Potential Applications of Affective Computing in the Surveillance Work of CCTV Operators

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Abstract. Affective computing is a branch of artificial intelligence that deals with the design of devices which can process human emotions. The data gathered by passive sensors can be compared to the cues humans use to perceive the affective state of others (e.g. a video camera might capture facial expressions, body posture or gestures). An automatic, machine-based emotion recognition system could operate on the basis of the output of these sensors. CCTV surveillance is a potential application for such a system which might be used to constantly monitor for mal-intent through the emotional cues exhibited by surveillance targets and alert CCTV operators as appropriate. Previous research showed that firearms are known to elicit certain emotional states in their bearers. Consequently, these states might be reflected in the change of the individuals' body language. The potential for automating the detection of the associated emotional cues in image processing algorithms is discussed.

Keywords: CCTV surveillance, Detection of illegal firearm carrying, Affective computing

1 Introduction

Illegal gun possession and its increased use is a problem of major importance these days. In relation to surveillance it gives rise to a question about how well human operators are able to detect a carrier of a firearm through observation of Closed Circuit Television (CCTV) imagery, and whether applying the concept of affective computing into automatic video surveillance systems may enhance the recognition of firearm related crime. The present paper is based on the assumption that the human operator's ability to predict an unlawful act accompanied with using a firearm may be linked to the ability to recognize the affective state of others through perception of physical signs or emotional cues conveyed by the body and face of surveillance targets. It also discusses the relevance of the application of affective computing in automated, computer-based visual surveillance in order to assist CCTV operators in the prediction of unlawful human behaviour in general, and the recognition of a firearm carrier, in particular. The results of experimental research on how

involvement in a (gun related) crime is accompanied by change in affective state of offender, and how this is recognized by other people will be discussed next.

2 Research on Human Affective Response to Carrying a Firearm or Committing a Crime

Several studies provide evidence that during a crime, or by preparing oneself to commit a crime, some affective processes are more likely to be present and to be reported by offenders than others, for example feelings of excitement, anxiety or anger [1], [2]. One of the influential factors which can cause a change in the criminal's emotional state is the experience of carrying a firearm. Evidence suggests that offenders tend to undergo different emotional states during unlawful activity that is associated with carrying an illegal firearm has been found in recent research conducted in England and Wales and commissioned by the Home Office [3]. The studies mentioned above provide evidence that committing a crime or carrying an illegal firearm is associated with a range of emotions which can be consciously appraised and reported by the offender.

In order to find more evidence that carrying a firearm might be associated with a range of emotions an experiment has been carried out. The study was a part of the Multi Environment Deployable Universal Software Application (MEDUSA) [4] project which is concerned with the identification of situations associated with gun related threats, based on behavioural interpretation of CCTV data and through combining psychological and image processing approaches. The experiment was designed to obtain the idealized video clips of people carrying firearms and to study whether carrying a gun would indeed elicit an emotional response in a firearm carrier. This was done by collecting self-reported affect when carrying a firearm compared to when carrying a matched innocuous object of similar weight and size. The results showed that when participants were carrying a firearm they reported feeling significantly more negative affect than when they had to carry an innocuous object.

In a subsequent study [5] the observers (i.e. surveillance operators and naïve participants) were presented with the same idealized CCTV footage in order to investigate the relationship between the detection of the person with a concealed firearm and the self-reported affect of firearm carriers mentioned previously. The results showed that the size of the influence of carrying a firearm on a surveillance target's anxiety was positively related to the number of times that individual was deemed to be carrying a gun. Further, the size of the influence of the firearm on the level of sensation seeking experienced by surveillance targets was correlated negatively with firearm detection sensitivity. These results imply that the mechanism by which the decision regarding whether or not a surveillance target was carrying a concealed firearm appears to have involved an interpretation of the surveillance target's affective state. However, the levels of concealed firearm detection sensitivity were consistently below zero, for both CCTV operators and lay people. Thus, although it can be assumed that those engaged in a surveillance task might use visual indicators of the affective state of a surveillance target to inform a decision as to whether or not that individual is carrying a firearm, it does not necessary leads to

reliable detection of a concealed firearm. Perhaps, an appropriate training is needed to enhance the performance of human operators on this task.

