CHAPTER 2

LITERATURE SURVEY

In various fields there is a necessity to detect the target object and also track them effectively while handling occlusions and other included complexities. Many researchers (Almeida and Guting 2004, Hsiao-Ping Tsai 2011, Nicolas Papadakis and Aurelie Bugeau 2010) attempted for various approaches in object tracking. The nature of the techniques largely depends on the application domain. Some of the research works which made the evolution to proposed work in the field of object tracking are depicted as follows.

2.1 OBJECT DETECTION

Object detection is an important, yet challenging vision task. It is a critical part in many applications such as image search, image auto-annotation and scene understanding, object tracking. Moving object tracking of video image sequences was one of the most important subjects in computer vision. It had already been applied in many computer vision field, such as smart video surveillance (Arun Hampapur 2005), artificial intelligence, military guidance, safety detection and robot navigation, medical and biological application. In recent years, a number of successful single-object tracking system appeared, but in the presence of several objects, object detection becomes difficult and when objects are fully or partially occluded, they are obtruded from human vision which further increases the problem of detection.
Tie Liu (2010) gave a new approach for detecting objects by template matching from the large database collection. The approach was suitable for multi-scale contrast backgrounds and used a color spatial method to detect objects. This approach failed to detect multiple objects in a given user scenario and also failed when the objects were in non-linear motion. This problem of failed detections was effectively overcome in the proposed system by training the system to identify the objects through an effective system learning technique and the objects in non-linear motion are tracked using the proposed particle grouping approach.

Scott McCloskey et al (2011), provided a kernel based method to detect objects even in the presence of partial occlusions. The blur kernel method was used to examine large partial occlusions when foreground object was out of focus. The key merit of this method was that it provided an exact solution for partial occlusions through background mapping. However, this was possible only through a series of assumptions made on background intensity such as the static nature of the background, the illumination changes, the color of the objects, etc. Also it was found viable only for self occlusion. A better solution to this problem was to utilize an active appearance model to detect the objects moving in dynamically changing background. And also the distance formulation technique based on bus topology is used to detect the presence of partial and complete occlusions with high accuracy in proposed MLP based object tracking.

Aniruddha Kembhavi et al (2011), presented an object detection method using color probability maps to capture the color statistics of vehicles and their surroundings. Partial Least Squares (PLS) to project the data onto a much lower dimensional subspace was the method highlighted and used. The advantage of this method was that PLS enables in the selection of a small subset of feature data. But the detector’s performance degrades with
decreasing illumination and acquisition angle. The proposed MLP based object tracking system is made robust by optimum selection of unique features and also by implementing the adaboost strong classification method.

2.1.1 Background Subtraction

The background subtraction method by Horprasert et al (1999), was able to cope with local illumination changes, such as shadows and highlights, even globe illumination changes. In this method, the background model was statistically modeled on each pixel. A computational color mode, include brightness distortion and chromaticity distortion was used to distinguish shading background from the ordinary background or moving foreground objects. The background and foreground subtraction method used the following approach. A pixel was modeled by a 4-tuple \( [E_i, s_i, a_i, b_i] \), where \( E_i \)- a vector with expected color value, \( s_i \) - a vector with the standard deviation of color value, \( a_i \) - the variation of the brightness distortion and \( b_i \) was the variation of the chromaticity distortion of the ith pixel. In the next step, the difference between the background image and the current image was evaluated. Each pixel was finally classified into four categories: original background, shaded background or shadow, highlighted background and moving foreground object.

Liyuan Li et al (2003), contributed a method for detecting foreground objects in non stationary complex environments containing moving background objects. A Bayes decision rule was used for classification of background and foreground changes based on inter-frame color co-occurrence statistics. An approach to store and fast retrieve color co-occurrence statistics was also established. In this method, foreground objects were detected in two steps. First, both foreground and background changes are extracted using background subtraction and temporal differencing. The frequent background changes were then recognized using the Bayes decision
An algorithm focused on obtaining stationary foreground regions as said by Álvaro Bayona et al (2010), which was useful for applications like the detection of abandoned/stolen objects and parked vehicles. This algorithm mainly used two steps. Firstly, a sub-sampling scheme based on background subtraction techniques was implemented to obtain the stationary foreground regions. This detects foreground changes at different time instants in the same pixel locations. This was done by using a Gaussian distribution function. Secondly, some modifications were introduced on this base algorithm such as thresh holding the previously the previous computed subtraction. The main purpose of this algorithm was reducing the amount of stationary foreground detected.

2.1.2 Template Matching

Template Matching is a technique for finding small parts of an image which match a template image. It slides the template from the top left to the bottom right of the image and compare for the best match with the template. The template dimension should be equal or smaller than the reference image. It recognizes a segment with the highest correlation as a target. Given an image S and an image T, where the dimension of S was both larger than T, output whether S contains a subset image I where I and T are suitably similar in pattern and if such I exists, output the location of I in S as in Hager and Bellhumear (1998).

Schweitzer et al (2011), derived an algorithm which used both upper and lower bound to detect ‘k’ best matches. Euclidean distance and Walsh transform kernels are used to calculate match measure. The positive things included usage of priority queue improved quality of decision as to
which bound-improved and when good matches exist inherent cost was dominant and it improved performance. But there were constraints like absence of good matches that lead to queue cost and the arithmetic operation cost was higher. The proposed methods dint use queue thereby avoiding the queue cost rather used template matching.

Visual tracking methods can be roughly categorized in two ways namely, feature based and region based method as proposed by Ken Ito and Shigeyuki Sakane (2001). Feature based approach estimates the 3D pose of a target object to fit to the image features the edges, given a 3D geometrical model of an object. This method requires much computational cost. Region based can be classified into two categories namely, parametric method and view based method. The parametric method assumes a parametric model of the images in the target image and calculates optimal fitting of the model to pixel data in a region. View based method was used to find the best match of a region in a search area given the reference template. This has the advantage that it does not require much computational complexity as in the feature based approach.

2.2 OBJECT TRACKING

A pattern for tracking moving objects efficiently was surveyed by Yilmaz et al (2006), through mining group movement. The work focuses on multiple group tracking based on local relationship and moving pattern. In this approach, similar object moving pattern could be efficiently grouped but different moving object could not be grouped and thus tracking failed in such scenarios leading to energy waste. An appropriate solution adopted here is to use individual trackers for the objects in the video under analysis.

A pattern for tracking moving objects efficiently presented by Hsiao-Ping Tsai (2011), through mining group movement. This work is
focused on multiple group tracking based on local relationship and moving pattern. In this approach, similar object moving pattern could be efficiently grouped but different moving object could not be grouped and thus tracking failed in such scenarios leading to energy waste. In the proposed Rk-d trajectory graph, moving pattern lead in the critical region identification which form groups to avoid collision. The grouped objects and differently moving object tracked successfully.

A system to detect and track multiple persons from a single uncalibrated camera was stated by Michael D. Breitenstein et al (2011). The system used a bootstrap filter to track multiple persons and target specific classifiers to select the objects and associate them to targets. The merits included effective handling of false positive detections but at the cost of a high computational complexity. The serious drawback was that no background modeling was done. In the proposed system, particle grouping minimized mapping complexity and dynamic scene modeling done so as to avoid extra computation.

