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Soft Computing Approach For Fire Brigade Deployment In Punjab

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Abstract

This paper Proposes a solution to a problem of stationing the Fire Brigade in the state of Punjab, India to optimize the population coverage so that emergency service are enabled to minimize the casualty and sufferings by the patients.In this Paper, we present a Wireless Sensor Networks approach for Fire Brigade deployment in the state of Punjab (India). The Fire Brigade fitted with necessary sensing, computing, communicating and energy source capabilities makes each Fire Brigade as an autonomous WSNs node. In this approach a computing device placed at central location act as a base station. The base station computes the deployment coordinates in terms of longitude and latitude and communicates these to Fire Brigade using WSNs routing strategies. Base station uses BB-BC based WSNs deployment approach for optimal coverage to ensure coverage of all rural and urban locations.The new soft computing approach proposes that every Rural and Urban geographical location of state has to be covered with at least one Fire Brigade by optimizing the deployment pattern of these Fire Brigade.

Keywords:- EHC, WSN, Soft Computing, Optimize

1. Introduction

Public Health Service is one of the key indicators of a prosperous society. A substantial amount of budget is allocated for this service by every nation. In vast country like India providing Emergency Service care at time of accident always remains a challenge.National Crime Records Bureau (NCRB-14) of Indian government reported 52 people across India die per hour. These figures indicate that there is an enough scope of improvement in EHS. One of the primary reasons for this lies with the technological limitations of the systems being used for providing Emergency Service . It is desired that Fire Brigade reach accident site in minimum time (response time). Location of Fire Brigade deployment is one of the key parameter in improving this response time (Gendreau, M. et al., 1997; Schmid, V. 2012; Kaur, et al 2019; Sharma et al 2016). Presently, it is observed that Fire Brigade are not uniformly deployed as most of the Fire Brigade is stationed in urban areas while Fire Brigade deployment density is low in rural areas. Considering the magnitude of problem and existing approaches of Fire Brigade deployment it is desired that improved approach must be proposed to minimize suffering by the patients. In this Paper, we present a Wireless Sensor Networks approach for Fire Brigade deployment in the state of Punjab (India). The Fire Brigade fitted with necessary sensing, computing, communicating and energy source capabilities makes each Fire Brigade as an autonomous WSN node. In this approach a

computing device placed at central location act as a base station. The base station computes the deployment coordinates in terms of longitude and latitude and communicates these to Fire Brigade using WSNs routing strategies. Base station uses BB-BC based WSN deployment approach for optimal coverage to ensure coverage of all rural and urban locations.

2. Literature Review

One of the prime challenges that affect the performance of WSNs is to achieve optimal deployment of sensor nodes in the marked area. As, deployment of nodes in WSNs ranges from small area like human body to large deployment like underwater sensing in the oceans. Some other examples of WSNs that shows their deployment area diversity are use of invasive body sensors in a single limb during an operation to the fire sensors in a forest where the area is in hundreds of kilometers. So, to have the same performance accuracy all around has always been a key concern of researchers. Till this research, plenty of work has been done for the optimization of sensor deployment in different scenarios using various techniques and algorithms. Soft computing techniques were also reported for wireless sensor network deployment particularly where the implementation has to be done in large monitored areas. Some of the good research papers that have used the recent optimization techniques for deployment are listed below:

More and Raisinghani, 2016 proposed Edge Based Centroid (EBC) algorithm which improves area coverage along with minimization of energy consumption of mobile sensor network. This algorithm used the concept of dividing the sensing field into polygons with one sensor node for monitoring of regions covered in sensed area which further improves coverage in comparison with other algorithms.

Huang et al., 2014 suggested an Ionic Bond-directed Particle Swarm Optimization (IBPSO) algorithm for enhancing the coverage for WSNs. This algorithm gave the combination of the ionic bond method with particle swarm optimization (PSO). The ionic bond method made use of a sensible ionic bond between two sensor nodes to locate out the path, movement and direction of the nodes.

