Abnormality Detection of Sensors in IOT Controllers using Fuzzy Approach for Smart Home

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***Abstract*— Smart home innovation is developing quickly as an energizing new worldview. An extensive variety of perspectives that incorporates security, energy sparing, ventilation, shrewd kitchen is canvassed in this paper. The greater part of the above is executed with the assistance of keen gadgets, for example, remote control, security alerts, sensors and so forth. In this paper we exhibit the previously mentioned innovations and devices that can be incorporated in home frameworks which can give security energy optimization and other such keen parameters. Various scenarios in terms of case study is also present in this literature. Euclidean distance mechanism is used to analyse closest pairs with in smart home dataset for future abnormality predictions. Results in terms of energy consumption and time consumed show optimization through the energy conservation mechanisms incorporated.**

***Keywords*— Smart home, Scenarios, Euclidean distance, Energy consumption, Prediction accuracy**

I. INTRODUCTION

Smart home is the combination of innovation and administrations through home systems administration for a superior nature of living. It utilizes diverse advancements to prepare home parts for more canny checking and remote control and empowering them for persuasive symphonies cooperation among them to such an extent that the regular house works and exercises are computerized without client intercession or with the remote control of the client in a less demanding, more advantageous, more productive, more secure, and more affordable way. Sometimes, Integrating the home administrations enables them to speak with each other through the home controller, thereby empowering single catch to control the different home frameworks as per pre-customized situations or working modes. Smart homes can possibly enhance home solace, comfort, security and energy administration. Additionally it can be utilized for senior individuals and those with handicaps, giving protected and secure situations [1].

Home automation is necessary for convenience and safety of people at home or outside home. For automation of home various automatic systems such as HVAC (Heating Ventilation and Cooling), lightening, anti-crime and fire detection systems are used. Smart home consists of hardware components (light bulb, sound system, sensors etc.), software components (controllers etc.), medium of communication (wired or wireless) all are prone to failure. Failures create problem for disabled persons. In order to resolve these failures to make living of people safe this paper presents prediction accuracy of abnormality of sensors.

The objective of this paper is to minimize energy consumption when sensors communicate, minimize time of execution and improve the prediction accuracy. All these objectives are fulfilled by the use of various scenarios. Different scenarios are sensors (heat map) detecting heat in the kitchen, detection of heat or smoke emitted by geezer in washroom and activity monitoring.

Rest of the paper is organized as follows: Section II provides information about equipments and techniques used, Section III provides brief description of the surveyed literature, Section IV describes literature gap, problem definition with objectives and proposed work is further described in section V. Next, section VI provides results of proposed work and comparison with existing work, Section VII concludes the paper.

II. EQUIPMENTS AND TECHNIQUES USED IN SMART HOMES

A) Network Used

Smart home system innovation can be arranged into two principle sorts, which are wiring framework and remote framework. In wiring framework here are many sorts of wires that individuals might need to introduce in divider. Many home automations are associated through wiring framework, for example, new wire (contorted combine, optical fiber), Powerline, Busline, and so forth. A case of extraordinary innovation is X10, which is open standard for home mechanization. X10 transmits double information utilizing the Amplitude Modulation (AM) system. What's more, X10 controllers send motions over existing AC wiring to beneficiary modules. In the remote framework, there must have two primary components that are sender and beneficiary[2]. Numerous new machines utilize remote innovation to speak with different gadgets. The case of remote correspondence framework are microwaves, Infrared (IR), radio recurrence (RF), Wi-Fi [3], [4], Bluetooth [5]–[7], IEEE 802.11, etc. Moreover, some of smart home system standard can work utilizing both wiring framework and remote framework. A case of remote correspondence framework for smart home is Z-wave, which is a solid and reasonable remote home automation arrangement.

B) Smart Home Controllers

Smart home controlling gadgets are utilized for dealing with the frameworks by sending information or flag to control the actuators. The cases of the controllers are not just the remote control,but they can likewise be smartphones, tablets (iPad, Galaxy tab), web programs and Short Message Service (SMS), messages and so on [2], [8].

C) Smart kitchen

Most charming utilization of smart innovation is kitchen. For instance, machines which are smart are coolers, microwaves, espresso creators, and dishwashers. The Internet Refrigerator applies the innovation of smarthome to make many works significantly less demanding. It is Internet empowered and enables clients to speak with it by means of the Internet, so it can download formulas and after that show them on its LCD screen. In addition, the cooler additionally takes a programmed stock of things within it and it can alarm the clients to what is there. In addition, microwaves are additionally smart. Microwaves can speak with smart refrigerators and propose formulas in view of the nourishment things accessible in the cooler. The microwave can even be set to begin at specific circumstances while clients are far from hom e[9], [10] .

