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Installation of IR Camera in Smart Watches for Facial Expression Recognition

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Abstract— IR camera, with its various advantages, can be found in many different fields. The most important application of an IR camera is that it can be used even in the dark, unlike an ordinary camera. Using this plus point, we can integrate this with other technologies to help us locate obstacles in the dark. This is due to the fact that IR cameras can detect heat instead of just capturing and since everything on this planet gives off heat, these IR cameras can detect these obstacles. Many methods have been implemented to deal with such problems but there are not easily available and are quite expensive. IR camera have been used in as surveillance cameras and also in movies to make the inanimate idealistic. However, they have not been integrated with smart watches which are easily available nowadays and are much cheaper than any other alternatives. The idea is to integrate this IR camera with a smart watch that would make it portable and easy to use anywhere. Not only is this technology aimed to help the general public but also the blind. Detection of any facial expression would alert the watch wearer that someone is in vicinity. Since IR camera can sense heat, they would be better recognizers of different expressions. This would not only allow them to navigate on their own, but also inform about the whereabouts of the user to their close friends and family in case of emergency.

Keywords— IR camera, smart watch, GPS, Blender animation, 3D face matchmaking, MATLAB.

1. INTRODUCTION

With progress in computing and telecommunication technologies, digital images and video are playing key roles in the present information era. Human face is a salient biomeric entity in image and video databases of surveillance systems [15]. Facial emotions or expressions are a form of non-verbal transmission, acknowledging them assists to enhance the human-machine interaction [1] [11]. In a world full of technologies, any task from reading the news to having things delivered at your doorstep has us depending on technology. Life now without technology renders us helpless. Having said that, there are various technologies that can simply be modified into a better version instead of creating something anew. IR cameras have been used in various fields for various purposes but have never been used repetitively in our day-to-day lives. Film industries, securities cameras, and facial expression based emoticons have one thing in common - IR camera but never has it ever been integrated with a daily used gadget such as a smart watch. Now, the purpose of integrating an IR camera is that it gives more features to a smart watch such as allowing it to recognize a person’s emotions based on the camera’s ability to sense heat. This can help not only the common people but also the blind. Now, a blind person who needs help would like to approach a friendly, likable person. This set-up can recognize the expression of the person in front of the user and notify the user. In that way it would become easier for a blind person to ask for help. IR cameras are not only good at sensing heat given off by the living but also by any non living object. So any blind person can detect both living and non living things. Another scenario where this set-up can be used is in the dark. No girl likes to travel alone in the dark. Now this set-up can help such people by alerting their close friends and families about their location every now and then. There will be a GPS tracker in the set-
up which will locate the current location of the user and will directly forwarded to their close friends and families in the case of emergency. IR camera has been used in distinct ways and has been used for recognizing the facial expressions as discussed in section II.

2. RELATED WORK

Procuring an image can be accomplished by digitally scanning an existing photograph (2D) or by using a video image to procure a live picture of a subject (3D). Once it identifies a face, the set-up determines the head’s position, size and pose. The system then measures the curves of the face on a sub-millimeter (or microwave) scale and creates a template. Matching- If the image is 3D and the database contains 3d images, then corresponding will take place without any changes are made to the image.

However, there is a summons currently facing databases that are still in 2d images. 3D provides a live, moving variable subject being estimated to a flat, stable image. New technology is addressing this challenge. When a 3D facade is taken, different point (usually three) are identified. For example, the eye’s outside, the eye’s inside and the tip of the nose will be pulled out and measured. Once those measurements are in place, an algorithm (a step-by-step procedure) will be applied to the image to convert it to a 2D façade. After conversion, the software will then collate the image with the 2D images in the database to find a potential complement [10].

The Texas 3D face recognition database will be a valuable resource to the 3D face recognition research community [13]. Currently, it is the largest publicly available database of 3D facial images acquired using a stereo imaging system [1]. The database holds 1149 3D models of 118 adult human subjects. The set of images of each subject varies from 1 per subject to 89 per subject. The subjects’ ages range from ~ 22-75 years. The database encompasses images of both males and females from the major ethnic groups of Caucasians, Africans, Asians, East Indians, and Hispanics!

