Innovative Approach in Digital Forensics: Shortcut-Based Speech Recognition, Sentiment Analysis and Body Language Evaluation

Özgecan SİYEZ

Summary:

In the field of digital forensics, the analysis of audio and video recordings plays a critical role. Traditional methods require manual examination of these recordings, which is time-consuming and prone to errors. In this paper, we introduce an innovative method that performs multi-faceted analyses such as speech-to-text conversion, sentiment analysis, and body language evaluation using user-defined shortcut keys. This method, termed "Shortcut-Based Speech Recognition, Sentiment Analysis, and Body Language Evaluation," significantly enhances forensic analysis processes by speeding up and increasing the accuracy of evidence analysis.

This new method leverages speech recognition technology to convert audio recordings into text, conducts sentiment analysis on the text, and performs body language evaluation from video recordings. Users can execute these analyses using their chosen shortcut keys and save the results to a log file. This enables forensic experts to examine digital evidence more efficiently and effectively. Our innovative approach contributes to digital forensic investigations by providing accuracy and speed in identifying critical information. The user-defined shortcut keys simplify and accelerate the analysis process, aiding researchers and forensic experts in achieving faster and more accurate results. Furthermore, the method's multi-analysis capabilities offer a comprehensive approach to evidence evaluation, facilitating stronger evidence presentations in court.

Keywords: Digital Forensics, Speech Recognition, Sentiment Analysis, Facial Expression Analysis, Motion Analysis, Video Analysis, Body Language, Shortcut-Based Method, Evidence Analysis, Innovative Technology, Computer Vision, Digital Evidence Examination, Critical Word Detection, Evidence Marking

What is Digital Forensics?

Digital forensics is the process of collecting, analyzing, and presenting electronic data obtained from digital devices. This field plays a crucial role in investigating crimes, resolving legal disputes, and identifying security threats. Digital evidence can be extracted from computers, smartphones, servers, networks, and other digital devices. Digital forensics experts analyze this data to determine how events occurred, who was involved, and how evidence was gathered. These analyses can be used as evidence in courts and play a significant role in various forensic investigations (Henkoğlu, T., 2020).

The Role of Audio and Video Analysis in Digital Forensics

Audio and video analyses hold a critical place in digital forensics. Here are the primary uses of these technologies in digital forensics:

1. **Evidence Collection:**
    - Audio recordings from crime scenes and security camera footage provide crucial evidence for understanding how events transpired.
    - Suspects' and witnesses' statements are analyzed through audio recordings to verify their accuracy.
2. **Identification:**
    - Voice analysis can be used to identify suspects. Vocal tones, speech patterns, and other vocal characteristics provide key clues for identification.
    - Video analyses, combined with facial recognition technologies, are used to identify individuals.
3. **Emotion Analysis:**
    - Emotion recognition technologies can determine the emotional states of suspects or witnesses from their voices and facial expressions. This information is used in lie detection and psychological analyses.
4. **Timeline Creation:**

- Audio and video analyses are used to create timelines of events, helping to establish the chronological order of occurrences (Özen, M., & Özocak, G., 2015).

Purpose of This Study

The purpose of this study is to develop software that demonstrates how audio and video analyses can be used in digital forensics and to evaluate the benefits this software provides to forensic experts. Specifically, it aims to detect specific words and emotional states in real-time using a shortcut-based method.

Main Objectives:

1. **Word Detection:** Develop a system that can quickly and accurately detect specific words in audio recordings and video files.
2. **Emotion Recognition:** Perform emotional analysis on the speech in audio recordings and video files and classify emotional states.
3. **Real-Time Analysis:** Provide a system that allows users to perform analyses instantly with a user-defined shortcut key.
4. **User-Friendly Interface:** Create a system that can be easily used with shortcut keys without a graphical user interface.
5. **Forensic Applications:** Evaluate how the developed system can be used in digital forensic applications and the benefits it provides in this field.

Requirements and Tools

Requirements:

- **Python 3.x**: The main programming language used for development.
- **Libraries:**
    - `speech_recognition`: For performing speech recognition.

- `keyboard`: To enable operations with shortcut keys.
- `pyAudioAnalysis`: For audio and emotion analysis.
- `pyaudio`: For processing audio files.

Tools:

- **Sample Dataset**: Necessary for testing on audio and video files.
- **Python IDE**: Development environment (e.g., PyCharm or VSCode).

Explanations:

Speech-to-Text Conversion:

- **Speech Recognition**: This involves converting an audio file to text using the `speech_recognition` library. This checks if the user-specified word is present in the audio file.
- **Function**: This function is used to convert an audio file into text.

Emotion Recognition Function:

- **Function**: This function predicts the emotional state in the audio file using the `pyAudioAnalysis` library.

Shortcut Key Function:

- **Function**: This function is triggered when the shortcut key is pressed, performing both the search and emotion recognition.

Shortcut Key Listening:

- Using the `keyboard` library, the shortcut key function is called when the specified shortcut key is pressed. This code segment allows the user to search for a specific word in the audio file and perform emotional analysis by pressing a user-defined shortcut key.

In this method, while listening to an audio file, the user can press a specific shortcut key to search for a particular word and perform emotional analysis of the audio file. This can be particularly useful in areas such as forensic computing, customer service analysis, user experience evaluation, and education.

How the Software Can Be Used in Digital Forensics

The use of audio and video analyses in digital forensics plays a significant role in solving crimes and clarifying legal disputes. In this section, we will detail how the developed software can be used in digital forensics.

Key Application Areas:

1. **Crime Scene Investigation:**

- **Audio and Video Evidence**: Data recorded by audio recording devices or security cameras at the crime scene can be used to understand how the crime was committed and who was involved. The developed software analyzes these recordings to detect important words and emotional expressions.

2. **Statement Analysis:**

   - **Suspect and Witness Statements**: When statements given by suspects and witnesses are recorded, these recordings can be analyzed to verify the accuracy of the statements. The software can detect specific words and analyze emotional states to identify lies or emotional changes.

3. **Threat and Harassment Cases:**

   - **Phone Calls and Messages**: Threatening or harassing phone calls and voice messages can be analyzed to assess the severity of the threats and the emotional state of the target. The software can quickly detect specific words in such cases and provide information to relevant units.

4. **Missing Persons:**

   - **Last Records and Conversations**: Analyzing the last conversations or audio recordings of missing persons can provide information about their last seen location and time. The software can analyze these recordings to reveal important clues.

Technical Process and Operation:

1. **Data Collection:**

   - ✓ Audio and video files are collected in digital format and loaded into the software.
   - ✓ If necessary, audio and video recordings are converted according to predefined standards.

2. **Feature Extraction:**

   - ✓ The software extracts features such as Mel Frequency Cepstral Coefficients (MFCC) from audio files.
   - ✓ Facial expressions and synchronized emotional expressions are analyzed from video files.

3. **Word and Emotion Analysis:**

   - ✓ Specific words and emotional expressions are detected.
   - ✓ Analysis operations are accelerated with user-defined shortcut keys.

4. **Reporting:**

- ✓ Analysis results are reported to digital forensic experts.
- ✓ Reports present the identified words and emotional states according to the timeline.

This innovative approach significantly enhances the speed and accuracy of evidence analysis processes in digital forensics. By utilizing speech recognition technology to convert audio recordings into text, performing emotional analysis on the text, and evaluating body language from video recordings, this method allows forensic experts to examine digital evidence more efficiently and effectively. The shortcut-based method simplifies and accelerates the analysis process, aiding researchers and forensic experts in obtaining faster and more accurate results. Additionally, the comprehensive and holistic approach provided by the method's multi-analysis capabilities enables more robust evidence presentations in court.

Sample Scenarios and Use Cases

Scenario 1: Crime Scene Investigation During a bank robbery, audio and video recordings captured by security cameras and ambient listening devices are available. Forensic experts upload these recordings to the software. The software detects key words used by the robbers (e.g., "gun," "money," "run") and analyzes the stress levels of the robbers. These analyses help in understanding how the robbery was planned and who was involved.

Scenario 2: Examination of Threat Allegations An individual claims to have received threatening phone calls. These phone calls have been recorded. Forensic experts upload these recordings to the software and search for specific threatening words (e.g., "kill," "harm"). The software also analyzes the emotional state of the speaker and assesses the severity of the threat. The obtained data can be presented as evidence in court.

Scenario 3: Missing Person Case When a person goes missing, their last phone calls and voice messages can provide critical clues. Forensic experts upload these recordings to the software and detect specific words (e.g., "meeting," "place," "time"). The software provides information about the last known location and time of the missing person. This information is used to guide search and rescue operations.

Scenario 4: Suspect and Witness Statements During an investigation, the statements of suspects and witnesses are recorded. Forensic experts upload these recordings to the software and search for important words in the statements. The software also performs emotional analysis to help determine if the suspect or witness is lying. These analyses enhance the accuracy and reliability of the investigation.

Comparison and Advantages of Traditional Methods vs. the New Method

Traditional Methods

In digital forensics, audio and video analyses have traditionally been conducted using various techniques and software. Traditional methods generally involve the following steps:

1. **Manual Review:**

   - ❖ Experts manually listen to and watch audio and video recordings.
   - ❖ Specific words and emotional states are noted by the listener.

2. **Transcription:**

    - ❖ Audio recordings are converted into written texts.
    - ❖ This process is often time-consuming and costly.

3. **Audio Analysis Software:**

    - ❖ Specialized audio analysis software is used to detect specific frequencies, tones, and words.
    - ❖ These software tools typically require specialized expertise.

4. **Video Analysis Software:**

    - ❖ Video recordings are analyzed for features such as facial recognition and motion analysis.
    - ❖ These software tools are also usually complex and expensive (Özen, M., & Özocak, G., 2015).

Shortcut-Based Method

The shortcut-based method we have developed can be used to quickly detect specific words and emotional states in audio and video recordings. This method involves the following steps:

1. **Loading Audio and Video Files:**

    - ➢ Audio and video recordings are uploaded to the software.
    - ➢ The software analyzes these files.

2. **Shortcut-Based Search:**

    - ➢ Users set shortcut keys to search for specific words or emotional states.
    - ➢ When the specified shortcut keys are pressed, the software instantly performs the analysis and displays the results.

3. **Real-Time Emotion Recognition:**

    - ➢ Emotional states in audio recordings are analyzed and classified.
    - ➢ This analysis can be quickly performed using a user-defined shortcut key.

4. **Automatic Reporting:**

    - ➢ Analysis results are automatically reported.
    - ➢ These reports provide forensic experts with quick and accurate information.

Differences and Advantages:

Criteria	Traditional Methods	Shortcut-Based Method
Examination Time	Long due to manual review and transcription.	Instant analysis and quick results with shortcut keys.
Cost	High, requires specialized software and manual labor.	Lower cost, user-friendly software.
Ease of Use	Complex and requires expertise.	Simple and user-friendly, easy to use with shortcut keys.
Accuracy	Manual errors and inaccuracies possible.	Higher accuracy with automatic analysis.
Real-Time Analysis	Not possible, requires manual review.	Real-time analysis and fast feedback.
Emotion Recognition	Limited support, either manual or with limited software.	Automatic emotion recognition and classification.
Reporting	Manual reporting, time-consuming and prone to errors.	Automatic reporting, fast and accurate.
Comprehensive	Individual and time-consuming.	Multiple word and emotion analyses, fast and comprehensive.

Advantages of the New Method

1. **Time Saving:**
   - Shortcut-based method saves time by eliminating manual review and transcription time.
   - Results are available instantly with real-time analysis.

2. **Cost Effectiveness:**
   - With lower cost software solutions, the need for manual labor decreases.
   - It offers a user-friendly system instead of complex software that requires expertise.

