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Speech Enabled Smart Home Automation

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Abstract: **Smart Home Automation is the major need nowadays and is gaining popularity because of the development of compact and smart as well as intelligent devices. In this proposed approach, a new scheme is introduced to operate the devices in home via a more intelligent manner with the help of smart technologies like speech enabled integrated Internet of Things (IoT), which uses the internet as a medium to establish a bridge between local device and the remote server. The main objective of this paper is to implement a new system which can support voice assisted home automation with extreme security and range-free localization principles. The idea of the proposed paper is integrating the power of IoT with Classical Home Automation as well as deviating from the regular home automation schemes. The proposed system is named as "Speech Technology enabled Smart Home (STeSH)", which gathers the voice from the respective user and checks whether the user is a registered person to the particular device to operate or not. If the user is an authorized person, the device will be operating accordingly based on the voice commands raised by the user.**

Index Terms: **Speech Technology, IoT, Home Automation, STeSH, Voice Processing, Speech Recognition.**

I. Introduction

Now-a-days smart devices and technologies rule the world with their powerful approaches and provide many intelligent services to people to operate their needs by using such devices. In parallel, the communication medium is another growing entity, which supports this gadget to work in an intelligent manner to provide ultimate support to people to meet their global communication needs. Specialists do connect computerized gadgets with scientific and authoritative devices to make complex frameworks for quickly extending attributes of uses and physical pursuit. For the advancement of intelligent urban areas, there is a need to switch to systematic mode for everything, so the idea of smart home automation framework is a thought, which is utilized to make the city shrewd. A Smart Home is one that gives solace, security and gives the comfort feel to individuals. Intelligent homes additionally receive some advantages such as less-current consumption and consistency in availability, for each person at home. Smart Home Automation implies the observing and control of family unit questions wisely for viable utilization. The family unit items ought to be shrewdly interconnected just as give data to better activities. SmartHome Automation expanded with the Internet of Things (IoT) gives better adaptability in overseeing and controlling family questions in a more extensive angle. This will bolster the interconnectivity of countless SmartHome for better asset use in more extensive territory. In this paper, we planned to integrate the latest technologies along with intelligent communication methods to automate the people's regular usable devices such as electronic gadgets, charging devices, A.C., Television and many more household devices. In this concert, we need to elaborate the two technologies further to clear, the first one (Figure-1) voice enabled services for operating the household devices with speech technology enabled services.

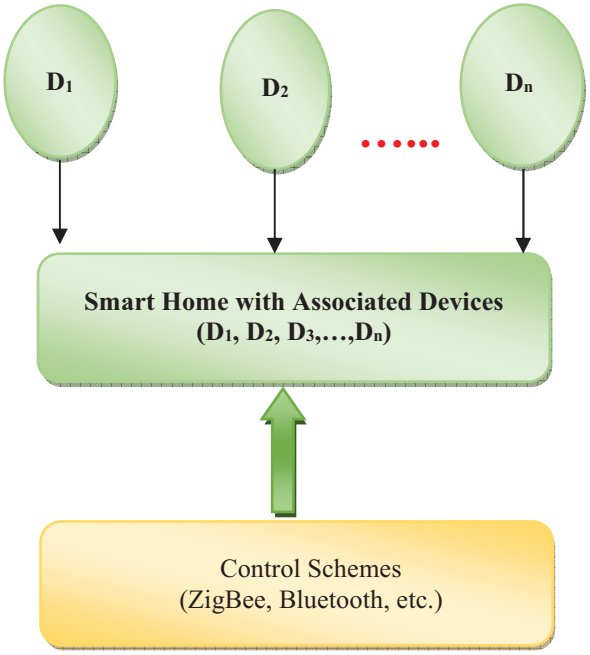

Figure 1. Classical Smart Home Automation System Working Model

These Speech Enabled Services are applied to our smart home automation services by means of triggering the devices using customer voice. In this position all of us have a question like, if any other person or third-person or other intruders operate the device by using their voice means, so here is a question mark for the device to manage this situation. And the second query is if we applied a classical communication scheme such as Bluetooth and ZigBee, the range of communication is within a few feet only, then management of the communication limits properly is also another task. So, the mentioned two queries are the major concern to deal with every smart home automation service. Those queries are rectified by using our proposed approach called Speech technology enabled Smart Home (STeSH), which collects the user voice and registers it for their own home usages at one time and provides the separate authorization and authentication norms for further operations or controlling of devices. And the second concern called communication range limitation deals with proposed powerful technology called Internet enable service IoT. The following section clearly illustrates the difference between

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existing and proposed systems as well as the result and discussion area clearly illustrate the outcome proof with a proper prototypical model.

