An Efficient and Optimized Technique for Obstacle Avoidance in Realistic Environment

A Dissertation

Submitted

By

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Under the guidance of

Ms.Himanshu,16833

(Asst.Professor)

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2. Topology analysis & management
3. Enhancement and analysis of routing protocols

Signature of Supervisor 16833 18/9/14

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*Supervisor should finally encircle one topic out of three proposed topics and put up for approval before Project Approval Committee (PAC)

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*One copy to be submitted to Supervisor.

Student is writing paper on this also which will be further published in IEEE Journal (upcoming)

CERTIFICATE

This is to certify that Hannan Syed Shah has completed M.tech dissertation titled "**An efficient and optimized technique for obstacle avoidance in realistic environment"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the dissertation has ever been submitted for any other degree or diploma. This dissertation is fit for the submission and the partial fulfillment of the conditions for the award of M.tech Computer Science & Engineering.

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ABSTRACT

This thesis deals with the various techniques that have been used for obstacle avoidance in the realistic environments. In this work, various mobility models have been studied, and an improved technique is provided to avoid the obstacles and chose the best path to the destination. The traits of humans including various inherent properties have been studied, games theory based approaches have been analyzed, and finally an improved technique has been proposed for better accuracy than the previous ones.

The technique is to be simulated in a MATLAB, to prove the efficiency of the method proposed. Various parameters correlating to the actual scenarios are to be considered, and simulated.

ACKNOWLEDGEMENT

Praise to the Almighty God who helped me by providing the strength for my work. I owe the completion of this work to a number of people including my friends who provided me unrelenting support. Their suggestions were always very valuable to me. I am especially thankful to my advisor Miss Himanshu Sharma, whose guidance motivated me to pursue the work in a very easy manner. She taught me the various principles and techniques of conducting the research in a very fine manner. I could not have got a better advisor than her.

I give my special thanks to my friends who gave me their suggestions for my research.

I am highly in debt to the support provided by my family, whose continuous prayers help me succeed in my work. I thank for their commitment and love for me all the years. I dedicate this thesis to them. I am thankful to my friends for inspiring me to do my thesis.

Finally, I thank all of them whose names are not listed here.

DECLARATION

I hereby declare that the dissertation proposal entitled "An efficient and optimized technique for obstacle avoidance in realistic environment" submitted for the M.Tech degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date: **Investigator**

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INTRODUCTION

1.1 Adhoc networks

Adhoc networks consist of nodes that can be automatically configured by them. Each node works as a router, and is characterized mainly by adaptability.

Wireless sensor network is a technology consisting of sensors that are autonomous and are adapted such that any physical or environmental change can be sensed by them, and this change can be communicated to a central system through a series of responses. Wireless sensors networks are a type of Adhoc network. They consist of different components as shown in the following figure:

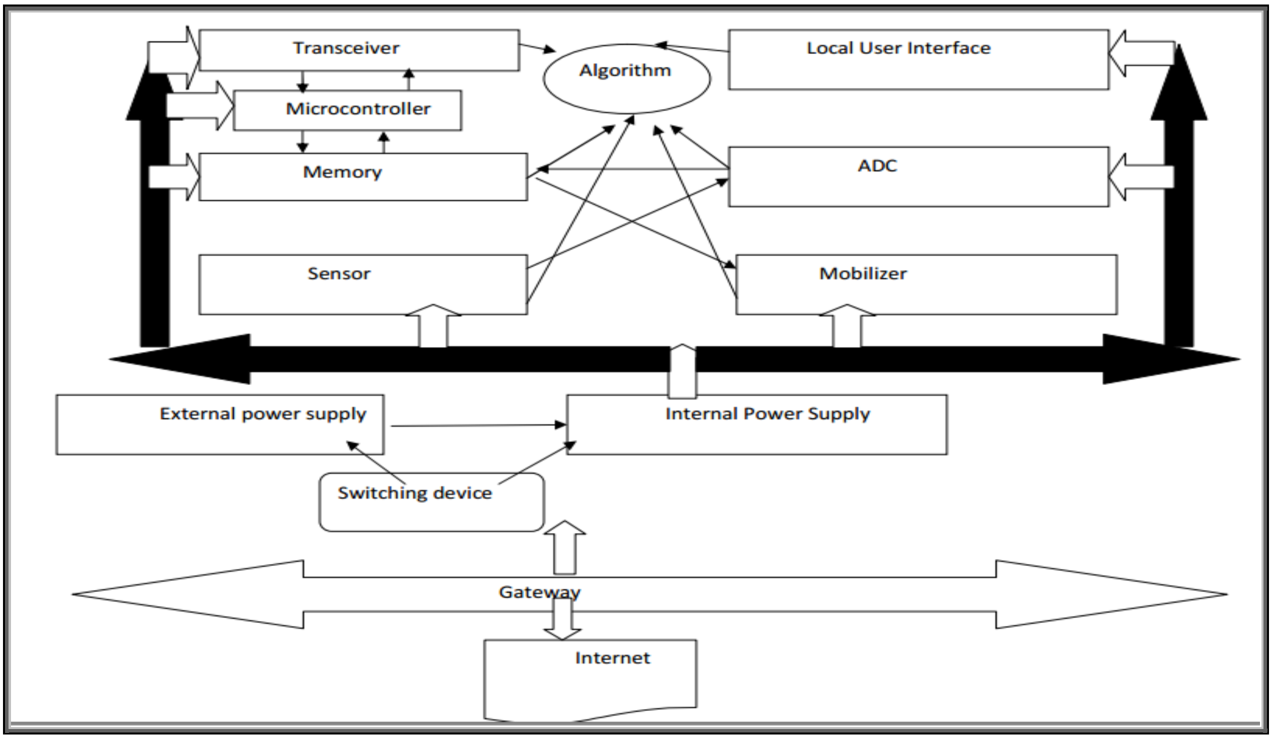


Figure 1.1

The components work in coordination with each other. WSNs are resource constrained a set of distributed systems with features such as low bandwidth, low energy requirement and short communication range. Some of the features of wireless sensor networks include self organizing capabilities, dense deployment. Many modern technologies are integrated in wireless sensor networks such as radio sensing, CPU, processing and communication. Though wireless sensor networks suffer from various limitations their application cannot be denied because of their diverse application in various fields.

1.2 Components of WSN

The components of wireless sensor networks are delineated as under:

1. Sensor: Sensor is a device, a transducer that senses the environment and converts various signals including vibratory, electromechanical such as sound, sensory waves, etc into electric signals. Sensors are generally very small in size especially for distributed sensing e.g. over a large area. A number of sensors are available. They can be thought to belong to different sensing modalities.

Sensing modalities refer to the various means by which different parameters such as that of motion can be measured.

Sensing Modalities:

Some sensing modalities are as under:

a. Motion sensors: These consist of binary-doppler shift sensors, passive infrared sensors etc.

b. Thermal imagers: These consist of different arrays such as polyvinylidene fluoride arrays , micro-bolometer arrays etc.

c. Vibration sensors: These consist of accelerometers, seismic sensors ,piezoelectric sensors, laser microphones etc

d. Binary sensors: These consist of breakbeams, ultrasoundmotion sensors etc.

e. Environmental recognition sensors: These consist of wearables cameras,microphones, wifi fingerprinting etc

f. Inertial sensors : These consist of gyroscopes , magnetometers etc

g. Chemosensors: These include sensors like humidity sensors, carbon dioxide sensors etc.

h. Cameras: These include CCD image sensors, edge detecting imagers etc.

i. Scanning range sensors: These consist of sonars, radars, ladars etc.

j. Pressure sensors: These consist of piezo- electricmaterials, piezo-resistors.

2. Mobilizer: A mobilizer is used to provide motion to the sensing nodes as and when necessary. Imagine a situation where a sensor needs to move so as to measure specific signals. In such cases high amount of energy is needed for the operation, and this is where mobilize is needed.

3. Power generator: Power generator is used when the wireless sensor network needs to be operated for longer durations. It is an important part of wireless sensor networks.

4. Algorithm: An efficient algorithm is essential for proper transmission of packets. Without proper algorithm, various issues can occur such as delayed acknowledgment, faulty delivery etc.

5. Power unit: A power unit consists of battery that supplies energy to various devices in wireless sensor networks. Battery lifetime is an important issue to consider. High backup batteries must be used in wireless sensor networks to prevent any unnecessary shutdown of the sensor network. Power is consumed both in computation and transmission. It is notable that the maximum power consumption is due to transmission. A variation in energy source other than that used by batteries is the use of solar energy, which acts as a driver for solar cells. The sensor nodes are generally designed to run on AA batteries . Other types of batteries can also be used. Monitoring power consumption of the sensor nodes is very important. There are various types of batteries either based on charging capability or the type of material used.

6. Gateway: Gateway serves as a pathway or an interface to the internet.

7. Processing unit: The function of this unit is the data acquisition, processing of the information received and sent, and finally adjusting the routing information which is dependent on the conditions of transmission. The processing unit includes memory, converters, timers, Universal Asynchronous receive and transmit interfaces.

8. Memory unit: The data connected during the sensing phase is saved in the memory. The use of the memory unit is to store two things: one is the program code, and other the data. In order to achieve this ROM is used for storing the data while memories like flash, EEPROM(Electrically Erasable Programmable Read Only Memory) can be used to store the program code.

9. Communication unit: The communication unit consists of sensor nodes which participate in the transmission of the information. The transmission is achieved by using the electromagnetic spectrum. The information may be either transferred directly to the sink, or it can be transmitted to the neighboring nodes, or any other specific routing algorithm may be utilized for this purpose.

10. Base Station: The base station is also referred to as the sink. A sink may be defined as a node that has no or practically very less constraints on the power supply and on its computational capabilities. A sink can be static or dynamic, but mobility introduces various problems due to problems imposed by the routing protocols. Also, there may be multiple base stations, and they provide various advantages such as decreased delay in the network.

Communication unit can be interfaced to the external network via base-station. This is depicted in the figure 1.1a.

1.3 Delay tolerant networks:

There exist a large number of networks where direct end to end communication does not take place. Instead, there exist a large number of intermediate nodes that utilize a store and forward approach. One of the requirements of a delay tolerant network is to use hardware that can store large amounts of data. They are also called opportunistic networks. The protocol requirement for delay tolerant networks is the less use of transactions between the source and the destination.

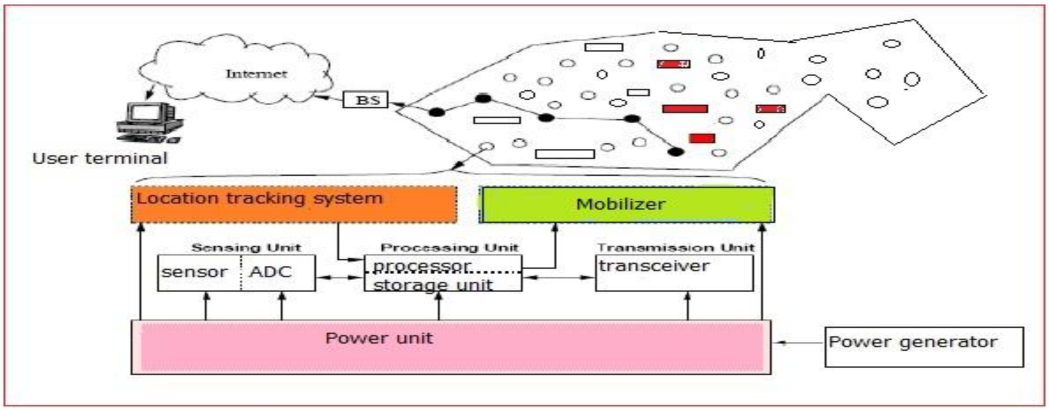


Figure 1.3

1.4 Operation of Wireless Sensor Networks

Sensor nodes are wireless connected. They transmit information at different intervals of time to some particular nodes. The function of these nodes is to perform various computations on the data collected using a process called data fusion. After this process, several critical decisions are done based on the transmission.

1.4.1 Communication Patterns

The communication between the nodes is any or combination of the following:

a. Node to base-station:

In this type of communication, a number of nodes can communicate to the base-station either directly or indirectly. This type of communication is a reverse-multipath communication. There can be multiple base stations. Alternatively, there can be a cluster head which can transmit the information to the base-station.

b. Base station to node:

In this type of communication, the base-station requests the data from the nodes. On receiving the request, the sensor nodes possessing the required data can transmit it to the given base-station. Further, the nodes may be identified by their locations, unique identification numbers etc.

c. Node to node

In this type of communication, data is passes through multiple hops i.e through multiple nodes until it finally reaches to the destination.

1.5 Characteristic features of Wireless Sensor Networks

1. High deployment density

A sensor network consists typically of hundreds of thousands of sensor nodes. These nodes are arranged either in a predetermined fashion, or they are simply distributed over a geographical area.

2. Low resource availability

A WSN is constrained in-terms of power because of the high usage by an enormous number of sensor nodes. Power efficiency is therefore an important consideration in WSNs. Also, memory and processing capabilities are also less.

3. Type of environment

WSNs are deployed generally in a static environment. Due to recent advancements, mobility has been introduced. The mobility may be provided to sensors, sinks, actuators, and even to the applications which consist of code.

4. Recovery mechanism

Sensor nodes are deployment in different environments which may range from drastic to hostile. The nodes may be subjected to intrusion, or they may suffer failure from the environmental conditions. So, there arises a need for self adaptation of the nodes to the failures. This would avoid the network partition, and thus would prevent the failure of entire communication in WSNs.

1.6 Types of signaling approaches

Signaling approaches may be classified into the following types: Active signaling and passive signaling.

1. Active signaling approaches are those approaches that use their self formatted specific signals for transmission and in return of the responses they receive from the environment measure their properties.

2. Passive signaling approaches are those approaches which directly measure the properties of the signals received from the environment.

1.7 Types of sensors

Various classification parameters are used to describe the sensors, such as on the basis of the property sensed, such as by measurement of vibration, or measurement of intensity of radiations etc.

Sensors can also stimulation the environment, or they can receive some stimulation from the environment. On the basis of this, sensors are classified into the two categories:

A, Active sensors: These sensors stimulate the environment so as to have information of the changes in the environment. Examples include: infrared sensors, seismic sensors etc.

B, Passive sensors: These sensors don't stimulate the environment in-order to monitor the environment. Examples include: humidity measurement sensors, light sensors etc.

1.8 Wireless Sensor Network Applications

Applications of wireless sensor networks:

Sensors find applications in various areas. In health sector sensors allow to monitor the health of the patients especially in critical conditions. In agriculture, sensors help to know about the quality of soil and the moisture level. Sensor is used for gathering weather and environmental information. One of the very important and interesting systems in which wireless sensor networks are employed is employed is structural data acquisition system. This type of system involves the structural response analysis to the following types of excitations:

1. **Ambient vibration excitation**

2. **Forced vibration excitation**

1. **Ambient vibration excitation**: Ambient excitation for a specific structure such as a building or a bridge is defined as the excitation of it under its default operating conditions. By default operating conditions, normal mode of operation of a particular structure is implied. Ambient excitation tests are gaining a lot of popularity in civil engineering.

2. **Forced vibration excitation:** Forced vibration excitation is carried out using an electromagnetic shaker unit. It is a portable device. This excitation involves various excitations such as 'sinusoidal' excitation. Analyzing motion is a subject of great interest. Dynamic traits are solely dependent on the human activity. Wide range of motion is exhibited by a human, animal or any other physical moving object.

Dynamic movement of humans:

While building various systems for dynamic trait detection, it is important for the system to possess at least the following properties:

1. Compactness and simplicity.
2. Use of efficient and optimum priced components so that it is widely available for use.
3. Use of energy efficient and feasible algorithm,
4. System developed should address the current problems as well as aim at solving the possible future problems.

Motion of a moving object may be specialized i.e. involving a large number of complex arbitrary paths or a simple one .A simple motion may be shown by using a right handed orthogonal coordinate system. A more complex motion would require the use of polar coordinates. It is worthy to realize that for a very small distance of several meters the motion is apparently straight. Thereafter, the motion tends to be curvilinear.

1.9 Latency & Delay Tolerant networks

Latency is defined as the time take by the packet to travel from one location to another location in a network under consideration. A number of factors exist that contribute to the latency. They are:

Transmission medium & packet size:

The transmission medium (air) introduces a little amount of delay in the packet. Also, the size of the packet is a contributor to the delay. It is evident that a small packet would require short duration to reach destination point while bigger packets

Processing in nodes:

The nodes especially gateway nodes process the header information especially time to live (TTL) field and this takes considerable time, and thereby introduces delay.

Chapter 2

REVIEW OF LITERATURE

Spatio-temporal properties are the key properties when we deal with the particular object whether at motion or in rest Some spatio-temporal properties are identity, location, count, presence , track. An important relationship exists among these properties. Such as any information about knowledge indicates or provides an idea about count. For examples any non-zero , non-negative value of count can provide the information about the presence of an entity, practically it can give us an idea about the exact number of entities in an area under consideration. Besides, spatio-temporal properties, an entity are expected to have various behavioral properties such as pose, action, behavior etc. Human sensing is an important part of monitoring the activity. Human sensing has been defined as a well defined process governed by certain measurement techniques which provide information about the people in some environment. [1]

Mobility models pave a way for measuring these properties. There are a number of metrics used to characterize the mobility models. These metrics are listed under:

1. Movement time of node:

The average time a node is not at rest is called the movement time of the node.

2. Move-stop ratio:

It is expressed as the numerical ratio of the total movement time to the total time the node is at rest.

3. Speed:

It refers to the instantaneous speed of a node.

4. Relative speed: It is defined for a group of particular nodes, and is the relative speed of the first node to the second node.

5. Mobility factor:

The average change in distance between a node and its neighboring nodes is expressed in terms of the mobility factor.

6. Degree of spatial dependence:

It is defined for the nodes that are near to each other. It is defined as the limit upto which the two nodes have similarity in velocity.

7. Density of node:

The density of nodes is defined in terms of the number of neighbors per node.

8. Pause time of node:

It is defined as the mean time for which the node is at rest for entire simulation scenario.