3. **Ease of Use:**
   - Users can quickly analyze with shortcut keys.
   - It is a simple and effective method that does not require complex software knowledge.

4. **Accuracy and Reliability:**
   - Automatic analysis minimizes manual errors and mistakes.
   - Reliable results are obtained with high accuracy rates.

5. **Real-Time Feedback:**
   - Instant analysis can be done with shortcut keys and the results can be seen immediately.
   - This is a great advantage, especially in emergencies and situations where quick decisions need to be made.

6. **Comprehensive Analysis:**
   - The software can analyze multiple words and emotional states simultaneously.

- Provides more information to digital forensic experts by providing comprehensive and detailed reports.

The shortcut-based method offers significant advantages over classical methods. Advantages such as time saving, cost effectiveness, ease of use, high accuracy and real-time feedback in audio and video analysis in computer forensics reveal the advantages of this method. This software plays a critical role in solving crimes and clarifying legal disputes by providing forensic computer experts with a more effective and faster analysis process.

Why We Chose the Shortcut-Based Method?

1. **Speed and Efficiency:**

   - ✓ Allows for instant analysis and quick access to results with shortcut keys.
   - ✓ Time-saving enhances the effectiveness of forensic investigations.

2. **Ease of Use:**

   - ✓ A simple and user-friendly interface enables forensic experts to adapt quickly.
   - ✓ Doesn't require complex settings or graphical tools, reducing the learning curve.

3. **Resource Saving:**

   - ✓ Provides high performance with fewer system resources.
   - ✓ Effective for fieldwork and use on mobile devices.

4. **Automated Processing:**

   - ✓ Minimizes manual tasks and ensures more reliable results with automated analysis.
   - ✓ Frees the user from routine tasks, allowing them to focus on analysis.

5. **Real-Time Feedback:**

   - ✓ Offers real-time analysis and feedback with shortcut keys.
   - ✓ Provides a significant advantage in urgent situations requiring quick decisions.

6. **Application and Scenarios:**

   - ✓ Effective use in common forensic scenarios such as threat assessment, missing person cases, and crime scene investigations.
   - ✓ Enhances the accuracy of forensic investigations with comprehensive analysis and detailed reporting.

Visual Data Analysis Methods

Visual data analysis involves analyzing visual information in video content, including facial expressions, gestures, movements, and other visual cues. In digital forensics, visual data analysis is used to detect suspicious behaviors in videos or to determine emotional states from facial expressions. Computer vision techniques and machine learning algorithms are used for visual data analysis.

Example Visual Data Analysis Techniques:

1. **Face Recognition and Facial Expression Analysis:** Can be used to determine emotional states from facial expressions.
2. **Motion Analysis:** Analyzing movements and activities in videos.
3. **Object Recognition:** Identifying specific objects or scenes in videos.

Integrated Approach

In digital forensics, the analysis of audio and video recordings is critical for accurately evaluating evidence. Traditional methods are time-consuming and prone to errors due to manual review. In this article, we propose a shortcut-based method based on speech recognition and text analysis. This method analyzes specific words and emotional states from audio recordings but does not analyze visual data in video content.

We propose a new integration method: combining speech recognition and emotion analysis with facial expression and motion analysis in video recordings. This integrated approach allows for more comprehensive and accurate results in digital forensics studies. This innovative method provides significant advantages in evidence evaluation for researchers and digital forensics experts.

By performing visual data analysis in addition to speech and text analysis, you can obtain a more comprehensive analysis. This allows you to gain more information by analyzing both audio and video recordings.

Example Scenarios

Scenario 1. Extortion Case

Situation: A person sends threatening voice and video messages to another person for extortion. The victim submits these threat messages to law enforcement authorities.

Analysis:

1. **Speech Recognition and Keyword Search:**
    - Threatening words ("kill," "extortion," "threat") are searched in the audio recordings.
    - Sections containing these words are identified and time-stamped.
2. **Emotion Analysis:**
    - Emotional analysis is performed on the threatening messages.
    - The emotional tone of threats is determined (e.g., anger, hatred).

3. **Visual Data Analysis:**

    - Facial expressions and gestures in video messages are analyzed.
    - The suspect's facial expressions (e.g., anger, threatening looks) are identified and marked.

Result: Digital forensics experts create a comprehensive report containing threatening words, emotional tone, and facial expressions. This report is used in court to prove extortion.

Scenario 2. False Confession Case

Situation: A person is being blackmailed with a video recording allegedly confessing to a crime. The victim claims that the confession is false and seeks help from digital forensics experts.

Analysis:

1. **Speech Recognition and Keyword Search:**

    - The audio recording is analyzed to search for critical confession words ("crime," "confession," "I did it").
    - Sections containing these words are identified and time-stamped.

2. **Emotion Analysis:**

    - Emotional analysis is performed on the confession in the audio recording.
    - The emotional tone of the confession is determined (e.g., guilt, fear).

3. **Visual Data Analysis:**

    - Facial expressions and gestures in the video recording are analyzed.
    - The victim's facial expressions (e.g., distress, stress) are identified and marked.

Result: Digital forensics experts present evidence showing that the confession is false based on facial expressions and emotional tone analysis.

Scenario 3. Workplace Harassment Case

Situation: An employee alleges harassment in the workplace and submits audio and video recordings containing harassment messages. The employer calls in digital forensics experts to investigate these claims.

Analysis:

1. **Speech Recognition and Keyword Search:**

- Audio recordings are analyzed to search for harassment-related words ("harassment," "insult," "curse").
- Sections containing these words are identified and time-stamped.

2. **Emotion Analysis:**

    - Emotional analysis is performed on the audio recordings containing harassment messages.
    - The emotional tone of the harasser is determined (e.g., anger, contempt).

3. **Visual Data Analysis:**

    - Facial expressions and gestures in the video recordings are analyzed.
    - The harasser's facial expressions (e.g., anger, contempt) are identified and marked.

Result: Digital forensics experts create a comprehensive report containing harassment-related words, emotional tone, and facial expressions. This report assists the employer in taking appropriate legal actions.

This integrated method allows for a more comprehensive analysis of audio and video recordings in digital forensics. While speech recognition and emotion analysis detect specific words and emotional tones, facial expression analysis marks body language and gestures. This helps in obtaining more reliable and detailed results in evidence evaluation.

The applicability of this method is crucial for improving the accuracy and effectiveness of evidence analysis in digital forensics. Shortcut-based marking allows for the recording of timestamps for analyzed events and expressions, making evidence more organized and accessible.

Speech Recognition and Emotion Analysis Method Software

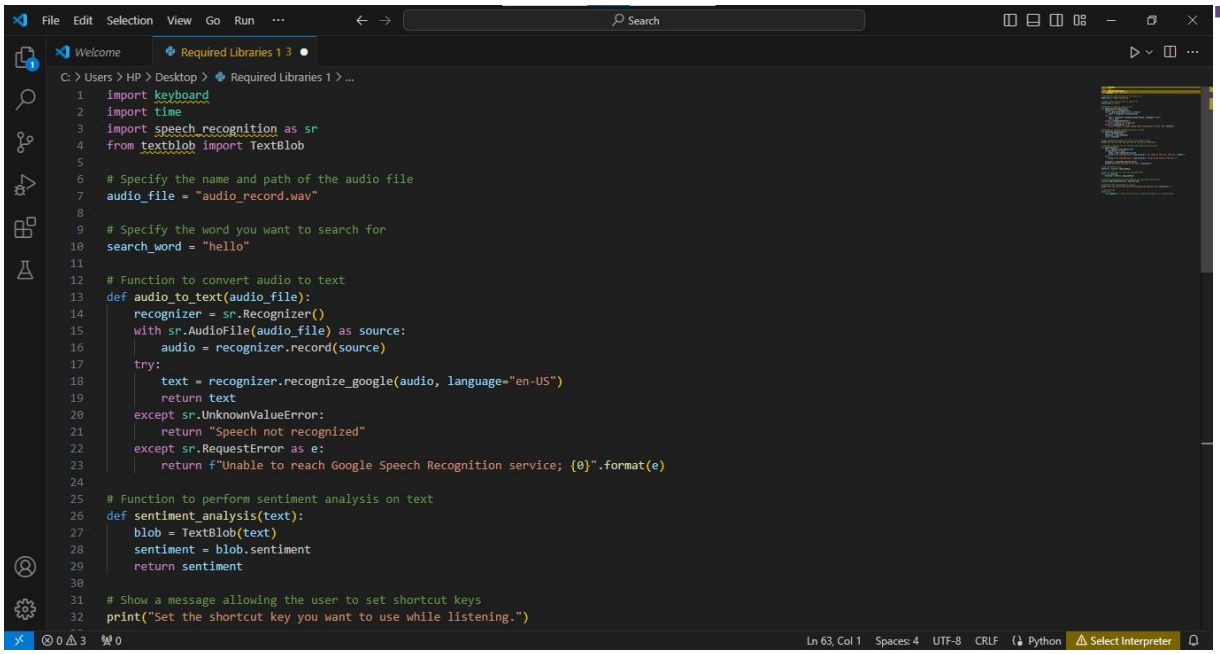
The following example is a simple software application created using Python. This software converts an audio recording into text, searches for specific keywords, and analyzes emotions mentioned in the text. Users can initiate these processes with predefined shortcut keys.

Required Libraries

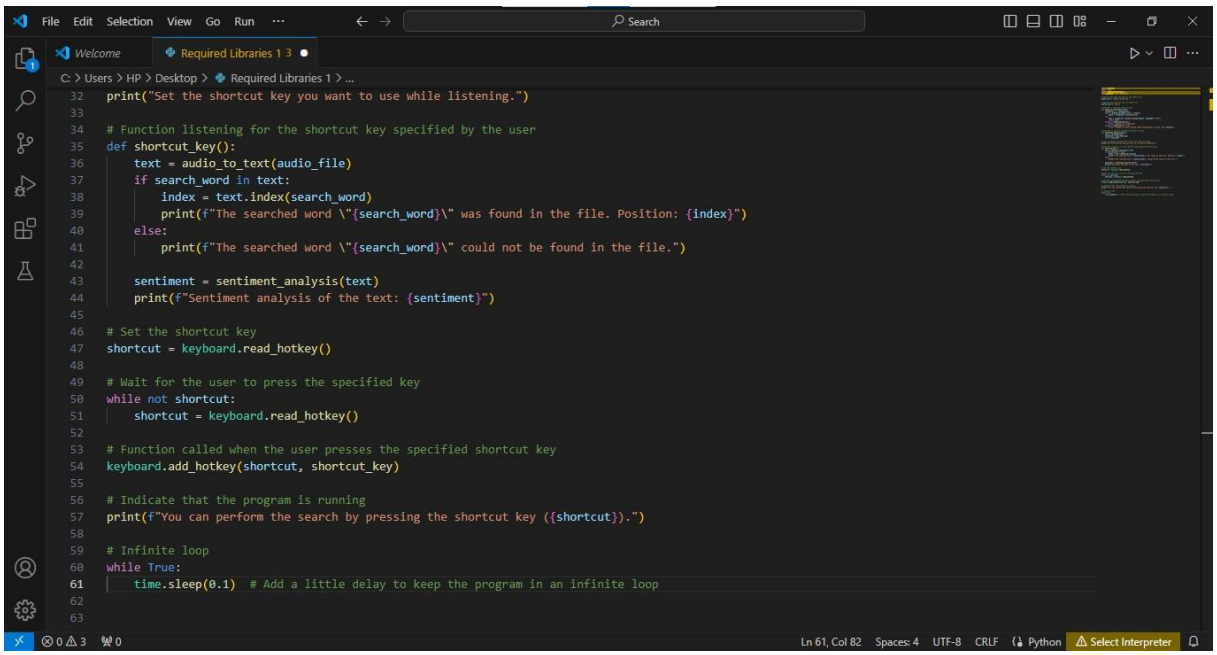
You will need speech_recognition, textblob, and keyboard libraries for this software. You can use these commands to install these libraries:

