A Communication Network Design for Robotics through a Queen Bees Algorithm

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ABSTRACT

This design of network establishes communication between the bunch of robots and control room, through the set of controllers and machine learning core controllers, and uses UHF for internal communication.

Here, the machine learning main controller communicates with the control room through the WI-MAX and keeps control over all slave miniature unmanned vehicles or robots. During the entire operation, it gets the plan and instruction from the control room, as well as it keeps learning the entire situation to handle any critical problem.

Finally, this paper presents a queen bees algorithm and mathematical explanation for control and movement of all robots or Unmanned Vehicles for complex tasks.

General Terms

Robotic Networks; Queen Bees; Unmanned Vehicles; Algorithm, Machine Learning; et. al.

Keywords

UHF; Repeaters; Wi-MAX; wireless Switches; Unmanned vehicles;

1. INTRODUCTION

Controlling a single robot or unmanned vehicles is not very complicated work now days. Although, it is also proved that deterministic robot-network localizations is not so easy, it have a lot of difficulties, shown in [1], And it is still a challenge to communicate with the bunch of automated machines to control them or to assign a particular job to the network node(s). Particularly, when it is done for the complex task such as explosive detection or observation in space, a single automated machine wouldn't be enough to perform the job quickly. This problem directs us to go for a design of the network, which can efficiently control a bunch of miniature vehicles and can solve a set of complex jobs.

The following are the advantages of this system over the tasks done through a single robot or a miniature vehicle:

- Multi Robotic Network design helps to do all the operations faster than a single robotic system.
- This network design helps to distribute the robots in the work area and also to restore them to the origin point.
- Monitoring and handling multi robotic environment is easier like managing a single robot.
- It provides an accurate task results as well as a freedom to perform operation in more broad area.
- It has more applicability when compared to a single robotic environment.

1.1 Introduction to network architecture

The network architecture is divided into four parts as the 1) Machine learning controller 2) Master relay switches with internal transmitter 3) Unmanned vehicles or robots 4) Control room with the core network. All these blocks of network are supposed as queen bee, colony queen bee, and remaining public bees respectively in the introduced algorithm, except the control room and core network.

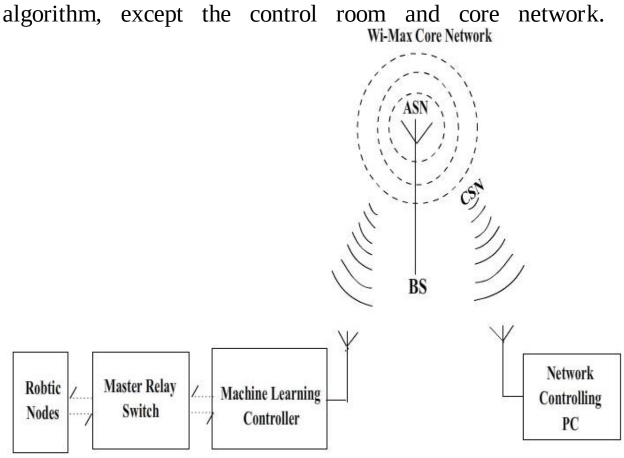

Figure.1: Block Diagram of Robotics Network

1.1.1 Introduction to Machine learning Controller:

Machine learning controller is the one, which gets the all commands given from the control room and sends it to the robots through master relay switches, as well as it gets the task results and passes to the control room. The block diagram of this proposed device has been shown in the figure.3 as the transponder block diagram of machine learning controller. A similar communication system has been also shown in [5]. This has been explained as a bee hive queen bee gives order to the remaining public bees through the colony queen bee, in the algorithm.

1.1.2 Master relay switches and Internal Transmitter:

The work of the master relay switches is to make a path to establish communication between the unmanned vehicles and the machine learning controller. The block of master relay switch for this purpose has been given in figure.1. and, a similar communication model based on UHF has been also discussed in [3]. This device allows each unmanned vehicle to communicate with the machine learning controller serially, and works similar to the switches of the LANs. As well as, it can broadcast any message to all the unmanned vehicles in its own colony using the internal transmitter, which uses UHF waves and has been shown in [3].

1.1.3 *Unmanned Vehicles or Robots:*

These are the leaf node of the network, which follows all the given orders from the bee hive queen (i.e.) machine learning controller, as well as it sends the task results to the queen for further actions.

