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VOICE RECOGNITION BASED HOME AUTOMATION SYSTEM FOR LOW RESOURCE LANGUAGE

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Abstract: The " Voice recognition based I0T Home Automation System " is a cutting-edge loT project designed to revolutionize the way homeowners interact with their living spaces. This project, undertaken, has been crafted with the aim of bringing convenience and efficiency to everyday tasks through voice recognition technology and interconnected smart devices. By integrating voice commands through popular smart speakers, this system enables users to control a range of home devices, from lighting and climate control to security systems. With a strong focus on user privacy and data security, the project ensures that voice data is managed responsibly, and encryption measures are implemented for secure communication between the IOT hub and connected devices. The project boasts key features such as personalized voice commands, customization of routines, and real-time feedback. Users can create scenarios like "Movie night" that adjust multiple devices in a single command. A range of technologies, including cloud-based voice recognition services, IOT hubs, and end-device control mechanisms, are harnessed to create a seamless and intuitive experience for home owners. The "Smart Home Automation System" delivers numerous benefits, including enhanced convenience, energy efficiency, and improved quality of life. By simplifying daily tasks and promoting efficient energy use, it contributes to a more sustainable and comfortable living environment. As the project evolves, we anticipate implementing features to further enhance user experiences, such as integration with emerging smart devices and expansion of customization options.

Index Terms **- IOT, Smart Home, Voice Recognition, Automation**

I. INTRODUCTION

In the era of the Internet of Things (IoT), the concept of a "smart home" has transformed the way we interact with our living spaces. These intelligent environments offer us unprecedented levels of convenience and control, where our voices can command a symphony of devices, from adjusting the thermostat to dimming the lights. However, this vision of a voice-activated, IoT-powered home remains a challenge when applied to low-resource languages and resource constrained edge IoT devices. This project ventures into the intriguing intersection of linguistics, edge computing, and mobile technology to address a unique and often underrepresented linguistic domain: Galician. Galician, a Romance language spoken in the northwest region of Spain, presents a significant challenge due to its limited digital language resources.

In this context, our aim is to create a Voice Recognition Based IoT Home Automation System specifically tailored to Galician, ensuring that individuals using this language can fully benefit from the advantages of IoT technology. Moreover, the landscape of IoT is evolving, pushing the boundaries of where and how these devices can be employed. One of the most promising frontiers is "mobile opportunistic scenarios," which involve leveraging mobile devices as both a hub and a controller for IoT systems. In such scenarios, flexibility, adaptability, and the ability to function in resource-constrained environments become paramount. This project introduces a comprehensive system designed to bridge these two fascinating domains—Galician as a low-resource language and mobile opportunistic scenarios for IoT. We will delve into the technical intricacies of developing an automatic speech recognition (ASR) model tailored for Galician, accommodating the linguistic nuances of the region. Additionally, we will explore how resourceconstrained edge IoT devices can seamlessly interact with this ASR system, resulting in a voice-controlled smart home. First and foremost, this project is driven by the imperative of linguistic inclusivity. It acknowledges the linguistic diversity that exists across the globe, with many languages considered "low-resource" due to their limited digital language resources. By focusing on Galician, we aim to bridge the gap and ensure that individuals speaking such languages are not left behind in the rapidly evolving landscape of smart home technology.

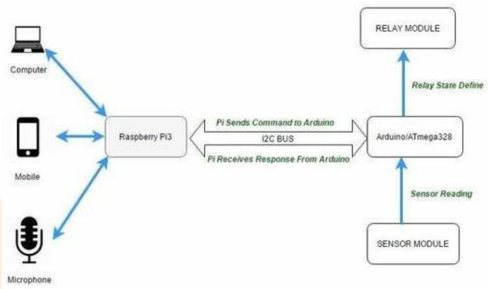

Fig 1: Home automation model

It strives to make technology universally accessible, culturally meaningful, environmentally responsible, and user-centric. In this pursuit, we aspire to unlock the full potential of IoT, breaking free from the constraints of language and resources, and fostering a more inclusive, innovative, and linguistically diverse technological landscape. Furthermore, the motivation extends to the preservation and promotion of these low-resource languages. Languages like Galician, with unique cultural and regional significance, are at risk of waning in the digital age. By creating a technology that integrates Galician into everyday life, we contribute to the preservation of cultural and linguistic heritage, fostering a sense of identity and pride within the Galician-speaking community. Ultimately, this project is motivated by the principles of accessibility, cultural relevance, sustainability, and community empowerment