pip install speechrecognition textblob keyboard

Software Code:



```python
import keyboard
import time
import speech_recognition as sr
from textblob import TextBlob

# Specify the name and path of the audio file
audio_file = "audio_record.wav"

# Specify the word you want to search for
search_word = "hello"

# Function to convert audio to text
def audio_to_text(audio_file):
    recognizer = sr.Recognizer()
    with sr.AudioFile(audio_file) as source:
        audio = recognizer.record(source)
    try:
        text = recognizer.recognize_google(audio, language="en-US")
        return text
    except sr.UnknownValueError:
        return "Speech not recognized"
    except sr.RequestError as e:
        return f"Unable to reach Google Speech Recognition service; {0}".format(e)

# Function to perform sentiment analysis on text
def sentiment_analysis(text):
    blob = TextBlob(text)
    sentiment = blob.sentiment
    return sentiment

# Show a message allowing the user to set shortcut keys
print("Set the shortcut key you want to use while listening.")
```



```python
print("Set the shortcut key you want to use while listening.")

# Function listening for the shortcut key specified by the user
def shortcut_key():
    text = audio_to_text(audio_file)
    if search_word in text:
        index = text.index(search_word)
        print(f"The searched word \"{search_word}\" was found in the file. Position: {index}")
    else:
        print(f"The searched word \"{search_word}\" could not be found in the file.")

    sentiment = sentiment_analysis(text)
    print(f"Sentiment analysis of the text: {sentiment}")

# Set the shortcut key
shortcut = keyboard.read_hotkey()

# Wait for the user to press the specified key
while not shortcut:
    shortcut = keyboard.read_hotkey()

# Function called when the user presses the specified shortcut key
keyboard.add_hotkey(shortcut, shortcut_key)

# Indicate that the program is running
print(f"You can perform the search by pressing the shortcut key ({shortcut}).")

# Infinite loop
while True:
    time.sleep(0.1)  # Add a little delay to keep the program in an infinite loop
```

Working Principle

1. **Converting Audio File to Text:**

    - The `convert_audio_to_text` function takes an audio file and converts it to text using the Google Speech Recognition API.

2. **Keyword Search:**

    - The `shortcut_key` function searches for a specific keyword in the text and indicates its location when found.

3. **Sentiment Analysis:**

- The `sentiment_analysis` function analyzes the emotional tone of the text and displays the result to the user.

4. **Shortcut-Based Control:**

    - When the user presses a designated shortcut key, both keyword search and sentiment analysis are performed.

Advantages

- **Comprehensive Analysis:** Enables both keyword search and sentiment analysis.
- **Speed and Ease:** Offers instant analysis through a shortcut key.
- **Evidence Integrity:** Provides detailed information that can be used in forensic processes.

This method allows for more comprehensive and reliable analysis of evidence in digital forensics. The ability to search for specific keywords and analyze the emotional tone of the text provides significant advantages in evidence evaluation.

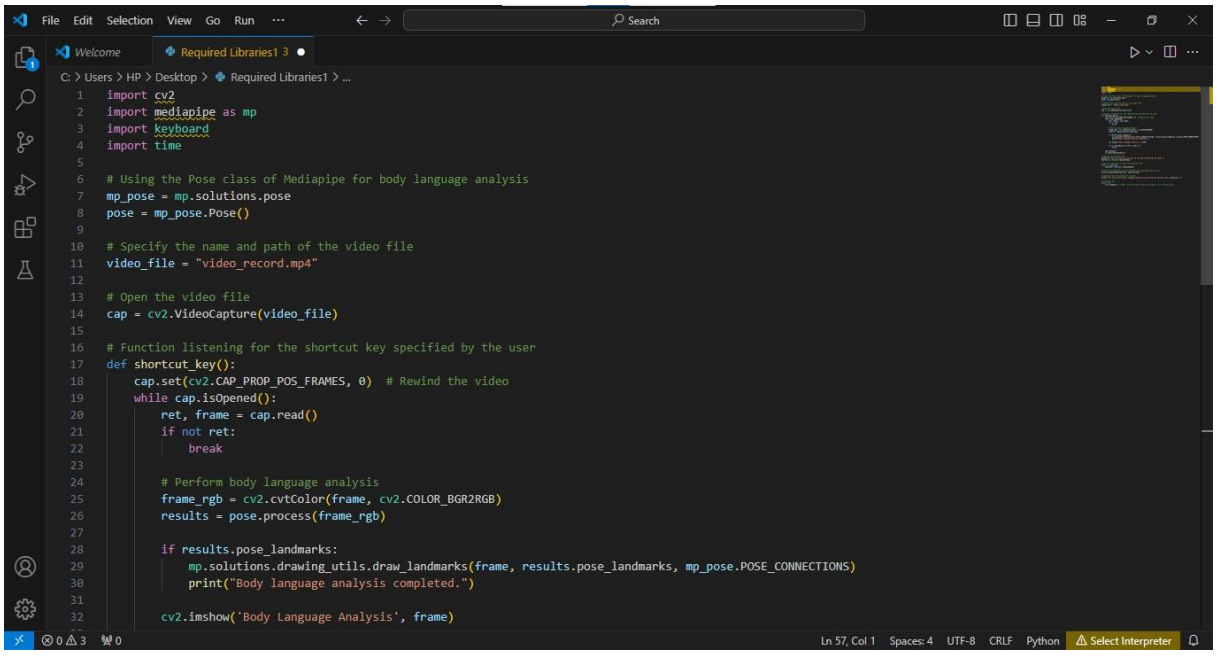
Body Language Analysis Method

Required Libraries

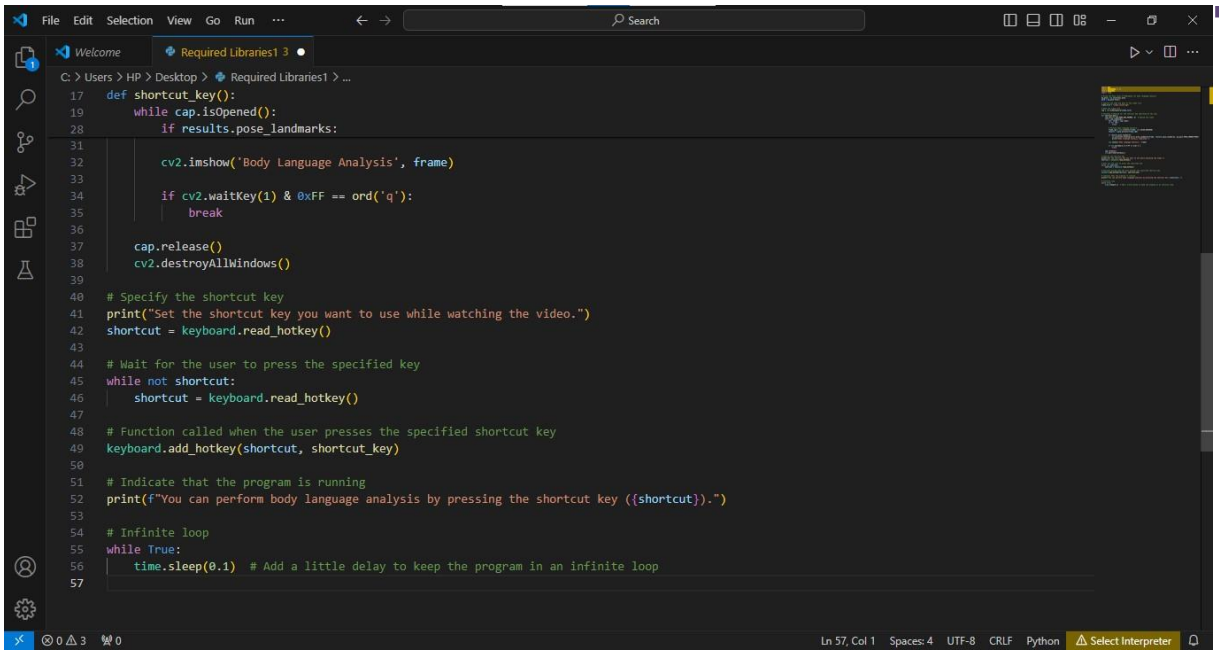
OpenCV, Mediapipe, and Keyboard libraries are needed for body language analysis. You can use these commands to install these libraries:

pip install opencv-python mediapipe keyboard

Software Code:



https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191



Working Principle

1. **Video Analysis:**

    - The video file is opened using `cv2.VideoCapture`.
    - Body language analysis is performed using the `mediapipe` library.
    - The video is processed frame by frame, and body language in each frame is analyzed.

2. **Shortcut-Based Control:**

    - When the user presses a designated shortcut key, the video is replayed from the beginning and body language analysis is conducted.

Advantages

- **Visual and Auditory Analysis:** Provides comprehensive evaluation by performing body language analysis in addition to speech recognition and sentiment analysis.
- **Speed and Ease:** Offers instant analysis through a shortcut key.
- **Evidence Integrity:** Provides detailed information that can be used in forensic processes

