AN INNOVATIVE APPROACH FOR MONITORING BRIDGE SAFETY SYSTEM USING IOT

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Abstract.

An IOT based device is being developed using WSN technology. We have become smarter and more effective in our daily lives as a result of the arrival of ultra-technological devices. Sensor technologies have advanced as a result of the integrated problem-solving bridge tracking system, which assist with emergency case. An Internet of Things-based bridge protection control device is being developed. Wireless sensor nodes can collect a variety of data, including environmental patterns, vibration, and air quality, as well as high-priority structure data, such as accident data. It will also be beneficial to monitor and monitor such data. This paper, main purpose is to create a gadget that can protect flyovers and bridges from collisions and structural disasters. This proposal analyses the various techniques for tracking bridge conditions and offers a system for tracking continuous infrastructure as well as a water sensor to track the river's water level in order to stop traffic from the bridge under flood conditions. Users can track bridge conditions in real time using mobile telecommunications devices since the identified data is sent to the server and database.

Keywords.

1. AIM

Our project's goal is to create an internet of things-based bridge well-being surveillance entity that includes monitoring systems established in the overpass ambient, communication appliance that connect the bridge estimation mechanisms to the cloud computing service, a vital databank that forages bridge quality record, and a cloud computing environment that measures and examinates data emitted from the surveillance system. The state of a bridging and its surroundings, along with water points and additional security concerns, will be monitored, and analyzed in real time by this technology.

2. INTRODUCTION

One of the most widely used systems for monitoring and detecting environmental conditions is the structural health monitoring system. Under the influence of dynamic loads such as moving cars, crowds, wind, and earthquakes, the bridge structure may shake. The analysis is a crucial part of the overpass construction examination. This information could be utilized in favor of bridge security administration also disaster rescue within the failure case. WSN technology is used by the system for monitoring and information communication. As a cordless smart sensing element system, it acts a vital function in distant controlling in a wide range of geographical locations. When a bridge collapses, it puts human life and property in jeopardy. Many of these bridges are deteriorating because of both external and internal issues. It causes a tremendous vibration in the bridges due to dynamic loads, earthquakes, and ground motion. As a result, the acceleration increases, affecting the ease and surety of the overpass framework. We present an IoT-based comprehensive bridge surveillance scheme for preventing flyover accidents and structural calamities. The server receives the problem-solving time worth from all sensors also sends over the server. In case sensing element rate exceeds a set boundary, the method gives persistent sound also a buzzer which alerts operators/users. There are numerous bridges in Korea that have real-time monitoring systems, such as the Akashi Kaikyo Bridge. Sensor technologies have improved the accuracy and speed of the monitoring process. The method created in this study has the potential to prevent accidents and increase bridge safety monitoring in the face of various disasters such as flooding, wind, earthquakes, large loads, and vibration.

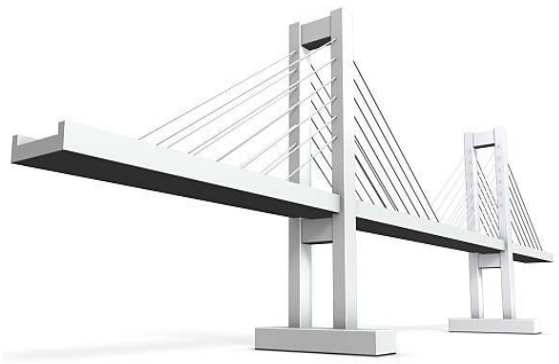


Fig 1: Bridge

3. LITERATURE SURVEY

R. Pawar [1] described the constructional Structural health controlling device is utilized to estimating the fundamental framework of the structural and surroundings terms on a constant basis at actual-time. Aims of structural health monitoring is to find construction harm, security, accident etc. In late period the overpass examination is a critical point because of vast count of bridges crumbling accidents. Therefore, it is required to take concern of bridges by utilizing various enhanced as well as smart technological views.

Ren-Guey Lee et al. [2] grants an effective and reliable substitute design for overpass controlling device by utilizing the wireless sensor network. By gathering the surroundings limits sending the numeral record to entry over the numerous hop transfer, and then it advance stores info in the back-end server for the particularized controlling staffs to examine and report. This device will be capable to enhance the nuisance to include or eliminate sensing elements in an existent wired overpass controlling system. It is primarily utilizing wireless detector network in order to assemble relevant atmosphere framework also to send the numeric record to portal over multiple-hopping relay.