Pan Pan and Dan Schonfeld (2011), provided a graph based solution for single object and also used an extension of the approach to track multiple objects with Hidden Markov Model. In this method multiple objects were tracked with minimum energy consumption but the demerits were that a fixed state space with static background was constructed where total occlusions went undetected and also led to the increase in computational complexity. In contrast, no graph construction done in the proposed MLP based system but dynamic scene modeling performed.

Nicolas Papadakis and Aure lie Bugeau (2010), introduced a silhouette method for object tracking and used the Max flow Min Cut algorithm for each object under analysis either visible or occluded. The main
merits of the graph cuts based approach was the focus on varying image intensities, multiple colored objects and energy minimization. The method also suffered from a few issues namely resource wastage due to bad predictions and errors. Also complete occlusions went undetectable while tracking. In the proposed MLP based system, bus topology implementation handles occlusion effectively.

A two-level background maintenance approach for object segmentation in real-time multiple object tracking was presented Tao Yang et al (2005). The work included feature correspondences between the foreground regions. The assumptions made were that during occlusions, trajectory of individual object was same as that of the group and that the pixel value of the moving object’s position changes faster than those in the real background. The key merits of the system were that it was able to cope with long duration and complete occlusions with no prior information required about shape or motion required for tracking. But the system failed in tracking objects under highly non-linear situations in the presence of occlusions. The proposed particle grouping based MLP approach for tracking proves to be effective in handling the non-linear object motion.

Bohyung Hun and Larry Duvis (2005), practiced object tracking by adaptive feature extraction using principal component analysis based on likelihood images and mean shift tracking was proposed. The merits of the work were that the tracker’s performance was improved in low-resolution video and noisy environment. But the demerit was that visual information about the likelihood image was lost due to projection as only Colour information was used for feature extraction. In the proposed system, position gives the state of the object and also kinetic and potential energy of the object under motion are accounted so as to avoid loss of visual information while tracking.
Visual surveillance in dynamic scenes, especially for humans and vehicles, was one of the most active research topics in computer vision given by Weiming Hu et al (2004). It has a wide range of potential applications, such as traffic surveillance in cities, human identification and security guard for communities or important buildings, etc. In general, the processing framework of visual surveillance in dynamic scenes including the following stages: objects detection, tracking, understanding and description of behaviors and human identification. Behavior understanding and human identification depend on the results of objects tracking which is one of the most important parts in visual surveillance.

Roh et al (2000), used an appearance model based on temporal color to track multiple people in the presence of occlusion. They used temporal color features which combined color values with associated weights. The weights were determined by the size, duration, frequency and adjacency of a color object. In some instances, this method can only deal with partial occlusion. The proposed MLP based approach can handle any kind of occlusions in an effective manner.

Heungkya Lee and Hanseok Ko (2004), presented occlusion activity detection using Kalman prediction. Using the predicted information, occlusion status was verified. This method works only on prediction. The proposed MLP based method handles occlusions through training and Bus topology calculation and yields more accuracy.

Iulian (1998), used Kalman Filter as an alternative to classical LMS algorithm for training RBF. The simulation results of chaotic time series prediction were presented. The proposed automatic KFB deals with KF and RBF for tracking objects.
Kostic (2010), gave a method for Collision free motion coordinated by a group of in cycle agents. The control signals were the constraint in this method avoid collisions in a retinotopic way and uses LOCUST based approach which yield accurate time to collisions.

Imran et al (2011), had done a work on self-similarities of action sequences explored and striking stability observed. Intuition and experimental validation demonstrating its high stability were provided. The advantage of this method gave efficient cross-view action recognition and superior performance on public. Making assumptions about the rough localization of a person in the frame was its major downfall. The proposed MLP based method made no assumptions and yet can track multiple objects.

A single target tracking technique was given by Andrew Senior et al (2006), with color motion integration mechanism using particle filter. The advantages of the method included single object being tracked successfully even in a cluttered background and partial and full occlusions was handled effectively. The main drawback of the system was that it assumed to be tracked in a static background where overlapping objects go undetected. The overcoming solution is, applying dynamic background modeling with individual particle filter trackers and it is practiced in proposed MLP based approach.

Bonnaud and Lobit (1997), tracked object lists, boundaries and adjustments. It can be noted that the tracking algorithm performed well on objects with significative boundaries. For segmentations that contained small regions and too short boundaries this method lack motion estimation. This difficulty is taken over in the proposed method where there is no segmentation done.
2.2.1 Filter Based Tracking

Jin Wang (2010), presented a model that improved the existing Kalman Filter to track objects even in the presence of occlusions. This work was a combination of appearance and motion information to track objects. The advantages of the method were that it was successful in locating objects accurately even when they were partially or fully occluded and was able to easily distinguish dissimilarly colored objects. The disadvantage of the method was its unreliability and less efficiency along with wrong correspondence when different objects have similar appearance. An effective solution to overcome these problems are provided in the proposed system by selecting motion parameters along with feature extraction and formulating the distance based bus topology framework.

Ibrahima and Patricio (2011), used EKF alone to estimate the position of deformable objects. Based on curve velocities predictions were done. This method just used a single filter for the movement of objects. The proposed automatic KFB uses a bank of filters which yield better results than using just a single filter for any type of movement.

St-Pierre (2004), had done a comparison between the UKF & the EKF for the position estimation module of an integrated navigation information system was performed. It focused on the use of EKF for positioning the navigation information system and UKF when prediction and update functions are highly non linear calculation becomes complex. Though this technique improved the precision of estimation, it renders the system useless when there is no GPS solution. And also the computational time of the fused EKF and UKF was proved to be 3% greater than the EKF alone. An apt solution for this issue is provided in the proposed system by particle grouping based approach for object tracking to minimize the computation.
An information theory-based analysis of partial and total occlusion in object tracking was offered by E. Loutas, C. Nikou and I. Pitas (2002). The work dealt with mutual information based metrics as a measure for tracking reliability and it was extended to analyze partial and total occlusions. The main advantage of the work was the effective characterization of the object’s appearance and re-appearance while in motion. The serious disadvantage of the work was that detection of moving objects was possible only under static scenes. Also feature point tracking was done only using Kalman Filter leading to the failure cases during non-linear object motion. To handle object tracking under non-linear motion, the bus topology based distance formulation and particle grouping based approach are proposed.

Xin Li et al (2010), had a feature based approach to handle multiple objects tracking method using Kalman Filter with the background subtraction technique for object detection. The centroid and area estimation was proposed for occlusion identifications. It was assumed to work only for a static background with fixed camera where inter-object occlusion was handled effectively. But the demerit of the system was that a fixed threshold value to measure the similarity between detected regions was assumed. This led to failure in tracking objects under full occlusion cases. The problem is overcome in the proposed system by applying the superposition estimation, bus topology based distance formulation and entanglement-free treatment in the occlusion handling layer.