![3D face reconstruction in existing model](image)

Fig. 1: 3D face reconstruction in existing model

In the diagram above, it is seen that three different expressions – surprised (surprised mean model or SMM), neutral (neutral mean model or NMM), and happy (happy mean model or HMM) are constructed with depth maps [13].

In this section, person-independent facial expression recognition was executed based on the proposed method in the previous section. For this experiment, a subset of the Radboud database with seven different facial expressions at five different poses (-0, -45, 0, +45, and +90 degrees) were used for testing images. The radboud faces database included 20 Caucasian male adults, 19 Caucasian female adults, 18 Moroccan male adults, 6 Caucasian female children and 4 Caucasian male children and
face images of each person were expressed with three different gaze directions. The seven expressions encompassed neutral, sad, angry, fearful, disgusted, happy and surprised.

Local Phase Quantization (LPQ) + proposed method. In this method, instead of the LBP operator the LPQ operator was applied to the image for feature extraction [3] [4] [13].

Local Gabor Binary Patterns (LGBP) + proposed method. In this method, instead of the LBP operator the LGBP operator was applied to the image for feature extraction [3] [13].

The faces are in neutral and expressive modes. The facial expressions present are smiling or talking faces with open/closed mouths and/or closed eyes. The neutral faces are emotionless. All subjects were requested to remove hats and eye-glasses prior to image acquisition. The proposed work has been discussed in section III. Please do not revise any of the current designations.

3. PROPOSED MODEL

IR cameras have been used as surveillance cameras and also in movies to make the inanimate idealistic. However, they have not been integrated with smart watches which are easily available nowadays and are much cheaper than any other alternatives.

The idea is to integrate this IR camera with a smart watch that would make it portable and easy to use anywhere. Not only is this technology aimed to help the general public but also the blind.

Detection of any facial expression would alert the watch wearer that someone is in their vicinity. Since IR cameras can sense heat, they would be better recognizers of different expressions. This would not only allow them to navigate on their own, but also inform them about the friendliest looking people to approach in case of an emergency, based on their expressions.

From the figure, it can be seen that the example of facial expression invariant 3D regeneration of a person is developed in blender software with different poses. This image contains the estimated 3D shape and 3D texture models in different new poses from -75 degrees up to +75 degrees. This technology can also be used by the general public at night where a person will be notified of any presence in their surroundings.

Fig. 2: 3D texture mesh of different poses

For example, a girl walking in the night would avoid narrow lanes that are brimming with people but cannot see if there is anyone in that lane due to the absence of light.
A. ADVANTAGES OF PROPOSED MODEL

Unlike the already existing system, we use an IR camera in smart watches. The advantage of using an IR camera is that it will allow blind people to hunch the emotions or facial expressions, not just superficially, but in complete depth since it can track muscle movements due to thermal imaging. The improvement of security level is due to facial recognition system that gives the power to only a certain group of people to handle these important components or parts required by the system [8].

![Fig. 3: A Smart Watch with an IR Camera](image)

From the above figure, the designed smart watch with IR camera will look like an ordinary watch and the IR camera and sensors will be fixed in the fob. IR camera has to keep in such angle so that it can sense the heat of living things as well as non-living things. Once the IR camera will recognize the object then a message will directed to the user through the watch assistant and the user will get to know what sort of object it is. The blind people will recognize the expressions of people and will know the obstacles ahead and be cautious. In case of any emergency, user can start locating their location through GPS tracker which is fixed in the watch, and can contact to their friends and family.

![Fig. 4: Process of face expression recognition (BLOCK DIAGRAM)](image)

The diagram above shows the process of the images of a person taken with different expressions. These images are pre-processed and then a median filter is applied to it so as to make the quality and space less so as to make storage easier as it will take less space but the main features can still be identified even after there is slight clarity decrease. It recognizes the pattern of the face and then the features of the face are extracted. The system is then trained to recognize the various expressions of the person and these expressions are classified into anger, sadness, happiness, disgust and are...
numbered accordingly. The apperception of objects in an image would probably start with image processing techniques such as noise removal, followed by (low-level) feature extraction to locate lines, regions and possibly areas with certain textures and is discussed in section V.

