

Online Meeting Summary Generator

Yashodara P.H.E.

Faculty of Computing Department of
Software Engineering
Sri Lanka Institute of Information
Technology
Malabe, Sri Lanka

Ranepura R.S.

Faculty of Computing Department of
Software Engineering
Sri Lanka Institute of Information
Technology
Malabe, Sri Lanka

Bhashitha W.P.K.K.

Faculty of Computing Department of
Software Engineering
Sri Lanka Institute of Information
Technology
Malabe, Sri Lanka

Thilakarathne M.H.K.T.S.

Faculty of Computing Department of
Software Engineering
Sri Lanka Institute of Information
Technology
Malabe, Sri Lanka

Anuradha Karunasena, PhD

Faculty of Computing
Sri Lanka Institute of Information
Technology
Malabe, Sri Lanka

Pradeepa Bandara

Faculty of Computing
Sri Lanka Institute of Information
Technology Malabe, Sri Lanka

ABSTRACT

Automated meeting minutes are a technological solution that can revolutionize the way organizations conduct meetings. Traditional meetings can be time-consuming, and inefficient, and often result in incomplete or inaccurate meeting minutes. Automated meeting minutes can address these issues by providing several advantages over traditional methods. The purpose of this research paper is to explore the development of an automated system for generating meeting minutes in the IT industry. The current manual process of creating meeting minutes can be time-consuming and prone to errors. The proposed system will use Speech Emotion Recognition (SER) technology to identify the emotional levels of meeting attendees, such as anger, joy, or neutral emotion, and analyze meeting progress using those emotional levels. The system will generate a meeting summary report that includes meeting objectives, attendance, decisions, issues, information on the next meeting, action items, and progress reports. It also aims to address the challenges faced by organizations when manually creating meeting minutes by automating the process. The proposed system will include important components such as meeting objectives, attendance, decisions, and issues, information on the next meeting, action items, progress reports, and emotional sensitivity analysis. The purpose of this research is to provide users in the IT industry with an interactive analysis of the meeting summary from various standpoints, including generating a meeting minute according to the agenda, identifying the action items of each attendee, tracking the progress of previous actions, and analyzing emotional sensitivity. The proposed system will utilize Speech Emotion Recognition (SER) technology to identify the emotional levels of meeting attendees, such as anger, joy, or neutral emotion, and analyze meeting progress using those emotional levels. The research aims to improve the efficiency and accuracy of meeting minutes in the IT industry and provide a more effective way of conducting meetings.

General Terms

NLP, Text Summarization, Emotional Sensitivity

Keywords

NLP, generate, meeting, speech, reports, action items, deadlines, emotional.

1. INTRODUCTION

Modern company operations are not complete without meetings, which provide a forum for deliberation, collaboration, and decision-making. They act as a platform for communication, information exchange, and group decision-making. Without adequate recording, many crucial facts can be overlooked, which might result in misunderstandings or divergent interpretations of the meeting's outcomes. Meeting minutes serve as a record of the topics addressed, decisions made, and any assigned action items. Despite the advantages, writing accurate and thorough meeting minutes can be a difficult task. Lack of clarity on action items or decisions taken during the meeting, missing crucial information, unclear or incomplete notes, and trouble keeping up with the meeting's speed are just a few potential issues. It's also crucial to decide who will record the meeting's minutes and what will be included in them. The contents of a meeting minute might differ, but they often include the meeting's name, date, time, participants, agenda items discussed, decisions made, assigned action items, and any other pertinent information. Physical meetings can also be challenging due to issues including travel time and costs, scheduling conflicts, low participation, and interruptions or distractions, which have been increasingly noticeable since the COVID-19 epidemic. Organizations may therefore need to investigate alternate meeting techniques, such as online meetings.

Meetings are an essential part of organizational communication in today's fast-paced business environment. However, traditional meetings can be time-consuming, and inefficient, and often result in incomplete or inaccurate meeting minutes. To address these issues, automated meeting minutes have emerged as a technological solution that can streamline the process of taking meeting minutes and provide several advantages over traditional methods. Automated meeting minutes can save a significant amount of time compared to traditional methods, capture the discussion and action items accurately, provide easy accessibility to team members, facilitate better collaboration, are easy to share, and are structured in a way that is easy to read and comprehend. These advantages make automated meeting minutes a valuable tool for organizations looking to optimize their meeting processes and improve communication among team members.

