

# The development of an Intelligent Fuzzy Expert System for The Home Safety System

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## Abstract

*This paper presents a home safety system assured the safety of home appliances and electrical usages that can be integrated with the existing home automation. This proposed system consists of a fuzzy expert system which has a fuzzy set of rules and inferences the home safety services according to the sensor input values. This system can be saved the electricity usage on the weekdays by the fuzzy set of rules, when everybody has gone to his/her work and nobody at home and also be provided the safety functions on weekends. This system can be obtained crisp output to control the home appliances by the Sugeno fuzzy inference method. The Geo Fencing system will also be applied to control the home appliances. IFTTT (If This Then That) method will provide the automotive function as a remote control. The Remote UI will be applied to monitor the condition of the home status.*

## 1. Introduction

There are many types of safety problems that may arise within a home environment. These safety problems can be classified into three big categories: safety of home appliances, safety of indoor environment and safety of interaction between home users and home appliances. The occurrence of home safety problem always have three bad consequences: cause casualty or cause home property loss or both [1].

The proposed system will use the fuzzy expert system to infer the home safety problem and electrical usage. Intelligent home is an integrated system in a home that integrates multiple home services, where the technology and process used to create a building that can act intelligently so that a home becomes safer and more productive for users and more efficient for its owners.

A fuzzy expert system is an expert system that uses fuzzy logic instead of boolean logic. In other words, a fuzzy expert system is a collection of membership functions and rules that are used to reason about data. Unlike conventional expert systems, which are mainly symbolic reasoning engines, fuzzy expert systems are oriented towards numerical processing [2].

The proposed system realizes by the sensors value rules. Firstly, this system needs to define the set of fuzzy rules. This system can also be saved the electricity usage on the weekdays, when everybody has gone to his/her work and nobody at home. And it can also be provided the safety functions on weekends. On the weekdays and weekends, the system automatically work based on the set of fuzzy rules to save the electricity. The Remote UI will also provide the functions to monitor and to control the status of home appliances.

People are always worried about what would be the condition of their homes and offices when they are not there. Therefore, this proposed system is trying to make a system which would

automatically provide the user to save and control the home appliances and electrical usage.

## 2. Related Work

In [1], the author proposed an effective approach for home safety problem detection and reaction is necessary. In order to be home safety problem detection, there are three levels of events defined: elementary event that excited by abnormal change of raw data, semantic event that is generated by one or more elementary events and entire event which represents the emergency level of a house. For the relationship between these events and raw data, a Finite State Machine (FSM) based modelling is applied. The raw data taken as input and output to the three levels of FSMs. Two simulation cases are proposed: one is heat stroke and another is carbon monoxide poisoning.

In [3], Expert systems are normally used in various problem solving and decision making activities such as monitoring, diagnosing and various training related activities. Yashwant Singh Patel proposed a framework that is based on wireless sensors and expert system to solve day to day problem occurring in home appliances. Whenever problem occurs in any part of home appliance, the sensor detects that problem automatically and sends it for solution to the expert system, Various noise removal algorithms for removing noise from the received data can be applied for getting noise free data. The expert system finds the solution based on the type of problem and sends the solutions with various images through SMS or e-mail to user's mobile or mail-id.

In [4], the author proposed the intelligent control in smart home based on adaptive Neuro Fuzzy Inference System (ANFIS). This research proposed the use of K-means clustering algorithm in the division of the input space.

Every cluster generates a membership function by approximation, the type of membership function is the bell, and then the optimization of the premise and consequent parameters in ANFIS model are realized through the combination of improved adaptive particle swarm algorithm and the least squares method. When the number of iterations that users set is reached, the satisfactory ANFIS model is obtained. The model also went through the simulation of controlling the electric curtains of the smart house in the Matlab platform. Theoretical analysis and simulation experiments show that this model can improve the learning ability of home control system.

In[5], intelligent home management system has been developed which has the ability to turn on and turn off the room lights automatically, record the controlled electronic devices usage status, switching on and off air condition regulating device automatically, showing temperature room in the house, detect fire signs in the house and turned on the sprinklers in the home in case of fire, supervising the home through surveillance cameras, storing photos and surveillance records on home, detecting people movement in home, and providing notification when someone entered home. System is implemented in prototype. The results show that the system can detect light intensity, flame, room temperature, movement of people, and home state and then the information is successfully sent to the server over the WiFi. The result can be read from server by using browser and there is a data logger in the server. Intelligent home management system prototype development covers hardware and software implementations.

### 3. Background Theory

#### 3.1. Geo fencing

Geo fencing is a technology used to monitor mobile objects (vehicles, persons, container, etc.), located by GPS. The geographic coordinates of the tracked object are automatically and regularly sent to a control center, via mobile phone networks. The set of geographic coordinates is used to constitute a virtual boundary (geo fence) around a geographic area. The system can determine whether the tracked object is located inside or outside the geo fenced area. This technology can also allow the detection of spatial proximity between the tracked mobiles and a specific geo fenced area [6].

