AUTOMATED BALL TRACKING IN TENNIS VIDEO

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INTRODUCTION

❑ **PROBLEM STATEMENT :** A quadcopter mounted with a camera captures the video of a tennis match. **The task is to track the ball in the video.**

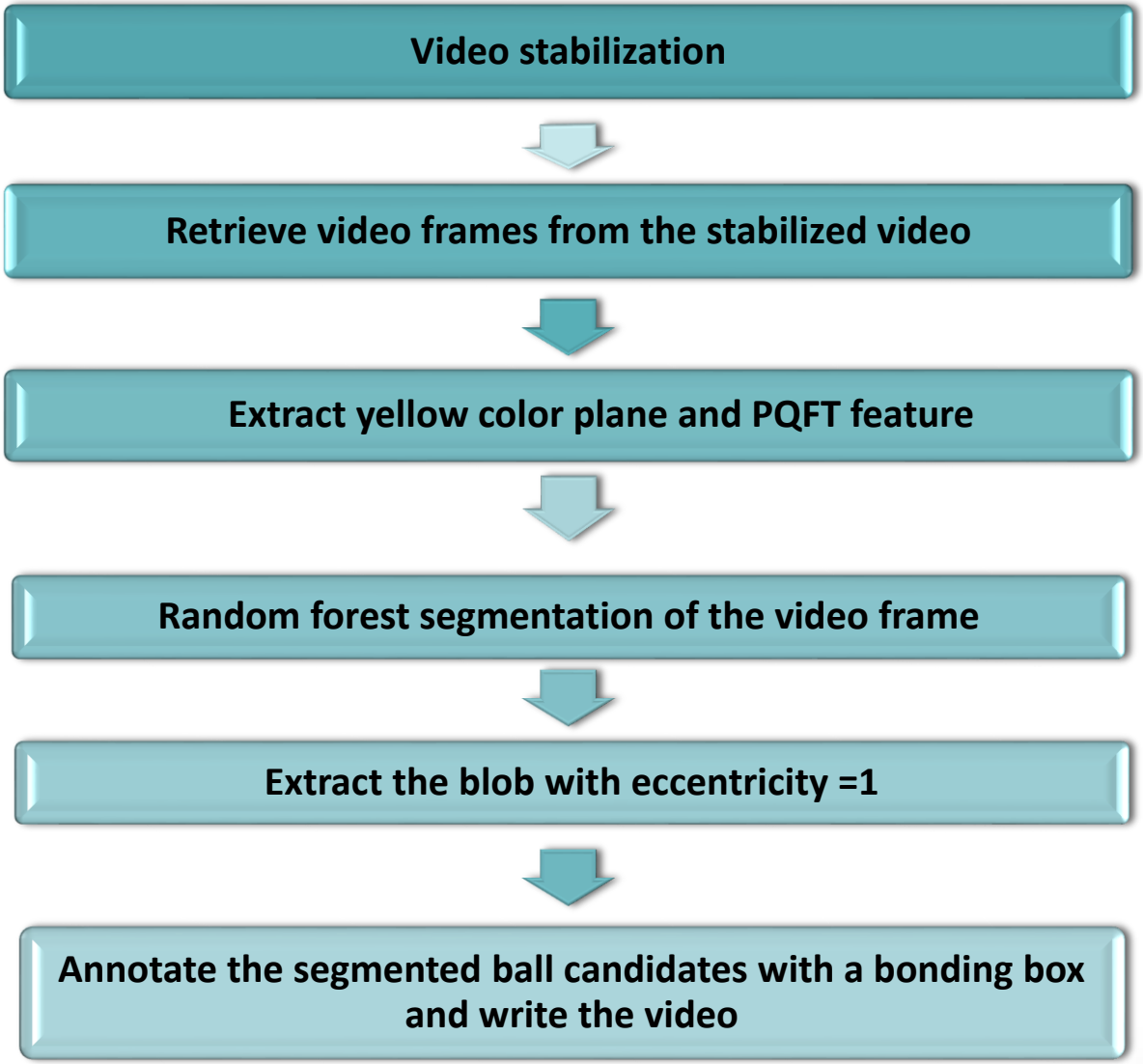
❑ **EXISTING TECHNIQUES:**

- Ball Detection: Frame differencing, Frame subtracting, Template Matching, Morphological Operations
- Ball Classification: Shape & Color Information, logical AND operation between frames, Masks of frames
- Ball Extraction: Blob Analysis based on shape, size, color of ball
- Ball Trajectory Generation: Position prediction, Particle Filter,2D motion model.

