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Trilateral Plane Estimation Between Nodes for the Improved Home Automation System Performance with the Integrated Internet of Things

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Abstract: The home automated system is also stated as the Smart Home technology which incorporates the Internet of Things (IoT). The application of IoT in the home automated system effectively practices every element in the home for the automated process. As smart home technology comprises amenities that are equipped with communication technology for the automated and remote-control process. The environmental control amenities in the automated system are air conditioning, heating, and lighting system. This paper presented a Trilateral Euclidean estimation of Information (TEEI) for the IoT integrated automated system. The Proposed TEEI model uses the Euclidean distance estimation between the nodes in the environment. Based on the trilateral estimation between the nodes the features are evaluated for application control. The experimental analysis is performed for the automated system for the temperature-sensing environment. The simulation analysis confirmed that the proposed TEEI model is effective for the coverage range of 100 meters. The relay in the automated system is turned ON when the temperature reaches around 260C. Through analysis, it can be concluded that the proposed TEEI model is effective for the automated home control system.

Keywords: *Automated Home System, Internet of Things (IoT), trilateral Plane, Euclidean Distance*

1. Introduction

Modern civilizations expect their lives to be improved by new ideas and new technologies. The Internet has brought dramatic changes in people's lives. The evolution Internet of Things (IoT) has huge potential to improve overall quality of life [1]. Under present condition, IoT has entered in every field ranging from agriculture, manufacturing, healthcare, smart cities and our homes too [2]. With IoT, modern homes have become more technology enabled, which could potentially generate comfort, convenience, protection, safety and security. Despite the strong and accepted concept of "Smart Home" in other countries, there are obvious hesitations in India [3]. For homeowners their personal belongings and physical asset both are most essential. They are afraid of losing their personal assets, information/ data which may be stolen and put to wrong use [4]. Therefore, protection of confidential information and physical asset is their top priority.

The interest and need for new technology are growing on a daily basis. Fascination with creativity, combined with the need for convenience, has given rise to the concepts, creation and output of these new technologies [5 – 8]. One technology in particular that has drawn tremendous attention is smart home technology. With smart home technology, the home can be designed for comfort, protection and accessibility by being able to monitor various parts of the home using a smartphone or remote control. A smart home as a place to live in computing and Information technology has been applied via networking inside and outside the home [9]. This solution can then adapt to the needs of everyone inside a home, and the service may provide functions that can be used to promote convenience, comfort, protection or entertainment [10]. Smart technology can be used to monitor TV, lighting, temperature, various sets of appliances (such as a coffee machine or air conditioner) and more. Although the Smart home automation will make our lives easier, it will also introduce new hazards. Users may face additional opportunities as well as risks, as with any other new advancement. Security and privacy are major problems for IoT technology and its widespread adoption, according to a number of academic study publications [11 – 13].

The provision of technology, techniques, practices, and infrastructure that mitigates unacceptable risks, systems that are sufficiently secure enable stakeholders to benefit from facilities and experiences that would otherwise be intolerably harmful [14]. The problem is the need to determine if there is an adequate protection, unacceptable threats to the related stakeholders [15]. This includes a clear understanding of vital principles such as safety, confidentiality, integrity, availability, transparency, etc.; awareness of risks, vulnerabilities, and controls; ability to understand, enforce, use, and sustain security controls; and ability to make trade-offs that align security and privacy with business imperatives: e.g., user privacy vs. ad-supported privacy [16]. Although attempts are being made to research and protect home environments, there is a substantial gap in the skills, experience, awareness and services available to home users and families. This paper presented a effective automated system integrated with the

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IoT for the home appliances. The developed model TEEI is effective for the temperature monitoring and environment sensing application.

2. Home Automation Trilaternal Euclidean Estimation

The IoT home automation system comprises of the data location information, personal information, assets and portable instruments those increases the efficiency of the automation process. The proposed Trilateral Euclidean estimation of Information (TEEI) model evaluates the information location of the node based on the position. Through consideration of the line of sight with the multipath effect the node location are computed with the RSSI values in the IoT node.

