Don't Worry; AI will Take Care of Your Sweet Home

Sudip Chakraborty [1] & P. S. Aithal [2]

[1] D.Sc. Researcher, Institute of Computer Science and Information Sciences, Srinivas University, Mangalore-575 001, India,
OrcidID: 0000-0002-1088-663X; E-mail: drsudip.robotics@gmail.com

[2] Senior Professor, Srinivas University, Mangalore, India,
OrcidID: 0000-0002-4691-8736; E-Mail: psaithal@gmail.com

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Sudip Chakraborty [1] & P. S. Aithal [2]

[1] D.Sc. Researcher, Institute of Computer Science and Information Sciences, Srinivas University, Mangalore-575 001, India,
OrcidID: 0000-0002-1088-663X; E-mail: drsudip.robotics@gmail.com

[2] Senior Professor, Srinivas University, Mangalore, India,
OrcidID: 0000-0002-4691-8736; E-Mail: psaithal@gmail.com

ABSTRACT

Purpose: *Now, we are in a bright living era. Smart devices and equipment surround us. We are familiar with beds, kitchens, bulbs, televisions, shoes, homes, etc., which are all smart. Around the clock, all the equipment and gadgets provide smart service to us. All these devices are suitable, but we might notice some things. Their smartness is bound inside their enclosure, not contributing to other activities. If smart bulbs get faulty, other standby lights should be triggered, and the report should be immediate. If cooking LPG is almost empty, book the cylinder automatically. We need a centralized control to coordinate all devices to address the issue. This research demonstrates using artificial intelligence (AI) to manage our sweet homes.*

Design/Methodology/Approach: *We install surveillance cameras in every corner of the house from where we need to capture the event and the action module to trigger the equipment. All the cameras are connected to one CPU, and all action modules are connected to one controller, which is attached to the CPU via a USB cable. When the system is powered up, it initializes all available cameras and action modules. The CPU always captures the image from every camera and analyzes the image around the clock. When it finds the incident, it finds from the database for action. Once the single action or series of actions is matched, take the action using the action module.*

Findings/Result: *the described concept is the application of the advancement of technology of IoT and AI. We can improve our living environment by employing both technologies in our homes. This system provides us with the ability to manage every activity nicely. We can have a secure life trusting technology. Every monotonous or repetitive task can be handled through this system, and we can be engaged with other innovative tasks. So, as a result, the outcome of the system is to enhance our quality of life in our busy lives.*

Originality/Value/ Novelty: *we studied several research works on this home automation field. Most of the research is on creating home automation using IoT with the help of smart electronic gadgets. Whatever smart devices we install in our homes are manually operated. When busy with another task, we need something to take care of our sweet home. Most of the research work only fulfills our needs. In this project, we fill those research gaps. We integrate the relevant technologies under one supervisory control, and we attach the AI to control not only logically but also emotionally. This kind of system fulfills our needs in our busy modern lives. So, this project will provide more value in our day-to-day activities.*

Type of Paper: *Conceptual Research.*

Keywords: AI Home, Change smart home to AI home, AI in home automation, Image processing in home automation.

1. INTRODUCTION :

Problem statement: We are familiar with smart home automation and technological evolution. The typical scenario is to install several intelligent gadgets, and we control those devices around the clock. The complete home automation we established is semi-automated, not intelligent. In most scenarios, the decision needs to be made manually. Consider an example: The smart TV cannot play a baby's favourite cartoon channel automatically when our baby is crying. In our busy schedule, we need full

automation, which means the situation should be decided independently. AI has started to change social evaluation. Using AI, we can create a full-fledged AI home, which we are dreaming about.

Indication of methodology: we mainly adopted image processing technology to capture home events. We install several cameras connected to a powerful central processing unit (CPU). It always captures the Image of all cameras. Then, it pre-processes and extracts the image features. Then, it is fed to the image detection module. Once the event is detected, find the action from the action database. If an action is discovered, it sends the action to the module, which is responsible for triggering a series of actions, which is physical activity. It may be the relay on/off or change the fan speed. The complete process runs around the clock. It serves us always.