9. Measurement of displacement:

It is defined as the difference between the true distance traveled by the node and its displacement.

It is very important to consider the factors affecting the sensing before employing specific sensors in any environment. There are various challenges for object detection and various other sensing tasks. They include active deception, sensing noise, similarity between actual signal and background signal, unpredictability etc. It has been shown if there are statistical fluctuations in the particle arrival rates, the sensors are susceptible to various noises. The presence of unwanted signals in the environment can lead to fooling of the sensors. Obstacle detection and avoidance are issue of interest. In-order to achieve considerable results various models have been proposed. Reynold in [2] (1987) proposed steer- to – avoid model. The model relies on an algorithm that detects the obstacle only in front of it. Then, it works by finding out the silhouette edge of the obstacle encountered in the path. A cooperative obstacle avoidance model in [3] (2009) has been introduced which uses the traditional flocking control model coupled with enhanced SA algorithm. This approach though good enough to detect obstacles is very complex, and detection time is high. A virtual circuit composed of various paths is shown in [4] (2009) that is used to determine and construct the obstacle free path. An obstacle hull is constructed which is modeled in terms of damaged sensors/non-working sensors. The obstacle hull is the set of these sensors. Two cases have been presented in this; one is when the number of non-working sensors is quite large. In this case, certain algorithms based on divide and conquer approach such as graham scan algorithm can be used. Another, approach for the construction of the obstacle hull is the incremental approach. This approach uses a step by step approach for determining the non-functional sensors. While these approaches use obstacle as dysfunctional or damaged sensor, realistic obstacle avoidance models incorporating hilly environments posing threat to human life are presented very less in the literature survey. Use of non-imaging sensors as in [5] (2011) offers an innovative approach for detecting a safe path for detection of people and animals. An approach purely based on the principles of physics has been used employing acoustic as well as seismic sensors. It is emphasized that the detection of the target should be done on the basis of classification of targets. This in turn helps enables to determine whether the properties of the sensor are sufficient to classify and detect the target under consideration. The sensors have been used for determining the various signatures of humans and other entities. Face routing algorithm in [6] (2008) a variant of geographic routing algorithm has been shown which is a promising approach to reach the destination. The core concept of face routing algorithm is the graph who's none of the two edges intersect with each other. It employs right hand rule. One of the holistic approaches to obstacle avoidance is that shown in [7] (2011) which employ a game theory based protocol for avoiding the obstacles. The approach solves the problem of rapid energy consumption at the end of the obstacles. The success rate of the transmission is increased. This technique considers the in-degrees and the out-degrees of some nodes. Moreover, the location information of the nodes is communicated to some hops in the network. Further, in [8] a cost based approach has been shown which is based on forwarding packets to the neighbor with lower cost than the sending node. This approach suffers from drawbacks such as it does not chose the best/optimal paths. There also exist hybrid techniques that use a suitable combination of the algorithms to achieve successful delivery of the packets. However, the complexity of the algorithm is high.

Mobility models have been developed to analyze the motion of various entities including humans, vehicles etc. Such models can be classified according to certain conditions: random based, time based models, neighbor influential models, location dependent models or a combination of any of the models (hybrid models).Random models don't rely on any specific condition, and there are no particular restrictions on the node movement. Neighbor influential models or spatial models are influenced by the movement of the nodes surrounding a target node. Location dependent models are restricted to a particular area [9].Mobility models provide an approach to analyze the motion paths of moving entities. A number of mobility models such as mobility model based on linearity, mobility model based on mass, or random way-point model. The mobility model based on mass assumes that an entity has some mass, and accordingly some quantity of motion is possessed by an object [10]. Further, in [11] the affect of clustering based approaches on various mobility models is simulated and discussed. Protocols based on movement and also those not dealing with any sort of position location are presented. It has been concluded that the overall performance of the considered network is improved. Model representing social behavior is presented in [12] presents the life of people in social environment like that of the university campus. This model closely relates with the realistic environment. In [13] a hotspot based approach has been provided in existing mobility models and the inter-contact times of existing mobility models have been studied. Every possible way has been accessed to correlate the model with the usual physical traits of the humans. Mobility models thus have been studied in great detail for the purpose of understanding the human behavior. Various books on mobility models describe the requirements for the mobility model. Mobility patterns are provided by certain elements such as syntactic elements and trace elements. These elements need to be explicitly defined in a mobility model. Various protocols like DSDV etc have been studied for depicting how much they are affected by mobility of various nodes in the network [14]. An alternative using the graph algorithm whose underlying approach is visibility is presented. Main focus had been laid on emergency situations. It is later on concluded in this model that obstacle avoidance mobility models have a wide impact on the underlying protocols. In [15] (2010) various harmonic functions have been used to simulate methods of detecting the obstacles in an aerial environment. A model has been developed to prevent the collisions. Moreover, the positioning is based on the line of sight communication.

In realistic environment, robots or humans equipped with the sensors may follow various patterns for their movements. So, a modeling is necessary to correlate the movements in the realistic scenarios with that of the simulation environment [16] (2013) in simulations, mobility model plays a pivotal role since it gives us information about the movement pattern exhibited by the nodes. A number of simulation environments have been developed and they are becoming advanced so as to encompass a wider range of scenarios. The obstacle avoidance mobility model presented by Jardosh is fascinating by introducing the obstacles in the simulation area, and thereby avoiding the obstacles using appropriate methods [17] (2014).

Some of the mobility models have been presented in this section:

1. Random Walk:

It deals with the random patterns exhibited in the nature. A given nodes speed and direction is fixed. A distribution of speeds is made which consists of minimum speed V_{min} and maximum speed V_{max}. The chosen angle i.e. the direction is between 0 and 2pi radians, [0-2π].

Disadvantages: This mobility model gives unrealistic movements with sharp turns in contrast to what happens in the real world.

2. Random Waypoint:

In this model, the given node also moves with a definite speed and angle. The node stops for a moment i.e. for a certain period of time. On the expiry of the timer, it chooses its direction and speed [V_{min} , V_{max}] from a given distribution. This model is basically a variant of random Walk model. The movement of the nodes is divided into two epochs.

1. The epoch of movement

2. The epoch of pause

Disadvantages: It is also an unrealistic model .Another disadvantage of this model is that the protocol performance is highly affected by the mobiles nodes especially those having their presence in the centre of the simulation area.

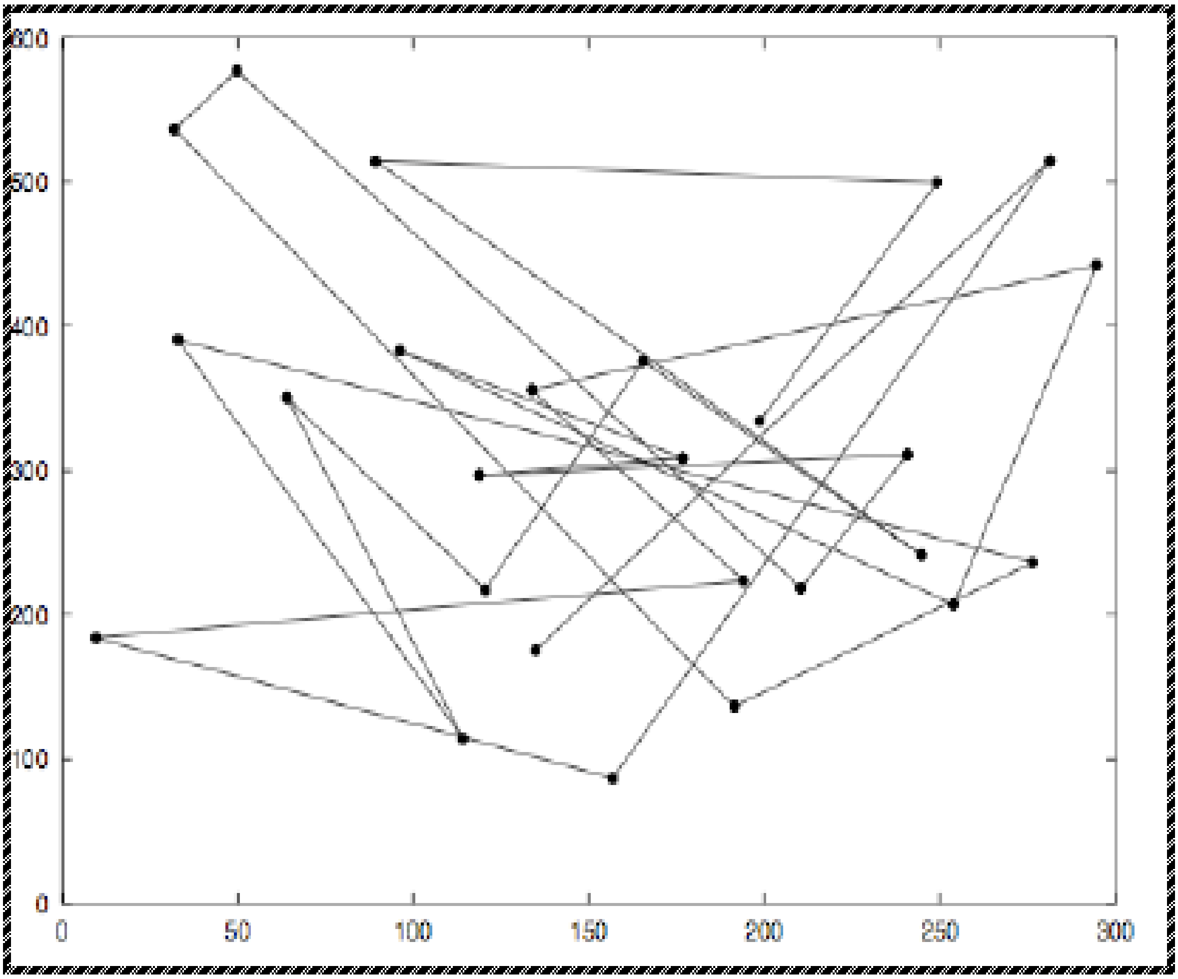


Figure 2.1- Path followed by a node in Random Waypoint Model

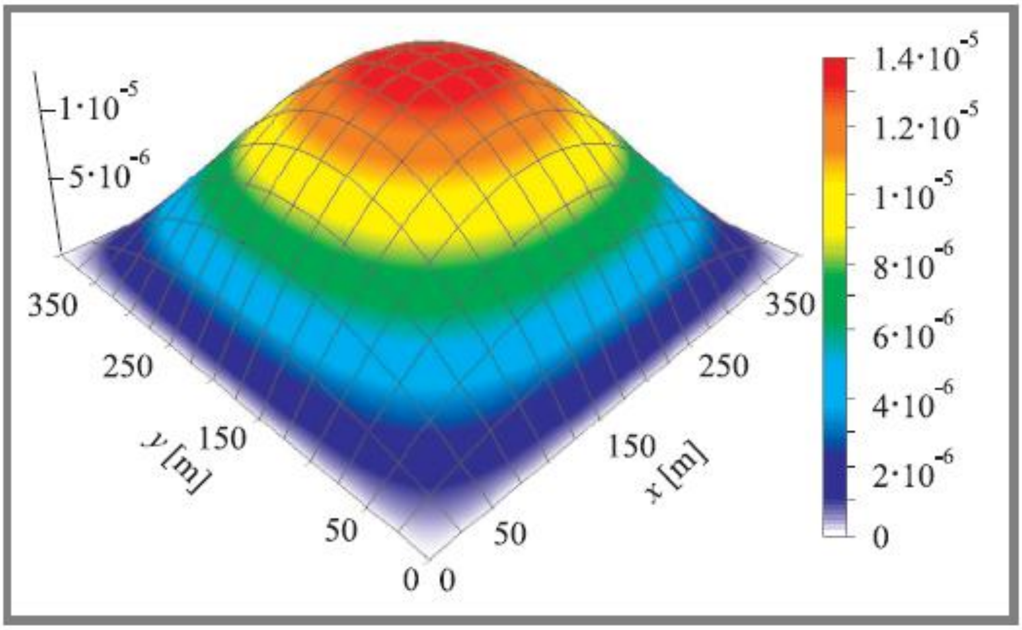


Figure 2.2 - Density in Random Waypoint Model

3. TwoRay Ground propagation Model:

It is simply a signal propagation model that considers ground path in addition to the direct line of sight path (LOS) path. This model provides various advantages over the free- space model especially over long distances. There are two basic formulae for this model, one conforms to free space model, and another is listed here. This one is used for the long distances.

$$P_r(d) = \frac{P_t G_t G_r {h_t}^2 {h_r}^2}{d^4 L}$$

4. Gauss- Markov Model:

The model was designed for personal communication networks. The updation of the node movements is one of the principal characteristics of the model. The movement is changed at fixed intervals. There exists a dependency between the movements of the nodes at different updates. The dependency can be shown as follows:

Movement (node at n^{th} update) → Movement (node at n-1^{th}update), where → symbolizes is dependent on.

5. Obstacle Avoidance Model:

A realistic model though through simulation yet useful is obstacle avoidance mobility model. In [18] obstacle avoidance modeling is presented in a beautiful way. The model is named as mission critical model. The model considers physical objects such as rectangles etc, which are a simulation equivalent of buildings. A target point is set for a particular node, and a node moves in the simulation area from the start point to this point while avoiding the obstacles. A recursive mechanism is used for this.

In addition to the mobility models described above some other models like free-way, Manhattan grid model have also been proposed in the literature. An interesting concept to model obstacle avoidance is the use of Voronio approach using Complex geometric algorithms.

6. Voronio approach:

In Voronio approach, the physical objects are first considered, and then the edges of the physical objects say a building is the required inputs to construct a Voronio diagram. It is mathematical concept. It involves dividing a given region of space into number of regions. It involves prior definition of generators or seeds. It is also called Voronio partition or Voronio decomposition. Voronio diagram had been applied in geophysics and meterology.Taking the networks into consideration, Voronio diagram is used to find the capacity of wireless links. The Voronio diagram is shown as under to provide an overview of the division of space. Each Voronio cell is the intersection of n-1 half-planes, considering n sites. Voronio diagrams are hence very useful.

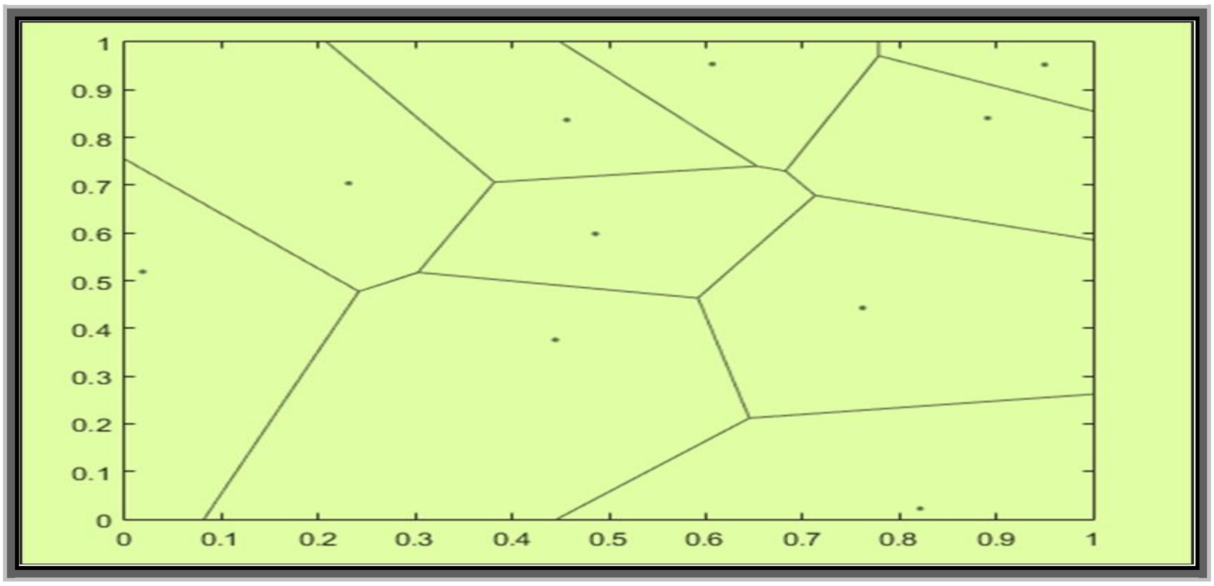


Figure 2.3- Divisions of area into sub-regions

A vertex is an intersection of 3 more segments, each equidistant from a pair of sites.