II. LITERATURE SURVEY

XINQI FAN.et.al.,[1] Proposed a Deep Learning Based Light-Weight Face Mask Detector With Residual Context Attention and Gaussian Heatmap to Fight Against COVID-19. Comparative analysis reveals that this model outperforms other models on two public datasets, AIZOO and Moxa3K, with a 1.7% higher mean average precision on the AIZOO dataset and an impressive 10.47% increase on the Moxa3K dataset. This model holds promise in aiding the general public in the fight against the 2019 coronavirus pandemic, bolstering public health efforts. This studies also offered a valuable intel to all the people using this application with the help of IOT.

JIANG BIAN.et.al.,[2] Designed Machine Learning in Real-Time Internet of Things (IoT) Systems. Algorithms for machine learning (ML) and deep learning (DL) have advanced dramatically over the past ten years and are now used in a wide range of applications, including computer vision, natural language processing, automated speech recognition, etc.Real-time safety-critical embedded and Internet of Things (IoT) systems, like security robots, drones, unmanned aerial vehicles (UAVs)

PATRICIA FRANCO.et.al.,[3] Proposed a Framework for IoT Based Appliance Recognition in Smart Homes. Using sensors, actuators, and metering devices, Internet of Things (IoT) technologies will be crucial in helping the smart grid achieve its objectives of monitoring, protecting, and controlling while facilitating a range of network functions and system automation. In this sense, home energy management systems, or HEMS, help users use energy more wisely by controlling their usage, giving feedback, and enhancing major appliance control.

MARC JAYSON BAUCAS.et.al.,[4] Proposed Improving Remote Patient Monitoring Systems Using a Fog-based IoT Platform With Speech Recognition. Remote patient monitoring (RPM) systems emerged as a practical substitute for getting healthcare services remotely as a result of the recent resource shortage in the healthcare sector. However when more patients and sensing devices are added to the system, data and network management becomes a problem.

ZHUXIAONA WEI.et.al.,[5] Proposed a Evaluation Speech-Based Smart Devices Using New Usability Heuristics. A collection of seventeen usability heuristics for speech-based smart devices was created. Based on an expert evaluation of three widely used devices, these heuristics can be applied to both design new interfaces and identify usability issues that already exist.

VITOR GRAVETO.et.al.,[6] Proposed a Network Intrusion Detection System for Building Automation and Control Systems Conventionally, specialized sensing and actuating devices as well as specialized communications protocols like KNX or BACnet serve as the foundation for building automation and control systems, or BACS. Even though people are more aware of the security risks connected to BACS, there aren't enough security tools available to safeguard this unique type of cyber-physical system. Additionally, we demonstrate a particular proof-of-concept application of this NIDS idea for KNX, one of the more popular BACS protocols. To this end, the suggested methodology was demonstrated and assessed using a real-world KNX deployment.

MURAD KHAN.et.al.,[7] Proposed a Modelling of Intelligent Sensor Duty Cycling for Smart Home Automation. The development of wireless sensor networks (WSNs) raises the standard of living for homeowners and enhances a number of smart home automation services. However, a large- scale sensor deployment is necessary for effective data collection and smart home automation. reducing the energy consumption of the sensors used to monitor and automate different tasks in a smart home is one of the most important and difficult tasks.In this post, we offer a way to manage the excessive energy usage of sensors that identify. different activities of daily living (ADL) for occupants of smart homes. A smart home network's sensors are separated into different groups and use dynamic time warping (DTW) and recurrent neural network (RNN) techniques to predict activities with high accuracy and low energy consumption.