Ding et al., 2014 proposed a new Particle Swarm Optimization (PSO) approach by modifying structure of PSO and also introduced disturbance (d-PSO) to resolve deployment issue in WSNs. The social behavior of a flock of birds is the base of the particle swarm optimization (PSO) algorithm.

Jena, 2014 proposed a novel multi-objective Artificial Bee Colony (ABC) algorithm based framework. The framework optimized the operational modes of the sensor nodes along with clustering schemes and transmission signal strengths. The ABC algorithm works well for numerical optimization problems and clustering techniques. The node placement was an essential task in wireless sensor network and is a multi-objective combinatorial problem in nature.

Kumar et al., 2013 examined fuzzy logic based model identification problem. The author applied Big Bang and Big Crunch (BB-BC) and parallel BB-BC approaches to the identification of fuzzy system to evaluate institutions of higher learning. In this system, all input and output variable parameters such as membership functions of all input variables, this

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membership function of consequent's, along with complete rule base was successfully evaluated from given input-output data.

Abbas et al., 2013 presented an approach for enhancing the lifetime of sensor networks. Biologically inspired algorithm particle swarm optimization (PSO) and ant colony optimization (ACO) was the base of the proposed technique. PSO was compared with ACO after modification based on inertial weight and the acceleration. The result shows that MPSO is faster than ACO because the update of the parameters was faster in previous one

Yoon and Kim, 2013 discussed the coverage deployment problem in wireless sensor networks. To solve this coverage deployment problem, an efficient genetic algorithm using a novel normalization method was proposed. This paper analyzed the properties of the problem space and tried to find better sensor deployments using novel genetic algorithms. According to the analysis, the relation between the genotype space and the phenotype space of the maximum coverage sensor deployment problem (MCSDP) was evaluated in terms of quotient space.

Romoozi et al., 2012 discussed application of genetic algorithm and clustering (K-mean) for sensor node localization in a new algorithm. They stated the two critical issues of WSNs namely energy consumption and coverage. Genetic Algorithm is a prominent nature inspired algorithm being used. GA operator's selection, crossover and mutation applied on the chromosomes (coordinates of node positions).

Ozturk et al., 2012 proposed a new soft computing approach based on artificial bee colony algorithm for mobile sensor deployment. Deployment was the critical parameter that affects the WSNs performance. The artificial bee colony (ABC) algorithm is a nature inspired approach which mimics the behavior of honey bees. Boolean sensor detection model was used for this deployment with the initial deployment was consider as random. This approach provides efficient dynamic deployment of WSNs. **Wang et al., 2012** proposed a Biogeography-Based Optimization (BBO) algorithm to solve the problem of dynamic deployment.

3. Problem Formulation

Occurrence of an accident is a random event and to rescue human, emergency vehicles such as Fire Brigade, police petrol and fire engines are required. Fire Brigade must be dynamically deployed to cater to any such unpredictable event. The term 'Dynamic Fire Brigade Deployment' is used because these vehicles move in and out from their locations, resulting in changing the whole deployment scenario. To ensure adequate coverage of an area by the remaining vehicles when one or more vehicles move out from their location is a challenging issue. It is also observed that Fire Brigade are not optimally deployed by hospitals rather their availability is more in urban areas as compared to rural areas. There is need to propose a dynamic Fire Brigade deployment system which must be intelligent enough to optimally deploy Fire Brigade so that best emergency care to all location could be provided.

