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Song Recommendation Based on Mood using Viola–Jones and Local Binary Pattern Algorithms

By

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Abstract

The brain shapes our emotions or moods and assigns an emotional value from the signals it receives, which are manifested through our faces. When we are happy, angry, sad, and confused, our face exudes these emotions better than our actions. Conversely, music is an effective antidote for our melancholy and a powerful amplifier of feelings. In this study, the user will take a picture of his current mood, and the system will recommend a song to play based on the facial expression it analyzed. Thus, a desktop-based machine learning application. The algorithm used for face detection is the Viola-Jones algorithm, while Local Binary Pattern Algorithms detect emotion based on the picture taken. Viola-Jones algorithm employs three object detection techniques, making it more precise in providing an accurate numerical description of what sets the human face apart from other objects in the photograph taken. Moreover, besides producing multiple detections, the algorithm has a post-processing step that reduces detection redundancy. After extracting the facial features, the following process is image classification. During the classification phase, the faces are compared with the trained data. After the user's emotion is recognized, the system recommends a suitable song the user could listen to. This study focuses on the accuracy of both Viola–Jones and Local Binary Pattern Algorithms regarding detecting the face and selecting the music to play. The preciseness of identifying the expression is largely dependent on the effectiveness of preprocessing the raw image; hence, the Local Binary Pattern algorithm, aside from the lighting condition and the weightings of different parts of the face. It is concluded therefore, that both algorithms are precise in the song recommendation based on the user's mood as depicted in the photo taken.

Keywords: recommender, facial expression, face detection, face extraction, Local Binary Pattern algorithm, Viola-Jones Algorithm, machine learning.

Introduction

Song recommendation systems have become increasingly popular in recent years due to the growing amount of music available and the desire for personalized music experiences. Traditional approaches for music recommendation systems involve analyzing users' listening habits and preferences. Still, in recent times, researchers have been exploring new ways to recommend music based on visual cues like facial expressions.

Facial expression recognition has become a popular area of research in computer vision, and the Viola-Jones algorithm is one of the most widely used algorithms in this field. Viola-Jones algorithm is a real-time face detection algorithm that uses Haar-like features and AdaBoost classifiers to identify facial detection. This algorithm has been used in various human-computer interactions, surveillance systems, and image-processing applications. On the other hand, a common texture descriptor in computer vision applications like facial recognition is called Local Binary Patterns (LBP). A feature extraction technique called LBP compares each pixel's intensity to that of its neighbors to represent the texture of a picture. The comparison outcome is then converted into a binary integer, which gives each pixel its texture pattern. Because it can record the textural features and facial expressions crucial for differentiating people, LBP is very effective at recognizing faces. A compact and discriminative representation of each face can be made by removing LBP features from facial photos. This method has been proven to work well in various facial recognition applications, such as access control, surveillance systems, and biometric identity.

By utilizing the Viola-Jones algorithm and Local Binary Patterns for face detection and facial expression recognition, it is possible to predict an individual's emotional state based on their facial expression and recommend music that fits the mood. For instance, if the algorithm detects a person is smiling, it could recommend an upbeat or happy song. In contrast, if the algorithm detects a person is frowning, it could suggest more calming or soothing music.

The use of facial expressions for music recommendation systems has great potential, as it could provide a more personalized and enjoyable experience for music listeners. Moreover, this approach can also be helpful in music therapy, where music improves mental health and emotional well-being.

In this context, this study aims to explore the potential of using the Viola-Jones algorithm for facial expression recognition and integrating it with music recommendation systems. Combining these two fields makes it possible to create an innovative music recommendation system that can provide an emotionally intelligent and personalized music experience.

Many application software has been made for many different reasons. With the advent of machine learning applications, face detection has been applied to more fields, like the most common of all, security. Face detection and recognition have been used in many areas, from identity verification to opening applications. This and more continue to emerge, and developers continue enhancing our daily lives. All developers of apps have but one goal, to ease the task of our daily undertakings, mostly to alleviate our activities from basic to complex ones. On the other hand, music is dubbed as the food of the soul, the language of feeling; it could either ameliorate or turn up our melancholy. When someone is in sorrow, music eases the pain, calms the mind, and comforts our troubles.