Jin-Linn Lee [3] elucidated Internet based overpass security device is designed by ZigBee technique. The device is composed of tracking devices established in the overpass habitat; communication systems linking the bridge surveillance systems as well as cloud database; a vital record that stores overpass status info; and a cloud database that computes also examines record sent from surveillance devices. In this work, an internet-based overpass security system is established by utilizing ZigBee methodology.

Ms.Shital Nandkishor Vitekar , Ms.Viddulata A. Patil [4] proposes a wirelessly smart detector system are carrying out necessity function in the utilization of distant controlling in extensive circulate geographical locations. Similar wireless network turns charge effectual and feasible method to control basic wellness condition of bridges which link road in equally rural and urban regions. Several of these overpasses are matter to degradation due to exterior and interior parameters. Web-based, effective time structural wellness controlling is an inventive device to assist quick area survey.

Shivan Haran, et al. [5] examines the observation of bridges exploitation by wireless sensing network. As a testbed, a diverse system of wireless sensor network also convectional P2P alongside a collection of detection system is utilized on overpass prototype. Problems associated with status evaluation of the bridge for things as well as faults, overloads, etc., also as examination of network and device execution is mentioned. Wireless sensing networks are demonstrating to be a better suit where actual time controlling of vigorous physical frameworks are essential.

Tyler Harms, etal., [6] proposed an older and deterioration of conveyance infrastructure posture substantial protection problems, specifically in light of higher utilize of this framework. The cost-effective decrease additional exacerbates such issues, mainly for crucial frameworks such as bridges, where substitutes is unfeasible, also support and renovate are high priced.

4. EXISTING SYSTEM

For a long time, bridge structural health monitoring (SHM) has been a hot topic of research. Installing sensors on a bridge is a traditional, straightforward method of collecting acceleration readings. The disadvantage about straight forward method is they necessitate a tangled as well as expensive digital framework that includes installation, sustainment, also capacity supply. Furthermore, while it is simple to obtain many data samples, labelling them is costly, as it includes physically inspecting the bridge and evaluating its condition; as a result, only a small number of data samples are obtained. This oblique overpass SHM becomes a semi-directed categorization issue because of this real-world limitation.

5. PROBLEM STATEMENT

- To help in the continuing bridge management activities of local bridge authorities, the research group has developed Structural Health Monitoring (SHM) techniques.
- The current standard procedure of bridge inspection is focused on biannual visual inspections that, by default, are arbitrary.
- The transition from the scientific community to realistic field application of conventional SHM techniques still needs to address challenging challenges, primarily due to technological and economic considerations

6. PROPOSED SYSTEM

The system sends actual-time monitored record to cloud computing database also to device database for substitute objective. The detectors established upon diverse sections other overpass controls their respective parameters. Crossing the threshold rate, the transmission device notifies the administration core granting alert. This entire framework of overpass are captured through microcontroller which sends to operator managing room. Wi-Fi is used for communication. Bridge overflow is detected using Water Level Sensors, Fire is detected using fire sensor, unstableness of the bridge is identified using vibration sensor, dense smoke is indicated by smoke sensor along with temperature and humidity value using DHT11. Also, whenever any accident is detected, a notification is sent to authorized person.

7. OBJECTIVE

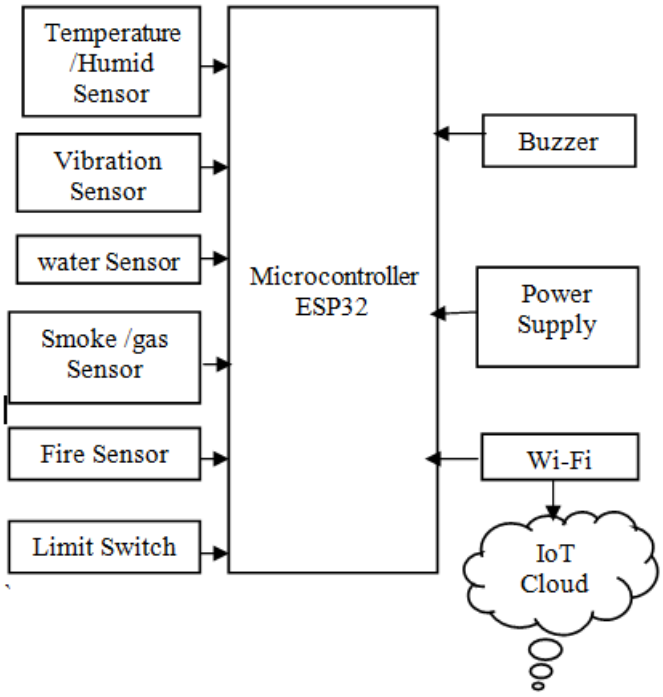
Our project aims to build an IoT-based bridge safety monitoring system consisting of monitoring devices mounted within overpass surroundings, message system linking overpass surveillance systems also a complex database that stores overpass controlling entities as well as cloud databases. This technology tracks and analyses the state of the bridge and its surroundings in real time, including the level of water and other safety conditions.

