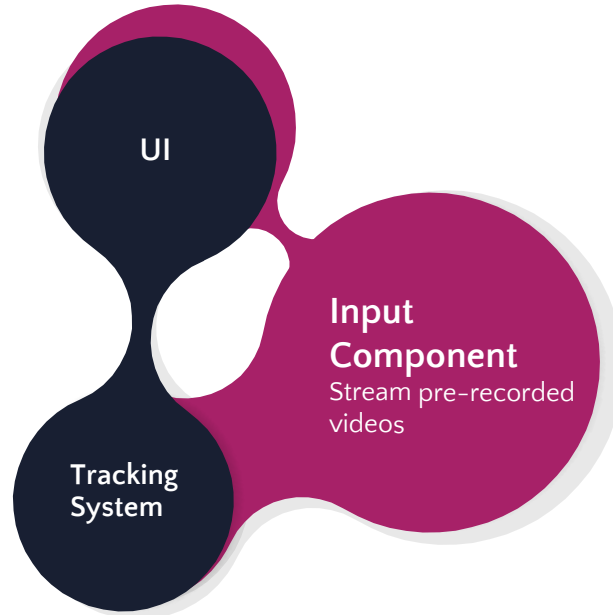
Tracking
System POC



Feb '18



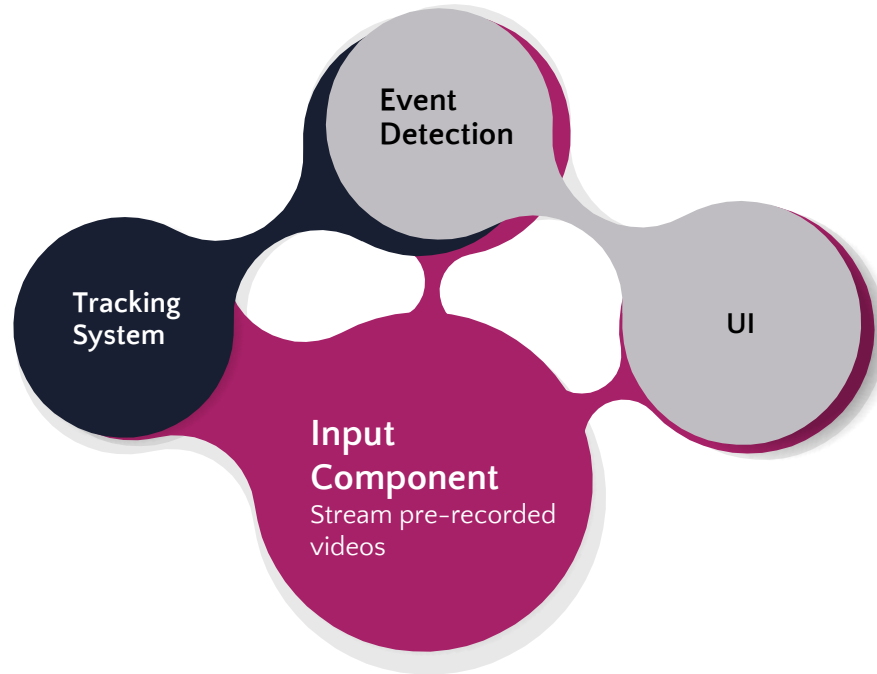
First demo



Apr '18



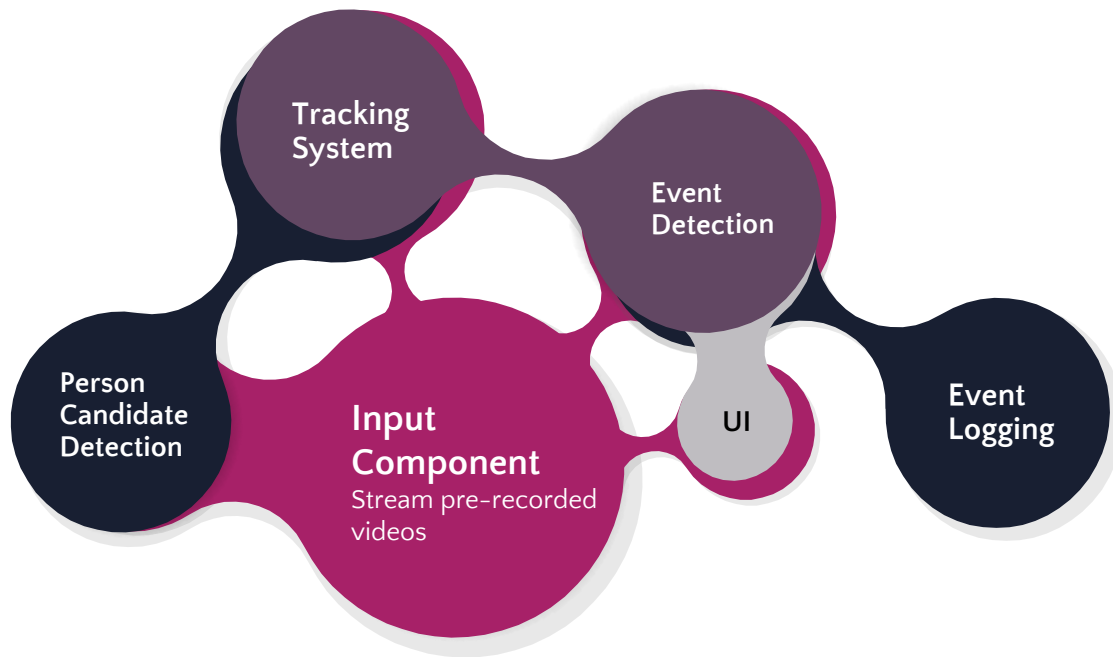