Essential findings of others in this field: we have many web studies. The enormous research work is ongoing. Here, we describe a couple of research works. The research work (Bouchard et al. (2014). [1]) demonstrates the practical guidelines on how to build smart homes. In this work, they use AI for cognitive assistance and various sensor modules like motion sensors, Ultrasonic sensors, loadcells, Video cameras, accelerometers, etc. The researcher Bouchard et al. (2012). [3] in their work provides a case study on the Guidelines for efficient smart home design for rapid AI prototyping. The research work (of Roshak et al. (2021). [7]) provides 70 recipes for building AI solutions for smart homes, industrial IoT, and smart cities. The most relevant research work is executed in the research work by Leitner et al. (2015). [9]). In this work, the researcher describes creating a home that will be "wise," not smart. Researchers Mahith et al. (2019) [11] demonstrated AI-enabled smart homes operated by the gesture. The above experiment describes creating a complete AI-enabled smart home close to our proposed concept.

What study is done in this paper: we study how we can enhance our lives better using the advancement of AI. We study several research projects. We also included a couple of projects in this project. We also examine the pros and cons of building an AI-enabled home. The project is conceptual-based, but every module is practical-oriented and tested in practical deployment. So, once the project is deployed, it starts working without fail and serves us as expected.

Principal conclusion: Nowadays, AI homes are the ultimate solution after smart homes. It will make our lives not only better but also secure and comfortable. Instead of partial automation using various intelligent gadgets, we demonstrate how we can achieve AI home implementation in this research work. Using the camera and embedded system, we can build our own AI home, which will work round the clock. The camera is used to capture the various events, and an embedded system is used to take action against the captured events. The system has self-learning capabilities. Any new events are learned and saved the learning in its database, which will help in the future to take action faster.

2. REVIEW OF LITERATURE/ CURRENT STATUS :

Much research has been carried out on AI home design. Here, we included some research projects where we found noticeable work already done. Table 1 lists a couple of research works and used technology in their research work.

Table 1: Lists the research work and technology used in AI home design.

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	Practical guidelines to build smart homes: lessons learned	AI is for cognitive assistance, motion sensors, and video cameras.	Bouchard et al. (2014). [1]
2	Is my home smart or just connected?	Artificial Intelligence	Furman et al. (2020). [2]
3	Guidelines to efficient smart home design for rapid AI prototyping: a case study	AI, IoT	Bouchard et al. (2012). [3]
4	The smart wife: Why Siri, Alexa, and other smart home devices need a feminist reboot	smart home devices	Strengers et al. (2021). [4]

5	Devices and data and agents, oh my: How smart home abstractions prime end-user mental models	IoT, Sensors	Clark et al. (2017). [5]
6	Artificial intelligent system for multimedia services in smart home environments	Artificial intelligent, multimedia	Rego et al. (2022). [6]
7	Artificial Intelligence for IoT Cookbook: Over 70 recipes for building AI solutions for smart homes, industrial IoT, and smart cities	IoT, Artificial intelligent	Roshak et al. (2021). [7]
8	More intelligence and less clouds in our smart homes: a few notes on new trends in AI for smart home applications	IoT, Artificial intelligent	Iannizzotto et al. (2020). [8]
9	The future home is wise, not smart	IoT, Artificial intelligent	Leitner et al. (2015). [9]
10	Smart home environment: Artificial intelligence-enabled IoT framework for smart living and smart health	IoT, Artificial intelligent	Geetha et al. (2021). [10]
11	AI Enabled Smart Home Interface Using Gesture based Controls	IoT, Artificial intelligent, Gesture based Controls	Mahith et al. (2019). [11]
12	Explainable activity recognition for smart home systems	IoT, Artificial intelligent	Das et al. (2023). [12]
13	AIoT-enabled smart surveillance for personal data digitalization: Contextual personalization-privacy paradox in smart home	AIoT, smart surveillance system	Zhang et al. (2023). [13]
14	Major requirements for building Smart Homes in Smart Cities based on Internet of Things technologies	IoT	Hui et Al. (2017). [14]
15	Smart home personal assistants: a security and privacy review	IoT	Edu et al. (2020). [15]
16	Robust triboelectric information-mat enhanced by multi-modality deep learning for smart home	deep learning	Yang et al. (2023). [16]
17	Smart home sensing and monitoring in households with dementia: user-centered design approach	sensing and monitoring system	Tiersen et al. (2021). [17]
18	A review of smart homes—Past, present, and future	IoT	Alam et al. (2012). [18]
19	A Review of Potential AI-Based Automation for IoT-Enabled Smart Homes	AI, IoT	Leong et al. (2023). [19]
20	Real-time indoor localization in smart homes using semi-supervised learning	Localization, semi-supervised learning	Ghourchian et al. (2017). [20]