One of the key objectives of Bridge Safety Monitoring device is utilizing internet of things to rescue the existence of the citizens, in order to safeguard from misadventure.

Some aims of the overpass safety surveillance device are:

- To deliver security for overpasses.
- To prevent misadventures against bad weather conditions.
- To enhance the overpass effectiveness.
- To overwhelm the technological as well as expenditure barriers.
- To avoid unnecessary traffic
- To make it free of pollution

8. METHODOLOGY



The current device is the progress of overpass surveillance device using internet of things. This device constantly tracks the overpass status. They utilize a distinct detector in order to access the overpass data like water detector, load cell detector, vibration detector, temperature detector and smoke sensor. The load of the vehicle is acquiring over the bridge is sensed by the trembling utilizing a vibration detector. Through utilizing the water detector device for acquiring the aqua rate beneath the bridge. Smoke or polluted air is monitored by smoke or gas sensor. All detectors obtain the actual-time rate which transmits to the database as well as to android. The examiner signs in to android system

where the record is examined which is later transmitted by the device. It transmits the info to the operators. Operator will be able to view the info which are previously recorded in the server this record would assist the operator to perceive the information of the overpass. This info will be useful to prevent misadventure also all particular record would be transmitted on mobile application. In case of detector value is beyond then the limit, the device will alert operators by an alarm by notifying them.

9. SOFTWARE AND HARDWARE REQUIREMENTS

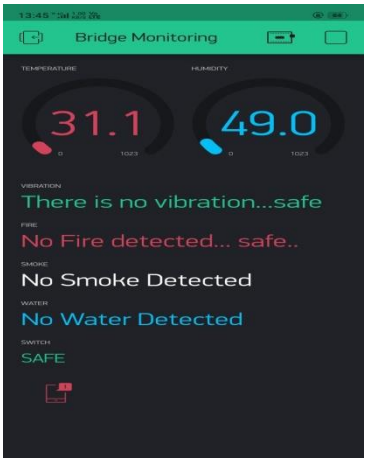
- **Software Requirement**

  - Arduino IDE
  - C++
  - IoT platform (BLYNK)

- **Hardware Requirement**

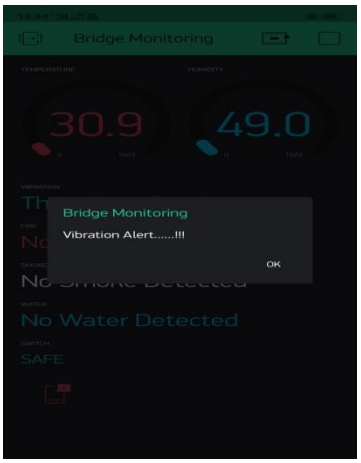
  - Water sensor
  - Vibration sensor
  - Temperature sensor
  - Smoke/gas Sensor
  - Buzzer
  - Limit switch
  - Fire sensor
  - Microcontroller (ESP32)

10. RESULTS



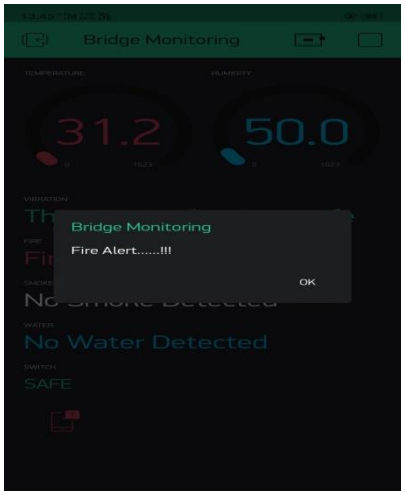
Result 1: Blynk App

The above Figure represents the Blynk Application.



Result 2: Vibration Sensor

Any unstableness in the Bridge the through the Vibration Sensor notification will be send to the Mobile.



