Interaction with IOT Comfort Technologies for Deaf and Dumb People

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Abstract. Sign language is usually spoken by the deaf and dumb community. However, there are many available constraints in this. The first being that there are around 138 to 300 total sign languages that are currently in use around the world so there is no cohesiveness between them all. This elongates the already huge communication gap not only between the non-sign language speakers but also the people who are part of this community. Secondly, not many people or rather the majority of the people capable of speaking and listening, don't bother to pick up and learn sign language. This distances people and prohibits them from communicating and connecting. People using sign languages also are unfortunate when it comes to modern and evolving technologies. What we hear today is "Voice-controlled"," Voice-activated"," Speak to control", these are the new buzzwords of this century. The entire development of comfort technologies revolves around this idea of ease of use, replacing the old capacitive buttons with the voice as the trigger. It is uncommon for developers to think about those who don't share the luxury of speaking and rely on their hands for communication. Pondering and researching about the feasibility of this concept of bringing the Internet of things for the people who talk through or whose voice is the Sign language, a new model is being discussed.

Keywords: Internet of Things, Voice-control, Sign language, Smart Home, Deaf and Dumb.

1 Introduction

There are so many comfort technologies coming up and are en route to be widely adopted into households, branding to be next-gen "Voice control", "Natural language processing" etc. However there is one shortcoming of such advancement, that is, it isn't trained or made or even inclusive of the deaf and dumb people. Now, it is clear that the target consumer of such technology is people without such challenges. But it is established in the ethics that any advancement in technology should strive to include everyone. Thereby the IoT field specifically the smart home branch needs some major revamp to make it adaptable and useable by the deaf and dumb people.

Every 3 child out of 1000 born in America alone are either deaf or dumb, in addition, there are thousands of people who go deaf or dumb due to some reason every year [1]. Although there are some ways which are available for them to interact with smart home appliances, none of the methods are as intuitive as the voice commands.

1.1 Deafness and Hearing Loss

Hearing loss is defined as the inability to hear. It also includes a person with hearing thresholds as 20 dB or higher in both ears ranging from mild to moderate to profound hearing loss. It affects one or both ears, making it difficult to hear conversational speech or loud noises.

Over 430 million people, or 5% of the world's population, require rehabilitation to address their "disabling" hearing loss (432 million adults and 34 million children). Over 700 million individuals, or one out of every 10 individuals, are expected to have debilitating hearing loss by 2050. [2]
People suffering from hearing loss often can’t speak or lose their ability to speak and this is a common phenomenon.

1.2 Speaking Disability

A speech disorder is a condition in which a person faces difficulty in creating or forming speech sounds needed to communicate with others, making the child's speech difficult to understand. [3]

Common speech disorders are dysphonia, Phonological disorder, Disfluency, Voice disorders or resonance disorders. [4]

There are several ways to make deaf and dumb people feel included in all the advancement taking place in the IoT and smart home technologies. Some of them are discussed in this paper.

2 Literature Survey

There are a variety of methods and ways researched in the field of sign language to speech conversion. One of the similar concepts that were researched used the concept of transfer learning using TensorFlow which focused on storing knowledge gained while solving one problem and applying it to a different but related problem. In this method, a bottleneck was calculated for all the training images. Once the bottleneck is calculated and stored the training of the top layer of the network begins which includes the calculation of training and validation accuracy[5]. This concept of prediction of sign language was scaled up in a paper where 2 models i.e Glove based and Vision-based were used to take in 3D models of the various body parts and position along with an Appearance-based model which were directly taken from images of the user. Combined data from the two models were used to produce the final result, which was the limitation of a great model as it only produced one letter at a time on the screen, which made it difficult to communicate as it wasn't cohesive or readable in the slightest form[6].