With the proposed TEEI model the distance between the nodes are computed for the loss in the signal strength. Through the radio propagation model the deployed IoT model signal strength are computed for the signal strength based on the distance. With the propagation model the transmitter and receiver signts are computed for the consideration of the obstacles. The signal power of receiver with the free space diatance are defined as d the distance between the transmitter are presented in equation (1)

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2 L} \quad (1)$$

In the above equation (1) the transmitted signal power is denoted as P_t for the signal power, the transmitter and receiver antenna gain is stated as G_t and G_r respectively. The loss in system L for the wavelength λ^2 the features are computed. Based on the communication range the free space models are computed based on all packets in the receiver.

The proposed TEEI model computes the ground refelection in the model with consideration of the two-ray ground model with consideration of the direct and reflected communication ray. The proposed model exhibits the accurate prediction of the measurements for the long-distance communication. In the automation system the received power signal value d is estimated based on distance as in equation (2)

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L} \quad (2)$$

where $h_t^2$and h_r^2 heights of the antenna for the transmitter and receiver respectively. With the TEEI model the features are computed with the shortest path estimation with the combination of the two-ray model. The communication range of the model is defined as in equation (3)

$$RSS = 10nlog_{10}d + A \quad (3)$$

The trilateration theory the nodes are considered of the nodes with node location and tracking. The determined two-dimension node location are estimated for the beacon signal transmission of the nodes with the omni-directional antenna for the each node for distance ® between location. The node distance (r_1^2) the nodes are computed based on the Euclidean distance as stated in equation (4)

$$(X_1 - X_4)^2 + (Y_1 - Y_4)^2 = r_1^2 \quad (4)$$

where $(X_1 - Y_1)$and $(X_4 - Y_4)$ the coordinate values are estimated based on the node in the network as stated in equation (5)

$$(X_1 - X_4)^2 + (Y_1 - Y_4)^2 - r_1^2 = 0 \quad (5)$$

Similarly, the coordinates are stated as $(X_2 - Y_2)$ and $(X_3 - Y_3)$ based on the location of the nodes are computed as in equation (6)

$$\begin{bmatrix} (X_1 - X_4)^2 + (Y_1 - Y_4)^2 \\ (X_2 - X_4)^2 + (Y_2 - Y_4)^2 \\ (X_3 - X_4)^2 + (Y_3 - Y_4)^2 \end{bmatrix} - \begin{bmatrix} r_1^2 \\ r_2^2 \\ r_3^2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \quad (6)$$

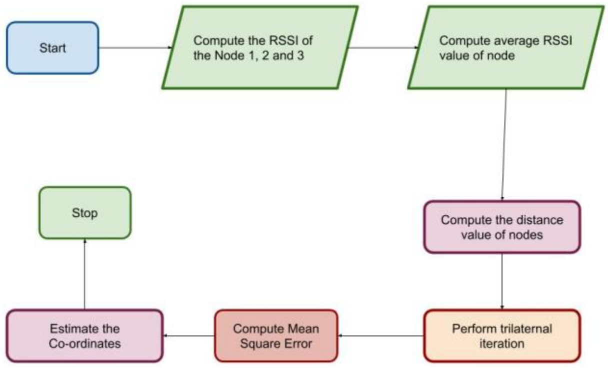


Figure 1: The coordinate estimation with the TEEI

The localization of the gateway nodes is computed based on the coordinates connected in the tracked nodes. Through the application of the programmable devices the computation is based on the flash memory. The gateway coordinate the RSSI values are estimated based on the anchor node estimation position.

3. Results and Discussion

The performance of the proposed TEEI computed with the RSSI value measurement for the displacement errors in the home automation is presented in the equation (7)

$$Error = \sqrt{(X_a - X_m)^2 + (Y_a - Y_m)^2} \quad (7)$$

In the above equation (7) the actual coordinate value $X_a$and Y_a and the measured coordinates are defined as X_m and Y_m. The RSSI readings are estimated based on the minimum square error, coordination and displacement in the trilateration plane. The table 1 provides the features of the measurement variable for the indoor environeent are estimated.