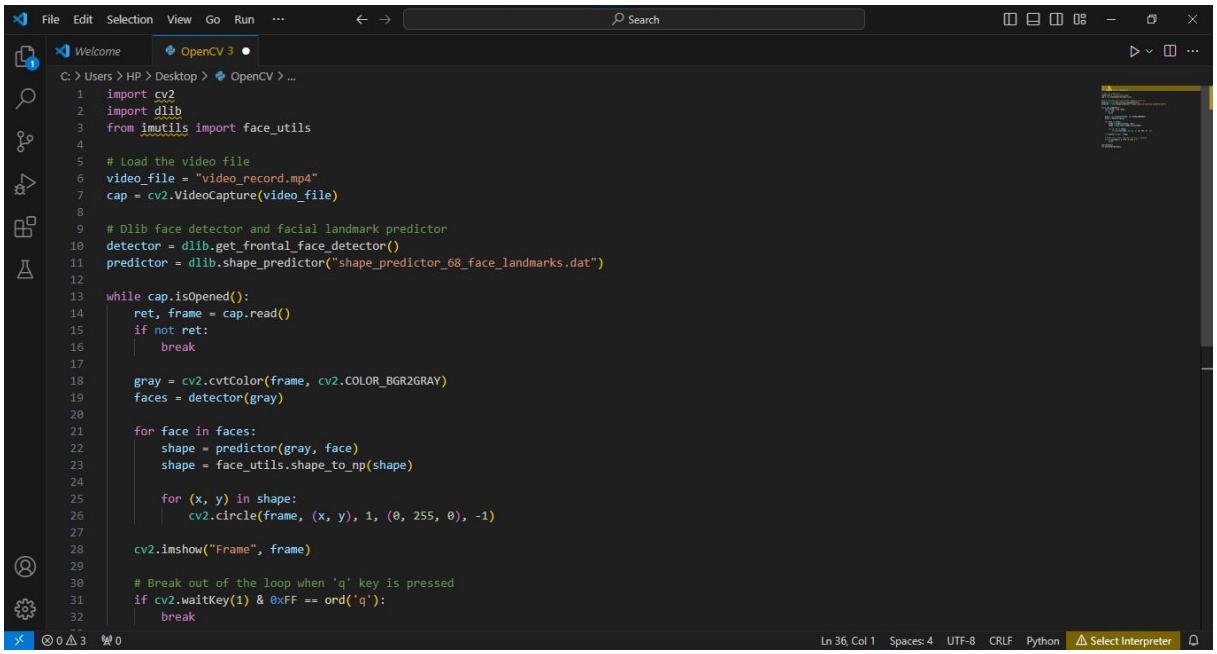
Audio and Visual Data Analysis

1. **Voice Recognition and Emotion Analysis**

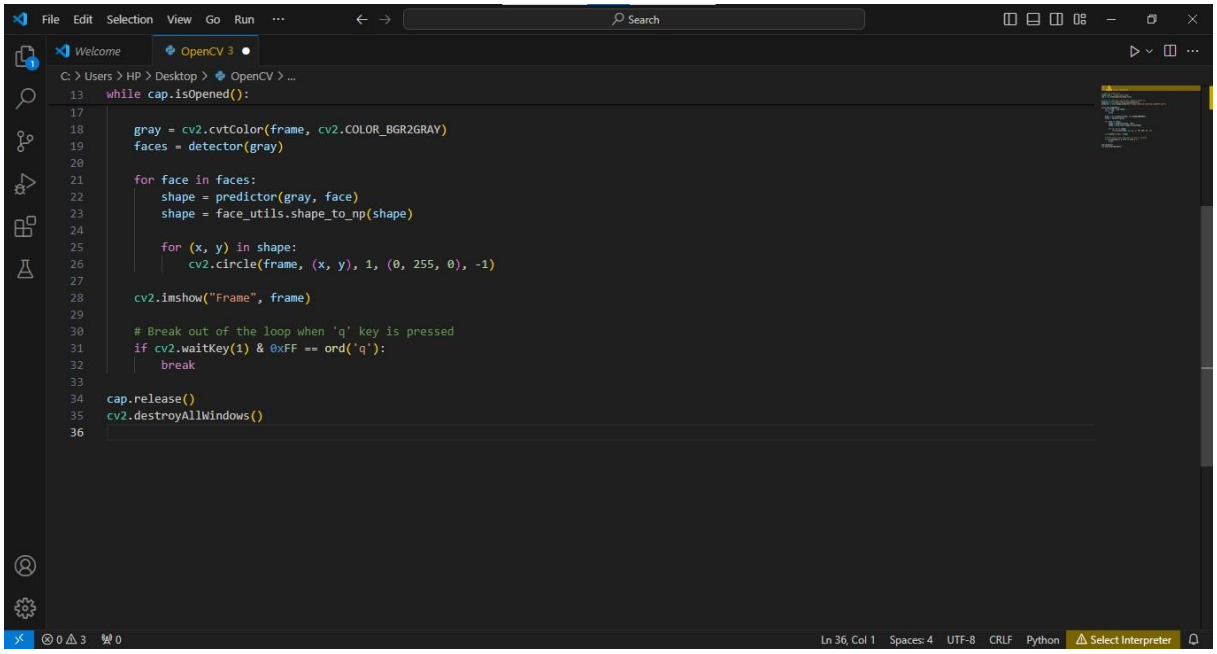
This section will remain the same as the shortcut-based voice recognition and emotion analysis code we provided before.

2. **Visual Data Analysis (Facial Expression Analysis)**

In this section, you can analyze facial expressions using libraries such as OpenCV and dlib. For example, here is a piece of code that analyzes facial expressions in a video file:



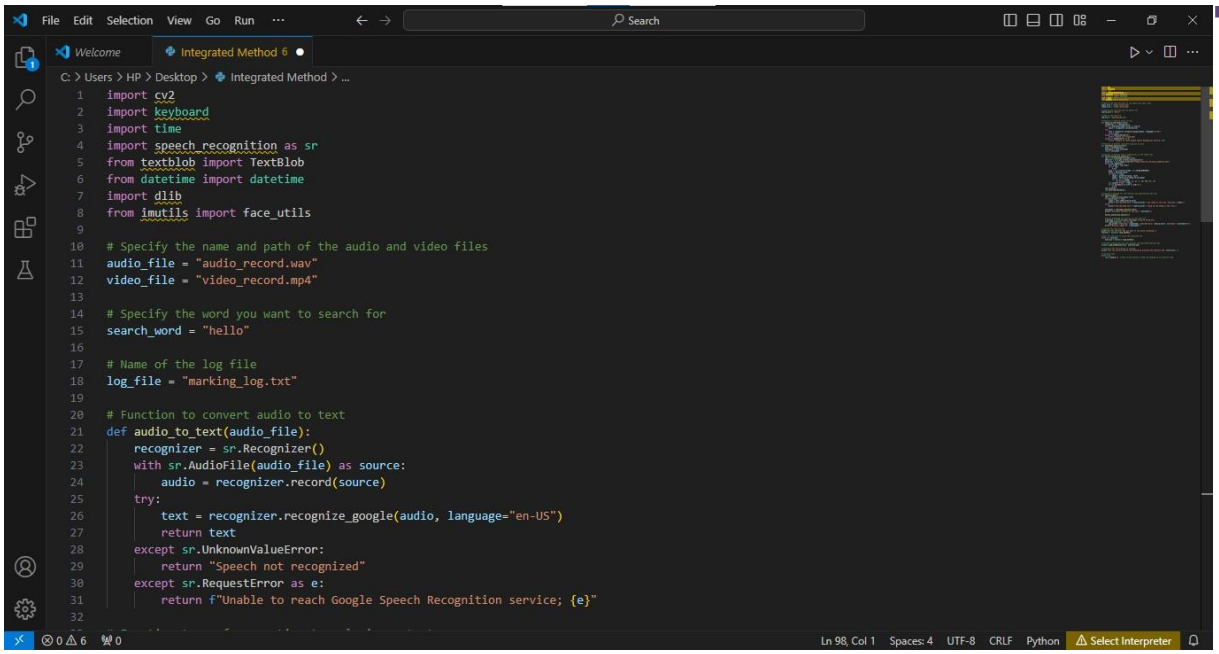
```python
import cv2
import dlib
from imutils import face_utils

# Load the video file
video_file = "video_record.mp4"
cap = cv2.VideoCapture(video_file)

# Dlib face detector and facial landmark predictor
detector = dlib.get_frontal_face_detector()
predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")

while cap.isOpened():
    ret, frame = cap.read()
    if not ret:
        break

    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    faces = detector(gray)

    for face in faces:
        shape = predictor(gray, face)
        shape = face_utils.shape_to_np(shape)

        for (x, y) in shape:
            cv2.circle(frame, (x, y), 1, (0, 255, 0), -1)

    cv2.imshow("Frame", frame)

    # Break out of the loop when 'q' key is pressed
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break
```



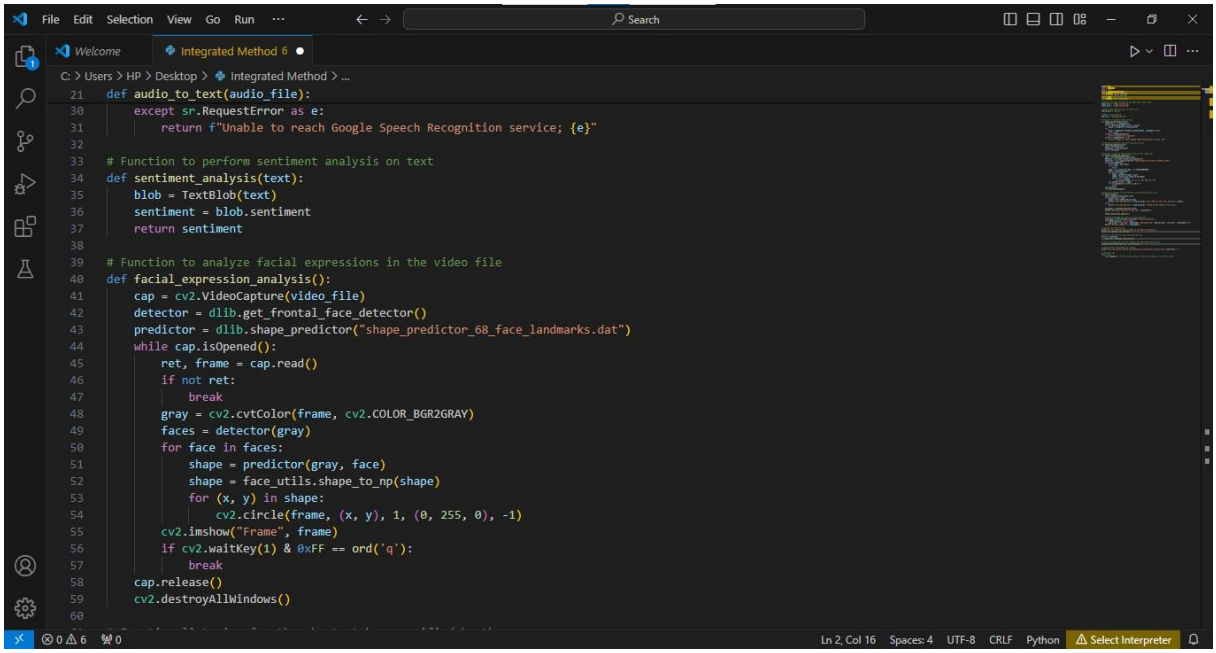
```python
while cap.isOpened():

    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    faces = detector(gray)

    for face in faces:
        shape = predictor(gray, face)
        shape = face_utils.shape_to_np(shape)

        for (x, y) in shape:
            cv2.circle(frame, (x, y), 1, (0, 255, 0), -1)

    cv2.imshow("Frame", frame)

    # Break out of the loop when 'q' key is pressed
    if cv2.waitKey(1) & 0xFF == ord('q'):
        break

cap.release()
cv2.destroyAllWindows()
```

Integrated Method

By integrating both audio and visual data analysis, we can perform a more comprehensive analysis in digital forensics studies. Here is a piece of code that implements this integrated method:

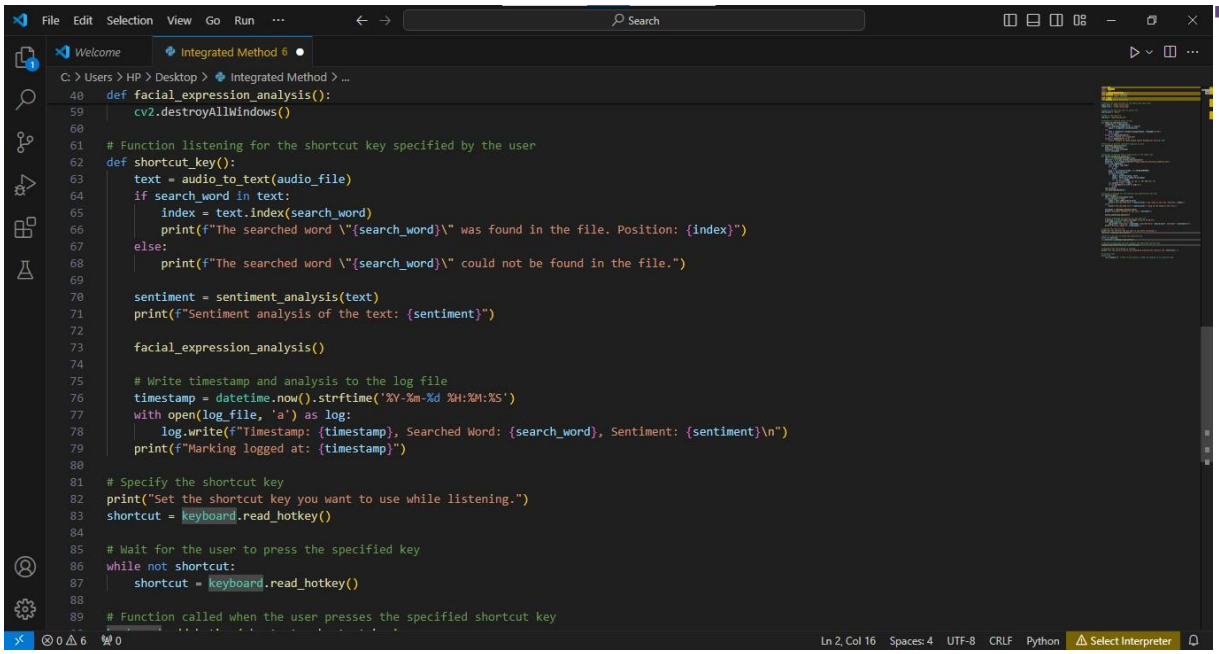


```python
import cv2
import keyboard
import time
import speech_recognition as sr
from textblob import TextBlob
from datetime import datetime
import dlib
from imutils import face_utils

# Specify the name and path of the audio and video files
audio_file = "audio_record.wav"
video_file = "video_record.mp4"

# Specify the word you want to search for
search_word = "hello"

# Name of the log file
log_file = "marking_log.txt"

# Function to convert audio to text
def audio_to_text(audio_file):
    recognizer = sr.Recognizer()
    with sr.AudioFile(audio_file) as source:
        audio = recognizer.record(source)
    try:
        text = recognizer.recognize_google(audio, language="en-US")
        return text
    except sr.UnknownValueError:
        return "Speech not recognized"
    except sr.RequestError as e:
        return f"Unable to reach Google Speech Recognition service; {e}"
```