❑ **OUR METHOD :**

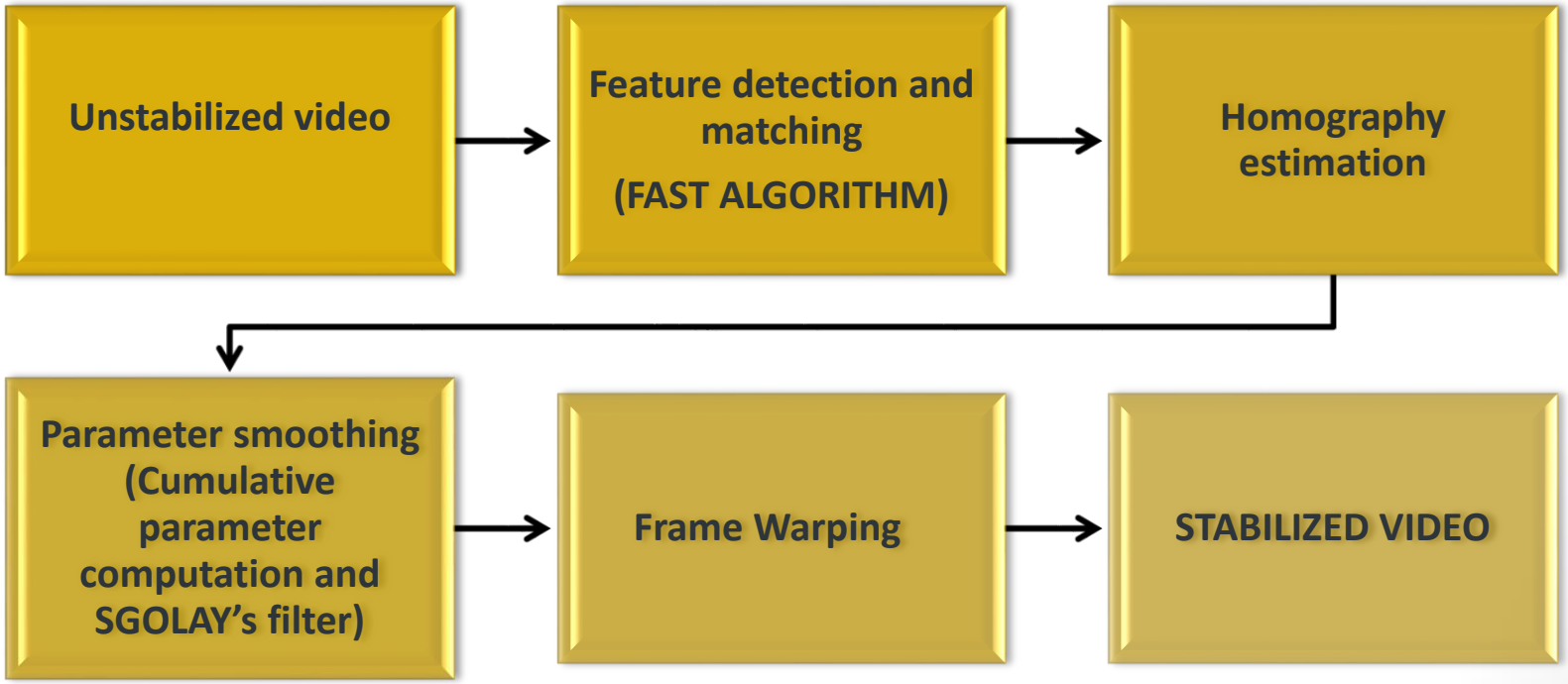
- Computer Vision + Machine Learning Approach
- Define a video stabilization framework followed by random forest segmentation approach for ball candidate extraction.

