WSN Localization Algorithm onUnderground Mining Area

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Abstract*:The main aim or goal of our research work is to localize the workers working in mining area exactly or with minimum localization error. Network formation in mining area is always very crucial. Laborers working in mining area need strong availability of network as when they go down or deep in a mining area they can be rescued easily. It can only be possible when we know the exact location of the worker working in the particular area. For this, we need better localization scheme. Many recent developments have been made in the field of mining area. Random forest scheme, SVM based regressive localization, Wi-Fi based localization, and these are some schemes developed so far. RSSI and Trilateration works for both indoor and outdoor localization. The difference is only in terms of temperature because indoor temperature is different from outdoor temperature. When we are working on the basis of distance and signal strength then the proposed localization algorithm is suitable for hill area too. From the results of simulation, the new localization algorithm proposed in paper with error checking and correction increases the accuracy of the localization in X direction is 99.98 and in Y direction is 99.97 algorithms based on RSSI and dual prediction.*

Keywords: **Biometric System, Attendance Monitoring System, Fingerprint Recognition, Employees Attendance**

1. INTRODUCTION

A significant factor in restricting the growth of the coal industry around the globe over past decades has been the safety issue of coal mines. Coal mine accidents in China happen annually; heavy losses of life and property are due to occasional accidents. Faced with this issue, the implementation of underground mining environmental monitoring [1-4] and the localization of miners would minimize losses and, to the extent possible, ensure miners' safety. Recently, the use of wireless sensor networks (WSNs) has gained a great deal of attention and has become a hot research point in coal mine location system due to its benefits of self-organization, distributed activity, high reliability and low cost[5,6]. Location service is pivotal for the extraction of WSN information. Most of the sensory data with location information is significant, in particular the real-time underground data about the miners' location. Therefore, to understand the exact localization, many localization algorithms and frameworks are suggested to understand different techniques in WSNs. A rather distinct application is the localization of WSNs between the open world and the underground climate of coal mines. In general, in the coal mine tunnel environment, there is a multipath effect and shadowing, so an acceptable approach needs to be chosen to consider the underground location.

In WSNs, two classes include localization algorithms: range-dependent algorithms and algorithms that are range-free. [7,8] The co-ordinates of three reference nodes can be used for range-based algorithms to measure the absolute or relative location of unknown node. The absolute distance, depending on the Euclidean distance, is determined between the reference node and an unknown node. Trilateration is representative of the range-based algorithm, to give an instance. Connectivity knowledge, such as a multi-dimensional scaling map (MDS-MAP) [9] and DV-HOP, is used to achieve localization for the range-free algorithm [10]. At the expense of greater hardware costs, the range-based algorithm is having ability to achieve higher localization accuracy. There is no complicated hardware support needed for the range free algorithm; it is possibly less precise than the range-based algorithm. The trilateration algorithm is used to locate three nodes for the minimum scale, in view of the working conditions in the underground coal mine, and it shows that location area can be divided into few different regions that can be uniquely identified by sequences of signal strength indications obtained (RSSI). These sequences are computed by rating the distances to each region from the reference nodes [11]. The trilateration method spends a lot of time at the production point of the RSSI series; the estimated location matched with the corresponding sequence is determined from the centre of the field at the positioning stage [12]. For the localization of workers in the world of coal mining, this strategy is sufficient. However, position errors are likely to be serious in the neighboring areas. Most possibly, the node's RSSI value is equal to the neighboring regions' RSSI value at the borders of the neighboring regions, causing the field to mismatch. A new algorithm, called the dual prediction algorithm, was suggested to resolve this downside. The notion of dual prediction is to optimize the matched area selection process based on the trilateration technique.

2. RELATED WORKS

In this part, we discuss recent monitoring techniques for underground coal mining utilizing wireless sensor network localization, where multiple localization techniques of the sensor network are described along with their main observations, benefits and disadvantages. The underground method of mining systems control and communication has been studied by Moridi et al.[13] et al. In general, underground mining networks challenge complex terrain, and problems with reliability and effectiveness can be caused by changing the topology of the network. Through using the ZigBee networking system in this job, automated control processes are updated. This research shows the benefits of ZigBee in managing underground mines.