Result 3: Fire Sensor

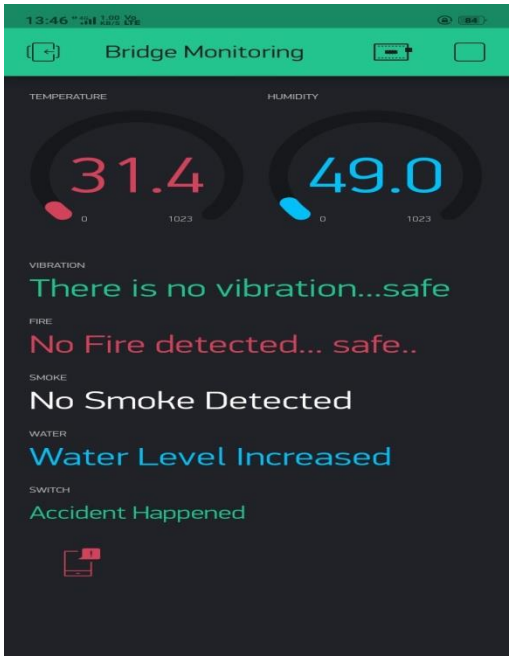
If any fire Hazards happens on the bridge the fire Sensor sends the signal to the ESP32 from ESP32 to Mobile (Blynk Application).

Result 4: Smoke Sensor

If any Smoke is detected the Sensor sends the data to the ESP32 then ESP32 to Blynk Application.

Result 5: Water Rate Level Sensor

If the Water Rate level Rises to the Bridge Level or to Some Pre-set Valve the Sensor senses the Water and sends the data to the Blynk Application.



Result 6: Switch

The push button switch is used when an Accident occurs the switch will be pressed so that the Accident Indication will be Displayed in the Blynk Application.

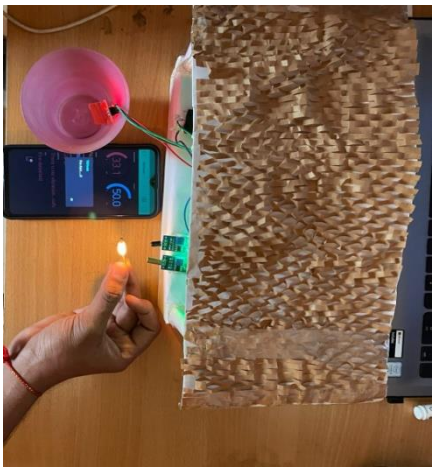


Fig 2: Complete Setup

The above Figure is the representation of the complete model Setup with ESP32, Vibration Sensor, Water Level Sensor, Fire Sensor, Smoke Sensor, Switch and Blynk Application.

11. CONCLUSION

The proposed concept is the creation about Internet of Things-based overpass security surveillance technique. The system uses water, fire, and smoke sensors to continuously check the bridge's condition. All sensors collect effective time record which transfers to the server, which is then presented on the Blynk Android app. The information can be useful in preventing accidents, and it will all be shown on a digital display. If the sensor value exceeds the threshold, this device urges a sound with alarm and alert users.

12. FUTURE SCOPE

The prototype of the system can be deployed as numerous structures in the future, such as enormous walls, in addition to buildings and bridges, making it more robust, portable, and user pleasant than present technology.

The system proposed is based on Artificial Intelligence, the Voice Bot utilizes the python programming language to provide an interface for the user to interact with as the GUI (Graphical user interface). The bot uses multiple API's (Application Programming Interface) for the speech recognition and text to voice conversion like the Speech Recognition and REST (Representational State Transfer), Django etc. For getting responses from the back end it utilizes SQL (Structured Query Language).

