AI Bedroom

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]

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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, artificial intelligence (AI) is booming. Day by day, AI is introduced into the new field. We have lots of expectations for the advancement of AI. In our modern busy schedule, we all expect our everyday monotonous homework to be executed by AI. We are introducing more and more smart devices to do our work smartly. But at the end of the day, all our smart home devices are operated manually. We are not fully satisfied with smart devices. Knowing this, the smart device manufacturer is adding AI features inside their devices. Here, we demonstrate how to build an AI bedroom for better living.*

Design/Methodology/Approach: *We install three devices inside the bedroom. The first is a surveillance PTZ camera, the second is the CPU, and the third is the action module. The camera will capture the events and is transferred to the central processing unit or CPU. It will process the image and then detect the event. Once the event is detected, then through the action module, we trigger the electrical or electronic equipment.*

Findings/Result: *the performance of the centralized system is better than that of distributed individually operated smart devices. Here, we account for two types of performance: the event detection and the action module on the specific action. The event detection module takes much more time due to the processing overhead of the image. We get the result within a couple of milliseconds. Due to the dedicated CPU, the processing is faster than on a cloud-based server, which depends on the bandwidth of the internet.*

Originality/Value/ Novelty: *We studied several research documents on smart homes and artificial intelligence-integrated homes. Most AI homes are built using several smart home appliances operated manually. And there is no centralized control. Without central control, the system could not deliver the best performance. Here, the complete system is nicely controlled by a centralized CPU, which makes it a unique approach to this project.*

Type of Paper: *Conceptual Research.*

Keywords: AI-based bedroom, AI in home automation, Event detection from camera image. Smart home device management using microcontroller-based action controller.

1. INTRODUCTION :

Problem statement: the smart devices are everywhere. Every day, we make lots of intelligent devices for a better life. Using this type of device, we are now habituated. So, we are expecting more. Now, smart devices like smart TVs, smart bulbs, LED tube lights, intelligent beds, etc., come into our bedrooms. Several smart devices are inside the bedroom, but we are still operating them manually. We are so excited about an evaluation of the AI and expect it will soon be introduced into our bedroom.

Indication of methodology: we mainly create a system to complete the bedroom automation using the latest AI technology. First, we installed a PTZ surveillance camera inside our bedroom. It will always be on round the clock. In every millisecond, it reads and processes the image from the camera and will try to detect the event that just happened in front of the camera. Once the event is detected, it matches it with the event configuration file. If it matches, it takes the action through the action module.

Essential findings of others in this field: we have studied several projects related to the AI home. Most researchers have made significant contributions to this field. The researcher Ghourchian et al. (2017) [20] described real-time indoor localization in smart homes using semi-supervised learning. The research work by Leong et al. (2023). [19] reviewed Potential AI-Based Automation for IoT-

Enabled Smart Homes. The research work (Tiersen et al. (2021). [17]) demonstrates Smart home sensing and monitoring in households with dementia: user-centered design approach. The researcher Zhang et al. (2023). [13] describe AIoT-enabled intelligent surveillance for personal data digitalization: Contextual personalization-privacy paradox in the smart home. The researcher Iannizzotto et al. (2020). [8] describe More Intelligence and Less Clouds in Our Smart Homes.

What is done in this paper: We studied several projects to find an excellent solution to create an AI bedroom where most of the work will be operated from a centralized processing unit. An action module drives the smart device used in the bedroom. We also study how we can build a robust system to run around the clock without creating any issues. We also studied to cover the event structure of the AI-based bedroom so that most of the events were covered when the system was in operation. We also study what hardware and software are required to establish an AI-enabled bedroom and what action module is needed to cover the smart device operation.

Principal Conclusion: Nowadays, instead of smart homes, we feel the need for AI homes. Several advantages are available over smart homes. The smart homes are smartly operated manually, but a completely autonomous process operates the AI home. Using the camera, take the image and process it around the clock. The system has an inbuilt event database. Once the event is captured, it matches with the event database. Once the event is found, it fetches the action to trigger the action module. So, in the complete process, there is no manual interaction. The AI home is the future of our living home.

