PC POWER MANAGEMENT VIA FACIAL EXPRESSION RECOGNITION & FACE DETECTION

W.A.R.P. Settinayake and J.C. Balasuriya

Abstract

The concept of saving energy is one of the burning issues when working with a computer as the computer goes idle many a time without a user in front of the screen, sometimes for hours. Generally it is found that a CRT 17" Monitor consumes almost 90W when it is on, and LCD 17" Monitor consumes 40W. The core aspect of this PC Power Management System is to reduce this huge power consumption through sleeping the monitor which utilizes well below 20W. Therefore, it is obvious that keeping the monitor on every time without even a user in front of the computer paves the way to squander excess power. This system makes sure that the monitor goes to sleep whenever there is no user available in front of the computer for 10 seconds, and the user is not in a condition to use the computer. To tackle this issue, a Computer Vision based method has been introduced here in this project. That is, to place monitors and computers into a low-power "sleep mode" depending on face detection & expression recognition. Placing monitors in the sleep mode can be done in two ways: one is to sleep the monitor when there is no one in front of the screen for 10 seconds, and the other is to sleep the monitor when the user is exhausted and sleepy, both which are identified by facial expression recognition. Activating sleep features saves energy, money, and helps protect the environment. As long as the computer goes into sleep/standby when it is not being used, the computer doesn't use a lot of electricity, compared to the rest of household. Actually, it saves a lot more energy (0-15 watts) by addressing heating, cooling, and lighting use rather than consuming over the computer. But the major challenge of this project is based on using real-time facial expression recognition to power management.

Introduction

Many computer users have been concerned about the excess power usage caused by the computer itself. However, there are certain ways of controlling power usage using simple concepts. PC power management with the use of face detection and facial expression recognition, is one of those simple but challenging concepts. Here, in this project, a great deal of attention is paid to real time facial expression recognition rather than face detection, since face detection has not been considered as a daunting task anymore. In fact, there are several well-known techniques of recognizing facial expressions, but this paper discusses the approach of Active Appearance Model (AAM) (Lucey, Ashraf & Cohn, 2005), (Vacchetti, Lepetit & Fua, 2004) to identify real time facial expressions accurately and quickly with a minimum of delay. In point of fact, AAM has still been applied to only recognize faces, and this study is an effort to step in to another level.

The face is the main focus of attention in social interaction, which plays a key role in transmitting identity and emotion. It is quite remarkable that human beings are capable of recognizing thousands of faces and recognizing familiar faces at a glance even after years of separation. However, this project is not based on recognizing faces but on recognizing facial actions in real-time, from which lots of modern world complex scenarios can be addressed. Though some may not be aware of the real value of facial expressions, they actually assist communication through non-verbal cues which play a significant role in interpersonal relations. These cues may also complement speech by helping the listener to extract the intended meaning of spoken words. As per the research done by Mehrabian (Pantic & Rothkrantz, 2000) is concerned, facial expressions have a substantial effect on a listening interlocutor. According to his research, it is proved that the facial expression of a speaker accounts for about 55 percent of the effect, 38 percent of the effect conveyed by voice modulation and 7 percent by the spoken words.

The concept of real-world automatic facial action recognition has been taken in to consideration with the arrival of modern computer vision and pattern recognition techniques. Since then, the emergence of various methods of facial expression recognition has managed to enrich modern technology. In fact, automatic recognition of facial expressions can be regarded as one of the vital components of natural human-machine interactions as well as it may also be utilized in behavioral science (Donato et al. 1999) (Essa & Pentland, 1997) and in clinical practice as well. Moreover, facial action recognition can be applied to the most advanced cases such as identifying the differences between simulated and genuine pain, differences between people telling the truth versus lying, and differences between suicidal and non-suicidal patients. However, though in human beings' point of view, recognizing facial expressions seems virtually an easier and quicker task. It is still a huge challenge to recognize facial expressions reliably by machine. Automatic Facial Expression Recognition via Active Appearance Model (AAM) is a technique used largely to recognize faces automatically, but has not still being extended to recognize expressions despite a lot of research. As an initial step, with the use of the AAM technique, simple expressions such as happiness, exhaustion, and sleepiness are subjected to recognition through this project.

