

## **DECLARATION BY THE CANDIDATE**

JULY 2014

Date:\_\_\_\_\_

I here by declare that the work presented in this thesis entitled “**Tracking the Objects in Motion**” has been carried out by me under the guidance of **Mr. Rajesh Rohilla**, Associate Professor, Department of Electronics & Communication Engineering, Delhi Technological University, Delhi and hereby submitted for the partial fulfilment for the award of degree of Master of Technology in Signal Processing & Digital Design at Electronics & Communication Engineering Department, Delhi Technological University, Delhi.

I further undertake that the work embodied in this thesis has not been submitted for the award of any other degree elsewhere.

**Varun Sangwan**  
2K12/SPD/22  
M.Tech (SPDD)

---

## **CERTIFICATE**

It is to certify that the above statement made by the candidate is true to the best of my knowledge and belief.

**Rajesh Rohilla**  
Associate Professor  
Electronics and Communication Department

Dated:

Delhi Technological University, Delhi-110042

## ACKNOWLEDGEMENT

I express my sincere gratitude to my guide **Mr. Rajesh Rohilla** for giving valuable suggestion during the course of the investigation, for his ever encouraging and moral support. His enormous knowledge and investigation always helped me unconditionally to solve various problems. I would like to thank him for introducing me with the problem and providing valuable advice throughout the course of work. I truly admire his depth of knowledge and strong dedication to students and research that has made him one of the most successful professors ever. His mastery of any topic is amazing, but yet he is such a humble and down to earth person. I am glad that I was given opportunity to work with him. He surely brings out the best in his students.

I am greatly thankful to **Prof. Rajiv Kapoor, Professor and Head**, Department of Electronics & Communication Engineering, entire faculty and staff of electronics & Communication Engineering for their, continuous support, encouragement and inspiration in the execution of this “**thesis**” work.

I would like to thank my parents who bestowed upon me their grace and were source of my inspiration and encouragement.

I am thankful to my friend **Vasu Mani Kumar Bandaru** for his valuable discussion and suggestions during my research work.

I am thankful to almighty god his grace and always with me whenever I felt lonely. I am also thankful to my classmates for their continuous support and helpfulness whenever it is needed.

**Varun Sangwan**

2K12/SPD/22

M.Tech (SPDD)

## ABSTRACT

Visual surveillance especially for humans, has recently been one of the most active research topics in machine vision because of its applications such as deter and response to crime, suspicious activities, terrorism or human behaviour recognition. In this dissertation, we have proposed a model which combines features and appearance so as to make the system robust for multiple object tracking. The system works on the principal of background subtraction for which the background is learned using Gaussian Mixture Model. The system uses Kalman filter for the prediction and tracking. So the system is able to predict the position of the object in case of full occlusion. To deal with partial occlusion, the system performs the matching of features. Color, edge, texture and FAST features are extracted and compared with previous frame during partial occlusion. Bhattacharyya distance is evaluated for the matching of color, edge and texture. Texture feature has been extracted using Gabor filter which uses multiple scales and orientations. The key points in the objects are extracted using FAST features. These key points are matched so as to make the system robust. Experimental results on several real videos sequences from different conditions have shown the effectiveness of our approach.

# CONTENTS

<b>CERTIFICATE.....</b>	<b>ii</b>
<b>ACKNOWLEDGEMENT.....</b>	<b>iii</b>
<b>ABSTRACT.....</b>	<b>iv</b>
<b>CONTENTS.....</b>	<b>v</b>
<b>LIST OF FIGURES.....</b>	<b>vii</b>
<b>LIST OF TABLES.....</b>	<b>vii</b>
<b>LIST ABBREVIATION USED.....</b>	<b>viii</b>
CHAPTER 1 .....	1
INTRODUCTION .....	1
1.1 OVERVIEW.....	1
1.2 ORGANIZATION OF THESIS.....	4
CHAPTER-2.....	5
BACKGROUND MODELING USING GMM.....	5
2.1 INTRODUCTION.....	5
2.1.1 Principle of Background Modeling Using Mixture of Gaussians .....	6
CHAPTER 3 .....	10
APPEARANCE BASED MODEL.....	10
3.1 COLOR HISTOGRAM .....	10
3.2 EDGE HISTOGRAM .....	12
3.3 GABOR FILTER FOR TEXTURE ANALYSIS .....	16
CHAPTER 4 .....	18
FEATURES BASED MODEL.....	18
4.1 INTRODUCTION.....	18
4.2 FAST DETECTOR .....	19
CHAPTER 5 .....	23
KALMAN FILTER .....	23
5.1 INTRODUCTION.....	23
5.1.1 Mathematical Mechanism.....	23

5.2 KALMAN FILTER FOR THE OBJECT TRACKING .....	25
5.2.1 Motion Estimation Model.....	26
5.2.2 Feature matching .....	27
5.2.3 Model Update .....	28
5.3 PROS AND CONS OF KALMAN FILTER .....	28
CHAPTER 6 .....	30
PROPOSED METHOD .....	30
6.1 FLOW CHART OF PROPOSED METHOD .....	30
6.2 IMPLEMENTATION .....	31
6.2.1 ALGORITHM OF PROPOSED METHOD.....	32
CHAPTER 7.....	35
RESULT .....	35
7.1 Tracking Results with Various Videos.....	35
7.2 Conclusion and Future Work .....	39

## REFERENCES

## LIST OF FIGURES

<b>Fig 2.1</b>	Foreground detected after background subtraction using GMM.....	9
<b>Fig 3.1</b>	Color histogram of whole frame of video.....	11
<b>Fig 3.2</b>	Color histogram of object in frame.....	11
<b>Fig 3.3</b>	Canny edge detector output of whole frame.....	14
<b>Fig 3.4</b>	Canny edge detector output of object's image in frame.....	15
<b>Fig 4.1</b>	Illustration of pixel examined by the FAST detector.....	20
<b>Fig 4.2</b>	A circle of 16 pixels around the centre pixel p.....	21
<b>Fig 4.3</b>	Detection of FAST Features.....	21
<b>Fig 4.4</b>	Matching of FAST Features in a stereo image pair.....	22
<b>Fig 6.1</b>	Flow chart of proposed method.....	30
<b>Fig 7.1</b>	Tracking scenario of objects in hostel compound.....	36
<b>Fig 7.2</b>	Tracking Scenario of multiple objects in good lightening condition.....	38
<b>Fig 7.3</b>	Tracking Scenario of two objects with occlusion.....	39

## LIST OF TABLES

<b>3.1</b>	5*5 Gaussian Filter Output.....	13
<b>3.2</b>	Gradient Operator.....	13

## LIST OF ABBREVIATION USED

<b>MOT</b>	Multiple Object Tracking
<b>MTT</b>	Multiple Target Tracking
<b>GMM</b>	Gaussian Mixture Model
<b>MoG</b>	Mixture of Gaussian
<b>LoG</b>	Laplacian of Gaussian
<b>DoG</b>	Differentiation of Gaussian
<b>SIFT</b>	Scale Invariant Feature Transform
<b>SURF</b>	Speed Up Robust Feature
<b>FAST</b>	Features from Accelerated Segment Test
<b>SUSAN</b>	Smallest Univalued Segment Assimilating Nucleus
<b>USAN</b>	Univalued Segment Assimilating Nucleus
<b>MS</b>	Mean Shift
<b>PF</b>	Particle Filter