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Research Article

IMPROVING MOBILE ROBOTS TRACKING AND NAVIGATION THROUGH INCREASING VELOCITY AND ACCURACY IN SENSOR NETWORK DATA

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ABSTRACT

By advancement of science and technology use of robots is an inevitable issue in human life. Different sensors are used in robots structure that each one undertakes a transmission task in a certain signal. In this context some sensors are available named joint. These sensors are composed of an incremental encoder. The moving part of encoder is connected to motor shaft. Mobile robots are one of the mechatronic research contexts which have indicated a lot of research in different contexts. Considering the objective of study aiming to improve mobile robots tracking and navigation through increasing speed and accuracy of sensor network data, in this study the Matlab software is used for analysis of obtained data. Thus, obtained results from ant colony algorithm are transferred to antcolony and the outputs are investigated.

INTRODUCTION

By advancement of science and technology use of robots is an inevitable issue in human life. Considering different utilities as well as availability in places inaccessible for human, these robots can have a strong driving force which in addition to high abilities can be handled and guided.

Within robots structure, different sensors are used that each one undertakes the task of transmitting a certain signal. In this context, some sensors are available named motor. These encoders are consisted of two channels with 500 lines and one channel with a reference line. Reference lines for measuring in this structure are obtained through optical obstacles. Other sensors which are used in this respect are force sensors. Biped robots benefit two six axial torque-force sensors. These sensors are located in the robot's leg place. The produced forces and torques are identified during motional activity by simulation programs. Mode sensors contribute effectively in robots structure. Robots' rotation is determined using combination of gyroscopes and accelerometer. Accelerometer sensors present correct signals in static phase (Loffler, 2003).

Similarly, there are noticeable points in control of mobile robots which urge researchers to conduct various studies to obtain their objectives; among important issues within such robots are speed and accuracy in robots' performance. This is not possible unless one consider some measures for guiding and evaluating sensors, network data, because thee sensors in spite of the fact that they have high efficiency, they have short life, and the same reason has bearing on the performance of robots. Current study attempts to consider ant algorithm which is one for energy preserve and storage for assessing sensors performance and it is effective for improving mobile robots navigation and tracking.

Concept and feature of mobile robots

Using robots over recent years is boosted in industrial and academic works. Robots are used in industry when it comes to high accuracy. Similarly, in places dangerous for activity of human being, using robots can prevent industry to people (Jaradat, 2010). Mobile robots are among a class of smart robots able to be used in different environments with variety of capabilities. Among these robots one can point out to menial, nurse, submarine, vacuum robots etc. (Roland, 2002).

Mobilerobots usually should move ins determined environment and reach to a definite objective, for example, one consider a determined objective for submarine robots such as certain point in the bed of ocean for detection. Meanwhile in the movement path of submarine in the bed of ocean, there are a lot of rocks and up and downs to pass through to attain the target. Therefore two points should be noticed for this kind of robots: moving toward the target and avoiding the obstacles (1), this is referred to as navigation. Navigation problem in an unknown environment includes two principal topics: localization and path planning (Filliat, 2003, Mayer, 2003).

Introducing a type of mobile robot

Within this scheme an investigative robot named Chamro is used which has two left and right wheels and is equipped to 9

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infrared sensors (figure 1). The order of robot sensors is shown in figure (2).

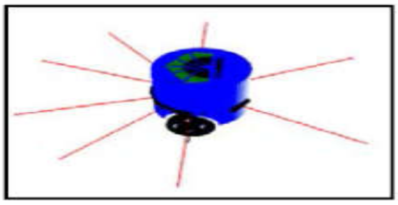

Figure 1

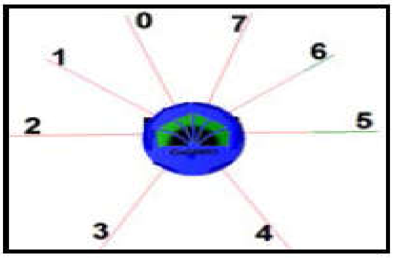

Figure 2

This robot is programmable and can move straightly forward, backward and rotate leftward and rightward. Currently this robot is used for study in the context of mobile robots in Ahvaz Chamran University, department of mechanical engineering.

