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Stepwise Regression Analysis Based Decision Tree Classifier for Target Tracking In WSN

J.Srimathi, B. Srinivasan

Abstract: Target tracking is a key problem to be resolved in Wireless Sensor Network (WSN). In addition, energy consumption during the tracking process is the key concern to prolong the network lifetime. In existing works, many techniques designed for target tracking in wireless network. However, target location and trajectory tracking accuracy was not sufficient. Further, energy utilization during target tracking was not minimized. In order to overcome such limitations, Stepwise Regression Analysis based Decision Tree Classifier (SRA-DTC) Model is proposed. In SRA-DTC, three types of nodes, namely reference node, sensor node and target node are initialized. Reference node transmits the beacon message to all sensor nodes in order to discover target node location. When the target node enters into the network, sensor node senses the target node and sends the sensed information to the base station. After that, base station performs the stepwise regression analysis of sensed data to track the target with lesser energy consumption. After that, target trajectories are identified through Decision Tree Classifier in SRA-DTC model. Base station uses Decision Tree Classifier to identify the target trajectories based on the collected information. By this way, tracking accuracy of target location and trajectory is gets improved. The simulation process of SRA-DTC model is carried out on factors such as target tracking accuracy, target tracking time, energy consumption, and network lifetime with respect to number of sensor nodes. The simulation result shows that the SRA-DTC model is able to increases the target tracking accuracy and also reduces the energy consumption in WSN as compared to state-of-the-art works.

Keywords: Angle of Arrival, Decision rules, Decision Tree Classifier, Energy, Reference Node, Sensor Node, Stepwise Regression Analysis, Target Node, Time of Flight

I. INTRODUCTION

Wireless Sensor Network (WSN) contains several low-cost sensors to monitor targets inside their sensing range. The sensors are distributed in a random manner. The targets are moving and their trajectories are subject to uncertainty. Target tracking process involves the tracking of moving path and detecting the target position. Minimizing the energy consumption while performing target tracking is a significant problem as sensor nodes are energy constraints. Different data mining techniques have been applied to identify target node location and trajectory. However, energy consumed during target tracking was not minimized.

Therefore, SRA-DTC Model is developed in this research work to achieve energy efficient target tracking in WSN.

With the objective of tracking the target with minimum time, Generalized Unscented Information Filter (GUIF) was presented in [1]. With the application of information filter, as unwanted nodes were eliminated, target tracking time was reduced. However, target tracking accuracy was not improved using GUIF. To address this issue, Mixed maximum likelihood (ML)-Bayesian framework was developed in [2] for achieving accurate target tracking in radio environment. But, the energy consumption was high during the indoor target tracking process in WSN. With the objective of reducing the energy being consumed, an energy-efficient Localization and Tracking (eLOT) system was introduced in [3]. The eLot system was found to be highly effective by introducing low-cost and portable hardware and hence addressed accurate target tracking. However, target tracking time was not concentrated. To minimize the target tracking time, a data suppression approach was introduced in [4] for target chasing in WSNs. In this way, the time consumed for data suppression target tracking was found to be lesser. In [5], a sinusoidal waveform with duration was employed to broadcast sensor decision to the fusion center (FC), for addressing tracking time. However the target tracking accuracy was lower. Hierarchical prediction strategy (HPS) was presented in [6] for energy-efficient target tracking in large-scale WSNs. But, network lifetime was not improved. Matheuristic-based column generation algorithm was used in [7] to preserve and balance the residual capacities of the sensors during target tracking in WSN. But, target tracking performance was not sufficient. An efficient target tracking (ETT) mechanism was designed in [8] to reduce the number of working sensors while the user-defined tracking quality is fulfilled. However, energy efficient target tracking was not obtained.

A nonlinear smoothing algorithm was employed in [9] to address the target tracking problem with asynchronous estimation. However, energy efficiency during target identification was remained open issue. A novel protocol was introduced in [10] to obtain better communication delay and therefore reduces tracking error while maintaining reasonable energy consumption. But, the amount of time needed for detecting target node was more. In order to resolve the above mentioned existing issues, SRA-DTC Model is proposed. The main contribution of SRA-DTC Model is described in below,

❖ To enhance the accuracy of target location tracking in WSN as compared to state-of-the-art works, Stepwise Regression Analysis is applied in SRA-DTC Model. On the contrary to conventional works, Stepwise Regression Analysis contains an ability to handle large amounts of sensor nodes during target location detection process.

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Besides to that, Stepwise Regression Analysis is also faster than existing methods. This helps for SRA-DTC Model to find target location in WSN with a lower time.

❖ To improve the performance of target trajectory tracking in WSN as compared to conventional works, Decision Tree Classifier is applied in SRA-DTC Model. On the contrary to existing works, Decision Tree Classifier is also handle high number of sensor nodes for efficient prediction of target path in network. Generally, decision tree classifier has good accuracy on the existing works as it employs the decision rules to correctly discover the trajectory of target node.

