

Home Automation Using Hand

Faijan Shakir Khan¹, Vivek Sundarlal Turkar², Sanskruti Shrikant Singanjude³,
Sagar Premkumar Moon⁴, Gunjan Dilip Kakde⁵, Ganesh Digambara Gabale⁶

^{1,2,3,4,5,6}*Computer Science & Technology, GH Rasoni University Amravati, Nagpur, Maharashtra*

Abstract—Imagine being able to control the fan and lights in your room with a wave of your hand. This project makes that possible. This home automation system uses hand gestures in place of switches or smartphone apps. A simple camera, like a webcam, records your hand signals. A computer program then determines the gesture you are making. Once it understands your command, it tells a small device called an Arduino to turn your appliances on or off. This is very helpful for people who have difficulty speaking or moving around because it gives them a simple way to organize their living area. There's also a special hand signal for sending an emergency alert.

This proposed gesture-based home automation system leveraging both a Personal computer and Arduino integrates hardware and software components to provide an intuitive and interactive control interface for smart homes. Webcam captures handgestures video and it is going to be fed to the personal computer. Sophisticated gesture recognition software (python), employing computer vision using a machine learning technique (CNN-Convolutional Neural Network) detects and classifies these gestures respectively. By analyzing movement patterns and features, the system translates gestures into predefined commands. The personal computer then communicates with Arduino to operate the corresponding device which is bulb.

Index Terms—ConvolutionalNeuralNetwork, home appliances such as bulb and fan, gesture recognition, python,opencv,CNN.

I. INTRODUCTION

The places we live in are expected to provide us with a sense of security, besides being sources of delight and relaxation. The last ten years saw technology trying to maintain and even enhance that comfort with the introduction of “smart homes.” Perhaps you know someone who has been able to turn on the lights through a mobile app or asked a voice-recognizing device to play music.

To be fair, stating that these solutions are not for all users is justified. A situation where a person has to look for their phone just to turn off the fan can be irritating. An aged grandparent, who is not accustomed to smartphones, might find a complicated app very confusing and eventually a little scary. On the other hand, for an arthritis patient or a physically disabled person, using small buttons on either a remote or a touchscreen may lead to inconvenience or even unendurable pain. It can happen that voice commands are not heard in a loud room, and a person who cannot talk will not find them helpful. Our project is meant for such cases. We put forward a very straightforward question: which is the most natural and easy thing to do for a human to communicate without having to talk or use tools? The answer is: using our hands.

Every one of us uses a variety of hand movements every day to communicate and say "hello," "come here," or "stop." Our project is based on this very human instinct. We have developed a system that allows you to operate your household devices by merely making hand gestures. No touching, no speaking, and most importantly, no stress while interacting with your surroundings.

The project aimed at creating something not just intelligent but also a kind one. It was meant to be a blessing, particularly for the most disadvantaged and helpless. It is reasonably priced so that it can be used in many families and it is so easy to learn that it will take a person just a few minutes to become acquainted with it.

II. LITERATURE SURVEY

It was clear to us, even before the very first line of code was written, that the help from the past would be invaluable. Reading and understanding the former researches in the fields of gesture recognition and home automation was very time-consuming for us. It was not copying but gaining the knowledge of what is

good and what is bad and then finding an area that is very different for our project. What we found out was a very exciting trip through the technology evolution. Dreaming of controlling machines only with the movement of one's hand goes back for centuries, and maybe the idea was inspired by science fiction. The very first practitioners of the technology tried to do it by using very primitive image processing methods to make the computer a "vision" system for the hands. These experiments usually consisted of color tracking with a very low accuracy or having the user wear gloves that were very brightly colored so that the camera could easily find the hand. The systems that were developed could only work under very closely controlled laboratory conditions but were unusable for an average household. To give an example of the discomfort, imagine the user needing to put on a special glove every time he/she wants to turn the light on! It was thus deduced that the system which would be the most useful should be the one that can recognize the hand of an ordinary person and operates in a normal household environment.