PETROS SPACHOS.et.al.,[8] Proposed Voice Activated IoT Devices for Healthcare: Design Challenges and Emerging Applications. Our lives have undergone significant changes as a result of the recent pandemic, including the way we interact with physical objects. Voice-activated systems, for instance, are increasingly commonplace and allow users to interact with them by speaking commands. Simultaneously, voice functionality was made available to Internet of Things (IoT) devices that used low power audio transducers thanks to recent technological advancements.

SOHAG KABIR.et.al.,[9] Proposed A Security-Enabled Safety Assurance Framework for IoT-Based Smart Homes. The Internet of Things (IoT) rapid expansion has made it possible for safety-critical cyber- physical systems to permeate our daily lives. These systems have altered our way of life, but they have also introduced new difficulties that may have a negative impact on both the environment and our way of life. Two such issues that may prevent the broad adoption of new IoT applications are safety and security. An Internet of Things (IoT)-based system may enter unsafe and dangerous physical states as a result of numerous connected devices, their capacity to control vital physical assets, intentional attacks against them, and/or unintentional failure events like device malfunctions, communication problems, and unanticipated negative interactions between connected devices.

ZHIBO WANG.et.al.,[10] Proposed A Survey on IoT-Enabled Home Automation Systems: Attacks and Defences. Recent developments in Internet of Things (IoT) infrastructures and communication technologies have given rise to home automation (HA) systems, a new and promising paradigm that offers consumers convenient smart-home services. However, there are a number of security risks that can arise during the implementation and deployment of HA systems, posing a serious risk to user security. On the one hand, HA systems are naturally vulnerable to common IoT security threats, such as device intrusion and protocol vulnerabilities. However, the Trigger- Action Programming (TAP) model, which forms the basis of HA systems, arranges cloud platforms, local hubs, and smart devices according to user-customized rules.

TINGHUI WANG.et.al.,[11] Proposed Multi-Resident Tracking in Smart Homes With Sensor Vectorization. A low-cost, inconspicuous solution that powers activity-aware applications like building automation, health monitoring, behavioural intervention, and home security is provided by anonymous binary sensors installed in smart homes. Nonetheless, connecting sensor events to the appropriate residents in a multi-resident smart home can be very difficult. Prior approaches to multi-resident tracking in smart homes rely on additional data that may not be available or may be difficult to obtain in practice, such as sensor layouts, floor plans, and annotated data.

MUHAMMAD JAVED IQBAL.et.al.,[12] Proposed Smart Home Automation Using Intelligent Electricity Dispatch. Technology advancements have raised both local and global electric power consumption, which has sharply raised the demand for electric power. The rate at which electricity is consumed at home and in commercial settings varies. Sometimes, load shedding, power outages, and emergencies result in increased demand, which has an impact on home appliances. It includes an unexpected power outage brought on by a storm or a lot of rain. This study looks into how to adjust an ideal energy usage solution to accommodate a radical shift. A method is put forth to deal with the problems of low electric power and emergencies brought on by the unexpected discovery of electricity.

DAWEI WEI.et.al.,[13] Proposed Dataflow Management in the Internet of Things: Sensing, Control, and Security. Because of how commonplace the smart Internet of Things (IoTs) are, a lot of electric sensors and devices can be connected, which creates a lot of data. When compared to traditional big data, streaming dataflow faces notable difficulties like rapid speed, high variability, erratic continuity, and strict timeliness, all of which put its effective management to the test. We present an overview of IoT dataflow management in this paper. RONG-GUEI TSAI.et.al.,

[14] Proposed a Automation Tool for Home Fire Safety Check. Tools for simulating fires have been created in order to inspect environmental safety. They haven't, however, been heavily utilized for domestic purposes. The environmental model's heavy reliance on manual labour is one important factor in this. This letter discusses the use of image sensors to create an environmental model automatically and lessen the labour-intensive process of using fire simulation tools for a fire safety check. Our automation uses recognition models and suggested approaches to extract fire-related features from images and increase the accuracy of an environmental model. KE WANG.et.al.,

[15] Proposed Voice-Transfer Attacking on Industrial Voice Control Systems in 5G-Aided IoT Domain. Currently, certain voice control has progressively grown in importance for 5G-Internet-of- Things assisted industrial control systems. For example, the controller can use their telephone voice to control and adjust industrial Internet of Things equipment. But the security of a particular voice control system needs to be strengthened because voice cloning technology that relies on transfer learning can mimic the controller's voice with ease, which could result in industrial mishaps and other security risks. In order to get ready for the future development of a particular voice recognition system, the primary goals of this article are to examine and comprehend the fundamentals of voice cloning attack technology and to present a voice clone attack method.