The rest of paper is formulated as follows. Section 2 portrays the related works. Section 3 presents the detailed process of proposed SRA-DTC Model. In section 4, a simulation setting of proposed technique is demonstrated. Section 5 provides the results and discussion of certain parameters. Finally, the conclusion of the research work is depicted in Section 6.

II. RELATED WORKS

An innovative target tracking algorithm was presented in [11] by using learning regression tree approach and filtering methods based on RSSI metric. An energy-efficient LOcalization and Tracking (eLOT) system was designed in [12] for exact tracking of targets.

An adaptive decision threshold was employed in [13] for both Kullback–Leibler divergence (KLD) and a global optimal decision statistics to get higher accuracy for target discovery. A Probability-based Prediction and Sleep Scheduling protocol (PPSS) was developed in [14] to enhance energy efficiency in WSN.

Non-Myopic Energy Allocation was presented in [15] to increase tracking accuracy in wireless network. A sensor-independent tracking framework was intended in [16] for enhancing performance of target tracking in WSN.

An energy-efficient target tracking was introduced in [17] to minimize the energy usage in WSN. A computationally feasible optimization method was presented in [18] for joint sensor registration and target tracking in WSN.

Energy-Efficient Constant Gain Kalman Filter based Tracking (EECGKFT) algorithm was used in [19] to get better the tracking accuracy. A Lateration-localizing Algorithm was applied in [20] to carry out energy-efficient target detection in WSN.

III. STEPWISE REGRESSION ANALYSIS BASED DECISION TREE CLASSIFIER

In the field of regression, several target tracking methods have been introduced so far. In [1], Generalized Unscented Information Filters were presented to reduce the state estimation error related to target tracking in WSN. However, less focus was made on target tracking time. To address this issue, the Stepwise Regression Analysis based Decision Tree Classifier (SRA-DTC) Model is designed in order to improve the performance of both target location and trajectory tracking in WSN with minimal energy consumption. On the contrary to conventional works, SRA-DTC Model is introduced by combining the Stepwise Regression Analysis and Decision Tree Classifier. This assists for SRA-DTC Model to efficiently predict the target location and trajectory in WSN with minimal amount of time as compared to existing works[1] and [2]. The architecture diagram of SRA-DTC Model is presented in below Figure 1.

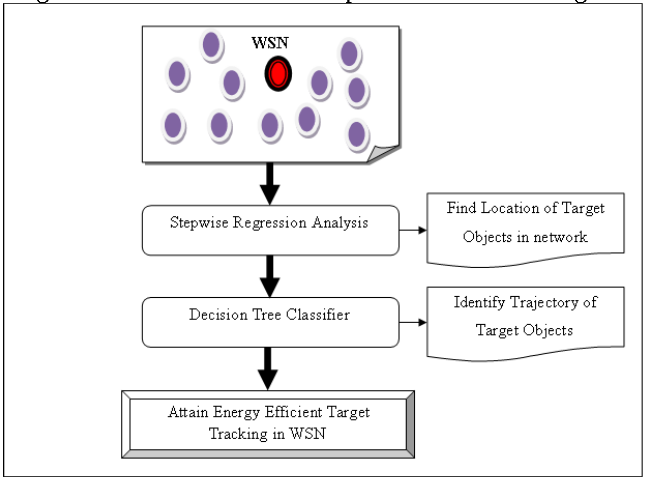

Fig:1 Architecture Diagram of SRA-DTC Model for Target Tracking in WSN

Figure 1 demonstrates the flow processes of SRA-DTC Model to increase the performance of target tracking in WSN with lower energy consumption. As presented in above figure, SRA-DTC Model consider a different number of sensor nodes '$\varphi_1, \varphi_2, \varphi_3 \dots, \varphi_n$' in wireless network. The SRA-DTC Model initially carried outs stepwise regression analysis to discover the position of target objects with a minimal time. During target tracking, stepwise regression analysis employs the Triangulation process to exactly find out the location of target node in WSN. After that, SRA-DTC Model use decision tree classifier in order to accurately track the trajectory of target node in network. From that, SRA-DTC Model enhances the accuracy of target tracking in WSN as compared to conventional works. The detailed process of SRA-DTC Model is described in below.

Let us consider wireless sensor network is represented as graph structure [4] '$G = (\alpha, \beta)$'. Here, 'α' includes a collection of vertices i.e. sensor nodes indicated as '$\alpha = \varphi_1, \varphi_2, \varphi_3 \dots, \varphi_n$' whereas '$\beta$' denotes set of edges as '$\beta = \varepsilon_1, \varepsilon_2, \dots, \varepsilon_m$' i.e. links between the sensor nodes. In SRA-DTC Model, three kinds of nodes such as Reference Node '(ρ)', Sensor Nodes '(φ_i)', and Target Node '(δ)' are employed. Initially, the reference node 'ρ' is located and sensor nodes '$\varphi_1, \varphi_2, \varphi_3 \dots, \varphi_n$' are distributed randomly in sensing area. The reference node 'ρ' broadcast beacons message to the distributed sensor nodes for identification in the network. Whenever the sensor nodes get the beacon massage and it sends a reply message back to reference node. The beacon massage transmission process is shown in below Figure 2.