Past research that has focused on meetings has been able to automate meeting minutes using NLP technologies. The NLP technologies that were used in the research were Voice-to-text, Text classification, and Text Summarization. While efforts have been made to automate meeting minutes, the existing academic efforts to automate the process have limitations.

1. In those researches, only an audio recording was used as input.
2. These studies are only concerned with one particular aspect (Voice-to-text, Text classification, and Text summarization).
3. The output is not displayed according to a proper template.

When studying those researches, found there are no researches that generate a full report of a meeting that includes the following features:

1. Generate automated meeting minutes according to uploaded agenda points and an audio or video recording.
2. Generate a progress report using an uploaded agenda and an audio or video recording, and predict the number of days for a task.
3. Identify the action items, the owners, and the deadlines, and measure the overall efforts of the tasks.
4. Generate an emotional sensitivity report.

This work includes four main components.

1. **Automated meeting minutes:** When the user inputs the agenda and an audio or video recording, it generates an automated minute according to a given agenda point. Also, the users can see a summarized detailed report of what they discussed in that meeting. Voice-to-text, text summarization, and text classification methods were used for this component.
2. **Action items and their owners:** By using the audio or video recording, it identifies the action items and who is responsible for those action items. Also, identify the deadlines and calculate the overall effort for each action item and display them in a proper template. Voice-to-text, Text classification, and keyword extraction were used for this component.
3. **Progress report:** With the help of the meeting agenda and the audio or video input, the system identifies the action items, the responsible team members of that action items, the status of the action items (pending, ongoing, not started), predict the number of days for a task and display it in a proper template. Text classification and keyword extraction were used for this component.
4. **Emotional sensitivity report:** Using the audio or video input the system identifies the emotional sensitivity of the attendees of the meeting and displays it in an understandable way.

2. LITERATURE REVIEW

A study conducted by the MIT Sloan Review found that only about 50% of meeting time is used effectively and appropriately, and these effectiveness numbers drop even further when it comes to remote meetings [1]. So, especially as remote work becomes more important, it's important to ensure meeting minutes accurately capture the key points discussed during meetings. Another study published in the Harvard Business Review, suggests that participants should be invited to contribute while the agenda is being developed to ensure that important issues are discussed, and everyone's needs are met

during the meeting [2]. Furthermore, short meetings focused on a specific topic tend to be more effective than long, unfocused meetings [3]. While there may not be much specific research on creating meeting minutes according to the agenda, the importance of meeting effectiveness and efficient communication and documentation is widely recognized. Therefore, using technology and NLP-based techniques to create accurate meeting minutes along the agenda and track participant tasks can be valuable tools for improving meeting effectiveness and productivity.

There are various systems and approaches have been put in place to identify each participant's task and notify them via email. One approach is to use task management tools such as Microsoft Teams that can be used to create task lists, assign tasks to specific team members, and track progress [4]. Similarly, Asana offers the ability to assign tasks and add task buddies via email, allowing team members to collaborate and stay in the loop [5]. Email task management is another option that involves using your inbox to categorize and organize your tasks, such as assigning them to specific people and setting deadlines [6]. However, keep in mind that emails are typically organized by sender, subject, and date rather than by task or priority. It is important to clarify the responsibilities and roles of each team member. This can be accomplished by outlining the job description and expected role. This helps employees understand what tasks they are responsible for and how they contribute to team goals [7]. There are various systems and approaches for identifying tasks and emailing team members. Task management tools like Microsoft Teams and Asana make it easy to assign and track tasks, but email task management is a useful approach to managing individual tasks. Additionally, clarifying roles and responsibilities helps keep everyone on the same page when it comes to tasks and expectations.