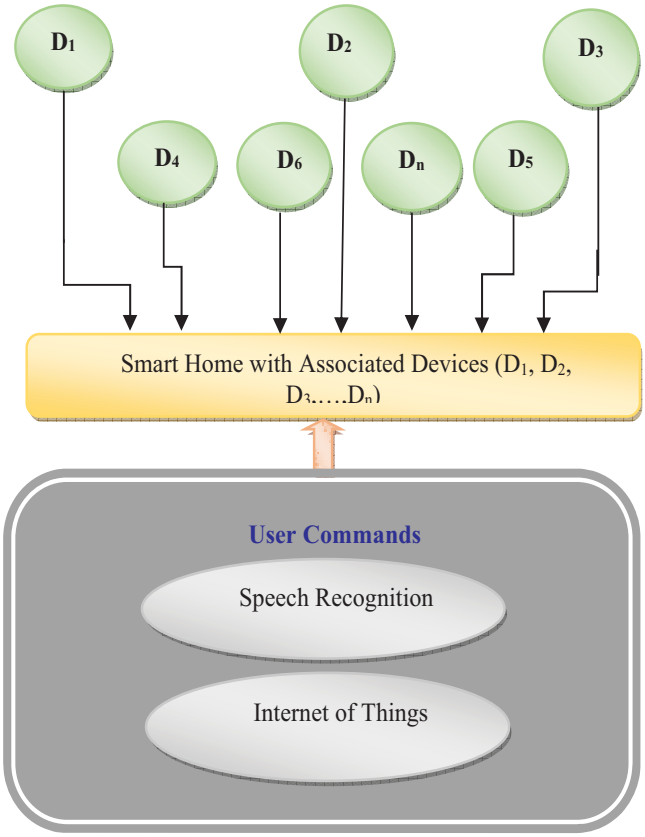

Figure 2. Proposed System Flow Diagram

Marie.A, Benedict.I et. al. proposed a SmartHome Automation Framework, which is based on Siri_Enabled application [1]. The main drawback of this application is as follows, which can be installed only in iOS_Apple devices. So, only the apple-mobile users only used this application, and they can only control the household devices by using this system. The implemented Siri_Enabled_Apple mobile application supports voice translation as well, so that the users feel free regarding languages and operate the application in fault free manner, but the major drawback of this platform supportivity and dependability makes this system poor and the budget of apple devices are usually highly compared to normal devices. So this Marie.A, Benedict.I et. al. (2015) implemented application fell into several flaws such as: (i) cost expensiveness, (ii) poor connectivity problems and (iii) platform dependability.

Piyare. R et. al [2] proposed the SmartHome Automation framework by using classical communication technology called Bluetooth, which can be able to connect up to 10 feet range and the connectivity problem of Bluetooth is really high compared to other connection enabled devices. In this system they applied Bluetooth services with an arduino_board base, which acts as a heart of the application to connect the system with Bluetooth and establish the communication interface properly to collect triggers and operate devices accordingly. But the main drawback of the implemented application is the short-range coverage area and the cost wise expense problems create the circuit more critical and make it not suitable for exact real-time applications.

Alshueili.H, Gupta.G et. al. [3] implemented a new approach in SmartHome application, which enabled household devices by means of human voices. This system collects the human voice and passes that signal as a trigger to the respective household device via communication interfacing and operates the device according to the respective voice trigger. The communication medium used in this paper (Marie.A, Benedict.I et. al. 2015) is called ZigBee, which can convert the human voice into a triggering signal and pass that to the controller for controlling the respective device. The major drawbacks identified in this paper are as follows: (i) Communication mode should be static, (ii) pulse based signaling is used in this approach, (iii) ZigBee can communicate up to the range of 20 feet and (iv) cost wise is expensive in practical scenarios.