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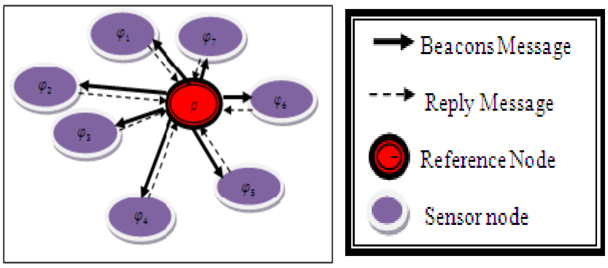

Fig2: Beacon Message Broadcasting Process

Figure 2 depicts the beacon message distribution process between reference node and sensor nodes in WSN. By transmitting the beacon messages, the distances between the reference node and sensor nodes are calculated in SRA-DTC Model with help of Time of Flight (ToF) [5] method. Thus, distance is estimated as time distinction between the beacon message transmission and reply message from the sensor node after receiving beacon message using below mathematical expression,

$$\omega(\rho, \varphi_i) = \tau_{\mathrm{BMT}} - \tau_{\mathrm{RM}} \qquad (1)$$

From above equation (1), 'ω' indicates a distance between reference node 'ρ' and i^{th} sensor node 'φ_i'. Here, 'τ_{BMT}' refers a sending time of beacon message and 'τ_{RM}' indicates a time of reply message get from sensor node. In this manner, the reference node in SRA-DTC Model discovers the sensor nodes within the network to find the location.

Whenever the target node is arrive, all sensor nodes in WSN sense and identify the target node. Subsequently the sensor node informs where a new target node is entered into the network to the reference node. In SRA-DTC Model, distance between the sensor node and target node is determined with aid of Received Signal Strength Indicator (RSSI) [9]. Based on RSSI, the distance is evaluated depends on strength of the signal received by sensor node. In SRA-DTC Model, the reference node continually transmits signal in terms of message, and a link quality evaluation metric (e.g., RSSI) is determined from the reply messages sent from the target node 'δ' using below mathematical expression,

$$\omega(\varphi_i, \delta) = RSSI = z\,\frac{\vartheta}{\omega^2} \qquad (2)$$

From equation (2), '$RSSI$' represents received signal strength at the reference node 'ρ', whereas 'ϑ' point outs a transmitted signal strength and 'ω' is the distance, 'z' refers a constant depending on transceiver. In SRA-DTC Model, a sensor node transmits a signal with a measured strength. When the distance between nodes is higher, signal strength is lower. According to the received signal strength at the node, the distance is measured between the sensor node and target node. After computing these two distances, the distance between reference node and target node is estimated as depicted in figure 3.

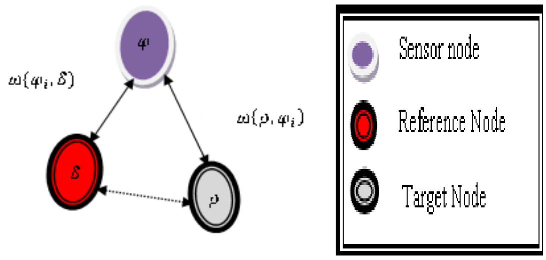

Fig3: Distance Calculation

Figure 3 illustrates the distance evaluation process between sensor node, the target node and reference node. As demonstrated in figure 3, the distance among the sensor node and reference node are calculated using time of flight (ToF). In the same way, the distance between the sensor node and target node are measured based on RSSI (i.e. 'b'). Let us consider triangle as shown in above figure and then identify distance between the reference node and target object (i.e. 'c'). With help of Pythagoras' theorem, SRA-DTC Model measures the unknown distance (i.e. 'a') using below mathematical formulation,

$$a^2 = b^2 + c^2 \qquad (3)$$

After finding the distance, the mobile sink '(μ)' gather information from sensor nodes, target node and reference node in the form of data packets '$d_1, d_2, d_3, \ldots d_n$'. Subsequently mobile sink transmit collected information to base station through the intermediate nodes for discovering target location which mathematically obtained as,

$$\mu\,(d_i) \rightarrow BS \qquad (4)$$

From the above equation (4), 'μ' indicates a mobile sink whereas 'd_i' point outs data packets and 'BS' denotes a base station in wireless network. In SRA-DTC Model, mobile sink node gathers data from all the nodes i.e. sensor nodes, target node, reference node. The gathered data about newly entered target node is broadcasted to a base station to find location. After getting the collected data, the base station discovers the location of the target node by using a stepwise regression analysis. In SRA-DTC Model, stepwise regression analysis collected gathered information and their distances with different directions as the input. The stepwise regression analysis is a powerful statistical method.

Stepwise regression analyzes the collected data using Triangulation process for finding an accurate location of target node 'δ' through distances informations with the geometry of circles. Triangulation is the process of discovering the position of a point by constructing triangles to it from known points. Triangulation computes the angles between the intersection lines of the target node and the reference node in WSN. The distance is calculated with those angles. Triangulation only requires two reference points to calculate the location of the target, as shown in below figure 4.