Yong Shan and Fan Yang (2007), gave tracking model for occlusion handling based on information fusion, which utilized multiple information to achieve moving object segmenting task. The drawback was that fusion of information lead to misconclusions. The proposed MLP method
does not go for fusion but follows calculative way thereby giving accurate results even in case of occlusions.

Jang et al (2000), modelled a new tracking algorithm. The algorithm constructed a model of the detected moving object and matched the model with successive image frames to track the target object. They used Kalman Filter to predict motion information in order to reduce the computation complexity.

Peterfreund (2000) used Kalman Filter to track contours of nonrigid objects. This method employed an optical-flow measurements and a Kalman Filter to detect and reject the measurement which belong to other objects. These works cannot deal with occlusions.

Tracking can be considered as a problem of estimating the probability by Wachter and Nagel (1999). It can be solved by a statistic model of probability which describes the motion state and a method of Bayesian estimation. Kalman Filter is a classic Bayesian estimating method. In linear and Gaussian conditions, the optimal solution about the motion state of objects can be obtained by Kalman Filter.

Wei Xue (2007), used a Robust Kalman Filter and Kalman Filter Bank in Fault Detection and Isolation (FDI) of sensor and actuator for aircraft control system. Each of the Kalman Filter in the bank is designed for a specific sensor fault detection based on a specific hypothesis. If a fault occurs, all filters in the bank except the one using the correct hypothesis will produce large estimation errors, from which a specific fault has been isolated. In case of Kalman Filter, the decision statistics keep changing regardless the faults in the actuators or sensors. Robust Kalman Filter is used to distinguish the sensor and actuator faults easily. But, it cannot be used to isolate which actuator is faulty. An assumption is made that only one of the sensors or
actuator will fail at a time. Fault detection and isolation between different actuators is not considered. Using filter Bank, faults in different actuators can be isolated.

A fusion of two non linear filters (SOEKF and UKF) had introduced to help the tracking of maneuvering target by Behrooz Sadeghi, Behzad Moshiri (2007). UKF overcomes the occasional divergence of SOEKF and SOEKF overcomes the problem of dealing with highly non linear equations. It is found that the fusion algorithms enhance the accuracy. It is found that the computational time of the fused SOEKF and UKF is 2 % greater than the SOEKF alone. This computational time can be reduced by using filter banks.

Jiyan Pan, Bo Huand Jianqiu Zhang (2008), considered the challenges to robustly determine a portion of the target that is occluded. Content Adaptive Progressive Occlusion Analysis (CAPOA) algorithm and Accurate tracking-Variant Mask Template Matching (VMTM) were used to locate the target when the occlusion situation-current frame-unknown accurately. To properly update the template-preventing damages caused by outliers & template drift, a drift-Drift Inhibitive Masked Kalman Appearance Filter (DIMKAF) was used. Occlusion- Local Best Match Authentication (LBMA) algorithm reliably detected the reemergence of the target & recapture it after complete occlusion. But the constraints faced were it failed to recognize the face as a part of the target when there is a shift in frontal to rear view of the face and the target became out of searching range due to the irregular motion of the target during complete occlusion. The proposed method is capable of tracking the objects of any type of occlusions using the superposition estimations.

In order to track objects, estimation algorithms are needed by Zhigang Liu and Hua Yang (2010), since estimation is the process of inferring
the value of a quantity of interest from indirect, inaccurate and uncertain observations. Estimation is used for both constant parameters and state variables. In target tracking applications in the second type has been used for target parameters (e.g. position) change with time. The most commonly used types of state estimator are the Kalman Filter. It is an optimal estimator for linear systems, but unfortunately very few systems in the real world are linear. Some algorithms like UKF and EKF can be used for tracking objects in non-linear motion.

An enhanced Camshift approach as introduced by Ken Chen et al (2010) in conjunction with Kalman Filter has been used with the aim of tracking the multi human- faces with occlusion in the moving course. Starting with detection of facial region of interest, the proposed tactic induces overlap coefficient into determining whether or not the target occlusion occurs in the course of motion. The matching matrix is subsequently set up based on the target's dynamic model, solving the likely mismatching problem arising from posteriority of occlusion. The algorithm is put to test suggesting adequately promising occlusion-resistance capacity and practicality.

Radial Basis Function networks have been traditionally used as a multidimensional interpolation technique. RBF networks typically have three layers: an input layer, a hidden layer with a non-linear RBF activation function and a linear output layer. In input layer, predictor variable consists of one neuron and its value is fed into hidden layer. The hidden layer consists of radial basis function which computes Euclidean distance between the input neuron and training neuron. The sum of all outputs from hidden layer is an output of the output layer as proposed by Iulian. This leads to a dramatic reduction of the computing time with the supplementary benefit of avoiding the problem of local minima, usually encountered when simulating standard multilayer perceptrons.
Pang Chen-peng and LID Zao-zhen (2009), utilized the Adaptive Track Fusion algorithm to fuse the output of the GPS/SINS Kalman Filter and GPS Kalman Filter. In case the GPS outages occur, accuracy of the system will be degraded rapidly due to the lack of measurements of the two Kalman Filter. An algorithm of bridging GPS outages using radial basis function neural network is used to improve accuracy of the navigation system during the GPS outages. This method used radial basis function neural network to predict measurement of GPS/SINS Kalman Filter during GPS outages in order to ensure the regular operation of the filter, resulting in the reliable performance of the system.

Most of the present navigation systems rely on Kalman Filtering methods to fuse data from global positioning system (GPS) and the Inertial Navigation System (INS). In general, INSIGPS integration provides reliable navigation solutions by overcoming each of their shortcomings, including signal blockage for GPS and growth of position errors with time for INS. Present Kalman Filtering INWGPS integration techniques has several inadequacies related to sensor error model, immunity to noise and observability. This paper by Aboelmagd Noureldin (2004), introduced a multi-sensor system integration approach for fusing data from an INS and GPS hardware utilizing Artificial Neural Networks (ANN). A multi-layer perceptron ANN has been recently suggested to fuse data from INS and Differential Global Positioning System (DGPS). Despite of being able the positioning accuracy, the complexity associated with both the architecture of multilayer perceptron networks and its online training algorithms limit the real time capabilities of these techniques. This uses an alternative ANN architecture. This architecture is based on radial basis function (RBF) neural networks, which generally have simpler architecture and faster training procedure than multi-layer perceptron networks.
Branimir Todorovic (2002), addressed a problem of continuous neural network adaptation (often called on-line learning or sequential adaptation) in non-stationary environment. In this paper, the on-line learning of the Recurrent Radial Basis Function (RRBF) network by applying the EKF was considered. In dynamic of the neuron outputs and parameters of the recurrent neural network (RNN) were represented by the state-space model and the EKF is applied to the resulting non-linear estimation problem. The EKF is applied to the simultaneous estimation of states, time-varying parameters and structure of the RRBF network. The on-line structure adaptation of the RRBF network is achieved by combining the growing and pruning of the hidden neurons and connections. The Kalman Filter consistency test is used as the criterion for adding new hidden neurons or network growing.