III. NOVELITY

3.1 System Architecture

When it comes to designing a voice-based HA system, it is important to distinguish two parts: • Voice-processing. It involves the initial preprocessing of the audio, thus generating the inference related to the ML model and detecting the specific commands from the speech. In the system described in this article, all voice processing will be performed exclusively by the Voice Assistant Device (VAD). Such a device has the following characteristics:– It operates on the edge without needing to connect to a server. – It is portable, since it is carried continuously by every user. – It is able to interact with the different deployed IoT devices by using voice commands. – It can also perform other types of general tasks that require connectivity (i.e., to search for specific information on the Internet, to retrieve news or the weather forecast, or to make phone calls). • System communications. This part is in charge of managing the information exchanged between the deployed IoT sensors and the VAD. • The IoT device layer includes the different sensors actuators nodes of the system. It is worth noting that the layer includes nodes with constant energy supply that need fast response times while others do not have critical time-response requirements or have power supply restrictions (thus prioritizing energy saving over response time, becoming Low Power-consumption Nodes (LPN)).

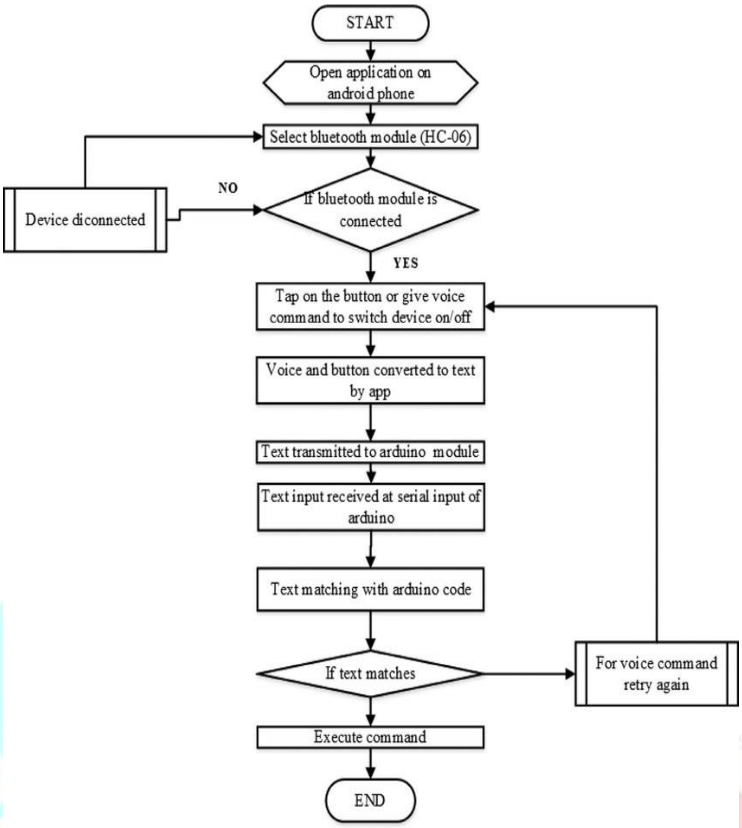

Fig. System Architecture

3.2 WER and Success Rate

The Word Error Rate (WER) is a standard metric for ASR systems . Although the WER is closely related to the performance of an IoT voice assistant, an exact transcription is not the expected goal (i.e., the objective is to execute an IoT command). This fact allows in part for overcoming the loss of accuracy that results from reducing the size of the model, since, regardless of the WER obtained by the model, the reduction and quantification processes will always worsen the accuracy of the model output slightly. The main problem that the use of architectures like wav2vec2 and Whisper solves is the difficulty of performing speech recognition in different languages. This is a common problem in NLP: most corpus for specific tasks only support English. However, with such architectures it is much easier to obtain a transcription model in different languages. For example, the fluent speech corpus allows for building a specific grammar for HAs, but it needs to map the audio speech to a certain grammar, which is highly complex when performed for every available language.So, instead of generating a model that associates language-specific audios with specific intents related to HA (as it is carried out in Fluent Speech Commands), it is possible to use a model that associates speech recognition patterns with specific intents, which is much more straightforward, as it only involves using grammar, as many DistilBert models

IV METHODOLOGY

The phases were data collection, preprocessing, feature extraction, training/testing and gesture classification.

A. Dataset Creation The scope of this project involves the development of a voice-based IoT system for home automation, aiming to provide users with a seamless and intuitive control interface for various smart devices. The system will encompass features such as voice-controlled lighting, thermostat adjustments, security system integration, appliance control, and entertainment system management. The project's architecture will incorporate both hardware and software components, specifying communication protocols for IoT devices and implementing a reliable voice recognition system.