The machine learning hype, among others, is the chief reason behind the current state of deep learning, while the latter, on the other hand, effectively represented the very first step towards human-computer interaction (HCI). An HCI implementation that affects communication with all users, even those that are difficult to hear, is the perfect example mentioned, that is, the translation of Indian Sign Language for the deaf and mute. The systems were developed by research teams that not only managed to recognize complicated signs but also carried it a step further to pass on the message in spoken or written form. Such developments in technology were indeed very heartwarming experiences, as they not only opened up new ways of human interaction but also accentuated the social aspect of technology, thus challenging us to think beyond just the issue of technology being an easy way of doing things graciously. The realization came that if a machine can be trained to recognize a whole language's subtle signs, then it should be a pretty straightforward task to teach it to recognize simple commands like "light on" or "fan off." This change of thought made it possible for us to view our work not as mere tech demonstration but rather as a desirable empowerment tool.

Besides that, we have really investigated the household automation systems existing in the market today. The

manufacturers have come up with various and up-to-date methods for the users to oversee and manage their homes from abroad, by smartphone, remote, or even via voice commands. These choices are very handy for many, but at the same time, negative aspects have been noticed. A technologically challenged older person might consider the tech app a very difficult thing to handle. A person with a disability might find it a huge challenge to locate and press a button that is not very visible. Some might consider the use of voice assistants but won't be able to. They might have an accent that is very hard for the machine to understand, or there might be noise in the background, or they could simply not be in a setting where they can talk. We were right when we thought that a non-verbal, intuitive, and nonhaptic interface had to be created.

Anyways, we carefully examined the devices that were involved in different gesture control systems. Some of these researchers had gone for very complicated and expensive depth-sensing cameras or had the Leap Motion controller - a special sensor - as their technique. These devices are fantastic concerning precision, but on the other hand, they make the solution too expensive for a typical family that was our key market—be not expensive at all. So, our leading principle became "inclusivity and low price." Then we started pondering: "Is it possible to transform something very cheap into the superlative and most ubiquitous sensor?" So, that was our main differentiator: the application of a common USB webcam.

A review of the current systems with respect to gesture recognition yielded a significant and straightforward pattern that is common to all successful gesture recognition projects. It is a learning process of a human almost to the same extent that he or she would learn and respond to a new sign language. Think of it this way, you're teaching a friend to decipher your signals with hands. The first action, which the pyramid illustrates as "Fetch Gesture," is merely an act of observing your hand by him/her. Technically, this is where the camera, which acts as the system's eye, captures a live video feed of the person's hand. This is the crucial point; the first and foremost thing to do is to see the gesture because without seeing it nothing else can be done. The moment your friend spots your hand, his/her brain does not take in the whole picture at once. He/she will block out the background, your shirt color, and everything else and will concentrate

only on the form of your hand. This is exactly what is going on in the "Pre-processing of Image" phase. The raw image captured by the camera is processed. The computer may, for simplicity's sake, convert it to black and white, improve the hand's visibility by enhancing the contrast, and filter out the visual "noise." It is as if the system is squeezing its eyes to get the most important person, the gesture, clearly! At this moment, your friend will see hand clearly but won't he/she have to interpret the gesture? Is it "thumbs up" or "open palm"? "Gesture Classification" process is the one where the decision has to be less clear. The pre-processed image is given to the smart "brain" of the system—usually, a Convolutional Neural Network (CNN) that we have already trained for the task. This brain has already gone through a "Gesture Database," which is a huge collection of labeled hand images. It gets the new hand in the camera feed and compares it to what all it has learned from that database and thus makes its best guess: "This is Gesture A. Nonetheless, it is significant to note that being aware of the sign does not imply that it will be of no function at all. Let's say your friend interprets your "thumbs up" as a good sign; he will probably respond with a smile. In this scenario, the machine interprets the sign of recognition as a cue for a predetermined outcome. The flowchart depicts this as "Action 1," "Action 2," or "Action 3" respectively. This is the point where the digital command is given a physical form. For instance, a computer here sends a command to a microcontroller, for example, Arduino, which then performs the actions of lighting, fanning, or turning off the emergency alarm, etc. The last step of the action has now completed the entire process, converting the common, instinctive hand gesture into a real output, and at the same time, the interaction does not appear to be anything other than a magic trick.

