World of Fast Moving Objects

- A |F|ast |M|oving |O|bject is loosely defined as an object traveling the distance larger than its size in a single video frame or image.
- FMO appears as a blurred streak in the direction of motion.
- Tracking FMOs is a challenging problem due to lack of any texture on the blurred object.

Goal:
Real-time tracking algorithm of balls in sports videos where the balls undergo motion characteristic for FMOs. ➔ Learning-based approach (segmentation neural network)

Synthetic data generator

To train the network, a synthetic data generator synthesizes the data on the fly.
1. YouTube sport videos were filtered using the median filter to erase any unwanted FMOs. These sequences are used as a background for synthetic data.
2. Motion trajectory generator simulates plausible motion and creates synthetic trajectories.
3. Trajectories are split into individual frames.
4. Finally, the generated trajectories are convolved with the foreground (ball) and alpha-blended with the background to generate realistic FMOs.

Given that:
- $I_t(x)$ - composed image;
- $P_t(x)$ - generated path;
- $b_f$ - overexposure factor;
- $F(x)$ - foreground image (ball);
- $M(x)$ - foreground image mask;
- $B(x)$ - background image

The image synthesis can be described using the following formula:

$$I_t(x) = [P_t * b_f F](x) + (1 - [P_t * M])B(x)$$

Method

The proposed solution is based on the U-Net Inception type network called ENet trained on synthetic data. The network input is a 15-channel image consisting of 5 consecutive RGB frames. The resulting output is a segmentation map of the FMO.

Tracking

The output of the network is a segmentation map with false positives. The most probable blob is identified using blob size and shape heuristics. The selected blob is used as a trajectory estimation for the tracker. Kalman filter is used for prediction and connection of broken trajectories.

Results