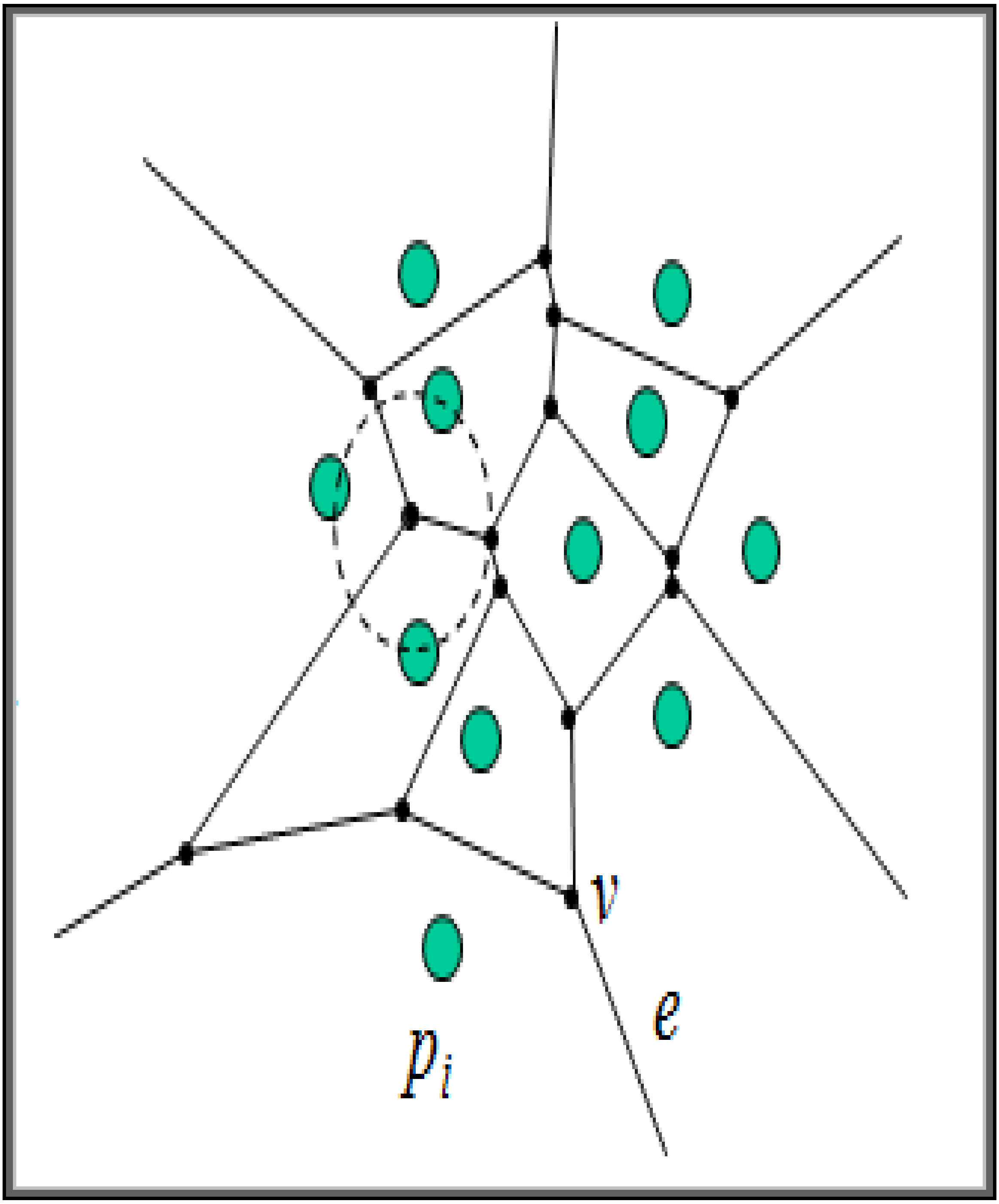


Figure 2.4 Voronoi diagram

Here, e is the voronoi edge, v is the voronoi vertex, and p_i is the site point.

Chapter 3

PRESENT WORK

3.1 Problem formulation:

"An efficient and optimized technique for obstacle avoidance in realistic environment". The scope of this work is not only limited to monitoring the ways for human passing but also to the vehicles that employ smart techniques to make a choice regarding their paths while detecting the obstacles in their way. By monitoring the nodes, the user movement is monitored as if it were in realistic scenarios as close as possible.

Applications:

1. Environments in which safety of the persons is endangered due to the various obstacles in the form of landslides.

2. Automated vehicles that are evolving.

Constraints:

As with every simulation, every real world problem poses different problems which are sometimes difficult to cope up. So, any such change or improvement shall be incorporated in this work.

3.2 Objectives of the problem

An effective technique is presented that can be useful for determining the safe and optimized path for reaching the destination; the path being full of various hurdles. This thesis aims at modeling the real life scenarios with movement of nodes in a multipath environment. The movement realistically determines the movement of the people especially military men passing through complex, slide prone terrains.

The objectives are delineated under:

1. To design an efficient technique for well parameterized and controlled movement.

2. To correlate the model with certain realistic scenarios such as obstacle avoidance and detection.

3. To study and delineate the affect of various parameters, and to determine the adaptability of the model to various environments. Various environmental conditions are studied which can affect the technique so as to avoid any false alarms.

4. To provide a platform for more realistic techniques.

5. To delineate the conclusions of the research after retrieving and studying the outcomes.

3.3 Research Methodology

The research methodology employed consists of two approaches namely qualitative and quantitative: a hybrid approach.

3.4 Approaches to research

Qualitative research approach is used for the purpose of exploring. In this research, following procedure is adopted for qualitative research methodology:

Literature review

1. Study the principles of WSNs including MANETS:

In this step, WSNs, MANETS were comprehensively studied, and various routing techniques were studied. The applications of WSNs were also studied. Moreover, the performance metrics for different techniques were also studied.

2. Review the existing techniques for analyzing the motion

3. Review the existing approaches for obstacle avoidance and detection.

4. Find out the problems in the existing approaches.

5. Selection of the performance metrics.

7. Design the technique/methodology.

Quantitative research approach

A study needed for the validation of the findings from the literature has been done in this part.

The following procedure is applied for this approach:

1. Tools selection: An appropriate tool for simulation purposes such as MATLAB, the one simulator etc shall be selected for validation of the results, designing the network for simulation: The network shall be designed for simulation purposes involving different entities.

2. Result of simulation and analysis: A number of simulations shall be run for different scenarios and the result shall be evaluated

The following figure shows the research methodology

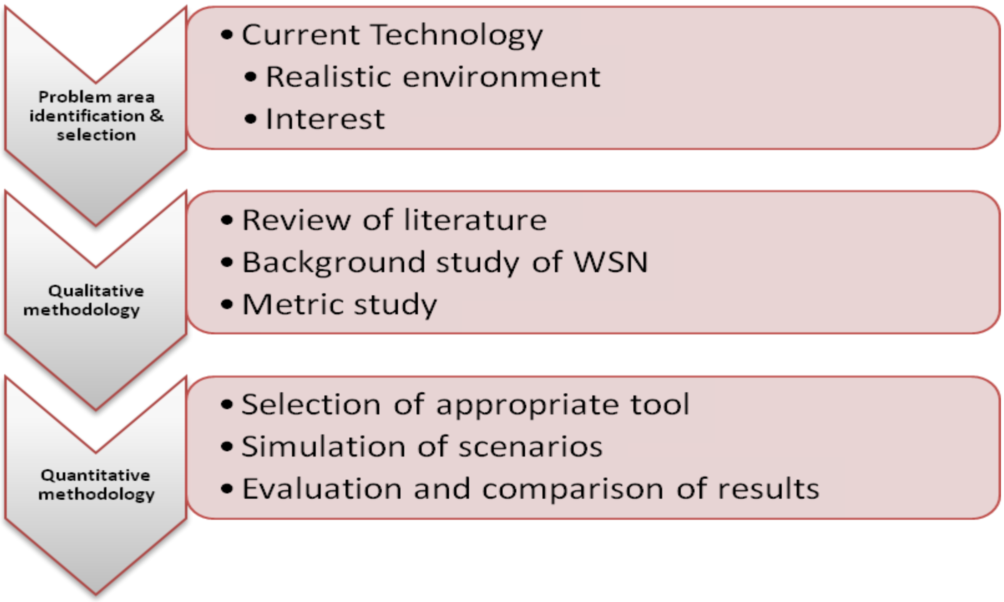


Figure 3.4 Approaches to Research

3.5 Implementation scenario

Obstacles are found in everywhere on streets. Their size ranges from small to big. Real life scenarios are shown under:

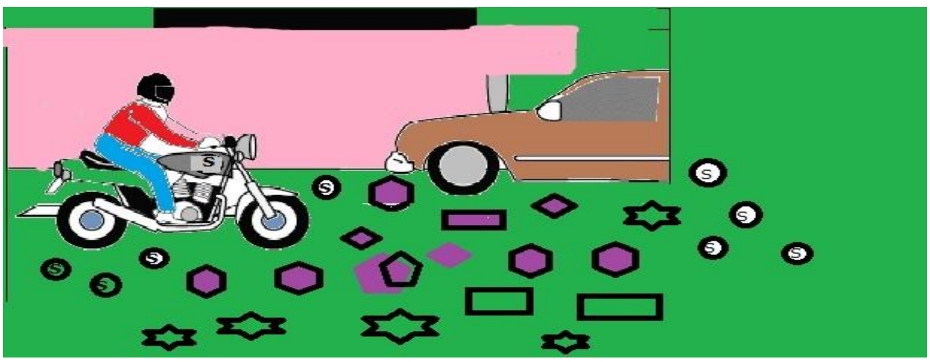


Figure 3.5a Implementation Scenario

The obstacles in real life situations are of different shapes and sizes. For the purpose of simulation, some geometrical figures which resemble closely with real obstacles are assumed.

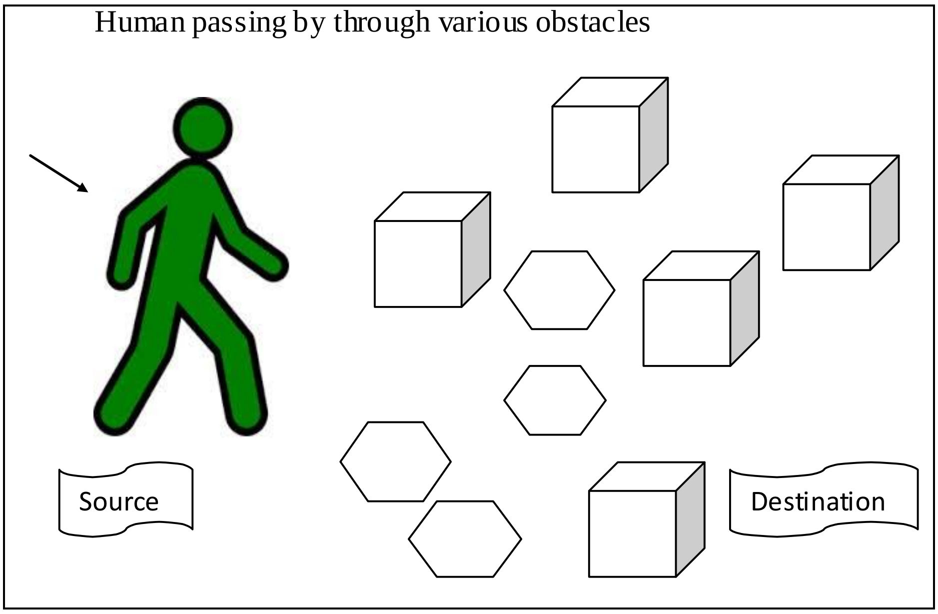


Figure 3.5b Passage through obstacles

3.6 Proposed Implementation Strategy

Assumptions: The obstacles are assumed to be of fixed geometrical shapes for simulation purposes. Shapes include rectangles, and polygons etc.

Taking into consideration of the requirement of a novel and highly robust algorithm fr obstacle avoidance in wireless communication networks, such as wireless sensor network and wireless mobile network here in this thesis a novel algorithm for obstacle avoidance has been developed. This chapter predominantly discusses the algorithm developed and its optimal implementation for obstacle avoidance. The overall algorithm has been developed for two scenarios. Initially the algorithm has been developed for wireless sensor network where the nodes have been placed as static and in the second approach the mobile nodes have been introduced for the simulation needs and the respective obstacle avoidance has been incorporated. This chapter discusses the varied aspects of developed algorithms and its implementation towards obstacle avoidance in communication network.

The following section represents the algorithm development for obstacle avoidance in wireless communication network. Before representing the overall system implementation and its realization, in the following section, the key components of the obstacle avoidance and its significance have been discussed. This section also discusses the fundamental concept of the proposed algorithm and associated parameters, variable and functions.

System Formulation and Parameter definition

In the developed approach of obstacle avoidance in WSN and mobile network, certain specific characteristics of mobility has been considered. Similar to the mobile movement in the Adhoc communication protocol, the dynamic location and node statics has been updated in the node table after each 1/32 seconds. The node statistics has been updated for its relative position and the information update at the frequency of thirty two Hertz facilitates optimal analysis for effective dedition process in trajectory decision. In this thesis and the proposed algorithm, the mobile node possess the information about its position, source node location, destination node information and its location and the information of other neighboring nodes or obstacles. In order to simplify the overall process and implementation, in the proposed simulation framework the destination node has been fixed while introducing the mobility in the source nodes. This is also the fact that in the initial phase of implementation, the source, destination nodes have been fixed for WSN simulation. In the developed simulation framework, the mobile node would be behaving as a point in space where all the comprising objects would possess a diameter of 1 meter. Here for effective algorithmic implementation, the physical dimension of the mobile node has been considered in form of point due to easy implementation and the size of obstacle has been increased while realizing the genera environmental or network conditions. On the other hand, the circular obstacles have been considered for estimation the obstacle avoidance. In case of WSN simulation, varied multiple obstacles at its complex localization has been considered so as to exhibit the robust efficiency of the proposed system in indoor application scenario or even urban network conditions. To simulate the system, the mobility speed has been defined at 4m/s and the respective acceleration is fixed at $5\ m/s^2$.

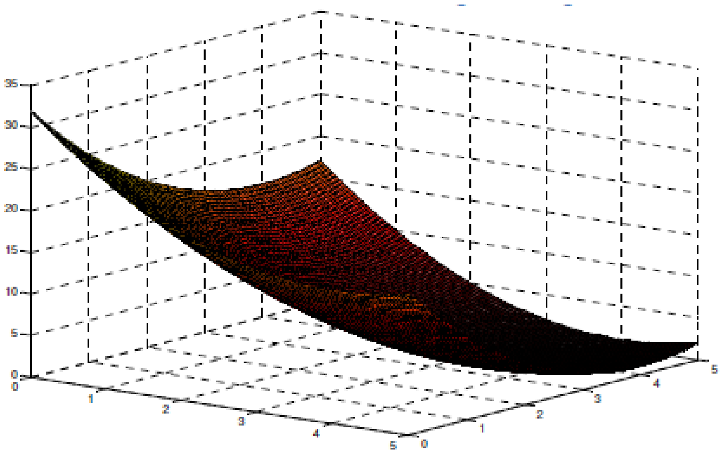
The descriptions of the proposed algorithms and its sub components or functions are given as follows:

Destination of Target Node Function

In the developed simulation model, the nodes or the mobile node possesses certain initial points from where it starts moving, which is called initial source point and it approaches towards the destination or the target points. In this algorithm, we have intended to avoid the obstacles while traversing from source point to the destination. Such system enhancement can reduce the loss of data packets and can provide an optimal solution of quality of service (QoS) assurance in mobile communication. In order to define the source as well as destination node function a local function called target function has been developed which is given as follows:

$$f(\vec{p}, \vec{p}_T) = (x_r - x)^2 + (y_r - y)^2$$

Where, the variable signifies the respective location given by $\vec{p} = [x, y]$. in fact it exhibits the current location of the mobile node. On the other hand, the other variable $\vec{p}_T = [x_T, y_T]$ refers for the destination function location of the destination node. Thus the minimum of the function has been accomplished at the situation when $\vec{p} = \vec{p}_T$. The illustration of the target function obtained with the aforementioned dimensional configuration is given in the following figure (Figure 3.1).



Target Function

Dynamic Boundary Function

In the developed model all the comprising areas where the mobile node is supposed to be confined so as to avoid collision with the obstacle. This confinement has been represented by a boundary. This function in fact facilitates the information about the current position of the obstacle and varied dimensions it, on the basis of which the dynamic trajectory could be obtained. In this simulation mode, the obstacle has been made in circular form so as to present a better illustration of obstacle avoidance. The encompassed obstacles possesses $\vec{p}_b$ as centre with an obstacle radius of R = 0.25 m. In the developed algorithm the mobile node that employs the algorithm does not contains any shape and to make the system well functional the node has been presented as a point. In addition, it also reduces the computational complexity. In the developed model, the comprising boundaries require approximate 0.25 meters bigger shape and size so as to compensate for the fact that the mobile node is a point in dimension.

In this algorithm the boundary function defined for a circular obstacle can be stated as follows:

$$g_j\left(\vec{p},\vec{p}_{B_j},R\right) = -\left(x_{B_j} - x\right)^2 - \left(Y_{B_j} - Y\right)^2 + R^2$$

Here, the area within the presented curve is positive; on the other hand the external area is always a negative. In addition, the variable $\vec{p}_{B_j} = \left[x_{B_j}\, Y_{B_j}\right]$refers the centre of the obstacle$j$.

Here the destination or target function together with the developed boundary function with $g_j \leq 0$ for all the considered obstacles in the simulation network generates an optimization issue, where certain optimal trajectory or the path is needed to be obtained from source to destination. The other variable in this algorithm is the obstacle function which is discussed as follows:

Obstacle Function

In order to explore the optimal trajectory of the mobile nodes under the obstacle presence, the proposed research work encompasses certain mobile obstacles. To incorporate the presence of obstacles with the proposed system, the prime intricacy is the generation of the path or trajectory the particular node has to follow without intersecting any of the boundaries. In order to address these issues, in this thesis we have introduced a novel approach of obstacle introduction in the communication area. For individual obstacles in the communication scenarios, the obstacle function developed can be given as follows:

$$B_j\left(\vec{p},\vec{p}_{B_j},R\right) = -\frac{1}{-g_j\left(\vec{p},\vec{p}_{B_j},R\right)}$$

Here the obstacle function generates an obstacle with certain infinite dimension. Here specifically the height is infinite for the obstacle function. The following figure represents the obstacle function for obstacle function is considered together and is added to the destination function. Thus the final function for the destination node or target function is given as follows:

$$T\left(\vec{p},\vec{p}_r\, \vec{p}_{B_j},R\right) = f\left(\vec{p},\vec{p}_r\right) + \sum_j B_j\left(\vec{p},\vec{p}_{B_j},R\right)$$

Penalty Function

This is a specific functioned proposed in this thesis which significantly influences the controllability of the obstacle and the node movement across the simulation network. In fact the importance of an obstacle is controlled by penalty function itself. Here the current position or location of node position $\vec{p}$ estimates or determines whether the node should be provided higher priority within the total target function or not. The significance of the penalty function fades away in terms of distance along the obstacle, and in such a manner it ensures that only the significant obstacles which are close to the node, are considered for estimating the total target function.