III. Related Work

R. Orpwood et al. [27] presented design of smart homes for people suffering with dementia. Information about their behavior is gathered and designs new technology to interact with people with dementia. Design do personal care of people but sometimes responses are unpredictable that must be taken carefully.

Sébastien Guillet et al. [31] This paper presented first work for reconfiguration controllers using DCS (Discrete Controller Synthesis) technique. Controllers are reconfigured to re-execute the results by providing correct configuration. This reconfiguration is based on UML/MARTE that provide control specification. MARTE presents modes as operational state of system and transitions between different modes. All the transitions are according to UML

Md. Ahmed Ullah et al. [28] Presented a touch controlling system using smartphones to control the smart home appliances. The response time to detect, communicate and control devices is calculated and approximately it is 1.1 second .

Sébastien Guillet et al. [30] In this paper DCS technique for controllers is used. Proposed technique is helpful for disabled people in smart home and provides save and secure surrounding as sometimes people living in home are not able to overcome the faults in the system. DCS technique automatically adjust according to the activities done by the people.

Ali Hussain et al. [29] This paper presented smart home for disabled peole. Designing of smart home is done by using two types of neural network that helps people to live independently with secure environment. The system presented detects the next work of the people and accordingly take appropriate action (Feed-Forward Neural Network). Second type of neural network (Recurrent) provides security by giving alert for the awareness of disabled people.

Md. Ahsan Iqbal et al. [26] Built control system for disabled people using Kinect and X10 module. Devices work according to the position, voice and action of the people. The approximate response time of the system is 3.75 seconds. This system is helpful for old age people and for disabled people.

Sébastien Guillet et al. [15] In this context, this work aims at improving the security of the environment through a design methodology involving formal synthesis techniques. Reconfigurable controller is considered as a mean to provide fault tolerance mechanism. This proposal makes a contribution by providing a design methodology, relying on DCS to build smart home controller systems guaranteeing safety properties.

IV. Problem Definition

1) Research Gap

In techniques that are explained above in the literature survey has defined different fault tolerance methods. In these methods the various algorithms like remote computing, Neptune etc. All these methods give fault tolerance methods that are not energy efficient. In our proposed model we gives a strategy that is used to mange fault along with least energy consumption.

2) Problem Definition

Energy utilization particularly power is viewed as a standout amongst the most major issues in family units nowadays. It is on account of the measure of power devoured is more than the sum that individuals really require. This implies there is an abusing which come about because of the burden of moving to the change to kill the light or any machines and it is regularly that end the light is forgettable, for example; furthermore, there are no apparatuses for observing how much energy that is devoured in occupants. Sensors presence and interaction is critical in evaluation of faults and energy conservation [11], [12]. This gives problem definition listed as under

1) Energy conservation in sensor is critical which is absent in existing literature.
2) Faults due to sensors limited storage capabilities are required to be dealt with.
3) Comparison of various approaches or scenarios associated with smart homes is required to be analysed.

4) Future predictions regarding abnormal situation with accuracy is desired.

3) Objective

The proposed literature tackles the issues of energy consumption [5], [13] and fault tolerance in case of ambient intelligence field smart homes[14]. Various scenarios have been considered for evaluation. Scenarios considered for analysis are listed as under

1) Activity monitoring within smart homes

As the person moves from one section of his house to another motion detector detect person motion [16], [17]. Controller makes previous sensor to be at sleep. Hence energy is conserved and storage requirement is also minimized.

2) Heat Map

Gas burner considered for evolution in this situation. Sensors are placed within the kitchen [18], [19].

3) Geezer temperature enhancement detection

Geezer temperature detection sensor is placed in order to figure out the temperature of the hot water so that it could be bearable for the person. Sensor threshold is static that means if the water density is low than the threshold then it will be fine but if in case the density of the water is increased by the threshold value then it will immediately alert the person [20], [21].

Data will be recorded in each of the above scenarios and proposed methodology is applied. Accuracy, predictions, energy consumption and time of execution is compared against existing literature without Euclidean distance mechanism.