Objectives

With the expansion of computer vision, many researchers are very keen on other areas which they could exploit(Crowley, Coutaz & Bérard, 2000), (Jan, Piccardi & Hintz, 2003), (Szeliski, 2009). Real-time facial expression recognition and face detection are regarded as the most common applications of computer vision. Therefore, the main objective of this research is to take the maximum use of the above techniques in order to trim down the power surplus caused by personal computers. Moreover, the experiment of applying Active Appearance Model (AAM) as an effective method for real-time facial expression recognition (Lucey, Ashraf & Cohn, 2005) has been a highlight.

Research Issue and Study Framework

There have been several issues in selecting an appropriate technique which can quickly and precisely recognize facial expressions in order to conserve the excess power consumption. Some of the key and most common techniques of facial expression recognition are Facial Action Coding System (FACS) (Cootes, Edwards & Taylor, 2001), Facial Expression Recognition Techniques Using Constructive Feed forward Neural Networks and K-Means Algorithm (Ma, 2009), and Facial Expression Recognition using a Dynamic Model and Motion Energy (Moghaddam & Pentland, 1994). But considering the fact that in all of these methods retrieval time becomes much higher due to training through artificial neural networks, there is a need of a new technique with a much quicker retrieval time. This paves the way to recognize facial expressions through Active Appearance Model (AAM) which is actually the base of this project. AAMs have been established to be an excellent technique for aligning a pre-defined linear shape model that has also a linear appearance disparity, to a previously unseen source image containing that object. It also consists of a statistical model of the shape and grey-level appearance of the object of interest which can generalize to almost any valid example. This matching to an image engages in finding model parameters which reduce the difference between the image and the created model example, projected into the image. Nevertheless, this might be a complex problem when there are large numbers of parameters. However, it is observed that displacing of each model parameter from the correct value makes a particular pattern in the residuals. The training process is based on recognizing of these patterns.

Methodology

Since the core aspect of this project is to minimize power wastage to a great deal, it is interesting to take a glance at the process of conserving energy. This Real Time PC Power Management System actually consists of two models as detecting faces and recognizing facial actions.

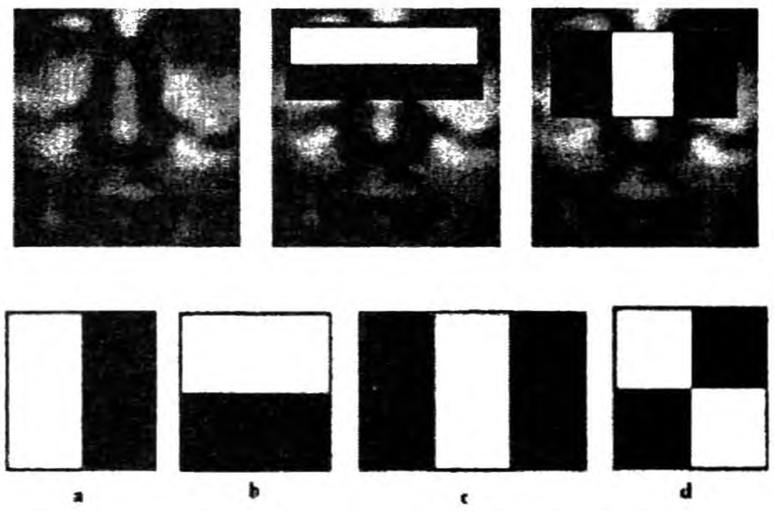
Real-Time Face Detection Module

This module is all about providing the capability to place the monitor in the sleep mode while there is no one in front of the computer for 10 seconds. Even though detection of faces is not that difficult since there is Open CV Library, it cannot be regarded as the least important module of this system, mainly because there is no use of placing the monitor in the sleep mode only depending on facial expressions. In fact, most of the practical occurrences are based on the scenario handled by this module. However, this module is just responsible for sleeping the monitor when there is no one around but is not in charge of re-activating the sleeping monitor.

The main reason of choosing Open CV library is to get the service of one of the most efficient face detection methods available - Viola Jones Ada- boosted Algorithm.