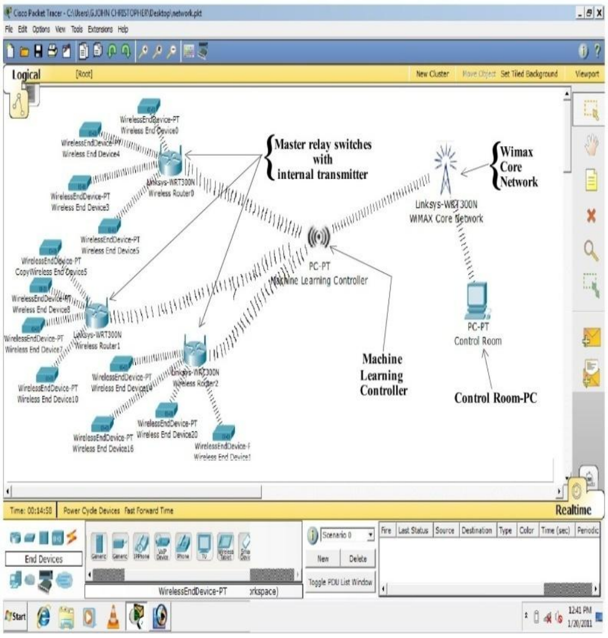

Figure.2 : Model of the Network Design in Packet Tracer 5.3

These unmanned vehicles can be used for solving complex tasks; such as a robotic system has been shown in [2].

1.1.4 *Control Room and core network:*

The control room is the one, which has the authorization for controlling the entire network and to get result for a given task to the network nodes. A control room personal computer has been shown for this purpose in the figure.2. This control room do authentication with the machine learning controllers via secure channels during all the session for retrieving the information. Such communication and authentication system has been shown in [5].

1.2 Queen Bees algorithm for Communication Network:

This queen bee algorithm helps to control and monitor entire network and it defines the way of communication in between all the networks nodes. As well as, it defines distribution and restoration of robots on the operation site.

This algorithm supposes the machine learning controller as queen bee, master relay switch and internal transmitter as colony queen bee and leaf nodes or robots as remaining public bees. And it defines the control of entire communication system

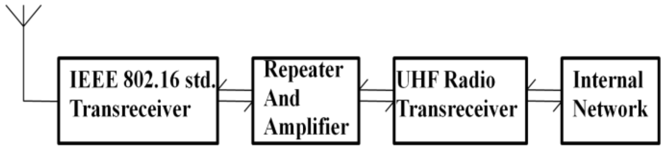

Figure.3 : Machine Learning Controller (Transponder Design)

similar to the queen bees and bee hive. This algorithm has been introduced in the section-III, of this paper.

2. NETWORK ARCHITECTURE

The network architecture for this purpose contains four sub-divisions and the model of the network design in the packet tracer 5.3 is shown in the figure.[2]. And hence, the architecture is divided as hardware and software part of required network.

2.1 Hardware Architecture of Network:

This includes of the control room and core network, machine learning controller, master relay switches with internal transmitter, and unmanned vehicles.

2.1.1 *Control Room and Core network Connectivity Architecture:*

The control room for this purpose uses an IEEE 802.16 std. Receiver for connectivity of core network. The block diagram for this purpose has been shown in the Figure.1.

As shown in the block diagram, the base station (BS) of core network uses the Omni directional antenna and transmits signals in all the possible directions of its range for the control room as well as the machine learning controller, installed with the same IEEE 802.16 receiver. The control room system goes to connect with the network through the ASN i.e. access service network, CSN i.e. connectivity service network; the work of these blocks is to create logical boundary to network access, to provide IP service to the network, and to transmit signal in the cell area respectively. A communication and authentication system for this purpose has been introduced in [5].

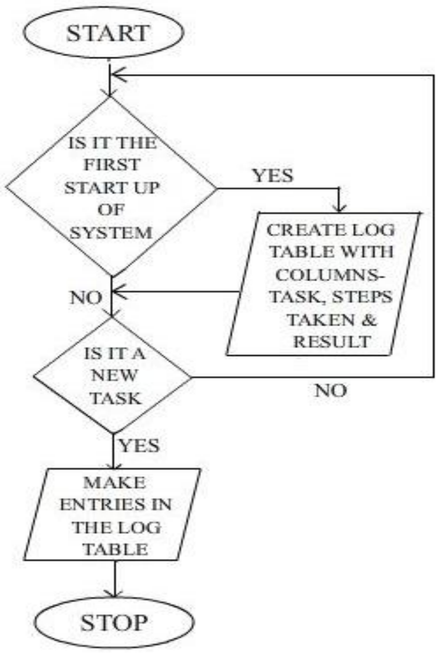

Figure.4 : Flow-Chart for Machine learning Process

2.1.2 Machine Learning Controller:

The machine learning controller contains of the transponder i.e. (IEEE 802.16 receiver and internal UHF radio transreceiver) and internal query analyzer and learner, the flow chart for analyzer and learner processes has been shown in figure.5 and figure.4 respectively. The block diagram for the transponder is shown in the figure.3. Where the transponder receives the signals from the WiMAX core network reconstructs it and retransmits it on the UHF waves for communication with colony queen bee i.e. (master relay switches with internal transmitter). A similar transponder design has also been introduced in [4].