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Vol-22-NO-30 Special Issue- December-2019

3. Challenges in Emergency Care in India:

Statics available from National Crime Records Bureau (NCRB-14), Government of India shows that accidental death rate is increasing day by day is shown in Table 1

Table 1 Number of accidental deaths within 10 years from 2003-2013 (Source: http://ncrb.nic.in/)

Year	**Total number of Accidental Deaths**	**Increase over previous year**
2003	259625	
2004	277263	6.79
2005	294175	6.10
2006	314704	6.98
2007	340794	8.29
2008	342309	0.44
2009	357021	4.30
2010	384649	7.74
2011	390884	1.62
2012	394982	1.05
2013	**400517**	1.40

PROPOSED SOLUTION

This section purposes a new WSN based Fire Brigade deployment system suitable for optimal deployment of Fire Brigade and other emergency vehicles such as police patrol vans and fire-engines. The system consists of a combination of hardware and software modules for local communication between Fire Brigade and also provides global access for remote monitoring if required.

The Fire Brigade fitted with necessary sensing, computing, communicating and energy source capabilities makes each Fire Brigade as an autonomous WSN node. In this approach a computing device placed at central location acts as a base station. This proposed soft computing approach (BB-BC) of artificial intelligence is responsible for making hardware fitted in each vehicle 'virtually intelligent' for optimal deployment.

The proposed system though it helps in tracking of vehicles, was not a simple tracking system alone but an intelligent system for optimizing Fire Brigade deployment as well. The proposed system instead of telephonic connectivity utilizes existing WSN's routing for connectivity. In WSNs there was no need for internet or telephonic connectivity at all as each node is self-sufficient to transmit and receive location information.

Salient feature of the system lies in computing optimal deployment/position location by soft computing approach at the network base station. BBBC is a nature inspired search and optimization technique. BB-BC approach applied to WSNs deployment was implemented in MATLAB to compute Fire Brigade deployment locations. Log of complete location entries of Fire Brigade was accessed from a remote location as computing device in base station was connected to internet. Whole network data e.g. which Fire Brigade was present where, on what date, at what time can be accessed globally. This makes the system more transparent as actual state of Fire Brigade deployment could be monitored to prevent false claims

The advantage of the present system is its low-cost hardware fitted in Fire Brigade does not require any telephonic connectivity within the vehicle in the form of GPRS. This system is designed to works even for the areas where telephone network or connectivity is missing like in case of remote hill areas and rural interior areas. The proposed system provides solution by dynamically deploying Fire Brigade in rural and urban areas in such a way that every location must lie in the coverage of at least one Fire Brigade all the time.

COMPARSION OF THE PROPSED SYSTEM VS EXISTING SYSTEM

Extensive patent and literature survey was carried out to compare the proposed system with existing systems (Yue, Y. et al., 2012; Schmid, V. 2012: Brotcorne, L. et al., 2003). No such method has been disclosed in Indian Patents or in other Patents as evident from search of Indian Patent Office site and other databases. Table 5.2 below gives a comparison of existing approach with the proposed approach on the basis of below listed four parameters.

The proposed dynamic Fire Brigade deployment approach is implemented for state of Punjab (India). The approach consists of four major software/hardware constituents

Sectorization module that carries out sectoring of the State (Punjab) by using ISRO-Geo portal

ISSN: 0971-1260
Vol-22-NO-30 Special Issue- December-2019

Sensing Module

Soft computing based deployment module: Determination of optimal Fire Brigade deployment locations

Hardware module for receiving and transmission of sensing, command and control data.

a. **Sectorization (Dividing an area into sectors)by using ISRO-Geo portal**
b. **Sensing Module:**
c. **Soft Computing based deployment Approach:**