In addition, the attenuation of ZigBee radio signal is also studied, which helps to get optimal distance for curved and straight tunnels for ZigBee node placement. Improved performance is seen, but the key downside to the work is that it may be applied to short underground ranges of monitoring, and a challenging problem is also the cost of implementation. A novel blended approach to underground surveillance using ZigBee and Wi-Fi contact models has been proposed by Wang et al.[14]. The main purpose of this research is to split the study focused on the equal use of network resources where ZigBee can be used to use various data types to distribute Wi-Fi strategies. Information is transmitted over the ZigBee network according to this method, and video and audio information is transmitted over a Wi-Fi network that has no video, audio and picture information of any sort. This realization of data transfer helps save transmission resources and helps to decrease the use of energy during the transmission of data. Likewise, Bedford et al.[15] assessed underground mine monitoring problems and proposed low-cost ZigBee-based components utilizing radio frequency (RF) techniques for location estimation. In two tunnel cases, where different conditions are met for location-based techniques, this study is taken into account. Time of flight calculation technology is used to estimate the precise location. This research demonstrates that RF waves suffer from distinct interference with the shape of the microwave network deployed in mines. These localization and underground coal mine monitoring systems can be implemented for coal mine monitoring purposes, based on RF communication, ZigBee communication and Wi-Fi but the cost and complexity of implementation in this field remains an unaddressed issue. For the control of underground coal mines, the Ultra Wideband (UWB) networking technology Qin et al.[16] has recently been suggested. Therefore, researchers have introduced UWB systems that are capable of using the time phase of flight measurement to provide an acceptable range for accurate measurement. Prior to this work, the relevance of UWB for real-time communication systems was also discussed Chehri et al.[17].

UWB systems have many benefits, such as low implementing costs, low complexity and critical design, in order to provide time domain resolution that allows for estimating location and monitoring applications. This study aims to locate underground mines, estimate ToA, fingerprint, and positioning algorithms based on area. Wireless sensor networks also play an important role in tracking mine conditions and providing miners with protection in this area of underground coal mine monitoring. A WSN-based coal mine monitoring system Liet al.[18] has been proposed where a Structure-Aware Self-Adaptive sensor network is constructed on the basis of the communication principle of the wireless sensor network. At this point, in the form of a mesh network, the sensor network is deployed and the beacon strategy is used to create contact. In addition, in different situations where environmental conditions are changing, this device is versatile for handling queries. This study shows that, as opposed to other wireless communication systems, the use of the wireless sensor network would have better results for the underground coal mine monitoring system. Multiple studies were presented using the wireless sensor network technique for underground coal mining. Wu et al.[19] gave a thorough routing system using WSN in the underground coal mine industry. Standard WSN protocols are based on the layered protocol architecture in order to isolate the complexity depending on each layer, but optimum efficiency in the layered protocol becomes a difficult challenge. A holistic approach to underground communication to tackle this issue was proposed by the authors.

Bhattacharjee et al. [20] proposed a novel method for monitoring and protection purposes, used for fire detection, tracking and alarming purposes in underground coal mining. This research helps to define the location of the fire and its spreading path, using WSN for the Bord-and-Pillarcoal mine panel. Furthermore, it helps avoid the spread of fire with the assistance of early fire detection. The coal mining control system Chen et al. [21] has been implemented and the direct spatial-temporal relation of coal mine tunnels has been investigated. In this work, the authors concentrated on reducing resource usage and improving the efficacy of underground tunnel monitoring networks. Therefore, along with Bayesian decision formulation, the network node correlation based approach is used. A choice between tunnels and routes is made on the basis of the miners' movement and the Bayesian decision-based method is used to forecast direction in the underground environment. Recently Zhou et al.[22], the mapping of coal mine tunnels using wireless sensor networks was addressed. In WSN, the proper deployment of the sensor node is most critical, which can help obtain useful information. The 3D band-type node deployment stage is introduced to cope with this, where different characteristics and features, such as performance sensing, coverage characteristics, redundancy principles, and radio features, are taken into account. In the next step, the implementation of the target node is discussed and, finally, the optimization method based on simulated annealing is discussed to provide optimum performance. In this chapter, a brief overview of recent underground coal mine control techniques is given. We have discussed many approaches in this article, several of which concentrate on ZigBee communication, Wi-Fi and RF communication, etc.

3. PROPOSED WORK

In mining the main problem arises is to locate the exact coordinates of the workers working in that particular area. In various previous papers many researches had been done on localization. To locate the workers exactly many algorithms like Random forest-based localization, Regression based localization and many more had been implemented before.