III. PROPOSED SYSTEM

This component is the device part that actually connects your home appliances.

1. The Heart (Arduino Nano): Arduino Nano is a very small, very cheap and very adaptable microcontroller. Our device is built on this particular circuit part. Instead of having to run a complex operating system like Windows, it is dedicated to the task of waiting for the computer to command it and then turning the switches accordingly. It is also the best choice for this

job because it is dependable and it consumes very little power.

2. The Muscle (Relay Module): A relay is a switch that works through electricity. It's like a very strong muscle that you can only see when the circuit is completed. An Arduino can generate only a weak 5V signal, while a device like a lighting bulb or a fan needs 220V coming from the mains supply. Thus, a relay is placed in between. The small signal from Arduino can instruct the relay to make a much stronger circuit, hence safely turning on or off the high-power appliance. It's like a child controlling the release of a giant garage door remotely with the help of a remote.

3. The Appliances: While performing our experiment, we used LEDs as lights and a tiny DC motor as a fan. This is very safe for testing purposes and shows the same principle of control for real, larger appliances.

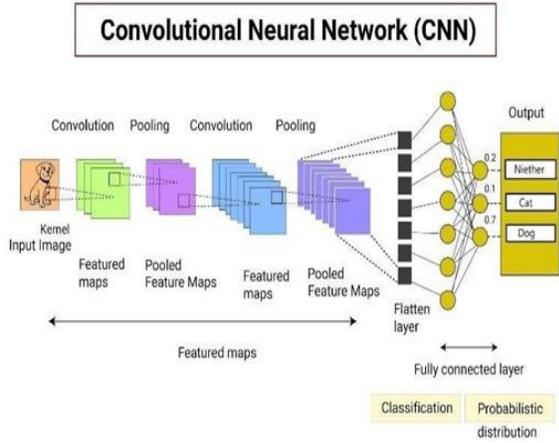
IV. STEPS INVOLVED IN SYSTEM WORKING

You Make a Gesture: Everything kicks off as soon as you show a specific hand signal, the like of which is a "Index Finger Up," to the computer's camera. The Camera Captures the Video: The webcam is the system's optical receptors, perpetually watching and streaming live video feed. The Computer Finds Your Hand: The software applies OpenCV and MediaPipe to spot your palm in the footage and distinguish important characteristics (like fingertip and knuckle locations). The AI Brain Recognizes the Gesture: The already trained CNN model decodes the hand features and links it to a predefined gesture, e.g., "Index Finger Up." The Command is Decided: The app sees "index finger up" as a command "Light On."

A Message is Sent: The PC sends a simple signal, essentially like the letter 'A', through the USB cable to Arduino Nano. The Arduino Receives the Order: The Arduino is in a continuous listening mode; thus, it collects the 'A' signal and erroneously takes it for an instruction to execute. 8. The Relay is Activated: The Arduino allows a small current to pass through to the relay module, which is a powerful electronic switch. The Appliance is Powered: The relay closes the circuit, thus energizing the bulb or fan by connecting it to the power source. The Action is Completed: The light is switched on instantly, thereby performing your command.

The entire process from Step 1 to Step 10 completes so quickly that it seems the system is really fast and responsive.

A. Image classification of input gesture



The real enchantment starts once the device can see the hand clearly. Here are the teaching process of the computer and the analogy with the child's learning to different shapes recognition.