One could be happy if an app pulls out music depending on that person's mood. This is mainly the reason why this research has been realized, but with more emphasis on the speed, the mood detected, and the accuracy of the song match, thus the algorithms Viola-Jones and Local Binary Pattern. Based on four(4) moods, happy, sad, angry, and fear, a person can take a photo of themselves using a webcam, and the picture will be analyzed, and the app will play a song based on the detected mood.

Face detection algorithms are powerful for recognizing and locating human faces in digital media. As this technology continues to advance, it is likely to significantly impact a wide range of industries and fields.

Related studies

There definitely are existing studies and apps like this; however, as mentioned earlier, the focus of this is more on the use of the algorithms Viola-Jones and Local binary pattern, the first being the algorithm used to detect the face and the latter as the algorithm used to detect the emotion. A face recognition system has three main phases: capturing the face from a web camera, face feature extraction, and face recognition.

The processes of detection and recognition are distinct. Face detection is a computer technology that uses Artificial Intelligence (AI) to discover and recognize human faces in digital photographs. This technology counts the number of faces in a picture or video without memorizing or storing specifics, which is an essential component of face recognition. It may specify some demographic information, such as age or gender, but it cannot identify specific people.

Face recognition compares a face in a photo with a database of trained images to identify it. Faces must be entered into the system to build a database of distinctive facial traits. After then, the system separates a new image into its essential components and compares them to the trained data in the database.

There are, however, challenges in the detection process, factors like skin color, illumination, lighting environment, and such.

Researchers Yong and Yanru[2017] showed that the variation in skin color is evident under various lighting conditions. This issue is resolved using the technical basis of two skin color space illumination. The skin color model is used to differentiate between different skin tones. It efficiently reduces the effect of light on skin tone, making it easier to recognize and place through their classifier. The findings of the comparative experiment demonstrate that the approach is highly robust during the experiment, the experiment's rapid detection speed, and the outcomes of the face detection and positioning are excellent. Based on the influence of various illumination effects, Yong investigates the impact of face recognition in an uncontrolled lighting environment. Thus, the lighting condition influences the success rate when the picture is taken.

Refat and Azlan[2019]added that deep earning is a practical approach for challenging feature object detection. However, all face expression models at the time were based on the training of the data for deep learning took too long. Hence, there is a need to create a new model that could lessen Real-time processing and the time spent on training data sets.

Given the prevalence of challenges over the different face recognition algorithms, the Viola-Jones algorithm was developed. Despite its outdated framework, its use in real-time face identification has shown to be highly significant, and its power is quite impressive. According to Winarno[2018], one of the greatest in terms of detecting efficiency to work speed is Viola-Jones. This is why Viola-Jones was selected as the research approach. The Viola-Jones face detection method yields the highest precision results based on the experiments. Viola and Jones have provided an object detection method that minimizes computing time while obtaining good detection accuracy.

Another algorithm used is the Local Binary Pattern(LBP) which is used for emotion recognition. The algorithm is known for its benefits, such as its tolerance of monotonic illumination changes and its computational simplicity; the Local Binary Pattern (LBP) has been successfully used for many different image analysis tasks, including facial image analysis, biomedical image analysis, aerial image analysis, motion analysis, and image and video retrieval (Huang, et. Al). However, the study mentioned that the limited 3x3 neighborhood of the primary LBP operator is one of its limitations because it is unable to capture dominating characteristics with large-scale structures.

Facial expression identification still depends on knowing how to combine feature extraction and classification, and research into this topic has been going on for years. Based on Kasim, et. Al[2017] research, even the best classifier may not achieve accurate recognition if insufficient characteristics are used. As a result, Local Binary Pattern (LBP) is employed as a feature extraction method for the recognition of facial expressions, where it is assessed using local statistical features. The most recent study has shown that LBP is an effective technique since it is quick, discriminative, and resilient to low-resolution images.

Automatic facial expression analysis is a fascinating and challenging topic with essential applications in many fields, including data-driven animation and human-computer interaction. The study of Shan, et. al [2002] suggested that, for suitable facial expression identification, it is imperative to create an accurate facial representation from the source photos. The study experimentally assesses the facial model for person-independent facial expression identification based on local statistical features, Local Binary Patterns. On numerous databases, various machine learning techniques are methodically examined. Multiple types of research reveal that LBP characteristics are helpful and efficient for identifying facial expressions.