Here the project is based upon localization and we have proposed a hypothetical model in WSN (Wireless Sensor Network). Like mining area, and considered an area of 100 x 100 sqmeters in WSN. Then assuming random nodes as workers, we deploy in that considered network area. After that, we have applied Trilateration Algorithm to find three nodes at minimum distance [23]. The nodes which are at the least distance are considered to be estimated value of the target node. The trilateration algorithm forms the three-node relationship and resolves three established relationships from which the target coordinate (x, y) is obtained.

4. LOCALIZATION LGORITHM DESIGN FOR NODES THAT SHOULD BE MARKED WITH VERIFICATION AND ERROR CORRECTION

The anchor node localization is primarily intended to assist in locating the nodes to be measured. The network formation of random node is initialized after that moving object is located then trilateration algorithm is applied to find node at minimum distance after that received signal strength is applied to locate the location of actual node then we apply dual prediction algorithm to calculate the predicted node if the desired prediction node is less than or equal to moving object then prediction accuracy is calculated and if no then repeat cycle.

To complete the localization, the node to be determined requires for applying its localization data frame. The anchor node task is to spread its own coordinates, and task of the under-test node is to complete the storage of the coordinates, time accumulation, and localization algorithm execution for the anchor node. For the nodes that are to be decided, Figure 1 displays the localization algorithm flowchart. After networking the anchor nodes, the anchor nodes will transmit their position data frames in an ordered manner, mainly via sequence trigger mechanism, sending out data frame every 2 seconds of interval. For once, the data frame is transmitted here, mostly to avoid big data conflicts. We need to verify whether the node that has been relocated to be measured has obtained the data frame when finding the data frame of an anchor node. If it does, it is vital to evaluate the total distance of the two data frames. The total number of RSSI values can be stored in such a way when it's small. The localization algorithm can be performed when the data frames from three or more anchor nodes are collected by the node that is to be determined. The coordinates of local anchor nodes require to be chosen at this stage. The higher the hop count, the higher the RSSI distance cumulative error, so that, if necessary, the location data frames of anchor nodes with lesser hop counts should be chosen, in order to guarantee the location accuracy of node to be calculated on network.

The localization algorithm can be performed when the data frames from three or many more anchor nodes are collected by the node that is to be determined. At this point, coordinates of nearby anchor nodes require to be chosen. In order to guarantee the location accuracy of node to be estimated on network, the higher the hop count, the higher the RSSI distance cumulative error, so that, if possible, the location data frames of anchor nodes with lesser hop counts should really be chosen.

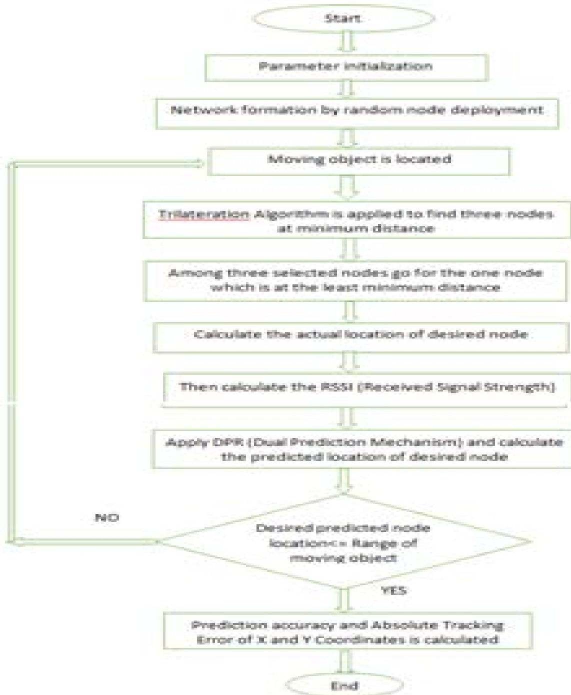

Figure 1: Localization algorithm flowchart for measuring nodes

Trilateration Algorithm

The locations for the estimation of all nodes will be settled at once by planning methodology after all the approximate distances are obtained, because either for the location estimation or the localization algorithm, the algorithm does not have a simple boundary and instead adopts the cross approach. There will be several errors in localization arising from the use of multiple planning solutions. In the propagation process, signals will be attenuated, thus varying across the RSSI value will cause distance errors and, as a result, in the trilateration scheme, the three circles don’t all converge at only one point. The real circumstance could be comparable to outcome depicted in Figure 2.