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 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 acquire knowledge before implementing the AI home project. Because the AI bedroom project combines various projects, it is only possible to face many challenges in understanding small projects.

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 of objectives.

1) To study the feasibility of designing an AI-based system for our bedroom to control the complete bedroom automation.
2) Review the research work already carried out in our AI-enabled bedroom.
3) To analyze the performance of our bedroom automation system.
4) To compare the efficiency of the various systems integrated into AI homes.
5) To prove the capability of the AI-based system.
6) To design an AI-based automated home.
7) To interpret the functional block diagram of the AI-based system.

4. METHODOLOGY :

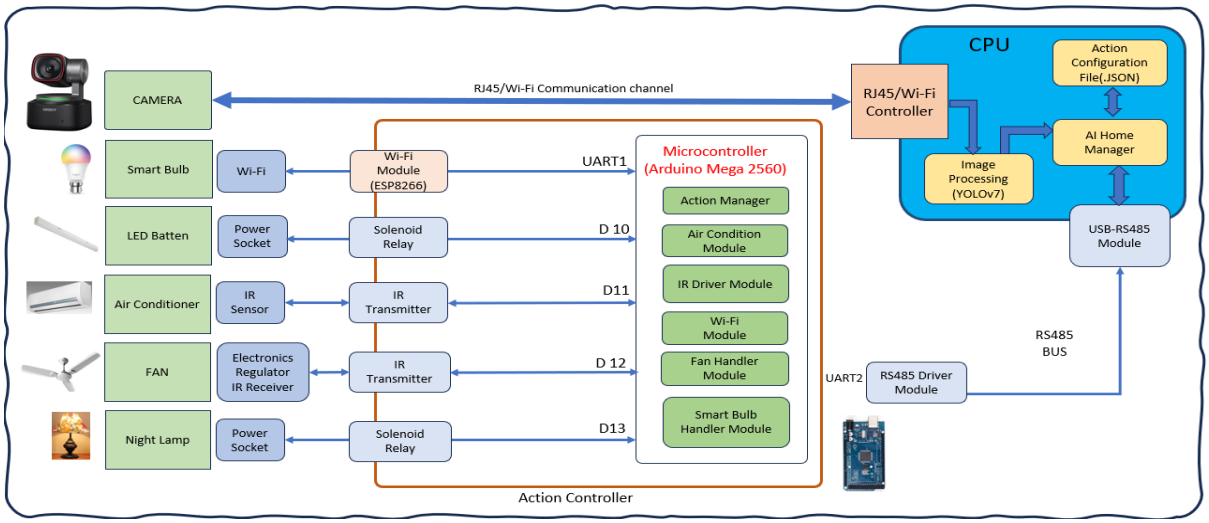

Fig. 1: The project block diagram (Image: Author)

Figure 1 depicts the project block diagram. The central part of the complete diagram is the action controller and the CPU. Now, we are describing the two parts below:

Action controller: All smart gadgets are connected to the action controller. It is built on the Arduino mega 2560 board with many IO and four UART ports. It is open-source hardware. The board can be programmed easily using Arduino IDE. The most significant advantage is that most of the hardware, software, and sensors library is free. For the prototype development, this framework is ideal. Within a few days, we can quickly develop a project without issues. We can customize the hardware once our prototype is ready and we want to go for production. The controller's digital output pin can not drive the devices directly. For that, we need a relay module. The controller drives the relay module, and the relay module triggers the devices. We need to connect via an optocoupler for any input because the external noise can damage the controller. To communicate with Wi-Fi devices, we use an ESP Wi-Fi module. It is connected to the controller via a serial port. Any serial port is OK. For Arduino left, the

debug UART for board debug purposes. The action controller is linked to the CPU via RS485 communication. One serial port is attached to the RS485 driver. The action controller is the slave, and the CPU is the master in the RS485. The action controller is always in listening mode. When some command is received from the CPU, it pursues and executes. The command may be to turn on the smart bulb or to switch on the television. Table 3 depicts the connected module and the function of the action controller. Figure 2 illustrates the microcontroller board used to build the action controller.