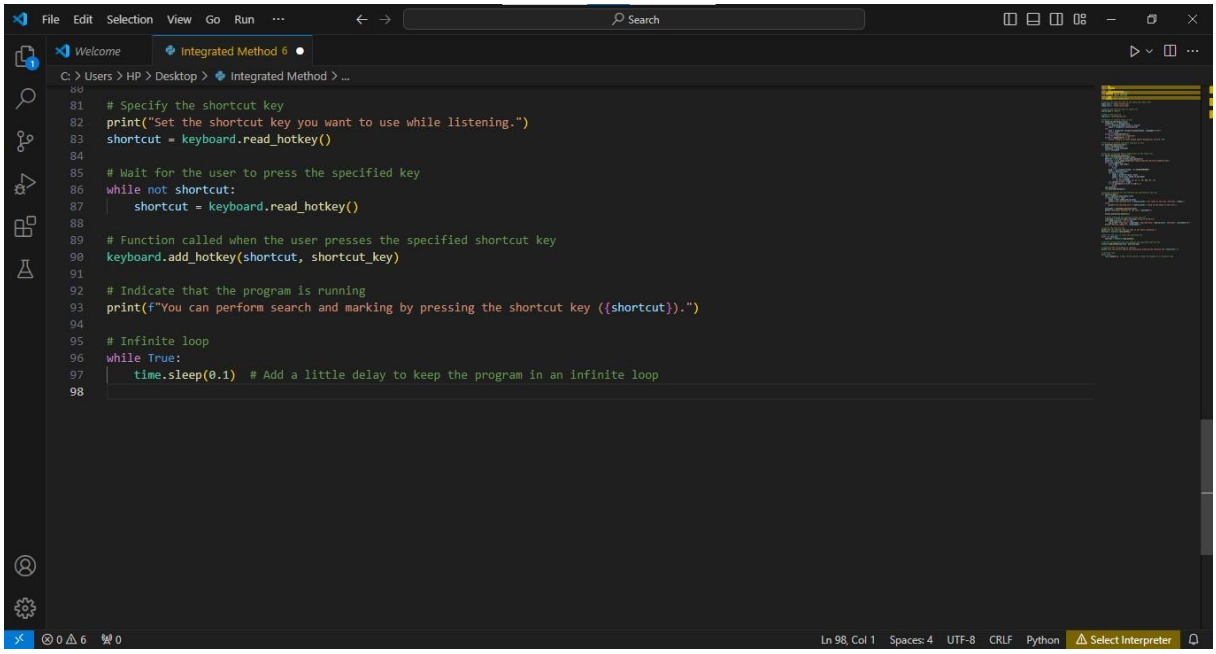


```python
def audio_to_text(audio_file):
    except sr.RequestError as e:
        return f"Unable to reach Google Speech Recognition service; {e}"

# Function to perform sentiment analysis on text
def sentiment_analysis(text):
    blob = TextBlob(text)
    sentiment = blob.sentiment
    return sentiment

# Function to analyze facial expressions in the video file
def facial_expression_analysis():
    cap = cv2.VideoCapture(video_file)
    detector = dlib.get_frontal_face_detector()
    predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")
    while cap.isOpened():
        ret, frame = cap.read()
        if not ret:
            break
        gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
        faces = detector(gray)
        for face in faces:
            shape = predictor(gray, face)
            shape = face_utils.shape_to_np(shape)
            for (x, y) in shape:
                cv2.circle(frame, (x, y), 1, (0, 255, 0), -1)
        cv2.imshow("Frame", frame)
        if cv2.waitKey(1) & 0xFF == ord('q'):
            break
    cap.release()
    cv2.destroyAllWindows()
```

https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191



```
def facial_expression_analysis():
    cv2.destroyAllWindows()

# Function listening for the shortcut key specified by the user
def shortcut_key():
    text = audio_to_text(audio_file)
    if search_word in text:
        index = text.index(search_word)
        print(f"The searched word \"{search_word}\" was found in the file. Position: {index}")
    else:
        print(f"The searched word \"{search_word}\" could not be found in the file.")

    sentiment = sentiment_analysis(text)
    print(f"Sentiment analysis of the text: {sentiment}")

    facial_expression_analysis()

    # Write timestamp and analysis to the log file
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(log_file, 'a') as log:
        log.write(f"Timestamp: {timestamp}, Searched Word: {search_word}, Sentiment: {sentiment}\n")
    print(f"Marking logged at: {timestamp}")

# Specify the shortcut key
print("Set the shortcut key you want to use while listening.")
shortcut = keyboard.read_hotkey()

# Wait for the user to press the specified key
while not shortcut:
    shortcut = keyboard.read_hotkey()

# Function called when the user presses the specified shortcut key
```



```
# Specify the shortcut key
print("Set the shortcut key you want to use while listening.")
shortcut = keyboard.read_hotkey()

# Wait for the user to press the specified key
while not shortcut:
    shortcut = keyboard.read_hotkey()

# Function called when the user presses the specified shortcut key
keyboard.add_hotkey(shortcut, shortcut_key)

# Indicate that the program is running
print(f"You can perform search and marking by pressing the shortcut key ({shortcut}).")

# Infinite loop
while True:
    time.sleep(0.1)  # Add a little delay to keep the program in an infinite loop
```

Integrated Audio and Visual Data Analysis:

- **Advantages:** Analyzes both audio and visual data to provide more comprehensive information. This allows for more detailed and multi-dimensional examination of evidence.
- **Disadvantages:** More complex and computationally intensive, requiring more processing power and time. Additionally, the setup and maintenance of integrated analysis systems can be more costly and complicated.

Marking Analyzed Locations:

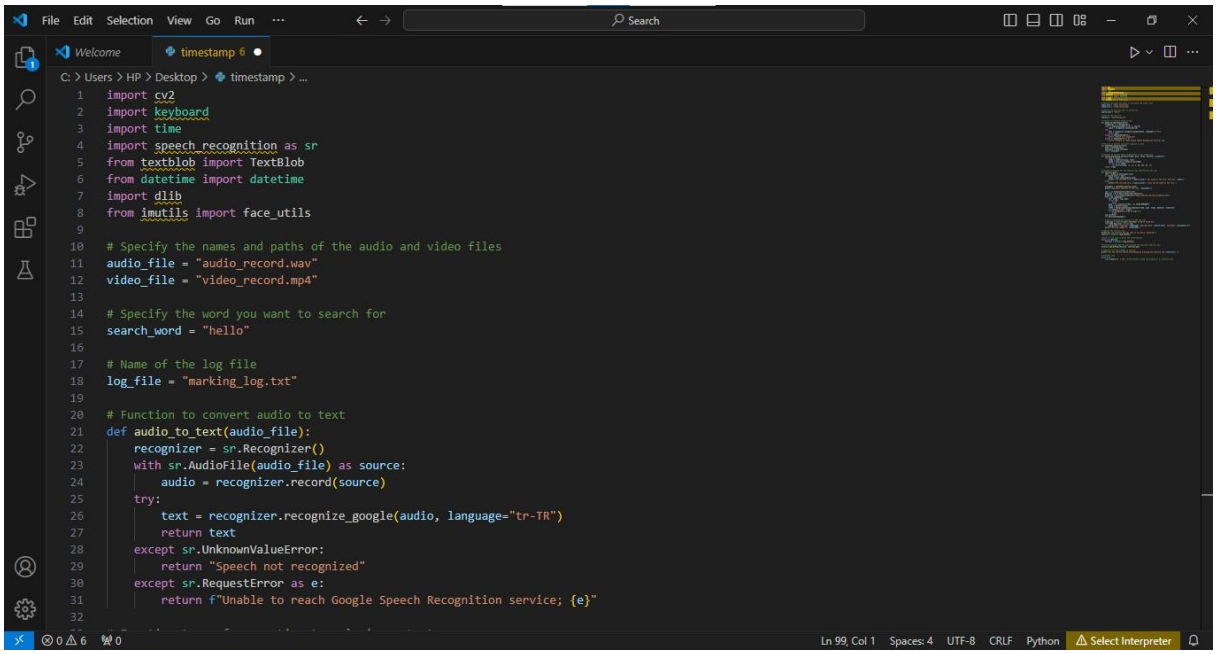
This involves logging timestamps and analysis results of specific events or expressions in the analyzed video or audio recordings. This way, locations where specific events or expressions occur are marked.

Technical Details

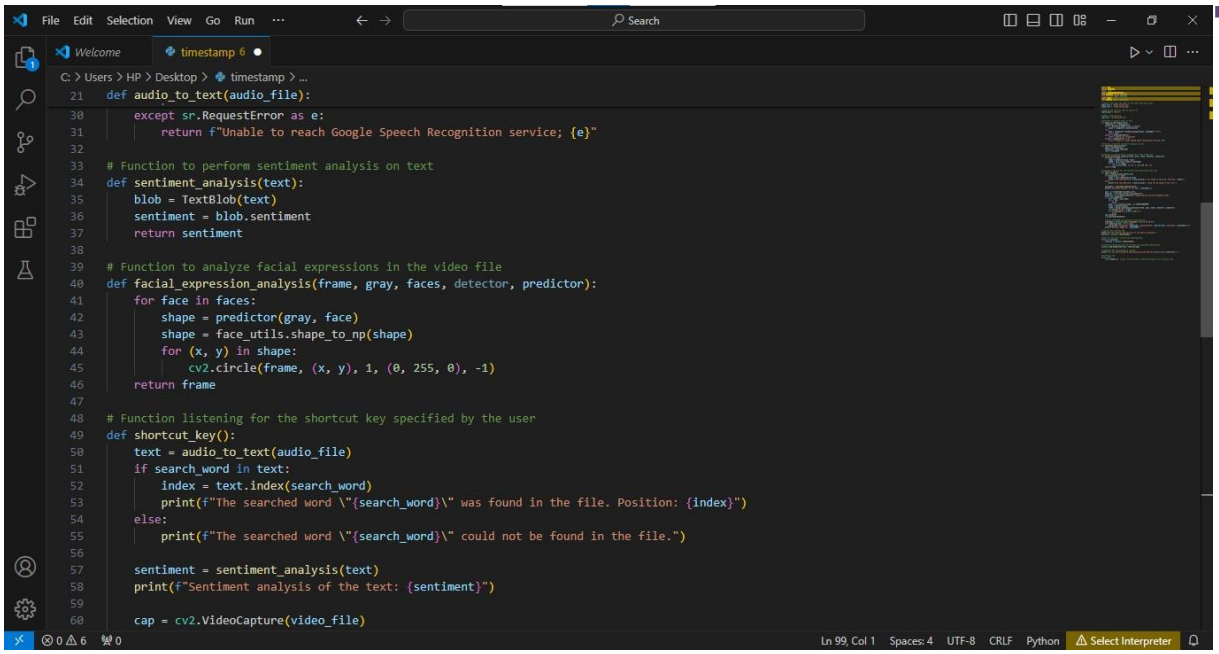
1. **Audio Recognition and Sentiment Analysis:**
    - We can log timestamps and sentiment analysis results where specific keywords occur.
2. **Visual Data Analysis (Facial Expression and Movement Analysis):**
    - We can log timestamps where specific facial expressions or movements are detected in the video recordings.