PROPOSED APPROACH : BALL TRACKING FRAMEWORK



PROPOSED APPROACH : BALL TRACKING FRAMEWORK

VIDEO STABILIZATION



PROPOSED APPROACH : BALL TRACKING FRAMEWORK

EXTRACTING TRAINING FEATURES

❑ YELLOW COLOR PLANE INTENSITY FEATURE

- A tennis ball appears white in yellow color plane.
- We extract the following matrix to represent the yellow color plane.

$$Y = g - \frac{r}{1.45} - \frac{b}{1.45}$$

- Apply thresholding value > 11

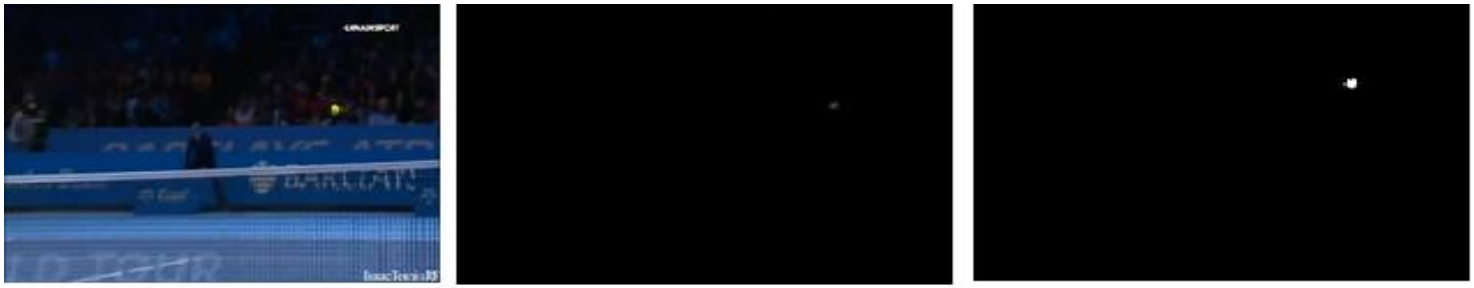
❑ PQFT FEATURE

- Compute the Phase Quaternion Frequency Transform of the frame.
- Segments the most salient feature in the frame i.e. the ball.
- Apply thresholding value < 0.5

PROPOSED APPROACH : BALL TRACKING FRAMEWORK

EXTRACTING TRAINING FEATURES

I. YELLOW COLOR PLANE INTENSITY FEATURE



a) b) c)

Figure 1: (a) Sample Frame (b) Frame as appears in yellow color plane (c) Frame after thresholding is applied

II. PQFT FEATURE

a) b) c)

Figure 2 :(a) Sample Frame (b) PQFT saliency map of the frame (c) Frame after thresholding is applied

PROPOSED APPROACH : BALL TRACKING FRAMEWORK

❑ **RANDOM FOREST SEGMENTATION**

Random Forests is an ensemble classifier that consists of many decision trees and the output of the random forest classification is the class which is mode of the outputs of the individual decision trees.

❑ **BLOB ANALYSIS**

The blob with **eccentricity equal to 1** is selected as the ball candidate.

❑ **VIDEO ANNOTATION**

The bounding box position of the ball blob is obtained and the ball candidates in the corresponding input video frames are annotated.

RESULTS AND DISCUSSIONS

a) b)

Figure 3: (a) Mean of 10 original input frames and (b) Mean of 10 corrected frames.

(A) DATA SETS FOR EVALUATION

- Classifier is trained on Achanta's dataset.
- On 100 images resized to 300*300
- Corresponding binary masks are used as labels.
- Features: Matlab 2014a
- Random Forest Segmentation : Python
- Time taken to segment frame of size 500*500 is 1.76 sec.

(B) VIDEO STABILIZATION RESULTS

- Programming: Matlab 2014
- Time taken to compute a stabilized frame: 1 sec on 2.3GHz Intel Dual Core i5 processor.

RESULTS AND DISCUSSIONS

PERFORMANCE EVALUATION

(A) Performance evaluation on 3 video sequences of tennis shots played by Roger Federer

S.NO.	DURATION (SEC)	TOTAL NUMBER OF FRAMES	NO. OF FRAMES WITH BALL CANDIDATES AVAILABLE (X)	NO. OF FRAMES TRUE BALL CANDIDATES DETECTED (Y)	ACCURACY (Y/X %)
1	11	332	237	223	94
2	10	302	266	200	75
3	13	390	360	172	47

(B) Comparative performance analysis for the methods

METHOD	TOTAL NO. OF FRAMES	NO. OF FRAMES WITH BALL CANDIDATES AVAILABLE (X)	NO. OF FRAMES TRUE BALL CANDIDATES DETECTED (Y)	ACCURACY (Y/X %)
Yu *et. al*	341	294	250	85
OUR METHOD	**341**	**234**	**223**	**94**