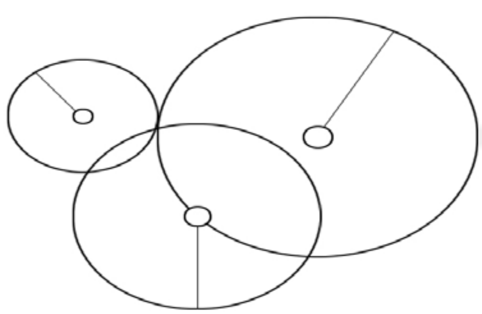

Figure 2: Algorithm of Trilateration

Figure 2 shows that the actual estimate, which is affected by environmental variables, is very different from the desired result. The effects on the external environment's RSSI value are still relatively strong, since there are still unstable variables. There are numerous interference errors in different application settings, and several variable factors affecting the nodes' wireless signal transmission are present in the localization node application environment.

Reviewing the RSSI varying correction model

RSSI is a technology for localization that, using a radio frequency signal propagation model, determines the location of a node. Distance to be calculated between nodes and several anchor nodes is mainly determined by signal attenuation degree, and then, based on the distance calculated, the locations of the node to be observed are estimated. In practical experience, radio wave diffraction is influenced in several ways, thus decreasing the accuracy of localization. The coordinates of all anchor nodes are set by us to be observed as (xi, yi) and the co-ordinates of nodes to be observed as (x, y), which can calculate the different circles along with surrounding anchor nodes, as shown in the following formula.

$$R1= \sqrt{(xi-x)^2-(yi-y)^2}(i=1,2,3\ldots m) \quad (1)$$

When noise interference is not considered, the intersection of these circles, as shown in Figure 3, will be the coordinates of node to be determined. The location of anchor node is defined in such a way that the distance is constant between any two anchor nodes and, as shown in Formula (2), the node to be determined is situated with two anchor nodes on the hyperbola as the intersections with respect to the plane system:

$$R_{i,1}= Ri - R_1= \sqrt{(xi-x)^2-(yi-y)^2} - \sqrt{(x1-x)^2-(y1-y)^2} \quad (2)$$

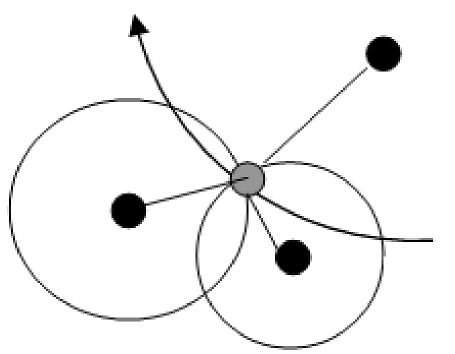

Figure 3: CirclesIntersections

Where i=2,3...M; and M denotes the number of network anchor nodes. The performance of localization is influenced by path loss model's accuracy. The localization accuracy will improve if loss model may correctly calculate propagation distance; otherwise, it will be low. To solve the accuracy problem, we utilize the RSSI-based circular correction technique here. The general design concept is given as: first, the node to be calculated, gets data frames sent by anchor nodes around it and the localization algorithms utilized to observe all RSSI values, then sort the node's RSSI values and locate the three anchor nodes among the surrounding ones with the highest RSSI values, and then decide the node's coordinates to be measured. In this way, using the localization algorithm, the node's new coordinates will be estimated and the node's offset position will be determined. Again, from the anchor nodes, the anchor node with largest RSSI value is excluded. -If the node travels a certain distance, to achieve greater precision of localization, the position will be replicated.

Dual Prediction Reporting Mechanism

To evaluate the relationship between the real performance of a unit in a sample and one or more defined unit attributes or characteristics, predictive modeling uses predictive models. The purpose of the model is to assess the probability that the same output will be exhibited by a similar unit in another study. In several nations, this category covers models. Here, we suggest a dual prediction-based reporting system in which the future movements of mobile objects are predicted by both sensor nodes and the base station [24]. Sensor reading transmissions are avoided as long as the forecasts are compatible with the motions of real objects. One of the most potent applications of the wireless sensor network for moving object detection is the dual prediction-based reporting mechanism. We investigate the influence of various device parameters and moving actions of tracked objects on the effects of dual prediction-based reporting mechanisms [25].