Smart tracker roadway



May 18

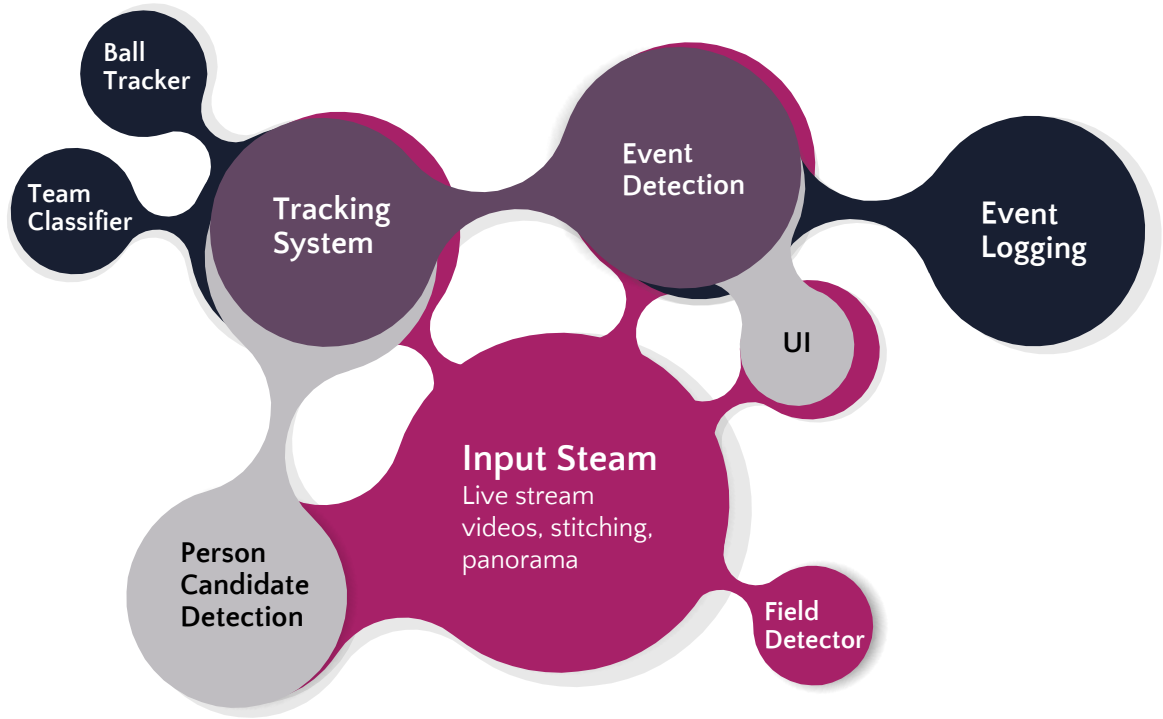


Second demo



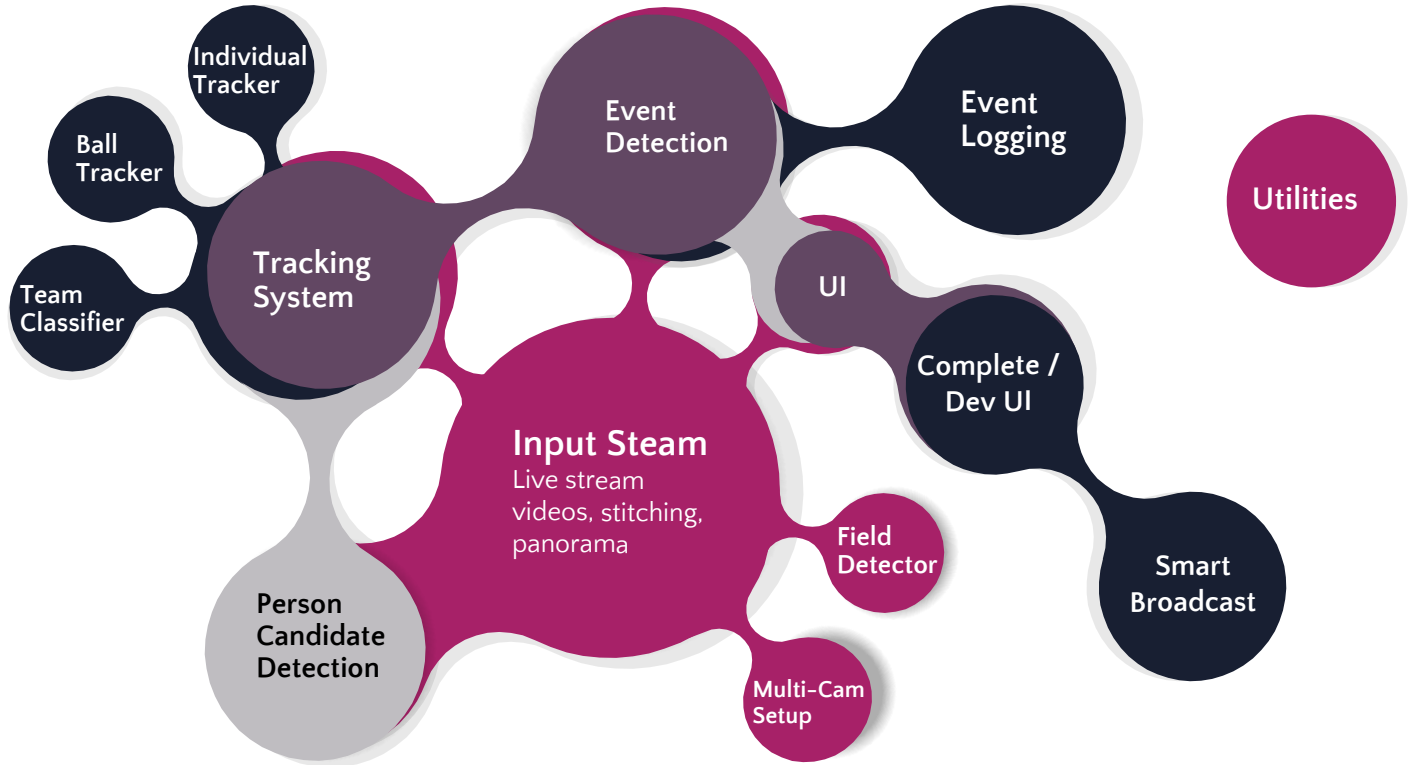


Live tracking system



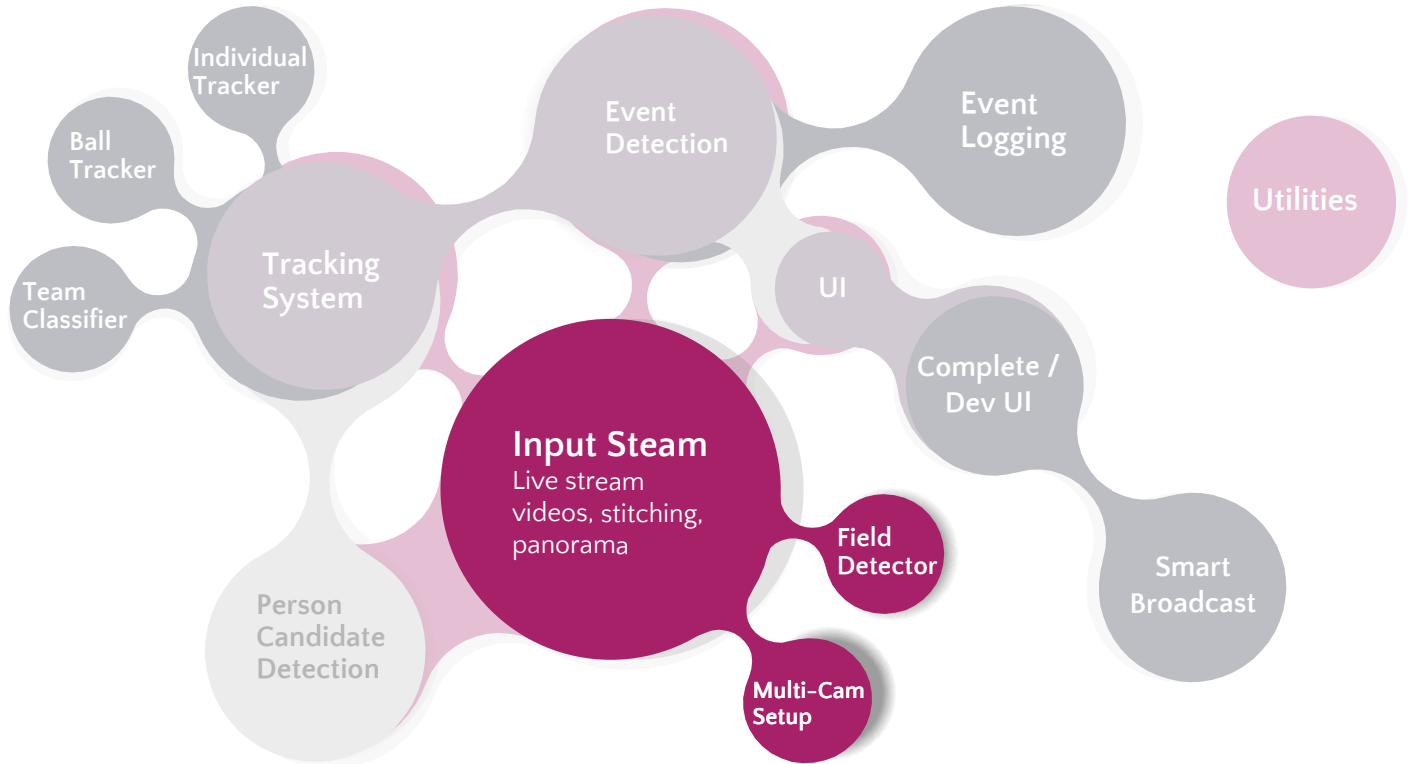