4. **TECHNIQUES**

For facial expression recognition, there are three type of images used in Digital Image Processing. They are: Binary image, Gray Scale image, Color image.

**A. Binary Image**

A binary image is a digital image that has only two feasible values for each pixel. Typically the two colours used for a binary image are black and white though any two colours can be used. The colour utilized for the object(s) in the image is the foreground colour while the rest of the image is the background colour.

**B. Gray Scale Image**

A gray scale Image is a digital image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black-and-white, are composed exclusively of shades of gray (0-255), varying from black (0) at the weakest intensity to white (255) at the strongest.

**C. Colour Image**

A colour image is a digital image that includes colour information for each pixel. Each pixel has a particular value which determines its appearing colour. This value is qualified by three numbers giving the decomposition of the colour in the three primary colours Red, Green and Blue. Any colour visible to human eye can be represented this way [6]. The decomposition of a colour in the three primary colours is quantified by a number between 0 and 255. For example, white will be condensed as \( R = 255, G = 255, B = 255 \); black will be known as \( (R,G,B) = (0,0,0) \); and say, bright pink will be \( (255,0,255) \).

**D. Handle Graphics**

This is the MATLAB graphics set-up. It encompasses high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also encompasses low-level commands that grant to fully personalize the emergence of graphics as well as to build entire graphical user interfaces on your MATLAB applications.

5. **ALGORITHM**

**ACTIVE APPEARANCE MODEL (AAM)**

**A. Description:**

The whole purpose of recognizing human emotions is to allow imitation of these emotions so that it would look more realistic [6][7]. Active Appearance Model is one such algorithm that would help in making this theory practical. This algorithm has significantly increased the accuracy. Like Digital Image Processing that extracts features from a human face, AAM extracts the various human expressions required, such as anger, sadness, disgust, happiness, etc [2][7][9].
B. Input

The pictures of a person with various expressions are taken. Here, we use AAM with point correlation as it is faster.

Let $a(x, y)$ be the Euclidean distance between the point $x$ and $y$. Then the following ratios are to be calculated:

$$A_{mouth} = \frac{d(22,28)}{0.5d(17,20)+0.5d(11,14)}$$

$$A_{eye} = \frac{0.5d(17,20)+0.5d(11,14)}{d(39,36)}$$

$$A_{eyebrows} = \frac{d(4,5)}{d(13,16)}$$

Using these calculations, we can determine that the mouth of a person is usually large when the person is happy or mad and small when the person is surprised. The eyes usually become larger when the person is surprised than it is when a person is happy. The eyebrows are also a way to express emotions as anger would make them contract.

C. Output:

Once the input image is processed and the calculations are made, based on the previous recorded observations and experiments conducted, it can be said whether the person in the given image is angry or sad or happy.

As seen in the diagram, face featuring points are used to mark the features of sample face to track their movements during different expressions.
D. Applications

It has diverse utilization such as Facial gesture recognition [5], Real-time processing solutions and systems, Face-based surveillance, biometrics, and multimedia applications. Face recognition in compressed domain is another application [15].

6. ACKNOWLEDGEMENT

It should use a video-based approach because facial expressions always involve motion and their subtle changes cannot be recognized otherwise [2]. This choice reduces the application areas but the performance improvement obtained is worth it. It should use a 3D model of the face and a feature-based approach, where each facial feature is determined by a set of vertices in the 3D face model.

The eyebrows, the eyes, the nose, the mouth and the chin should at least be tracked. The head silhouette or at least the face bounding itself should be modeled and the orientation and position of the face should be tracked. This information can be used to improve the facial feature tracking procedure and to be used as an additional information source to recognize emotions. Regardless of the facial feature tracking procedure followed, feature-based tracking cannot recognize every subtle facial expression change. Therefore, optical flow or any other motion recognition procedure should be used locally in the surroundings of each facial feature in order to recognize them.

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