Viola-Jones method uses rectangle filters as masks shown in Figure 1 and creates an integral image as new image representation.

Figure 1: Applying Rectangle Filters on Database Images (Viola-Jones & Morphology-based Face Detector, 2003)



There are many rectangle filters available in Viola-Jones Ada-boosted algorithm. Each and every sample image in the database has been evaluated with each rectangle filter which ultimately creates an integral image for each rectangle filter-sample image combination. Afterwards, these integral images are sorted according to filter values. However, selecting the best threshold for each filter based on the minimum error is quite a challenge. For this purpose, the sorted integral images are used in order to scan for optimal threshold. Thereafter, selection of the best filter/threshold combination is done and all the sample images are subjected to reweight eventually. Because of the sorted nature of this algorithm, time spent on detecting faces becomes less. Therefore, this technique has been regarded as one of the most efficient face detection methods.

Real-Time Facial Expression Recognition (FER)

This module is considered to be the most significant and challenging module. The activation of this module begins after face detection module only when there is a user available in front of the computer. Here, simple expressions such as sleepy, happy (smile), exhausted and normal will determine the operation mode of the monitor. In fact, expressions such as sleepy and exhausted are capable of placing the monitor in the sleep mode while a smile is responsible for re-activating the sleeping monitor. Moreover a normal (neutral) expression doesn't alter any mode and an expression of a smile (happy) will act as same as the neutral expression if the monitor is in the on-mode.

Active Appearance Model for Expression Recognition

Active Appearance Model is one of the most widely used techniques for recognizing faces and tracking. This model locates 40 face featuring points (Figure 2) in each sample image, and then determines expressions according to the variations of those points.

Figure 2: 40 Face Featuring Points

In fact, Active Appearance Model is a commanding generative class of methods for cases such as modeling and registering deformable visual objects. In recent years, this technique has been admired by experts due to its exceptional performance. The major highlighted feature of AAM is its compact representation of appearance, including shape and texture in addition to its quick fitting to unseen images (Akshay Asthana et al. 2009)

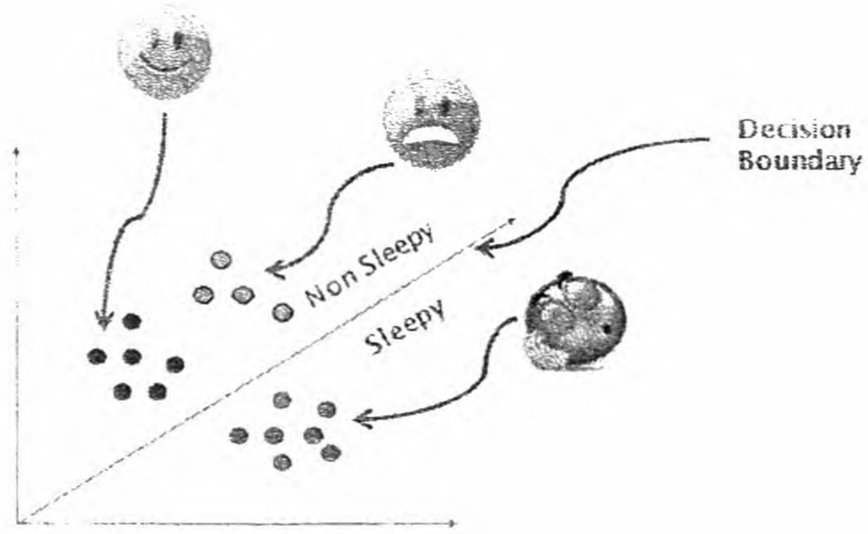
The process of recognizing facial expressions through AAM is quite a challenge. As shown in figure 2, the input image or web cam video stream is subjected to be tracked by the AAM tracker, which is computed using a large number of images (Face Database), in order to extract useful facial features. The classification of expressions has been performed using Support Vector Machine (SVM) (Hsu, Chang & Lin, 2005)