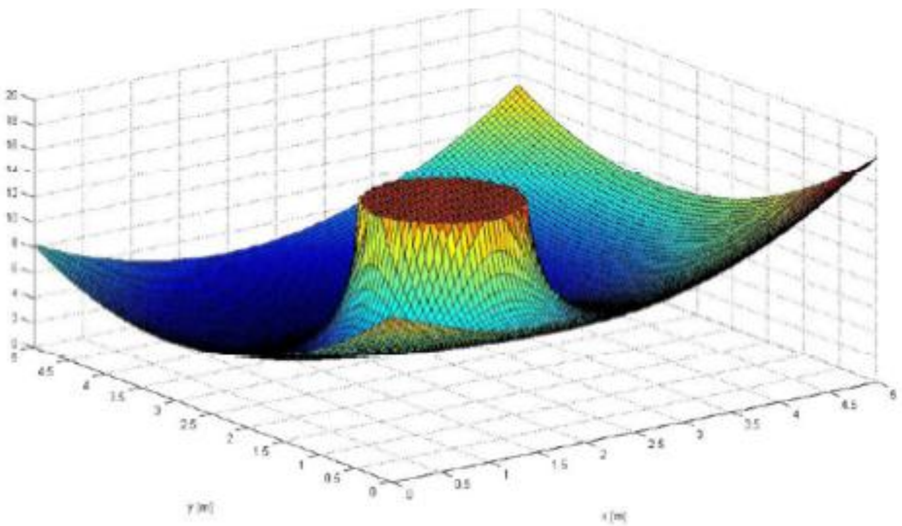


Illustration of the total target function with one boundary

In this project work, the penalty function is estimated by calculating the distance between the obstacle and the nodes. The specific distance with which the node moves in the direction of or away from the obstacle has been employed for increasing or decreasing the penalty function and in such a manner the obstacle function becomes highly significant for estimating the total target function. Mathematically it is given as follows:

$$r_{B_j}\left(\vec{p}, \vec{p}_{B_j}\right) = r + e^{-a.d} \qquad d = \sqrt{\left(x - x_{B_j}\right)^2 + \left(y - y_{B_j}\right)^2} < 0$$

$$r_{B_j}\left(\vec{p},\vec{p}_{B_j}\right) = r - e^{-a.d} \qquad d = \sqrt{\left(x - x_{B_j}\right)^2 + \left(y - y_{B_j}\right)^2} > 0$$

Where a refers a constant factor which is in general estimated by a hit and try approach for optimal results. In this thesis it has been put as 2, because with this variable the overall efficiency has been found to be better. Meanwhile, due to the mobility in the communication network, the variation in distance has been estimated by the following expression.

$$d = \sqrt{\left(x - x_{B_j}\right)^2 + \left(y - y_{B_j}\right)^2}$$

Here the variable d represents the distance between the mobile node and the obstacles under consideration. In some test cases it has been found that for a penalty factor ranging between 0.05 and 1, the accuracy is better and it also justifies the requirements that the penalty function should neither be high nor be small enough to deliver output. In case of a penalty factor of value more than 1, then the mobile node would always stay far away from the obstacle that can not be advisable. Hence, the optima penalty factor must be will always be considered to be 0.05. Thus the final target function obtained is given by the following expression:

$$T\left(\vec{p},\vec{p}_r\ \vec{p}_{B_j}, R\right) = f(\vec{p},\vec{p}_r) + \sum r_{B_j}\ B_j\left(\vec{p},\vec{p}_{B_j}, R\right)$$

In the proposed thesis work, the Newton direction approach has been obtained for path planning and trajectory exploration. A brief discussion of the Newton direction is given in the following section.

Newton Direction

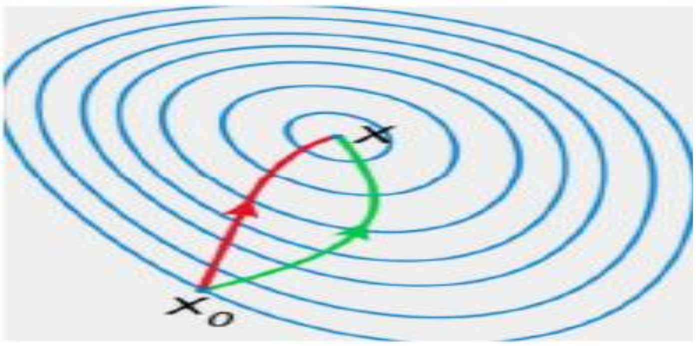
In the proposed algorithm, the path is estimated by exploring at the best possible trajectory for the node to perform movement at its current position. The paradigm of the proposed Newton algorithm has been employed for trajectory decision process. The Newton Direction has been estimated for representing the optimal direction in which a step must be taken or movement must be done to ensure obstacle avoidance. In this thesis work, the Newton Direction approach has been defined as:

$$\vec{s}(\vec{p}_k) = -\underline{H_T^{-1}}(\vec{p}_k).\nabla T(\vec{p}_k)$$

Where, ∇T refers the gradient value of the obtained total target function. The inverse of the Hessian function has been represented as H_T^{-1} that illustrates the second order derivative of the total target function which has been estimated at the point $\vec{p}_k$. Furthermore, the variable ∇T or the gradient of the total target function represents the first order derivative.

In this thesis, the prime reason of the implementation of the Newton approach is due to the second derivate utilization that means that ensures the estimation of the slope for both first derivative as well as second derivative. In the simulation scenario of the developed mode, the tilting of the slope has been observed towards left or right. In fact this information is of great significance as it has been employed for moving towards the precise direction towards which the sloping is getting tilted. On the other hand, it should be noted that the evaluation of the first order derivative might only estimate the steepest decent of the slope, and not all the needed projections and direction of the destination node or the target points.

For illustration, the following figure can be considered where the height profile has been depicted using two different paradigms for trajectory or the path estimation. Here the green line shows the path retrieved through the steepest decent approach in which the estimation of only the first derivative is needed. On the other hand, the red line indicates the proposed Newton’s method in which the second order derivative has been employed. From the view the efficiency of the second order derivative can be seen precisely.



Efficiency of generic steepest decent and Newton method for path estimation.

In the above mentioned diagram, the steepest decent approach has been found to be little less effective as compared to Newton Method, due to the region that, Newton method is a local method and therefore the trajectory might be ‘stuck’ in the local minimum and due to this reason the trajectory might not proceed further. On the other hand, considering the real time communication scenario, such events might not happen as there is always certain noise presence in the signal that could cause the minimal value to get rise up. In addition, the nodes in the communication network would be moving (for mobile network), which could make the minimal value to increase. Furthermore, one more issue might be caused called the saddle points which could cause the function to move or even point in certain wrong direction, due to two slopes down. In this thesis to eliminate such limitations and problems, it has been ensured that the Hessian has been kept always positive as well as definite.

Algorithm Foundation

In the proposed model in this thesis is based on a foundation model where the simulation model of the nodes and obstacles has been defined. In this approach, a invariable constant speed of 4 m/s has been defined which has been represented by a step size of 0.125 m. In implementation, the step size has been obtained when multiplying the speed of the node by the interval in which the information or the node statics is obtained. Mathematically, $4.\frac{1}{32} = 0.125m.$ in the mobile communication and obstacle avoidance the basic algorithm based on which we have enhanced the performance is given as follows:

1. *Define the iteration step k=1.*
2. *Define the tolerance factor* δ.
3. *Define the initial framework parameters.*
4. *For every k:*
   - *Calculate the Hessian* $\underline{H_T}(\vec{p}_k)$ *and gradient factor based on total gradient expression* $t\nabla T(\vec{p}_k)$. *Verify for positive and definite of Hessian metric.*
     In case on negative and indefinite Hessian, adjust the variable to achieve positive and

definite Hessian metric

5. *Estimate the Newton Direction using* $\vec{s}(\vec{p}_k) = -\underline{H_T^{-1}}(\vec{p}_k).\nabla T(\vec{p}_k)$
6. *Perform the normalization of the Newton Direction:* $|\vec{s}|\ \frac{\vec{s}}{\sqrt{s_x^2+s_y^2}}$
7. *Estimate the dynamic step size:* $\overrightarrow{\Delta q_k} = \vec{s}(\vec{p}_k) = 0.125$
8. *Estimate the new point for projections and new path towards destination node* $\vec{p}_{k+1} = \vec{p}_k + \overrightarrow{\Delta q_k}$
9. *In case* $\|\nabla T\| < \delta$*,continue*
10. *If not, update* $k = k + 1$ *and repeat the loop (step 2).*
11. *Complete simulation*

Constraints Based Optimization

Developing the obstacle avoidance approach with a defined step size for trajectory formation, it has been found that the algorithm encountered few imitations such as saw-tooth pattern, which comes into existence while traversing from source to destination nodes. It has been found that such limitation is caused due to the defined step size, but in practical to provide a robust function of the proposed obstacle avoidance algorithm in mobile communication, the adaptive variation in speed is inevitable and it can be done only by decreasing the step size. Therefore in our developed model we incorporated the step size as 1/16 in stead of 1/32 in the previous phase. The implementation of 1/16 step gives better results and trajectory formation. While implementing this updated variable in implementation at some points with zoomed analysis pattern, some saw tooth patterns were obtained which illustrates that the new point for path planning is not the best point to be considered for path construction. Considering a definite step size might cause the new path or trajectory point to be very far away. It refects that the point after that might coordinate the path back, and thus resulting into saw tooth pattern. In fact this path is exhibiting the zigzag pattern for the best possible path towards destination node and the prime cause of such events was the constant speed. On the other hand, in practical utilities, the node possesses speed and acceleration constraints.

Thus, to make it more practical and real scenario function certain constraints were needed to be incorporated. A brief discussion of these constraints is given in the following section of the presented manuscript.

Constraints Addition

In order to estimate the updated new point $\vec{p}_{k+1}$, it is required to explore the varied constraints such as speed and acceleration of the mobile entity.

Consider that the speed of the mobile node is $\vec{v}_k = \begin{bmatrix} v_x^k \\ v_y^k \end{bmatrix}$ and the respective acceleration is given by $\vec{a}_k = \begin{bmatrix} a_x^k \\ a_y^k \end{bmatrix}$. Here the prime constraints are $|\vec{v}_k| \geq \frac{4m}{s}$ and $|\vec{a}| \leq 5\ m/s^2$ which are specified by the nodes specifications. Let t be the prime time constraint and now considering these variables the speed of the node at every instant can be estimated and can be updated for next instant $k+1$. It can be given as

$$\vec{v}_{k+1} = \vec{v}_k + \vec{a}_k . t$$

Consider that the initial speed is fixed to $\vec{v}_k(k=0) = 0m/s$ representing the start of node from a standstill. To form the movement trajectory, a line can be formed on the x, y -plane representing all the comprising point along the Newton Direction $\vec{s}_k$. In such way, the path line or the Newton direction line traverses through point $\vec{p}_k$, and hence the trajectory line can be represented by a mathematical expression:

$$y = \frac{s_y}{s_x} . x - \frac{s_y}{s_x} . p_x + p_y$$

The line thus generated represents all the comprising point which exist along the best possible Newton Direction and in our proposed system the mobile node is needed to be moved in the best possible and optimal Newton direction. Thus, the speed and the acceleration can aso be estimated which is needed to move the node towards the destination without any collision with the obstacles. In the following illustrative figure, it can be found that a circle in red color, at the end of the speed parameter of vector V, which depicts the field of the points, can be reached by employing the acceleration on the speed of the mobile node. To accomplish it, the radius of the circle can be retrieved by the following expression:

$$r = \frac{1}{2}.|\vec{a}_k|.t^2.$$

In the above expression, the acceleration value can be given by $|\vec{a}_k| = \frac{v_{max} - |\vec{v}_k|}{t}$. In fact this defined acceleration vector possesses the speed constraint that avoids the node from exceeding its maximum defined speed during movement or the traversal. Considering this as the radius, the centre of the circle field can be obtained using geometrical characteristics. The centre can be obtained as follows:

It should be noted that the centre of the circle filed has been obtained at the point $\vec{p}_k + \vec{v}_k.t$

$$(x - (p_x + v_x.t))^2 + (y - (p_y + v_y.t))^2 = r^2$$

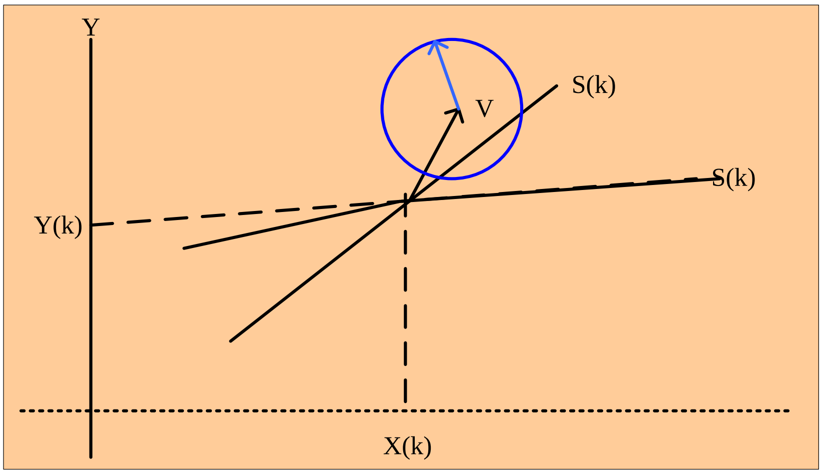


Figure 3.4: Estimation of new point for optimal trajectory

Now, let's consider two feasible conditions for Newton Direction in obstacle avoidance. The first one intersects with the circle and on the other hand another one doesn't even intersect the circle. Considering the first situation when the Newton trajectory line intersects, since these trajectory intersect the x-value, thus the new possible point might be obtained as follows:

$$(x - (p_x + v_x.t))^2 + \left(\left(\frac{s_y}{s_x}.x - \frac{s_y}{s_x}.p_x + p_y\right) - (p_y + v_y.t)\right)^2 = r^2$$

Now, solving the above mentioned expression, we do achieve multiple solutions, but in our model we have considered the one having highest possible acceleration so as to provide precise and swift processing. This has been obtained by exploring or obtaining the x values of the Newton direction vector and the positive values has exhibited the best solution for optimal trajectory formation for obstacle avoidance.

Consider a specific situation where $s_x = 0$. In this situation considering the above expression, it is impossible to get the solution and therefore, with $s_x = 0$ the Newton direction would always be pointing towards a straight upward or down. Hence, for $s_x = 0$ the new path would always be$p_x^{k+1} = p_x^k$. Meanwhile the y-value can also be obtained by the following expression:

$$(p_x - (p_x + v_x.t))^2 + (y - (p_y + v_y.t))^2 = r^2$$

Thus, from the obtained values of the y, the best optimal value has been selected to construct the Newton direction along the destination. Here the selection has been made in a way that in case it is pointing up$y - value > 0$ and hence the largest one is selected and on the other hand in case of pointing down$y - value < 0$, and hence the smallest one is selected.

Overshoot

While implementing the algorithm another issues was experienced which is nothing else but the Overshoot which refers that an acceleration large enough to achieve certain point on the Newton direction trajectory might not be generated and thus the optima solution can't be obtained and therefore there is the need to reach closer to the optimal Newton direction. To perform this overshoot point which is close to the experienced line will move towards the Newton direction or trajectory. It can be realized that in such situation that the line perpendicular to the optimal Newton direction line is needed to be obtained and the line is expected to intersect the centre of the circle.

While deriving an optimal solution for it an approach was realized where the new point wa obtained by adding three vectors altogether. These vectors are:

$$\vec{p}_k + \vec{v}_k.t + \vec{q}$$

Where $\vec{q}$ is $\vec{q} = \frac{\vec{s_\perp}}{|s_\perp|}$. r and r is the radius as obtained earlier.

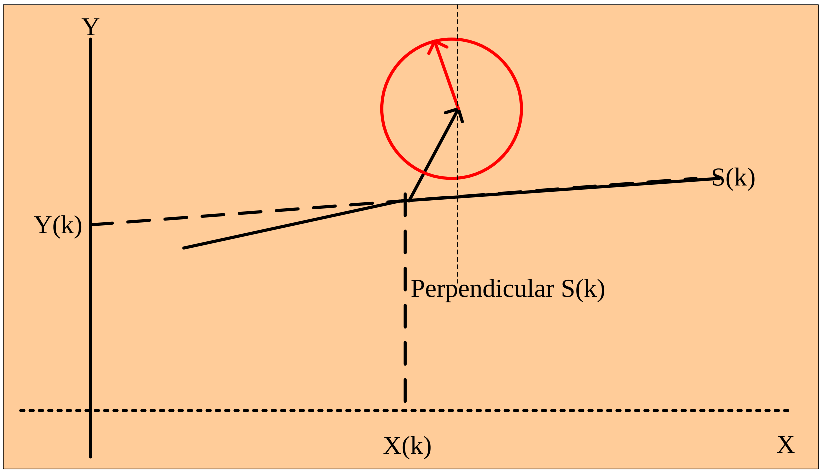
Here two directions of $\overrightarrow{s_\perp}$ can be found. These are:

$$\overrightarrow{s_\perp} = \begin{bmatrix} \overrightarrow{s_y} \\ -\overrightarrow{s_x} \end{bmatrix}$$

Or

$$\overrightarrow{s_\perp} = \begin{bmatrix} \overrightarrow{s_y} \\ \overrightarrow{s_x} \end{bmatrix}$$

In our developed algorithm, the precise direction has been selected by estimating the location of the speed vectors in reference to the Newton direction. In case, the speed vector is located on the left side of the Newton Direction, it is required to get the perpendicular direction matrix$\overrightarrow{s_\perp} = \begin{bmatrix} s_y \\ -s_x \end{bmatrix}$. In case of its presence on the right side of the Newton direction, the perpendicular matrix $\overrightarrow{s_\perp}$ $\begin{bmatrix} -s_y \\ s_x \end{bmatrix}$ is employed. An illustration of this mentioned discussion is given in the following figure.



The cases of Overshoot in obstacle avoidance

Algorithm Optimization

In order to eliminate all the associated issues, in this thesis the Newton direction based obstacle avoidance algorithm has been optimized. In this optimization approach the variables speeds as well as the acceleration have been employed that estimates the precise position of the new point $\overrightarrow{p}_{k+1}$. This optimization paradigm can be stated in the following sequential implementation approach.

