

CERTIFICATE

This is to certify that the work contained in this dissertation entitled “**A novel technique for Foreground Segmentation and Object Tracking**” submitted by **Indu Sirohi (03/SPD/10)** of Delhi Technological University in partial fulfillment of the requirement for the degree of Master of Technology in Electronics & Communication is a bonafide work carried out under my guidance and supervision in the academic year 2010-12.

The work embodied in this dissertation has not been submitted for the award of any other degree to the best of my knowledge.

Guided by :

Mr. Rajesh Rohilla

(Associate Professor)

Delhi Technological
University

Delhi -110042

ACKNOWLEDGEMENTS

Firstly I thank the Almighty who has given me this excellent opportunity. This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to my guide **Mr. Rajesh Rohilla**, Associate Professor in Electronics and Communication Department at Delhi Technological University, who has always encouraged me in my work . **Prof. Rajeev Kapoor**, H.O.D, Electronics & Communication has been my source of inspiration as I overcame all the obstacles during the completion of this research work with his guidance.

I would also like to take the opportunity to present my sincere regards to **Prof. S.D Joshi , IIT Delhi** for his guidance that solved one major hurdle in my work.

The undergraduate students and classmates were of great help as various discussions with them proved to be a boon. I express my regards towards Mr. Baljeet Singh, Lab Coordinator in Electronics and Communication Departments and the other officials for their assistance in the availability of the adequate resources.

Last but not the least to my family and friends for their love and support which has given me enormous support.

Indu Sirohi

M.Tech (Electronics & Communication)

College Roll No. 03/SPD/10

University Roll.No: DTU/MTech/171

ECE Department

Delhi Technological University,

Delhi-110042

ABSTRACT

An elementary goal of computer vision lies in its ability to analyze motion, which ranges from the simple task of locating or tracking a single rigid object as it moves across an image plane. It recovers the full pose parameters of a collection of non-rigid objects interacting in a scene. Automation is a need of today's growing demands and machine vision has proved itself to be a rudimentary tool to accomplish it. Machine vision deals with the study and implementations of systems that allows machines to recognize objects from acquired image data and perform useful tasks from that recognition. It is an application of the vast area of computer vision which has got detection and classification of moving objects as its important area of research. Computer Vision enjoys numerous of astounding achievements varying from their use in mobile robots, human-computer interactions, security systems, surveillance, activity analysis, event recognition, interpreting facial expressions, optical motion capture, enhanced reality and many more. Computer Vision aims at imitating a computer to be a human wherein the Digital camera plays the role of the eye and Image Processing Software as the human Brain. Thus, there is a need to imbue in them the flexibility to handle new inputs, and to adapt automatically without the manual intervention of human engineers. Our work addresses this aspect of the computer vision application. We begin with the discussion of the challenges of foreground segmentation and tracking a rigid object in video. Our work is based on learning a tensor based appearance model, which is having wide importance for background modeling and object tracking. Various subspace learning based algorithms are available that have been used to model the appearances of objects or scenes. In this work we have proposed an advanced adaptive algorithm for robust and efficient background modeling and tracking in colored video sequences that has the capability of capturing the intrinsic spatiotemporal characteristics of scenes. The proposed method is named as 3D-ITSL (3-Dimensional incremental tensor subspace learning) algorithm that

effectively works with the spatiocolor-temporal (SCT) information by adaptively updating the means and the basis vectors of the corresponding flattened analogue in an online manner. The proposed method employs the wavelet transformation to an optimum decomposition level in order to reduce the computational complexity by working on the approximate counterpart of the original scenes. Our tracking method is an unscented Particle filter that utilizes appearance knowledge and estimate the new state of the intended object.

INDEX

Chapter 1 Introduction	1
1.1 Overview	1
1.2 Image Processing	2
1.2.1 Analog Image Processing	5
1.2.2 Digital Image Processing	6
1.2.3 Operations Performed in DIP	8
1.3 Video Processing	12
1.4 Research aims and Objectives	12
1.4.1 Strengths	13
1.4.2 Weakness	14
1.5 Distinct characteristics	15
1.6 Organization of the thesis	15
Chapter 2 Related work	17
2.1 In the area of Foreground Segmentation	17
2.2 In the area of Object Tracking	18
2.3 Comparison over the current techniques	22
Chapter 3 Foreground Segmentation	25
3.1 Overview	25
3.2 Background Subtraction	26
3.2.1 Background Modeling	28
3.3 Tensor based Foreground segmentation techniques	31
3.3.1 Offline Tensor Analysis (OTA)	33

3.3.2 Dynamic Tensor Analysis (DTA).....	33
3.3.3 Streaming Tensor Analysis (STA).....	34
3.3.4 Window based Tensor Analysis (DTA).....	35
3.3.5 HOSVD.....	36
3.3.6 IRTSA-GBM and IRTSA-CBM.....	38
Chapter4 Object Tracking.....	41
4.1 Introduction.....	41
4.2 Basics of object tracking.....	43
4.2.1 Features of tracking.....	44
4.3 Methods for tracking.....	46
4.3.1 Point tracking.....	47
4.3.2 Kernel tracking.....	52
4.3.3 Silhouette tracking.....	53
4.3.4 Graph based tracking.....	54
4.4 Handling Occlusion.....	54
4.4.1 Self Occlusion.....	54
4.4.2 Inter-Object Occlusion.....	55
4.4.3 Background scene structure occlusion.....	55
4.4.4 Combination of different kinds of occlusions.....	55
Chapter 5 Multilinear Algebra.....	56
5.1 Definition.....	56
5.2 Glimpse of the notations.....	57