Support Vector Machines (SVMs) have been established to be extremely useful in a number of pattern recognition tasks including face and facial action recognition. This type of classifier endeavors to find the hyper-plane that maximizes the margin between positive and negative observations for a particular class. A linear SVM classification decision is made for an unlabeled test observation $\mathbf{o}^*$ by,

$$\mathbf{w}^T\mathbf{o}^* \underset{\text{false}}{\overset{\text{true}}{\gtrless}} b$$

where **w** is the vector normal to the separating hyper plane and b is the bias. Both **w** and b are estimated so that they reduce the structural risk of a train-set. Characteristically, **w** is not defined explicitly, but through a linear sum of support vectors. As a result, SVMs present additional appeal as they tolerate the employment of non-linear combination functions through the use of kernel functions such as the Radial Basis Function (RBF), polynomial, sigmoid kernels. A RBF kernel is used in our experiments throughout this paper due to its good performance, and ability to carry out well in many pattern recognition tasks (Hsu, Chang & Lin, 2005). Since SVMs are essentially binary classifiers, special steps must be taken to expand them to the multi-class scenario required for facial expression recognition. This project obtains the services of one of the SVM methods called "one-against-one" approach (Hsu, Chang & Lin, 2005) in which K(K " 1)/2 classifiers are constructed, where K are the number of Action Unit classes, and each one trains data from two diverse classes. In classification, a voting strategy is used, where each binary classification is regarded to be a single vote. A classification decision is achieved by choosing the class with the maximum number of votes. The following Figure 3 assists further clarification on SVM algorithm.

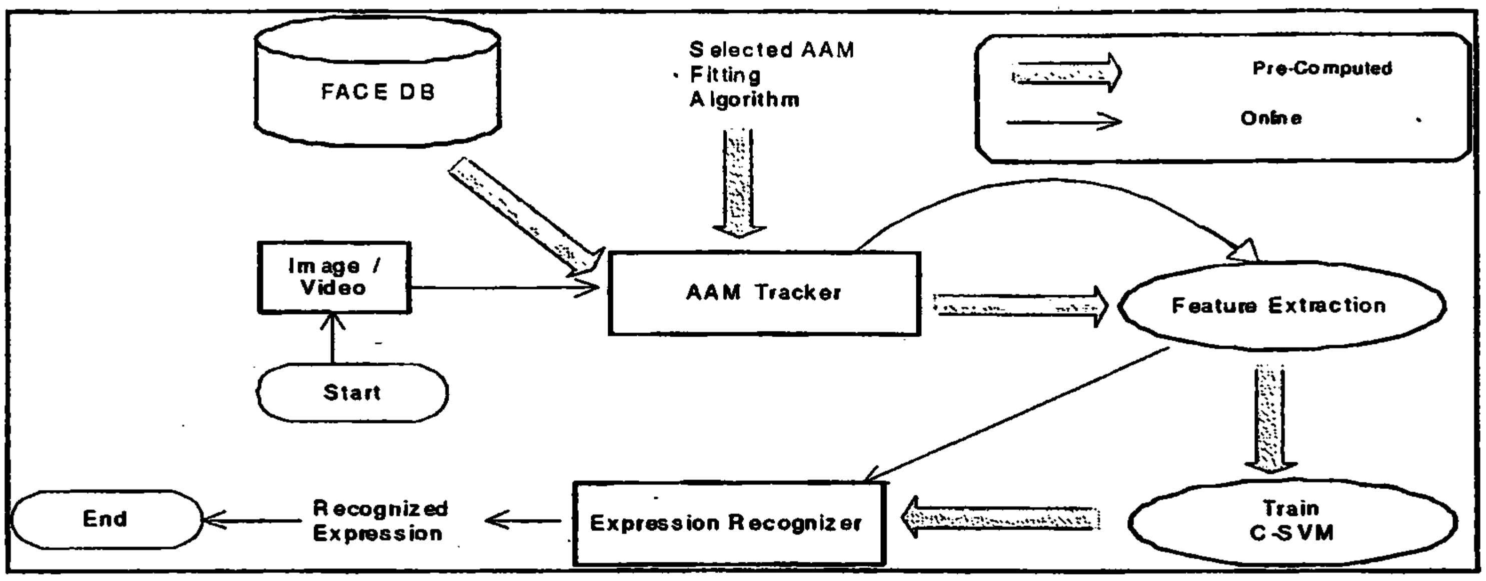
Figure 3: Classification of SVM



Findings

Although the concept of PC power management seems to be a simple application of FER and face detection, it requires a great deal of time in order to achieve the required accuracy. Here, The Yale Face Database B (The Yale Face Database, 2001) is used as the face DB which consists of 5760 single light source images of 10