Infrared sensor is used in this robot. Basis of work of this infrared sensor is that by radiating infrared ray to an obstacle and receiving it back, based on intensity of received ray, a value is reported to processor. As the robot is nearer to the obstacle, more is the value of received ray (figure, 3).

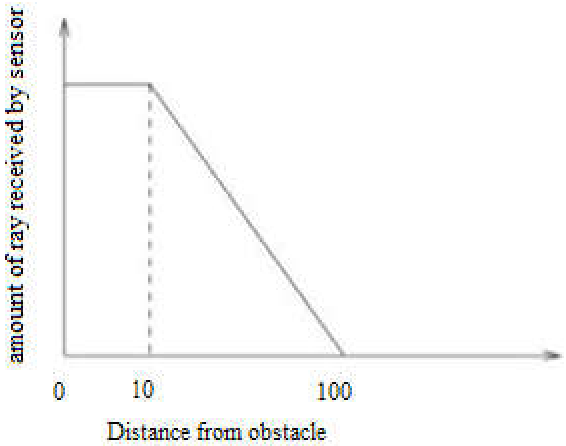

Figure 2 intensity of received ray by the sensor based on the distance of sensor to the obstacle

Robot kinematics is calculated based on equation 1 and 2 (Daee, 2011).

$$\begin{bmatrix} x \\ y \\ \theta \end{bmatrix} = \begin{bmatrix} \cos\theta \\ \sin\theta \\ 0 \quad 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix}$$

$$v = \frac{r}{2}\,(\omega_r \quad \omega_l)\ ,\omega = \frac{r}{L}\,(\omega_r \quad \omega_l$$

Within these equations, v Stand for linear velocity of center of robot forward. X, y represents absolute speed of robot along global axis and theta is rotational velocity of entire robot denoted by ω. $\omega_r$is rotational velocity of right wheel and similarly ω_l is that of left wheel. Theta is orientation angle of robot with respect to north axis (Z axis). These variables are shown in figure (4).

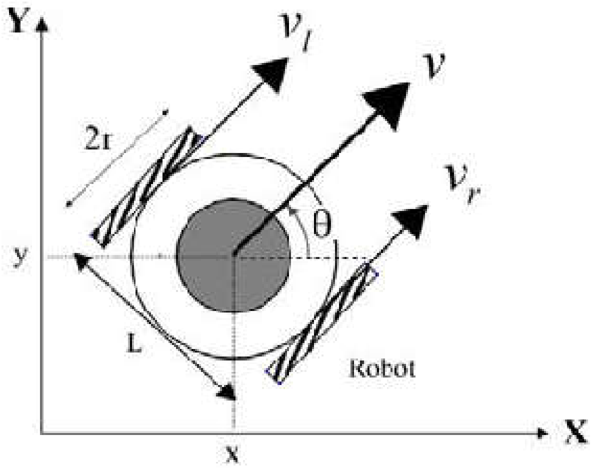

Figure 4 robot variables in global coordinate system

Appropriate adoption of a robotic system has a significant bearing on manufacturing and quality of industrial products. These systems work well when adopted in defined and predictable environments. Robotic systems have wide range of applications such assembling, packaging and object displacement. These iterative general processes are carried out instructured environments (an environment that the objects within it are placed in determined positions and directions). Design of structured environments has significant impact on cost and time of developing a robot application, as it has direct relation with robot flexibility (one of key features of robot). If robots can operate smartly based on sensed and known information, then the need to determined operational environment is reduced and robots would have more freedom with respect to unknown environments and changes in environment. Robotic systems are divided into two classes when it comes to type of development: 1- mobile robots which can freely move in any direction 2- robotic arms which their base is fixed in a place (Alavi *et al*, 2011).