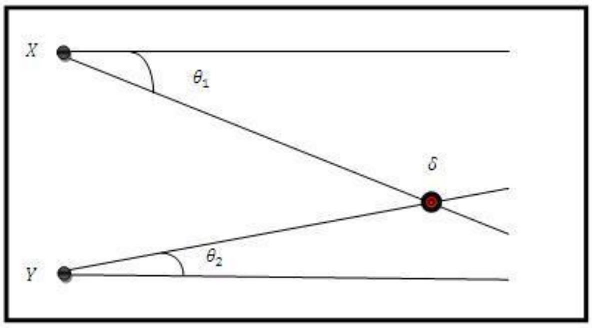

Fig 4: Triangulation process for Target Location Tracking based on Angle of Arrival

In figure 4, 'X' and 'Y' are the minimum required reference points with known coordinates, 'θ_1' and 'θ_2' are the angles measured with Angle of Arrival method and 'δ' is the target node with unknown coordinates. By using the triangulation process, stepwise regression analysis tracks the location of target object in WSN with higher accuracy and minimal time. During the target node identification process, the energy usage of sensor node is key concern to prolong network lifetime. The amount of energy utilized by a sensor node 'φ_i' for discovering target node is mathematically obtained as,

$$\sigma_U = \sigma_T - \sigma_R \quad (5)$$

From equation (5), 'σ_t' represents energy utilized for tracking target node and 'σ_T' indicates total energy of the sensor node 'φ_i' and 'σ_R' refers a remaining energy of the sensor node 'φ_i'. From that, SRA-DTC Model considers only sensor nodes with minimum energy consumption as energy efficient sensor nodes to perform target tracking process. This helps for SRA-DTC Model to accomplish target tracking process with lower energy utilization in WSN as compared to conventional works.

After tracking process, base station employs decision tree classifier to find trajectories of target node in WSN. Decision tree classifier in SRA-DTC Model is a popular tool for classification and prediction. A Decision tree is a tree structure, where root node takes gather data of target node at different time and subsequently applies decision rules to predict the path in WSN. In decision tree classifier, each leaf node (terminal node) holds a class label (i.e. target path or not a target node). The structure of decision tree classifier for identifying target trajectory is shown in below Figure 5.

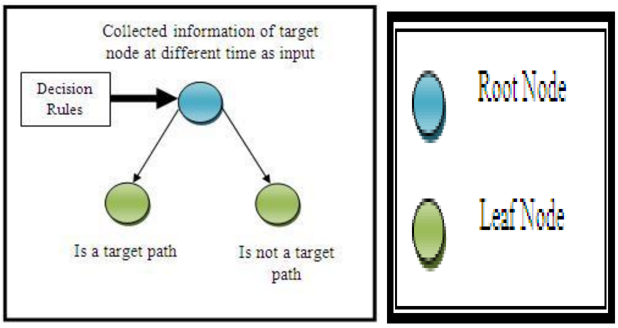

Fig 5: Structure of Decision Tree Classifier

Figure 5 illustrates the decision tree classification for discovering the target trajectory in wireless network. The decision rules 'DR' are constructed using below mathematical expression,

$$DR = R_1, R_2, R_3, \ldots R_n \quad (6)$$

From above equation, 'n' number of decision rules 'R_i' are created to accurately find path of target in WSN. Based on designed decision rules, the SRA-DTC Model increases the target trajectory performance with a minimal time as compared to existing works [1] and [2].

The algorithmic steps of SRA-DTC Model explained in below,

Input: Number of sensor nodes '$\varphi_1, \varphi_2, \varphi_3 \ldots, \varphi_n$', reference node '$\rho$', Mobile sink '$\mu$', Number of data packets '$d_1, d_2, \ldots d_n$', Target Node 'δ' , Base station 'BS', Stepwise Regression Analysis 'SRA'
Output: Enhanced Accuracy for Target Node and Trajectory Tracking with a Minimal Energy Utilization
Step 1: Begin
Step 2: Define ρ and number of sensor nodes 'φ_i'
Step 3: Calculate '$\omega(\rho, \varphi_i)$' with help of ToF using (1)
Step 4: Sensor node sense target node while entering into a network
Step 5: Evaluate '$\omega(\varphi_i, \delta)$' based RSSI using (2)
Step 6: Compute '$\omega(\rho, \delta)$' with aid of Pythagoras' theorem $(i.e\ a^2 = b^2 + c^2)$ using (3)
Step 7: Mobile sink 'μ' collect data $d_1, d_2, \ldots d_n$
Step 8: Mobile sink send gathered data to BS using (4)
Step 9: Apply stepwise regression analysis 'SRA'
Step 10: SRA uses triangulation process to identify (X, Y) coordinates of target node
Step 11: Calculate energy 'σ_U' to attain energy efficient target tracking using (5)
Step 12: Apply decision tree classifier
Step 13: Get gathered information of target node at different time as input
Step 14: Construct decision rules using (6)
Step 15: Exactly track the trajectory of target node in network
Step 16: End

Algorithm 1 Stepwise Regression Analysis based Decision Tree Classifier

Algorithm 1 shows the step by step processes of SRA-DTC Model to carry out the target location and trajectory tracking. The steps involved in the stepwise regression analysis based decision tree classifier is given below.