Current pipeline





Input Component





Camera Setup





Multi-Cam Input





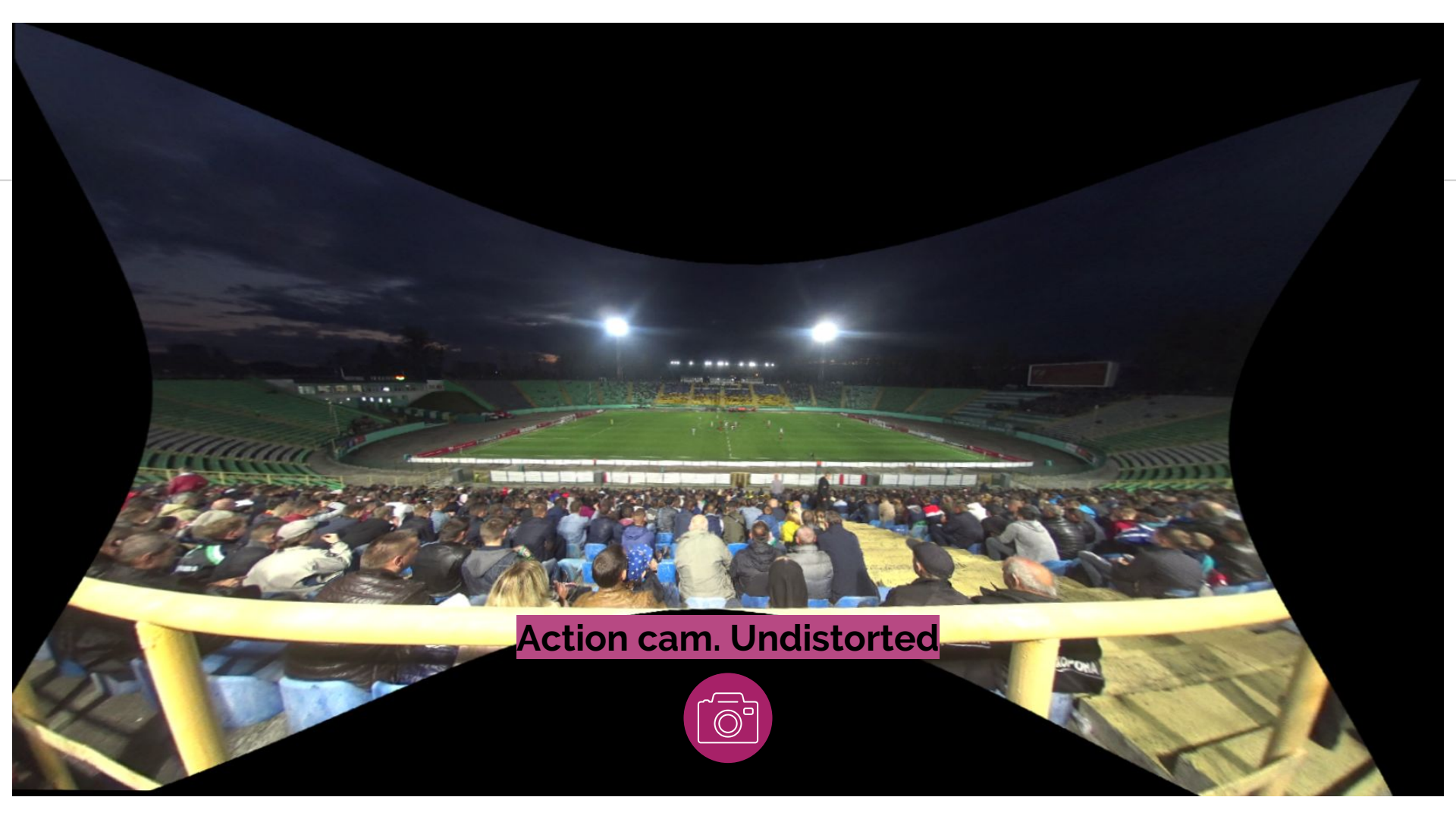
And if we will use some
“magic” tricks...





Action cam.