Applications for recognizing facial expressions call for precise, quick algorithms that can operate in real-time on platforms with constrained CPU power. The research of Gogic, et al.[2020] provided an algorithm that straddles the line between rapid but less accurate approaches and accurate but slow methods. The technique combines neural networks and soft boost decision trees. The mild boost decision trees are trained for each fundamental facial emotion to generate highly discriminative feature vectors (Local Binary Features) surrounding specific face landmark points.

Facial image analysis offers an excellent illustration of LBP's use, development, and performance since it is the most prevalent and significant application of LBP. In the study by Huang et al.[2011], the conclusion was drawn after a thorough overview: that the (1) local or component-oriented LBP representations are efficient representations for facial image analysis because they encode the information of facial configuration while providing local structure patterns; 2) since the local- or component-oriented LBP facial representations considerably lengthen features, feature selection is particularly crucial for a variety of applications in facial image analysis. Sing, et. al [2015] LBP is a highly effective way to describe the model and texture of a digital image. As a result, it was ideal for facial recognition systems' feature extraction. A facial appearance is first divided into smaller sections from which LBP histograms are extracted to create a single feature vector. This vector effectively represents the face region and can be used to compare how similar the two photos are.

The studies indicate that in terms of face detection, Viola-Jones has reached satisfactory and more correct results. As to face recognition, it has been found that the Local Binary Pattern is a practical feature for classifying textures.

Design and methodology

This section describes how the system works, from training data sets to the detection and recognition of the face.