3.1 SYSTEM MODEL

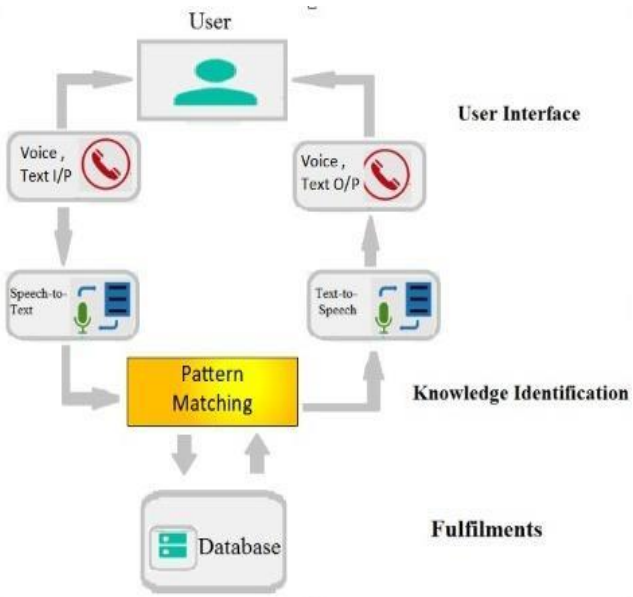


Fig 2. System Architecture of Voice bot

The Fig. 2 explains how the voice chatbot handles the queries from the user to give responses through speech and text with the help of text-to-speech and speech-to-text conversion and fetching responses from the database after pattern matching.

3.2. MODULES

3.2.1 VOICE TO TEXT DIAGRAM

The text to speech conversion system utilizes the speech recognition package where feature extraction takes place and the acoustic and language modules are applied to give out the textual output in the notepad. The user's input in the speech or voice format is converted to text and printed in the notepad as shown in Fig. 3.

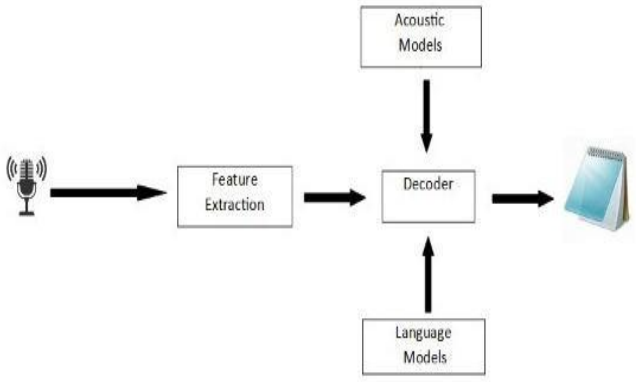


Fig. 3: Speech to text converter process in notepad

3.2.2. VOICE CHATBOT

The Voice chatbot makes use of the speech to text converter and also implements text to speech to provide the response. It uses Natural language processing with speech recognition and pyttsx3 (python text to speech).The Fig. 4 displays the working of the Voice chatbot.

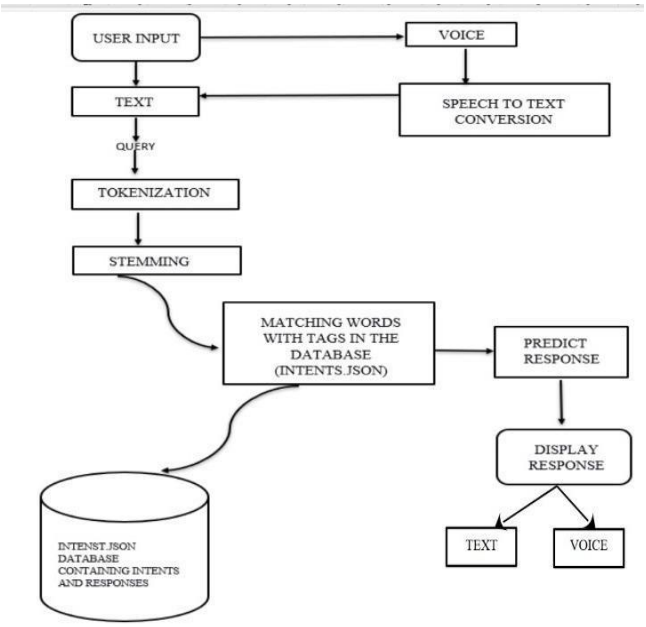


Fig. 4: The Working model of completed Voice bot

13. IMPLEMENTATION

4.1 ALGORITHMS

Lemmatization and POS (Part of Speech) tagging, using WordNet: Deleting of the data in the input text is done by removing keywords. The appropriate Lemmas keywords were obtained using the Lemmatization and POS tags, combined with a different type of translated word. WordNet from the Python package "NLTK (Natural Language Processing)" was used for this purpose.

4.2 NATURAL LANGUAGE PROCESSING

NLP (Natural Language Processing) is used as one of the most important concepts in bot design. Machines use sophisticated algorithms to separate any text content in order to extract meaningful information from it. The data collected is then used to further teach the machines the natural language skills.