2.1.3 Master Relay Switches and Internal transmitter:

Master relay switch is a network switch, which connects the robots or miniature vehicles to the machine learning controllers. It used to synchronize information with miniature vehicles as well as with machine learning controller in the entire operation by the help of its system clock.

Although, there is a provision of interrupt in the all available blocks. By using that all the system can communicate in case of critical situation. Algorithm for this purpose is given in the section [II.B.3].

2.2 Software architecture and algorithm:

The software algorithm and architecture is used for utilizing the network components in the efficient and secure manner.

2.2.1 Algorithm for control room and Machine learning Controller Authentication:

To avoid security issue, there is need of authentication in between the machine learning controller and the control room. There are two types of algorithms used for this purpose here, an authentication system and method has been also implemented in [6].

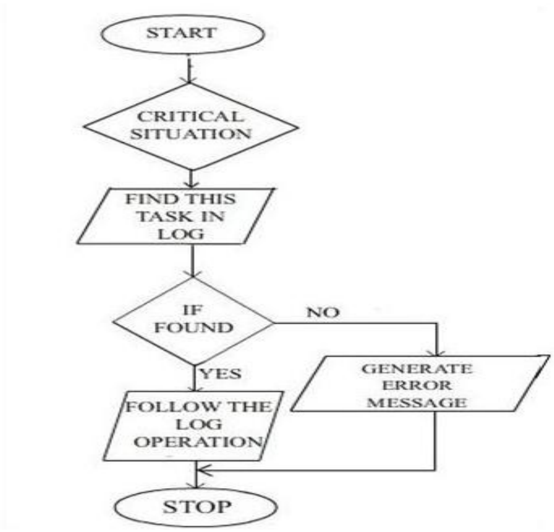

Figure.5: Flow Chart for knowledge extraction from machine learning block

2.2.1.1 Authentication through encrypted strings:

Step[1]: Install the digital signature in the offline mode and keep changing the key in the both sender receiver node according to system clock or random number generators.
Step[2]: Establish connection between control room and machine learning controller through the wi-max core network.
Step[3]: Get the encrypted identification number and password from the control room, and decrypt and match in the machine learning controller
Step[3.a]: If the authentication information is matched, authorize the requesting node to synchronize the information.
Step[3.b]: Else if the authentication information is not matched, block the requesting node for synchronization of information.

2.2.1.2 Authentication through face recognition:

Step[1]: Establish the connection between machine learning controller and control room using the digital signature installed in offline mode.

Step[2]: Continue only if the authentication is done through the encrypted id and password.

Step[2.a]: Get the user face sample from the control room.

Step[2.b]: Match the face patterns with the already saved patterns.

Step[3]: If the patterns are matched authorize the requesting node for synchronization of information.

Step[3.a]: Else Block the requesting node for synchronization of information.

2.2.2 Algorithm and flow-chart for Machine Learning Process:

The machine learning controller is based on log technique. It makes a log table at the time of first start up. And it stores the operation name and type, steps taken to do that, and the result of the operation in separate columns. These logs used to be very small in size. So, it wouldn't consume any more memory space. The algorithm for the process is written below and the flow chart figure.4 is shown for this process.

Step[1]: Create log table at first start-up of system with the columns such as operation name and type, steps taken to complete operation, and the result of the operation.

Step[2]: Make entry of all the successful operation are being done under the control room order in the specified column.

Step[3]: If there is no critical or emergency situation, Continue doing the operation and making the log.

Step[3.a]: Else if there is critical or emergency situation, Search the log containing similar operations to the operations need to be done currently.

Step[3.b.i]: If the log is found similar to the current operation, follow the log and do the steps were done previously.

Step[3.b.ii]: If no logs are found similar, generate the error message, "operation couldn't done through the machine learning controller".

This related flow chart for knowledge extraction from the Machine learning controller is shown in the figure.5.