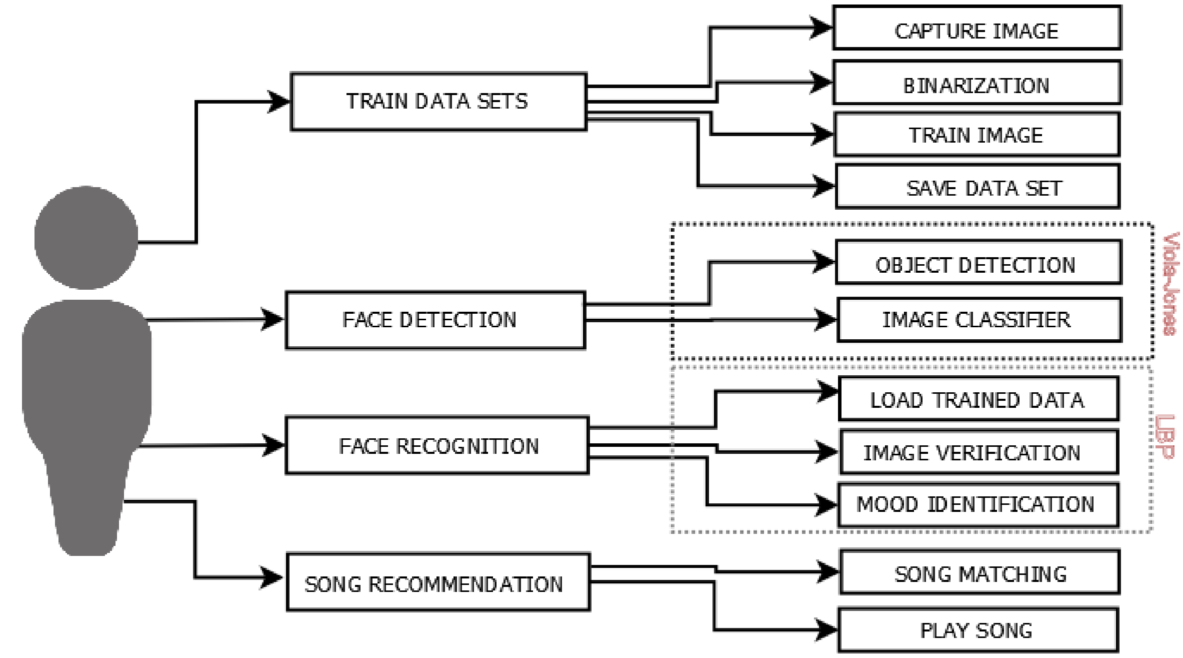

Figure 1: *Use-Case Diagram*

Figure 1 shows how the application software works. The user will take a picture of himself in several poses for each mood (happy, angry, sad, and fearful). The photo taken go through the binarization process, thus, splitting data into two groups and giving each group's members one of two values. This is often done by creating a threshold and providing all the data points below the threshold the value 0 and those above the threshold the value 1. Next is training the image; this is the subset of the actual dataset that the machine learning model uses to find and learn patterns. The first phase of the actual process is face detection. There are two(2) stages of the Viola-Jones Algorithm. First is the detection process, preferably performed in the training data sets phase. Viola-Jones works by converting the image into a grayscale before a face is detected since it is simpler to deal with and requires less processing power. The Viola-Jones algorithm locates the position on the colored image after first identifying the face on the grayscale image. Viola-Jones draws a box and looks inside it for a face. In essence, it is looking for these characteristics of the haar-like feature. After passing through each tile in the image, the box advances one step to the right. Several boxes detect facial features (Haar-like features) in more minor phases, and the data from all of those boxes together aids the algorithm in locating the face. The haar-like feature shows a box with a light side and a dark side, which is how the machine determines the feature. As with the edge of an eyebrow, there are occasions when one side is lighter than the other. It is possible for the center section to occasionally shine more brightly than the surrounding boxes, giving the impression of a face feature, e.g., the nose. The advantages of this algorithm include: detection based on features rather than pixels, integration picture calculation, Using a version, AdaBoost classifier, or learning algorithm; only significant features are discovered from varying quantities of features, and better detection rates can be achieved by combining multiple weak classifiers to create a robust classifier. In this process, images are classified based on the importance of simple features since feature-based systems operate more quickly than pixel-based systems.

The next part of the process is face recognition or verification, which has two(2) phases: feature extraction and classification. Feature extraction may be in terms of the movement, shape, and location of facial muscles and main organs like eyes, cheeks, nose lining, and lips. Local binary patterns can be expanded to depict faces and are primarily used for texture identification. Most significantly, they can recognize features that indicate the different textures of faces through facial emotions or movements. The local binary pattern operator is a type of image operator that converts a picture into a small-scale array of integer labels. These patterns' statistics use a histogram, which is then examined further. Numerous variations of the LBP operator are available for analyzing volumetric data, movies, and still images in monochrome and color. The process begins by loading the trained data set to which the new image taken will be compared. After loading the trained data of the images initially taken, is the preprocessing of face photos or the image verification. The main goal of preprocessing is to produce a pure facial expression image with normalized intensity and homogeneity in shape and size. Another effective technique for classifying samples with several features in the classification phase is using neural networks. They use a back propagation approach to train each layer effectively over several repetitions, reducing classification error and increasing adherence to the proper class. Here, a learning algorithm is used to recognize face and non-face classes and train to recognize the Haar features that identify the face portion of an image. This algorithm's extraordinarily large number of characteristics produces a small sub-window.

Since expression photos are rarely static, face expression analysis, which is based mainly on the feature texture of regions, requires that the features remain invariant to rotation. Natural patterns' local patterns have less variability and are thought to be uniform. Additionally, they give statistical representations resilience, making them exceedingly efficient theoretically in terms of comparison and computational cost. According to Ojala et al., LBP has effectively depicted flat sections, edges, spots, corners, and line ends. The Haar Cascade classifier analyzes the collected image to determine whether or not a face is there. If the face is missing, an error is shown in the user interface; otherwise, the image is transmitted to the trained model, which will identify the emotion. As soon as emotion is identified, it is displayed on the screen, and at the same time, using the emotion, The system then searches for songs in the database, matches the mood to the song, and plays the music.

