Drone Tracking and Verification using Deep Neural Network

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May 24, 2021

## Objectives

- Drone tracking and authenticity evaluation in real time scenario using computer vision based deep neural network

## Outcomes

- Real time drone tracking using camera feed
- Command generation according to drone trajectory
- Drone response evaluation

## Methodology

### Stage 1: Trajectory Prediction

The camera feed inputs a sequence of frames that captures the motion of the drone into the system. The system processes these RGB frames in 2 phases to track the drone's trajectory as shown in Figure 1.

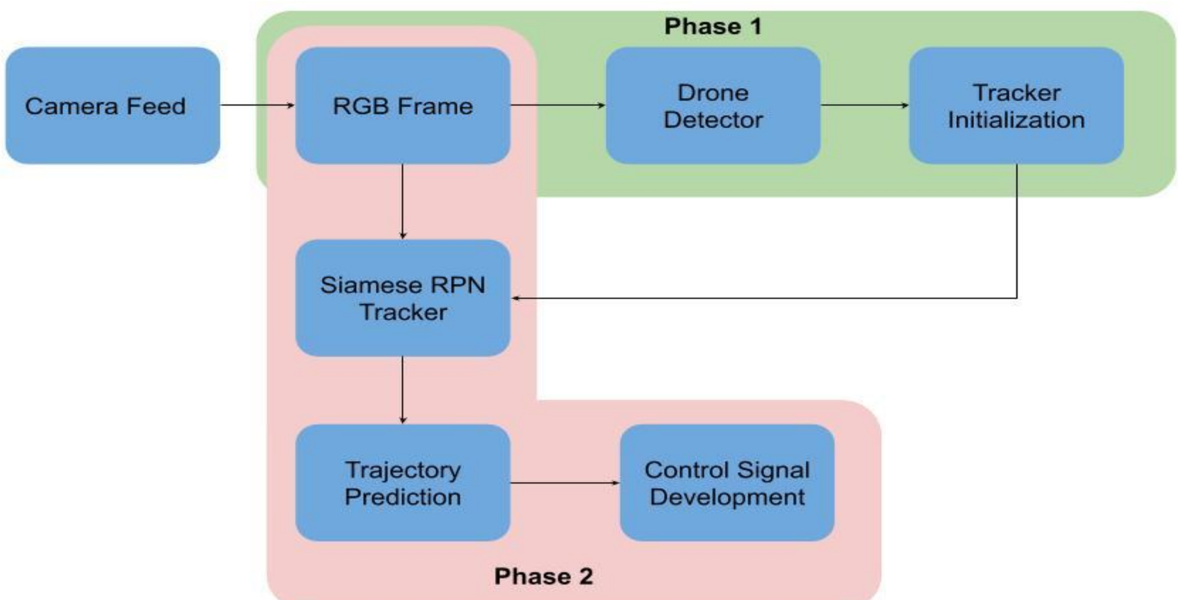


**Figure 1 :** Block diagram for trajectory prediction

First, the presence of a drone in the camera frame is detected manually by specifying a bounding box around it. Using this bounding box, the tracker is initialized. For ultra-fast, real-time and robust tracking, the Siamese RPN tracker [1] has been used to track the drone in each subsequent frame. A best fit line is generated using tracker outputs for a certain number of consecutive frames taken to estimate the drone trajectory over those frames. Once the trajectory is predicted, a control signal is generated that commands the drone to move in a direction perpendicular to its trajectory. This motion must be followed within a certain deadline by the drone.

## Stage 2: Trajectory Estimations after control signal is generated

After sending the control signal, the drone trajectory is again evaluated over a certain time till the deadline as shown in Figure 2. For each input frame, a best fit line for it and a number of previous frames is estimated using Siamese RPN tracker outputs. The direction of drone trajectory (slope of best fit line) for each time unit is stored in a vector for drone response evaluation.