Robots with moving base

In moving base robots, produced forces and torques in base arising from movement of robotic arm may give rise to instability of base and put the system in undesirable condition. Considering the robot application and environmental conditions operating in it, different methods are proposed for minimizing these reactions (Fattah in 2003 and S.K Arawal and Fatteh in 2004) using balance masses and mirror mechanism for eliminating reactions, one recommend that by keeping the mechanism center of mass still in the connection point with the base, the reactive torques and forces are eliminated. In another method, for reducing the reactions and dynamic balance of mechanism of robot, balance masses are used together with balance springs. Installing some robot actuator in base and designing the movement path of robot arms is proposed for the condition in which actuators eliminate the reactions of each other. Using simultaneous control of base and robot movement, reactive torques is eliminated in planar robot system. In another method, using kinematic redundancy for planar robot the movement path is designed without reaction. In (Garg, 2002 and Huang 2006) the design of movement path of reaction minimum is presented by optimization methods. Reaction free movement path are obtained by noise map, and by developing obtained noise map and by movement of final effect or on these practices, no reaction would be transferred to the base. In (Huang, 2005, 2006), one suggest using balance robot for eliminating noise arising from employer robot that by this method the noise stemming from movement of employer robot is neutralized by balance robot. Presented methods of using balance mass, the auxiliary arms for transferring motion of base to final effect or and balance robot give rise to increase of overall system weight which is not desirable.

Therefore, using methods for movement path design is appropriate for spatial robotic systems. In a study, a spatial robotic system with two arms installed on each satellite is selected for examining reactions. Through extracting motion and momentum equations, the reaction empty space algorithm is established for reaction free motion path planning is presented in robot joint space and by extending empty space algorithm the necessary condition is provided for pursuing the zero reaction potion path from start point to given final point. The extended algorithm is called extended zero reaction space algorithms. This research showed that robot motion in reaction free space, angular momentum and position variation and satellite situation is zero.

Neural network in robotics

In fact, a neural network in robotic is a tool that enable robot to do complicated operations, here neural network is considered by smart and cognitive works such as learning and optimization. In fact, problem of navigation is a mélange of cognitive learning, decision making and rapid reaction. For solving these problems one can use fuzzy logic and neural network (Song & Lin, 2006).

These methods are highly efficient and useful when it comes to robot with uncertain, imprecise and insufficient data from environment. However, processing imprecise, particularly noisy data using neural network is highly more efficient that classic ones, because neural network is drastically resistance against noise (Bekey, G. A. & Goldberg, 1993). Learning within neural network can be carried out in supervised or unsupervised manner. In supervised learning the network draws on classified pattern, while in unsupervised learning the minimum available information is used without classification. Unsupervised learning algorithms are featured by less computational complexity as well as less accurate than supervised learning. Sometimes researches draw on both supervised and unsupervised network to use sonar ultrasonic sensor for navigation in the form of sonar ring. Due to some problems that this sensor has in some structural conditions of environment and similarly overlapping of adjacent sensors, the URG04LX scanner laser sensor and combining it data with sonar is used (Mavaei *et al*, 2007).

Dynamic model of spatial robotic system

Dynamic model is basis of simulation which is used for motion planning and controlling.

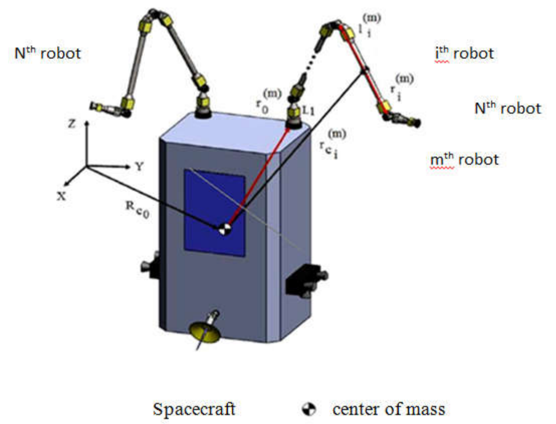

Figure 5 spatial robotic system

Figure (5), dynamic model of spatial robotic system with n robots and each one with Nm degree of freedom is illustrated. Base has 6 degrees of freedom where its three degrees of freedom is associated with position and other three with its state. In general system degree of freedom is $k = 6 + \Sigma^{\nu}_{\mu=1} N_m$, all joints related to robots are of rotational type. First hypothesis is relation to work environment of spatial robots. space robots are designed for operation in an orbit outside of atmosphere and considering orbital speed and centripetal cancelations arising from it, the impact of gravity is eliminated. Therefore in model formulation, there is ant any terms for gravity torque and force and theses terms are equal to zero. Similarly, it is presumed that robots' arms are rigid and their flexibility is insignificant, thus non-rigid effects of arms are not taken into account. Robots installed on the satellite base are modeled in the form of kinematic open arms (Musavian *et al*, 2011).