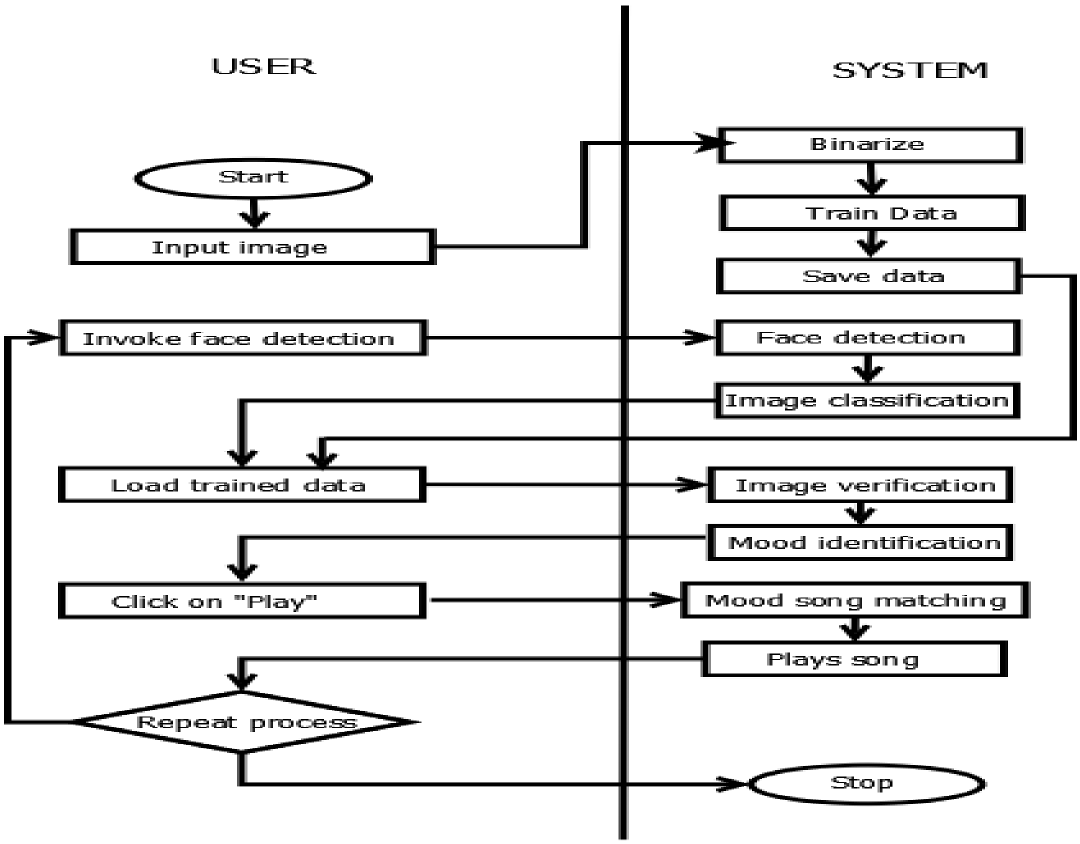

Figure 2. *Activity Diagram*

The figure on the previous page indicates the program flow and the execution of the process, as depicted earlier. The app will display a button to invoke the camera and take a picture. Once the user has set the photo, it will be loaded into the memory for binarization. After training the data, the initial data set is introduced as machine learning models to generate predictions. The prepared data set will then be stored in the database or as a file. On the screen display is another button to click so that the face detection process will commence; after the face is detected in the classification process. The software may categorize a user's emotion into four(4) moods: happy, sad, angry, and fearful. The system will prompt the screen for the user to load train data sets and then verify the photo taken from the trained data, followed by song matching, wherein the application then makes song recommendations to the user based on their emotional state. There are currently 20 songs in the data set. Following identifying the user's mood, the app plays the song from the collection associated with that feeling and plays the music.