Table 1: Computation of Variables

Time	Intensity of Light (Lux)	Temperature (ºC)	Node Voltage (Volts)
11:33:37	86.97	30.61	2.37
11:43:37	82.28	30.74	2.37
11:53:37	80.59	30.74	2.37
12:03:37	79.24	30.70	2.37
12:13:37	76.45	31.17	2.37
12:23:41	74.34	32.94	2.37
12:33:39	70.96	31.37	2.37
12:43:37	78.44	29.17	2.37
12:53:35	77.70	29.94	2.37
13:03:29	71.43	30.54	2.37
13:13:22	76.64	30.54	2.37
13:23:16	71.20	29.67	2.37
13:33:10	60.13	27.50	2.37
13:43:05	64.17	26.68	2.37
13:53:00	66.51	27.39	2.37
14:02:49	60.17	29.09	2.37
14:12:37	62.13	29.09	2.37
14:22:27	68.86	20.14	2.37
14:32:13	68.81	20.14	2.37

In the home monitoring system the features are extracted from the AC main connection, node operation voltage for the three hour duration. In figure 2 – 4 the measured response for the varying temperature, intensity and node voltage are presented.

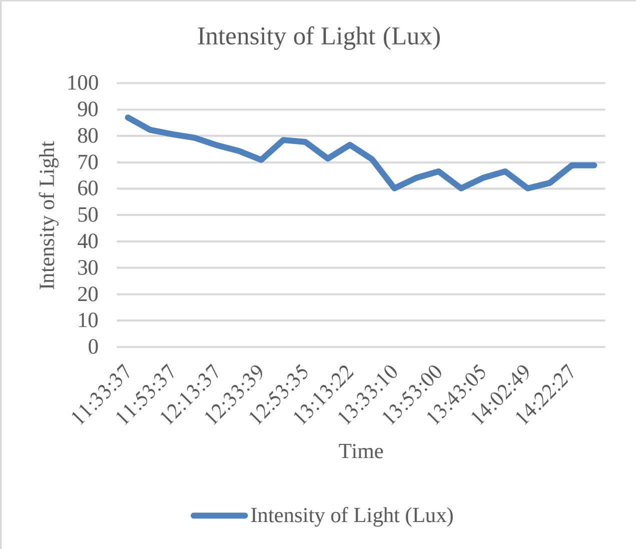


Figure 2: Estimation of Light Intensity

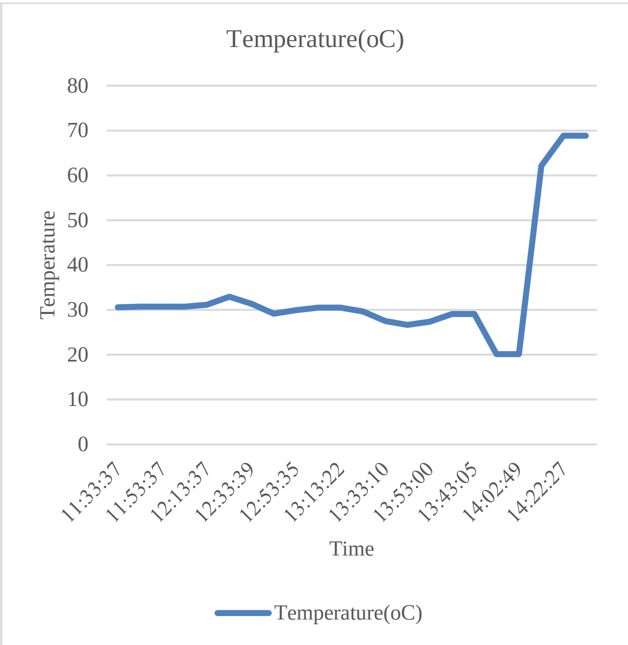


Figure 3: Estimation of Temperature

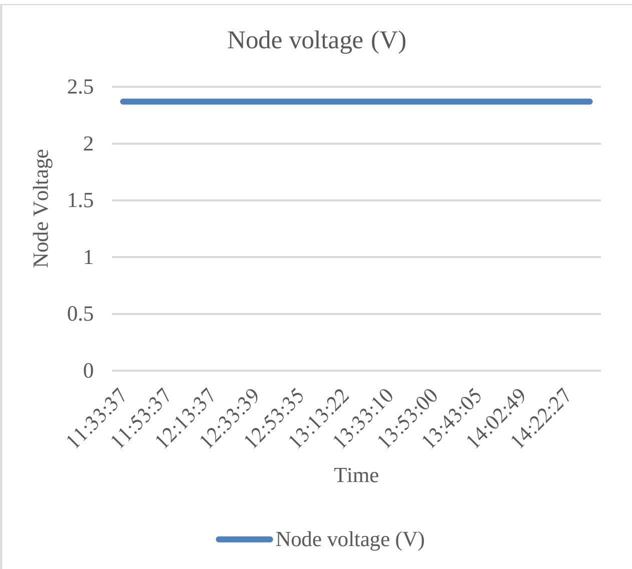


Figure 4: Computation of Node Voltage

In the table 2 the temperature profile response for the relay status of the node in the home automation system is presented. s

Table 2: Estimation between temperature profile and relay status

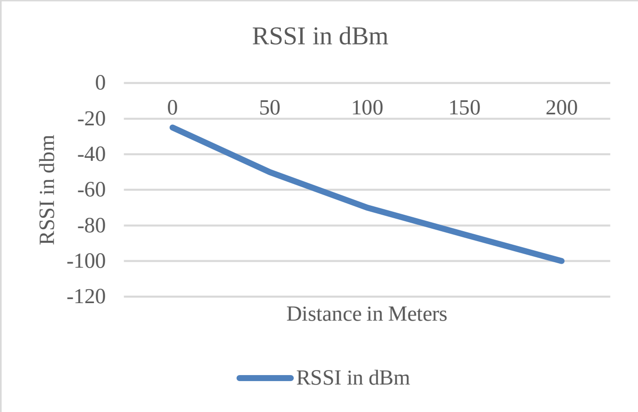
Time	Temperature (oC)	Relay status
11:35:35	26.34	ON
11:37:36	29.58	ON
11:39:35	29.67	ON
11:41:37	28.76	ON
11:43:39	27.63	ON
11:45:35	28.38	ON
11:47:37	26.73	ON
11:49:36	27.85	ON
11:51:38	28.87	OFF
11:53:34	26.53	OFF
11:55:33	26.34	OFF
11:57:36	27.56	OFF
11:59:41	22.35	OFF
12:01:38	26.85	OFF
12:03:45	24.83	OFF
12:05:39	25.75	OFF

In table 3 the relay status of the node for the varying temperature with the proposed TEEI model is presented. The estimation expressed that the proposed TEEI model ON the relay for the temperature higher than the 26 °C.

Table 3: Relation between Temperature and Relay