#### 3.2 Fuzzy Expert System

The primary objective of fuzzy logic is to map an input space to an output space. The way of controlling this mapping is to use IF-THEN statements known as rules. The order in which these rules are carried out is insignificant, since all rules run concurrently. Fuzzy logic is a powerful problem-solving methodology with a myriad of applications in embedded control and information processing. It provides a remarkably simple way to draw definite conclusions from vague, ambiguous, or imprecise information. In a sense, it resembles human decision making with its ability to work with approximate data yet finds precise solution [7].

Fuzzy logic provides an approach to data fusion and reasoning for uncertain data by using the human expert knowledge. Aleksandar Rikalovic proposed the expert system is based on Fuzzy Interference System (FIS), which solve the nonlinear optimization problem by using the available knowledge. The Fuzzy Expert System

is shown in Figure 1. The FIS is divided into three main components: the fuzzifier, the knowledge management and the defuzzifier [8].

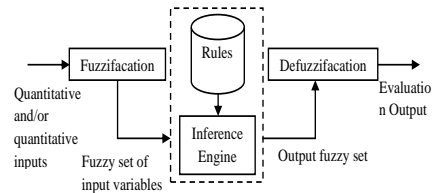
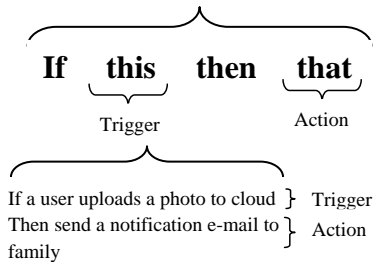


Figure 1. Fuzzy Expert System

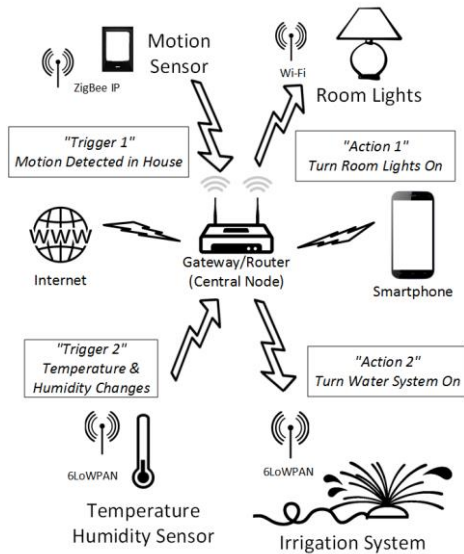
#### 3.3 IFTTT

IFTTT is a web based service that allows Internet users to create a chain-reaction from one web service application to another. Based on a user-defined conditional statement, called a recipe, the trigger of one web service application activates an action of another web service application. The IFTTT model can be applied to home automation devices where one device can trigger the action of another device. The IFTTT technology is described as shown in Figure 2. The Figure 3 describes how home automation devices would react on the user-define recipes. Two recipes are shown in Figure 3. First recipe is “If motion is detected in a room, then turn on the lights”. When the motion sensor in the room detects a movement, it sends a trigger to the central node. Based on the recipe and the trigger, the central node sends an action to the room lights to turn on. Second recipe is “If temperature and humidity changes in the garden, the turn on the irrigation system”. When the temperature and humidity sensor senses change, it sends the trigger to the central node. Then, the trigger is interpreted by the central node that sends an action to the irrigation system. These recipes can be generated by remotely accessing the central

node of the home automation system, or it can also be accessed within the home network. The central node acts as a router for the home devices to access the Internet and integrates all different types of data communication mediums. Therefore the central node offers a web interface to allow users to configure the different recipes, which can be accessed from computers, smartphones or tables [9].



**Figure 2. IFTTT description**



**Figure 3. Home automation overview**

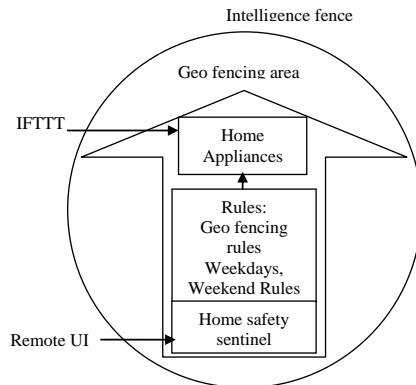
### 3.4 Remote UI

Remote UI refers to Web 2.0. The user can create new services by combining the object

provided services, it is called Web 2.0 or mashup. It can be specialized for the composition of services that enable accessing/controlling smart things [10]. A mashup is a web application or a web page which usually uses application programming interfaces (APIs) in order to blend information from multiple sources to create compelling services. As more and more embedded devices (like smartphones and sensor equipped appliances) will be apply to provide their functions as services online, and an abundance of real objects will essentially become a part of ambient spaces (interoperating and communicating over TCP/IP networks), the need to create value-added services by composing numerous embedded-device enable services [11].