Radial basis functions are embedded into a two-layer feed-forward neural network. Such a network is characterized by a set of inputs and a set of outputs (Yong Zhang 2009). In between the inputs and outputs there is a layer of processing units called hidden units. Each of them implements a radial basis function represents its equation. The way in which the network is used for data modeling is different when approximating time-series and in pattern classification. In the first case, the network inputs represent data samples at certain past time-laps, while the network has only one output representing a signal value. In a pattern classification application the inputs represent feature entries, while each output corresponds to a class. By using this method, monitoring data are extracted and optimized in mine safety monitoring.

Kataoka (2011), analyzed and proposed a football tracking system along with the players’ detection using particle filter. The ball’s trajectories and the corresponding movement of the football players were projected from a single camera’s image so as to track their motion. A combination of particle
filter and real adaboost classifier was proposed for tracking. Ball tracking was done by selecting a likelihood edge and color feature whereas player tracking was done by employing template matching and background subtraction techniques. The main advantage of this method was that tracking was effective inside the estimated pitch area but it proved to be inadequate and inefficient when many players moved around in very close proximity.

Kazuhiro Otsuka and Naoki Mukawa (2004), provided a tracking method using particle filter on densely populated objects. Tracking was based on a probabilistic framework of explicit multi-view occlusion analysis. It was found to be robust in case of severe occlusions and also suppresses memory consumption. But this rendered the system very slow (as low as 7 frames/second) due to increased operations on each object. As a solution to this problem, the proposed particle grouping approach along with powerful visual cues for object identification reduces the computations of the system.

Robust human tracking algorithm applied for occlusion handling was dealt by Huan Xu and Shie Mannor (2009), for single target tracking with colour and motion integration mechanism using particle filter. The advantages of the system were that single object was tracked even in cluttered background and also partial and full occlusions were handled. But the disadvantage of the approach was that overlapping objects go undetected even in a static background. The solution to overcome this detection problem is the automation of the object detection engine along with the proposed particle grouping approach.

2.2.2 Agent Based Tracking

In recent years ad hoc parallel data processing has emerged to be one of the killer applications for infrastructure-as-a-service clouds. Particular
tasks of a processing job can be assigned to different types of virtual machines. Goldszmidt and Yemini (1998), defined a high level language named DEAL (DElegated Agent Language). The main aim was to minimize use of the resources at the network level and processing time at the manager level.

Daniel Warneke et al (2011), discussed the opportunities and challenges in parallel data processing in the cloud and present Nephele, the first data processing framework to explicitly exploit the dynamic resource allocation. Nephele was cost-efficient as it allocated and de-allocated virtual machines according to the current job execution phase. It also provided the feedback data. However, the framework does not allow communication between the various task managers. Moreover, the user must decide the job graph and the code to be executed. Proposed work supports interaction and communication between the agents using FIPA ACL for collision avoidance.

Kohsia Huang et al (2001), designed a framework for coordinating distributed video camera to track human movement. However this framework did not provide the coordination method for the agents. Proposed work creates a coordinated cluster of agents which interact using FIPA ACL. The agents exchange messages to coordinate the work of object migration.

Hideaki Takeda et al (1997), came up with an agent-based framework where users communicate with a robot via a video camera located outside of the robot. The framework provided a ubiquitous access method that explores the agent as a means to establish communication between users and robots via distributed sensors. Although this framework is designed for Human-Robot-Interface using agent technology, it did not solve the offline problem. The offline problem is caused by the impermanent presence of a
robot. Proposed work uses a spatio-temporal database to retrieve information about the object. This removes the need for direct physical connection between the object to be controlled and the agent.

Stephen McArthur et al (2007), examined the properties of MAS and discusses how MAS technology offers the means to create flexible, extensible and fault tolerant systems and also a modelling approach for creating complex systems or market models. The relation between MAS standards and Common Information Model is taken into consideration in this paper.

Ting-Yuan Yeh et al (2005), discussed a tracking mechanism based on cluster topologies. Location update messages are sent only within a cluster and traces of footprints are created only on the proxy nodes of mobile agents in clusters. This work uses Home-Proxy and Forward-Proxy tracking mechanisms to resolve remote agent problem. But it does not apply this tracking model to mobile agent communication. Proposed work support mobile agent communication using Agent Communication Language.

Ming Hou et al (2011), came up with a generic conceptual framework for developing IAIIs to guide interface design. This framework integrated a user-centered design approach to the concept of proactive use of Adaptive Intelligent Agents (AIAs), aiming at maximizing overall system performance. Based on existing design approaches, identified challenges and IAI design needs the framework uses a multi-agent hierarchical structure to allocate tasks between operators and agents for optimizing operator–agent interaction as illustrated in Table 2.1.
Table 2.1 Comparison of Human-Machine and Operator-Agent Interaction

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Human-Machine Interaction</th>
<th>Operator-Agent Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levels of autonomy</td>
<td>Two levels of autonomy</td>
<td>Multiple levels of autonomy</td>
</tr>
<tr>
<td>Context</td>
<td>Context is typically static</td>
<td>Context is dynamic</td>
</tr>
<tr>
<td>Belief</td>
<td>The human has a belief about the Machine and Task.</td>
<td>The operator has a belief about Agent and Task.</td>
</tr>
<tr>
<td>Procedures</td>
<td>It is specific, systematic and associate with Standard Operating Procedures.</td>
<td>It is fuzzy and there may be many means to achieve the same end.</td>
</tr>
<tr>
<td>Trust</td>
<td>Trust is binary – Machine works or does not.</td>
<td>Trust must built over time</td>
</tr>
</tbody>
</table>

Valter Silva et al (2011), discussed a framework to provide consumers of location-based services with a richer end-user experience by means of service composition, personalization, device adaptation and continuity of service. This approach relies on a multi-agent system composed of proxy agents that act as mediators and providers of personalization meta-services, device adaptation and continuity of service for consumers of pre-existing location-based services. These proxy agents, which have Web services interfaces to ensure a high level of interoperability, perform service composition and take in consideration the preferences of the users, the limitations of the user devices, making the usage of different types of devices seamless for the end-user.
Daniela Bordencea et al (2011), designed a system that consist of embedding ultralow power, Wi-Fi transmission capabilities in a very small package. This system ran on batteries having a characteristic lifetime of a couple of years and offered a platform for sensor measurements. The monitoring system can use any existing infrastructure, with significant decrease of implementation costs.

2.2.2.1 Data retrieval using agents

Arun Kumar Yadav and Ajay Agarwal (2010), have discussed the various concurrency control algorithms for detecting and resolving the conflicts. The algorithms - Distributed 2PL, Wound-Wait, Basic Timestamp orders and a Distributed optimistic algorithm has been studied using a detailed model of a Distributed DBMS.