In the table below, we included a couple of our projects, which are the backbone of the current research project. The researcher can gather the knowledge before implementing the AI home project because the AI home project combines various subsystems.

Table 2: Lists the author's research on IoT, Data saving to the cloud, and sensors.

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	Let Us Create Multiple IoT Device Controller Using AWS, ESP32 And C#	AWS, ESP32 And C#	Chakraborty et al. (2023). [21]
2	Let Us Create An IoT Inside the AWS Cloud	AWS Cloud	Chakraborty et al. (2022). [22]
3	Let Us Create a Physical IoT Device Using AWS and ESP Module	AWS, ESP Module	Chakraborty et al. (2022). [23]
4	Let Us Create an Alexa Skill for Our IoT Device Inside the AWS Cloud	Alexa Skill, AWS Cloud	Chakraborty et al. (2023). [24]
5	Let Us Create A Lambda Function for Our IoT Device In The AWS Cloud Using C#	AWS Cloud, Lambda Function	Chakraborty et al. (2023). [25]
6	Let Us Create Our Desktop IoT Soft-Switchboard Using AWS, ESP32 and C#	AWS, ESP32 and C#	Chakraborty et al. (2023). [26]
7	Alexa Enabled IoT Device Simulation Using C# And AWS Lambda	C#, AWS Lambda	Chakraborty et al. (2023). [27]
8	IoT-Based Switch Board for Kids Using ESP Module And AWS	ESP Module, AWS	Chakraborty et al. (2023). [28]
9	Let Us Create an Alexa-Enabled IoT Device Using C#, AWS Lambda and ESP Module	C#, AWS Lambda and ESP Module	Chakraborty et al. (2023). [29]
10	IoT-Based Industrial Debug Message Display Using AWS, ESP8266, And C#	AWS, ESP8266 And C#	Chakraborty et al. (2023). [30]

3. OBJECTIVES OF THE PAPER :

Description for Objectives.

(1) To study the feasibility of designing an AI home that will manage repetitive tasks nicely.
(2) Review the research work already carried out and which technology is available to design an AI home.
(3) To analyze the performance of the existing system.
(4) To compare the proposed concept with another existing system already developed.
(5) To prove the proposed system's flexibility and versatility.
(6) To design an AI-enabled home with security and comfort.
(7) To develop a self-learning AI home that nurtures us.
(8) To interpret the AI-enabled home in all aspects.
(9) To create an AI home architecture that can run for years without failure.

4. METHODOLOGY :

The figure below depicts the project block diagram. The workflow is initiated from the camera. The image is captured from the camera, and then it starts preprocessing. After that, we extracted the features from the image, and finally, it detected the image. The image may be a single event, or it is a part of a series of events. For example, the primary door camera detects the baby returning from school, and the dining space camera detects the second image; the baby is sitting on a chair. So, to match the event sequence, we need to trigger the action module to run the dining space fan/AC. The action module is built using a high-end microcontroller. All the room's action modules are connected through the RS485 communication. The main action module is the master, and the rest is the slave. The master constantly pings all nodes sequentially.