Optimized Algorithm:

1. *Define the initial values of the mobile nodes* $\vec{p}_0$, *destination node or the target point* $\vec{p}_T$ *and obstacle location in the simulation framework.*
2. *Assign the variable k=0 and define a tolerance ratio factor* δ.
3. *Verify that the initial points must not be coinciding with any obstacle.*
4. *For each* $k = k + 1$:
   - *Calculate the Hessian matrix* $\underline{H}_T\ (\vec{p}_k)$ *as well as the gradient factor* $\nabla T(\vec{p}_k)$. *Verify whether* $\underline{H}_T\ (\vec{p}_k)$ *is a positive variable; otherwise, adjust the Hessian matrix to get positive definite value.*
   - *Estimate the Newton Direction*

     $\vec{s}(\vec{p}_k) = \underline{H}_T^{-1}\ (\vec{p}_k) \nabla T(\vec{p}_k)$

   - *Estimate the new point when traversing with maximum acceleration*
   - *Achieve the best line for Newton Direction*
   - *Verify, whether the path retrieved is still in compliance with the speed variable* $\vec{v}_{k+1} \leq 4m/s$.
   - *Estimate the acceleration vector* $\vec{a}_k$ *and the new speed* $\vec{v}_{k+1}$. *In case* $\vec{v}_{k+1}$ *is more than the permitted speed, estimate new highest acceleration with* $a_{new} = \frac{(v_{max} - |\vec{v}_k|)}{t}$ *and employ it for re-estimating the new point.*
   - *To avoid the overshoot scenarios in the simulation framework, estimate the vector from the centre of the circle to the edge of the circle nearest to the*

Newton Direction line.

- *Perform addition of the node that it might have travelled and the vector found from the centre to the edge and the perform addition it to the current location($\vec{p}_k$).*
- *Estimate the new acceleration as well as speed vector.*

5. *In case $\|\nabla T\| < \delta$, otherwise, update $k = k + 1$ and iterate step-2 (step 2).*
6. *End*

Algorithm Implementation

This is the matter of fact that quality of service (QoS) is of great significance in wireless communication system. On the other hand, the urbanization has been increasing with the vast space in addition with the indoor application. Thus, in these al application scenarios, the requirement of a robust communication scheme where the data drop could be reduced is always on higher priority for researchers. Not only in the mobile communication but also in wireless sensor networks, the obstacle avoidance algorithms are being developed to ensure QoS. With the same objectives, here in this thesis a highly robust and efficient algorithm for obstacle avoidance has been developed using the novel paradigm of Newton path finding approach. In this thesis, the proposed algorithm has been tested with varied functional parameters so as to ensure optimal functions and varied algorithmic optimization has been incorporated. In order to evaluate the system performance in this thesis work, two modules have been developed.

1. *An efficient & optimized Obstacle Avoidance Algorithm in Wireless sensor network.*
2. *An efficient & optimized Obstacle Avoidance Algorithm for Mobile wireless network.*

In the initial system, since all the nodes in the applications scenario of wireless sensor network have been kept stable or immovable, then considering the obstacles as the static the optimal path planning has been done. Here the prime objective is to avoid the obstacles in the communication area while ensuring minimal or even negligible collision with the obstacles. The simulation model developed for obstacle avoidance in WSN has exhibited the optimal solution where the simulation network has been prepared with single source and destination node while incorporating multiple obstacles placed strategically so as to provide certain barrier in the line of sight communication between source and destination node. In this algorithm, the overall function developed has exhibited optima solution with circular obstacles. Thus, achieving the optimal solution with wireless sensor networks, in this thesis the robustness of the proposed algorithm has been obtained for mobile wireless networks.

In case of wireless mobile network simulation, we have tested the performance of the system with single source node and destination where the obstacle has been incorporated in the mobile mode. The implementation of mobility in the communication system has raised a number of intricacies which has been eliminated using varied paradigms. Initially, the developed model was tested with one obstacle which was followed by the implementation of multiple obstacles and the mobile node scenarios. In the developed model, initially the obstacles were made to standing still. Later multiple obstacles have been employed for performance evaluation.

In this thesis two obstacles were employed for case study and the penalty factors were employed dynamically to achieve optimal performance. In order to implement the system model for mobile communication, the following parameters were employed:

Initial point; $\vec{p}_o = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$

Destination node position: $\vec{p}_t = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$

Position of the obstacle :

$\vec{p}_{b_1} = \begin{pmatrix} 0 \\ 2 \end{pmatrix}$

$\vec{p}_{b_2} = \begin{pmatrix} 3 \\ 1 \end{pmatrix}$

Speed of the obstacles :

$\vec{v}_{b_1} = \begin{pmatrix} 0.02 \\ -0.02 \end{pmatrix}$ $\vec{v}_{b_2} = \begin{pmatrix} -0.02 \\ 0.02 \end{pmatrix}$

Initial penalty factor $r = \begin{pmatrix} 0.1 \\ 0.1 \end{pmatrix}$

Step size = 0.1

Radius of obstacle filed: R=0.5m

Note: In our simulation approach, the system was evaluated and tested by varying the above mentioned parameters for multiple case studies.

In order to evaluate the respective performance, the penalty factor was varied from 0.1 to 1.0 with the step size of 0.1. An explanation will follow in the conclusion of this experiment. First another scenario with two objects is evaluated. While evaluating the system performance the collision was also observed for certain penalty factors and therefore the optimal penalty was explored that could avoid the collision in the network.

In this thesis the implementation of the proposed Newton direction approach based obstacle avoidance has exhibited optimal function for Wireless Sensor Networks as well as Mobile Network. The results obtained and its respective significances are discussed in the next chapter. The overall proposed system in this thesis for obstacle avoidance has been developed on MATLAB 2012a software tool. A brief introduction of MATLAB is given in the following section.

Software Requirement Specification

The software requirement specification for the proposed thesis work *"An efficient & optimized Obstacle Avoidance Algorith*m for Wireless Sensor and mobile Networks" describes what our developed program or software will be delivered and the technical specifications and other associated requirements. A brief discussion of the software requirement specification and its implementation is given in the following section.

System Perspective

In this thesis, it has been intended to develop a robust and efficient model for approach for the thesis title "A efficient & optimized Obstacle Avoidance Algorithm for Wireless Sensor and mobile Networks”. In this thesis, an effort has ben made to develop a robuist model that could avoid the obstacles while transmitting data or even moving from source to certain defined destination. Here the prime significance is to void the collision so as to reduce the data drop and to transmit the data efficiently. Here it must be noted that the developed model has not been incorporated with any data transmission, here primarily we have emphasized on the development of an obstacle avoidance algorithm which can be implemented with rea time systems in future. In order to implement both the approaches, obstacle avoidance in WSN and obstacle avoidance in mobile networks, a well integrated graphical user interface has been developed. The overall system model has been developed on MATLAB development platform where the programs and algorithms for varied components such as obstacle function, path estimation function, Newton direction function, destination function, gradient function, Hessian function, etc have been developed.

User Characteristics

Considering the well familiarity of user to execute the developed algorithm, a GUI model has been developed and to execute the function the user is expected to have the fundamental understanding and knowledge of MATLAB installation, editing, debugging and execution, etc. The program for Obstacle function, mobile nodes, network simulation parameters, network simulation environment, target function, penalty estimation and dynamic Newton path estimation algorithms and varied other functional sub-functions such as hessian function, gradient estimation approach or algorithms etc have been developed and implemented. The developed algorithms and associated sub-functions have been called where ever it is needed to be used to perform certain encompassing tasks. In order to eliminate the difficulty of understanding the research model, the respective hints and symbolic assistance has been provided to ensure optimal understanding and knowledge transfer.

Propagation medium	Extent of propagation
Wall (wooden)	Little influence
Wall (brick)	Marginal influence
Wall (Aluminum)	Strong influence

Figure 3.6 Effect of medium

It is thus evident that the property of attenuation can be exploited to find the optimal path free/or having minimum obstacles.

2. Zone based division

1. Organization of the nodes.

2. Fixing of the members in the group

3. Nodal occupancy region: It is the region surrounding the node

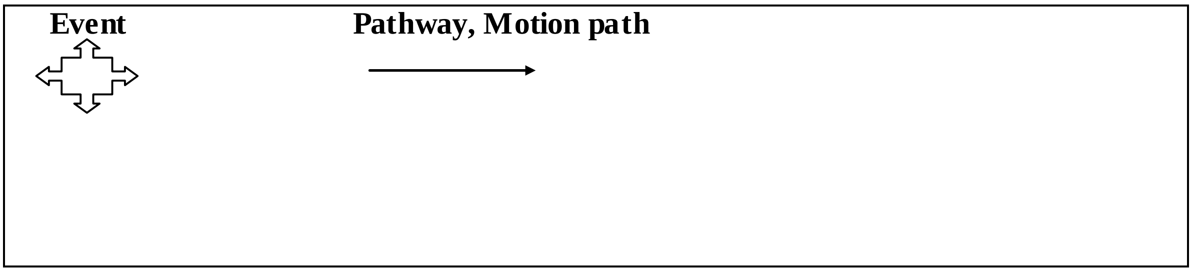
4. Obstacle occupancy region: The area occupied by the obstacle.

5. Calculation of shortest-path

6. Use of goal function: The goal function is used to reach the goal.

7. Change of trajectory on encountering obstacle

8. As soon as the node enters the nearby zone, trigger event information via message that obstacle is detected, and a particular path needs to be followed.



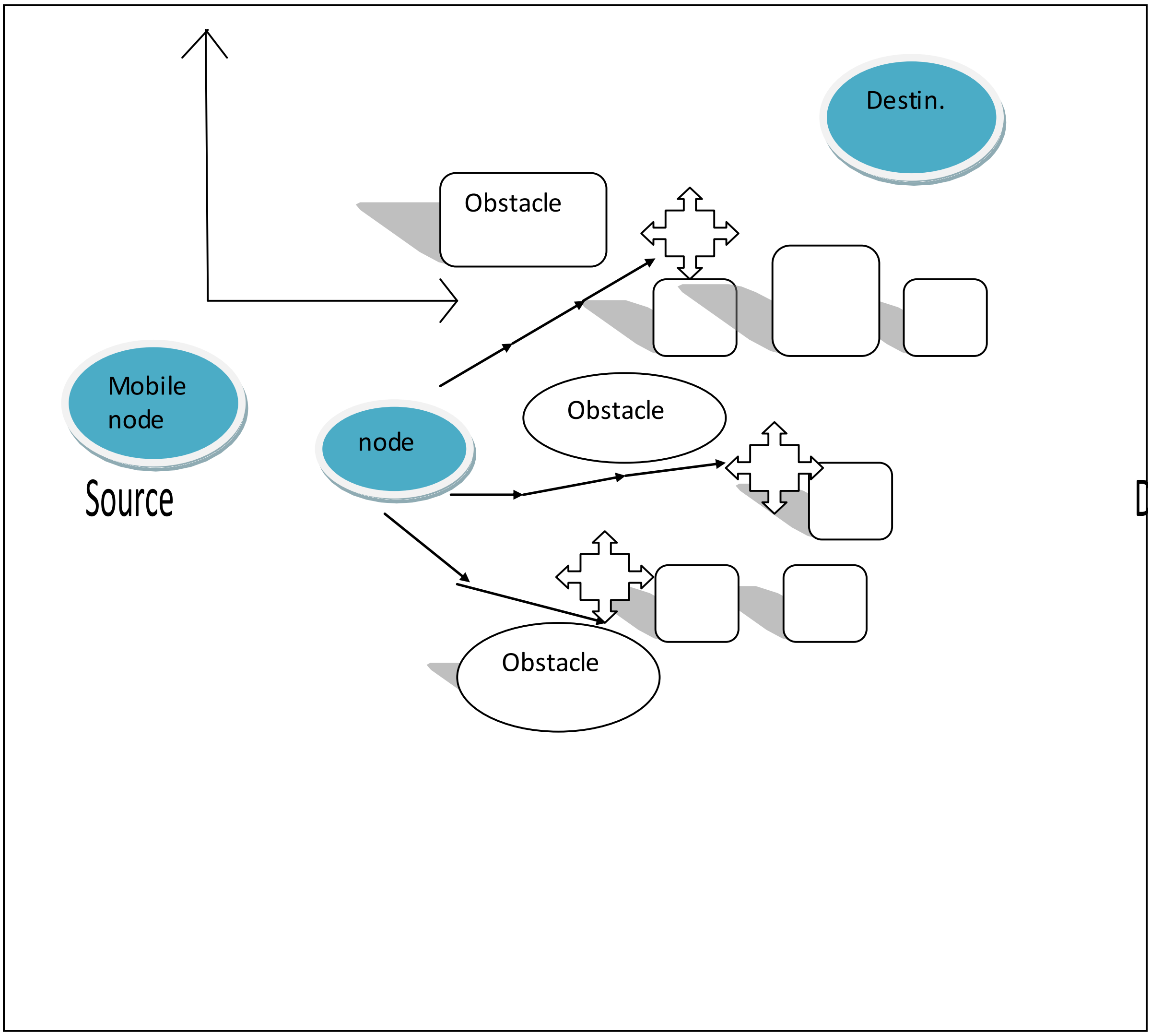


Figure 3.7 Mobility Scenario

Chapter 4

RESULTS AND DISCUSSION

Simulation Environment:

The simulation is done in MATLAB. Matlab is an interactive and innovative programming language developed at Matrix Laboratories. MATLAB was initially used to solve various problems related to linear algebra. Matlab is enriched with a number of features like rich graphics, linear algebra solving problems. Matlab is being widely used as a computational tool in the field of engineering. The applications of Matlab are delineated under:

1. It is employed in signal processing and in the field of communications.

2. It is used in computational geometry.

3. It is used in Fourier analysis.

A special feature of MATLAB is that it provides integration facility of using Matlab code with other external languages such as Java etc. Matlab has simulink which is used for dynamic environments. Simulink is a graphical tool with a wide variety of libraries.

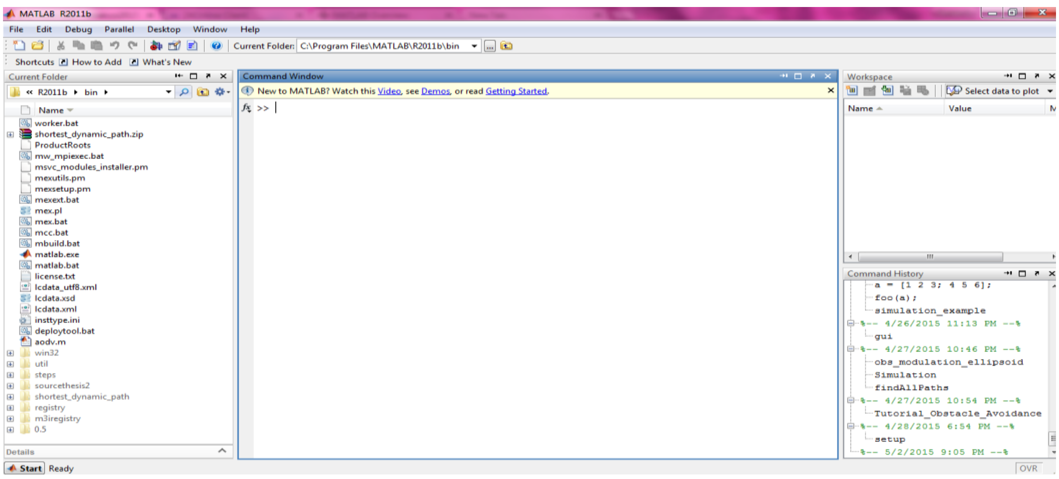


Figure 4.1 Matlab Desktop

This chapter provides the result from the simulation done in Matlab. The results are delineated under:

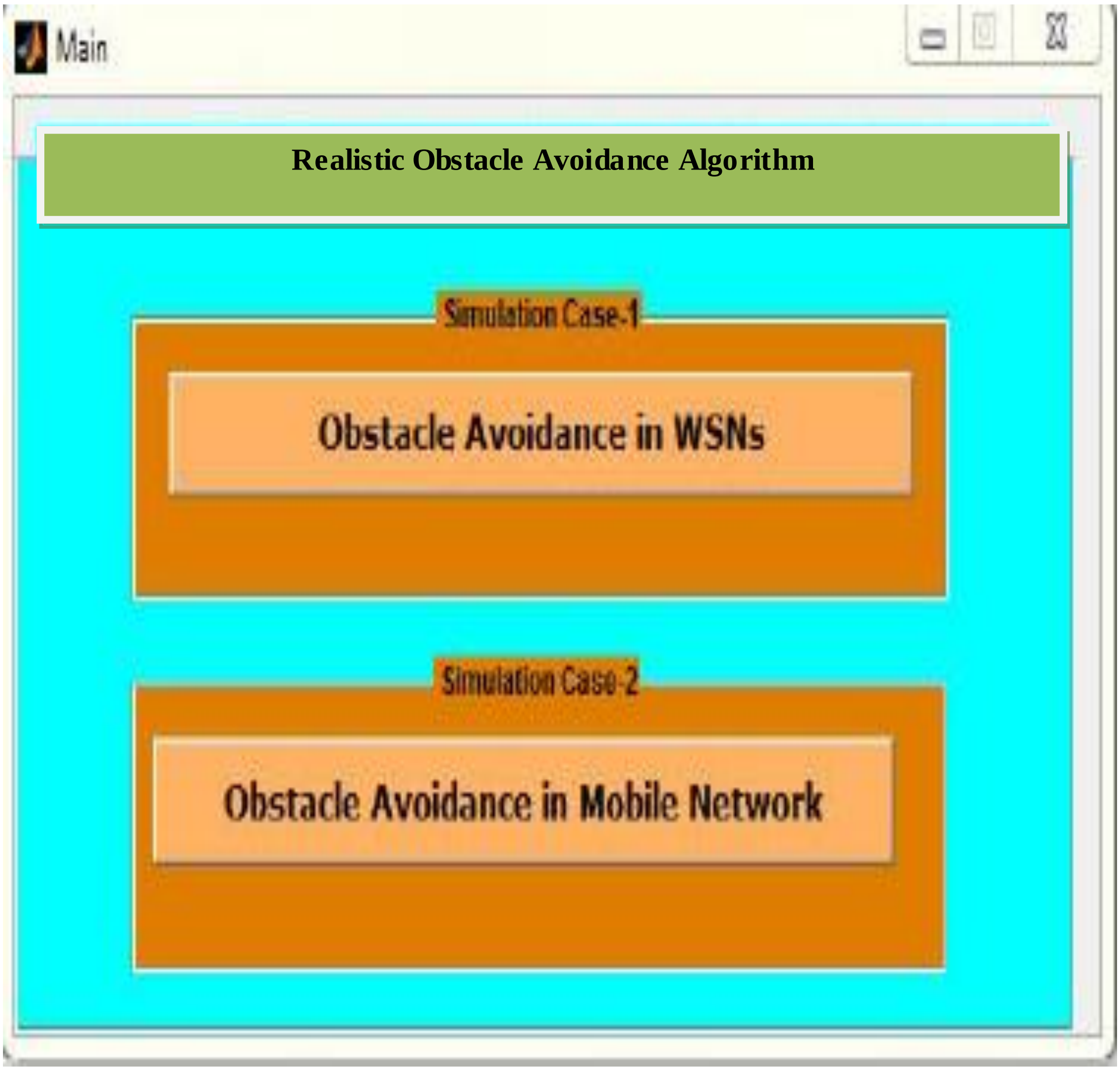


Figure 4.2 Simulation main Screen

This is the main simulation window of the work. It provides us two options one for static and another for the dynamic.