Another approach that was popular for solving the problem is by using physical sensors with research claiming that compared to vision-based systems, sensor-based gesture recognition systems (flex sensor) are sensitive and accurate as it provides a certain degree of freedom for hand movement and only requires a motion sensor rather than a camera making it a low-cost portable device with 99% recognition rate. In this system, the deaf and dumb people wear gloves (attached to resistors and sensors) to perform hand gestures. The system converts the gestures to the corresponding text and then synthesizes the speech for the corresponding text by using a text-to-speech synthesizer. The sensor glove helps in reducing the ambiguity in gestures and improves accuracy. However, it is limited in considering cameras to be highly expensive and not portable which is proven false as mobile cameras are the most commonly used devices. Apart from that, making a speech synthesizer dataset on a small scale instead of using open-sourced limits the range of what could be done[7].

Extending the work with physical sensors a similar approach consists of 5 Flex sensors to detect the palm movements as input and an accelerometer that detects the rotation of the palm which selects the communication language forming the 1st bit of binary number to be compared in the lookup table. The flex sensor has a foldable Resistive strip. The resistance varies with respect to the flex strip folds to indicate either logical 1 or logical 0 by providing the variable analogue resistive Input to the inbuilt ADC of the ARM7 microcontroller, which forms a 6-bit binary digit for each gesture. If the gesture matches the generated binary digit the ARM7 will search the audio file. If the file is found in the external memory, then μC will play the corresponding audio file with pronunciation of the word. This solves the problem of pronouncing whole words at once instead of letters however it isn't real-time and lacks continuity as an audio file is needed to be played for each individual word. This format of predictions is a little slower and isn't compatible with a wide range of devices[8].

Inspired by the previous work a new combinational model using the five flex sensors and the 3D model method was implemented, the difference was highlighted in the use of raspberry PI as the computational device, which according to the research was used for the purpose of making the model portable, however, the resultant output had similar limitations as the previous models[9].

Using Raspberry PI has been quite popular to be used as a computational unit for the physical sensor model as it was used for a model which uses the MPU 6050 which combines a 3-axis gyroscope and a 3-axis accelerometer in a small package. The gyroscope measures angular velocity through the orientation angle. Raspberry pi uses the Python language to develop a path recognition algorithm. The system supports three modes: learning mode, testing mode, and translation mode. In training mode, the features described in the path recognition algorithm will be generated for this gesture, and a database will be created. In the test mode, the features generated by the gesture at this point in time are compared with the features stored in the database. The learning model is used in system design. Path recognition algorithms are used to recognize letters based on specific gestures. The algorithm includes raw data extraction, signal preprocessing, feature generation, feature selection, feature extraction and classifier creation[10].

Another model used a similar approach of using the webcam for image acquisition for the purpose of prediction using the application of the Min EigenValue algorithm in MATLAB. It is a real-time application however it is bounded by only being able to predict 26 alphabets as well as the added step of converting each alphabet into sounds. This poses a similar drawback of being non-cohesive for a conversation[11].

Continuing on the path to use the webcam, the research used a CNN model to classify the sign language. Background subtraction is done on the image to segment out the foreground object which looks over 30 frames for different scenarios. The advantage lies in using CNN as it automatically extracts the features of the sign images without much complexity. However, the drawbacks are that it is limited to only 26 alphabets of Indian sign images as well as it works only when the background of the scene is static which is a difficult environment to achieve[12]. A different algorithm was also used which after capturing the images converted them into grayscale then black and white for more precise canny edge detection however the accuracy was similar to the CNN model, the only difference apart from the used algorithm was the ability to identify 32 different hand signs[13].

With the advent of virtual reality, hand gestures regarded as the input of computer commands has caused extensive research. This system proposed a method to recognize multiple static hand gestures. The system preprocesses the captured video image followed by feature extraction and classification. Gesture recognition is based on template matching. Hardware is developed which recognizes hand gestures and converts it into a voice[14].

There is a balance between the hardware and software approach for making a sign to speech conversion yet in the recent past the trend has been moving toward using camera and image processing algorithms for the same. Adding to the previous algorithms used, another research that tried to implement this was successful in converting the fingerspelling of the Indian sign language into speech using hand segmentation, feature extraction and finally classification, not adding on to the previous work but just trying another approach to the same problem[15] a variety of

other methods with a similar approach has also been published and the to achieve the validation accuracy of as high as 98.64%. This was achieved by using the facial expression for context and final interpretation[16].
There is a lot of work that has been done using similar physical sensors with slight variation in the execution and the final model, adhering to this an American sign language alphabets to speech converter was developed using the flex sensors and a microcontroller as a processing unit to distinguish between different letter being formed by the hand[17].

