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Facial Expression Change Detection Algorithm Using Optical Flow Technique

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Abstract—**This study is aimed to investigate the use of optical flow techniques in detecting changes in facial expressions. A person face expression detection is very important as we can identify a person's emotional and mental state. When communicating with people, human can identify someone's expression accurately compared to computer. Although many approaches are tackled on this topic, there are still several drawbacks and limitations. In order to yield better results, we have applied optical flow technique to detect facial expression. In addition, we have the technique with Horn-Schunck method to optimize the results. Based on the experiment conducted, the average value represented by every facial expression can be identified, and the values are significant for future research that is focused on facial expression classification.**

Keywords- optical flow, Horn-Schunck algorithm, facial expression Introduction

I. INTRODUCTION

The ability to detect changes in facial expressions is very important as we can identify expression and mental conditions of a person. A study by *Mehrabian psychologist* showed that only 7% of information are expressed verbally, 38% from an extended language, such as speech, tone and body language while 55% of information can be identified through facial expressions. Therefore, a lot of important information can be derived through facial expression detection, especially when a person is emotionally and mentally disturbed.

Human facial expression detection is divided into six simple categories, namely sad, happy, angry, surprise and hate. Various studies were conducted using these six categories, especially in image processing and pattern recognition in an effort to improve the present technology. Therefore this technology is widely applied in human-computer interface, computing, intelligent system, security cameras, pattern recognition, psychological analysis, social life, machine vision and social entertainment. With the advent of this technology, users accord with more comfortable life. In designing a system as such, some important aspects should be taken into consideration. Among other aspects that should be looked into are cost of equipment, maintenance cost, database, security level and also its user-friendliness. With those aspects taken into account, the system could have the necessary specifications which will meet consumers' expectations.

Early research by Charles Darwin in his book entitled "The Expression of the Emotion in Man and Animals" stated that emotion or expression defines humans as a species not a culture. In 1969, "Ekman and Friesen" classified emotion in a universal cultural difference which contains six expressions, namely happiness, grief, angry, hatred, shock and fear. Facial expression factor has a high stake value as it can easily be identified. When communicating with people, human can identify someone's expression accurately compared to a computer. Hence, intelligent system component exists in detecting human expression. The computer will be able to achieve accuracy in classifying expressions as good as humans if the algorithm that is used is as if human thought. Although many approaches are tackled on this topic, there are still several drawbacks and limitations. So, to yield better results, researchers use an optical flow technique to detect facial expression during one's disturbed emotions. If this technique is effective in identifying facial expression, it can facilitate and increase the performance of optical flow as one of the techniques that can be used to detect facial expressions. As a result, it can be utilised as the algorithm in future applications involving facial expressions.

II. LITERATURE REVIEW

Facial expression change detection (face expression recognition) has now expanded in many applications especially in security applications. Using a face image as basic image in facial expression change detection has many benefits. One of the benefits is such detection does not need facial change to be drawn or photographed. There are many techniques to find dimensions from images which will be processed, and optical flow is the technique being studied in this research. This

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technique is studied further to measure effectiveness level and capacity of security system and other intelligent applications. A variety of algorithms have been created or developed to fulfil introduction process of facial recognition. The image processing technique of this research is as discussed in the following section.

To resolve problems regarding facial recognition, it should be prioritised because it involves important processes in determining accuracy and how effective is the technique in identifying certain facial expression. Therefore, selecting the appropriate and suitable technique will be discussed in deciding the best method for facial change recognition. Apart from this, in the early 1970, a few researchers conducted studies on human facial expressions. Ekman et al. Posited that there are six (6) universal facial expressions; which are happiness, grief, angry, hatred, shock and fear.

There are various techniques that are applicable to detect changes in facial expressions nowadays. This research uses the Horn-Schunck technique as the major algorithm in detecting the changes in facial expressions. The Horn-Schunck algorithm has many advantages, namely its ability to launch current to images as explained in the book Determining optical flow 'Artificial Intelligence' (1981) in pages 185-203. This ability will minimise distortions or disrode the optic current itself and further enhance the image results being produced.

A. Surveillance Camera

A surveillance camera is one amongst the most extensively used technologies for corporeal security [1]. It also has become an important tool in security and has become a necessity to keep proper check [2]. As the number of surveillance cameras being installed in various fields increased, computational vision based object detection has become vital worldwide. In computer vision, this is the task of finding a given object in an image or video sequence. Several image processing techniques are developed for the detection of different objects from images and video sequences [2]. A video collection device is known as surveillance cameras. Surveillance cameras accomplishments have become intensified most contemporary. The technology has evolved in such a way that, it strives to accomplish automatically by operating via facial expression and emotion recognition using the information in the form of images obtained from a surveillance system. This is known as a group of communication impedimenta devices that cluster image data from a surveillance camera that is installed at specific locations. This transmits the captured images through a wired or wireless communication channel, so that the concerned person can retrieve it [1].