Hidayat.S and Firmanda.S [4] implemented a new work, which can support a lot of SmartHome Automation framework. This approach integrates RaspberryPI as a main controller/CPU to the automation system, which collects the voice command from the users and converts the collected commands as a digital signal. The converted signals are passed as a command to the household devices and allow the device to operate accordingly based on the given trigger from the controller [5]. The main drawback found over this approach is that it uses RaspberryPI as a controller, for enabling internet connectivity. RaspberryPI is not the only solution to deal with. Instead of using RaspberryPI, if we use other Wi-Fi enabled devices it is cheap and powerful, because RaspberryPI is not meant for enabling internet support, it is like a minicomputer. The major drawbacks found over the paper (Hidayat.S and Firmanda.S, 2015) is as follows: (i) Cost expensive, because RaspberryPI is costly compared to other controllers available into the market, (ii) Circuit Complexity is really high if you go with standalone purpose of RaspberryPI and (iii) practical application possibilities to real-world situations are really high.

K. Pradeep Mohan Kumar, M. Saravanan, M. Thenmozhi and K. Vijayakumar (2019) proposed a concept and illustrated a logic for identifying the intruders by using classification logic [11]. The proposed system of STeSH applies the logic for identifying the intruders to unwantedly operate the home devices without user permission (K. Vijayakumar et. al. 2019). By applying the logic of the Genetic Algorithm classifier, the authors proved the identification mechanism so clear. So, our proposed logic is improvised by means of applying such techniques to prevent our system from attackers further.

M. Nithya and K. Vijayakumar (2020) proposed a paper for dataset segmentation by using ICD dataset collection [12]. In our proposed logic of STeSh it is planned to apply the dataset nature for identifying the face logics of the user and watch the robustness by using CCTV camera's along with speech verification in future. So, the proposed system is so robust and powerful in the future.

M. Anathi and K. Vijayakumar (2020), proposed a paper for identifying the dynamic network traffic restriction

methodology by using MAC address verification strategy [13]. In our proposed system of STeSH, we include the nature of MAC address verification to eliminate the time consumption process over triggering of loads in parallel as well as which leads the system more fast and robust compared to all other existing schemes.

II. METHODOLOGY

The proposed system (figure-2) implements a new approach to solve all the issues found over existing SmartHome Control application, which is termed as "Speech technology enabled Smart Home (STeSH)". This proposed STeSH enables the invention of many intelligent things integrated together. The integration of multiple unique and best things leads to robust and secured mechanisms over the operation of voice enabled SmartHome controlling. The integrated intelligent features are as follows: (A) Speech Recognition, (B) Internet of Things (IoT) and (iii) SmartHome Automation.

A. Speech Recognition

The Speech Recognition methodology collects the user speech and processes the speech into many norms with voice-based feature extraction strategy [6]. In this method each and every voice pulses are segregated and compare those pulses with the authorized user voice. If the user input voice signal is matched with the registered/authorized user voice, then the voice recognition mechanism recognizes the voice and gives the positive trigger to the controller to operate the respective household device [7]. The following algorithm illustrates the logic of the Speech Recognition algorithm step by step in detail.

ALGORITHM: SPEECH RECOGNITION

Input: Analog Human Voice
Output: Digital Conversion and Recognized Boolean Result
Step-1: Importing the respective Speech Recognition library.
Step-2: Create a class and object to assign the imported speech variables from library.
Step-3: Creating a class and object for audio recognition and it will recognize the audio is extracted from human voice or else any recorded medium (Ex. Class Audio_Recognizer(Audio_Source)).
Step-4: Assign the recognized voice into a variable (Ex. Aud = Audio_Recognizer([input];).
Step-5: Creating a loop for reading a voice from first to last.
Step-6: With Aud.Read() as Input, this statement will start the loop.
Step-7: Raise the printing statement to be intimate to the user to give a respective input voice to the system.
Step-8: System automatically changes the mode from query the user to listen to the voice.
Step-9: Aud = Audio_Source.Listen(Input).
Step-10: Add the exception statements to monitor the steps from 1 to 9 for managing the system robustness and fault tolerance from unpredictable exceptions.
Step-11: Extracting Proper Audio from input and change the modulation from input audio collected from the user.
Step-12: Analyze the audio input and store the result into a defined boolean variable (Ex. Boolean R).
Step-13: R = Resultant_Voice(Input).
Step-14: Return R.