Time	Temperature (°C)	Relay status
12:11:35	28.13	ON
12:13:36	23.46	OFF
12:15:34	22.67	OFF
12:17:36	24.57	OFF
12:19:41	26.34	ON
12:21:39	28.56	ON
12:23:40	26.87	ON
12:25:41	26.84	ON
12:27:41	27.45	ON
12:29:38	28.56	ON
12:31:37	28.34	ON
12:33:36	28.56	ON
12:35:34	27.68	ON
12:37:33	27.94	ON
12:39:35	28.35	ON
12:41:36	28.46	ON

Through the examination of the control position the actuating relay in the nodes are estimated based on the time of the temperature and the relay values in the nodes. With the automated control system the position values are tested with the 6V relay values in the system for the automated home system monitoring in the IoT environment. In figure 5 the RSSI estimation based on the distance is presented



The analysis of the results are computed based on the consideration of the effective transmission and reception with the overall coverage range of 100 meters. The coverage limits are sufficient enough for the automated home system in the effective coverage distance computation.

4. Conclusion

Automated home system uses the IoT environment for the monitoring indoor and outdoor environment. To improve the effectiveness of the system Trilaternal Euclidean estimation of Information (TEEI) are developed and examined. The proposed TEEI model incorporates the feature variable for the computation of the indoor environment in the system. The proposed TEEI model computes the indoor relay for the consideration of the different applications. The experimental analysis expressed that proposed TEEI model convers the range of 100 meters which is significant enough for the effective monitoring. The relay in the home automated system is automatically ON over the temperature range of 26^0C. This implies that the proposed TEEI model is effective for the automated home system with the implemented IoT environment.

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