Sergio Ilarri et al (2006), presented a system that supports distributed processing of continuous location-dependent queries in mobile environments without overloading the user's wireless devices. The proposed system also supports continuous queries, moving queries and location-aware queries. A sample location-dependent query is shown in Figure 2.1. The query asks for police units that are within 0.56 miles around car38 (a stolen car) and the police cars within 0.42 miles around policeCar5.

```
SELECT policeUnit.id, policeCar.id
FROM policeUnit, policeCar
WHERE inside(0.56 miles, 'car38', policeUnit) AND inside(0.42 miles, 'policeCar5', policeCar)
    AND policeCar.id<> 'policeCar5'
```

Figure 2.1 Sample Location-Dependent Query
2.2.2.2 Autonomous agents

An autonomous agent is an intelligent agent operating on an owner’s behalf but without any interference of that ownership entity.

Ruth Aguilar-Ponce et al (2005), had studied about Autonomous Decentralized Systems (ADS) and utilized it to form a cluster of networked visual sensors. The ADS detects and tracks the objects. The Autonomous Observer Cells (AOC) send all the tracking information to the Autonomous Analysis Cell (AAC) which further analyzes the object. Based on the analysis the AAC decides what action to pursue further. The architecture diagram is shown in Figure 2.2.

![AOC-AAC Architecture](image)

**Figure 2.2 AOC-AAC Architecture**

However, this work has decentralized only the information gathering task. The main course of action to be taken should still be decided by the AAC. This reduces the level of decentralization. The work does not consider the collision avoidance of the objects. Proposed work decentralizes the work by splitting the environment into domains. Each domain has an MA and a CA taking care of the collision avoidance.
Markus Dietl et al (2001), presented methods for tracking objects from noisy and unreliable data. The multiple agents gather data about their environment and exchange them with a module for multi-agent sensor fusion. In this work, the information gets modified by the agent’s view of the world. Proposed work does not modify the data and uses the original data to predict and prevent the collisions in a domain.

2.2.3 Tree Based Tracking

The increase in computer applications has automatically led to the increase in database application and multidimensional database itself. When the database becomes large, search becomes a tedious work. The querying comes into existence at that point of time and it the different types of indexing and querying were given by Volker Gaede (1998)

In large databases, feature spaces are usually indexed by means of Multidimensional Access Methods (MAMs) in order to speed up the search process and minimize related costs, in which similarity queries naturally become neighborhood queries in the feature space. Feature based similarity search has a long development process which is still in progress. Its application range includes multimedia databases (Seidl and Kriegel 1997), time-series databases (Chakrabarti 2002). Indexing techniques help to improve the efficiency of queries to processing data. It is a very important aspect of relational databases, as well as in the extended query syntax and data from spatial databases.

Trajectory of moving object occupies an important place in indexing them in spatial networks, two trajectory index structures were proposed, i.e FNR-tree (Frentizos 2003) and MONtree (Almedia 2004). Both are similar with minor modifications, they used two-layered R tree to store moving object’s segments in addition to the spatial networks as it is fixed for
moving objects. This is because the time element of moving objects is subject to change.

Jae-Woo Chang et al (2010), extended MON tree and FNR tree, proposed a trajectory index structure named TMN tree to support spatio-temporal range query and the similar trajectory query for moving objects in spatial networks. The TMN tree is constructed by separating the spatial domain of the moving object’s trajectories from its temporal domain. To deal with the spatio-temporal query, the TMN-tree first maintains the spatial 2DR*-tree for indexing the spatial domain of moving objects and the temporal B+-tree for indexing their time domain. Separation of time and space domain is an additional complication to TMN tree. Proposed work overcomes this complication using a single graph to store the location and time domain of a moving object.

Q+Rtree (Yuni Xia and Sunil Prabhakar 2004) was based on the observation that i) most moving objects are in quasi-static state most of the time and ii) the moving patterns of objects are strongly related to the topography of the space. The Q+R tree is a hybrid tree structure which consists of both an R-tree and a Quadtree. The R tree indexes quasi-static objects. The Quadtree indexes fast moving objects. Using quad trees for indexing dynamic objects reduces frequent updates.

R k-d trajectory trie (Priyadasini et al 2011) proposed as a two layered structure with R k-d tree on the upper layer and trajectory trie on the lower layer. It also supports full, partial and recurrent pattern matching for queries. But the disadvantage being high memory consumption and querying cost as trajectory trie is maintained for each object in the R k-d tree. Enhanced work uses a common trajectory graph representing the trajectories of all objects. A wide range of graph specific queries are supported.
Dmitri V. Kalashnikov et al (2002), researched the performance of indexing approaches R-tree, R*-tree, grid tree and quad tree. R-tree and R*-tree index structures are designed to be disk based structures. R-tree is a pure data partitioning index structure. An optimal access is achieved by choosing the node size to be a multiple of disk space. R*-tree is a variant of R-tree where the definition of overlap of rectangles and splitting algorithm is different. Figure 2.3 shows example of R-tree (R*-tree).

![Figure 2.3 R-tree Example](image)

The grid index and the quad-tree are very closely related. They are both space partitioning indexing techniques and handle the overfull region by split operation. k-dtree is a pure space partitioning index structure. k-dtree has fan out independent of dimensionality and no overlap between subspaces.

Benetis et al (2002), came up with Time Parametrized R tree (TPR) for querying Reverse Nearest Neighbour (RNN) using velocity vectors. The main advantage was that it supports persistent and continuous queries. The major drawback was it prohibits movement outside route structure. The proposed method does not lay any rules based on the movement.
Lars Arge et al (2004), presented a pseudo-PR-tree that answers window queries efficiently. They also quote how PR tree is not a real R-tree, since it does not have all leaves on the same level. The PR-tree can be updated using any known update heuristic for R-trees, but then its performance cannot be guaranteed theoretically anymore and its practical performance might suffer as well. Alternatively, the dynamic version of the PR-tree using the logarithmic method, which has the same theoretical worst-case query performance can be used and can be updated efficiently. The performance degrades when heuristic update algorithms are applied.

Cho and Chung (2005), proposed Continuous Nearest Neighbour (CNN) queries and he proposed Dijkstra algorithm for NN queries. The main advantage was network distance independent. The main drawback showed that the densely distributed objects were not considered. To overcome this drawback even densely distributed objects are considered in current scenario and it is represented by its trajectory.

Jensen (2004), gave a new linearization technique exploiting the volatility of moving object location had been indexed. The advantage of this work was query region enlargement and it did not support continuous queries. The current work supports continuous queries and advanced pattern matching queries.

Papadias (2003), combined Euclidean and network information to track objects. The benefit of these approaches were the prune search space, preserved connectivity and location of objects. The weaknesses were overlapping R tree and no Time domain. The projected Rk-d method avoid overlapping and it contains the temporal domain.

Bhide et al (1993), presented the LRU buffer replacement policy for databases, query performance is mainly affected by the time required to
retrieve nodes touched by the query which do not reside in the buffer, as the CPU time required to retrieve and process buffer resident nodes is usually negligible. In Rk-d tree structure, the problem by treating the indexed subspaces as BRs in a DP-based data structure (which can overlap) is solved. A mapping the kd-tree based representation to an “array of BRs” representation is defined. This allows to directly apply the search, insertion and deletion algorithms used in DP-based data structures to the hybrid tree.