## 4. Proposed System Design

The architecture of home safety system is shown in Figure 4. This architecture includes the Geo Fencing rules for intelligence fence, IFTTT acts like as remote control, sensor value rules for controlling the home appliances and the remote UI for monitoring the status of home.

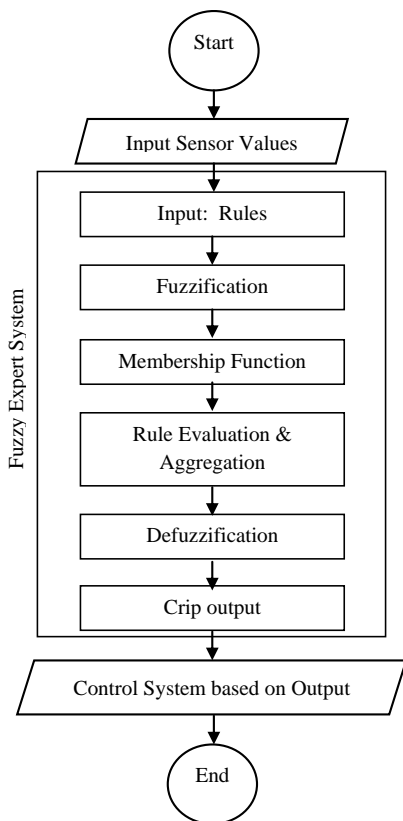


**Figure 4: The architecture of home safety system**

The proposed system will use the fuzzy expert system. Firstly, the system needs to define a set of fuzzy rules according to the input sensor

values. The input value can be obtained by the sensors. The proposed system design is shown in Figure 5.

Secondly, it proceeds to perform the fuzzy inference. And then this system will be made defuzzification by using the Sugeno fuzzy inference method to get crisp output. The Sugeno fuzzy inference method can be computed by the weighted average method. According the crisp output, finally the system will control the home appliances.



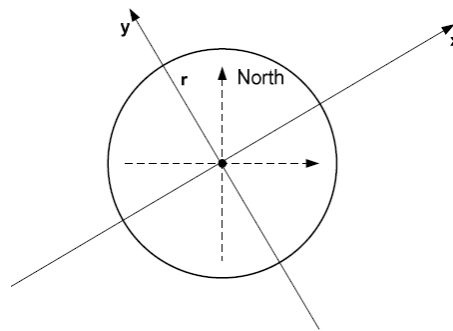
**Figure 5. The proposed system design**

In this proposed system, the size of geo fence size can range from a few tens of meters to several kilometers. The geo fencing areas can be defined by geometric shapes. The geographical

areas are defined as circular area, rectangular area and ellipsoidal area.

The proposed system defines the circular geographical area with a single point that represents the center of the circle and a radius. Coordinates from characteristic points of the shape are necessary to define the geo fence perimeter. These coordinates are used in equation (1), along with the inside or outside of the geo fence, which enables the computing of alerts. Sensor value rule uses the appropriate sensor values within the total range and the geofencing rules use fuzzy control logic, which is the IF THEN statements. The geographical circular area is described as shown in Figure 6. The function of geographical circular area is defined by equation (1).

$$F(x, y) = 1 - \left(\frac{x}{r}\right)^2 - \left(\frac{y}{r}\right)^2 \quad (1)$$



**Figure 6. The geographical circular area**

Where F is the function to determine the spatial characteristics of a point (x,y) relative to a geometric shape, r is the radius of a circle, x is the abscissa of a Cartesian coordination system with the origin in the center of the geographical area, y is the ordinate of a Cartesian coordination system with the origin in the center of the geographical area. The function F defined in equation (1), determines whether a point is located inside, outside, at the center, or at the

border of a geographical area. If the value function  $F$  is equal to one, the location is at the center point of the geographical area. If the value of function  $F$  is greater than zero, the location is inside the geographical area. If the value of function  $F$  is equal to zero, the location is at the border of the geographical area. If the value of function  $F$  is less than zero, the location is outside the geographical area.

IFTTT is a web-based service that allows Internet users to create a chain-reaction from one web service application to another. Based on the IFTTT (IF-This-Then-That) model, this proposed system will define a set of device communication protocols where devices' triggers and actions are combined to manage interactions for home safety. This system use Web 2.0 for remote user interface and create new services by combining the object provided services.

## 5. The Expected Impacts of Research

In this proposed system is a new technique of implementing home safety system that will give more safety for smart home appliances and electrical usage based on the rules. This proposed system will save cause casualty or cause home property loss or both. This proposed system will also provide the automotive functions as like remote control by using IFTTT. There exists several home safety systems. This proposed system to be more effectively and safety for home. This system will be acted intelligently the home safety services as like the human manner.

## 6. Conclusion

This paper proposes a home safety system which helps us to assure the safety of home appliances and home environment. This proposed system act as a sentinel, which knows

everything on home situations. It can provide home safety functions, and can also save the electricity usage. On the weekdays and weekends, the system automatically works based on the rules to save the electricity.

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