The following Pseudocode illustrates the algorithm logic of Speech Recognition and describes the flow implementation step by step in detail.

PSEUDOCODE: SPEECH RECOGNITION

```
Import Speech-Recognition
define Speech-Recognition as SR_1;
define Audio-Identifier as Aud;

SR_1 = Audio_Recognizer (Audio_Source);
With SR_1.MicrophoneObject() as Input:
        PrintStmt("Input Voice Fully from start to End");
        Aud = Audio_Source.Listen(Input);
Try
        PrintStmt("System think you said improper word: "
        + Audio_Source.Listen(Input));
Exception SR_1.UnknownValueError
    PrintStmt("Could not understanding the audio input: "
    + Audio_Source.Listen(Input));
Exception SR_1.RequestSystemError as expc:
        PrintStmt("System Error{0}: " + expc);
End Try
```

The following figure-3 explains the input and out mechanism of voice signals and the processing like when it is encoded and decoded under certain circumstances.

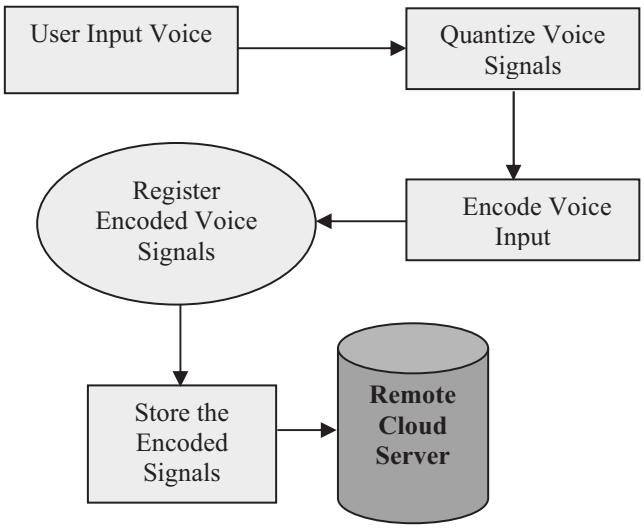

Figure 3. Voice Authorization Process Architecture

For this Speech recognition methodology, we use Google based Voice Assistance, which collects the user voice and matches that with existing authorized voice signals and

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provides the access permission to operate the corresponding devices. The entire process of speech recognition takes a few seconds and processes all these things based on input voice signals [8]. If the given/collected voice signals are not matched with the authorized voice signals, then the system informs the collected signal is based on an unauthorized person, please authenticate properly. So, that this system is proper for manipulating the user voices and provide good support to customers to operate the devices according to their convenience. The following figure-4 illustrates the overall workflow model including voice recognition and access control norms over the proposed system approach.

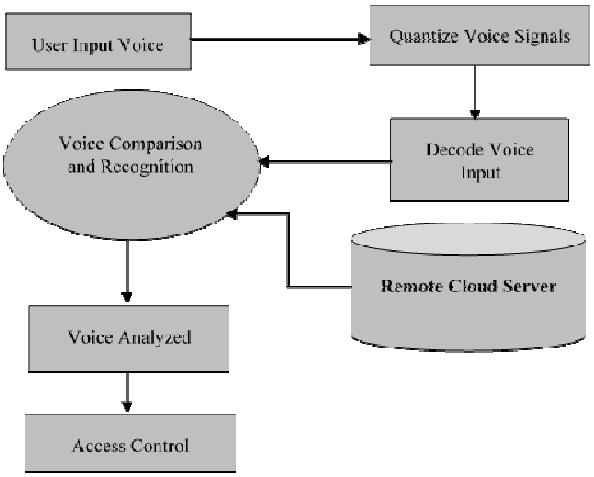

Figure 4. Voice Authentication Process Architecture

B. Internet of Things (IoT)

The term Internet of Things ruling a world with its power and connectivity, this is nothing but a refined form of network. IoT interconnect the remote cloud server with local devices, so that the user can communicate from anywhere at any time without any restrictions [9]. By using this internet enabled service user can speak and operate the device from anywhere in the globe without any range restrictions. So, that, the appliance of Internet of Things enables the system so secure and robust in many forms. The concept of IoT is illustrated in the proposed approach with the help of below defined equation, Eqn-1.

$$\text{IntEnable} \rightarrow \text{BCS} + \text{SxSy} + \text{Px} \rightarrow \text{T2R} \quad (1)$$

Where IntEnable is an object to indicate Internet Enable State, BCS indicates the basestation strength during internet establishment, SxSy indicates the total signal strength for the respective range coverage which belongs to X and Y surroundings, Px indicates the port number association with the defined connection and T2R indicates the total traffic ratio over establishing the internet connection.