B. Data pre-processing and Feature extraction Certainly! Data preprocessing is a critical step in developing an efficient voice recognition system for IoT-based home automation. To begin, collect a diverse set of audio samples that mirror the real-world conditions in which the system will operate, ensuring variability in speakers, accents, and background noise. Standardize the sampling rate and bit depth across all audio samples, typically opting for rates like 16 kHz or 44.1 kHz with 16 bits per sample. Normalize the audio samples to maintain consistent volume levels, facilitating the model's focus on speech content rather than volume fluctuations. Apply noise reduction techniques to mitigate background noise, considering filters or algorithms that differentiate between speech and non-speech sounds. Trim or pad audio samples to a uniform length, removing silences at the beginning or end. Extract relevant features such as Mel-Frequency Cepstral Coefficients (MFCCs) or spectrograms from the audio data. Augment the dataset by introducing transformations like pitch shifting, time stretching, or synthetic noise to enhance model generalization. Accurately label each audio sample with corresponding voice commands, ensuring a balanced class distribution. Divide the dataset into training, validation, and testing sets for model development and evaluation.

C. Training and testing The dataset should encompass a wide range of voice commands that users might employ to control smart devices in a home environment. It's essential to record various speakers, accounting for different accents, tones, and speech patterns to ensure the model's generalizability. Additionally, the dataset should cover potential environmental factors such as background noise, as users may interact with the system in varied acoustical conditions. A comprehensive set of voice commands, including variations in phrasing and pronunciation, helps the model accurately recognize and respond to user inputs. Moreover, the dataset should reflect the intended user demographic to enhance the system's adaptability. Once collected, these audio samples can be preprocessed and used to train the voice recognition model, enabling it to effectively understand and act upon user commands in a real-world home automation setting. Regularly updating and expanding the dataset ensures ongoing improvement and adaptation to users' evolving speech patterns and preferences.

D. Apply Machine Learning Algorithms Implementing an IoT-based home automation system with voice recognition involves leveraging machine learning algorithms to process and interpret spoken commands. One commonly used algorithm for this task is the Convolutional Neural Network (CNN) combined with recurrent layers. CNNs are adept at extracting hierarchical features from spectrograms or Mel-Frequency Cepstral Coefficients (MFCCs), which represent the frequency content of audio signals. Recurrent layers, such as Long Short-Term Memory (LSTM) or Gated Recurrent Unit(GRU), capture temporal dependencies in speech, enabling the model to understand the sequential nature of spoken language.