Yu *et. al* have used three ideas simultaneously to successfully track the ball : by ball candidate detection, tracking by trajectory generation and tracking by computing the missing location. **However, we have achieved better results in tracking the ball, solely by using a novel ball candidate detection approach.**

RESULTS AND DISCUSSIONS

BALL TRAJECTORY GENERATION

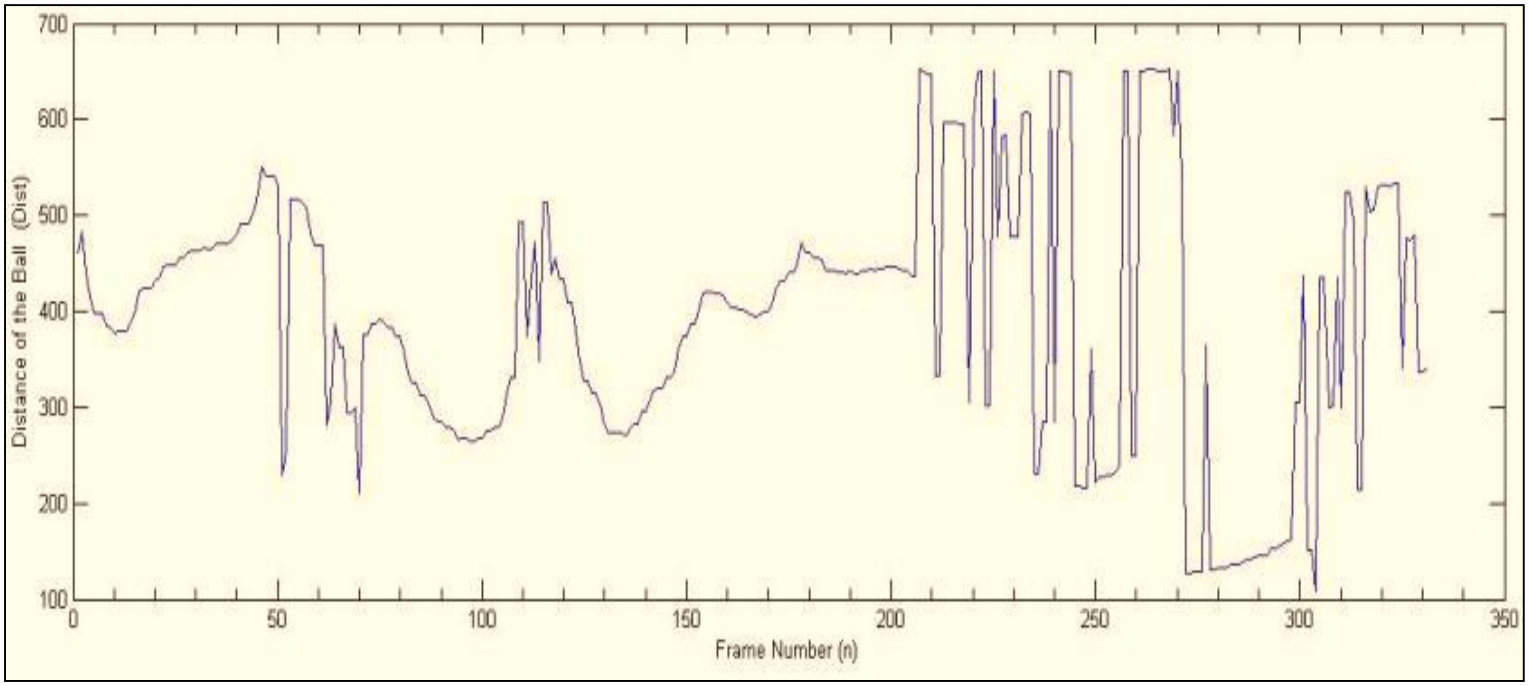


Figure 4: Graphical representation of the location of all ball candidates with time. If a moving object is successfully detected in each frame, it will be depicted by a smooth trajectory over a (relatively) long period of time. From this plot it is evident that the ball candidates are correctly detected in all the frames .