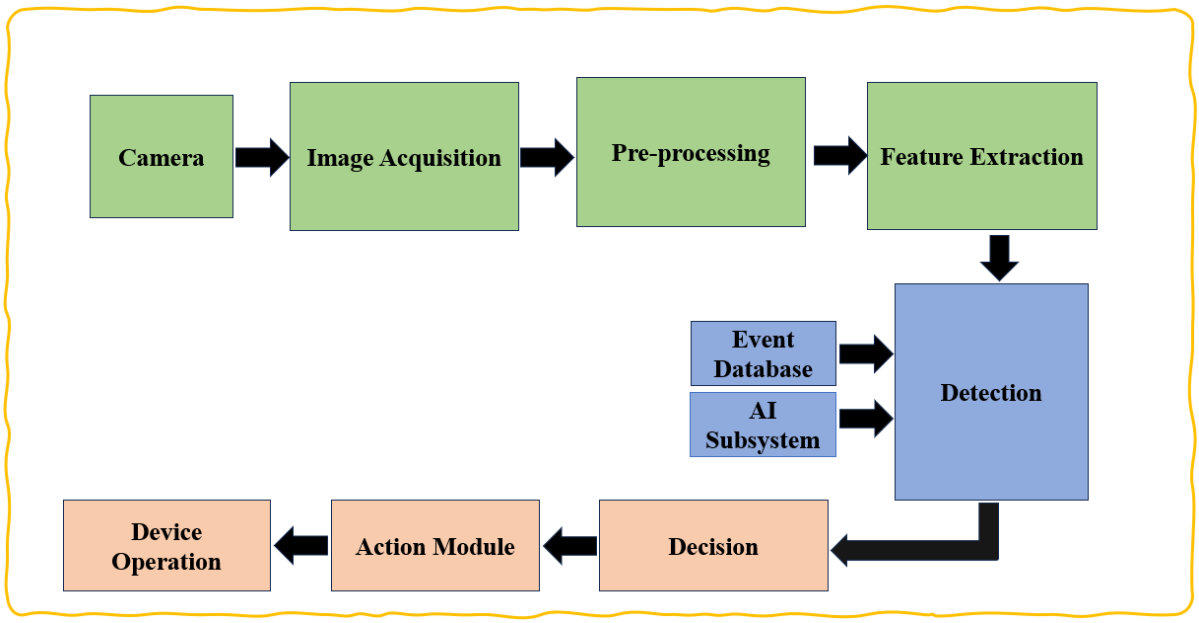

Fig. 1: the project workflow

Now, we describe the methodology of the project. The complete project is divided into two principal subsystems. One is the camera module, and the other is the action module.

Figure 2 depicts the camera subsystem installed at various places inside the home. According to the block diagram, surveillance cameras are installed in every room and are the most wanted place where we need to monitor the incident. All cameras are connected to one central processing unit. The camera connection may be wire or wireless; nowadays, wireless is preferable. But sometimes, the desired model comes with a specific interface; we need to comply with that interface.

Figure 3 depicts the action module subsystem we installed to trigger the electrical appliance. According to the type of device, we need to select the trigger type. The plane bulb is only in the on and off state; the fan is on, off, and speed control. For smart bulbs, various parameters need to be considered, like on, off, brightness, colour change, etc.

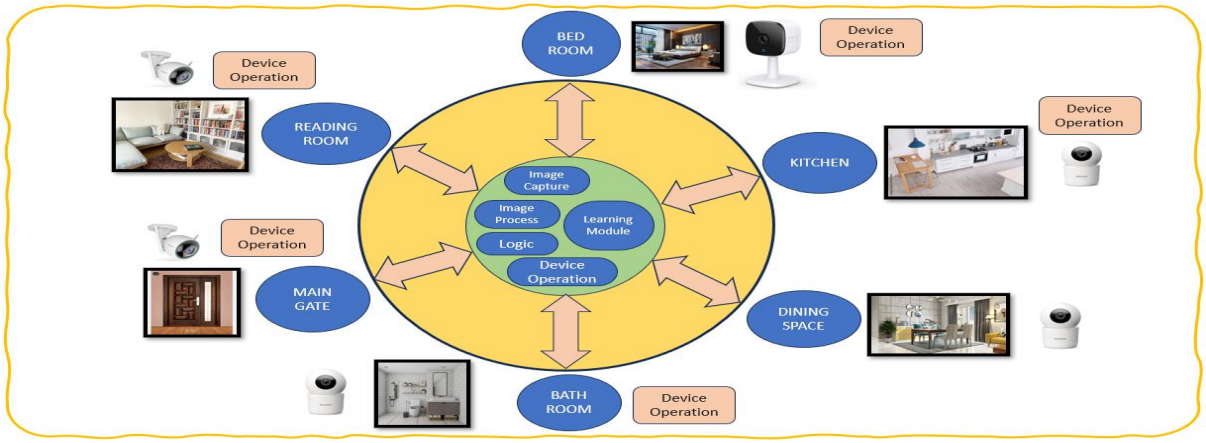

Fig. 2: The camera subsystem installed at various places at home.