Progress reporting is an important management tool for tracking project progress and evaluating the achievement of results. An effective way to keep stakeholders aligned and informed as the project progresses is using project status reports. These reports provide high-level updates that proactively let teams know if a project is on track, at risk, or off course [8]. A progress report is a document that shows the team's progress toward completing a project. Progress reports provide supervisors, managers, team leaders, colleagues, or clients with an overview of project status, milestones reached, and responsibilities of each employee or team member [9]. A monitoring and evaluation (ME) system refers to all the functions necessary to measure the progress of a project/plan and evaluate the achievement of its outcomes. This system typically consists of a set of outcomes (collectively referred to as an outcomes framework), measured against metrics through monitoring tools, and a manual describing the roles and responsibilities associated with their implementation [10]. A progress report is a management tool used by all types of organizations to provide an overview of completed tasks, activities performed, and goals achieved in relation to a project plan. A progress report describes some or all of the following: Has the scope of work been completed? What parts of the work are currently in progress? [11]. To create progress reports on each participant's tasks, it is important to identify the tasks assigned to each team member and their status. These tasks can be outlined in progress reports, along with milestones reached and obstacles or problems encountered. It's also important to clearly outline each team member's responsibilities and progress toward completing those tasks. This allows you to create comprehensive progress reports that clearly show project status and each team member's contribution.

Speech Emotion Recognition (SER) is a research area in which researchers attempt to identify and classify emotions from human speech signals. It has applications in various fields, such as smart healthcare, human-machine interaction, call centers, and automatic translation systems [12]. In recent years, many techniques have been proposed for SER, including not only traditional speech analysis and classification techniques but also deep learning techniques [13][14]. However, gathering knowledge from interdisciplinary fields such as applied psychology and human-computer interfaces is challenging due to the contrasting ways in which humans and machines perceive and associate emotional aspects of speech signals [15]. Overall, there has been extensive research on SER techniques, but their practical implementation to identify emotional sensitivity in real-world settings remains an area of ongoing development and investigation.

3. RESEARCH OBJECTIVES

3.1 Generate a meeting minute according to the agenda using NLP-based technologies.

The main purpose of creating minutes according to the agenda is to document the main points and decisions discussed during the meeting. This ensures that all participants have a clear understanding of what was discussed and what action items were assigned.

The sub-objectives are as follows:

- **Generate an issue-free meeting minute (Accuracy):** This sub-objective aims to ensure that the meeting minute accurately captures all the key points discussed during the meeting without any errors or omissions.
- **Save time on creating manual meeting minutes (Efficiency):** This sub-objective aims to save time by automating the process of creating meeting minutes.
- **Ability to handle easily (Manageability):** This sub-objective aims to make the meeting minute easy to manage by organizing it in a clear and concise format.
- **Ability to read and understand easily (Readability):** This sub-objective aims to make the meeting minute easy to read and understand by using clear language and formatting.

3.2. Identify the action items and deadlines of each attendee, send an email mentioning their tasks and deadlines using NLP-based technologies, and predict the overall effort of the tasks of a user using machine learning.

The main objective of identifying the action items and deadlines of each attendee and sending an email mentioning their tasks is to ensure that all attendees are aware of the tasks assigned to them during the meeting and have a clear understanding of what they need to do next. This helps to ensure that all tasks are completed on time and that there is no confusion about who is responsible for each task. Predicting the overall effort of the tasks of a user helps to get an understanding of how much effort they give for the tasks.

The sub-objectives are as follows:

- **Train a model using data sets:** This sub-objective involves using machine learning algorithms to train a model that can predict the overall effort of the tasks of a user.

- **Extract relevant data from the large data set:** This sub-objective involves using NLP-based technologies to extract the relevant data from the meeting records, including the action items and deadlines assigned to each attendee.

- **Identify action items, their owners, and the deadlines:** This sub-objective involves identifying the action items, their owners, and the deadlines associated with each task.

- **Send an email to the owner with their responsible action items and deadlines:** This sub-objective involves sending an email to each attendee with their responsible action items and deadlines.