2.2.3 Algorithm for Definition of critical situation and its handling:

There is provision of critical or emergency situations in the network. A priority table is created for this purpose, which includes the column, such as critical situation name, and priority. This priority defines here the priority of the work to be done first in the case of two or more critical situation. And also, it defines the critical situation with the high priority when compare to a normal operation. This algorithm needs to be implemented in the colony queen i.e. master relay switches and internal transmitter.
The algorithm for this task is written below and the flow chart is shown in the figure.4 and figure.5.

Step[1]: Create a priority table at the first start up of the system with the column name critical or emergency situation name, and priority value.

Step[2]: If any device sends interrupt signal for critical or emergency situation, check the entry of priority table.

Step[2.a]: If the entry is found, as per the priority specified send the task to the machine learning controller i.e. queen of the network.

Step[2.b]: Else if the entry is not found, let it wait until the all critical task goes to complete on machine learning controller.

Step[2.c]: If the completed acknowledgement is received for all the critical situations, send the task, which was found without priority.

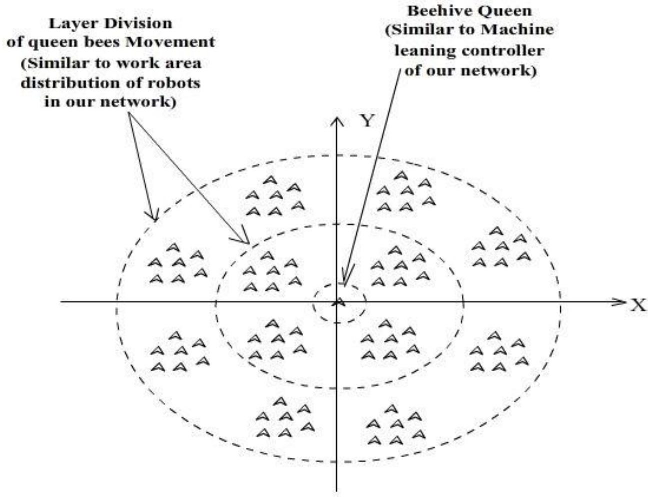

Figure.7: Patterns of work space distribution to the robots

3. QUEEN BEES ALGORITHM

3.1 Algorithm and Explanation

Therefore, during the distribution of work space to the robots the displacement needs to be defined by the following equation:

$$X_{dp1} + X_{dp2} + X_{dp3} + \cdots + X_{dpn} + Y_{dp1} + Y_{dp2} + Y_{dp3} + \cdots + Y_{dpn} = 0 \quad (1)$$

Similarly for the colony queen bees,

$$X_{dc1} + X_{dc2} + X_{dc3} + \cdots + X_{dcn} + Y_{dc1} + Y_{dc2} + Y_{dc3} + \cdots + Y_{dcn} = 0 \quad (2)$$

Where X_{dcn} , Y_{dcn} means the displacement taken by (n number of) colony queen bees in the x, y direction respectively in the equation (1) .

Similarly,TheX_{dpn}, Y_{dpn} means that displacement taken by (n number of) public queen bees in the x, y direction respectively in the equation (2).

Since, there is a single beehive queen. So, there is no need of displacement equation for it.

Now, we will define the equation of the displacement at the end of life time of the complex task. It means that, the displacement graph comes down and touches x axis, by ending the life time of the complex task.

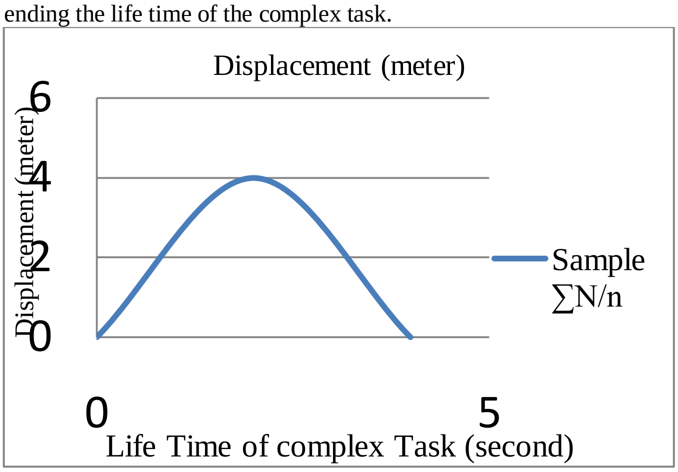

Figure.6 : Graph for Displacement Distribution of robots

This Statement can be defined by the given equation:

At the end of the life time of complex tasks of public bees,

$$D_{p1} + D_{p2} + D_{p3} + D_{p4} + D_{p5} + \ldots\ldots + D_{pn} = 0 \quad (3)$$

Similarly, at the end of the life time of complex tasks of colony queen bees,

$$D_{c1} + D_{c2} + D_{c3} + D_{c4} + D_{c5} + \ldots\ldots + D_{cn} = 0 \quad (4)$$

Here, Equation (3) and (4) defines that at the end of the task the robots should restore itself towards the origin point. The graph is shown in the figure.6 for this concept.