3 Analysis

Since dawn, the physically challenged community has been discarded and looked down upon for the fact that they are somewhat dependent on others for a variety of daily tasks. We fail to realise that what may be usual for us may take a lot of effort and help for them. With the rise of technology, it is necessary to keep the vision of developing products that are usable by all the different communities of people in our minds. Only then true progress could be achieved.
The earliest inclusion started with the voice feedback developed for the blind and has continued to evolve but at a really slow pace, one which hasn't caught up to the technology of today, which is rather frustrating for the differently-abled people.

One of the biggest revolutions that is happening today, observable by the common people, is the one in "Comfort technologies". Comfort technologies as the name suggests are the devices that are meant to ease the lives of ordinary people. These include smart bulbs, fans, air conditioners, refrigerators, cars and many more. These technologies, in the beginning, were merely a frustrating yet fascinating piece of toys but as time has passed update by update they are becoming more and more integrated with the lives of ordinary people. It is now a common scene for people to ask a virtual assistant to turn on and off the lights to start the coffee machine or to turn up the temperature. However, the one problem that remains is that these technologies are meant for the masses i.e "ordinary people" and aren't inclusive of the people with disabilities specifically the deaf and dumb people.

All the smart devices advertise to be "voice-controlled" which is true as there aren't any other ways for everyday users to interact with these devices. However, there isn't even an option available in the market which allows for differently-abled people to have this and use these techs to ease their life and problems.

At the present day and age with the development and advancement in the field of the Internet of things, Artificial Intelligence, Machine learning, Neural networks and effective algorithms there has been a birth of a variety of ways in which the lives of the physically challenged people could be made easier and they could have a chance at normal or rather independent life. The first and the major discussion is to create a bridge that enables deaf and dumb people to communicate with technology and use the Internet of things the same as people who speak do. Various methods and ways to achieve this will be discussed in detail in the following paragraphs.

3.1 In House positioning system

Wifi Based

A huge amount of research has been done in designing this system and the most effective way involves a set of wifi transmitters that are referred to as tags that are set up in the house in various positions. These tags continuously send packets to a number of wifi access points spread out in the house. These access points then report the strength, time and angle of arrival to the backend which uses a hybrid algorithm i.e Time Difference of Arrival(ToDA) and Angle of Arrival(AoA). The user's device that is needed to be positioned is a smartphone with wifi capabilities so we use a hybrid AoA/ToA technique to determine the target's position when there is only one WiFi AP. When it comes to numbers, when there are two or more nearby WiFi APs, we use AoA to get a more accurate position. Even if the number of adjacent anchors is restricted, this architecture can provide an accurate positioning service.[18]

Once an accurate position is determined it will be updated to the cloud where all of the data of smart homes appliances such as their indoor position and rooms will be already registered. This will enable us to determine what are the closest appliances that are available and then they could interact with those with a variety of methods mentioned in heading 2.

Pros of Wifi Based System

- Extensive customization options: Since wireless systems are not hardwired, you can easily add, move and modify the system. Wireless systems also be synchronized with other home automation systems and provide special features such as smart locks, smart lights and smart thermostats.[19]
- Remote accessibility. Wireless systems can be monitored and controlled remotely using applications, email alerts, or text alerts. This eliminates the need to use in-home control panels for all basic functions.[19]
- Less vulnerable. There is no single line of wireless system that an attacker can cut to disable the system. In addition, since most components of wireless systems are battery-powered, they are not prone to battery failure. Contrary to wired systems.[19]
- Easy installation and removal: Installing a wireless security system does not require drilling holes or laying cables, and many wireless systems have a DIY installation process, thus eliminating installation cost. These systems can also be easily removed and relocated to a new location. They are ideal for renters, historic homes, and buildings with brick, stone or marble interiors that are difficult to drill into for a wired systems.[20]