Action cam. Undistorted





Undistorted. Art magick





Video Undistortion

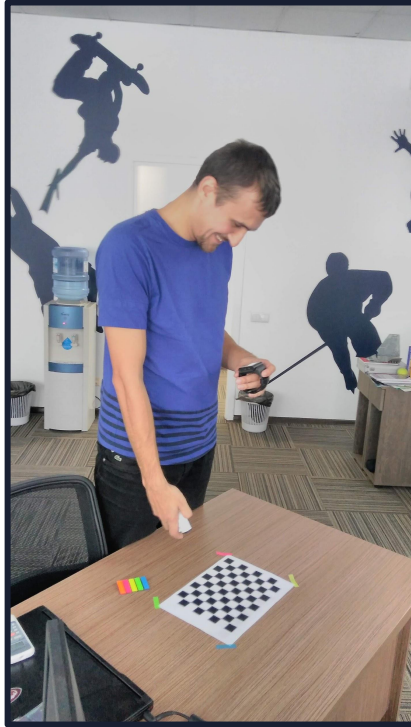
OpenCV

- + fast
- camera calibration using chessboard is required

Advanced algorithm

Calculates parameters of radial transformation that straightens lines

- + works for any video camera
- is not fast enough



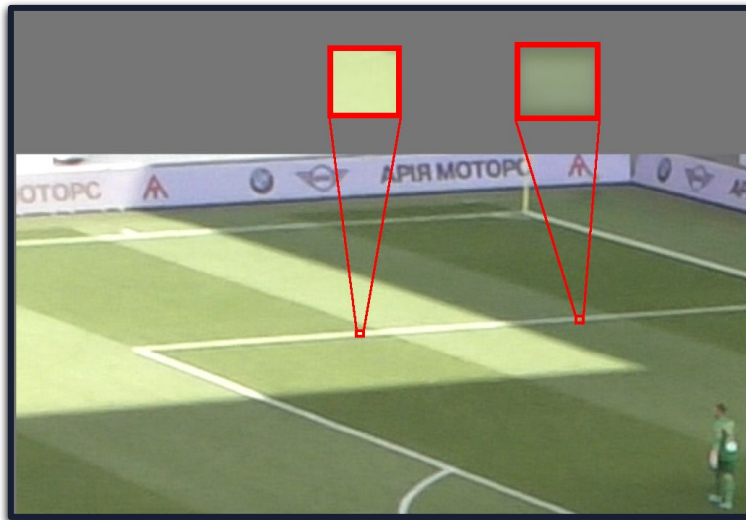
Like really lots of calibration required...





Field Detection Experiments

- ◉ Edge Detector + Hough Transform
- ◉ Edge Detector + Line Segment Detector (LSD)
- ◉ Edge Detector + Template Matching
- ◉ Color Clusterization



But you need to deal with luminosity



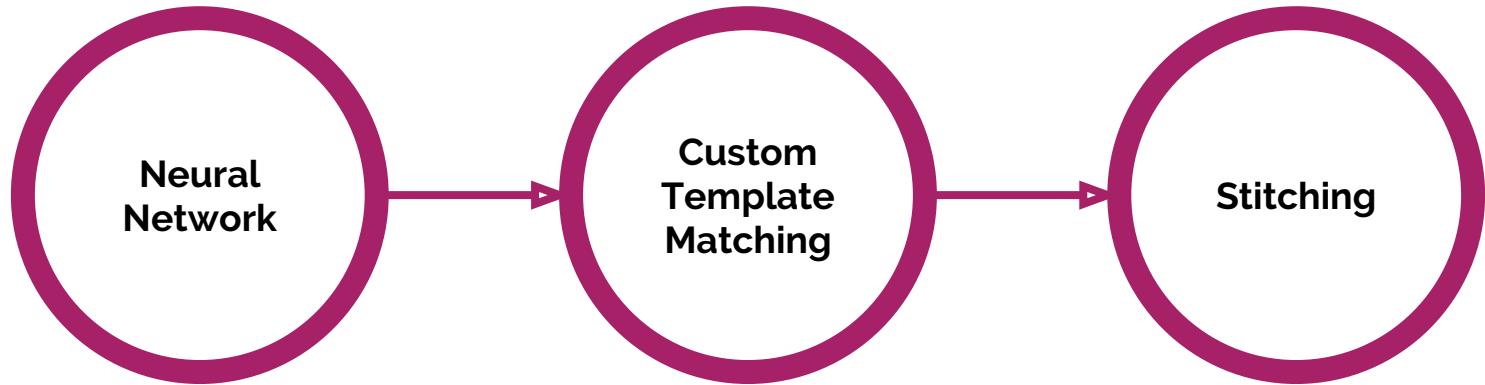


And no one cleans the field...