Table 3: The list of modules for the action controller

S. No.	Module	Function
1	Action Manager	Manage all action module
2	Wi-Fi Module	Responsible for communicating with Wi-Fi-enabled device
3	Air Condition Module	Remote module to operate air conditioner
4	IR Driver Module	Infra-red protocol handler
5	Fan Handler Module	Fan control module (on/off/ speed change)
6	Smart Bulb Handler Module	Protocol for Smart Bulb Operation
7	IR Transmitter	Drive infra-red LED to create the IR pulse train
8	Solenoid Relay	To trigger the various devices

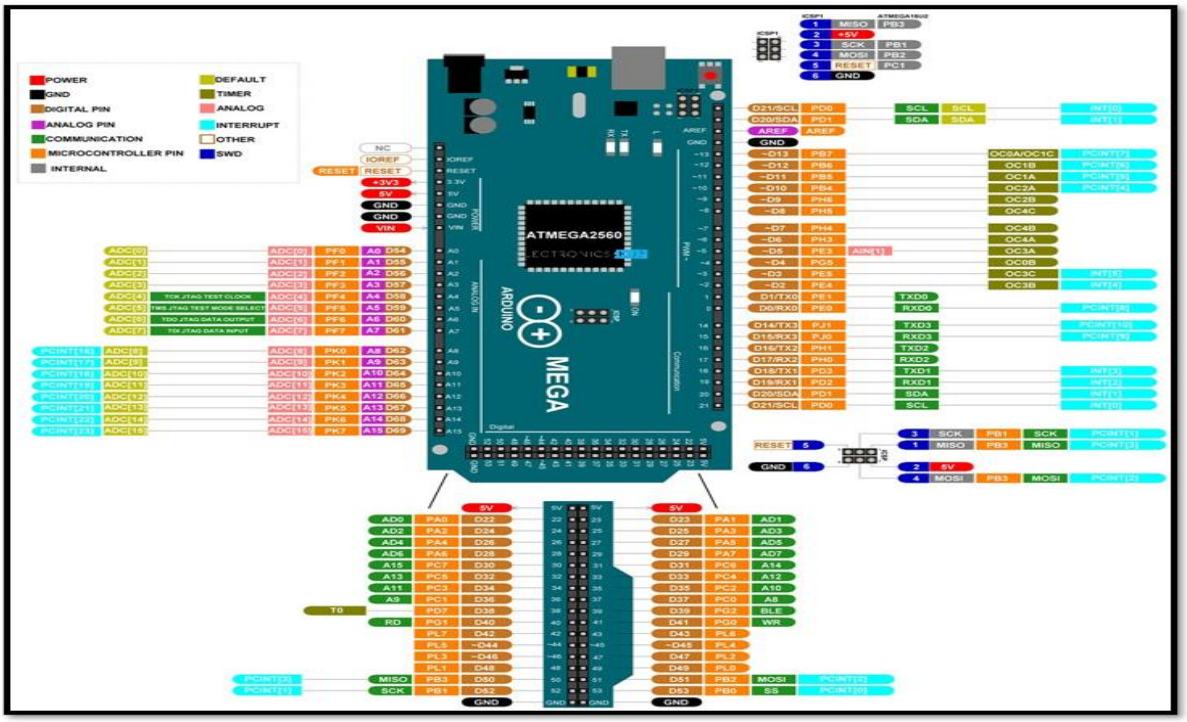

Fig. 2: Microcontroller board for action controller (image: www.google.com)