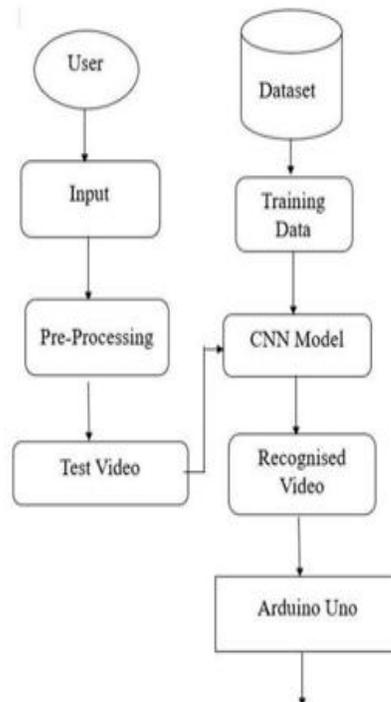
We employ a type of neural network architecture called a Convolutional Neural Network, abbreviated as CNN. Visualize this CNN as the cognitive entity of the system. However, this cognition is not intelligent right from the start; we have to guide it through the process. Our method of doing this involves presenting hundreds of pictures of our hands doing different signs the index finger up, the index finger down, the index and middle fingers up, etc. We made a directory specially for these pictures which we named the learning database.

The CNN can start learning from these images only after a preprocessing phase in which the images are lightly processed, and the hands are made the center of focus. Subsequently, through training, the CNN slowly discovers the patterns. It determines that a specific configuration of shapes signifies "Index finger up," while a different configuration denotes "Down index finger."

The training is finished, and the brain is now ready for the real environment. If the camera is pointed to a new gesture, the brain looks at it and thinks, "Eureka! This is an 'Index finger up' gesture". This recognition—this judgement is the most important part of the entire process.

Once the gesture is recognized, the system automatically knows what next step to take. Each gesture has a corresponding action in the programming logic. Thus, when the brain perceives an "Index finger up," it sends out the signal for "light on." This command is then simplified and communicated to the Arduino hardware, which activates the next stage of the process. Thus, a minor hand gesture transforms seamlessly into a physical world's concrete action.

Here the user interface to give the command :





V. TOOLS AND TECHNOLOGIES USED

1. Programming Language :(Python, C++)- Python is the best language for AI and machine learning because of its simple syntax and powerful libraries. C++ is what the Arduino understands, so we used it to program the microcontroller.
2. Arduino: Arduino is an open-source microcontroller used to interact with resources like led, motor etc.
3. Software Tools (VS code): VS Code is a fantastic, free code editor for writing our Python programs.
4. Packages and Libraries: OpenCV, TensorFlow, Keras, MediaPipe, NumPy.
5. Appliances: Led light, motor, Fan etc.

VI. RESULTS AND DISCUSSION

Our final system was a source of great excitement to us. The moment we connected all the wires and completed our program; it was time to check its performance. We placed ourselves in front of the camera and gradually lifted our index finger. To our surprise, the bulb lit up right away. It was an action of little effort, but it was like magic. We had done it, turned a light on without making any contact.

The system behaved in an absolutely the same way as we had scheduled for all gestures. The finger up meant the light on. The same finger down meant the light off. We needed a couple of fingers for controlling the fan. Raising both index and middle fingers made the fan start to rotate. Their lowering stopped the fan. It was amazing our simple hand movements were able to control such objects in the real world.

One of the most amazing things about it was the speed. There was no waiting nor any delay. The second our fingers became fully pointed or lowered the light or

fan responded without any interruption. This helped to make the system feel very natural and quick to respond, almost like the devices were reading our thoughts.

And we also tested how it would react to our attempts to confuse it. For instance, we tried showing a three-finger sign or a closed fist. Most of the time, the system was able to correctly ignore these gestures and was reacting only to the ones we had taught. This was a good sign of the model's acquiring the command versus random hand shape's ability.