Simulation Case 1: Static Mode

The first case corresponds to the wireless sensor network environment. The figure shows the node distribution i.e. How the nodes are distributed in the simulation area.

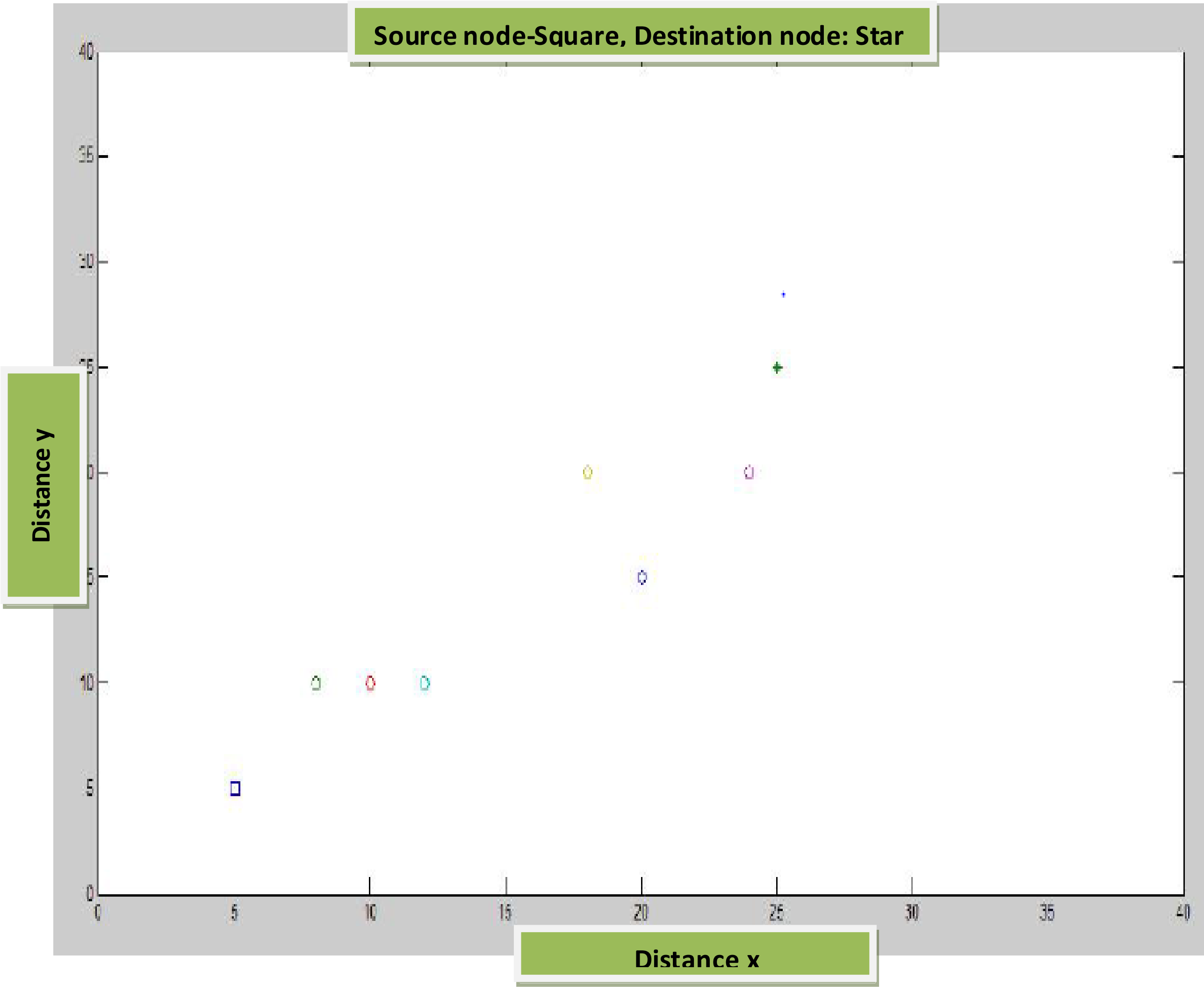


Figure 4.3 Node Visualization

The above figure shows that the source node is represented by square, and the obstacles are represented by the circles. The destination node is represented by star. The ultimate aim is to reach the destination node, the condition being that the obstacles encountered in the path should be avoided. In other words, the trajectory to the destination node should be devoid of the obstacles. Hence, the objective of the work stands justified.

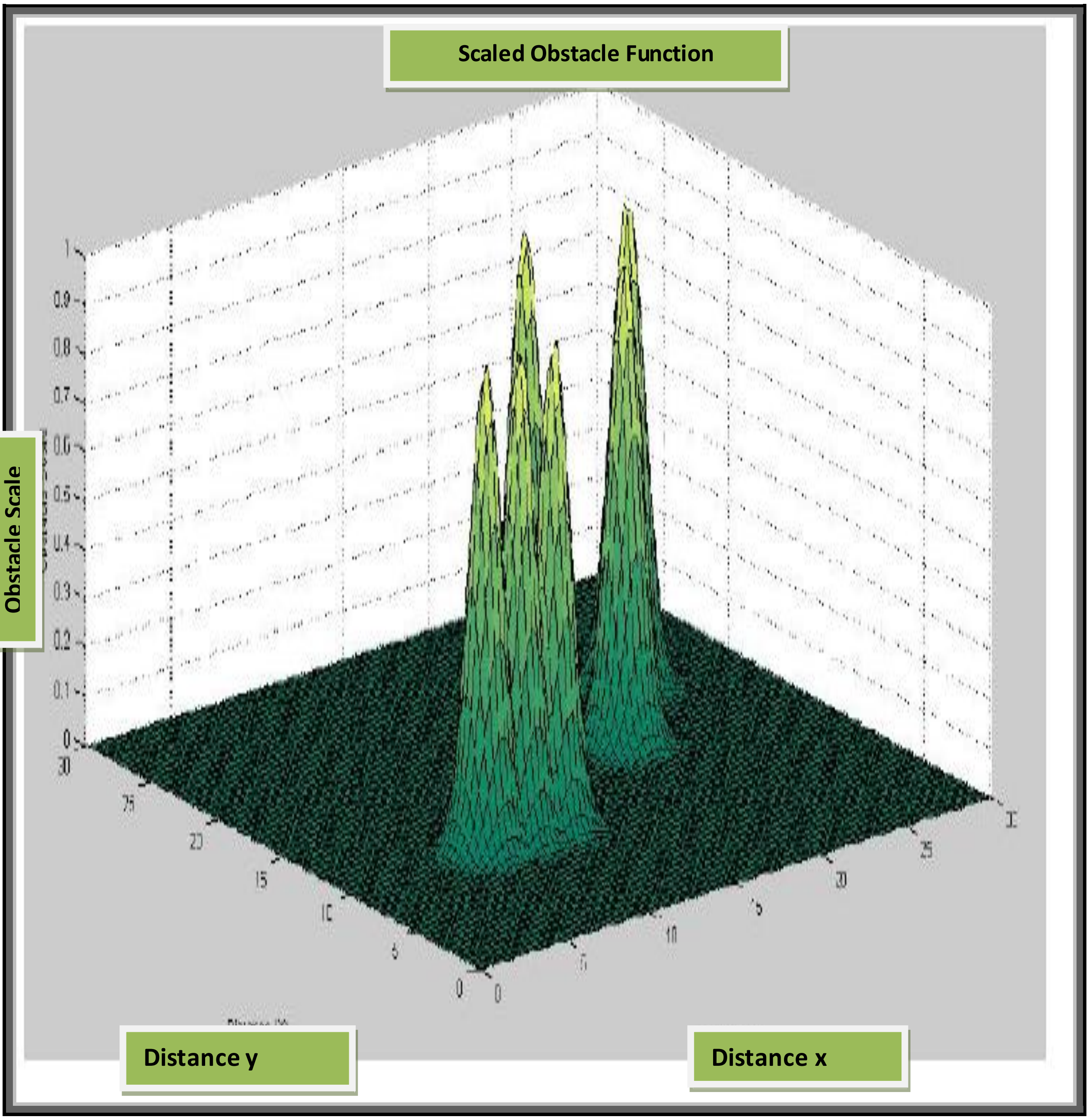


Figure 4.4 Obstacle function

The above figure provides a more clear visualization of the node distribution. The distribution is an important factor, and provides a measure of certainty of obstacle avoidance.

Moreover, a dependency between the source node, destination node, and the obstacles in the path can be derived from this visualization.

Region of occupancy:

The region of occupancy can be determined from the following contour map. The contour map shows the location of the source and destination nodes. It gives us the idea of the periphery of the node

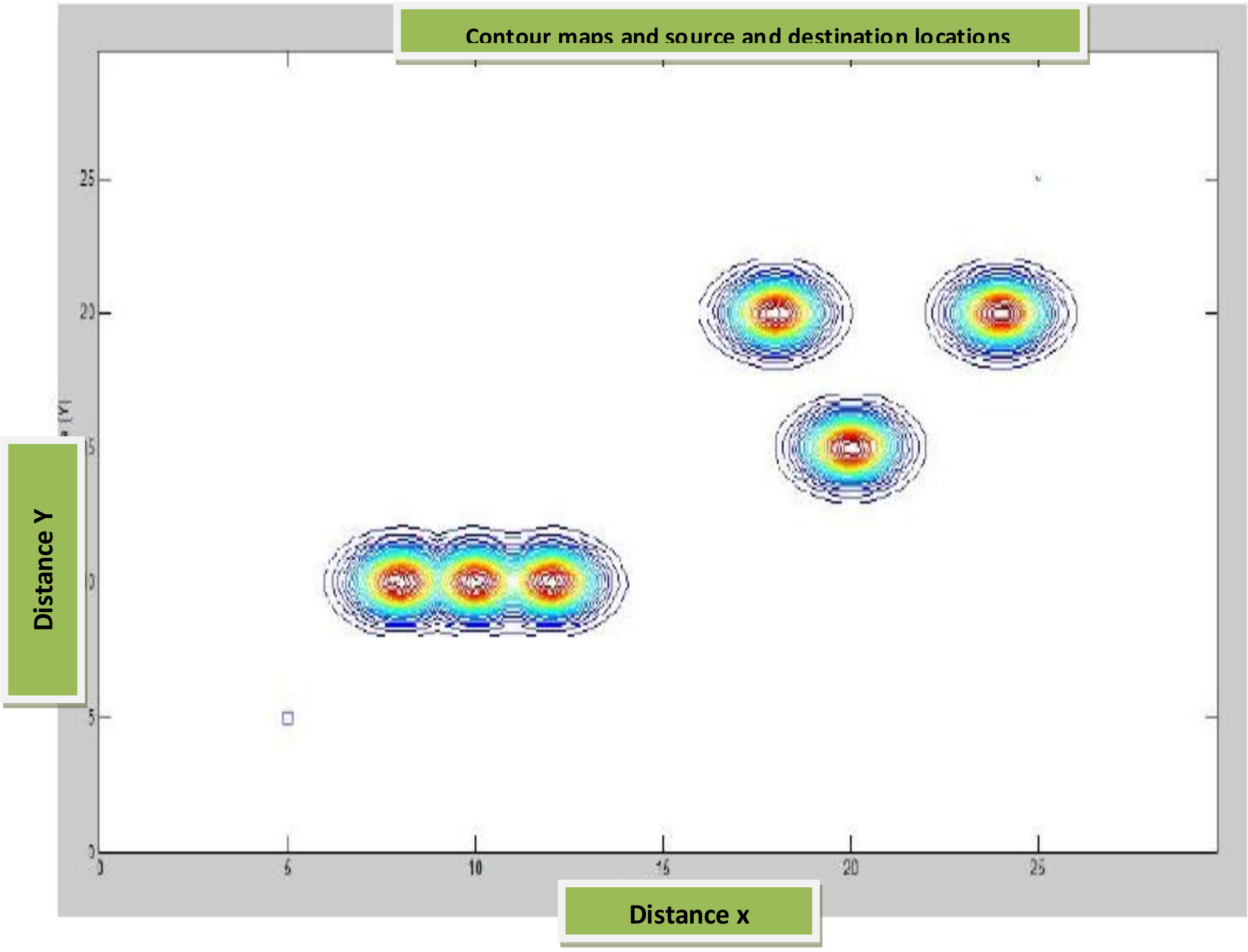


Figure 4.5 Occupancy

Use of contour map: It is possible that the region of passing between the obstacles is much smaller than the nodal diameter or its region of occupancy. Hence, it becomes an important factor to decide whether a node can effectively avoid the obstacles or not, as is seen in practical situations. Hence, the use of the contour map becomes an effective tool for analyzing this important statistic.

Destination Function:

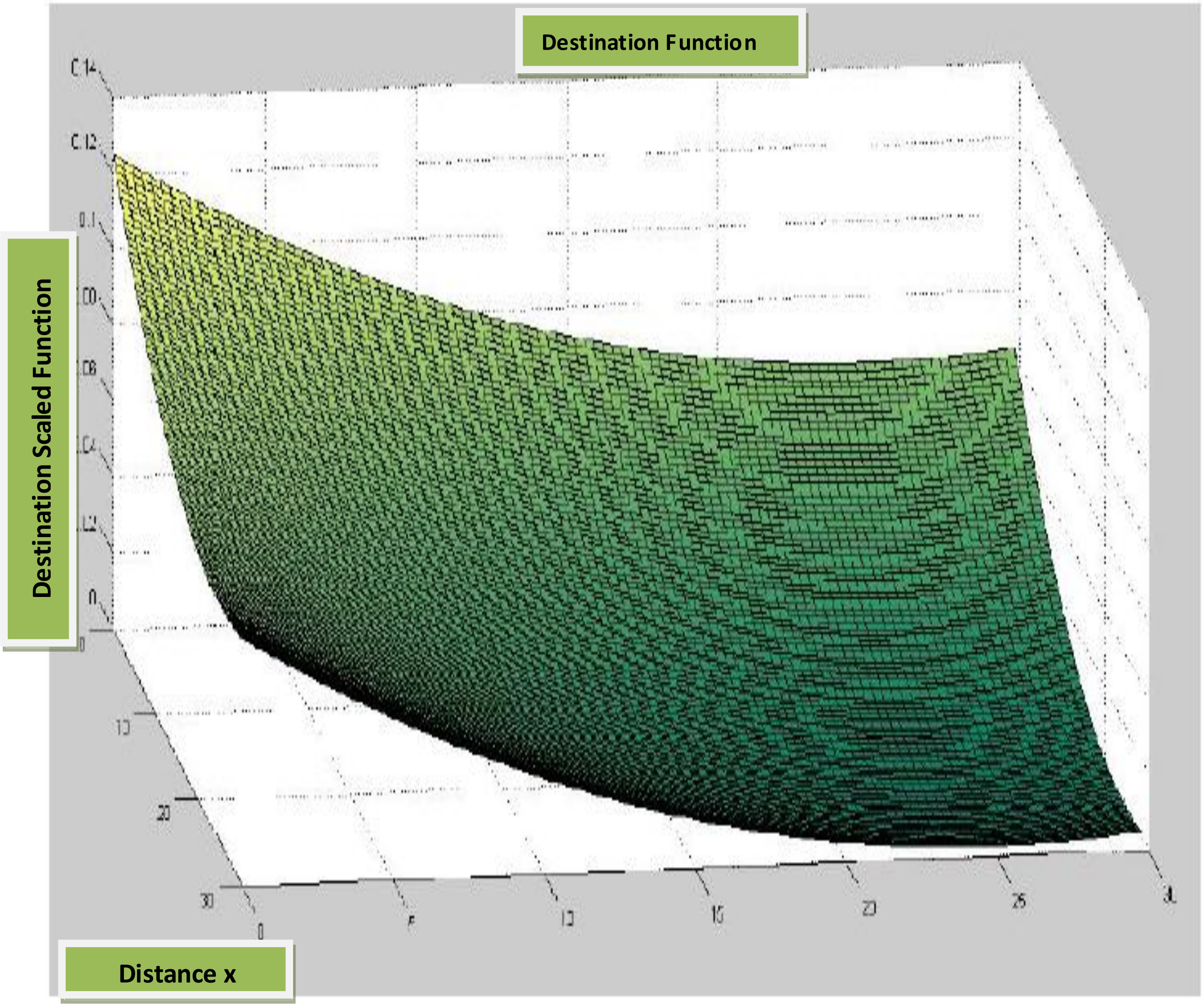


Figure 4.6 Destination function

The destination function provides a measure of reach-ability from the source to the target. The destination function has its uses:

The final destination should be known prior to simulation in contrast to the real life situations. The destination function provides visualization about the chances of successfully reaching the destination.