1. As given in the above algorithm, to start with for each sensor nodes and reference nodes,
2. First, known distance is measured that forms the difference between the beacon message transmission and reply message from the sensor node.
3. With the obtained distance value, next, after receiving beacon message, the reference node continuously transmits the signal via RSSI.

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4. Next, the unknown distances are measured by applying the Pythagoras theorem. In this stage, the mobile sink node also collects the data.
5. Now the mobile sink node sends the collected data to the base station by applying stepwise regression analysis.
6. Next, triangulation process is applied to determine the x and y coordinates of the target node. Followed by which, energy consumed for target tracking is also measured.
7. Finally, decision tree classifier is applied to the target being tracked for gathering node information gathered at different time and also decision rules are constructed to find the path.

By using the above algorithmic process, SRA-DTC Model increases the performance of both target location and trajectory tracking with a lower time complexity as compared to existing works[1] and [2]. As a result, SRA-DTC Model gives better performance of in terms of accuracy, time, energy consumption and network life for efficient target location and trajectory tracking as compared to conventional works.

IV. SIMULATION SETTINGS

In order to determine the performance of proposed, SRA-DTC Model is implemented in NS2.34 network simulator. The SRA-DTC Model considers 500 sensor nodes in a square area of 1100 m * 1100 m to perform simulation work. Simulation parameters are shown in below Table1

TABLE I
Simulation Parameters

Simulation Parameters	Values
Network Simulator	NS2.34
Square area	1100 m * 1100 m
Number of sensor nodes	50,100,150,200,250,300,350,400,450,500
Mobility model	Random Waypoint model
Speed of sensor nodes	0 – 20 m/s
Simulation time	250 sec
Protocol	DSR
Number of runs	10

The performance of SRA-DTC Model is measured in terms of target tracking accuracy, target tracking time, energy consumption and network lifetime and compared with two conventional works generalized unscented information filter (GUIF) [1] and Mixed maximum likelihood (ML)-Bayesian framework [2].

The steps involved in the stepwise regression analysis based decision tree classifier is given below.

1. As given in the above algorithm, to start with for each sensor nodes and reference nodes,
2. First, known distance is measured that forms the difference between the beacon message transmission and reply message from the sensor node.
3. With the obtained distance value, next, after receiving beacon message, the reference node continuously transmits the signal via RSSI.

4. Next, the unknown distances are measured by applying the Pythagoras theorem. In this stage, the mobile sink node also collects the data.
5. Now the mobile sink node sends the collected data to the base station by applying stepwise regression analysis.
6. Next, triangulation process is applied to determine the x and y coordinates of the target node. Followed by which, energy consumed for target tracking is also measured.
7. Finally, decision tree classifier is applied to the target being tracked for gathering node information gathered at different time and also decision rules are constructed to find the path.

V. RESULT AND DISCUSSIONS

In this section, the simulation result of SRA-DTC Model is compared with two state-of-the-art works namely GUIF [1] and Mixed maximum likelihood (ML)-Bayesian framework [2]. The effectiveness of SRA-DTC Model is determined with the aid of below tables and graphs.

A. Simulation Measurement of Target Tracking Accuracy

Target tracking accuracy 'TRA' determines how the base station accurately tracks target location and trajectory by using gathered information in WSN. From that, target tracking accuracy calculated as ratio of the number of sensor nodes gives the accurate sensed data about the target to the total number of sensor nodes considered for the simulation. The target tracking accuracy is mathematically estimated using below,

$$TTA = \frac{m_{PASD}}{n} * 100 \quad (7)$$

From equation (7), 'm_{PASD}' indicates a number of sensor nodes provides the accurate sensed data about the target node in wireless network whereas 'n' represents a total number of sensor nodes. The target tracking accuracy is evaluated in terms of percentage (%).

Sample Mathematical Calculation for Target Tracking Accuracy:

- ❖ **Proposed SRA-DTC:** Number of sensor nodes are 50 and number of sensor nodes exactly provide the sensed data is 45. The target tracking accuracy is measured as,

$$TTA = \frac{45}{50} * 100 = 90\%$$

- ❖ **Existing GUIF:** Number of sensor nodes is 50 and number of sensor nodes correctly give the sensed data is 40. The target tracking accuracy is evaluated as,

$$TTA = \frac{40}{50} * 100 = 80\%$$

- ❖ **Existing ML-Bayesian framework:** Number of sensor nodes is 50 and number of sensor nodes accuarely give the sensed information is 38. The target tracking accuracy is determined as,

$$TTA = \frac{38}{50} * 100 = 76\%$$

In order to estimate the accuracy of target tracking in WSN, SRA-DTC Model is implemented in NS-2 simulator by considering various number of sensor nodes in the range of 50-500.