Cons of wifi based system

- Less reliable. Like WiFi or mobile phones, the reliability of wireless systems can be affected by electromagnetic interference, structural interference, and even bad weather. For this reason, wireless security systems are more likely to be triggered by false alarms than wired systems.[20]
- Vulnerable to hacking. It’s essential to test the specifications of wireless systems to affirm that it’s not a smooth target for hackers. Wireless systems without encryption or authentication signals from access point sensors may be hacked and have their signals may be compromised, disabling the alarm and making it easy for burglars to enter a house undetected.[20]
- Not ideal for large spaces. Wireless security sensors generally have distance limitations, which implies that they are not ideal for a large house or large coverage property with multiple buildings. The average range of a wireless radio signal is approximately 500 feet.[19]
- High maintenance. Most components of a wireless system are electric, however many run on batteries, meaning the batteries will have to be replaced or charged periodically. If you have a wireless security system, it’s important to monitor the battery life to make sure everything is in order.[19]

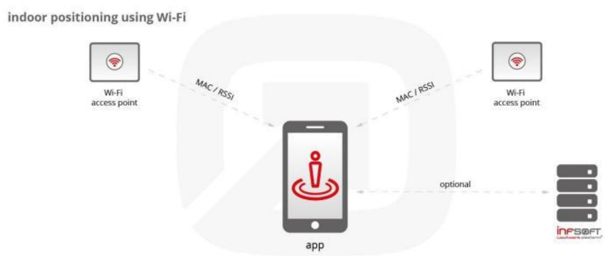


Fig. 1. Demonstrating the structure of Indoor Positioning System using Wifi

Ultra Wide Band

This is a radio technology, which means it uses really low power to achieve high-bandwidth connections which in return promises lossless connection and high precision. The tag locates itself by receiving wireless pulses sent by the base station in real-time. Finally, the raw data that is given back is filtered using the sliding window filtering process. High-precision positioning information with a maximum inaccuracy of 20 cm.[21]

A variety of Ultra bands placed in smart home devices will enable the mobile phone of the user to detect which devices are in close proximity of the user and then get ready to interact with it using the methods discussed in subtopic 2. This technology is although new but is promising as giants like Apple are already putting these chips in their phone and other devices, building the infrastructure.[22]

3.2 Collection and Processing of Data

The interdependent relationship between Cloud computing and IoT

Internet of Things and Cloud Computing are complementary technologies that are often discussed together when it comes to technical services and collaboration to deliver the better IoT solutions. However, there are significant differences between them, making each of them a viable technical solution individually and in combination.

Cloud computing in the Internet of Things is used to store IoT data and for cooperation. A cloud is a centralised server with computer resources that can be accessed at any time. Cloud Computing is a convenient way to transport large amounts of data packages generated by IoT. Big Data also helps in this process.
Internet of Things and Cloud Computing, when used together, enable system automation in a cost-effective manner that allows for real-time control and data monitoring.[23]

Table 1.1. Data stored at the time of registration of devices

	Room1	Room2	Room3
Common Controls	Bulb 1.1 Bulb 1.2 Fan 1.1 AC 1.1	Bulb 2.1 Fan 2.1 Fan 2.2 AC 2.1	Bulb 3.1 Bulb 3.2 Bulb 3.3 Fan 3.1
Specific Controls	Toaster 1.1 Microwave 1.1	Table Lamp 2.1	Desk Light 3.1

Table 1.2. Common Controls Table

Bulb	Fan	AC
On	On	On
Off	Off	Off
Change Color	Change Speed	Change Temperature

Table 1.3. Specific Controls Table

Task	Table Lamp	Desk Light
On	**On**	**On**
Off	**Off**	**Off**
Set Timer	**No**	**No**