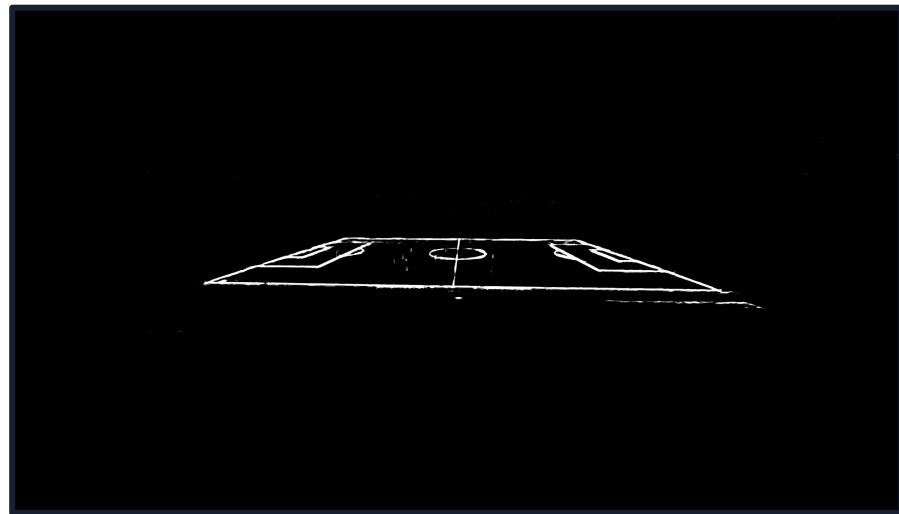


How does it works for us



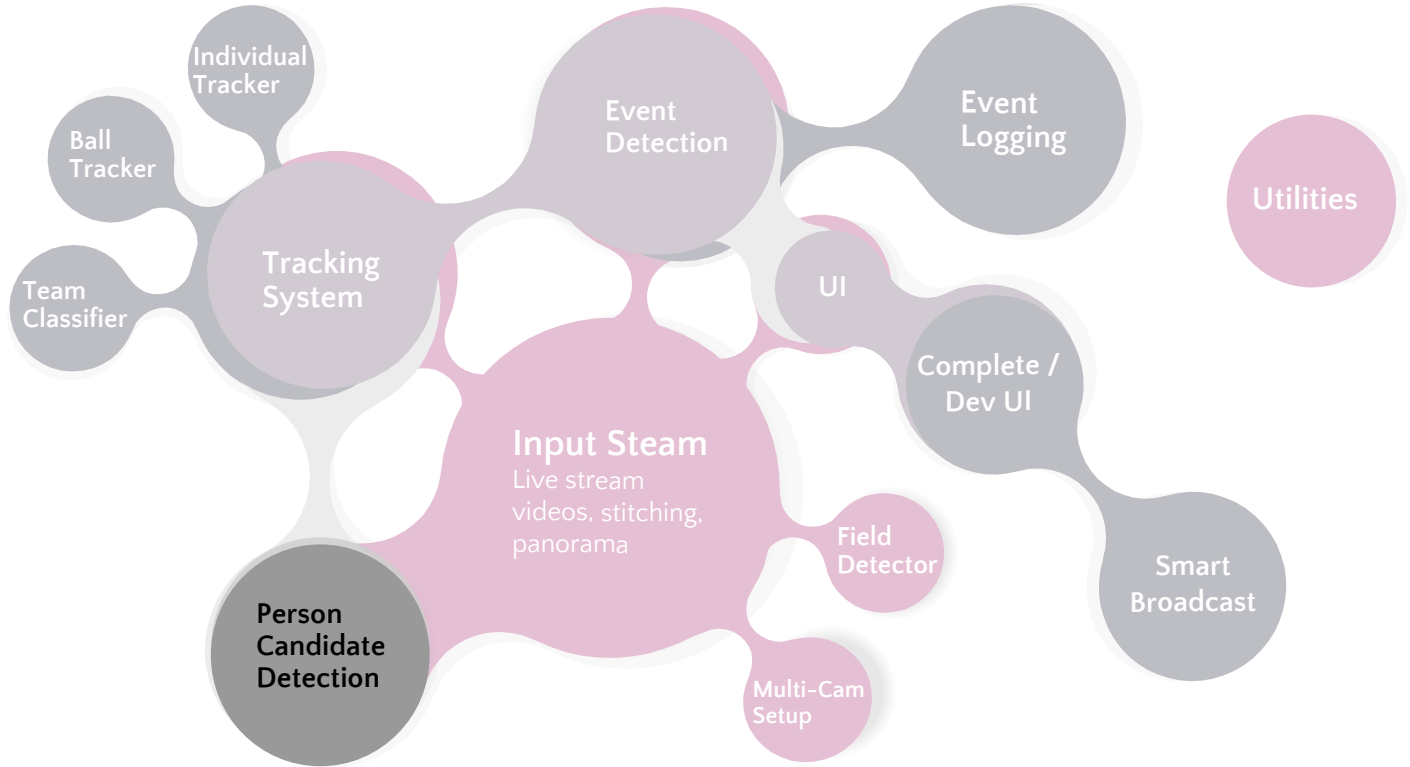


Example of **Neural Network** work on Undistorted Frame





Person Candidate Detection





Systems have been tested

YOLO

- + works great on parts of the field (e.g., 1/8th of the field)
- + allows person detection without further person classification
- not fast enough on big images
- not accurate enough for small objects

Foreground

- + finds both players and ball on videos with constant field lighting
- not stable on some videos due to a field lighting

Grid (cell) based

- + full control over the field
- takes too much time to check all boxes in the grid
- not that accurate (one object may relate to 2-3 boxes and it can be difficult to identify this object)

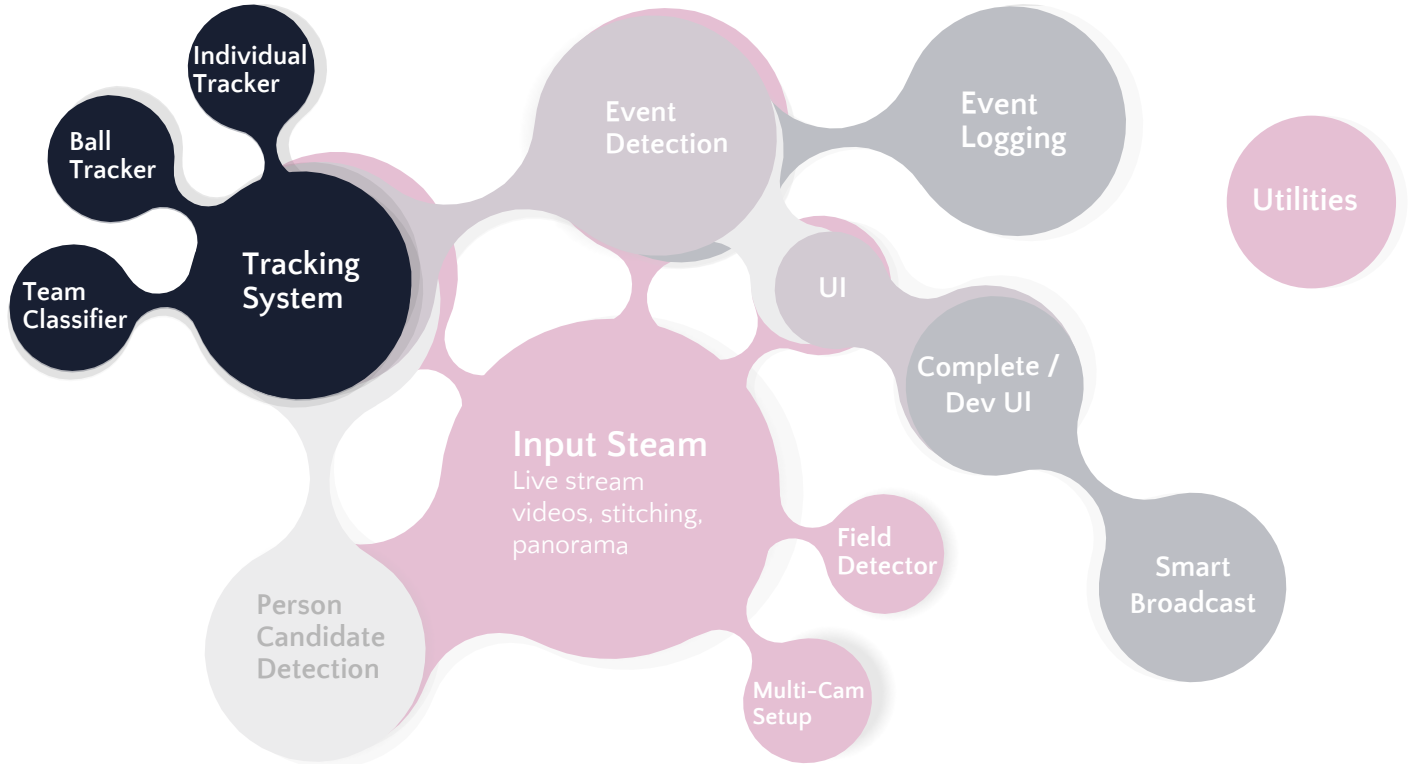


Finally selected system: NDA 〰_(ツ)_/〰





Tracking System





Team Classifier

Histograms

- + interpretable
- + fast *
- not accurate enough
- not generalized
- * - require extra libs (like ArrayFire)