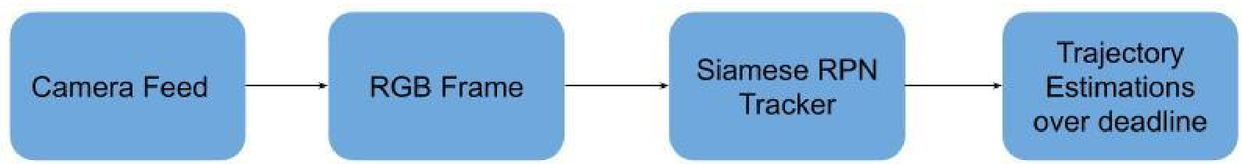


**FIgure 2:** Process flow for trajectory estimations after control signal is generated

## Stage 3: Drone Response Evaluation

As shown in Figure 3, the drone trajectories over the response time are evaluated to check if the drone followed the direction commanded by the generated control signal within the deadline. For this purpose, the drone trajectory slopes are compared with the expected trajectory slope for the generated command with a tolerance of *20 degrees*. With the response time, if 20% of the observed drone trajectories are similar to expected trajectory for the control system, the drone is declared as a “good drone” (authentic drone). Otherwise, the drone is reported as a “bad drone” (malicious drone).

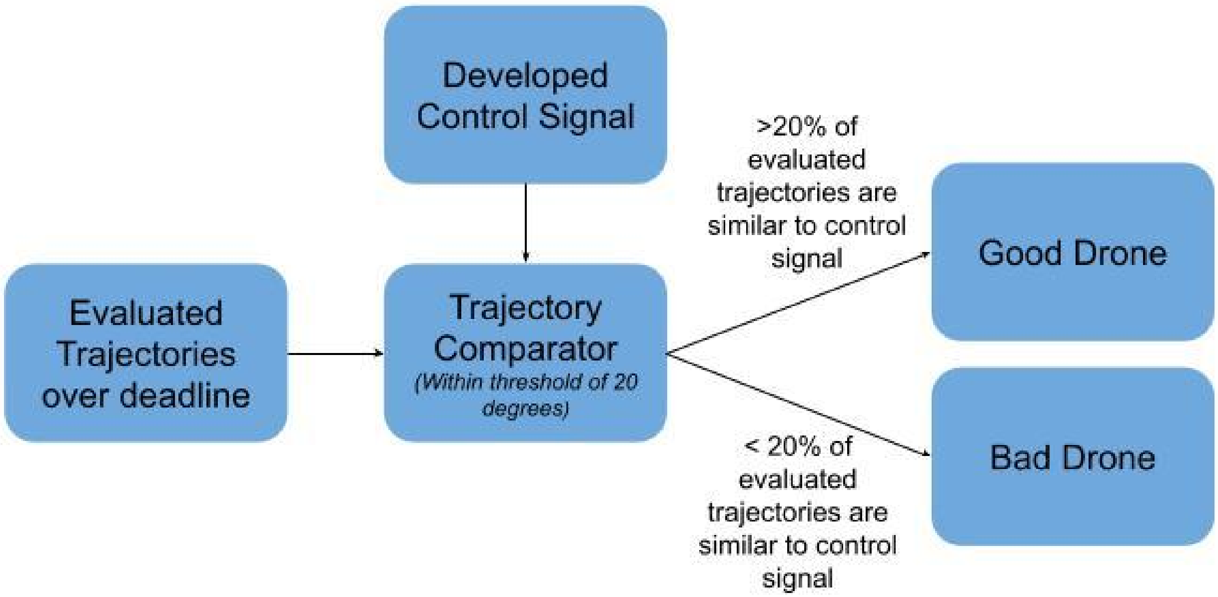


**Figure 3:** Drone Response Evaluation

## Results

The above described system has been implemented using pytorch deep learning library with CUDA support for real-time execution. The Quadro P5000 GPU has been used during the qualitative evaluation, and the system has been able to do the work at around 70 FPS. The following link shows qualitative evaluation of the developed system for two cases:

1. Authentic drone: when the drone follows the command signal

   Link to video

2. Malicious drone: when the drone does not follow the command signal

   Link to video

## References

[1] B. Li, J. Yan, W. Wu, Z. Zhu and X. Hu, "High Performance Visual Tracking with Siamese Region Proposal Network," *2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 2018, pp. 8971-8980, doi: 10.1109/CVPR.2018.00935.