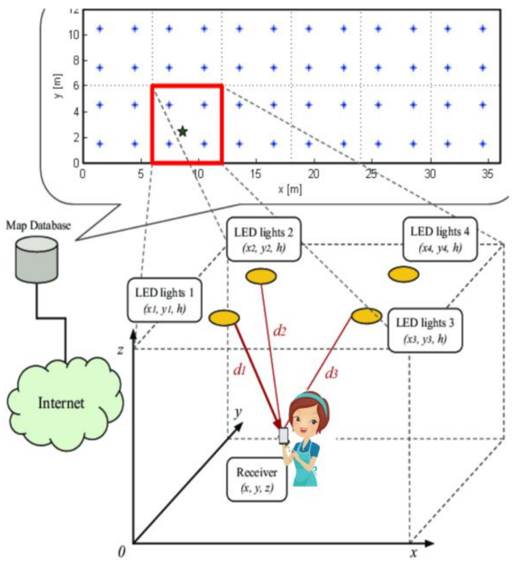


Fig. 2. Demonstration of all the IOT based tech interacting with the user

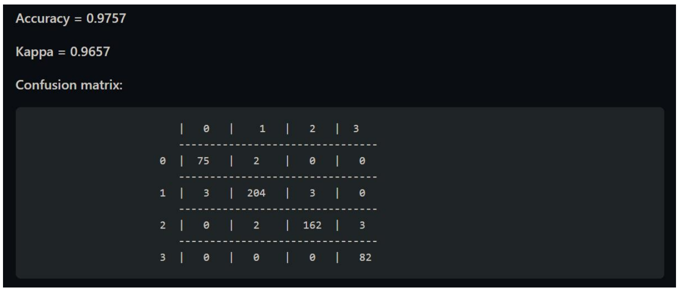
Computational algorithm

For wifi positioning

Two different things are required to be predicted while in a house in order for the system to work. The first is the floor prediction and the second is the room prediction. Houses with only one floor can skip the floor prediction and houses with multiple floors require extensive training.

For the floor prediction, upon testing the various algorithms the most accurate result was obtained using classification using the Random Forest algorithm. Although the

K-nearest neighbour is faster but is 5% less accurate and that is why the earlier algorithm is preferred.[24]


Accuracy = 0.9757

Kappa = 0.9657

Confusion matrix:

	0	1	2	3
0	75	2	0	0
1	3	204	3	0
2	0	2	162	3
3	0	0	0	82

Fig. 3. Accuracy of the Algorithm used for Wifi positioning system

Room prediction

The best method to approach the room prediction is by Regression using K-nearest neighbour.The KNN algorithm can be used for both classification and regression problems. The KNN algorithm uses 'feature similarity' to predict the values of each new data point. This means that the new point is assigned a value based on how closely it resembles the points in the training set.

Computational Algorithm for UBWs

If all the smart home appliances have Ultra band chips there is no need for a wifi positioning system as the UBWs in the appliance will work as a locator.
As the user enters the room the UBW in the mobile phone will detect all the nearby appliances and the app on the phone will send a request and pull all the controls of the detected appliances from the cloud. This would prove to be a faster way of interaction as the positioning part will be entirely eradicated.

Sending the computed information

At the time of registration of an appliance, using the app on the cloud, the user may also update the room number and the appliance number. This data will then be cross-referenced with the mapped out data(in the wifi positioning system) and will create a precise virtual map of the house. The cloud will also retain all the functionalities of the different appliances. The user's position will be tracked at all times in the house using either of the two functionalities mentioned above. As the user enters a room it will be updated to the cloud, where this data will be matched and positioned in the virtual map of the house. All the devices that will be identified in the user room their list will then be sent back to the smartphone.

3.3 Updation and UI controls

Once the details about the nearby appliances are received either by ultra-wide bands or by wifi positioning the app on the phone requests a variety of controls from the cloud. Those controls will be displayed on the UI allowing for seamless control over all the functionalities as demonstrated in the image. The controls would work on simple IoT protocols like MQTT (Message Queuing Telemetry Transport), CoAp (Constrained Application Protocol), AMQP (Advanced Message Queuing Protocol), DDS (Data Distribution Service), Wifi, Bluetooth and LoRaWan.
Other Ways of interactions are discussed in 4.