RESULTS AND DISCUSSIONS

BALL DETECTION

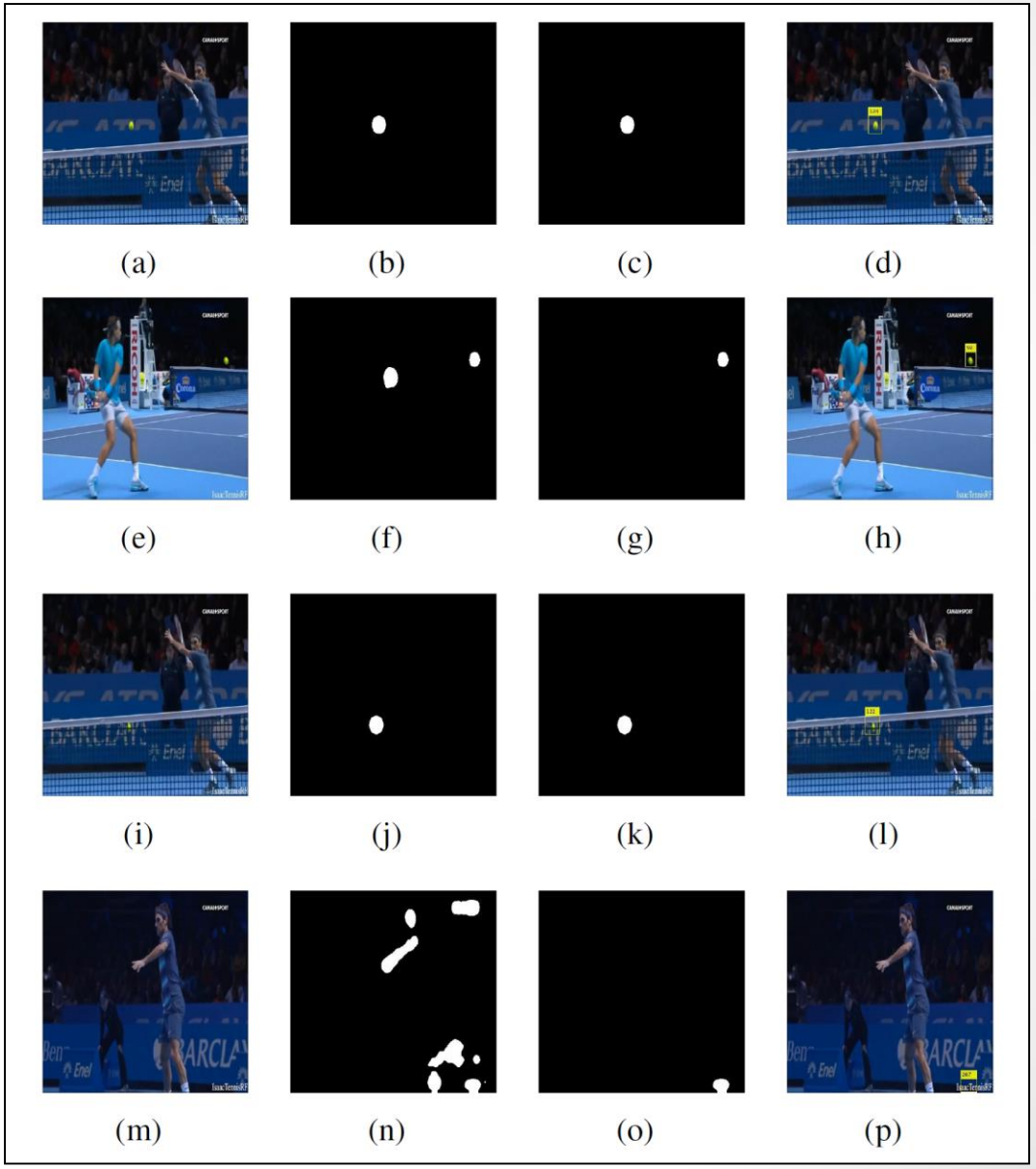


Figure 5: Results of ball detection. First row (a) input frame; (b) segmented frame; (c) after blob analysis; (d) annotated frames.

CONCLUSIONS

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i. We propose a **standalone algorithm for video stabilization and tennis ball tracking** using combined computer vision and machine learning based approach.

ii. The algorithm incorporates **video stabilization techniques** for stabilizing the shaky video and a **random forest segmentation** approach for extracting ball candidates**.**

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THANK YOU