Velocity in motion

Real time production of balanced motions for biped robot for moving within compound paths currently has significantly attracted the attention of researchers. One of the criteria for maintaining the dynamic balance of biped robots is ZMP criterion which is introduced by Vukobratovic (Vukobratovic& Borovac, 2004). Advanced robots such as ASIMO produced by Honda firm draw on this method for keeping balance. Zheng *et al* in 1998 studied the static and dynamic motion of biped robot on the sloped surface using ZMP criteria. Fajita, K. Tami, examined the robot control in hard paths through inverse pendulum. Above mentioned researched address the motion production in offline manner while biped robots are needed to produce stable motions and appropriate to new conditions in offline manner. For the same reason, researchers paid attention to soft computational methods. Among these researches one can point out to Salatian's works (1991), Pratihar *et al* (2005), who addressed simultaneous stable robot motion on stair using neural network. Producingstable motion and planning for climbing and descending on inclined plane is carried out using GA-NN, GA-FLC by Vundavilli (2010).

RESEARCH METHODOLOGY

Firstly required information are collected by library studies and over conducted studies tracking and navigation of mobile robots are addressed in terms of speed and accuracy increase in data collection through wireless sensor networks by emphasis on Ants colony algorithms. Proposed method in this study has been adapted by ant colony algorithm. Suggest solution should carry out a safety mechanism for resistance against some attacks which occur further in sensor networks rather than in normal wireless networks, because sensor networks are a part of hostile environments which are subjected to a lot of attacks, such as statistical disturbance, eavesdropping and physical attacks. In the following, results from this study are address regarding tracking optimization based on ant colony algorithm.

Robots tracking based on accuracy and velocity

One of methods presented in increasing velocity and accuracy within robots is path selection, as motion planning refers to avoiding from encounter that is a major challenge for robotic science researchers. Different schemes are presented by researchers that while differentiating from each other all are featured by various requirements such as pursuing shortest and smoothest path or minimizing the processing time. One of these systems attempted to find rapidly a smooth path with lowest computational cost (Rodriguez *et al*, 2015).

Robocop performance planning is one of the most important algorithms in which the issue of accuracy and velocity is addressed, thus Robocop is a quick and strong need for developing path planning algorithms in complicated environment. This global innovation caused that researchers from all around the world present their best advancements in the field of robotics, artificial intelligent and related contexts. Based on robotic innovations, every year several tournaments are held in different countries around the globe, therefore teams participate within different conditions.

Ant Colony Optimization (ACO)

As we know, problem of finding shortest route is an optimization problem that sometimes solving it is highly difficult and time consuming. If the number of cities is n, in general this problem is of (n-1) order and for only 21 cities it takes really long time.

$$Sm20 = 2.433 \times 10^{18} \times 10$$
$$= 1.7 \times 10^{13}\ day\ \ S = 2.334 \times 10^{16}$$

By conducting dynamic programming algorithm for this problem, the time is obtained in exponential order and this is not appropriate. However other algorithms are presented, but no one had the appropriate efficiency.

Ant colony algorithm

Ant colony algorithm was presented for first time by Dorigo as a multi-agent solution (Dorigo, 1992). This algorithm is inspired from food seeking behavior of some ant species around their nest with a random explorer behavior. As soon as the ant finds the food source, it evaluates it and brings back some amount of it to home. In the return path, it leaves a sequel from pheromone on the ground. This left pheromone which its amount depends on quality and size of food source directs other ants toward the food. Indirect relation between ants, i.e. using the pheromone sequel enables them to find the shortest route between food and home. Ant colony optimization metaheuristic is shown in figure (6) (Socha, K & M. Dorigo, 2008). After determining parameters and initiating pheromone, algorithm is iterated in a main loop in each iteration all ants make solutions, these solutions are fostered in a local search (these options are noncompulsory) and finally the pheromone value is updated.