C. Smart Home Enabling Model

The SmartHome Services are the major need now-a-days, which allows user to operate the household devices from anywhere in the world at any time, without any range restrictions.

This process happens only if the devices are properly bound over the communication medium, that support is launched by means of Internet enabled services over the proposed work model along with speech recognition procedures [10].

Figure 5. Internet of Things Service Model

The speech recognition system receives voice from the user and process the input according to speech verification norms and identify the authorized user is trying to operate the device or some others. If the authorized user is trying to authenticate the device means it permits the flow, but if an unauthorized user trying to login into the system, it cannot permit the user to flow further. The proposed framework is more secure and robust compared to the classical working model and it is more convenient to work with the proposed model because of its unlimited range support and easiness. For all the proposed system provides efficient and intelligent working model in results, which will be illustrated clearly in results further. The following algorithm illustrates the logic of SmartHome Enabling Model STeSH algorithm step by step in detail.

ALGORITHM: SMARTHOME ENABLING MODEL

Input: Human Voice or Recorded Speech input
Output: Convert Audio Transcriptions to Text and Triggered the Respective Load

Step-1: Importing the respective Speech Recognition library.
Step-2: Create an object to assign the imported speech variables from the library.
Step-3: Declare a voice_recognizing class to clearly recognize the speech from the user side. We are using google_speech recognition library over here.
Step-4: Speech file supported by speech_recognition in the format of "WAV/MP4".

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Step-5: Google recognizer reads English usually but need to add some language libraries for multilanguage supportivity.

Step-6: Match the input voice from the user voice repository.

Step-7: Identify the voice robustness and authenticity.

Step-8: Trigger the Respective Load according to the corresponding input.

Step-9: Return Triggered Load Details to User reflection area.

Step-10: Stop gathering Voice and go to Step-3.

This above-mentioned algorithm is technically derived by using the following equations. The following equations, Eqn-2 and Eqn-3 illustrate the nature of collecting human voice and maintaining it into the repository.

$$UV_x \rightarrow VX_i{:}1 \text{ to } n\ \Omega \quad \sum_{x=0}^{n} -1 \binom{n}{x}^{x} i_{v_{xi}} \qquad (2)$$

Where UV_x illustrate the storage of user voice input and x indicate the upper limit variations, VXi:1 to n illustrate the collected input voice range signals which is starting from 1 and ending in 'n'.

$$VR_X = 1 + \frac{Uv_x}{1!} + \frac{Uv_x^2}{2!} + \cdots, Uv_{xn} < N \qquad (3)$$

Where VR_X illustrate the storage of user voice storage repository and x indicates the upper range of the repository, Uv_{xn} illustrates the collected input voice range signals which are starting from 1 and ending in 'n'. All these voices are stored in order to the repository for managing the secured voice-based recognition to operate the smart home without any security issues.

III. Results And Discussions

In this summary, the result of proposed approach STeSH is explained clearly with output proofs, and it assures the proposed system robustness, classic method improvements, size compatibility and energy efficiency improvement scenario with graphical proof. The table-1 demonstrates the Comparison illustration of the Existing and Proposed system voice accuracy capturing and performance ratio, with respect to the comparison of checking the details with 50 different persons on different age groups between 10 and 60.

Figure-6 illustrates the Graphical Comparison View of the Existing and Proposed system voice accuracy capturing and performance ratio, with respect to the comparison of checking the details with 50 different persons on different age groups between 10 and 60.

Figure-7 exemplifies the Graphical Comparison View of the Existing Home Automation Technique and the Proposed Voice Based Home Automation Technique Time Consumption to trigger the Loads according to user control.