The objects are located by the RSSI and we find the location of the worker. The exact location is finding or not we see in it. After that we have applied DPR (Dual Prediction Reporting Mechanism). Prediction mechanism utilized in the proposed method is linear prediction method that estimates the next predicted location of target. This mechanism predicts the next objective position using the present and earlier goal positions. Use the i and i-1 (x_i, y_i) and (x_{i-1}, y_{i-1}) node coordinates at t_i and t_{i-1} of the target velocity *v*.

$$v = \frac{\sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2}}{t_i - t_{i-1}} \quad (3)$$

While direction is given by

$$\theta = \cos^{-1} \frac{(X_i - X_{i-1})}{\sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2}} \quad (4)$$

The predicted position of the objective is calculated after the defined time t (x_{i+1}, y_{i+1}) using the target velocity and direction and is given as:

$$X_{i+1} = X_i + vt\cos\theta \quad (5)$$

$$Y_{i+1} = Y_i + vt\, sin\,\theta \quad (6)$$

If the predicted location reading is within the range of an area of that object, then it is selected and considered as predicted value or coordinates of the target.

Now the absolute error is calculated considering the estimated coordinates and the predicted coordinates of the target worker. In our project the error is calculated in both x direction and y direction. For localization to be success, the error should be as minimum as possible.

5. RESULTS AND DISCUSSION

The RSSI-based triangular centroid and dual prediction algorithms and localization algorithm with error checking and correction implemented in this paper are evaluated in sense of anchor node number and contact radius via simulation test. Figure 2 shows the variance curves of the three localization algorithms' average localization errors under different anchor node numbers.

Here the all the graph shows all the results along x direction and along y direction.

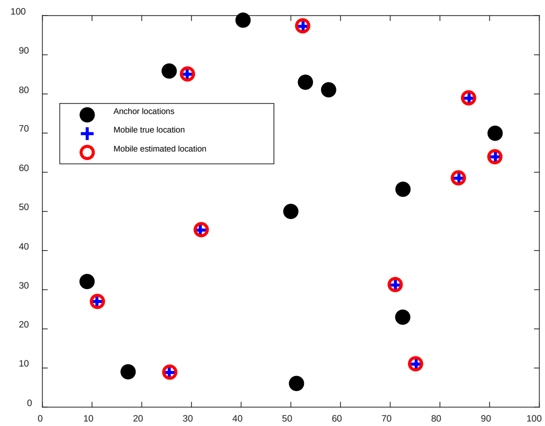

Figure 4: Mining project graph for detection of location

The figure 4shows the anchor node location, mobile true location and mobile estimated location. This above figure shows three types of symbols where black circle shows the nearby location of the worker. The red circle shows estimated location of the worker in the mining area. The plus symbol shows that we have got the true location of the worker so it is inside of the red circle.

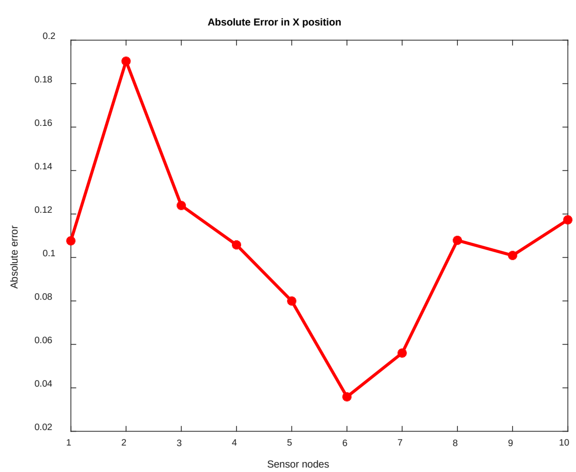

Figure 5: Absolute error in X position

The absolute error in X position is given by figure 5. Here the error has been estimated in one direction and in the other direction the sensor nodes has been taken. In our graphs the error in the figures is minimum so that the location of the worker can be measured accurately with the applying of RSSI and dual prediction algorithm. The prediction accuracy in X position is shown in figure 5 that is nearly 99.98 that is close to 100 so that the exact position of the worker can be measured in the X direction.