3.3. Generate a progress report of the tasks of each attendee using NLP-based technologies.

The main objective of generating a progress report of the tasks of each attendee is to provide an update on the progress made toward completing the tasks assigned to each participant. This helps to ensure that everyone involved in the project is aware of the progress made and any issues that may need to be addressed.

The sub-objectives are as follows:

- **Identify the participants who have tasks:** Involves identifying all participants who were assigned tasks during the previous meeting.
- **Identify the tasks of participants:** This involves identifying the specific tasks assigned to each participant, including the description of the task, the deadline, and any dependencies on other tasks.
- **Identify the state of each task:** This sub-objective involves assessing the progress made towards completing each task and identifying any issues or delays that may have arisen.
- **Predict the number of days for a task:** This sub-objective allows the users to manage their time accordingly.

3.4. Identifying emotional sensitivity using Speech Emotion Recognition techniques

The main objective of identifying emotional sensitivity using Speech Emotion Recognition techniques is to detect and recognize the emotional state of each person during a conversation or meeting. The sub-objectives are as follows:

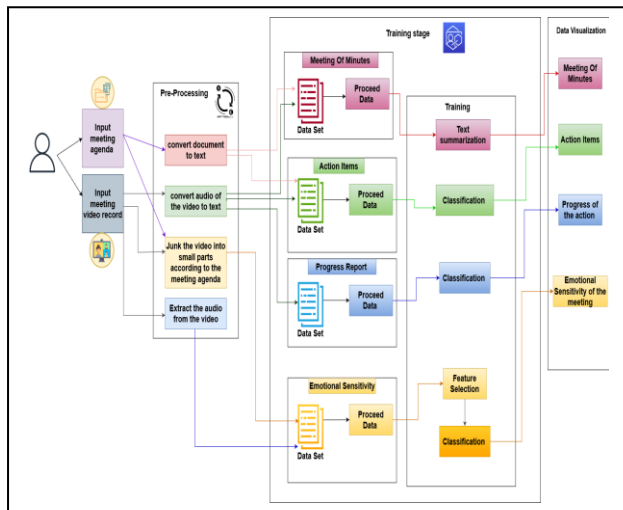
- **The company has the ability to identify whether employees are satisfied or dissatisfied with their work and can use this information to improve their decisions.**
- **Impact the accuracy of emotion recognition, as people may express their emotions differently when they are not fully engaged or paying attention.**
- **Ability to identify the emotional state of each person:** This sub-objective involves using Speech Emotion Recognition techniques to accurately identify the emotional state of each person, including emotions such as happiness, sadness, anger, and frustration.
- **Impact the accuracy of emotion recognition, as background noise can interfere with the recognition of emotional cues in speech.**

4. RESEARCH METHODOLOGY

The above figure shows the overview of a web application that allows users to upload a video recording and an agenda for a

meeting. Once the user uploads the video and agenda, the video information is stored temporarily in memory. The system then uses Natural Language Processing (NLP) techniques to convert the voice in the video recording to text by comparing it with a trained dataset using an NLP-based model. The system then proceeds to summarize and break the converted text data into segments according to the agenda points provided by the user. After this step, the system generates meeting minutes in the given format and displays them as output to the user. Overall, the paragraph explains the flow of how the system works and how the user interacts with the application to generate meeting minutes from a video recording.