Figure 4: Process of Facial Expression Recognition through AAM



Subjects, each seen under 576 (9 poses x 64 illumination conditions) viewing conditions included. In this research's point of view, only 4 poses have been taken into consideration such as exhausted, sleepy, happy and neutral. However, the accuracy of the system varies according to the available lighting conditions. Therefore, sometimes it takes a few seconds delay when recognizing expressions. During the implementation of face detection, the combination of motion detection with face detection would be an ideal solution, since in face detection the monitor goes to sleep even due to a slight movement of the user.

After completing the integration testing, it is appropriate to look in to the system testing which is the most crucial. The system also occupied the CKDb face database which contains 2488 images of 30 subjects (15 Males/15 Females).

The aim of sleeping the monitor became a nearly 100% success when a user is not in front of the machine. It is largely due to the high accuracy of the motion detection module which is independent from the inconsistent lighting conditions. At the FER module, the accuracy level considerably dipped compared to face detection as it is a dependent of many external factors. In FER, the monitor is directed to the sleep state depending on the emotion (sleepy and exhausted) of the user at the computer with nearly 80% of accuracy. However, external factors such as lighting conditions, ambiguous emotions etc bring the accuracy level somewhat down. The test cases of the entire system and their results are clearly mentioned in Table 1.

Table 1: Attestation of the Test Cases of PC Power Management System

Module	Test Description	Actual Result
Real-Time Face Detection	Checking the state of the monitor when a user is available and not available in front of the PC.	The monitor tempts to get stuck and waits 15 seconds anyway when a user slightly moves away from PC. Therefore the 15 seconds wait was excluded.
Facial Expression Recognition	Checking the emotions of the user and adjust the state of the monitor accordingly.	Expected output was achieved but sometimes due to inconsistent lighting conditions, the accuracy varied.

Discussion

Real Time PC Power management is largely an application of facial expression recognition. However, in terms of practical usage, sole facial expression recognition system does not guarantee power conservation. Therefore, the incorporation of face detection with facial expression recognition guarantees a better and meaningful solution. Facial expression recognition is one of the difficult and complex tasks computer science is facing. However, there are various methodologies available for solving the task of expression identification such as Facial Action Coding System (FACS), Facial Expression Recognition Techniques Using Constructive Feed forward Neural Networks and K-Means Algorithm, and Facial Expression Recognition using a Dynamic Model and Motion Energy. Although these techniques are able to identify facial expressions, they have their own pros and cons. In fact, for a real time expression recognition system, less retrieval time is a must. To fulfill this aspect, the method of Point Correlation in Active Appearance Model is being implemented in this project. It ensures results with a quick response time through an acceptable precision.

Both face detection and FER modules have been completely developed with an approximate 80% of accuracy. Actually, it is difficult to achieve 100% accuracy although more than 5000 sample images were trained using haar training, q-training and AAM fitting for more than two days. Nevertheless, the face detection module can be further extended to a motion detection module in order to cope with more advanced practical usages. It detects a movement of a user in front of the computer and makes the monitor go to sleep if a motion does not exist.

However, this project depends on only a real time video stream generated by just a single camera. Therefore, the accuracy level can be varied according to the angle and the various lighting conditions. The next version of PC Power Management is going to address the same scenario by using 2 web cams situated in 60^0 of angle. It guarantees better reliability and accuracy.

Conclusion

Real Time PC Power management is largely an application of facial expression recognition. However in terms of practical usage, sole facial expression recognition system would not do justice for the ambition of power conserving. Therefore incorporation of face detection with facial expression recognition guarantees a better and meaningful solution. Here the power or energy saving is performed by transforming the operation mode (Sleep mode and On mode) of monitor of the computer.

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