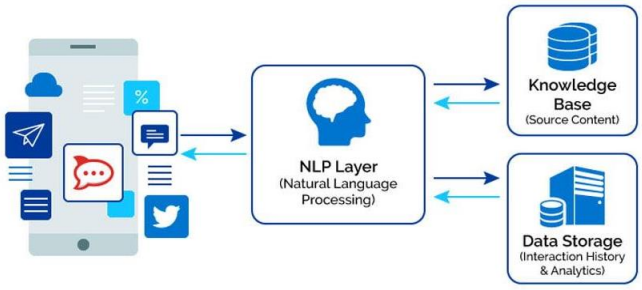


Fig5: NLP Working from KollaBhanu Prakash, "Chatterbot implementation using Transfer Learning and LSTM Encoder-Decoder Architecture", Volume 8.No. 5, IJETER, May 2020.

The Natural Language Processing layer utilizes both the data storage and the knowledge base in order to retrieve appropriate and accurate responses to the given query submitted by the user as shown in [7, Fig.5].

Incorporating NLP into chat bots gives the meaning of having higher human presence. When a chat bot is developed and used, this is a common use, hence there are questions asked regarding it. It seems so intertwined with human behavior that customers can try to trick and discard the chat bot. It can be solved by adding automatic answers, but that is often a failure as it is almost impossible to wait for what queries to be answered and how they will be solved. The goal of Natural Language Processing is to build a type of system that can understand and give meaning to a text and also perform tasks automatically like classification, translation, etc.

4.2.1 STEPS OF NLP ALGORITHM

1. Lexical Analysis – It is the first step in the Natural Language Processing responsible for the source code scanning in order to convert a string of characters into meaningful expressions, this phase divides the input text into sections, words and sentences. Tokenization, Lemmatization and Stemming techniques come under the Lexical Analysis.
2. Syntactic Analysis – This phase of NLP is mainly used for parsing and providing relationships between the different words and also to check their arrangement and grammar.
3. Semantic Analysis- This analysis is based on the meaningful representation of the words and it focusses on the literal meaning present behind them.
4. Discourse Integration – Integration of speech depends and is implemented based on the meaning of the sentences that come before it.
5. Pragmatic Analysis – This final phase focusses on information extraction from the provided text, it plays by a set of cooperative dialogue rules.

4.3 LSTM (Long Short Term Memory) ALGORITHM

Long Short Term Memory (LSTM) networks are a type of recurrent neural network required in complex problem domains like machine translation, speech recognition, and more .LSTMs are a complex area of deep learning.

The LSTM model network is called as the model that has influenced the past and is known to display the capability to learn from sequential data. LSTM consists of three gates-input, forget, output gates [7].

$f_{m+1} = (^{(h\to f)}h_m + \theta^{(x\to f)}x_{m+1} + b_f)$ forget gate (1)

$i_{m+1} = (^{(h\to i)}h_m + \theta^{(x\to i)}x_{m+1} + b_i)$ Input gate (2)

$c_{\tilde{m}+1} = \tanh(\theta^{(h\to c)}h_m + \theta^{(w\to c)}x_{m+1})$ update candidate (3)

$c_{m+1} = f_{m+1}\Theta c_m + i_{m+1}\Theta c_{m+1}$memory cell update (4)

$o_{m+1} = (^{(h\to o)}h_m + \theta^{(x\to o)}x_{m+1} + b_o$Output gate (5)

$h_{m+1} = o_{m+1}\Theta\tanh(c_{m+1})$ Output (6)

The above equations represent the LSTM model [8]. The input gate checks if there is a need to allow the fresh data or not, forget gate deals with the unnecessary details. The proposed framework approach consists of various steps, such as raw data selection, pre-data processing, feature extraction and NN preparation.

14. RESULTS AND DISCUSSION

Speech recognition systems are tested using two factors: Accuracy and speed. Platforms used for voice chatbot functionality Windows 10, Python 3.8 IDLE, and PyCharm 2021.3. The test requires the following specification: 64-bit operating system with Intel core Processor 5.1.60GHz, OS version - Windows 10 One Home Language, Ram - 8.00 GB.

The simulation of a voice robot is performed in two parts with respect to the accuracy of word recognition by pronunciation in English. Voice recognition module is said to boast about 75% - 85% accuracy under noise and greater than 85% in good conditions. The Table. 1 and Fig. 6 pie chart show test results of the conducted simulations.