Contour function of node and obstacle location:

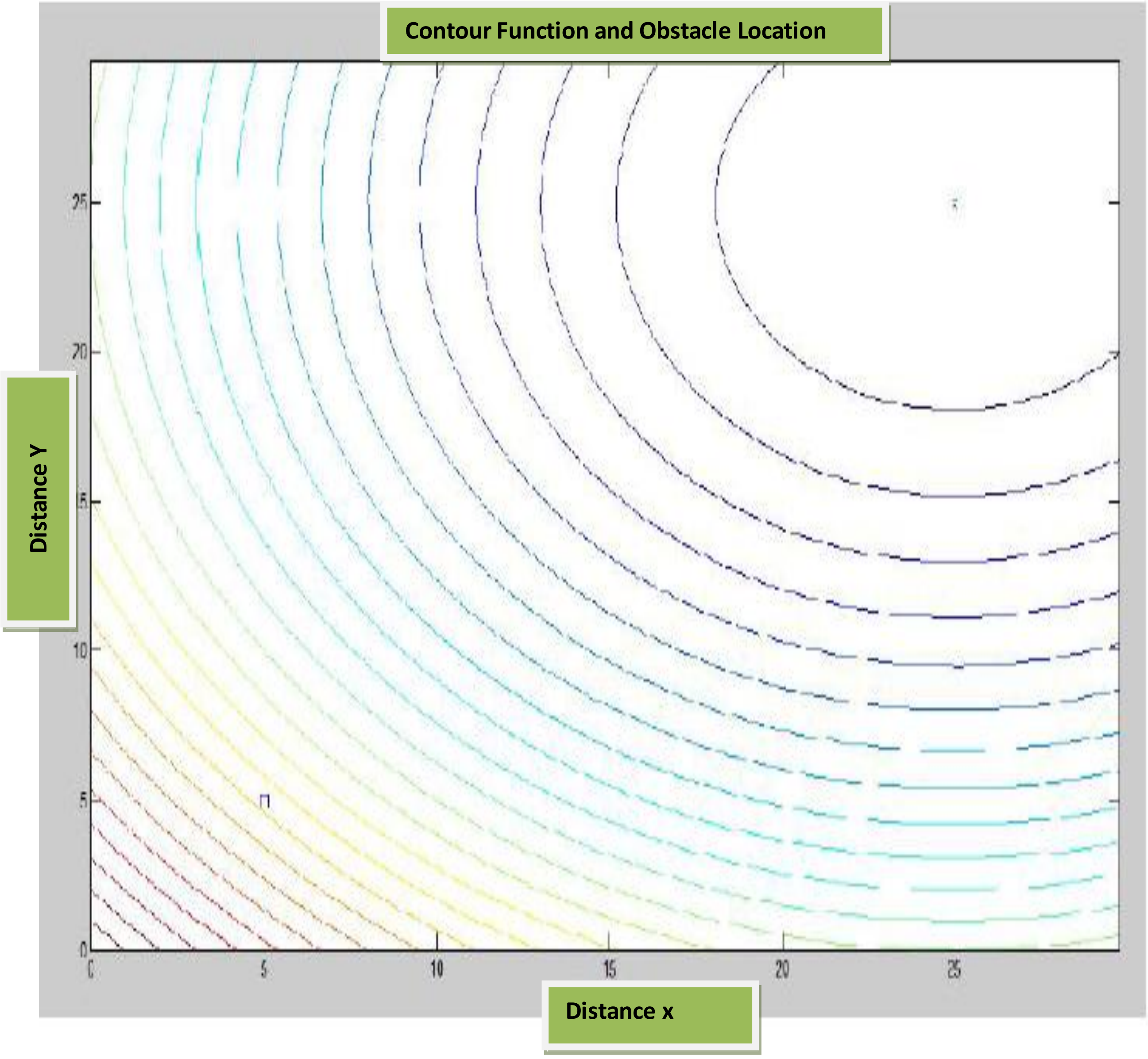


Figure 4.7 Contour function

The figure shows the contour function of nodes and the obstacle location. The region between the source and destination is viewed by the help of contour lines. These contour lines provide the region of obstacles between the two nodes.

Goal function:

A goal function is introduced which is shown here.

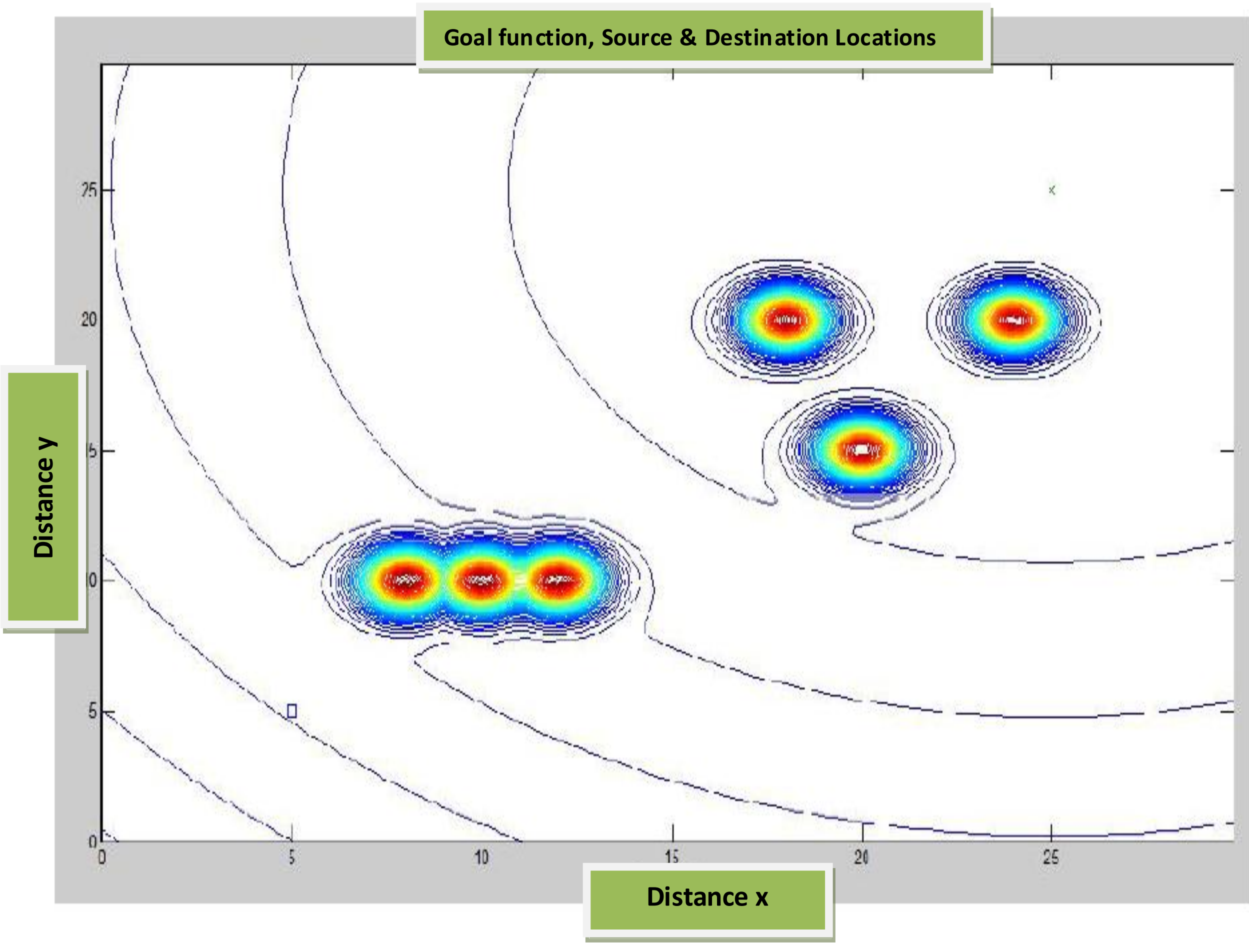


Figure 4.8 Goal function

The source and destination locations work as a subordinate of the goal function. The goal function is used for determination of the target node. The goal function also determines the step by step reach-ability of the node to the target location.

Trajectory of the node

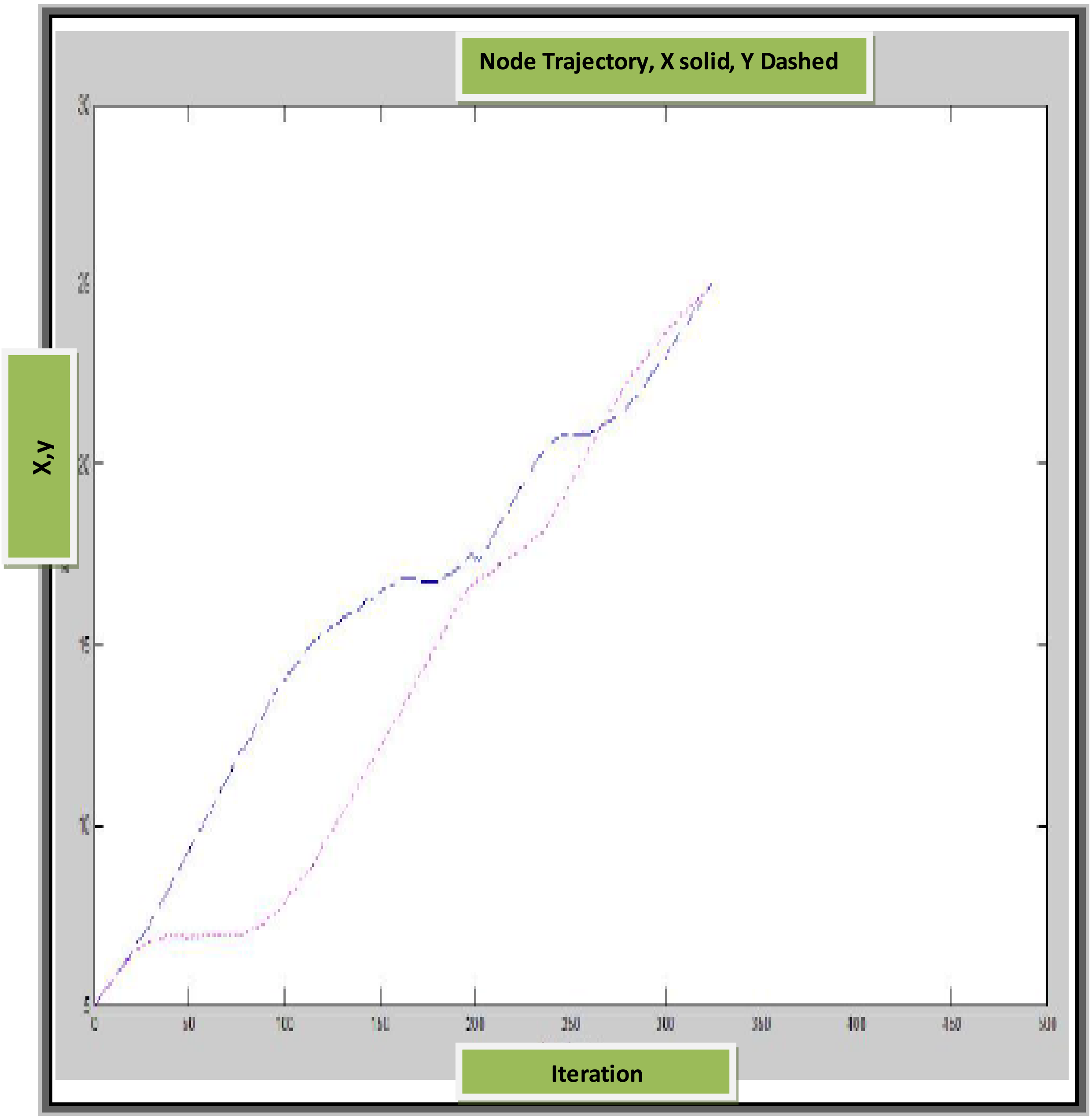


Figure 4.9 Trajectory of the node

The trajectory of the node as a function of the iteration is shown in figure. It shows the incremental motion of the obstacle, thus the full path followed by the node is shown in the figure. This trajectory is the unobstructed line of sight towards the destination.

Simulation case 2: Dynamic Mode

In order to simulate the developed model for obstacle avoidance in mobile network, a robust mobility model has been developed for obstacles where the movement and the path estimation has been done by employing speed of the node, acceleration and the associated penalty function. To achieve the best possible approach for obstacle avoidance, the Newton direction approach has been employed. In this thesis, the system performance has been obtained and evaluated with multiple obstacles and with varied performance parameters. In the following section, the system implementation and simulation with the two obstacles the obstacle avoidance has been discussed.

In order to implement the developed model, the variables have can be varied as per user wish. To simulate the developed mode, the following parameters have been employed.

Initial origin point for nodes $\vec{p}_o = \begin{pmatrix}0\\0\end{pmatrix}$
Destination node position $\vec{p}_t = \begin{pmatrix}4\\4\end{pmatrix}$
Location of Obstacle, Obstacle-1: $\vec{p}_{b_1} = \begin{pmatrix}0\\2\end{pmatrix}$ and Obstacle-2: $\vec{p}_{b_2} = \begin{pmatrix}3.5\\1\end{pmatrix}$
Respective sped for Obstacles (Obstacle-1: $\vec{v}_{b_1} = \begin{pmatrix}0.02\\-0.02\end{pmatrix}$, Obstacle-2: $\vec{v}_{b_2} = \begin{pmatrix}-0.02\\0.02\end{pmatrix}$)
Radius of circle R=0.5m
Initial penalty factor $r = \begin{pmatrix}0.1\\0.1\end{pmatrix}$

The simulation results obtained in the mobility model is presented in the following section.

The following figure represents the initial or the origin of the node and its traversal towards the destination. In between the obstacles and the respective movement can also be found in the following figures

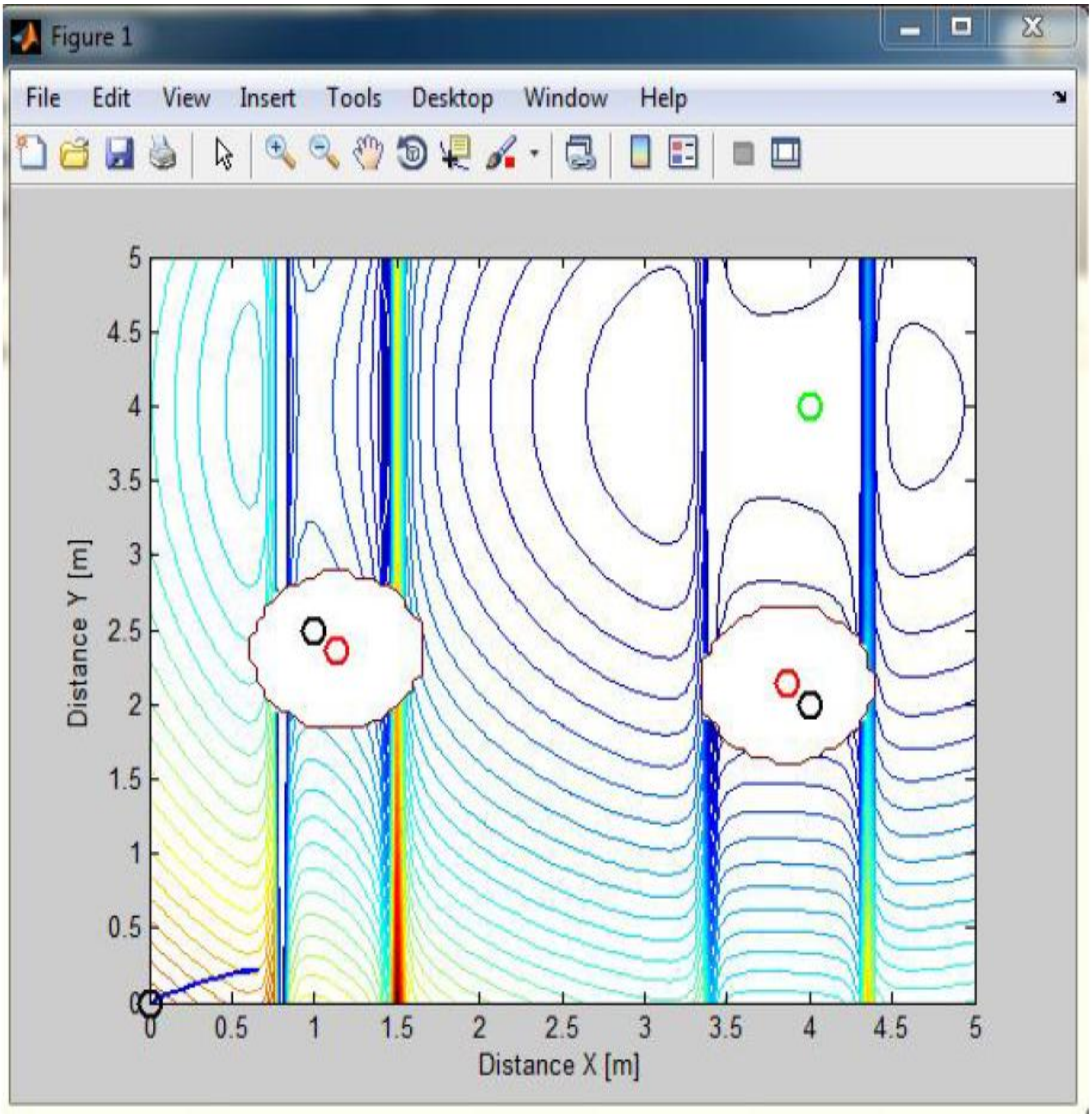


Figure 4.10 Dynamic environment

The figure shows the obstacle avoidance in case of mobile nodes. The above visualization shows the distance function of the nodes. The nodes are dynamic and objective is to avoid the obstacles.