Code Example:

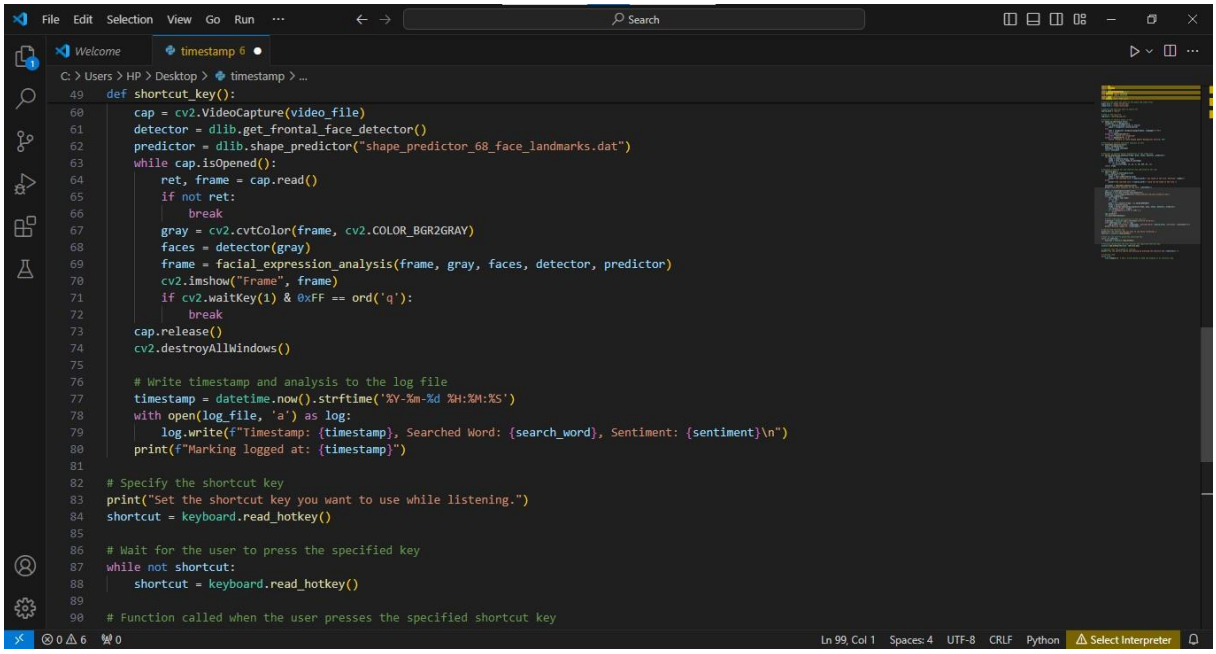
Below is an example of Python code that does these markups. This code detects certain words and facial expressions and records timestamps in the log file.



https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191

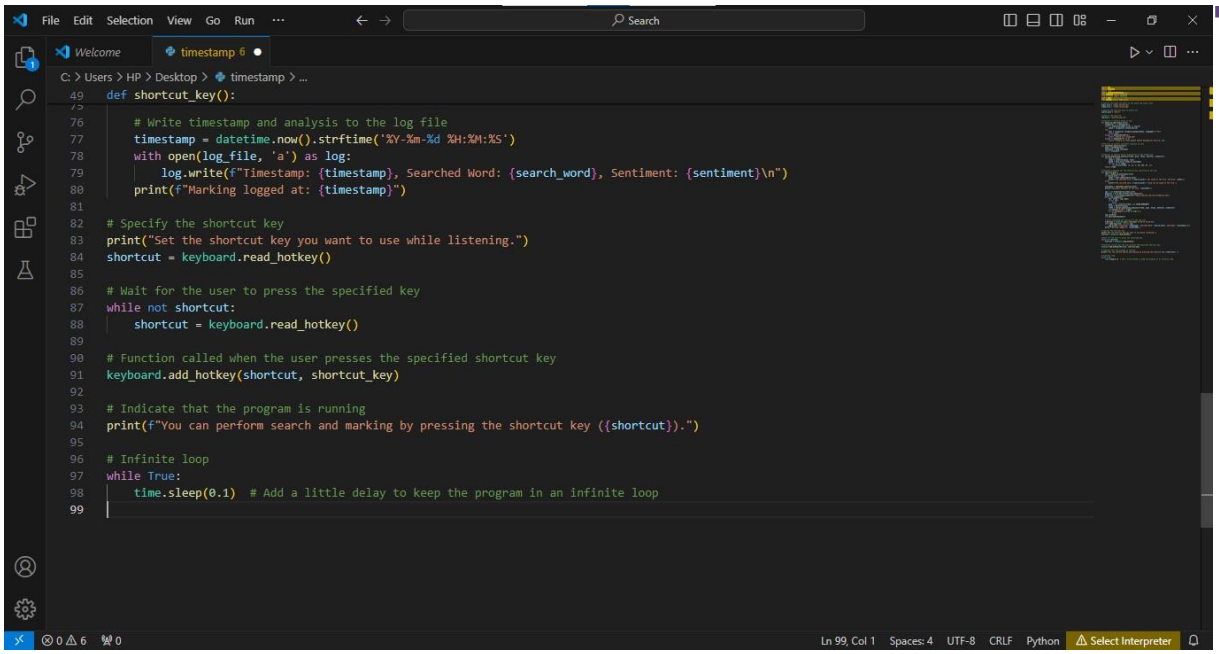


```
def audio_to_text(audio_file):
    except sr.RequestError as e:
        return f"Unable to reach Google Speech Recognition service; {e}"

# Function to perform sentiment analysis on text
def sentiment_analysis(text):
    blob = TextBlob(text)
    sentiment = blob.sentiment
    return sentiment

# Function to analyze facial expressions in the video file
def facial_expression_analysis(frame, gray, faces, detector, predictor):
    for face in faces:
        shape = predictor(gray, face)
        shape = face_utils.shape_to_np(shape)
        for (x, y) in shape:
            cv2.circle(frame, (x, y), 1, (0, 255, 0), -1)
    return frame

# Function listening for the shortcut key specified by the user
def shortcut_key():
    text = audio_to_text(audio_file)
    if search_word in text:
        index = text.index(search_word)
        print(f"The searched word \"{search_word}\" was found in the file. Position: {index}")
    else:
        print(f"The searched word \"{search_word}\" could not be found in the file.")

    sentiment = sentiment_analysis(text)
    print(f"Sentiment analysis of the text: {sentiment}")

    cap = cv2.VideoCapture(video_file)
```



```
def shortcut_key():
    cap = cv2.VideoCapture(video_file)
    detector = dlib.get_frontal_face_detector()
    predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")
    while cap.isOpened():
        ret, frame = cap.read()
        if not ret:
            break
        gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
        faces = detector(gray)
        frame = facial_expression_analysis(frame, gray, faces, detector, predictor)
        cv2.imshow("Frame", frame)
        if cv2.waitKey(1) & 0xFF == ord('q'):
            break
    cap.release()
    cv2.destroyAllWindows()

    # Write timestamp and analysis to the log file
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(log_file, 'a') as log:
        log.write(f"Timestamp: {timestamp}, Searched Word: {search_word}, Sentiment: {sentiment}\n")
    print(f"Marking logged at: {timestamp}")

# Specify the shortcut key
print("Set the shortcut key you want to use while listening.")
shortcut = keyboard.read_hotkey()

# Wait for the user to press the specified key
while not shortcut:
    shortcut = keyboard.read_hotkey()

# Function called when the user presses the specified shortcut key
```

https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191



Explanation

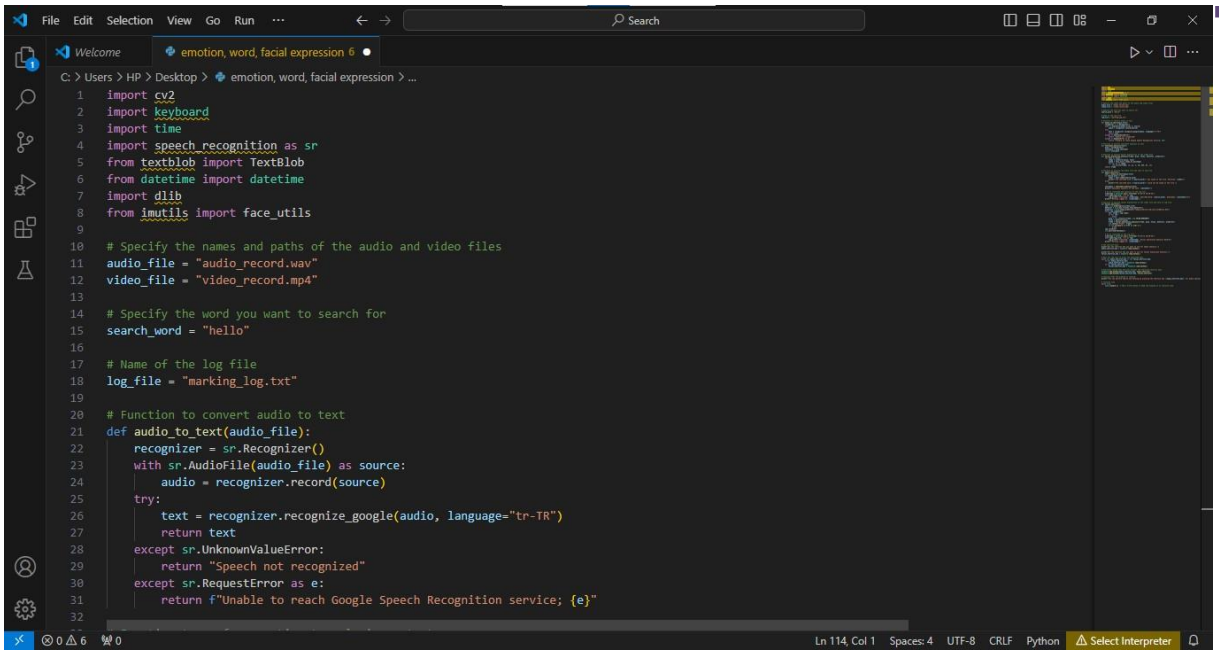
- **Audio Recognition and Sentiment Analysis:** The `convert_audio_to_text` and `sentiment_analysis` functions analyze specific keywords and emotional tones in audio recordings.
- **Facial Expression Analysis:** The `facial_expression_analysis` function analyzes facial expressions in video recordings and marks specific facial points.
- **Shortcut-Based Marking:** When the user presses a predefined shortcut key, the analysis results and timestamps are logged into a file.