Figure 1. System Overview Diagram



A. Generate a meeting minute according to the agenda using NLP-based technologies.

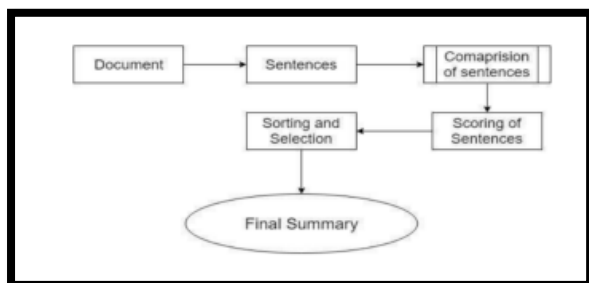


Figure 2. Extractive Summarization Flowchart

The proposed application aims to automate the process of creating meeting summary reports by utilizing NLP techniques and extractive summarization techniques. The user is required to upload the video recording of the meeting and the agenda to the system. Once the video recording is uploaded, the system will analyze it using NLP techniques to convert the voice in the video to text. The system will then summarize the text according to the agenda points using an extractive summarization technique. Extractive summarization involves selecting important phrases or passages from the original text and condensing them into smaller text. This technique involves three main steps, including producing an intermediate version of the text that highlights its main ideas, selecting sentences that represent these ideas, and picking a summary with a few sentences. Overall, the proposed web application aims to make the process of creating meeting summary reports faster and more efficient by automating the process using NLP techniques and extractive summarization techniques.

B. Identify the action items and deadlines of each attendee, send an email mentioning their action items and deadlines using NLP-based technologies, and predict the overall effort of the tasks of a user using machine learning.

For the proposed implementation, the first step is to collect meeting records. Audio data from both males and females will be gathered to produce more accurate results.

Django framework, which is a Python-based framework is used for web development. Django ORM is used to map the database and the object. It creates a table for the entity and saves data after it defines the model. The model is the one that integrates with the database. The voice-to-text method will be used to convert the audio recording into text. Firstly, the sound will be extracted from the video record. To do this, the moviepy library will first convert the video to an mp3 file, followed by the pydub library, which will convert the mp3 file to a wav file. The wav file will then be segmented into chunks using audio segmentation to accurately identify each team member's tasks and deadlines. It will analyze sound variations and then will segment the chunks by measuring silences. This will be done by the pydub's split on-silence method. Then each chunk file will be turned into text using speech recognition. Google Recognizer library will be used to convert voice into text. It will save text files for each user separately. Finally, all the text files will be appended to create a single text document.

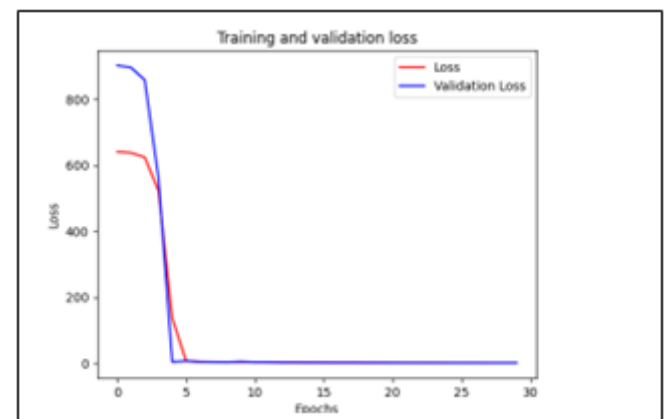


Figure 3. Model Evaluation

Text classification will be used to categorize the text into groups of words based on context. Natural Language Processing (NLP) will automatically evaluate text and categorize it using predetermined tags or categories. A set of linguistic rules will be defined to group texts into categories. Users will need to define a list of words characterized by groups based on their handcrafted linguistic criteria. Text classification and keyword extraction methods will be used to identify action items, deadlines, and the owners of these action items. After identifying them, these details will be saved in the database. To send email notifications, first, the data will be fetched from the database according to the user ID of the action item owner. Then the email content will be created including his tasks and deadlines. These details will be passed as parameters to the send email framework method and then the email will be sent to the action item owner.

Another implementation of the application is to predict the overall effort of the tasks of a user. To do this, first, a data set should be collected since the model will be trained using this data set. Then this data set will be imported into the Pandas data framework. Pandas framework cleans messy data sets and makes them readable and relevant. eeee, linear

regression is used. It is used to predict the value of a variable based on the value of another variable. The tasks will be taken as independent variables and the overall effort will be taken as the dependent variable. The data set will be split into two categories. One category is used to test the set and the other category is to train the model. From the overall data set, 30% will be given for testing and 70% will be given for training. The train set is used to train the model and to optimize it, and the test set is used to evaluate the performance of the model and to test the accuracy of the model.