Table 2: Comparison of existing vs proposed deployment approach

Existing System	**Proposed System**
Hardware- Tracking devices fitted in each emergency vehicle; computing device located at call center.	Hardware- dedicated WSN hardware kit fitted in each Fire Brigade; computing device located at base station i.e. any centralized physical location.
Intra-vehicle communication method- No communication. If existed, then telephonic or internet based and that too need based or incident based. Not real time based.	Intra-vehicle communication method- All Fire Brigade communicate with each other with the help of WSN enabled kit. They communicate with each other and base station in real time without use of telephone or internet.
Software- Algorithm receives and processes information from multiple vehicles about their location to give result that which vehicle is nearest to accident site. Does not send data in real time to each and every vehicle, due to which dynamic deployment is not possible.	Software- Base station receives and process information from all Fire Brigade and sends deployment information in real time to Fire Brigade. BB-BC dynamic deployment algorithm is used to compute optimal locations at the base station. This algorithm is simulated in MATLAB to find optimal locations
Redeployment- When one Fire Brigade moves out to cater to an emergency call, no real-time redeployment is carried out for providing coverage to that locality.	Redeployment- As in this system deployment of Fire Brigade is carried out with an objective to provide complete coverage of marked area. The Fire Brigade are redeployed in real time when any vehicle moves out providing optimally best emergency care.

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Figure 2 Map of Punjab highlighting Map (http://www/mapsofindia.com)

RESULTS OF SIMULATION

In order to evaluate the proposed Fire Brigade deployment approach, we implemented BB-BC optimal deployment approach presented in MATLAB on a core i7@2.5GHz processor with 8 GB RAM machine running at Windows 7 platform. We considered 50,362 square kilometer geographical area of Punjab state as target area of deployment. This area was divided into eight sectors by applying BHUVAN software. For our simulation, area of each sector was considered as a network scenario and an Fire Brigade was considered as sensor node with coverage range of each Fire Brigade considered to be 8.5 kilometer. We conducted 20 sets of experiments for each network scenario with number of nodes (Fire Brigade) mentioned in table 4. Average covered area of these trial for each scenario were recorded in the table 4.

Table 4 Results after implementing the proposed techniqueIt is observed from the results that this approach provided minimum coverage area of 97% to all eight sectors. It is also observed that 236 total numbers of nodes (Fire Brigade) were deployed to achieve minimum 97 % coverage. From the results, conclusions could be drawn that with 236 Fire Brigade this approach provided more than 97 % coverage to the entire state of Punjab. However, for 100% coverage the number of Fire Brigade required per sector will further go up.

CONCLUSIONS

In this Paper, we present a Wireless Sensor Networks approach for Fire Brigade deployment in the state of Punjab (India). The Fire Brigade fitted with necessary sensing, computing, communicating and energy source capabilities makes each Fire Brigade as an autonomous WSNs node. In this approach a computing device placed at central location act as a base

ISSN: 0971-1260
Vol-22-NO-30 Special Issue- December-2019

station. The base station computes the deployment coordinates in terms of longitude and latitude and communicates these to Fire Brigade using WSNs routing strategies. Base station uses BB-BC based WSNs deployment approach for optimal coverage to ensure coverage of all rural and urban locations

In order to validate the proposed Fire Brigade deployment approach for Punjab we implemented it in MATLAB and simulated. Average number of Fire Brigade of 15 trials required to provide coverage for each sector was observed. It was observed that 236 dynamically deployed Fire Brigade at optimal location in all eight sectors provide coverage to each and every location of the state

Sector No.	**Area (Km^2)**	**No. of Sensors (Fire Brigade)**	**Value of Longitude**	**Value of Latitude**	**Dimensions**	**Coverage %**
1	22134.71	87	74.66	31.06	184.95	98.39
			76.36	31.06	117.86	
2	14586.94	57	74.56	31.83	175.25	97.27
			74.56	31.12	80.11	
3	5740.367	22	76.24	31.31	45.79	97.84
			76.24	30.13	135.59	
4	5465.588	21	73.84	30.45	95.23	98.06
			74.70	29.99	57.38	
5	4517.74	17	74.93	30.05	143.44	97.94
			76.19	30.05	32.96	
6	3984.017	15	74.62	32.13	147.92	98.54
			75.91	32.13	30.52	
7	2095.586	8	74.21	30.98	45.92	98.72
			74.61	30.98	48.36	
8	2379.816	9	76.61	30.78	35.48	98.67
			76.61	30.33	78.8	

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