B. Horn-Schunk Optical Flow Algorithm

In this research, we propose an optical flow method for moving images because the characteristics of optical flow are quite robust to abrupt movement [3,4]. Previous research has used optical flow because it enables the extraction of velocity and angle. Hence this technique will calculate the displacement and dense of intensity in each frame in the movement video[4]. The Horn-Schunk algorithm (HS) is one of the classical algorithms in an optical flow due to its reasonable performance and simplicity of the algorithm. This algorithm is based on a differential technique computed by using a gradient constraint (brightness constancy) with a global smoothness to obtain an estimated velocity field [5,6]. In conventional predictive methods for motion estimation, the difference between the current frame and the predicted frame, based on a previous frame (motion vector, or MV), is coded and transmitted; then it is used to reconstruct a higher resolution still image or video sequence from a sequence of low resolution images in achieving super-resolution [7]. Optical flow presents an apparent change of moving object's location or deformation between frames. Optical flow estimation yields a two-dimensional vector field, i.e., motion field, that represents velocities and directions of each point of an image sequence [8,9]. Previous research [10] has compared differential optical flow fields from Horn-Schunck, Lucas Kanade and Brox's warping techniques. The Horn-Schunck algorithm aims for better smoothing effect by providing denser fields compared to others. Within the large range of object displacements, it provides consistent fields of optical flow. However, the fields are very sensitive to errors derived from the variety of their neighboring points [10].

III. METHODOLOGY

This section will explain the different steps required for the facial expression recognition process. The following describes which pictures were used and how they were pre-processed. This will be followed by an explanation about the developed facial expression and interpretation process. The flow chart in Fig. 1 shows the process by which the facial feature extraction process is performed. The format used in processing the raw video file is ".avi" towards behavior classification. The video file chosen being extracted into frames and the Horn-Schunck optical flow is implemented to two different frames of facial expression in order to find the velocity of moving objects.

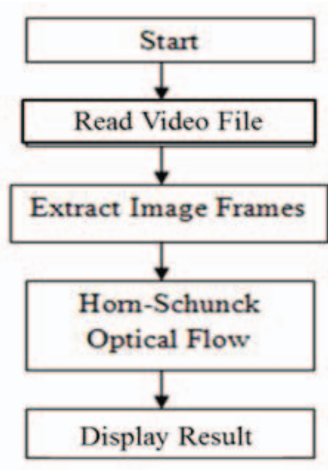


Figure 1. Flow charts of Facial Expression Change Detection

A. Image pre-processing

The facial image pre-processing includes: video of the facial expressions collection and image frame extraction.

Colored images of the facial expressions were then transformed into grayscale images.

B. *Facial feature extraction*

For facial feature extraction, the video file being extracted into image frames and the Horn-Schunck optical flow is implemented to facial expression frames chosen in order to find the velocity of moving objects. The idea of motion detection is based on finding amount of difference in two consequent frames of a video sequence.

C. *Facial expression classification*

After the feature points were tracked and the velocity of the points calculated (facial expressions feature data). The next step of the classification process identifies the facial expressions of each sequence into the four categories: normal, happy, shocked and sadness category. The classification process compared the optical flow plot of selected image frames from the video file which were calculated for each of the four expressions categories: normal, happy, shocked and sad.

IV. Result And Discussion

Based on Table 1, we can identify the average value represented by every facial expression that is derived from (1). Through this average value, we can make a rough analysis on the optic flow change which occurred with the existence of two frames of facial expression images with different rates. Table 1 shows that Experiment 3 has an optical flow value that is the highest compared to Experiment1 and Experiment 2. This proved that Expression 3 has more facial expression, compared to Expression 1 and Expression 2.

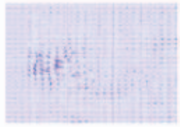
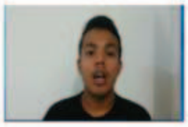
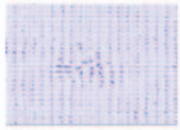
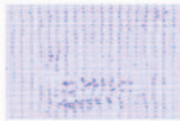
$$t \text{ value} = \text{maximum optical flow} - \text{minimum optical flow} \quad (1)$$

TABLE I. Results Of Average Value

Info	Experiment 1	Experiment 2	Experiment 3
Minimun OF	-1.013	-1.121	-1.136
Maximum OF	+1.105	+1.140	+1.175
*t*value (Maximun OF – Minimum OF)	+2.135	+2.261	+2.311

In conjuction with values in Table 1, Table 2 shows that Expression 3 has an optical flow value that is the highest compared to Expressions 1, 2 and 4. This proves that Expression 3 has more facial expression, movement compared to Expressions 1, 2 and 4. Meanwhile Expression 1 has an optical value stream that is the lowest compared to Expressions 2, 3 and 4.

TABLE II. Results of average value

Video	Selected Frame	Optical Flow Plot	*t* value
Expression 1 (normal)			+1.083 (lowest value)
Expression 2 (happiness)			+1.115 (medium)
Expression 3 (shocked)			+1.118 (highest)
Expression 4 (sadness)			+1.1131 (medium)

Meanwhile Experiment 1 has an optical value stream that is the lowest compared to Experiment 2 and Experiment 3. This showed that (Experiment 1 < Experiment 2 < Experiment 3).

V. Conclusion

Based on the experiments that has been conducted, the average values of the facial expressions were identified. Through this average value, researchers can make a preliminary analysis on the optic flow changes which occurred with the existence of two frames of facial expression images that are derived from two different rates.

Future work will consider classifying the expressions so that we can determine human behaviour by applying Horn-Schunck algorithm and will be integrated with thermal data for more accurate results.

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