3.4 Ways of interaction

Once all the gathered information is structured, processed and the final location of the user has been established there are a variety of ways by which the interaction can take place between the smart home appliances and the user. The point to be noted is that the interaction should be dumb and deaf-friendly and is specifically designed for them to use. There will be main 2 segregation, one would be smartphone-based interaction and the other would be using the virtual assistant devices such as amazon echo and google nest(required to be camera-equipped).

Camera equipped virtual assistant devices

There are several virtual assistant devices that come equipped with a camera and screen to interact with and almost all of them provide the opportunity for developers to develop models and skills that can be deployed on these large networks of devices.
One of the best examples is the Amazon Echo hub which hosts amazon Alexa and has a camera and touch screen. There are also Alexa video skills that a developer can develop and could be deployed to every device out there with just one upload.[25]

Development of sign language model

Standard ISL

To make the model or skills cohesive and easier to use without much effort, the machine learning model could be trained using Standard Sign languages. However, the standards are different in various parts of the globe. For instance American Sign Language (ASL)British, Australian and New Zealand Sign Language (BANZSL), Chinese Sign Language (CSL), Arabic Sign Language.,Indian Sign language. People living in various parts of the world may be trained in a variety of sign languages so the deployed model should be the one based on the location of the device on earth. There are numerous excellent data sets and even models already available for this purpose. Most of them are free and even scalable and flexible according to the use. The only thing is to import and implement them with the designed GUI for these devices.

User Trainable model

However, no matter how great standard languages are the statistics show only 1% of the total deaf and dumb people use sign languages. If we lean on this statistic then the entire idea of interaction of user and smart home appliances using sign language is a failure. However, the other way to go about this is to allow users to train a model and basically develop their own sign language or precise commands for the virtual assistants to understand and interact with. Using this technique we can scale the model for the other 99% of the population.

Preparation for user Trainable dataset

This employs a kNN (k-Nearest-Neighbours) algorithm, which is quite rudimentary as it performs no "learning". It classifies an input image (from a camera) by applying a similarity function or distance metric to find the label of training samples closest to this input image. The image is initially passed through a tiny neural network called SqueezeNet before being fed to the kNN. The output of this network's penultimate layer is then passed into the kNN, allowing you to train your own classes. The advantage of doing it this way rather than putting raw pixel values from the webcam into the kNN is that we can use the high-level abstractions that SqueezeNet has already learnt, resulting in a better classifier being trained.[26]

Google teachable Machine

Teachable Machine is a web-based application that makes building machine learning models quick, simple, and accessible to anyone. Teachable Machine is adaptable; you can utilise files or live-capture demonstrations. It's considerate of your working style. You can even utilise it exclusively on your device, with no data from your webcam or microphone leaving your computer. Educators, artists, students, innovators, creators of all types — basically, anyone with an idea they wish to explore — may all utilise this.
Teachable Machine's first iteration allowed anyone to train their computer to recognise photos via a webcam. There is no need to have any prior experience with machine learning. It will develop an automatic model behind it based on some video input, photos, and voice input and provide an excellent outcome with good accuracy.[27]

How will it work?

Once the user downloads the skill on his/her device, they will have to write the commands they want a sign for as shown in Table 1.1. After writing all the commands they will be asked to place themselves in a static and noise-free background and start training the commands with a sign of their choice.
After all the commands have been trained the developed model would be deployed on the local system or the network of systems the user has in their home.

A custom application

The application built for registering information can also serve as a host for a sub-application that allows gesture controls for smart home appliances. This is for those people who don't want to either use standard or trainable sign language models and prefer to have only their smartphones and not any cam enabled virtual assistant device. Once the app is set up it will provide custom commands and the ability to assign gestures for those commands. The interface will be a black screen either inside the app or the lock screen when the device is locked.
For example, while setting up if the user draws a spiral-like structure and assign it for the command "Turn on the lights". When the user draws it on the screen of the phone, it will send this command to the closest led(determined by the positioning system) via the cloud. Although this is rudimentary and supports only a limited amount of gesture it is an absolute fit for people who won't be comfortable with other methods.