Ant Colony Optimization metaheuristic

while termination conditions not met do
ScheduleActivities
AntBasedSolutionConstruction( )
PheromoneUpdate( )
DaemonActions( ) {optional
end ScheduleActivities
endwhile

Figure 6 ant colony algorithm metaheuristic

A review on smart routing protocols within wireless sensor networks

Routing protocols are divided into three groups, i.e. data centered, hierarchical and location based protocols. Over recent years, by development of smart calculations, routing protocols are based on smart algorithms. Smart algorithms present adaptive mechanisms which can yield a smart behavior in variant and difficult environments which cause that the many to one distribution of real time algorithm design to be feasible. Some algorithms should operate well in certain conditions such as communication disturbance and motion topology changes. GA and NNs have high processing load and usually draw on centralized applications. FL is used for routing implementation and links clustering (Bayan & Littman, 1994). In this case, the presented solutions are not optimized and it calls for fuzzy rules so that in case of topology change learning would be carried out again. ACO is highly flexible, however it brings about high traffic that is used in ant sending and returning. RL perform best in routing and is carried out by least operational cost and it is first option when it comes to high flexibility and low cost (Barbanko *et al*, 2006).

Optimized ARA for WSNs

In WSN, terrific pattern is in many-to-one mode when sensor nodes receive environmental values and send them to sink nodeorbase station. Thus, using routing algorithm of normal antsis not efficient for establishing routes between each sensor and base station, because sending FANT by each brings about overall costs and energy consummation, similarly the network lifetime decreases, because FANT distributes and propagates through flowing process. Thus in this study it is attempted to detect route based on station which send a FANT alternative to all sensors in network to be able to notify sensors in network from route to base station , before waiting for Fant from each sensor which this is highly costly, especially when it is considered to increase number of sensors.

In this example, ants routing algorithms allow the sensor to send a FANT for establishing rout of base station by performing this operation by base station. FANT alternation is used in terms of duration by sensors for sending environmental values to fixed base station to facilitate the access to routes.

Forward ant (FANT)

Like conventional ant colony routing algorithm, forward ant is sent for detecting all potential routs between start station and each sensor in network. Fant is dispersed in entire network and examine each sensor in network, similar to actual ants that by inspecting the middle node gives rise to internal value of pheromone ($\Delta\varphi$).this suggested ants colony routing model attempt to influence on sending FANT to base station. FANT is responsible of notifying sensors in throughout network with respect to location of basestation. Thus each sensor is identified in the network a route which is ended to base station and repeatedly run the FANT program. For preventing from routing loops and waiting network resources, FANT is run by each sensor once using unique sequence which influences on new FANT. Thus, each sensor specifies the number of sequences that are or are not run so far when it does not receive the FANT. If the FANT is not run, it is distributed throughout the network to reach the network margin, otherwise it is neglected.

Backward ants (BANT)

In a conventional ARA, BANT is produced by target node in a reverse route, and it issent by FANT to determine the final route between start point and target. Like FANT, BANT modifies the amount of pheromone by adding a constant amount of pheromone ($\Delta\varphi$)in each middle node. In optimized ARA, BANT is sent by each sensorafter receiving the FANT from basestation and after a predetermined delay for hindering crowding in the network. Any middle node decides for BANT next hub based on calculated probability using artificial pheromone in pheromone equation that is discussed in previous section.