Happy	Sad	Angry	Fear

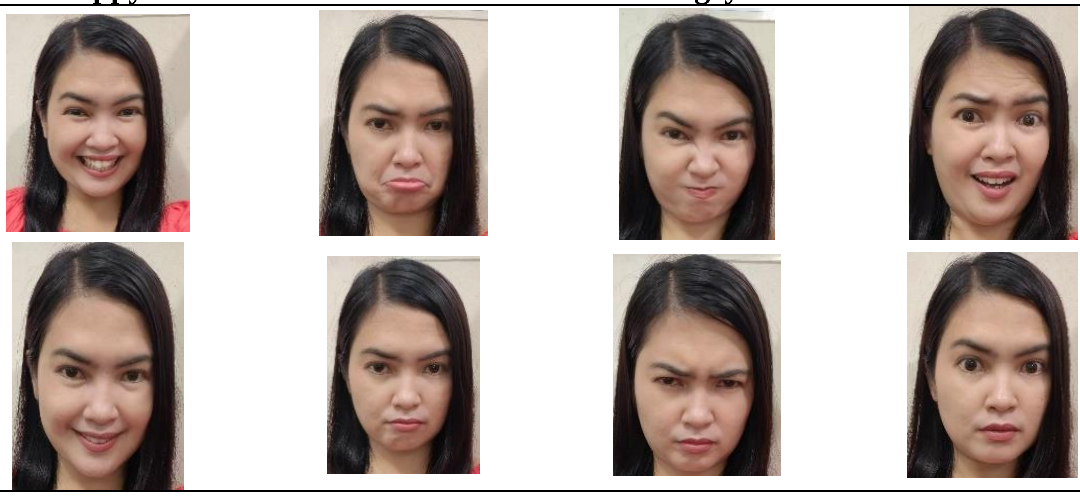

Figure 3. *The data set of Moods*

An artificial intelligence task called image recognition aims to examine an image and categorize the objects in it according to their respective categories. The training stage of image recognition is the main topic of this article. For the model to function properly, training is essential. According to artificial intelligence and machine learning, a newly installed and configured application needs to be trained on a specific number of labeled samples in order to acquire the ability to recognize the objects in an image. Since it mimics the functioning of the human brain, it must produce outcomes that are equal to or superior to those produced by a person. In order to train your object detection model from scratch, you need an appropriate image database. Once your data has been entered, a particular format must be followed. Your machine learning application needs to be able to grasp all image formats in order to function. The system will find it difficult and time-consuming to process anything if the picture quality or dimensions fluctuate too much.

After formatting is finished, the model must detect what kinds of things need to be identified and categorized. Image recognition applications frequently employ face detection and identification techniques. This will be necessary when you train your app. The Image Recognition application can be deployed if the results are satisfactory following the training of all these layers on the training data. A factor you should take into account is that your app will perform and be more accurate the longer you train your model.

In figure 3, various facial expressions or moods were shown, trained, and stored in the computer's memory.