4 Variable factors

Widespread implementation of such technologies requires the involvement and acceptance of giant companies. These are the companies whose products are most widely used and acceptable. These are the companies that people trust and use and if they are open to such ideas only then technologies such as the above can be implemented. So this idea of inclusion is dependent on various variables such as.

1. Keeping Development of software open source and Allowing access of the hardware system to the third-party developers

   The ideas presented are only possible if the companies allow the use of their product hardware such as camera-enabled virtual assistant devices or camera-equipped refrigerators, Ultra-wide bands NFC etc and deploying third-party developed software and programs onto their devices. If they decide to opt-out of this provision in the future, there is little or no scope at all for the widespread implementation of the ideas such as mentioned in the paper. This is because the target audience for this solution of a problem is so small that developing a hardware-based solution won't be feasible as the requirements and adaptation won't be enough to sustain it.
2. Privacy Policy

   Day by day more giant companies are becoming stringent about their privacy policies and sharing of data and resources with third-party developers and companies. Although the trend of open-sourcing features is also increasing and so is the distrust between the companies. So it will be viable for the product companies to trust the developer and for a developer to work according to the rules and expectations of the companies. If for some reason there is a distrust between the companies and the developers the deployment of these features would be impossible on such a large scale.

5 Limitations

No model, idea or technology is perfect as there are always areas and implementations that could be improved. In the testing of the paper, a few limitations were identified which are highlighted below.

- If the wifi is of low bandwidth then it won't be able to support all these operations at once.
- Slower internet speeds could cause delays which cause distress.
- The deployment is a little costly as several hardware components are required for the model to work.
- It is hugely dependent on the companies which produce this hardware as if they choose to close off their product to the third-party developer then, there is nothing that could be done.
- The camera-enabled device may raise suspicion regarding privacy and security.
- It is vulnerable prone to cyber attacks
- Often there is little or no homogeneity in the appliances which results in different standards and protocols.

6 Future Scope

The model discussed in the paper is quite scalable and has an improvable future based on the advancement in technologies.

- Point and shoot: This is a method once small area positioning improves the idea is to point the mobile phone or a bracelet of a kind at a device and control it intuitively.
- Ultrasonic sensors: These if widely embedded into the homes can hand detect gestures and movements in the 3D space without depending on the mobile phones etc and can then enable controls of the smart appliances.
- Embedded system: If the idea gains popularity the implementation could be made by the first party developers and manufacturers. This will allow much more scalability and opportunities as there will be no barriers to overcome.
- Wide-Scale adaptability: The appliances and the solutions are a little expensive, but in the future, once the cost of installation goes down more and more houses will adapt to this.

7 Conclusion

There is one major component of IoT advancements in comfort technologies such as smart home appliances etc, that is voice dependent on use. It is its biggest selling point however it makes deaf and dumb people who don't have the luxury of speaking excluded and not represented in the technology world. Unable to participate in technological advances causes disparity. This is a major problem and one that needs to be addressed as fast as possible. With the advancement in various fields of technology such as better and faster wifi, bluetooth. Ultra wide bands, 5G, machine learning, Artificial intelligence, cloud computing etc. it is now easier than ever to solve this issue. There are several ways in which the controls of a smart home can be made intuitive for deaf and dumb people, some of which that were discussed in the paper included a combinational model of an indoor positioning system using both wifi and Ultra-wide bands along with a standard sign language or user teachable custom signs commands for the virtual assistant's convertor. There is also a method using phones sensors and screen for gesture recognition which is even more intuitive and adaptable. The entire model is deployed on the cloud for seamless integration and high processing speeds both which are essential for the wide acceptability of the system. Although there are some limitations that come with the model such as dependency on main producers of the smart appliance, privacy, cost etc however it promises an efficient and easy to deploy solution in the present as well as high scalability and wide-scale adaptability in the future. In a nutshell, inclusion of people without the ability to speak is very much important in the further development of IOT comfort technologies and this is an important issue which needs to be discussed and be worked towards more in the future.

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