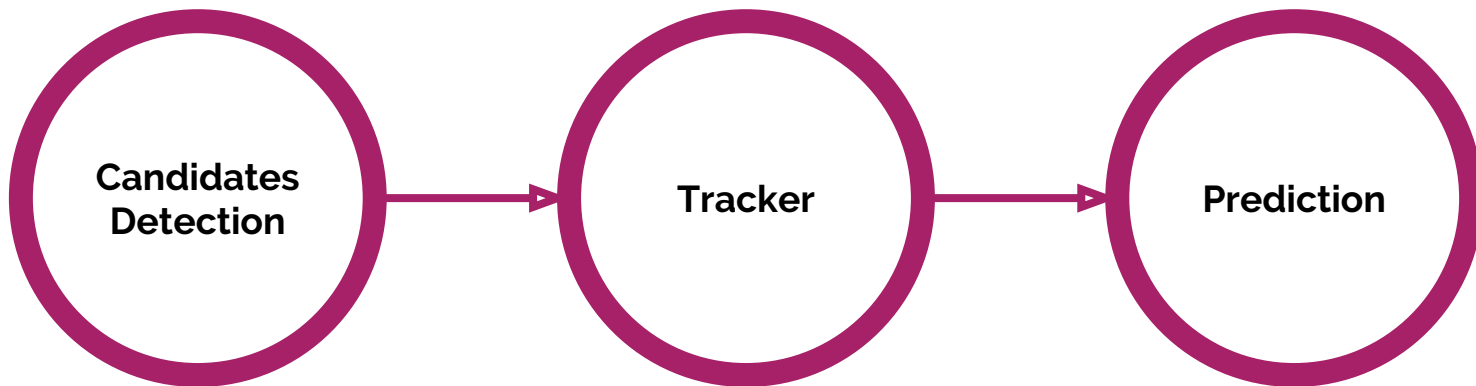
Neural Network Embeddings

- + high accuracy with custom layers like LSoftmax, CosFace etc.
- + generalization
- prediction is slower than hists *
- require custom layers optimization

* - pyTorch 0.4.1 🙄_/_



Ball Tracker Pipeline





Ball Tracker

HOG + Hist+ LightGBM

- + allows to identify shape and color
- + classifies the ball based on feature vectors
- HOG takes too much time to run
- HOG needs vectorization on a set of images
- Histogram same as HOG: slow run, need vectorization
- HOG + Histogram is only one specific way of image representations while NN may learn other (better) representations

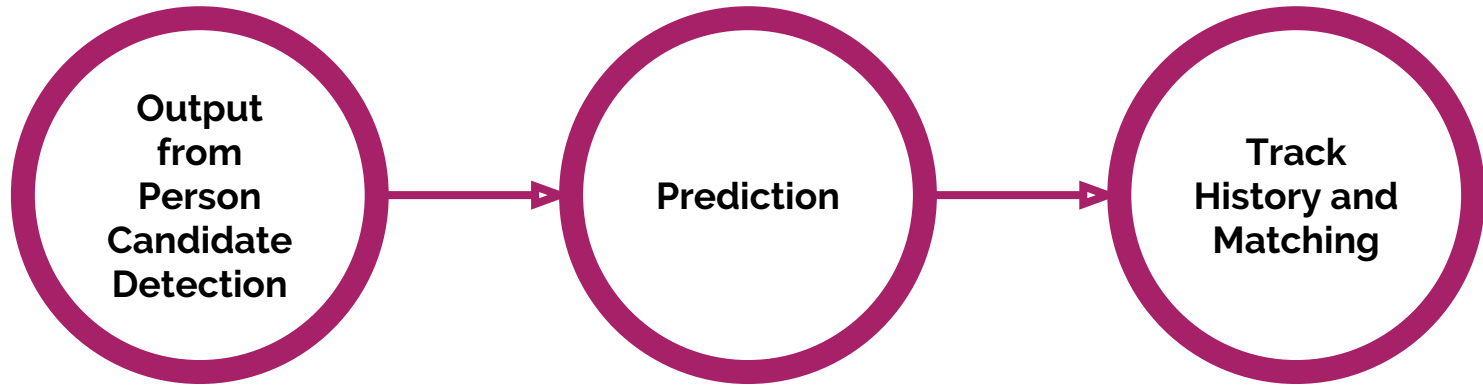
Neural Network

- + classifies images with very high accuracy and almost no preprocessing needed
- takes too much time for prediction (especially if the NN architecture is very deep) *