CPU: Table 4 depicts the connected module and its CPU function. It is the high-end central processing unit. In common practice, the installed RAM is higher than the general CPU. At least 32 GB RAM is the best for the operation. The primary input of the CPU is the camera image, which reaches over either the ethernet cable or Wi-Fi. The general surveillance camera has a coaxial cable interface. The IP camera has an ethernet port; the modern smart camera generally comes with an RJ45 connector, which means it is an IP-enabled camera. The CPU is connected to one RS485 module to send the command to the action module. Inside the CPU, there is an operating system. It may be Windows, Linux, or any other operating system. Now, Python is a popular language. Most of the camera companies provide their driver in Python language. The complete project can be developed in Python without issues. We need to install the Python IDE, like Pycharm. Then, libraries like YOLOv7 or later can be installed for image processing. To read the image, process the image, detect the image, and send the command to the action module, we need one coordinator. The project module coordinator

manages all activities. It handles a state machine. Inside the state machine are a couple of functions in every state. The available functions are executed inside the process flow.

Table 4: the modules connected with the CPU.

S. No.	Module	Function
1	RJ45/Wi-Fi Controller	CPU physical interface to connect with the camera
2	Image Processing (YOLOv7)	Process the captured image
3	Action Configuration File(.JSON)	Action configuration to trigger the action module
4	AI Home Manager	Coordinate all modules
5	USB-RS485 Module	Send action data to the action module

Table 5: Example action list for bedroom event

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
	Someone is waking	1) Toilet light on
	Come back from the toilet and go to bed again	The toilet light goes off
	Morning came	1) If any alarm set, trigger 2) Put the geyser on if it is time to bathe, or the water temperature is too cold.
	Some family members' body temperatures are not normal	Inform the concerned person.
	Some members suddenly fall on the floor	Inform the concerned person
	The date changed, and some member's birthdays. Wait for the member's awake time.	Play a happy birthday song and greet them.
	Found the family member's birthday on Date changes	Greet the member by playing the happy birthday song.
	If someone is watching mobile beyond bedtime	Alert frequently for sleep

5. SUGGESTIONS :

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

(1) Use high-quality PTZ cameras for better performance and accurate event detection.
(2) Use the latest YOLOv7 for better performance and optimized performance
(3) Place the IR transmitter in the proper place so that it should not be an obstacle to our body
(4) This kind of camera is good: https://www.amazon.in/OBSBOT-Tiny-AI-Powered-All-Pixel-Conference/dp/B0C3B6ZR1V/ref=pd_ci_mcx_mh_mcx_views_0?pd_rd_w=kxBPV&content-id=amzn1.sym.cd312cd6-6969-4220-8ac7-6dc7c0447352%3Aamzn1.symc.ca948091-a64d-450e-86d7-c161ca33337b&pf_rd_p=cd312cd6-6969-4220-8ac7-6dc7c0447352&pf_rd_r=GFP3A8AXGSZ8B6WXH14J&pd_rd_wg=XUtKG&pd_rd_r=c598246e-d19c-4d18-816d-59283eb201ea&pd_rd_i=B0C3B6ZR1V

6. CONCLUSION :

Artificial intelligence is our future. Day by day, the manufacturer designs AI-based products. AI is a promising technology. In our home, smart devices solve most of the issues. AI can benefit us more, leading us to a better and more beautiful life. Here, we demonstrated how to build and get what type

of benefit from an AI-based bedroom. We started the project with an introduction. Our future is an AI-enabled home. In the introduction section, we add the problem statement, an indication of methodology, a couple of good research projects, what we did in this paper, and a principal conclusion. After that, we added some research projects in this field. Then, we said the paper's objective with a couple of lines. Then, we discussed the research methodology. In the methodology section, it is depicted with a few pictures. Then, we gave suggestions, conclusions, and acknowledgments. Finally, we added some limitations and references from where we got benefitted.

5. LIMITATIONS :

A couple of limitations exist in this research work. The limitations are as follows:

- The event detection entirely depends on image capture. Sometimes, the object is not aligned correctly with the camera. In that scenario, the camera may not detect the event properly and can not trigger the action module. This problem can be solved using multiple cameras, but it increases the project's cost.
- Sometimes, the camera detects the wrong event and triggers the action module with improper command.
- The system runs round the clock. It consumes the electricity. It is reflected in electricity billing.

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