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When taking 400 sensor nodes as input to perform simulation work, SRA-DTC Model gets 98 % target tracking accuracy whereas conventional GUIF [1] and ML-Bayesian framework [2] obtains 91 % and 86 % respectively. Hence, SRA-DTC Model attains enhanced accuracy to identify the target node in WSN as compared to other state-of-the-art works. The comparative result analysis of target tracking accuracy is depicted in below Table 2.

TABLE 2

Tabulation Result of Target Tracking Accuracy

Number of sensor nodes	Target Tracking Accuracy (%)		
	SRA-DTC	GUIF	ML-Bayesian framework
50	90	80	76
100	95	87	82
150	93	83	75
200	95	86	81
250	97	83	78
300	95	87	80
350	96	88	82
400	98	91	86
450	96	88	82
500	97	89	85

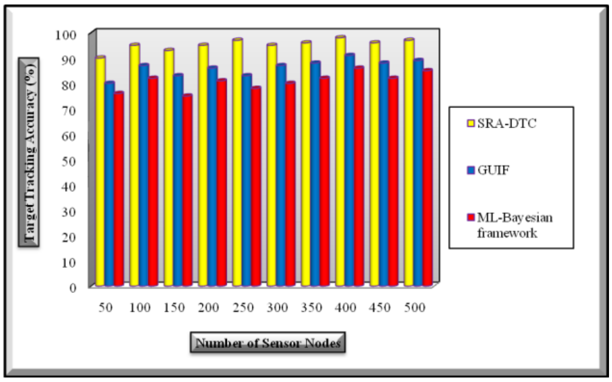

Fig 6: Performance Measure of Target Tracking Accuracy versus Number of Sensor Nodes

Figure 6 shows impact of target tracking accuracy with respect to different number of sensor nodes using SRA-DTC Model, GUIF [1] and ML-Bayesian framework [2]. As depicted in above graphical representation, SRA-DTC Model provides better target tracking accuracy in WSN with increasing number of sensor nodes in WSN as compared to GUIF [1] and ML-Bayesian framework [2]. This is owing to application of stepwise regression analysis and decision tree classifier in SRA-DTC Model on the contrary to existing works[1] and [2]. By using the stepwise regression analysis with triangulation process, SRA-DTC Model precisely finds the location of target based on collected data in wireless network. Besides with application of decision tree classifier, SRA-DTC Model exactly identifies the path of target node in WSN depends on gathered data. Therefore, SRA-DTC Model enhances the target tracking accuracy by 11 % and 18 % as compared to GUIF [1] and ML-Bayesian framework [2] respectively.

B. Simulation Measurement of Target Tracking Time

Target tracking time 'TTT' measures amount of time needed to identify the target node location and trajectory in WSN. The target tracking time is mathematically calculated using below,

$$TTT = t_E - t_S \quad (8)$$

From equation (8), 't_E' point outs an ending time whereas t_S indicates a starting time of target node tracking and it determined in terms of milliseconds (ms).

Sample Mathematical Calculation for Target Tracking Time:

- **Proposed SRA-DTC:** number of sensor nodes are 50. Let us consider starting time is 0 ms and ending time of target node discovery is 16 ms. Then the target tracking time is calculated as,

$$TTT = 16\ ms - 0\ ms = 16\ ms$$

- **Existing GUIF:** number of sensor nodes is 50.Starting time is 0 ms and ending time of target node detection is 22 ms. Then the target tracking time is computed as,

$$TTT = 22\ ms - 0\ ms = 16\ ms$$

- **Existing ML-Bayesian framework:** number of sensor nodes is 50. Starting time is 0 ms and ending time of target object identification is 26 ms. Then the tracking detection time is estimated as,

$$TTT = 26\ ms - 0\ ms = 26\ ms$$

For determining time complexity involved during target tracking process in WSN, SRA-DTC Model is implemented in NS-2 simulator with different number of sensor nodes in the range of 50-500. When considering 250 sensor nodes as input to carry out simulation process, SRA-DTC Model acquires 29 ms target tracking time whereas existing GUIF [1] and ML-Bayesian framework [2] gets 39 ms and 42 ms respectively. From these results, SRA-DTC Model achieves minimum target tracking time in WSN as compared to other conventional works. The tabulation result analysis of target tracking time is shown in below Table 3.

Table 3

Tabulation Result of Target Tracking Time

Number of Sensor Nodes	Target Tracking Time (ms)		
	SRA-DTC	GUIF	ML-Bayesian framework
50	16	22	26
100	21	28	30
150	23	31	33
200	27	35	37
250	29	39	42
300	33	41	45
350	35	44	49
400	39	46	51
450	42	49	53
500	46	52	56

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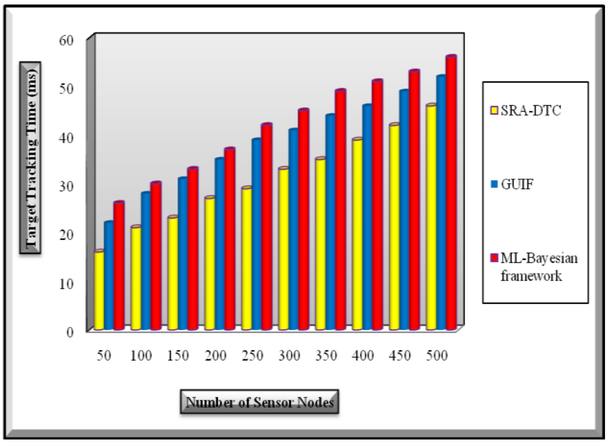