To train the model, Keras sequential model is used. The dense layers can be changed to get the most accurate output. The model's internal architecture can be saved as a .png file. For model evaluation matplotlib is used. It plots the training and validation loss per epoch. Then the keras model will be saved as an h5 file. Finally, the overall effort of the tasks can be predicted by loading the saved h5 model as well as using the trained model.

Overall, the proposed implementation of the component uses a combination of audio processing, NLP, and machine learning techniques to automate the process of identifying and categorizing action items, responsible persons, deadlines from meeting recordings and predicting the overall effort of the tasks of a user.

C. Generate a progress report of the tasks of each attendee using NLP-based technologies.

The proposed component for implementing the progress report involves using NLP techniques and Python libraries. The meeting recording is converted to text using the Speech Recognition Python library, and then the audio is chunked according to the agenda points, which can be used to identify each participant separately. Generated text will be used to identify the tasks for each participant and the status of each task. The number of days for a task and the priority of each task will be predicted.

Text classification techniques will be applied to the generated text and then used to identify the tasks and task status for each participant. The models will be trained using large datasets to generate a task list as a result. Another model will be trained to predict the number of days for a task. The model will be trained using a dataset that consists of story point values for development, unit testing, integration testing, and total days for that task. The number of days will be predicted once the user inputs story point values for each task. To implement the prediction feature, datasets will be imported using the Pandas library, and then using the Keras regressor algorithm, the model will be trained. Then a linear regression graph will be generated using the PyPlot library to evaluate the model's accuracy. Model accuracy will be measured using the mean squared error.

For the backend implementation, Python and the Django framework will be used for development. This application is designed as a web application for cloud-based web applications and will likely use AWS or Google Cloud for this purpose.

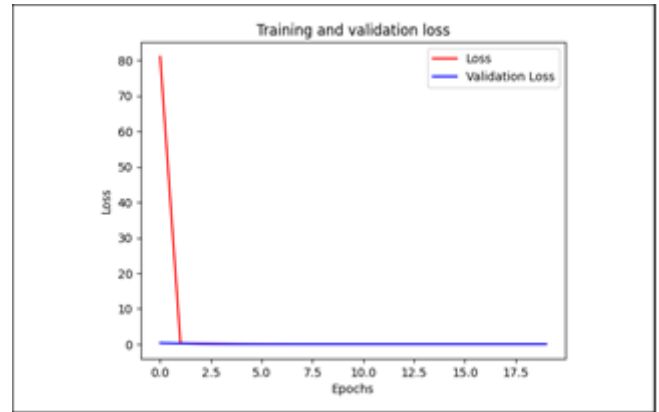


Figure 4. Model Evaluation

D. Identifying emotional sensitivity using Speech Emotion Recognition techniques

Identifying emotional sensitivity using Speech Emotion Recognition (SER) techniques based on deep learning Convolutional Neural Networks (CNN) and Mel-frequency cepstral coefficients (MFCC) can be a powerful approach for detecting and classifying emotions in speech signals. Need to collect a large dataset of speech samples that are labeled with their corresponding emotions. The dataset should include various emotional states, such as happiness, sadness, anger, and fear, to enable the training of a model that can recognize a wide range of emotions. Preprocess the speech signals by applying the MFCC feature extraction technique to obtain a compact representation of the spectral characteristics of the speech signal. Augment the dataset by applying different transformations to the original speech samples, such as pitch shifting, time stretching, and noise addition. This can increase the diversity of the dataset and improve the generalization of the model. Train a deep-learning CNN model using the preprocessed and augmented dataset. The model should be trained to recognize the spectral patterns in the MFCC features that are indicative of specific emotions. Evaluate the performance of the model using a test dataset that is separate from the training dataset. This can be done by calculating metrics such as accuracy, precision, and recall.

5. RESULTS AND DISCUSSIONS

The developed application features Generate a meeting minute according to the agenda using NLP-based technologies, identify the action items and deadlines of each attendee and send an email mentioning their action items and deadlines using NLP-based technologies, predict the overall effort of the tasks of a user using Machine Learning, generate a progress report of the tasks of each attendee using NLP-based technologies, and identifying emotional sensitivity using Speech Emotion Recognition techniques has yielded positive results. One of the major positive outcomes of the application is its accuracy. The application's ability to generate meeting minutes without any errors or omissions is commendable. This has resulted in improved productivity and efficiency, as it saves time that would otherwise be spent manually creating meeting minutes.