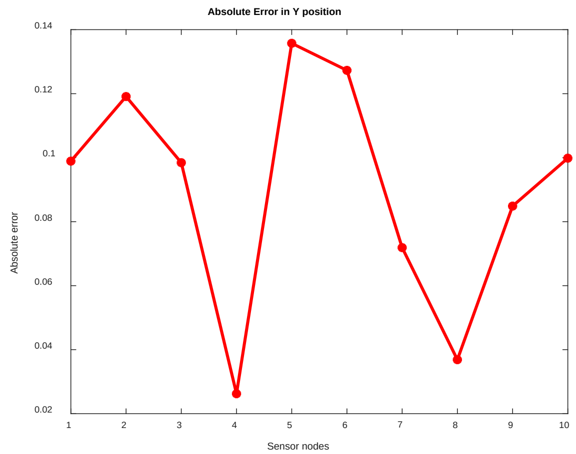

Figure 6: Absolute errors in Y position

The figure 6 shows absolute error in Y direction. Here the absolute error has been estimated in one direction and in the other direction the sensor nodes has been taken. In our graphs the error in the figures is minimum so that the location of the worker can be measured accurately with the applying of RSSI and dual prediction algorithm. The prediction accuracy in Y position is shown in figure 6 that is nearly 99.97 that is close to 100 so that the exact position of the worker can be measured in the Y direction.

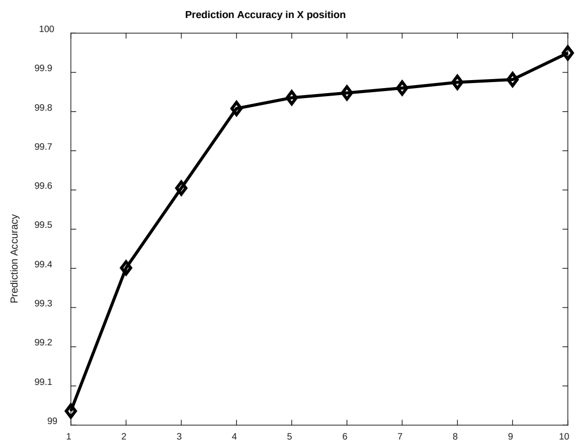

Figure 7: Prediction accuracy in X direction

The above figure 7 shows the prediction accuracy in the X position that is nearly 99.98. This shows that we have minimum error to calculate the position of the workers. The figure 8 shows the prediction accuracy in the Y position. The accuracy to find the position of worker is nearly 99.98 that is close to 100. So that the accuracy in Y position and X position calculated accurately and location can be measured.All the graphs are based on simulation results where anchor location, mobile true location and mobile estimated location is given in figure 4. After that the location in X direction and Y direction has been estimated. The absolute error in X position is given in figure 5 and absolute error in Y direction in figure6.

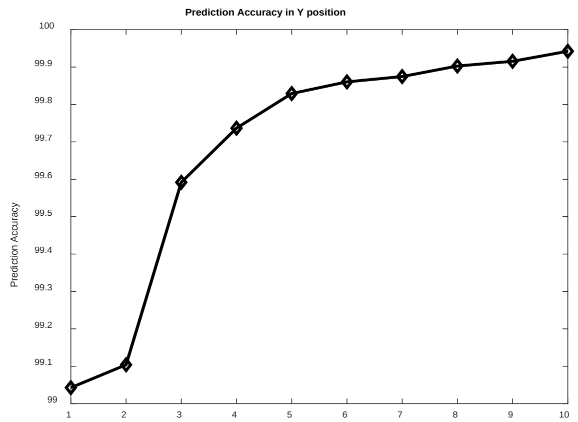

Figure 8: Prediction accuracy in Y direction

In our graphs the error in both the figures is minimum so that the location of the worker can be measured accurately with the applying of RSSI and dual prediction algorithm. The prediction accuracy in X position is shown in figure 5 that is nearly 99.98 that is close to 100 so that the exact position of the worker can be measured in the X direction. The prediction accuracy in Y position is shown in figure 6 that is nearly 99.97 that is close to 100 so that the exact position of the worker can be measured in the Y direction. So that all the simulation results can be shown that the worker position can be exactly found in the mining area.

6. CONCLUSION

In wireless sensor network applications, a primary technology for node localization technology is and it is primarily used in all aspects of the lives of people. In recent times, with the perpetual growth of smart networks and communication technologies, the precise positions of target artifacts are very crucial for all networks monitoring, and its research in science significance has even been given widespread scholars attention. This paper allows several changes to the traditional localization algorithm since there is a rather unreliable conventional localization algorithm and the position error is high, but more importantly, it reduces the range of algorithms and location measurement errors and improves the WSN node's localization accuracy. The RSSI algorithm and Dual prediction algorithm used to find the workers location. Here the accuracy is very good that is shown in figure 7 and figure 8.

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