* - still pyTorch 0.4.1 🙄_/_

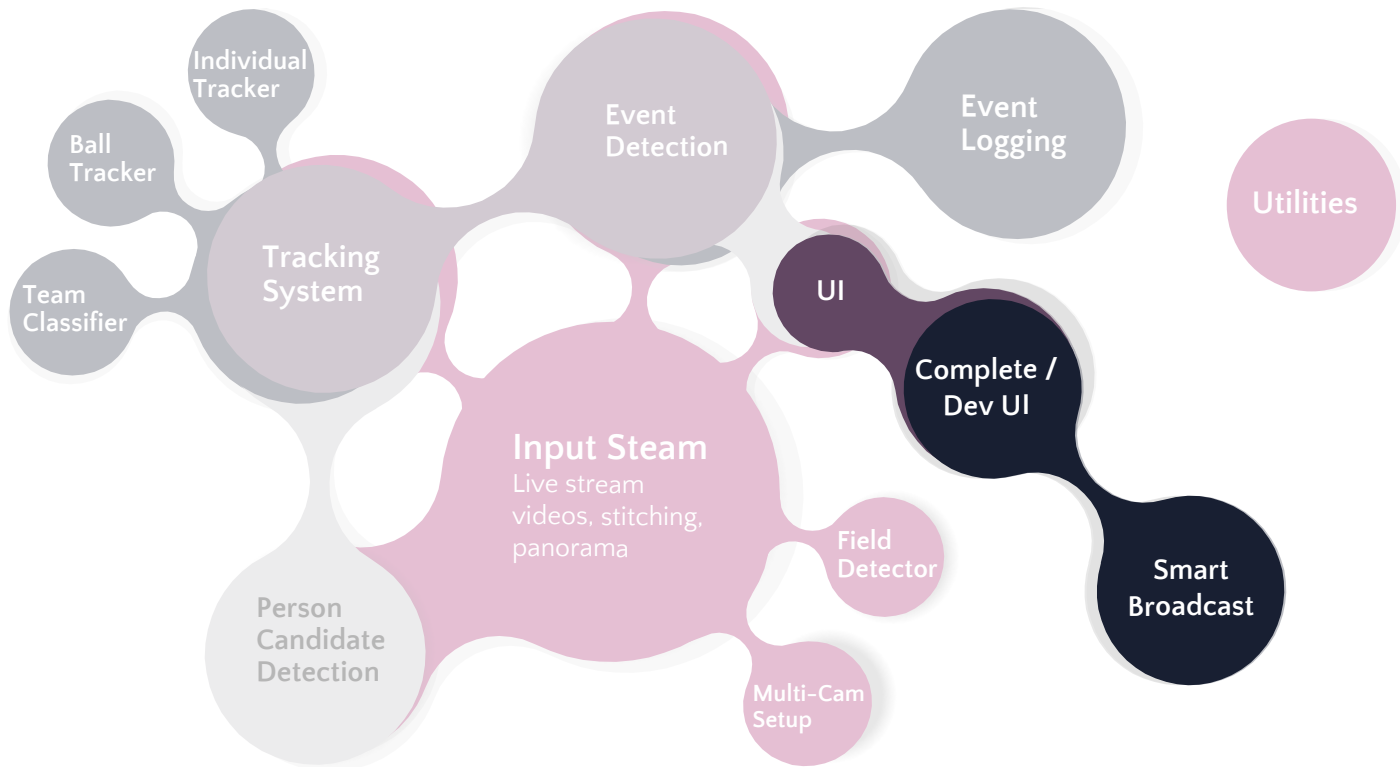


Individual Tracker Pipeline





UI





UI Pipeline





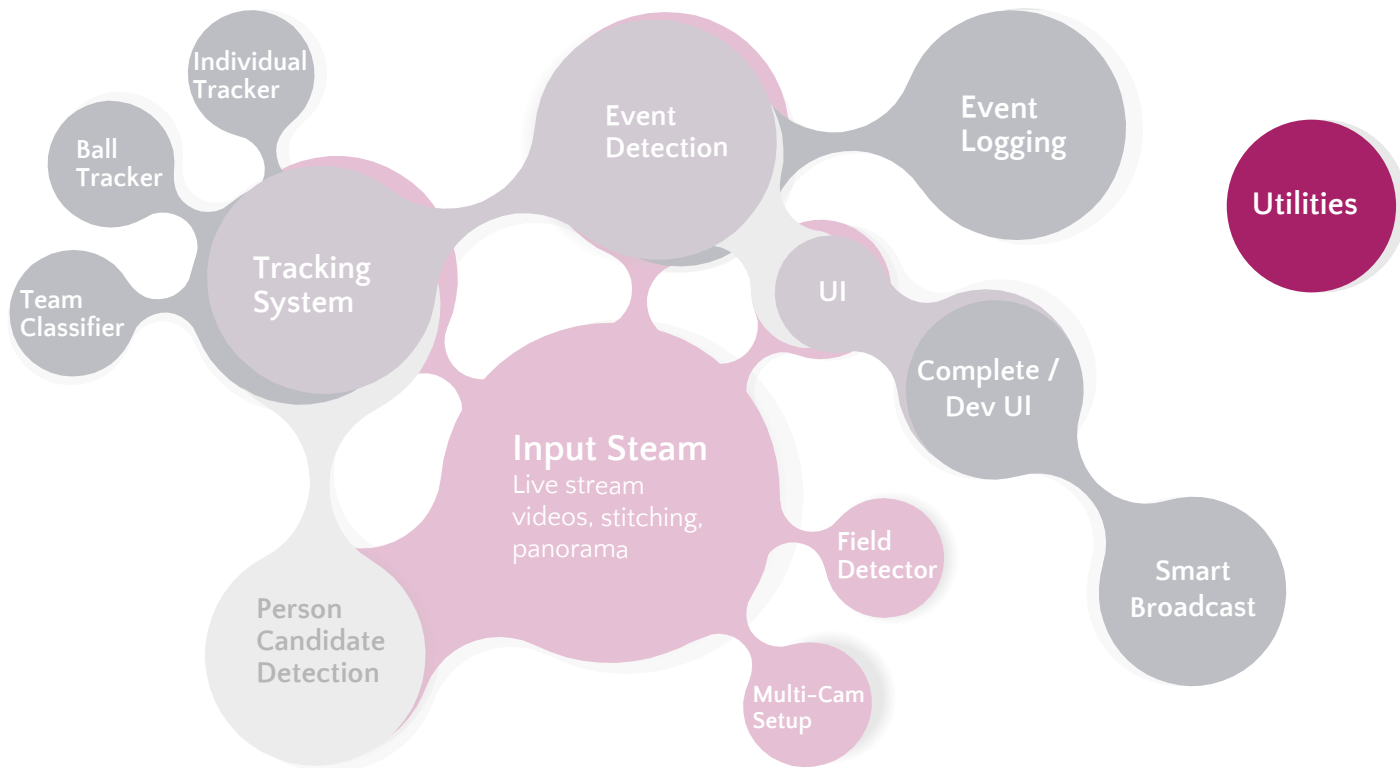
Smart Broadcast (auto PTZ)

Represents camera movement and automated zoom in/zoom out. Behaviour depends on detected ball position:

- ◉ direction and zoom change smoothly
- ◉ zooms out when the ball moves quickly, and zooms in when the ball moves slowly
- ◉ doesn't change direction if the ball moves not far from the frame center



Utilities





Core Tools

Manual Image Labeling Tool

Custom created tool for manual labeling.

It is used to gather dataset for neural networks in individual tracker and ball tracker

Auto-labeling Tool with Mask-RCNN

Updated publicly available Mask-RCNN on pyTorch for auto-labeling.