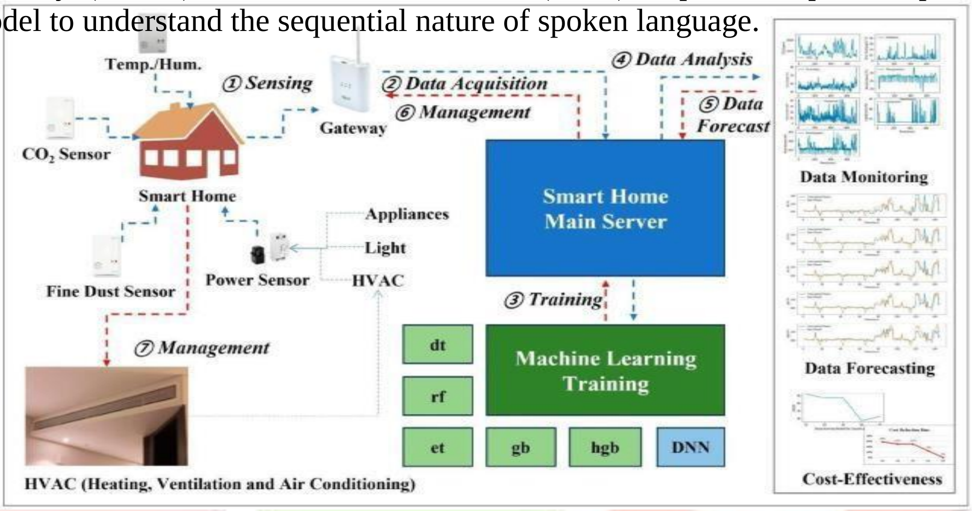

Fig : Smart Home Data Analysis

E. Navie-Bayes the realm of IoT-based home automation with voice recognition, Naive Bayes algorithms can offer a straightforward and computationally efficient approach to processing spoken commands. Naive Bayes is particularly well-suited for text classification tasks, and in the context of voice recognition, it can be applied by converting speech to text. The algorithm assumes that the features (words or tokens) are conditionally independent, given the class label (voice command category), which simplifies the modelling process. For voice recognition, the algorithm can be trained on a dataset of labelled voice commands, where the features are derived from the text transcriptions. The probability of a particular voice command given the observed features is computed using Bayes' theorem. Despite its simplicity and the "naive" assumption of feature independence, Naive Bayes models can perform surprisingly well, especially in scenarios with limited training data or when real- time processing is crucial. However, it may not capture complex relationships in speech as effectively as more sophisticated algorithms like neural networks.

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

V RESULTS AND DISCUSSION

The project's potential extends beyond home automation, potentially impacting areas like education, healthcare, and information access in low-resource language settings. However, responsible development is crucial, ensuring fairness and inclusivity while addressing potential biases in language models. By overcoming these challenges and prioritizing ethical considerations, this project can contribute significantly to a more accessible and inclusive technological future. Existing open-source tools and libraries can accelerate development by offering pre-trained models, training data, and development tools specific to low-resource languages. While voice commands offer hands-free control, incorporating visual or auditory feedback can improve user experience, especially with potential accuracy limitations.

Despite its potential for accessibility and affordability, an IoT-based home automation system using voice recognition for lowresource languages faces several hurdles. Lower accuracy and limited vocabulary in these language models can lead to misinterpreted commands and restrict the range of controllable functions. However, careful selection of commands and model optimization techniques, such as keyword spotting and vocabulary expansion, can mitigate these issues. Furthermore, the project must prioritize user privacy by implementing secure data storage and acquiring clear user consent for voice data capture and processing.

VI. CONCLUSION

In conclusion, while IoT-based home automation using voice recognition for low-resource languages presents exciting possibilities for accessibility and affordability, it faces challenges like lower model accuracy and limited vocabulary. However, careful design choices, leveraging existing open-source tools, and optimizing models can address these issues. Furthermore, prioritizing user privacy and fostering collaboration with local communities are crucial for ethical and culturally-sensitive development. If these hurdles are overcome, this technology holds immense potential to create an inclusive and accessible future, not just in home automation, but also in education, healthcare, and information access for diverse communities using low-resource languages. This project has the potential to empower individuals with disabilities, bridge the digital divide, and foster greater technological inclusion. Further research in noise cancellation, user-specific vocabulary adaptation, and expanding language model support can further refine and solidify this technology's impact. Therefore, continued collaboration and dedicated efforts are crucial to unlock the full potential.

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