This integrated method allows for a more comprehensive analysis of audio and video recordings in forensic investigations. By detecting specific keywords and emotional tones through audio recognition and sentiment analysis, and marking body language and movements through facial expression analysis, more reliable and detailed results can be achieved in evidence evaluation.

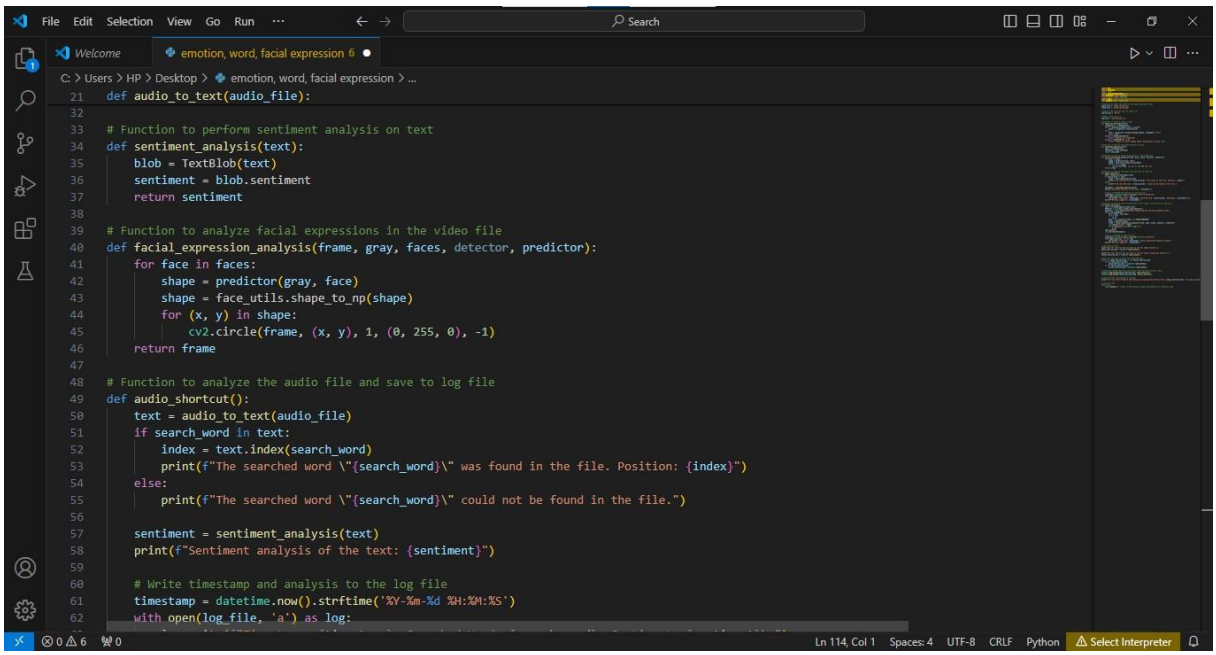
The applicability of this method is crucial for increasing the accuracy and effectiveness of evidence analysis in digital forensics. Shortcut-based marking ensures that analyzed events and statements are logged with timestamps, making the evidence more organized and accessible.

We can also create shortcuts for facial expression and movement analysis. Thus, when the user detects certain facial expressions or movements, he can mark these detections by pressing a certain shortcut and save them in the log file.

Below is a sample Python code with shortcuts created for emotion, word, facial expression, and gesture analysis:

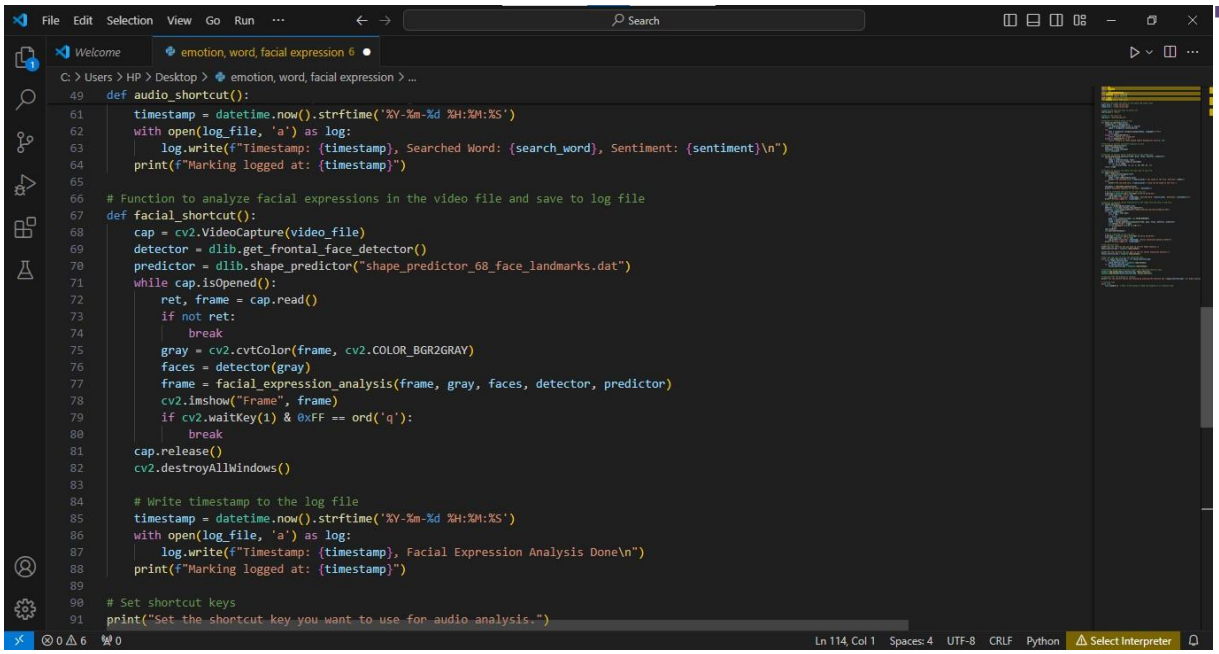


```python
import cv2
import keyboard
import time
import speech_recognition as sr
from textblob import TextBlob
from datetime import datetime
import dlib
from imutils import face_utils

# Specify the names and paths of the audio and video files
audio_file = "audio_record.wav"
video_file = "video_record.mp4"

# Specify the word you want to search for
search_word = "hello"

# Name of the log file
log_file = "marking_log.txt"

# Function to convert audio to text
def audio_to_text(audio_file):
    recognizer = sr.Recognizer()
    with sr.AudioFile(audio_file) as source:
        audio = recognizer.record(source)
    try:
        text = recognizer.recognize_google(audio, language="tr-TR")
        return text
    except sr.UnknownValueError:
        return "Speech not recognized"
    except sr.RequestError as e:
        return f"Unable to reach Google Speech Recognition service; {e}"
```

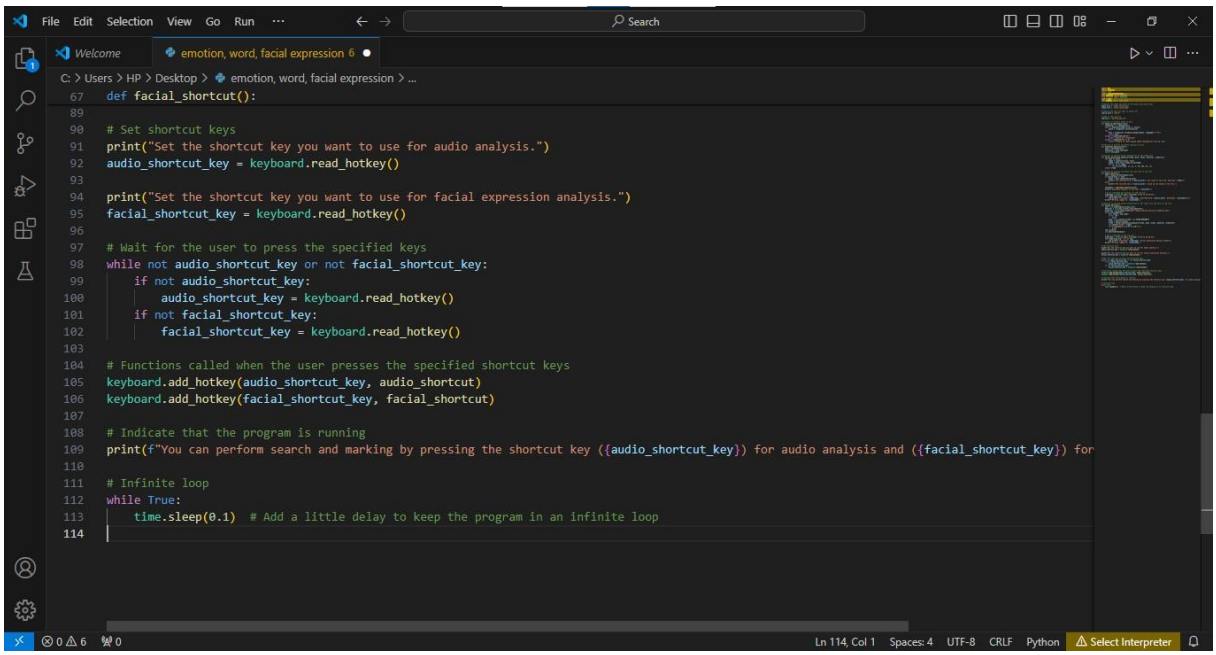


```python
def audio_to_text(audio_file):

# Function to perform sentiment analysis on text
def sentiment_analysis(text):
    blob = TextBlob(text)
    sentiment = blob.sentiment
    return sentiment

# Function to analyze facial expressions in the video file
def facial_expression_analysis(frame, gray, faces, detector, predictor):
    for face in faces:
        shape = predictor(gray, face)
        shape = face_utils.shape_to_np(shape)
        for (x, y) in shape:
            cv2.circle(frame, (x, y), 1, (0, 255, 0), -1)
    return frame

# Function to analyze the audio file and save to log file
def audio_shortcut():
    text = audio_to_text(audio_file)
    if search_word in text:
        index = text.index(search_word)
        print(f"The searched word \"{search_word}\" was found in the file. Position: {index}")
    else:
        print(f"The searched word \"{search_word}\" could not be found in the file.")

    sentiment = sentiment_analysis(text)
    print(f"Sentiment analysis of the text: {sentiment}")

    # Write timestamp and analysis to the log file
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(log_file, 'a') as log:
```

https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191



```python
def audio_shortcut():
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(log_file, 'a') as log:
        log.write(f"Timestamp: {timestamp}, Searched Word: {search_word}, Sentiment: {sentiment}\n")
    print(f"Marking logged at: {timestamp}")

# Function to analyze facial expressions in the video file and save to log file
def facial_shortcut():
    cap = cv2.VideoCapture(video_file)
    detector = dlib.get_frontal_face_detector()
    predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")
    while cap.isOpened():
        ret, frame = cap.read()
        if not ret:
            break
        gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
        faces = detector(gray)
        frame = facial_expression_analysis(frame, gray, faces, detector, predictor)
        cv2.imshow("Frame", frame)
        if cv2.waitKey(1) & 0xFF == ord('q'):
            break
    cap.release()
    cv2.destroyAllWindows()

    # Write timestamp to the log file
    timestamp = datetime.now().strftime('%Y-%m-%d %H:%M:%S')
    with open(log_file, 'a') as log:
        log.write(f"Timestamp: {timestamp}, Facial Expression Analysis Done\n")
    print(f"Marking logged at: {timestamp}")

# Set shortcut keys
print("Set the shortcut key you want to use for audio analysis.")
```



```python
def facial_shortcut():

    # Set shortcut keys
    print("Set the shortcut key you want to use for audio analysis.")
    audio_shortcut_key = keyboard.read_hotkey()

    print("Set the shortcut key you want to use for facial expression analysis.")
    facial_shortcut_key = keyboard.read_hotkey()

    # Wait for the user to press the specified keys
    while not audio_shortcut_key or not facial_shortcut_key:
        if not audio_shortcut_key:
            audio_shortcut_key = keyboard.read_hotkey()
        if not facial_shortcut_key:
            facial_shortcut_key = keyboard.read_hotkey()

    # Functions called when the user presses the specified shortcut keys
    keyboard.add_hotkey(audio_shortcut_key, audio_shortcut)
    keyboard.add_hotkey(facial_shortcut_key, facial_shortcut)

    # Indicate that the program is running
    print(f"You can perform search and marking by pressing the shortcut key ({audio_shortcut_key}) for audio analysis and ({facial_shortcut_key}) for

    # Infinite loop
    while True:
        time.sleep(0.1)  # Add a little delay to keep the program in an infinite loop
```

Explanation

- **Audio Recognition and Sentiment Analysis Shortcut:** The `audio_shortcut_function` analyzes an audio file when the user presses the designated shortcut key, logging specific keywords and emotional tones to the log file.
- **Facial Expression Analysis Shortcut:** The `facial_shortcut_function` analyzes facial expressions in a video file when the user presses the designated shortcut key, logging the results to the log file.