Hence, this queen bee algorithm explains the method to distribute and to restore back the robots in the work field according to the queen bees patterns, shown in figure.7.

3.2 Possible Error and Solution in this algorithm:

The possible error can occur in the algorithm, while the work-circle of the bees goes to touch to each other. The figure.8 has been shown for this purpose. Where, the shaded part never goes to be served by any bee or by any bee colony.

This situation only comes, when the four circular patterns of the bees touches to each other. This is the following algorithm goes to run, when the case happens.

3.2.1 Error Reporting to Machine Learning Controller:

Step[1]: while (the four circular patterns are touching to each other)

Step[2]: send error acknowledgement to machine learning controller and pass the argument (radius of the circular pattern, coordinates of the origin of pattern) .

3.2.2 Response of the Machine Learning Controller:

Step[1]: while (Reception of the same error message from four different colonies/ bees)

Step[2]: Choose any one node randomly from the error reporters and follow the solution algorithm given in the {section III.C } with relaying the passed argument to the machine learning controller.

3.3 Algorithm and method of Error Recovery

We suppose that, the radius of the pattern is received as (R_p). So, the not serviced area (A_e) from the bees/colony will be,

$$A_e=(2R_p)^2 - \pi(R_p^2) \quad (5)$$

Now, Suppose the received origin of the patterns are (X_1, Y_1), (X_2, Y_2), (X_3, Y_3), (X_4, Y_4).

The center of the not serviced area will be defined by the equation:

$$(X_c, Y_c) = ((X_1 + X_2 + X_3 + X_4)/4, (Y_1 + Y_2 + Y_3 + Y_4)/4) \quad (6)$$

Now, the following will be executed as order from the machine learning controller for the colony/bee, which was chosen randomly:

Step[1]: Move immediately to the location (X_c, Y_c) .

Step[2]: While (current coordinates –((X_2, Y_2) || (X_3, Y_3) || (X_4, Y_4)) != R_p) .

Step [2.a]: Keep moving and serving the area till the step [2] condition satisfies.

Where, symbol (||) represents the (or), and the symbol (!=) represents the (not equals to) respectively.

Hence, this is the possible error may occur in this algorithm and has been solved in the section.

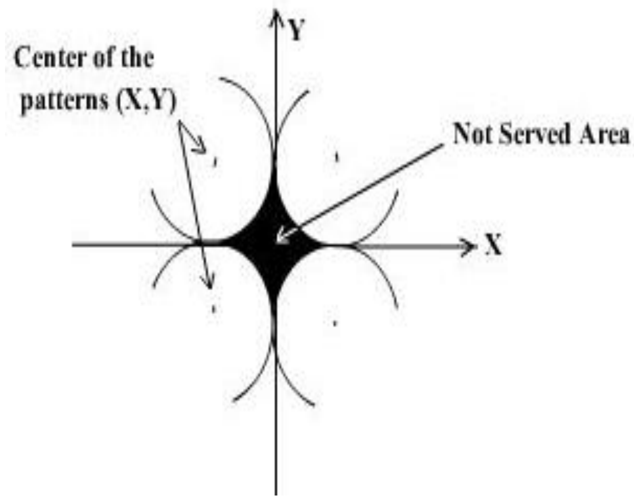

Figure.8: Figure of the not served Area

4. APPLICATION

The application of this type of network is having a broad range. This work is purposely done for the network of robots for explosive detection, shown in [2]. It can also be applied for running the unmanned vehicles in the army. Apart from that, this type of robot can be very useful for the search operation done in the space, such as searching water or a particular element on the moon or on any other satellite by using different signals.

Also, this type of robotics network can be used for detection of land mine in the time of war. This robot network can also be used for forming the robot army, which may do possibly more things than a human shoulder can do.

5. CONCLUSION, SUMMARY AND FUTUREWORKS

The conclusion of this work is network design, which is using a new technique: queen bee algorithm to monitor and utilize the robots or unmanned vehicles in easy and better way. This algorithm describes the concepts of robotic distribution in the work field from the origin point of distribution, the working style, as well as the restoration of the robots to the origin point.

The future work purposed in this work field is to find more and more accurate way of “Network for robots”.

6. ACKNOWLEDGMENTS

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