Input photo	Face Detection	Mood Identification	Song

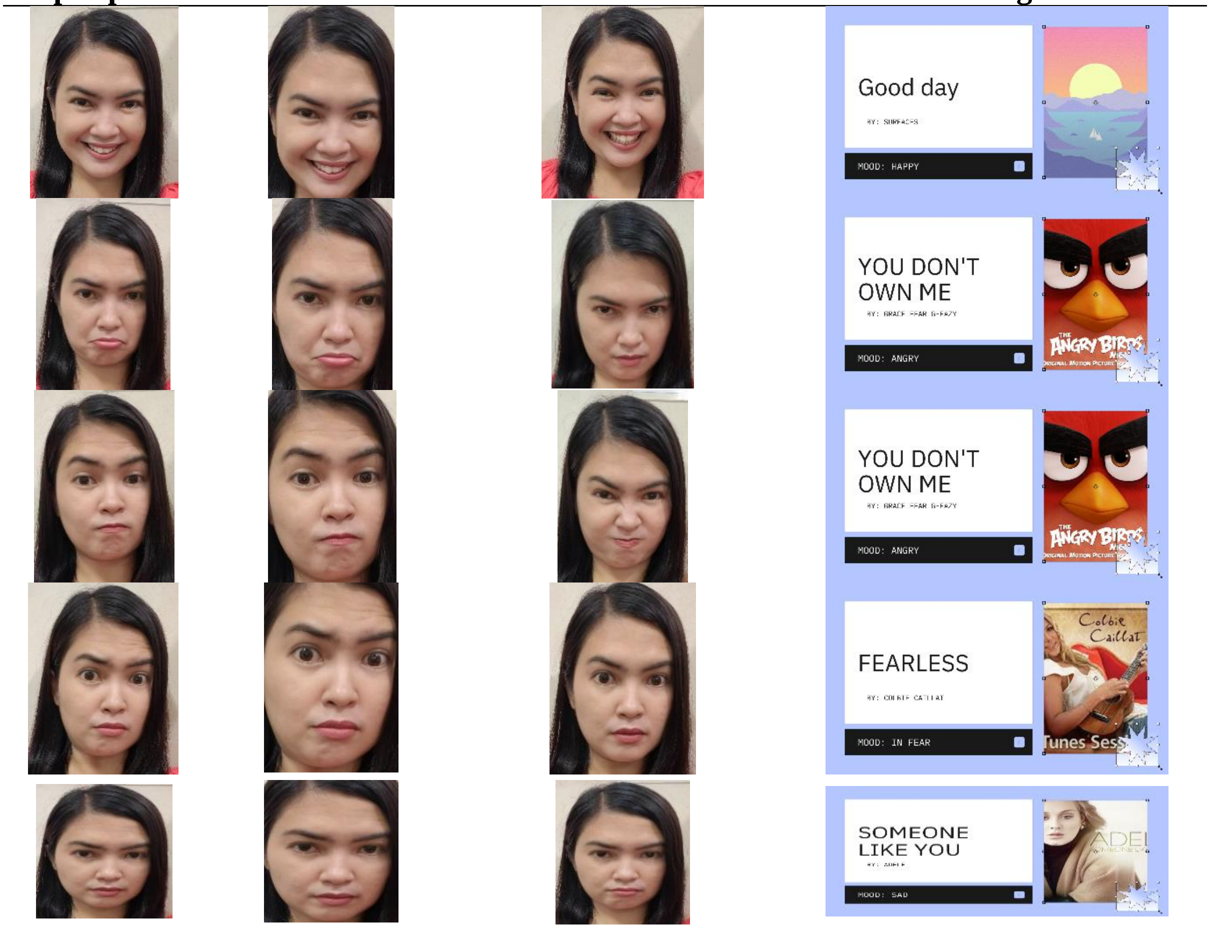

Figure 4. *Facial Recognition and Song Recommendation*

As shown in figure 4, the "sad" mood was retested since the system recommended the incorrect song. Hence, the result was correct the second time.

Results and Discussion

The computer vision community has paid much attention to the complicated job of face identification and recognition. Several variables, including image quality, illumination, and occlusions, can affect the outcomes of face detection and identification algorithms. Nevertheless, face detection and identification systems have performed exceptionally well recently because of advancements in machine learning and deep learning techniques. The Viola-Jones algorithm has been a popular technique for face detection since it can accurately and quickly identify faces in real time. The Viola-Jones algorithm, however, might have trouble identifying faces that are partially obscured or have unusual orientations. Local binary patterns (LBP) have been demonstrated to be an efficient feature descriptor for face recognition that can capture the textural details and facial emotions critical for person identification. Nevertheless, issues including differences in position, lighting, and facial emotions may provide problems for face recognition systems. To sum up, while face detection and identification algorithms have advanced significantly in recent years, more work needs to be done to meet the difficulties presented by real-world circumstances.

Table 1. *Accuracy Results of the App*

Facial Expression	Songs Played	Accuracy
Happy 5 photos	5	100%
Angry 3 photos	2	67%
Sad 5 photos	4	80%

We combine computer vision, machine learning, and deep learning techniques into the application software to detect facial emotion and make music recommendations based on it. The strategy aims to learn the most suitable feature abstraction using deep learning techniques.

In the table shown, we took photo shots and invoked face detection. On the first test, five (5) happy faces were successively taken; the application also played five songs corresponding accurately to the mood detected. However, when angry facial expressions were tested, out of three (3) photos, the system played to songs correctly, resulting in a specificity percentage of 67%. This was because the photo taken did not have the same illumination, and lighting conditions were the trained data., photo quality and the lighting setting affect the detection and recognition process. As to the angry mood, three (3) photos were taken, and only four(4) were precisely played. The third photo was taken with the face of the subject looking sideways. Viola-Jones is better able to detect frontal faces than faces gazing sideways, above, or downwards because it was created for frontal faces. The image is changed to grayscale before a face is detected since it is simpler to deal with and requires less processing power.