V. Proposed Work

Proposed system provides various scenarios in which sensors are placed and detects abnormal situations [22], [23]. Sensors capacity and smart home scenarios are predicted. Activity of users is noted and sensors are made to sleep in case person goes out of scope of sensors, hence conserving energy. Scenarios are depicted in this section.

1) Scenario Description

TABLE I
Smart Home Environment

Smart Home Environment	Description
Area	2000 Sqcm
Sensors	Heat Sensors Range 32 Sqcm Smoke Sensors Range 20-60 Sqcm
Number of sensors	4
Gas Burners	2
Activity Monitor Sensors	4
Controller	1
Protocol	IPv6 128 Bits
Mail Server	Simple Mail Transfer Protocol
Geezer	1 with 250W

Scenario 1:

Simultaneous Burners heating detection through Sensors:

In case gas burners are lighten up temperature starts to rise. Heat and smoke sensors are placed in order to determine amount of temperature rise detected. In case temperature rises beyond threshold values then alarm is going to blow. Mail system is setup using SMTP server. Mail is going to be transferred towards registered relatives of disabled persons. Sensors description for smart homes used for overheat detection is as under

TABLE II
Scenario 1 Set Up

Simulation Area	Sensor Configuration
Kitchen	1 heat and smoke sensor MLX90664
Gas Burners	Max heat emission 50°C

[8]Sensors do not react to single burner since maximum heat emission per burner is 50°C. In case second burner is switched on heat emission exceeds 50°C and alarm blows. Along with alarm, email to disabled person relatives is also transferred. The simulation environment situation along with action taken in case Norms are violated is as under

TABLE III
Situations And Corresponding Actions

Situation	Action
Temperature<50°C with Single Burner	No Action
Temperature>50°C with Single Burner	Issue Warning in terms of alarm
Temperature>50°C with Two Burners	Alarm and emails sent to relatives of disabled person
Temperature>200 °C	Automatically switch off burners and bring temperature under 50

Screen shot predicting scenario 1 is shown as under

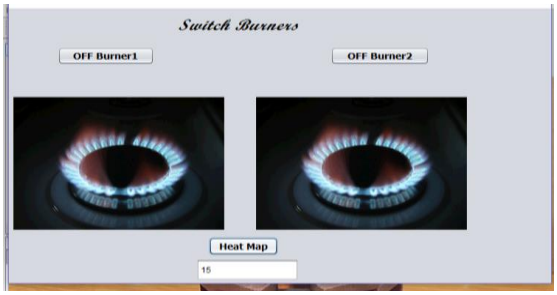

Fig.1 Showing Heat Map Scenario

Scenario 2

Second situation described the sensor placement within the wash room. The heat and smoke sensor placed in wash room detect heat and smoke emitted through Geezer [20], [24]. Alarm is blown and preventing abnormal situation and allows the user to be informed about the situation. Controller is present which controls the operation of sensor. Sensor is made to sleep in case Geezer is switched off.

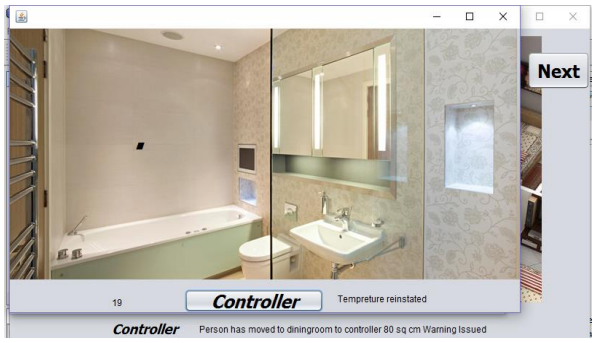

Fig. 2 Heat and Smoke Sensor Placement in Washroom

Scenario 3

Activity Monitor is used as a third situation. Sensor detects the motion of a person as persons moves from one room to another. Energy conservation is a prime objective of this scenario [16], [25]. Sensor detects movement of a person and accordingly starts or switch off the sensor in order to conserve energy. All the sensors are attached with the controller. Distance estimations are made in order to perform sleep operation active with sensors. Scenario is depicted through following screen shots.

The smart home is the technology enhancement mechanism allowing the users to control appliances within home remotely.

Proposed Flowchart

The smart home is the technology enhancement mechanism allowing the users to control appliances within home remotely. Proposed system depicts 3 scenarios. All of these scenarios are depicted in the flowchart. Different scenarios have their own working according to the description given in the above discussion. Here the work of scenarios is not described but the overall flow of the proposed work is shown in this flowchart.