BDE (Binary Differential Evolution ) (Yan Dong et al 2009, Alp Emre Kanlikilicer 2007 ) algorithm selected the best feature subsets. The relativity of attributes is evaluated based on the idea of mutual information. The approach uses a population-based heuristics to evaluate the worth of features. This method was found very effective to improve the correct classification rate on some datasets, but was not comparatively efficient to extract the dataset from a relatively large database. This problem can be solved by a hybrid data structure which has a better time complexity and works faster than the other feature extraction models.

Clement et al (2002), published a method to retrieve n similar text document from multiple databases using rank and estimation methods. It had been shown that the effectiveness of the best-search algorithm was the same as that of evaluating the user query against all database representatives. The main downside was faced when the number of databases large, it was organized into a hierarchy and employed a best-search algorithm to search the hierarchy. The proposed Rk-d trajectory graph method overthrew this hierarchical timing by constructing a graph for which the search is easier and less time consuming.

A strategy to perform a window query is first to decompose the corresponding window W into square subwindows, then the window query becomes the integration of the smaller subqueries over smaller subwindows.
These subwindows are named maximal quadtree blocks. The subwindows are the blocks corresponding to the leaf nodes in the quadtree, which represent the window region within the image space (Katayama 1997). The limitation was that these types of quad-trees were not able to deal with overlapping regions. Rk-d trees on the other hand, uses bounding region based techniques that tend to have low fanout and a high degree of overlap between Bounding Regions (BRs) at higher dimensions.

Dongxiang Zhang et al (2009), had offered spatio-keyword mCK (Closest Keyword) query and indexed bR* Tree for query processing. The major advantage was low cost implementation and reduced mCK query response time. There was a drop in this method while dealt with a large number of keywords. The projected Rk-d graph handle both spatio and temporal domain and since it is a graph, it can handle any number of keywords.

The features of multimedia data are useful for discriminating between multimedia objects. The SOM R-tree eliminates the empty nodes that causes unnecessary disk access and degrade the retrieval performance in case of poorly structured trees the disk access time is increased, thus leading to a poor performance (Kun-seok Oh 2001). In r-kd tree structure, reduce the time-complexity by using minimum bounding rectangles is done which automatically ignores the empty nodes.

R k-d tree by Anandhkumar et al (2010), was a hybrid approach to multidimensional indexing and provides optimal search performance. The hybrid tree provides search based on arbitrary locations and regional functions. The indexed subspaces need not be mutually disjoint. The overlap is allowed only when trying to achieve overlap-free would cause downward cascading splits and hence a possible violation of utilization constraints. R k-d
tree can be extended to support better indexing of MOVObs trajectory with less time complexity and provision to manage dynamic movement of objects.

Saltenis (2000), had done efficient querying of current and anticipated future locations of moving points. The main advantage was Supports timeslice, window and moving queries. The main drawback was overlapping R* tree and the storage cost was high. The current work reduces the space complexity.

Smith et al (2011), presented classical decision tree building algorithms to handle data tuples with uncertain values using two approaches namely averaging and distribution based algorithms. The advantages showed that series of pruning techniques were useful for building decision trees with high accuracies when there were tremendous amounts of data tuples. The drawback included complicated entropy computations.

2.2.4 Quantum Based Tracking

Glenn Beach et al (2003), had an approach that uses a quantum search algorithm in Image Processing. They had used Quantum algorithms for searching a particular value in a n x n array of values. In an N x N array, if a n x n array is searched then the time complexity is $O(N^{2n^2})$. But Quantum search algorithm requires only $O(Nn^2)$ time complexity. They had proved that the time complexity of quantum algorithm is far less when compared to other conventional search algorithms.

Mitja Perus et al (2004), has a potential alternative implementation into a quantum-wave medium for a better image-recognition method. Quantum-net’s capacities of connectivity, parallelism, storage, associativity, speed and miniaturization are enormous. The Hopfield model with real-valued (thus not necessarily binary) activities of units/neurons, having linear (not
sigmoid or signum) activation function, can be transformed into a quantum-holographic procedure where the Hebbian memory storage is replaced by multiple self-interferences of quantum plane waves. This translation succeeded by the simplest variable exchange in the Hopfield’s real-valued variables with the complex-valued variables changing as sinusoids (waves). Thereby, all input-to-output transformations are preserved. Thus quantum-wave image recognition functions equivalently to Hopfield’s one.

Hichem Talbi et al (2007), proposed that Quantum computing is a new field in computer science which has induced intensive investigations and researches during the last decade. It takes its origins from the foundations of the quantum physics. The parallelism that the quantum computing provides reduces obviously the algorithmic complexity. Such an ability of parallel processing can be used to solve efficiently optimization problems. Since there are no powerful quantum machines till today, some ideas such as simulating quantum algorithms on conventional computers or combining them to existing methods have been suggested to get benefit from this new science. In this paper we are using a combination of evolutionary algorithms and quantum computing principles which has already proven its usefulness in solving many problems such as the knapsack problem, the traveling salesman problem, the N-queens problem and image registration.

2.2.5 Linear Programming Approach

Hao Jiang et al (2010), had come up with an approach that uses linear programming relaxation scheme for the class of multiple object tracking problems. This scheme models object tracking as a multi-path searching problem. It models track interaction, such as object spatial layout consistency and optimizes multiple object tracking simultaneously. It uses Network model for tracking multiple objects. They had proved that accuracy rate is 94% per frame.
2.3 COLLISION AVOIDANCE

When multiple objects are tracked, one of the major goals is to predict and prevent the collisions.

Wei You et al (2008), discussed a method for multiple-object tracking in smart environments where the objects may have the same features. The work combines facial features and the whole body histogram to uniquely identify and label an object. The system does not consider the collisions between the objects. Proposed work has a framework for collision avoidance based on clustered agents. Both inter-domain and intra-domain collisions have been taken care of.

Mei Han et al (2004), developed a multiple object tracking algorithm that seeks the optimal state sequence which maximizes the joint state-observation probability. It estimated the state sequence or “trajectory” instead of the current state. The algorithm is capable of tracking multiple objects whose number is unknown and varies during tracking. They use a Hidden Markov Model as the probabilistic model to maximize the joint probability between the state sequence and the observation sequence.

Zhengya Xu et al (2009), proposed a real time object tracking system based on multi-view cameras is proposed in this paper. In order to track a moving object, an active camera mounted on a pan/till platform controlled by static cameras is used in this system. A background modeling based moving object detection and analysis technique for the multi cameras based real time object tracking system have been proposed for obtaining the necessary signal for the control.

Ulrich (2003), proved that behavior of mobile robot is chaotic. This was quantitatively proved using the divergence property of the trajectories of
the robots. In proposed work, divergence and convergence property of the objects has been used to detect the objects contributing to the critical region. The critical region is the region where there is a high probability of collision. More the degree of convergence of various trajectories at an instant, more the probability of collision. The proposed work aims at avoiding collision better by considering grouping of the environment.

Herman (2002), used the Bayesian probability on a number of application-dependent and arbitrary choices for decision making. This approach has been mainly used for uncertainty reasoning. In proposed work, Bayes computation has been used to predict the possibility of migration based on the past details of the trajectories of the objects. Better the analysis of migration pattern better will be tuning of trajectories to avoid collision.