Simulation (Eng.-in)	Total words	Detected Words	Undetected Words	Accuracy
1	80	75	5	93.75 %
	90	84	6	93.33 %
	100	92	8	92.00 %
	110	97	13	88.18 %
	120	105	15	87.50 %
Total	500	453	47	90.6%

Table. 1: Manual Analysis Simulation 1

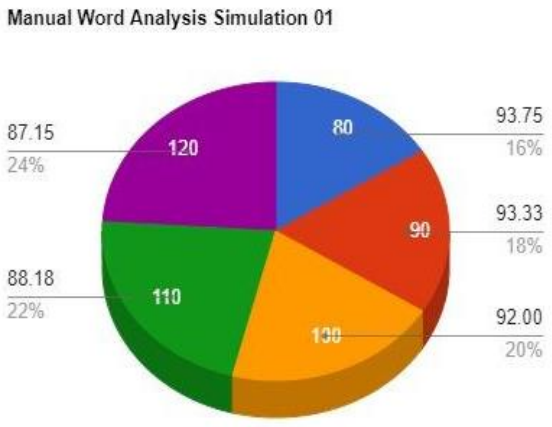


Fig. 6: Pie Char 1 for manual analysis 1

Second simulation was performed with a bit lower net speed and some introduction of background noise. The Table. 2 and the Fig. 7 pie chart below show the results.

The percentage is a bit less compared to previous simulation due to the presence of noise affecting the accuracy.

Simulation (Eng.-in)	Total words	Detected Words	Undetected Words	Accuracy
2	80	72	8	90.00%
	90	82	8	91.11%
	100	93	7	93.00%
	110	95	15	86.36%
	120	101	19	84.36%
Total	500	443	57	88.6%

Table. 2: Manual Analysis Simulation 2

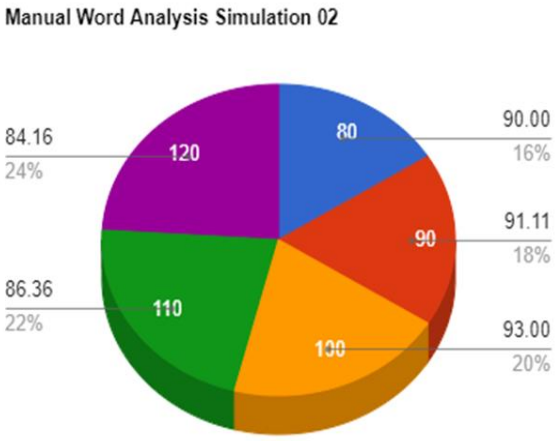


Fig. 7: Pie Chart 2 for manual analysis 2

15. OUTPUT RESULT

The outputs considering three scenarios are listed below:

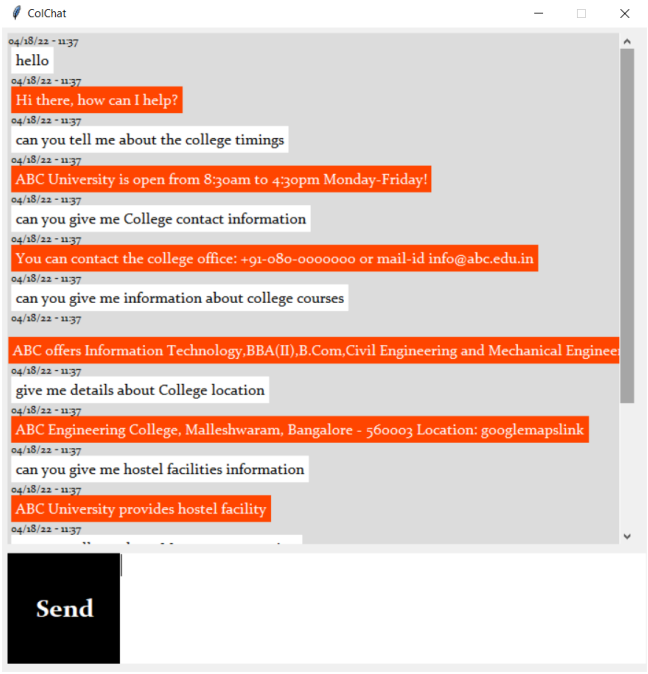


Fig. 8: Accurate Responses of the Voice bot

In Fig. 8 for any given input by the user or the customer as a query, the bot processes it and searches in the database, accurate responses are obtained in both textual and voice format to the user in the GUI (Graphical User Interface) and the speakers.