Values are collected from scenarios and then Euclidean distance is applied to see the abnormality in the values which is then predicted as drift in the sensor by using fuzzy approach where 'u' represents the membership function. Proposed flowchart is shown in fig. 3.

Proposed Algorithm

Algorithm describing all situation depicted in flowchart is given as under

Input: Heat and smoke
Output: Alarm, future prediction accuracy, time & latency
1) Analyze Scenarios
2) If Scenario 1
   a) Observe gas burner
   b) If number of Gas Burner>1 and Temperature>50°C, Blow alarm and send mail to concerned person
   c) If number of Gas Burner<1 then No action taken
   d) If number of Gas Burner>1 and Temperature<50°C, Issue warning

2) If Scenario 2
   a) Sensor Observing heat from Geezer
   b) If Heat or Smoke>50 °C Issue alarm for abnormal situation
   c) Else No action Taken
   d) If Scenario 3
   - Check for activity of person
   - If Person _Range>Range_of _sensor then Make sensor sleep
   - Else Make current sensor observe activity

   e) Apply Euclidean distance to determine abnormal situations prediction in near future
   f) Fuzzy rule is used for abnormal situations to get prediction accuracy.

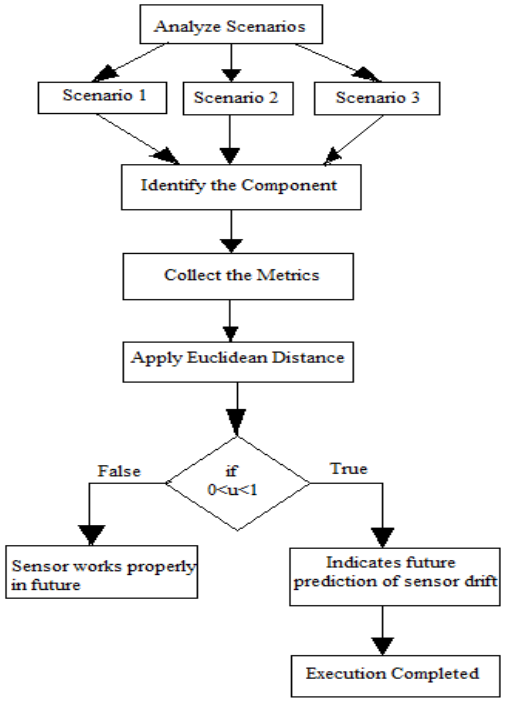

Fig. 3 Proposed Flowchart

VI. Result And Performance Analysis

Results in terms of time consumed and accuracy of prediction is presented. These results are compared with system without Euclidean distance. Result obtained with Euclidean distance is better as compared with the existing approach without Euclidean distance.