Imran Saleemi (2007), provided a probabilistic model of scene dynamics which can be used in video surveillance. The motion patterns of objects in the scene are modeled in the form of a multivariate nonparametric probability density function of spatiotemporal variables. Kernel Density Estimation is used to learn this model in a completely unsupervised fashion. Learning is accomplished by observing the trajectories of objects by a static camera over extended periods of time. Once the model is learned, a unified Markov Chain Monte Carlo (MCMC)-based framework is used for generating the most likely paths in the scene and deciding whether a given trajectory represents an anomaly to the observed motion patterns. But it cannot be implemented for a large number of objects because of the large set of paths an object can take. Proposed work use path based sampling to counter this problem.
2.3.1 Visual Angle

Kahlouche Souhila et al (2007), developed an algorithm for visual obstacle avoidance of autonomous mobile robot. They have used optical flow information extracted from the image sequence for this purpose. The time to collision is found using the optical flow information. The major limitation of this method is that it is sensitive to noise. The proposed work gives a new geometric method to calculate the TTC which is less sensitive to noise.

Steffen Gormer et al (2009), produced a system with Forward Collision Warning, Lane Departure Warning and Electronic Stability Control. They have also proposed a novel vehicle detection approach and a robust TTC calculation system. The main disadvantage in the TTC calculation procedure given in this work is that the knowledge of the actual distance of the leading car and relative speed of both vehicles is required. The proposed work does not require the actual distance or speed to be known. Instead it calculates the TTC using the rate of angle sub tense of an approaching object.

2.4 MANAGING DYNAMIC UPDATES

With the rapid advances in positioning systems- such as global positioning systems and mobile computing technologies, managing up-to-date information about the locations of massive moving objects has become a critical area of research. Kwon et al 2002, developed lazy updates performed in a bottom-up manner by adopting a secondary index on the R-tree.

More recently, Biveinis et al (2007), projected R*tree which exploits in-memory operation buffer in the form of another R-tree and supports bulk-insertion algorithms.
MoonBae Song et al (2009), presented an R-tree-based index structure (called Rsb-tree, R-tree with semi bulk loading) for efficiently managing frequent updates from massive moving objects. The concept of semi bulk loading is exploiting a small in-memory buffer to defer, buffer and group the incoming updates and bulk-insert these updates simultaneously. Proposed work extends the semibulk loading technique to R k-d trajectory graph for maximizing the update throughput of moving objects. Proposed flush algorithm was extended in order to improve update and query performance together.

Lee et al (2003), developed an in-memory summary structure to improve both updates and queries. In-memory buffer contains an object registry, histogram and destruction list. Object Registry (OR) is a set of object-tuples (objID; p; cid; tstamp;NhIt) hashed based on object-id, where p is location of object; cid is an identifier of a histogram cell, tstamp is a time stamp assigned by GlobalClock and NhIt is the number of updates performed within OR (called OR hit). The capacity of OR (ORSize) is defined as a fraction of the total number of moving objects, N. The histogram is two dimensional hash structure that divides the data space into cells (g*g). Each cell contains the value hist and object ID of OR entries whose location are completely enclosed by it. Destruction list contains information about obsolete entries to be deleted.

Jing Zhou et al (2007), discussed a distance-based location update scheme by finding an optimal distance threshold. To determine an optimal threshold adaptively, this work proposes two optimization algorithms, namely, conjectural algorithm and progressive algorithm. Conjectural algorithm guesses the current system condition based on which it directly determines the most probable optimal value whereas the progressive
algorithm starts with a certain threshold value and adjusts it gradually towards the optimal point.

2.4.1 Query Processing

An increasing number of applications require processing of moving Points of Interest (POI) based on the underlying network. They require snapshot queries rather than continuous monitoring. Spatial data processing is an active research field. K. Mouratidis et al 2005, focused processing POIs and aimed at continuously monitoring a set of moving nearest neighbors. But two main challenges when supporting POI mobility on a network are (a) efficiently managing object location updates and (b) provide fast network distance computations.

To address these issues Haojun Wang et al (2010), designed a novel system to process location based queries on moving objects. The goal is to bi-directionally map the two structures on-disk R*-tree and the in-memory grid index and retrieve a minimal set of data for processing the queries. It helps in pruning the search area. Based on the set of grid cells overlapping with a given edge, algorithms execute range as well as k nearest neighbor queries were presented. But in this approach continuous queries are not supported and incorporating dynamic network updates are critical. This is overcome by implementing snapshot based queries in dynamic environments and extending the functionality of R k-d trees to support continuous queries. Real time user needs are also satisfied through relevance feedback environment based on the user opinion and query results. The query processing will be continued with more relevant query conditions from the previous results feedback from the users, thus achieving better query performance.

Prabhakar et al (2002), had considered velocity as constraint and came up with query based indexing. The main advantage was that it handled
network queries and the updates efficiently. A constraint in objects behavior was the negative in this method. The proposed Rk-d method does not place any constraints for the object movement.

2.4.2 Spatial Database

In various fields there is a need to manage geometric, geographic, or spatial data, which means data related to space. A spatial database is a database that is optimized to store and query these data related to objects in space, including 2D and 3D points.

Austin Parker et al (2009), discussed the notion of “optimistic” selection, where there is an efficient indexing technique to execute optimistic selection queries over SPOT (Spatial Probabilistic Temporal database) databases. Furthermore, spatial details are argued to be indexed effectively with a cautious query selection using data structures like BSP tree and SPOT trees. But, it is seen that when addressing queries such as selection queries, by retrieving data from distributed databases, a challenge remains as there are no efficient joins or aggregate operations on the structures considered by them. Proposed work supports all the possible spatio-temporal queries with join operations and advanced type of trajectory pattern matching queries.

Kolahdouzan (2004), offered two technique addressing C-KNN (Continuous k- Nearest Neighbor) queries in SNDB (Spatial Network DataBase) namely intersection examination and upperbound algorithm. The main advantage is efficiently finding the location of objects. The disadvantage being a decrease in performance when POI (Point Of Interest) were densely distributed in networks. The proposed methods use spatial and temporal database and so even the densely distributed network can locate the objects.
The heterogeneous distributed database environment integrates a set of autonomous database systems to provide global database functions. Aidong Zhang et al (2001) proposed a new concurrency control criterion for the execution of flexible and local transactions, termed F-serializability, in the error-prone heterogeneous distributed database environments. They present a scheduling protocol that ensures F-serializability on global schedules. But it is recognized that the effects of retrial and alternatives for concurrency control must also be considered in order to generate unavoidable blocking on the execution of flexible transactions. This model poses a trade-off between flexibility of specifying global transactions and high concurrency on the execution of transactions which is overcome by the failure resilient flexible transaction model that ensures Global concurrency and serializability.

2.4 SUMMARY

- A summary of different trees are compared in Table 2.2 to 2.4.