The application's ability to handle large data sets and extract relevant information is also noteworthy. This has made it easier to identify action items, their owners, and the deadlines, resulting in improved task management and progress tracking. The application's ability to send emails to the task owners with their responsible action items and deadlines has also saved time and effort for the meeting organizer.

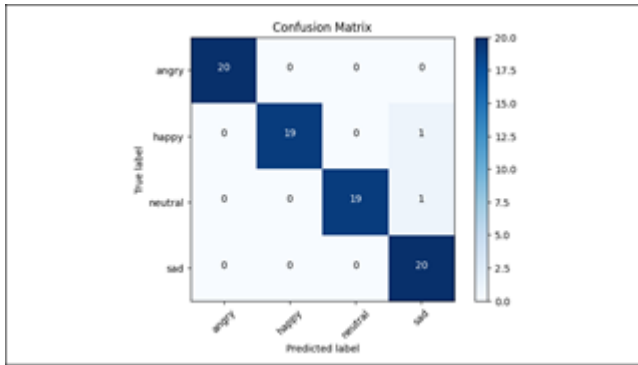


Figure 5. Confusion Matrix of Model SER

The MFCC features were extracted from the preprocessed speech signals, and the model was trained to recognize the spectral patterns in the MFCC features that are indicative of specific emotions. The results of the study showed that the deep learning CNN model achieved high accuracy in recognizing emotions in speech signals. The model achieved an accuracy of 97.5% on the test dataset, which outperformed other traditional machine learning algorithms, such as support vector machines (SVM) and random forests (RF). The study also found that the MFCC features were effective in capturing the spectral characteristics of speech signals that are indicative of specific emotions. The MFCC features were able to represent the speech signals in a compact and discriminative manner, which enabled the deep learning CNN model to learn the patterns in the data and accurately recognize the emotions. Overall, the developed application has been successful in achieving its objectives and has yielded positive results. It has improved the accuracy and efficiency of generating meeting minutes, made task management and progress tracking easier, and helped to identify emotional sensitivity during meetings, resulting in improved meeting effectiveness.

6. CONCLUSION

Applications incorporating NLP-based technology and voice emotion recognition technology can greatly improve group communication and collaboration in the workplace. The ability to take meeting minutes using NLP-based technology saves time and reduces communication errors. It can analyze conversations and automatically generate meeting summaries to highlight key points and action items and provide reference documents for future discussions. Identifying each participant's action items, and deadlines, and sending an email outlining the action items and deadlines using NLP-based technology can save a lot of time and improve accuracy. The application will analyze conversations and identify action items, deadlines, and their owners and send emails with responsible action items and due dates to each owner. Predicting the overall effort of the tasks of a user is also very helpful to get an understanding of the effort a user gives to the tasks assigned to him.

Using NLP-based technology to generate task progress reports for each participant can help identify areas where progress is slow or where more resources are needed. It can analyze the progress of each task and generate a report summarizing the status of each task, helping you better plan future meetings. Using language and emotion recognition technology to identify emotional sensitivity can improve workplace communication and foster empathy. You can identify each person's emotional state, filter out background noise and voice, and build a system to get accurate results. This application has the potential to greatly improve communication and collaboration, resulting in a more productive and positive working environment. It is

especially useful in remote work environments or situations where face-to-face meetings are not possible, providing an effective way to communicate without physical presence.

Additionally, combining these applications may improve the overall effectiveness of group communication and collaboration. For example, the ability to recognize emotional sensitivity during meetings provides insight into how participants are responding to issues, leading to better understanding and more productive discussions. NLP-based progress reports produced by technology can inform follow-up meetings and identified tasks can be tracked and monitored by the same technology. These applications have the potential to revolutionize the way we communicate and collaborate in the workplace, improving productivity, and efficiency and creating a more positive work environment.

7. ACKNOWLEDGMENT

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