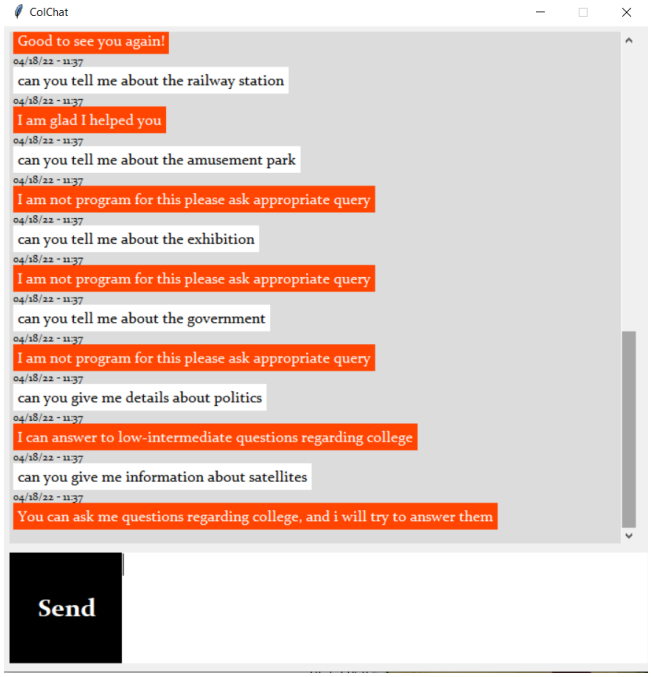


Fig. 9: Incorrect Response of the Voice bot

In Fig. 9 when the user asks queries not related to the domain the bot's response is as shown in the figure. Since the keyword is not found in the database the bot responds saying 'I am not programmed for this please ask appropriate query".

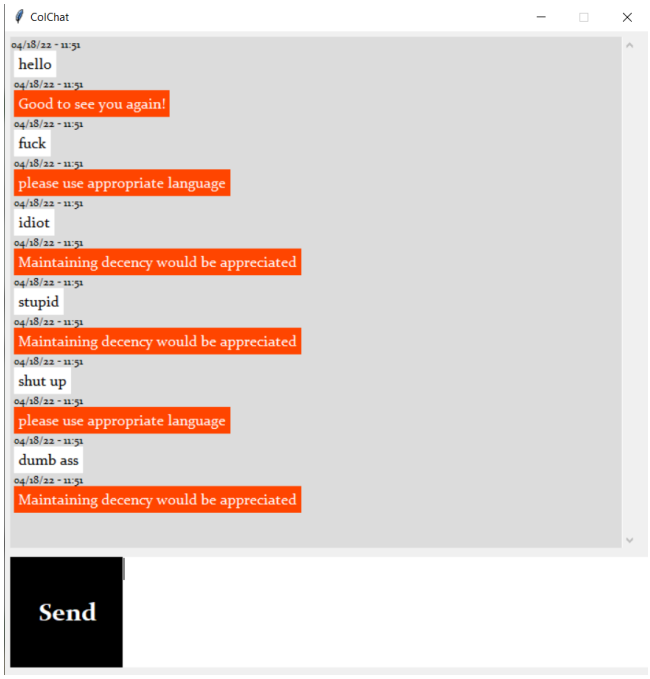


Fig. 10: Indecent Queries of the Voice bot

In Fig. 10 when the bot is misused by the user by cursing, it responds with either “Please use appropriate language or “maintaining decency would be appreciated”, which re the input given in the database for the usage of inappropriate queries. The bot can handle unethical behavior of users while taking the input from them. The database is equipped to handle such situations and if required can be improved with more content.

16. CONCLUSION

In today's world of automation the voice bot is well suited to its voice and text resources. The paper uses Voice Chatbots and Machine learning concepts, as well as NLP for input and feedback. The main goal is to reduce human interaction, increase automation, provide audio filters and provide in-depth information to disabled users and photographers by input and output in two ways. Objectives were introduced and applied to the bot.The bot can be made accessible to users on many web platforms on institutional websites, the accuracy of the bot can be increased through audio filtering functions. By combining a lot of pronunciation it can be used by different people. It can be upgraded to an app for frequent and easy access. It will be useful in all areas as without wasting much time, it gets to the right information and that too without filtering. It can be developed to receive queries in two languages and provide respond in the same input language as the user asks. It can be improved in the future by solving obstacles and taking it to the top in a web-based environment.

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