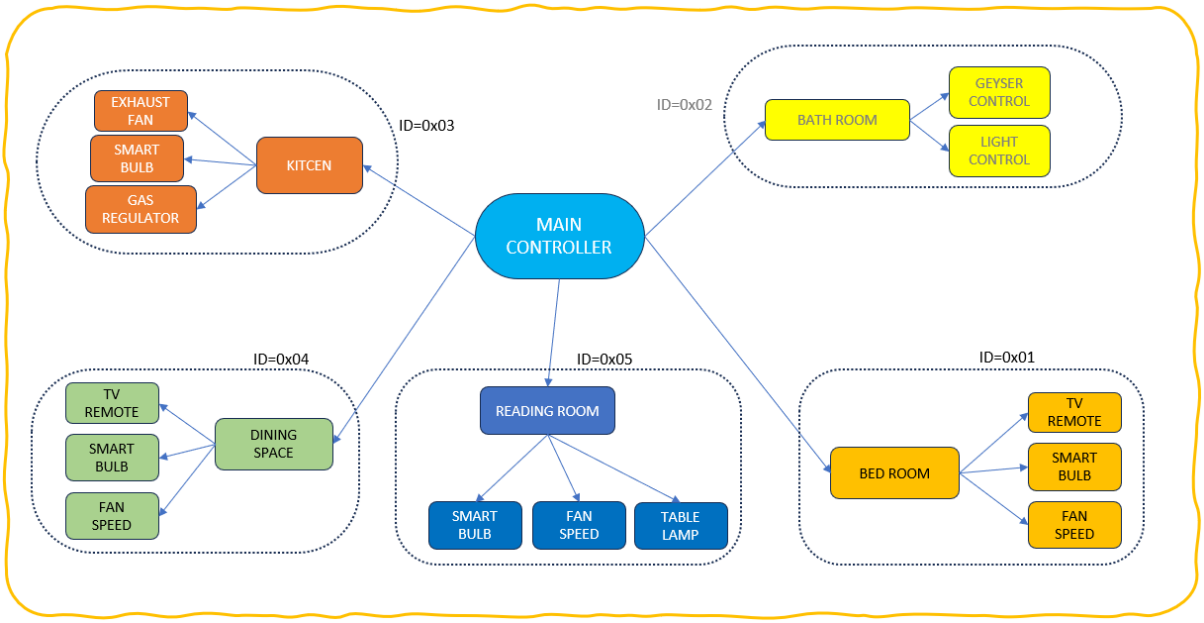

Fig. 3: the action module sub-system

Table 3 depicts a couple of sample events in the databases we use to decide on the action module.

Table 3: A couple of examples of logic

PLACE	Detected Activity	ACTION
Bed Room	all family members are sleeping on the bed, and it is nighttime	1) If the TV is running, do it off. 2) Smart bulb off 3) Night lamp on 4) Toilet light off 5) Control fan speed on surrounding temperature
Bed Room	Someone went towards the toilet.	Toilet light on
Bed Room	Come back from the toilet and go to bed again	The toilet light was made off
Time-dependent	Morning came	1) If any alarm set, trigger 2) Put the geyser on if it is time to bath
Dining space	Someone doing meal	trigger people-specific profiles (like music, light color etc.)
Event series	Some members came from the sunlight and felt tired	Trigger the Fan/AC for the respective room
Dining space	Kids are watching TV.	Smart TV on and set kids channel (for multiple kids select as per their frequent viewing channel)
Dining space	Kids watch TV during their study time	Just off the tv
Dining space	Senior citizens are watching TV.	On smart TV, set the channel according to the profile.
Home	Baby's body temperature is detected as not normal	Draw attention to seniors by using available predefined channel
Home	Some members suddenly fall on the floor	Inform the concerned person
Home	Fire incident detected	1) Trigger fire alarm. 2) Check the LPG knob. 3) Call or message the concerned person.