Fig 7:Performance Measure of Target Tracking Time versus Number of Sensor Nodes

Figure 7 illustrates impact of target tracking time based on varied number of sensor nodes using SRA-DTC Model, GUIF [1] and ML-Bayesian framework [2]. As depicted in above graphical representation, SRA-DTC Model provides better target tracking time in WSN with increasing number of sensor nodes in WSN when compared to GUIF [1] and ML-Bayesian framework [2]. This is because of application of stepwise regression analysis and decision tree classifier in SRA-DTC Model on the contrary to conventional works. The SRA-DTC Model correctly locates the position of target in wireless network with a minimal amount of time using stepwise regression analysis with triangulation process. In addition, SRA-DTC Model exactly predicts the trajectory of target node in wireless network with a lower amount of time. Thus, SRA-DTC Model reduces the target tracking time by 21 % and 27 % as compared to GUIF [1] and ML-Bayesian framework [2] respectively.

C. Simulation Measurement of Energy Consumption

Energy consumption 'EC' estimates an amount of energy used by the sensor nodes for tracking the target node location and trajectory in WSN. The energy consumption is mathematically measured as,

$$EC = n * \sigma\ (SS) \qquad (9)$$

From equation (9), 'n' indicates the number of sensor nodes and '$\sigma\ (SS)$' represents energy utilized by the single sensor nodes for finding the target location and trajectory. The energy consumption is determined in terms of a joule (J).

Sample Mathematical Calculation for Energy Consumption

- **Proposed SRA-DTC:** Number of sensor nodes is 50 and the energy used by single sensor nodes is 0.5 J. The energy consumption is computed as follows,

$$EC = 50 * 0.5 = 25\ J$$

- **Existing GUIF:** Number of sensor nodes is 50 and the energy employed by single sensor nodes is 0.7 J. The energy consumption is determined as follows,

$$EC = 50 * 0.7 = 35\ J$$

- **Existing ML-Bayesian framework:** Number of sensor nodes is 50 and the energy consumed by single sensor nodes is 0.8 J. The energy consumption is estimated as follows,

$$EC = 50 * 0.8 = 40\ J$$

For determining the energy utilization during target identification process in WSN, SRA-DTC Model is implemented in NS-2 simulator with help of varied number of sensor nodes in the range of 50-500. When employing 350 sensor nodes as input to accomplish simulation evaluation, SRA-DTC Model attains 46J energy to identify the target node location in network whereas conventional GUIF [1] and ML-Bayesian framework [2] takes 53 J and 56 J respectively. Accordingly, SRA-DTC Model gets energy consumption for target tracking in WSN as compared to other state-of-the-art works. The performance result analysis of energy consumption is demonstrated in below Table 4.

Table 4
Tabulation Result of Energy Consumption

Number of sensor nodes	Energy consumption (joule)		
	SRA-DTC	GUIF	ML-Bayesian framework
50	25	35	40
100	30	38	42
150	32	39	44
200	34	40	46
250	38	43	48
300	42	48	51
350	46	53	56
400	48	56	60
450	51	54	63
500	52	55	65

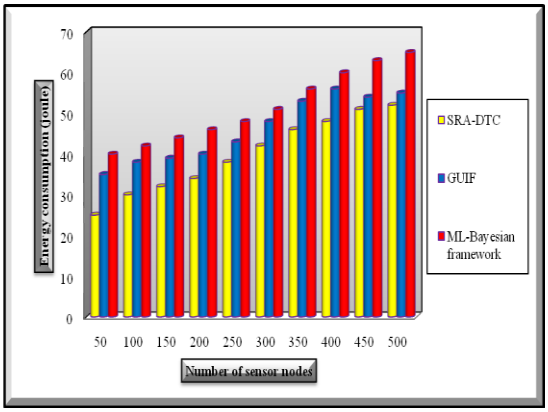

Fig 8: Performance Measure of Energy consumption Versus Number of Sensor Nodes

Figure 8 demonstrates impact of energy consumption with respect to diverse number of sensor nodes using SRA-DTC Model, GUIF [1] and ML-Bayesian framework [2]. As exposed in above graphical diagram, SRA-DTC Model provides better energy consumption for target location and trajectory tracking in WSN with increasing number of sensor nodes in WSN as compared to GUIF [1] and ML-Bayesian framework [2]. The SRA-DTC Model SRA-DTC Model employs only sensor nodes with minimum energy consumption to carry out target tracking process. This supports for SRA-DTC Model to perform target node location and trajectory tracking process with a minimal energy in WSN as compared to existing works[1] and [2].