Table 2.2 Classification of Trees Based on Space and Data Partitioning

<table>
<thead>
<tr>
<th>Tree Name</th>
<th>Advantage</th>
<th>Disadvantage</th>
<th>Solution</th>
<th>Time Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSP</td>
<td>Can be used in spaces with any number of dimensions</td>
<td>Needs a backtracking algorithm for successful alternate partitions.</td>
<td>Eliminating the recursive splitting of space into convex sets</td>
<td>O(n log n)</td>
</tr>
<tr>
<td>R Tree</td>
<td>1.Reduces search by the use of minimum bounding boxes</td>
<td>1.Requires high load time in inserting an object 2.Overlap of bounding</td>
<td>Insertion and deletion can be done by an efficient bottom up approach</td>
<td>O(log n)</td>
</tr>
<tr>
<td>k-d Tree</td>
<td>Efficient in static and dynamic fields</td>
<td>1.Leads to cascading splits 2.Fanout dependent on dimensionality</td>
<td>Advanced reconstruction methods such as lazy construction</td>
<td>O(n log n)</td>
</tr>
</tbody>
</table>
Table 2.3 Comparison of Index Structures

<table>
<thead>
<tr>
<th>Tree Name</th>
<th>Advantage</th>
<th>Disadvantage</th>
<th>Solution</th>
<th>Time Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>R k-d Tree</td>
<td>1. Fan out is independent of dimensionality 2. Fast intra node search.</td>
<td>1. Objects are static 2. Absence of time domain movement of object</td>
<td>1. Dealing with dynamic objects 2. Representing the movement of object</td>
<td>O(n log(logn))</td>
</tr>
<tr>
<td>TMN Tree</td>
<td>1. Storing temporal data and spatial data in separate structures 2. Preserving entire trajectory</td>
<td>1. Involves structures with complex index framework 2. Spatial domain of moving objects separated</td>
<td>1. Using a two layered Structure 2. Single hybrid index with space and time domain</td>
<td>O(n^2)</td>
</tr>
<tr>
<td>UTR Tree</td>
<td>1. Directed automatic route sections 2. Use of uncertain trajectory units</td>
<td>1. High updating cost for UT (uncertain trajectory) units 2. Network constrained</td>
<td>1. Use of UT units with minimum update cost 2. Introducing network adaptable trajectory</td>
<td>O(n^2 log^2 n)</td>
</tr>
<tr>
<td>MON Tree</td>
<td>Scalable even if more number of nodes are added</td>
<td>1. Only segments of trajectory are stored 2. Inefficient processing of temporal queries</td>
<td>1. Single index structure is used for both space and time 2. Supports spatio-temporal queries 3. Supports advanced pattern match queries</td>
<td>O(n^2 log^2 n)</td>
</tr>
<tr>
<td>Q’R Tree</td>
<td>Classification of moving objects into quasi static and fast moving objects</td>
<td>In many dynamic applications there are only small number of quasi static objects when compared to fast moving objects, which makes the tree construction inefficient</td>
<td>By simultaneously updating the index and evaluating the queries</td>
<td>O(log n)</td>
</tr>
</tbody>
</table>
### Table 2.4 Comparison of Different Existing Object Detection Approaches

<table>
<thead>
<tr>
<th>Author</th>
<th>Proposed Work</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Tie Liu (2010) | - Template matching  
- Color spatial method | - Multiscale contrast background | - Fails to detect multiple objects  
- Fails when objects in non-linear motion | - Automation of object detection through system learning |
| Scott McCloskey et al (2011) | - Kernel based method  
- Background mapping | - Detects Partial occlusion | - Fails in case of complete occlusion | - Bus topology approach  
Superposition estimation |
| Aniruddha Kembhavi et al (2011) | - Color probability maps  
- Partial Least Squares (PLS) | - Selection of small subset of feature data | - Performance degradation when illumination decreases | - Adaboost strong classification method |

- Summary of existing Kalman Filter (Table 2.5), Particle Filter (Table 2.6) are tabulated

### Table 2.5 Comparison of Different Existing Object Tracking Approaches using Kalman Filter

<table>
<thead>
<tr>
<th>Author</th>
<th>Proposed Work</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Jin Wang (2010) | - Combination of appearance and motion information | - Detection of objects even in presence of partial and full occlusions | - Unreliable and less efficient  
- Wrong correspondence when different objects have similar appearance | - Selection of motion parameters along with feature extraction |
| Mathieu St-Pierre et al (2004) | - EKF for position estimation for integrated navigation information system  
- UKF for state prediction and updation | - Improves the precision of estimation | - Calculations are complex  
- System becomes useless without Global Positioning System (GPS)  
- Computation time increases by 3% in comparison to EKF alone | - Grouping of particles reduces the processing time |
| E. Loutas et al (2002) | - Information theory based analysis for tracking | - Effective characterization of object appearance and re-appearance | - Static scene issue  
- Failed during non-linear motion | - AI technique for detection in dynamic scenes  
MLP with BPN approach |
Table 2.6 Comparison of Different Existing Object Tracking Approaches using Particle Filter

<table>
<thead>
<tr>
<th>Author</th>
<th>Proposed Work</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kataoka et al (2011)</td>
<td>Template matching, background subtraction for player tracking - Selection of likelihood edge and color features for ball tracking</td>
<td>Tracking effective inside the pitch area alone</td>
<td>Inadequate and inefficient when players moved under close proximity</td>
<td>Identity recognition of the particle groups for tracking when objects are under close proximity</td>
</tr>
<tr>
<td>Jiyan Pan et al (2008)</td>
<td>Color and motion integration mechanism - Blob based target association scheme</td>
<td>Tracking even under cluttered background - Partial and full occlusion handled</td>
<td>Failed in tracking overlapping objects with the same colored background</td>
<td>Feature set computation with Haar trainer and Adaboost classifier.</td>
</tr>
<tr>
<td>Kazuhiro Otsuka et al (2004)</td>
<td>Probabilistic framework of explicit multi-view occlusion analysis</td>
<td>Suppresses memory consumption - Robust in case of occlusions</td>
<td>Rendered the system very slow - Increased number of operations on each object</td>
<td>Reduction of computations by grouping particles</td>
</tr>
</tbody>
</table>

Qualitative Comparison

The Table 2.7 analyses the different filters in terms of the number of objects tracked, the motion of the object under which the object(s) was tracked, if training of system was done and the effectiveness of the filter in presence of occlusion.

Table 2.7 Qualitative Comparison of the Filters

<table>
<thead>
<tr>
<th>Filter Used</th>
<th>Number of Objects</th>
<th>Motion</th>
<th>Training</th>
<th>Occlusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalman Filter</td>
<td>S &amp; M</td>
<td>L</td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>Extended Kalman Filter</td>
<td>S &amp; M</td>
<td>NL</td>
<td>Y</td>
<td>P &amp; F</td>
</tr>
<tr>
<td>Unscented Kalman Filter</td>
<td>M</td>
<td>HNL</td>
<td>N</td>
<td>P &amp; F</td>
</tr>
<tr>
<td>Particle Filter</td>
<td>S &amp; M</td>
<td>L, NL, HNL</td>
<td>Y</td>
<td>P &amp; F</td>
</tr>
</tbody>
</table>