Similarly the figure-8 explains the Graphical Comparison View of the Existing Home Automation Technique and the Proposed Voice Based Home Automation Technique Energy Consumption ratio.

TABLE I.
VOICE CAPTURING ACCURACY LEVELS

Age Group	Existing Voice Capturing Accuracy	STeSH Voice Capturing Accuracy
10 to 15	80%	85%
16 to 20	79%	92%
21 to 25	78%	94%
26 to 30	82%	95%
31 to 35	84%	95%
36 to 40	85%	96%
41 to 45	80%	93%
46 to 50	85%	90%

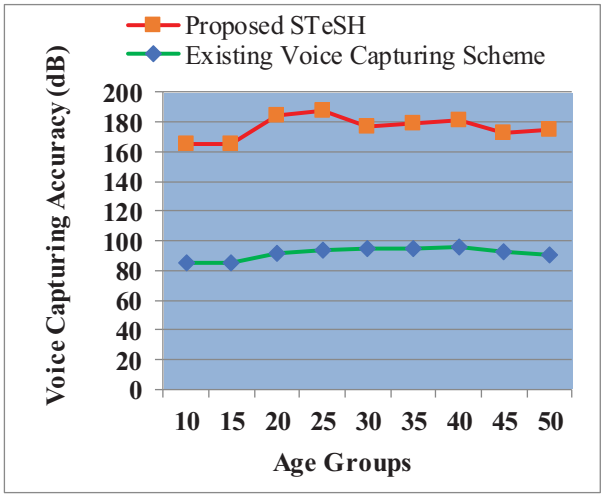

Figure 6. Graphical Comparison View of Existing and Proposed Accuracy Levels

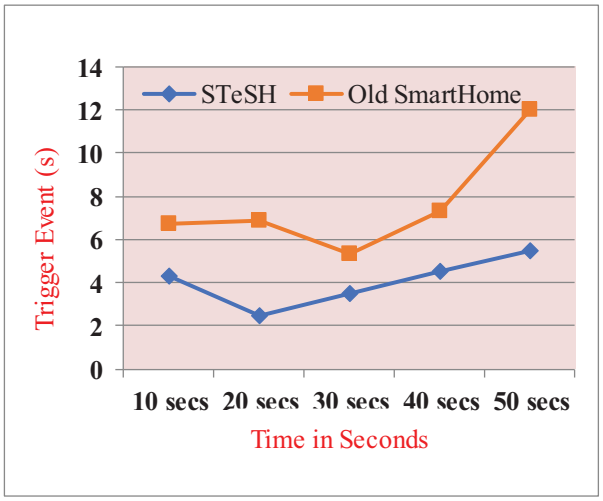

Figure 7. Graphical Comparison View of Existing and Proposed Time Consumption

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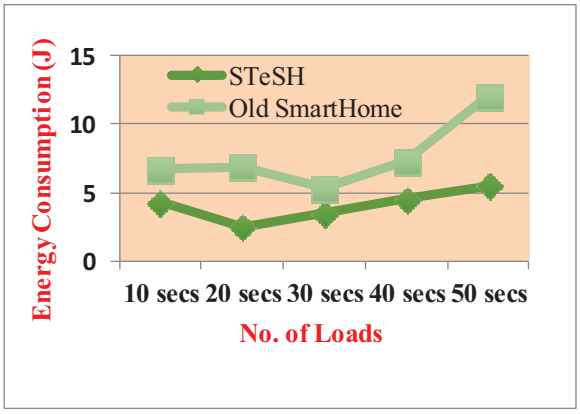

Figure 8. Graphical Comparison View of Existing and Proposed Energy Consumption

IV. Conclusions

The proposed SmartHome Application system is completed properly with advanced speech technology-oriented processing and intelligent operational features such as Voice/Speech Recognition strategy and Internet of Things. The Google based Speech collection system is used to collect the user voice and send that to the remote server for processing. The server-side system converts the entire speech signals into encoded raw commands and stored it into the remote cloud server with proper access right specifications. Once the user authenticates into the system, automatically it crosschecks the voice input with the processed voice input over the server. If it matches, the respective user is allowed to operate the home devices without any interruptions otherwise the system blocks the user to proceed further. For all the entire system guarantees that this SmartHome Application System ensures a secure and robust way to automate the home in an easy and scalable way.

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