Usage

https://doi.org/10.33774/coe-2024-r7mc2 **ORCID:** https://orcid.org/0009-0008-4985-7191

1. When you start the program, you will be prompted to set shortcut keys for audio analysis and facial expression analysis.
2. Pressing the designated shortcut keys will trigger the respective analyses, and the results will be logged to a file.
3. The log file will contain timestamps and results of the analyses.

This way you can mark both words and facial expressions and save the analysis results in the log file. This method enables more effective analysis of evidence in computer forensics.

The use of such shortcut-based methods by forensic experts or experts in examining digital evidence can speed up analysis processes and make them more efficient. Here are the steps you can follow to actively use this type of system and how to use the relevant tools:

Step 1: Installing the Software

First, make sure the software is installed correctly and the necessary libraries are loaded. For this, install the following Python libraries:

pip install keyboard speechrecognition textblob dlib opencv-python imutils

Step 2: Preparing the Software

Save the Python code provided above to a file (for example, forensics_analysis.py). The code contains the necessary functions to analyze audio and video and prompts the user to specify specific hotkeys.

Step 3: Determining Shortcuts

When you start the program, the user is prompted to specify two separate hotkeys for voice analysis and facial expression analysis. For example, Ctrl+Shift+S can be used for voice analysis and Ctrl+Shift+Y for facial expression analysis.

Step 4: Analysis Process

When the specified shortcut keys are pressed, the relevant analysis process is performed and the results are saved in the log file. This file provides a reference point that the expert can refer to when analyzing the evidence.

Technical Description

1. **Audio Analysis Shortcut:**
    - When the user presses the designated shortcut for audio analysis, the `audio_to_text` function analyzes the audio file.
    - Specific keywords and emotional tones within the text are detected, and along with timestamps, they are logged into a log file.
2. **Facial Expression Analysis Shortcut:**

- Upon pressing the designated shortcut for facial expression analysis, the `facial_expression_analysis` function analyzes the video file.
- Specific facial expressions and movements are detected, and along with timestamps, they are logged into a log file.

By implementing these shortcuts, users can efficiently analyze both audio and video files, extracting valuable insights such as specific keywords, emotional tones from audio, and facial expressions from videos. The logged results, along with timestamps, provide a comprehensive record for forensic analysis.

Example Usage Scenario

1. **Preparation of Audio and Video Files:**

    - Place the audio and video files to be analyzed into an appropriate folder.
    - Ensure that the paths for `audio_file` and `video_file` variables are correctly set.

2. **Running the Program:**

    - Run the Python file: `python forensic_analysis.py`
    - The program will prompt you to set two shortcut keys for audio and facial expression analyses. Assign these shortcut keys.

3. **Using the Shortcut Keys:**

    - Perform the respective analyses by pressing the designated shortcut keys. For example:
    - Pressing the shortcut key for audio analysis will trigger the analysis of specific keywords and emotions in the audio file, which will be logged into a log file.
    - Pressing the shortcut key for facial expression analysis will trigger the analysis of facial expressions in the video file, and the results will be logged into a log file.

This workflow facilitates the efficient analysis of both audio and video files in forensic investigations. The use of shortcut keys streamlines the process, allowing for quick and convenient access to analysis results.

Examining the Log File

The log file contains the timestamps and results of the analyzes performed. This dossier helps experts better understand the timing and context of the events being analyzed.

Timestamp: 2024-05-29 14:30:00, Searched Word: "hello", Sentiment: Sentiment(polarity=0.5, subjectivity=0.6) Timestamp: 2024-05-29 14:32:00, Facial Expression Analysis Done

Digital Evidence Examination Scenario

Scenario 1: Detection of Critical Words in Audio Recording

- **Situation:** An expert witness needs to identify critical words in a suspicious phone call during a fraud investigation.
- **Method:** Launch the program and set a shortcut for the critical word "money" in the audio recording.
- **Procedure:** Press the shortcut to identify the occurrences of the word "money" and the emotional tone of the conversation, which will be logged.
- **Outcome:** Points where the critical word is mentioned and the tone of the conversation are presented to the expert witness.

Scenario 2: Facial Expression Detection in Video Recordings

- **Situation:** Specific facial expressions of a suspect are to be examined in an interrogation video.
- **Method:** The expert launches the program and sets a shortcut for facial expression analysis.
- **Procedure:** While analyzing the suspect's facial expressions, the expert presses the shortcut to record the detected facial expressions in a log file.
- **Outcome:** Timestamps of detected facial expressions are presented to the expert witness.

These scenarios demonstrate how the program can be utilized to efficiently analyze digital evidence, providing valuable insights for forensic investigations.

From a Legal Perspective:

When evaluating the potential positive and negative aspects of shortcut-based voice recognition, emotion analysis, and body language assessment methods from a legal standpoint:

Positive Aspects

1. **Speed and Efficiency:**
    - **Advantage:** Shortcut-based methods quickly conduct voice and video analysis, thereby expediting investigative processes.
    - **Legal Implication:** Swift analyses facilitate faster examination and presentation of evidence in court, contributing to the swift administration of justice.
2. **Accuracy and Reliability:**
    - **Advantage:** Automated analysis systems minimize human error and provide more consistent results.
    - **Legal Implication:** Objective and accurate evidence examination enables stronger and more reliable evidence presentations in court.

3. **Comprehensive Analysis:**

    - **Advantage:** Conducting voice recognition, emotion analysis, and body language assessment together allows for a multidimensional evidence examination.
    - **Legal Implication:** This method enables a more comprehensive and holistic evidence evaluation, facilitating detailed and convincing evidence presentations in cases.

4. **User-Friendliness:**

    - **Advantage:** User-defined shortcuts facilitate easy and quick analysis.
    - **Legal Implication:** Assists forensic experts and digital forensic professionals in conducting analysis processes more efficiently and user-friendly.

Negative Aspects

1. **Risk of Faulty Analysis:**

    - **Disadvantage:** Voice recognition and emotion analysis technologies may not guarantee 100% accuracy and may produce false positive or false negative results.
    - **Legal Implication:** Incorrect analyses can lead to erroneous evidence presentations and, consequently, miscarriages of justice, negatively impacting the course of cases.

2. **Dependency on Technology:**

    - **Disadvantage:** The effectiveness of the method depends on the accuracy and currency of the technology used.
    - **Legal Implication:** Technological malfunctions or software updates may disrupt analysis processes and raise questions about reliability.

3. **Privacy and Security:**

    - **Disadvantage:** Processing of personal data during the analysis of voice and video recordings poses risks to privacy and data security.
    - **Legal Implication:** Non-compliance with legal regulations concerning the protection of personal data and privacy may lead to legal issues and sanctions.

4. **Legal Acceptance:**

    - **Disadvantage:** Acceptance of new technologies as evidence in courts may take time and require legal procedures.
    - **Legal Implication:** Court acceptance of new technologies and validation of their validity may require lengthy and complex legal processes.

Conclusion and Recommendations:

- **Positive Aspects:** Shortcut-based voice recognition, emotion analysis, and body language assessment methods offer advantages in terms of speed, accuracy, and comprehensive analysis in forensic processes.
- **Negative Aspects:** Challenges include the risk of faulty analysis, technology dependency, privacy and security concerns, and the legal acceptance process.

In light of these assessments, efforts should be made to increase the accuracy rates, strengthen security measures, and ensure compliance with legal processes to garner wider acceptance of the method in the legal field. Additionally, completing the necessary legal procedures to validate and establish the validity of these new methods in legal systems is essential.

Discussion and Conclusion:

When it comes to the reliability of working with libraries in forensic analysis of audio and video, there are various advantages and considerations that need to be taken into account.

Advantages

1. **Rapid Development:**
    - Existing libraries expedite the development process and provide essential functionalities.
    - These libraries often contain reusable code snippets, saving time in development.
2. **Community and Support:**
    - Popular libraries usually have a large community of developers providing support.
    - Assistance can be sought from the community when encountering issues, and they are typically well-documented.
3. **Updates and Maintenance:**
    - Actively developed libraries receive regular updates.
    - These updates include security patches and performance enhancements.
4. **Accuracy and Performance:**
    - Especially in the realm of audio and video processing, libraries have undergone years of development and optimization.
    - They generally offer high accuracy and performance.

Considerations and Risks

1. **Security Risks:**

- Libraries may have security vulnerabilities, especially those that are not regularly updated or maintained.
- Conducting security scans and analyses when using external libraries is crucial.

2. **Dependencies:**

   - Using numerous libraries increases project dependencies and management complexity.
   - Updating one library may affect others and lead to conflicts.

3. **Performance Issues:**

   - Libraries may introduce unnecessary overhead or excessive computational load in certain cases.
   - Particularly large and complex libraries may cause performance issues.

4. **Licensing and Legal Concerns:**

   - The license terms of libraries should be carefully examined.
   - Incorrect usage of licenses can lead to legal issues.

Working with libraries offers significant advantages in audio and video analysis in forensic computing. However, attention must be paid to security, performance, and compliance considerations.

Looking ahead, as technology progresses, the role of this technology in forensic computing is expected to expand further. Future developments could include:

- **Enhanced Speech Recognition Technologies:** Advances in speech recognition technologies will provide more accurate and reliable speech-to-text conversion, enabling more effective operation of speech-based search algorithms.
- **Integration of Artificial Intelligence and Machine Learning:** Increased use of artificial intelligence and machine learning techniques can further enhance speech-based search algorithms. For example, deep learning models can be used to better understand and analyze complex audio files.
- **Faster and More Efficient Algorithms:** Advanced algorithms can make speech-based search algorithms faster and more efficient. This can enable faster searches in large datasets and allow forensic experts to work more effectively.
- **Multilingual Support:** In the future, speech-based search algorithms may support more languages. This can facilitate the analysis of audio files in different geographical regions and languages.
- **Security and Privacy Improvements:** Speech-based search algorithms and speech recognition systems can be equipped with better security and privacy measures. This ensures the secure processing and protection of sensitive data. These developments could make speech-based search technologies more effective in forensic investigations, leading to more accurate and efficient execution of forensic investigations.

REFERENCES:

1. Henkoğlu, T. (2020). Computer forensics: Obtaining and analyzing digital evidence. Compass.

2. Özen, M., & Özocak, G. (2015). Legal Regime of Search and Seizure Measures in Forensic Information Technology, Electronic Evidence and Computers (CMK Art. 134). Ankara Bar Association Journal, (1).