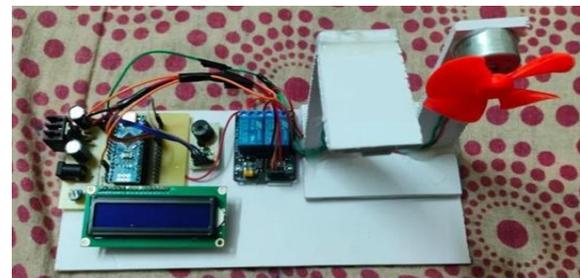
Naturally, we also encountered some minor problems. One thing was that the system's performance depended on the stability of the hand. If we moved too fast, sometimes the camera would take a blurry shot. We also noticed that the plain wall behind our hand was the best option for getting the best result. A busy background with lots of colors and objects could sometimes distract the system even for a second.

Another thing that we got to know was about lighting. The system was a star performer under good lighting conditions. But when the room was dimmer in the evening, sometimes the system had difficulty recognizing our fingers clearly. Then we realized that the camera could see the gestures properly only when there was consistent and good lighting.

Even though there were some small challenges, we are still very satisfied with our creation. The main objective of us was to design a system that is so simple that anyone can operate it, and we did it. The gestures are so easy to be remembered— light for one finger, fan for two fingers. This is a perfect case for a person who could find it hard to use switches or remotes.

Eventually, our project is a strong testimony that this idea works.

We have demonstrated that by employing some simple technology, we are able to control our home environment in a new and intuitive manner. It is a tiny step, but it leads to the development of smarter and more user-friendly houses for everyone.



VII. APPLICATIONS

This innovation is beyond being a simple academic experiment; it has the potential to really aid people and enhance their quality of life.

The Most Significant Application is the Freedom of the Elderly and the Disabled: This is the very first and most vital application. An older patient suffering from arthritis can turn on and off the fan and light of his bedroom without even leaving his bed. A disabled person will gain an entire new level of control over his environment which will inevitably lead to less reliance on caregivers for minor tasks and thus when confidence is there, independence is there too.

Infection-free and Hands-free Control in Fields and Hospitals: Your hands are usually too dirty to do any operation in a kitchen. But with this system, you could simply wave your hand to turn on the water faucet or the exhaust fan without making your hands greasy. The same goes for doctors and nurses in hospitals where they can create a germ-free zone where lighting is not an issue while treating patients or accessing medical records on a monitor without the need to touch anything.

A Fun and Convenient Smart Home for Everyone: It is an easy and story-like interaction with the house even for the able-bodied users. Coming to a room with your hands filled with groceries? Just a wave can switch on the light. Hence, it is a routine life that is slightly more comfortable and very much more enchanting.

VIII. CONCLUSIONS

To sum up, a hand gesture-based home automation system prototype has been designed and built successfully. With the use of very basic and inexpensive components along with smart software, we have proved that it is possible to design a system that is not only functional but user-friendly at the same time. Such a system provides a technological pathway for people to communicate with their home devices in a manner that is natural and intuitive, thus enhancing their independence and safety.

This venture is a very strong initial stage. We are really looking forward to its prospects, and we have precise plans on how to improve it even more in the future.

Our Future Plans

Smarter Recognition: One of our main goals is to make the model's intelligence even sharper. To do so, we will subject it to thousands of images in varying light conditions, with different skin colors, and against complex backgrounds. Furthermore, we will look at employing a totally different kind of model that is capable of comprehending a succession of movements (like a hand waving), rather than just being limited to static poses. **Cutting the Cord:** Turning the system into one that is entirely wireless is the next great leap. The existing USB cable will be replaced with Bluetooth or Wi-Fi modules (such as an ESP32 board). This change will result in a more orderly system, that will be easier to set up and more flexible. **Control More of the Home:** The range of the system will be extended to include more devices such as TVs, ACs, and curtains. This will necessitate the identification of a larger number of gestures and the usage of IR (infrared) blasters or additional relay channels. **Developing a Mobile Companion App:** It is our desire to create a mobile application that will be linked to the system. The app will be capable of providing a record of all the commands, giving immediate phone notifications when the emergency gesture is activated, and even allowing remote access to the house when the owner is away. **User-Friendly Customization:** In the final version, we imagine an app where users can easily "train" the system on their own custom gestures. You could literally show the system a new hand sign and tell it, "This means 'turn on the coffee maker."

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