ARA safety

Safety is a highly important issue within wireless networks due to audiovisual nature of media that allows them to modify the exchanged data in network neighborhood. Thus, using safety scheme for protecting exchanged data against outer attackers is of high importance. As a consequence, one should launch the symmetrical encoding key to be able to encode the ordinary traffic in base station. This study suggests that for keeping the safety of these networks, BANT are sent to sensors to base station. For implementing the features of safety scheme in ARA one assumes that:

- The base station has a pair of key which is used for confirming base station by sensors.
- Each sensor has ability to store of minimum general key of base station and key used for encoding data.
- Each node of sensor receives general key of base station before establishing an offline communication.
- For adopting encoding keys between sensor and base station, sensor during receiving FANT carries out the handshake method and by producing a random symmetrical key, this key is encoded by general key of base station and it sends that to BANT.
- This study suggests that symmetrical key should be encoded by general key of base station to ensure the safety of this key, because only base station has valid private key for encoding this message that ensures its importance, integration and correctness.

BANT is used as backup for keeping the poser of sensor battery, because each sensor needs only one encoding of symmetrical key with general key of base station which it is not important in terms of energy consumption. After receiving BANT by base station, all keys of encoding are restored in global table which is for identifying each sensor and safe relation with it. For performing safety, updating active key in an alternative manner is done by sensor. This updating can be done by mentioned handshake. Duration of updating key is defined in terms of complexity of used encoding algorithm and size of key nature of establishing environment is taken into account too.

Using encoding of elliptic curve coding (ECC) on Mica2dots particle the 22.82 mJ Berkeley/Crossbow platform is consumed by a 160 bite key. Therefore, for coding symmetrical key of 64 or 128 bites, the total energy will be 22.82 mJ. Comparing with other schemes, in Lee *et al*, 2007, it seems that distribution scheme of proposed key is more efficient than considered routing for accessing to primary handshake.

Optimal ARA analysis

Energy consumption

Energy cost of each routing protocol is specified by required energy for transmitting and receiving protocol messages by each sensor such as FANT and BANT. General size of FANT and BANT in ARA is nearly 5 bites, using dots2Mica of Berkeley/Crossbow platform; transference of general bite of data requires 52.2 µJ and 28.6 µJ for receiving. Thus transmitting and receiving BANT and FANT requires 269 µJ for transmitting and 143 µJ for receiving. For scalability test OARA, network size was changed from 9 to 100 and then consumed energy required for routing has been evaluated in ADOVA, ordinary ARA and optimized ARA.

Figure (7) depicts the energy consumption of route detection in three routing algorithms i.e. AODV, ARA and OARA. One can observe that ARA showed best results with respect to AODV (Perquins *et al*, 2001), because its energy consumption is less for routing. In other word, OARA showed better energy consumption than AODV and ARA.

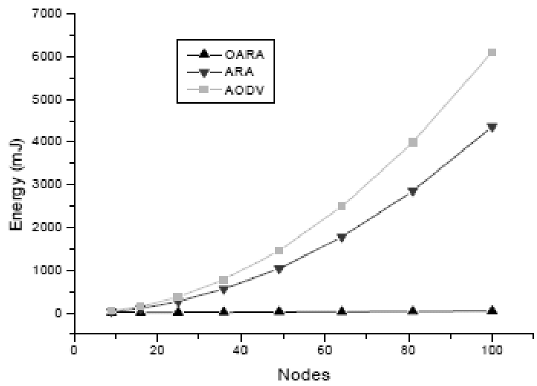

Figure 7 Routing energy consumption

Since traffic pattern OARA which is presented for wireless sensor networks in routing, is so that for each sensor always transmits the equal number of FANTs to any size of network. In the cases of AODV and ARA, number of FANTs and route demands increase by expansion of network, because each sensor carries out the routing solely and this is not possible for wireless sensor networks with large scale. This suggests that OARA scales increase by network expansion effectively in terms of route detection mechanism which brings about traffic pattern of wireless sensor network.

Scalability

This index is related to possibility of keeping equal performance of network considering the overall cost of network and energy consumption in terms of network expansion. This is an important issue because future sensor networks will increase in terms of dimensions and size so as to be able to receive thousands of sensors in the region. As it has been proved through simulation, it seems that OARA is related to network expansion, because each sensor runs equal number of FANTs and BANTs for each routing which keeps the performance of network in a constant level.