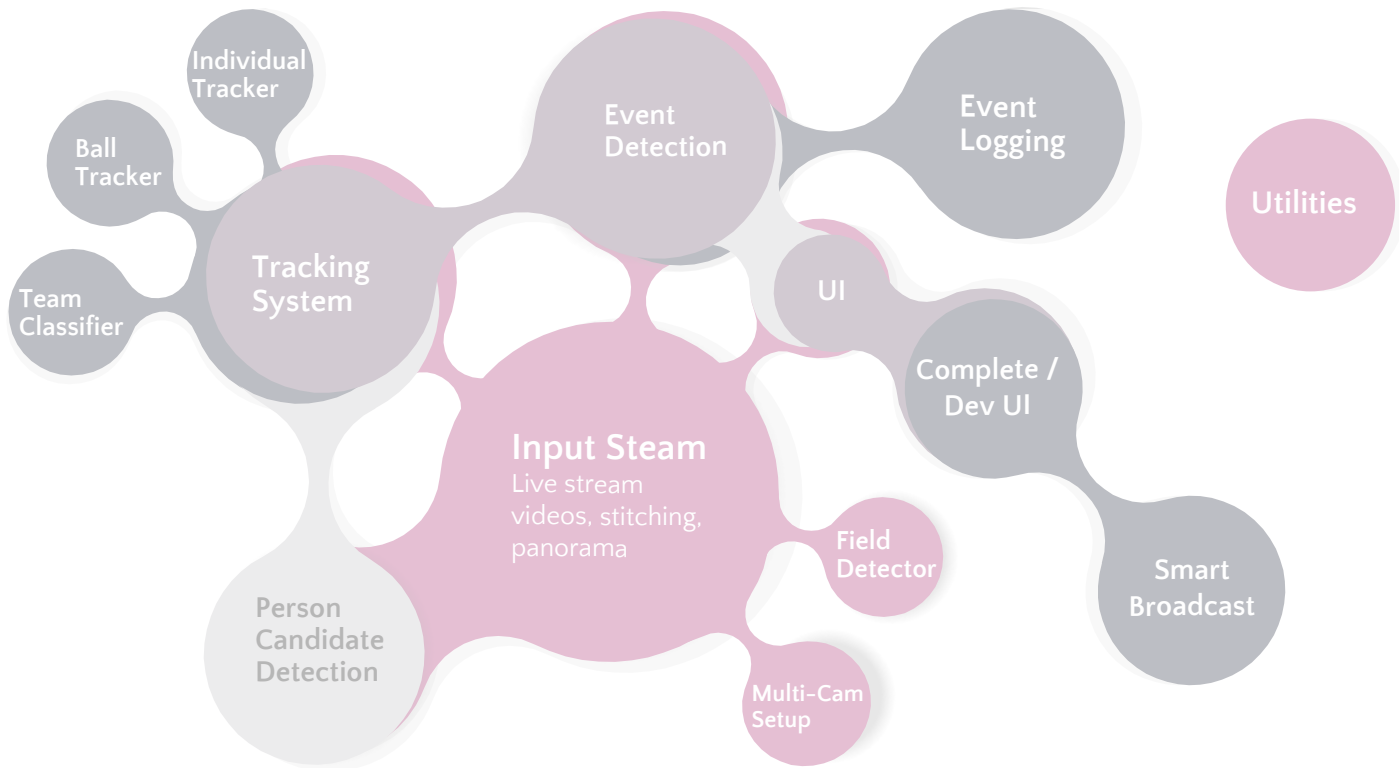
It is used to gather dataset for neural networks in individual tracker and team classifier

Data Version Control or DVC

Simple git-like tool that helps in dataset and video management and sharing



Highlights



18 games

were recorded with our hardware

5 different stadiums

were captured

30h of videos

were tested with our system



5 neural networks

are used in current pipeline in different components

1.5m images dataset

for all neural networks

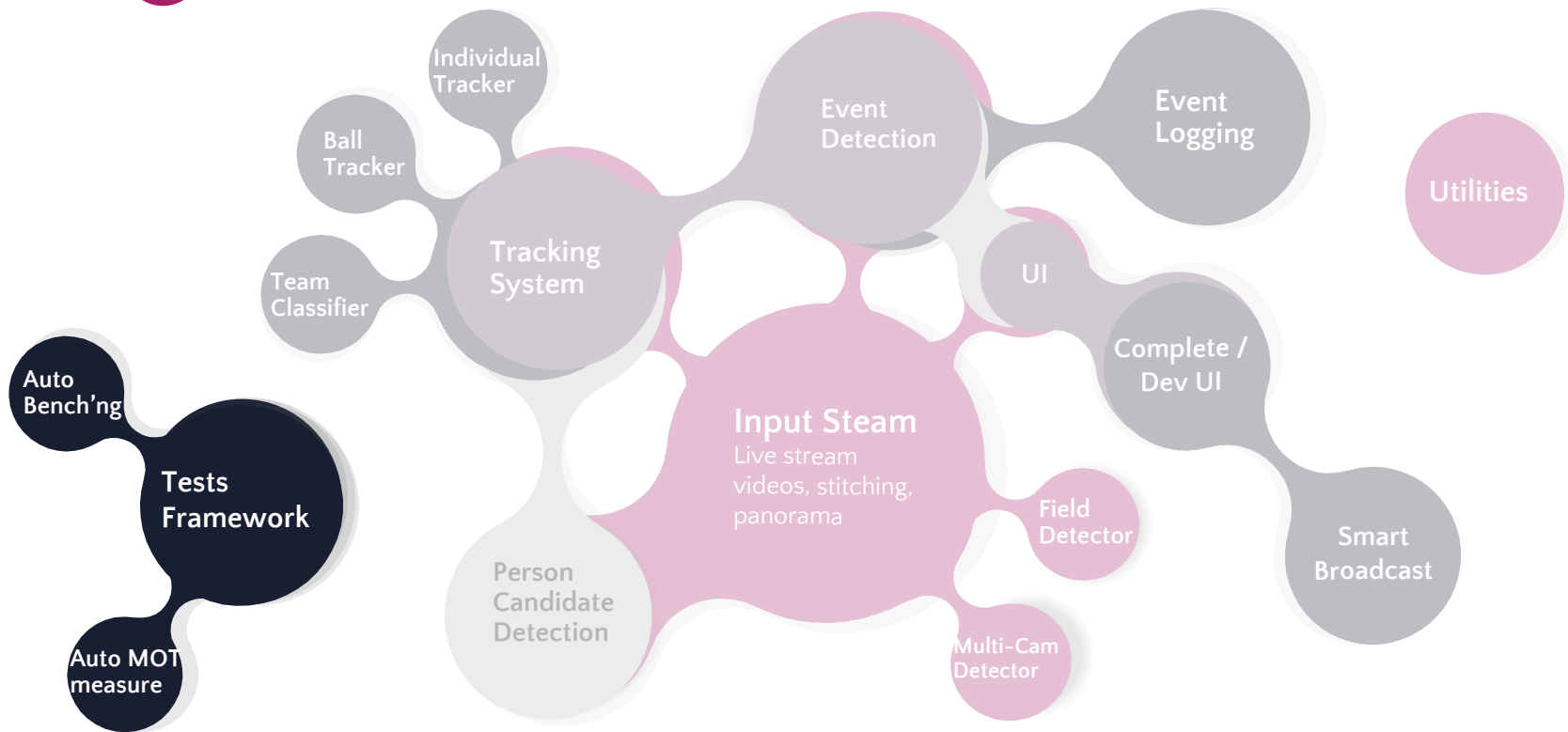
9 months

of R&D to current pipeline point





Near future updates



Current Point.

Recorded video:
Olimpik, Donetsk
Karpaty, Lviv



... And One More Thing



24 FPS

It is on Python and it is Real-time!





Thanks!

Any **questions** ?

You can find me at

- fb.com/askoldim
- fedjukov@gmail.com