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Thus, SRA-DTC Model decreases the energy consumption by 15 % and 23 % as compared to GUIF [1] and ML-Bayesian framework [2] respectively.

D. Simulation Measurement of Network Lifetime

Network lifetime 'NL' measured as a ratio of the number of energy efficient sensor nodes are taken for finding target node location and trajectory among the number of sensor nodes in WSN. The network lifetime is mathematically calculated using below,

$$NL = \frac{m_{EESN}}{n} * 100 \quad (11)$$

From equation (11), 'm_{EESN}' refers number of energy efficient sensor nodes are considered for target discovery and 'n' signifies the number of sensor nodes. The network lifetime is measured in terms of percentage (%).

Sample Mathematical Calculation for Network Lifetime:

- **Proposed SRA-DTC:** Number of sensor nodes are 50 and number of energy efficient sensor nodes are employed is 46. The network lifetime is obtained as,

$$NL = \frac{46}{50} * 100 = 92\%$$

- **Existing GUIF:** Number of sensor nodes is 50 and number of energy efficient sensor nodes are used is 41. The network lifetime is measured as,

$$NL = \frac{41}{50} * 100 = 82\%$$

- **Existing ML-Bayesian framework:** Number of sensor nodes is 50 and number of energy efficient sensor nodes is selected is 38. The network lifetime is calculated as,

$$NL = \frac{38}{50} * 100 = 76\%$$

In order to measure the network lifetime when performing target tracking process, SRA-DTC Model is implemented in NS-2 simulator with help of diverse number of sensor nodes in the range of 50-500. When using 450 sensor nodes for simulation evaluation, SRA-DTC Model achieves 96 % network lifetime whereas conventional GUIF [1] and ML-Bayesian framework [2] obtains 88 % and 82 % respectively. As a result, SRA-DTC Model acquires enhanced network lifetime in WSN as compared to other existing works[1] and [2]. The simulation result analysis of network lifetime is portrayed in below Table 5.

Table 5
Tabulation Result of Network Lifetime

Number of sensor nodes	Network Lifetime (%)		
	SRA-DTC	GUIF	ML-Bayesian framework
50	92	82	76
100	96	88	82
150	93	84	75
200	97	86	81
250	98	83	78
300	95	87	80
350	97	88	82
400	97	91	86
450	96	88	82
500	98	90	85

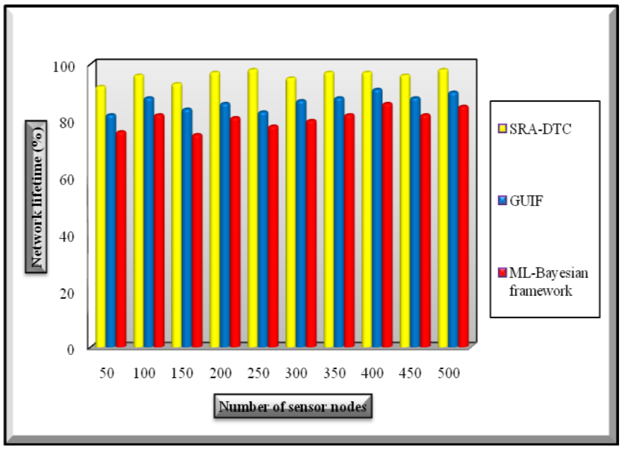

Fig 9: Performance Measure of Network Lifetime versus Number of Sensor Nodes

Figure 9 portrays impact of network lifetime based on various number of sensor nodes using SRA-DTC Model, GUIF [1] and ML-Bayesian framework [2]. As shown in above graphical diagram, SRA-DTC Model get enhanced network lifetime in WSN with increasing number of sensor nodes in WSN when compared to GUIF [1] and ML-Bayesian framework [2]. The SRA-DTC Model SRA-DTC Model selects only sensor nodes with lower energy utilization in wireless network to predict target node location and their path. This helps for SRA-DTC Model to reduce the amount of energy utilized to find the target node location and their trajectory in WSN. Therefore, SRA-DTC Model performs energy efficient target detection in wireless network as compared to conventional works. Thus, SRA-DTC Model increases the network lifetime by 11 % and 19 % as compared to GUIF [1] and ML-Bayesian framework [2] respectively.

VI. CONCLUSION

An effective SRA-DTC Model is developed with aiming at enhancing the performance of target location and trajectory detection in WSN with lower energy utilization. The objective is achieved by applying stepwise regression analysis and decision tree classifier. By applying the stepwise regression analysis and triangulation process, precise detection of target node in WSN is said to occur with minimal time. Besides, the target path is also detected with lesser time via decision tree classifier. This objective is said to be achieved by only selecting the energy efficient sensor nodes that predicts the target location and trajectory discovery. With this, SRA-DTC Model attains improved energy efficient target tracking performance with a minimal time as compared to conventional techniques. The performance of SRA-DTC Model is estimated in terms of target tracking accuracy, target tracking time, and energy consumption, network lifetime and compared with two existing works. The experimental result illustrates that target tracking provides better performance with an improvement of target tracking accuracy and minimization of energy consumption when compared to state-of-the-art works.

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