		4) If there is no response from the concerned person, call the fire station
Kitchen	no cooking item + gas regulator knob on	Do gas regulators in off-state and inform senior.
Kitchen	Milk is boiling in the oven, and no one is present	The regulator makes off state.
Home	The date changed, and some member's birthdays.	1) Wait for the member until he/she is awake. 2) Play a happy birthday song and greet.

5. EXPERIMENTS :

We can do experiments to create the project. We could follow the below steps to experiment. The following steps are for reference only. We are providing the direction. It is a big project. There are several sub-tasks available that need to be executed. Below is the project execution route the researcher can follow.

(1) Install a camera where we need to track the situation
(2) Wiring through RJ45 cable and ethernet switch. Arrange a power supply for every camera.
(3) Install a CPU at a convenient place.
(4) Install a Python environment like Pycharm or equivalent.
(5) Install the Python package for OpenCV.
(6) The make code to read the IP camera. Many documents are available to process the image from the camera using the Python package. Check that all cameras are accessible from the system.
(7) Install YULU or any other image detection package with which we are familiar.
(8) now, it is time to integrate the action module subsystem. It has several sub-steps. Schematics design, PCB design, component procurement, assembly, testing, debugging, and deployment. There are other ways to cut down the above route. Now, many development controller boards are available in the market. We can purchase and use it like Plug and Play.
(9) Customized the action module based on the requirement.
(10) All action modules connect through Modbus.
(11) Write firmware and test.

6. RESULTS & DISCUSSIONS :

Once we install the complete system, a couple of months is required to train it. Once it is trained, the system will respond. The system will train day by day. It learns from family member's behavior as we learn daily from our environment. The logical response we feed through the database will respond from day one. But the reaction from learning will take time to understand. In our busy lives especially, the earning family member cannot always care for everything. This kind of intelligent home is most relevant in every home. It will nurture, secure, and protect us overall. It is like a family well-wisher supervisor who watches us round the clock and takes action on predefined learning events.

7. ANALYSIS OF RESULTS :

The future of this system is promising. Around the globe, we are researching how to provide comfort to our sweet home. The two types of systems are available for home automation implementation. One uses several sensors connected around the home, like gestures, motion, etc. From that sensor, the data is fed to the central system, and the load is calculated according to the data. The second one is our system. Here, we use that kind of sensor for the action module, and the camera subsystem plays a significant role. The camera acts like an eye watching in a specific room or place. Once the event matches, the action module takes the action. We can call this system a hybrid system. This one is more powerful and relevant to modern living than the previous smart system.

8. SUGGESTIONS :

Here, we include some recommendations for the researcher if they want to continue the research work.

(1) Use the high-end and low-latency camera so that image detection is as perfect as possible
(2) The CPU and the action module should be as fast as possible. It leads to making decisions faster.
(3) The IP camera with an ethernet port is the best. A Wi-Fi camera is also acceptable. The Wi-Fi camera has some drawbacks. More Wi-Fi cameras in a place can create broad congestion, which delays data flow.

9. CONCLUSION :

Our future is glorious with AI. Now, it is proven that AI can do many things that we didn't think about before. Every day, researchers are finding more and more fields where we can introduce AI. Introducing AI in the automation field is not new. The researchers have already introduced AIoT for home automation. Here, we provide information on creating an AI-enabled home using AI and an embedded system.

10. LIMITATIONS :

Every system has pros and cons. This project also has some cons. Below, we describe the cons of the designed system.
(1) The system is based on an Image processing technique. Not all events might be included in the project.
(2) The event response time depends on the event detection and action-taking time.
(3) Some emergency functions, like a call to the fire stations, need special care to identify the event precisely. We can provide a confirmation layer that a human decision-maker drives for this.

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