Conclusion

Based on the given information, it can be concluded that the face detection algorithm performed well in detecting happy faces and accurately recommended songs that corresponded to the mood detected. However, when angry facial expressions were tested, the algorithm's accuracy was lower, resulting in a specificity percentage of 67%. This was because the photo taken did not have the same illumination and lighting conditions as the trained data, indicating that the quality of the image and the lighting setting can affect the detection and recognition process. Furthermore, the algorithm had difficulty detecting faces that were not frontal, such as faces gazing sideways, above, or downwards, as it was created primarily for frontal faces. However, the algorithm was able to detect faces accurately when the image was converted to grayscale, indicating that more straightforward image processing methods can result in improved performance. Overall, these results suggest that further improvements are needed to enhance the accuracy and robustness of face detection and recognition algorithms in real-world scenarios with varying illumination, pose, and expression.

In conclusion, the Viola-Jones algorithm was specifically designed for detecting frontal faces, and it has been shown to be particularly effective in this regard. However, the performance of Viola-Jones can be limited when it comes to detecting faces that are not in a frontal position, such as sideways, upwards, or downwards. Therefore, while Viola-Jones is a robust face detection algorithm for frontal faces, it may not be the most suitable option for non-frontal face detection applications. In such cases, researchers may need to consider alternative face detection algorithms that can handle non-frontal faces more effectively. Nevertheless, Viola-Jones remains a popular and widely-used face detection algorithm. Its success in detecting frontal faces has contributed significantly to the development of face detection and recognition systems.

Although, notably, there are advantages of using the Viola-Jones algorithm, to wit, rapid detection; easy comprehension and application; fewer training data are required than for other machine learning models, images don't need to be resized, and a lot easier to interpret than modern models. And in the case of the Local Binary Pattern, the robustness of the LBP operator to monotonic gray-scale changes brought by, for instance, changes in illumination may be its most crucial characteristic in real-world applications. Additionally, it has a high ability to discriminate simple computation, invariance to changes in grayscale, and is vital in performance. Its computational simplicity, which enables picture analysis in difficult real-time conditions, is another crucial characteristic.

Recommendation

As for the drawbacks, LBP is not rotation-invariant, and in addition, the size of the features grows exponentially with the number of neighbors, increasing the computational complexity in terms of time and space, and the amount of structural information it can capture is constrained. The magnitude of information is discarded, and only the pixel difference is used.

Based on the observed data, it is recommended that future research focus on addressing the limitations of LBP for face recognition. To improve the invariance to rotations, new feature extraction techniques can be explored that take into account the rotation and orientation of the facial features. In addition, to reduce the computational complexity of LBP, new feature extraction techniques can be developed that capture more structural information while using fewer features. This can lead to faster and more efficient feature extraction, which is critical for real-time face recognition applications. Moreover, new feature extraction techniques can be developed that capture both pixel difference and magnitude of information, which can result in more robust and accurate feature representations. Overall, by addressing the limitations of LBP, researchers can improve the performance and efficiency of face recognition systems and enable more precise and reliable facial recognition in real-world scenarios.

On the other hand, Viola-Jones’ intelligent feature selection and scale-locating invariant detector of Viola-Jones are just two of its many benefits. Instead of scaling the image itself, it can scale the features. It can be trained to recognize other objects, such as cars because the detection strategy is universal. However, it has its drawbacks too. Tilted or rotated faces are harder to identify using this algorithm. Due to sub-windows overlapping, there may be varying detections of the identical face because it is sensitive to lighting circumstances. Viola-Jones is only better at detecting frontal faces than faces gazing sideways, above, or downwards because it was created for frontal faces. Additionally, there is difficulty identifying face features due to various corruption (illumination, noise, occlusion), and also because of the complicated background, features are difficult to discern.

Therefore it is highly recommended that future research focus on developing new face-detection algorithms that can address Viola-Jones' limitations. To improve the detection of tilted or turned faces, new algorithms can be developed that take into account the pose and orientation of the face and handle non-frontal faces more effectively. Additionally, to address the sensitivity of Viola-Jones to lighting conditions, new algorithms can be developed that can handle variations in lighting and can detect faces more accurately under different illumination conditions. Moreover, to reduce the possibility of various detections of the same face, new algorithms can be developed that incorporate more advanced window selection techniques and reduce the overlap of sub-windows. Overall, the development of new face detection algorithms can improve the accuracy and robustness of face detection systems and enable more effective and reliable face recognition in real-world scenarios. Therefore, researchers should continue exploring and developing new face-detection algorithms that can overcome Viola-Jones' limitations and improve the performance and efficiency of face-detection and recognition systems.

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