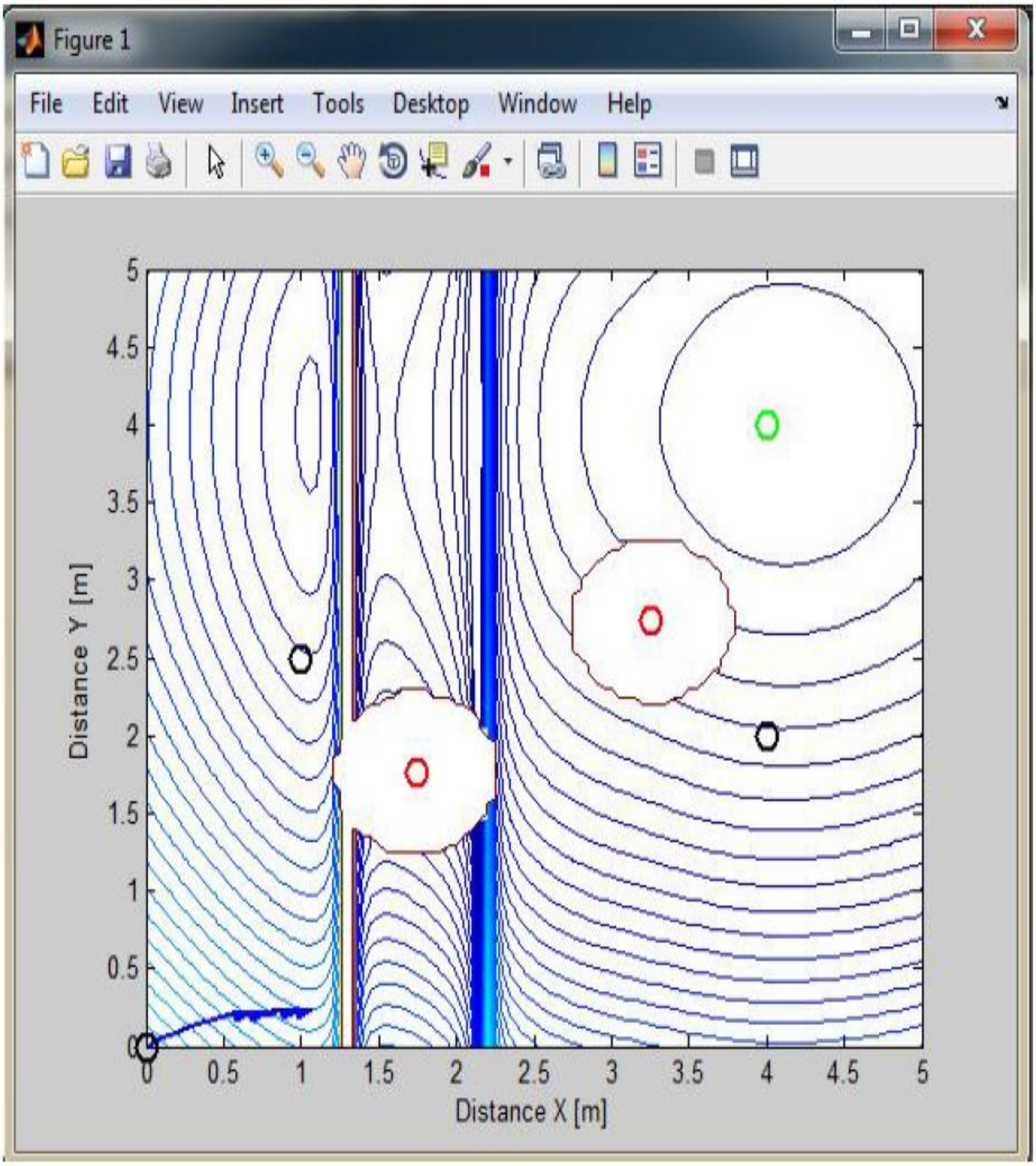


Figure 4.11 Node in motion

The above figure shows trajectory taken by the node as it comes across the obstacle. This is also visualized in-terms of the distance function.

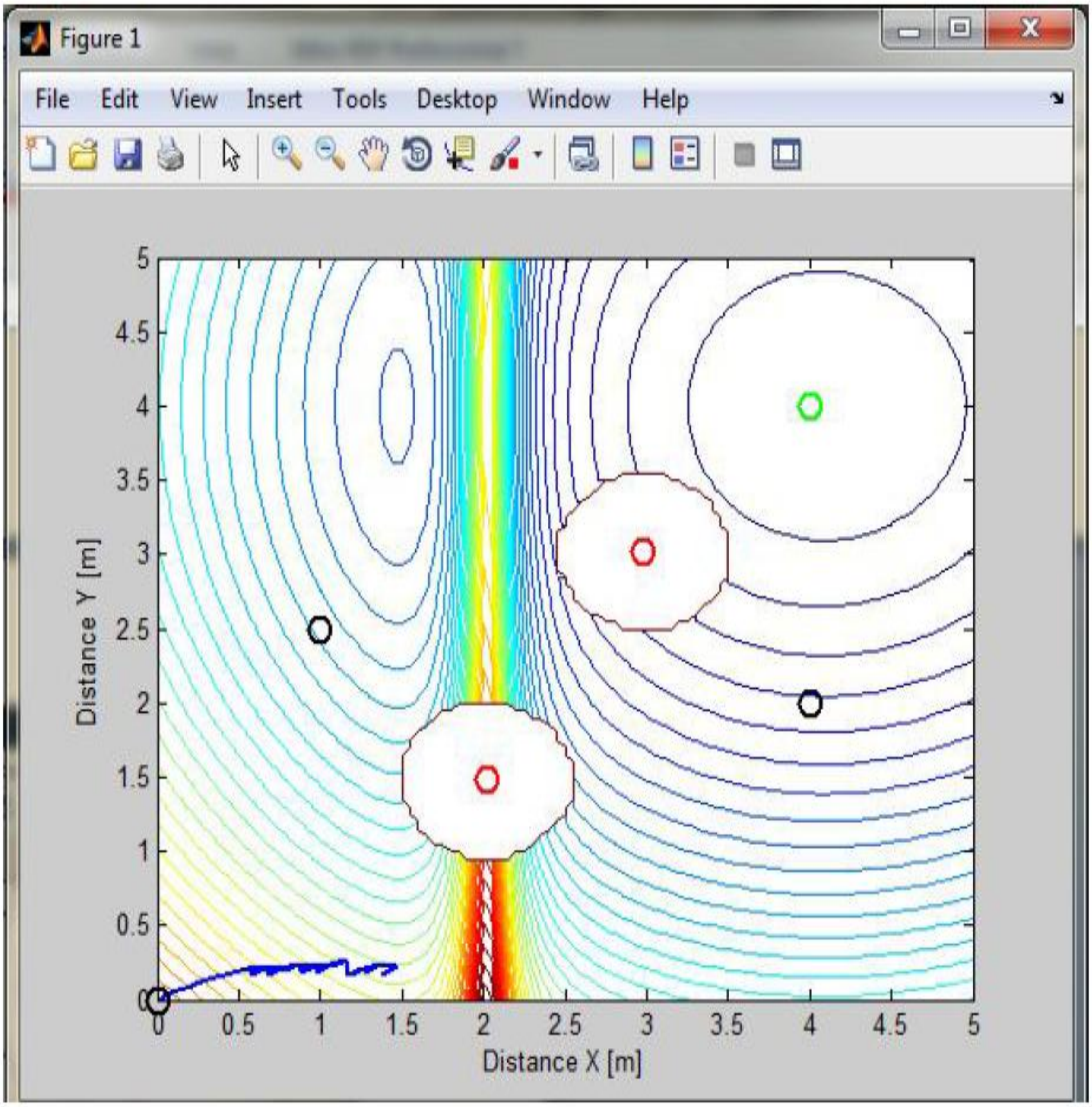


Figure 4.12 Proximity to obstacle

The figure shows the progress of the node as reaches the obstacle. Due to entrance in the region of the obstacle, the node changes its trajectory so as to avoid it. After, changing the path, it moves to the destination in a given time frame.

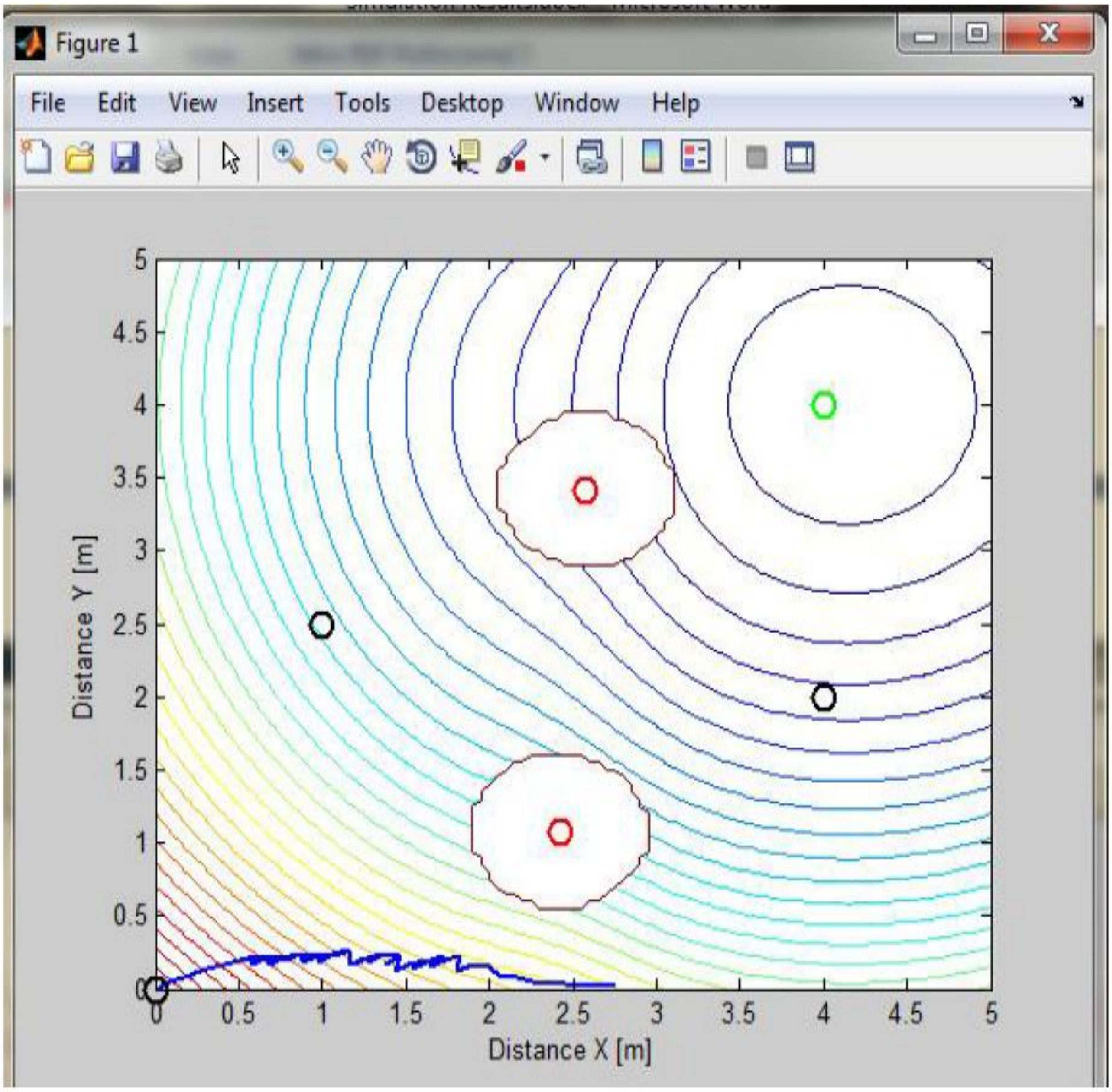


Figure 4.13 Change in trajectory

The obstacle comes in the path of the node, and the node changes its path so as to reach the destination.

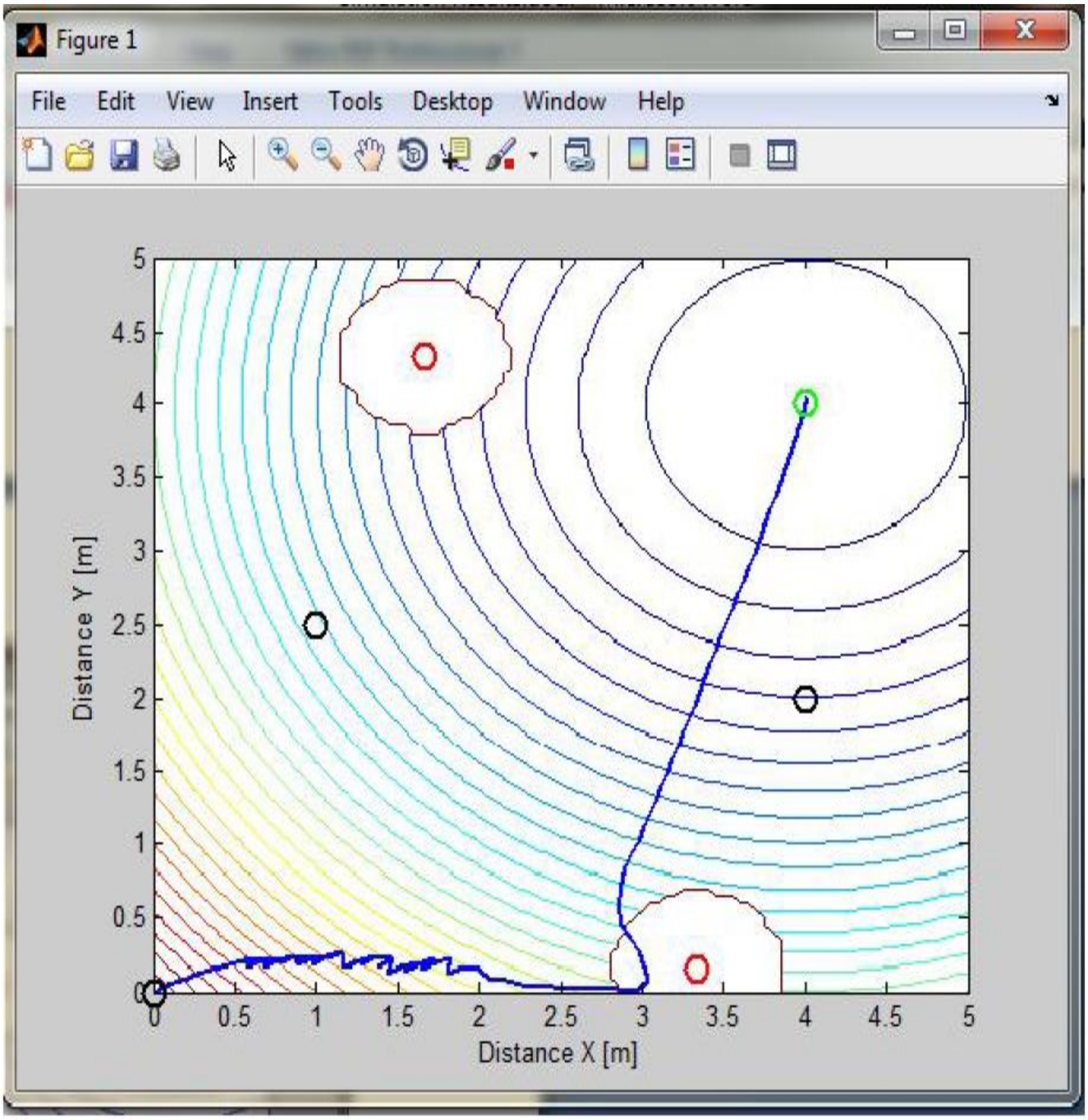


Figure 4.14 Approach to destination

The figure shows that the node reaches the destination after avoiding the obstacle. The results are thus justified. The node has successfully avoided the obstacle

Chapter 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

This thesis aimed primarily at including the obstacles in the simulation environment so as to model the real life situations with that of the simulation, and it was successful. The targets were accomplished with expected results. The simulation scenario provides a base for the underlying mechanisms and methodologies to work properly. In reality obstacles are of varied shapes and sizes thus possessing different dimensions, so while path making decision would be affected by the properties of the obstacle. A lot of improvements can be made to the model by incorporating various real life features. This thesis effectively analyses the various techniques and thereby an improved approach is presented. In this work, various mobility models have been studied, and an improved technique is provided to avoid the obstacles and chose the best path to the destination. The traits of humans including various inherent properties have been studied, games theory based approaches have been analyzed, and finally an improved technique has been proposed for better accuracy than the previous ones. The mobility model can be made effective by assigning priorities to the nodes so that better and more realistic model could be built. Further, a wide variety of mobility models such as for marine environments. Hilly-terrain regions, spatial model such as for air-borne networks can be developed and effectively improved so as to consider the spatial and temporal properties of the space. In our proposed mobility model, obstacle is considered, the primary reason being that it helps in visualizing the areas such as that of used in the military warfare so as to reach a particular target point without any difficulty.

5.2 Future work

In future, a number of advancements can be made to the model, such as avoiding the obstacles having irregular shapes could be integrated in the model. The new modules can be created so as to incorporate the weaknesses in the existing ones. Taking the practical scenarios into consideration, we can come across variety of obstacle which may not be only static but may be in motion. So, it needs a different mechanism to solve this type of problem. Even the obstacles encountered in the real life are of varied shapes and sizes which imply that their region of occupancy is different. The main thing which is to be stressed is that it is not only the type of sensing device that is used but the sensing environment is also to be considered. The sensing environment includes an intricate type of obstacles as mentioned above. A number of possible improvements like assigning certainty values. Consider for example an area in which obstacles are using a specified area or path that is obstacles tend to move in that special region or area, then in that case a certainty factor can be assigned to that particular area, and as soon as the sensor node enters that area, the node should start applying some greedy algorithm, and wait for some time, and move towards the destination. Even the developed system can be further optimized by adding up the real time data packets with the nodes in the network.

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APPENDIX

Glossary of Terms

Adhoc: It refers to on the fly.

Mobilizer: A device capable of inducing mobility.

Modalities: Different means of measuring responses.

LOS Path: Line of sight path.

Target Point: It refers to the destination point.

Voronoi: It is part of computational geometrical algorithms.

Sink: The final place of energy or packet.

Spatial: It is related to space.

Temporal: It is related to time.