Securit

Security of a routing protocol is defined in terms of its capacity for ensuring data and network data reliability. In OARA, symmetrical coding key between each sensor and base station is used that it is used for coding of ordinary traffic to ensure the data reliability and comprehensiveness. Confirms sensors and base network is ensured using coding general key, because only base station is allowed to have the valid key for coding messages which are sent from sensors. Similarly only allowable sensors have valid general key before establishing which ensures the mutual correctness between sensor and base station.

RESULTS

Simulation results

In this part, results obtained from simulation for Ant colony routing algorithm are used. This algorithm is tested by Matlab software. Number of sensor points scattered throughout the network are 50.

The environments in which sensors are propagated and different routes between nodes are depicted in following table.

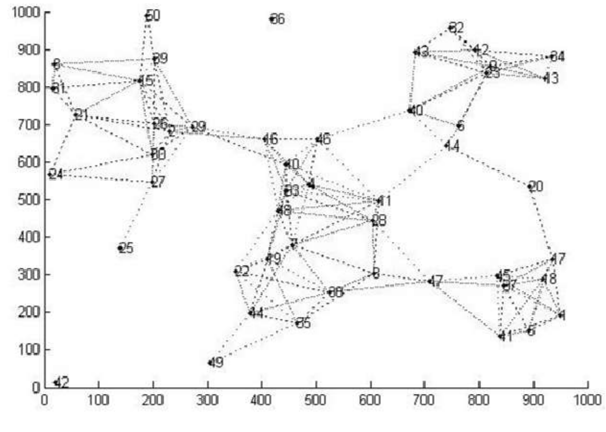

Figure 8 WSN environment

As it is shown in above figure, environment of wireless sensors network is $1000 \times 1000\ m^2$, here the routes that distance between them is less tham 200 m are shown by dashed line. By establishing information such as name, number of nodes, type or weight and coordinates of nodes of sensor network one can give this information to ant colony algorithm for analysis. After applying ant colony algorithm, routing sensors existing in network environment takes place as follows:

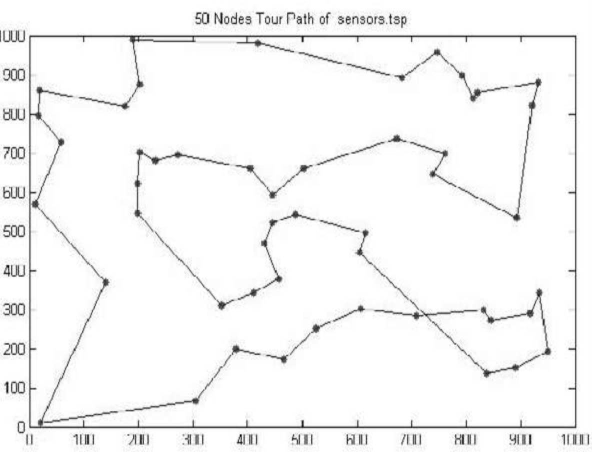

Figure 9 determined route for WSN by ant colony algorithm

In above figure on can observe that ant colony algorithm has selected best route between existing routes in network.

Figure 10 shows the best optimization of cost function namely least value of cost function for each step of algorithm iteration.

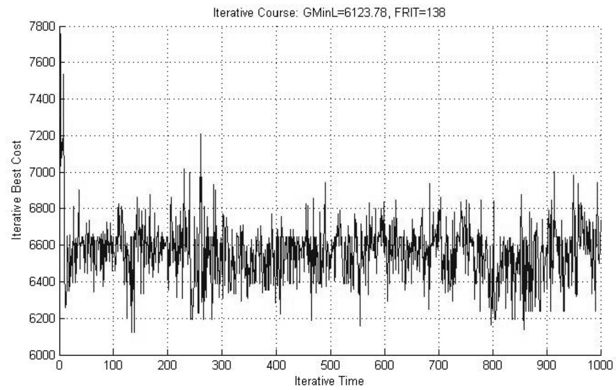

Figure 10 best optimization of cost function namely least value of cost function for each step of algorithm iteration.