TABLE IV
Prediction Accuracy With Various Dataset

DATASET	MANHATTAN DISTANCE	EUCLIDEAN DISTANCE
ADLERROR	67.56	89.898
ADLINTERWEIVE	70.568	88.698
WSKUK1	7.2145	89.365

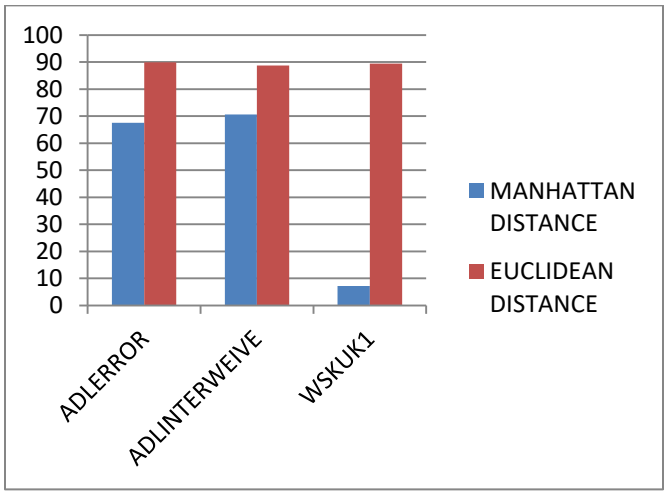

Fig. 4 Plots of comparison with different dataset

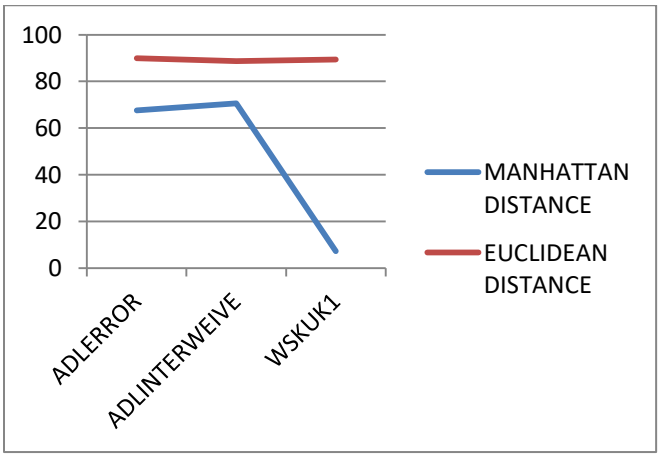

Fig.5 Line Chart of comparison with different dataset

Time consumption is one of the important factor considered in the proposed work.

TABLE V
Time Consumption With Various Dataset

DATASET	TIME CONSUMED EXISTING	TIME CONSUMED PROPOSED
ADLERROR	30.435	23.438
ADLINTERWEIVE	33.945	25.974
WSKUK1	35.785	27.043

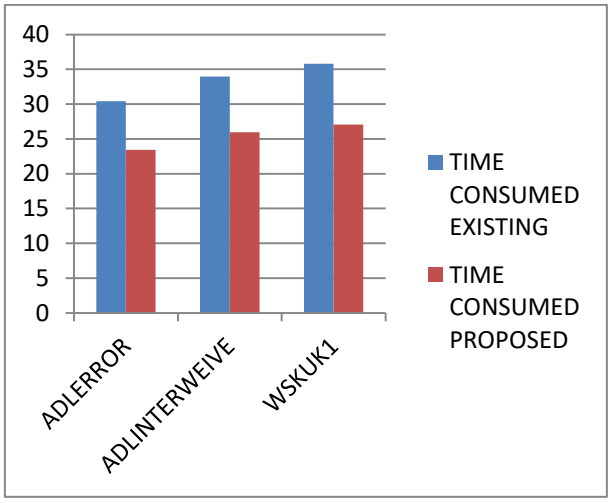

Fig. 6 Plots of time consumption in different dataset

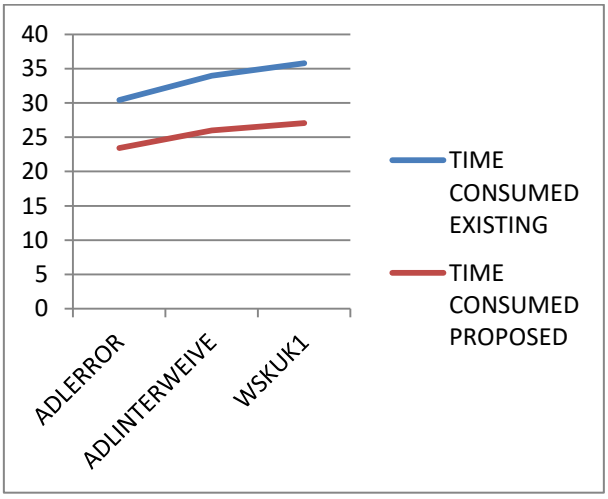

Fig. 7 Line chart of time consumption in different dataset

VII. Conclusion And Future Work

Innovative advances in inescapable detecting assume critical parts in utilizing the utilization of keen home datasets for

various uses of surrounding helped living. The hidden rationale of different orders strategies relies on upon assorted information singe characteristics so the dataset is altogether critical for their assessment. One of the fundamental difficulties is to register and break down information measurements and varieties. In this way, heat map information investigation is important to comprehend and reuse the datasets. In any case, the data furnished with shrewd home datasets is not generally adequate to explore the conceivable measurements of examination. We built up a system to break down the shrewd home datasets on predefined information qualities. It empowers the scientists to register information measurements that cover varieties in time, exercises, sensors, and occupants. To assess its adequacy, we demonstrated the impact of dataset attributes on the execution of the classifiers. We connected every classifier on three diverse datasets from three brilliant home ventures. The outcome demonstrates that ordinarily classifiers perform correlative to each other in light of dataset trademark for the acknowledgment of exercises. In this way, it is basic to pick a fitting dataset for a specific calculation. Subsequently, the effect of the proposed structure is to give a profitable and better comprehension of information for the area of heat and smoke emission detection. In future, we will extend this framework for recommender system of Green Products using content filtering.

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