5.2.1 Rank-1 tensors	58
5.2.2 Symmetry	59
5.2.3 Diagonal tensors	59
5.2.4 Matricization.....	59
5.2.5 Tensor Multiplication	60
5.3 Tensor Decomposition.....	61
Chapter 6 Results and Discussions	63
6.1 Problem Statement.....	63
6.2 Challenges faced.....	63
6.3 Our Proposed Foreground Segmentation method (3D-ITSL).....	63
6.3.1 Results of Foreground Segmentation.....	67
6.3.2 Remarks.....	71
6.4 Our Object Tracker	73
6.4.1 Bayesian Inference for Tracking.....	73
6.4.2 Unscented Particle Filter.....	74
6.4.3 Object Tracking Results.....	75
6.5 Conclusion and Future work	79

REFERENCES

LIST OF FIGURES

	<u>PAGE NO.</u>
Figure 1.1 : Interlaced scan	4
Figure 1.2 : An example of an Analog image	5
Figure 1.3 : An RGB image using imtool	9
Figure 3.1 : A pipelined view of Background subtraction.	26
Figure 3.2 : Gradual illumination changes in the scene	27
Figure 3.3 : Sudden illumination changes in the scene	27
Figure 3.4 : Dynamic backgrounds	28
Figure 3.5 : Background modelling techniques	29
Figure 3.6 : Subspace learning methods	30
Figure 3.7 : Third order tensor of a network flow data	32
Figure 3.8 : OTA projection	33
Figure 3.9 : Tracking a projection matrix	34
Figure 3.10 : Visualization of HOSVD	36
Figure 3.11 : Unfolding an extended third order tensor	37
Figure 3.12 : Foreground segmentation block diagram	38
Figure 3.13 : Architecture of the foreground segmentation framework	39
Figure 4.1 :Tracking approaches	47
Figure 4.2 : Point correspondence	47
Figure 4.3 : Different motion constraints	49
Figure 5.1 : A third order tensor	56
Figure 5.2 : Fibres of third order tensor	57
Figure 5.3 : Slices of third order tensor	58
Figure 5.4 : Diagonal Tensor	59
Figure 5.5 : An illustration of a third order tensor	60
Figure 6.1 : The proposed 3D-ITSL block diagram	66

Figure 6.2 (i) The results of our proposed method in foreground segmentation.	67
Figure 6.2(ii) The results of our proposed method in foreground segmentation	68
Figure 6.3(i) The results of our proposed method in foreground segmentation for example	69
Figure 6.3(ii) The results of our proposed method in foreground segmentation for example 2	70
Figure 6.4(i) The results of our proposed method in foreground segmentation for example 3	71
Figure 6.4(ii) The results of our proposed method in foreground segmentation for example 3	72
Figure 6.5 The Unscented Particle filter based tracker [6]	73
Figure 6.6 Illustration of an object feature i.e Extrema points	75
Figure 6.7 The result of tracking algorithm for the example 1	77
Figure 6.8(i) Result of tracking algorithm for the example 2	78
Figure 6.8(ii) Result of tracking algorithm for the example 2.	78
Figure 6.9 Result of tracking algorithm for the example 3.	79

LIST OF ABBREVIATIONS

PCA -Principal Component analysis

LDA- Linear Discriminant analysis

ICA- Independent Component analysis

NMF- Non-negative matrix factorization

HMM- Hidden Markov Model

PDE-Partial differential equation

SOM-Self-organizing map

ANN -Artificial Neural Network

DWT -Discrete wavelet transforms

CWT -Continuous wavelet transforms.

SVD -Singular Value Decomposition

3D-ITSL- 3-Dimensional Incremental Tensor Subspace Learning

SIS -Sequential importance sampling

PSO -Particle Swarm Optimization

BBO-Biogeography-based optimization

ACO -Ant colony optimization

KFDA- Kernel Fischer discriminant analysis

MOG -Mixture of Gaussians

GMM -Gaussian Mixture Model

ESS -Efficient Sub-window Search

EM -Expectation Maximization

MOT- Multiple Object Tracking

MRF -Markov Random Field

SGG -Single General Gaussian

MOGG- Mixture of general Gaussians

CBIR -Content based image recognition

HSI -Hyper spectral Image analysis

HOS -Higher order statistics

OTA -Offline tensor analysis

DTA -Dynamic tensor analysis

STA -Streaming tensor analysis

WTA- Windowed tensor analysis

MACA -Multi-Aspect Correlation Analysis

HOSVD-Higher-order tensors is obtained by

IRTSA -Incremental Rank tensor based subspace learning algorithm