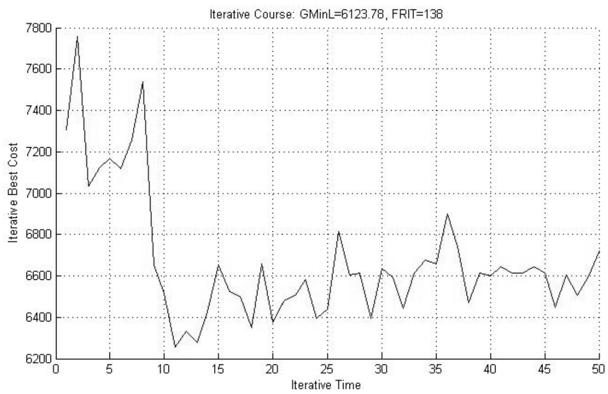

Figure 11 cost function optimization

One can observe in above figure that ant colony algorithm is minimized nearly after 10 step of iteration of cost function. In proposed algorithm the problem of nodes routing is solved1000 times. In this run one can note that among 1000 iteration, the algorithm calculate the least cost sum in 138th iteration. This value equals with:
GminL=6123.78

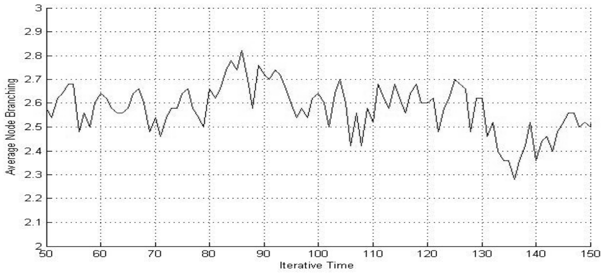

Figure 12 shows the average of nodes branching in iterations.

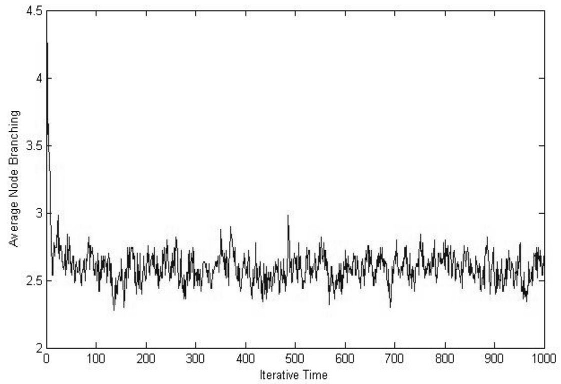

Figure 13 average node branching

As it is depicted again in 138th iteration, the algorithm reaches to the least route or in other word, in 138thiteration; average of routes of each node assumes a value up to nearly 2/3 which is the least possible value.

CONCLUSION

Results have shown than a routing algorithm based on ant colony algorithm is used for data of sensor network. Proposed optimization considers features of data of sensor network, such as traffic pattern and limitation of vehicles. This proposed protocol has bearing on operation of code detection on base station which runs alternatively FANTs. These FANTs are used by sensors for defining routs to base station in a coding manner rather than instantaneous performing the task that consumes the resources of network and decrease network lifetime in terms of FANT audiovisual nature. As it has been observed in simulation, OARA gives rise to enormous energy storage in the network and enhances network lifetime unlike ARA and AODV. Similarly in another section of this paper, examining the application of ant colony optimization is addressed for solving sensor network data problem. Furthermore, a routing algorithm based on ant colony is proposed and efficiency is assessed based on features of sensor network data. Obtained routing protocol called energy efficient ant routing draws on light weighted ants for finding routs between sensor nodes and sink nodes which is optimized in terms of distance and energy levels. These particular ants minimize communicational loads and maximize energy storage which is useful for increasing the life time of sensor network data. Results of tests haves shown that this algorithm results in good outcomes in different scenarios of sensor network data.

Recommendations

- It is suggested that other researchers and experts use this method in their future setups and different research contexts for enhancing quality and shortening the route.
- Comparing result of this method with other presented approaches is postponed to future studies and students and researchers can draw on it in their research plan.
- Similarly, one can examine the application of other methods on this issue and comparing the obtained results with results of this research
- Using other methods of classification and comparing solutions of these diverse methods can be considered as a topic for future researches.

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