While human operators could be able to sharpen their abilities to detect mal-intent reliably, for example through training, and, in addition, to apply the recognition of the affective cues in surveillance targets to this task, one should not forget that the real-time visual surveillance systems can also be active sensors which could be tuned to the recognition of affect in humans. The operator's ability to predict an unlawful act accompanied with using a firearm might be enhanced by using appropriate assistive CCTV technology. The development of artificial intelligence systems, the designs of which could be inspired by human processes in recognising affect from human gait, postures or facial expressions, could increase the effectiveness of the surveillance task.

3 Affective Computing

Human emotions play an essential role in a variety of cognitive functions, like for example in rational decision making, perception, and learning. Many emotion theories have argued for the role of emotions as a powerful motivation, influencing perception, cognition, coping in important ways [6]. The assumption that emotions play an important role in human cognition has attracted a number of researchers in computer science who have attempted to apply this statement to the development of emotionally intelligent technologies (e.g. [7], [8]). According to Picard [9] artificial intelligence systems lack understanding of affect inferred from observable human behaviour. Therefore, to make computers truly effective at decision making, emotions or emotion-like mechanisms working in harmony with their rule-based systems have to be added.

These beliefs gave rise to a concept of affective computing as a branch of artificial intelligence that deals with the design of "emotionally intelligent" devices which can process human emotions [9]. Human emotion can be perceived through observation of facial expressions or changes in non verbal behaviour, such as gait, gesture or posture. In affective computing the detection and processing of, for example, facial expression can be achieved through various methods such as optical flow, neural network processing or hidden Markov models [7]. The detection of affective information involves sensors which are able to capture data about the physical state or behaviour of humans. The data gathered is often comparable to the cues humans use to perceive the affective state of other people. A video camera might capture facial expressions, body posture or gestures. An automatic, machine-based affect recognition system could operate on the basis of the output of these sensors. CCTV surveillance is a potential application for such a system which might be used to constantly monitor for mal-intent through the affective cues exhibited by surveillance targets, and then alert CCTV operators as appropriate.

4 Tasks of CCTV Operators and the Current Supporting Video-Based Surveillance Systems

As discussed above, carrying an illegal weapon may evoke certain emotions in the would-be offender. These emotions may result in a change in his or her body movement and facial expressions which can potentially be spotted through careful observation of CCTV imagery. However, one of the problems with camera based security systems is that human operators are required to monitor too many camera images at the same time, visually scanning the images to decide whether or not suspicious activity is taking place [10]. Thus, the task is labour intensive. Additionally, majority of the operator's time is spent viewing images in which there is no suspicious activity. Consequently, it is also difficult to maintain vigilance. Digital video surveillance systems are used in CCTV surveillance as a first step towards employing image processing technology. However, such systems are often only capable of capturing, storing and distributing the videos. The responsibility for threat detection rests then entirely with human surveillance operators. The demand for more effective, automated security systems leads to the development of so-called 'smart video surveillance systems' which aid human operators in their surveillance task.

Currently, CCTV operators are being alerted about the possible presence of unusual, suspicious human behaviours through the automatic visual analysis technologies, for example through an analysis of human movement patterns [11], [12]. However, human movement patterns alone might be insufficient to make correct judgments about a surveillance target's true intentions. Greater accuracy might be achieved through the consideration of human affect recognition in the development of automated surveillance techniques. However, even though the automatic detection and processing of human movement and facial expressions can now be achieved, the automated analysis of spontaneous human expressions still raises a number of technical challenges (e.g. the tracking of head rotations or subtle facial movements) [13]. Many automatic visual surveillance systems have been shown to perform inadequately because of the unpredictable nature of human behaviour [14].

5 Conclusion

As the field of affective computing is still relatively young it has been characterised mainly by research with only a few real-life applications of it [15]. Future forms of computing might develop and involve increasing capability to interpret affect. Therefore, affective computing might be applied to more and more monitoring tasks in the future, as it may have the potential to extend the application of automated video surveillance. Recognition of people with mal-intent or people carrying illegal firearms might benefit from the recognition of a surveillance target's emotional state from their non-verbal behaviour captured by CCTV cameras. It can therefore be assumed that the development of artificial intelligence systems based on the human ability to recognise affect from human gait, postures or facial expressions would be beneficial to a computer-based CCTV surveillance system. Automated CCTV surveillance which is capable of the accurate processing of affective information derived from the

observation of human behaviour might enhance accuracy in detecting crime in general and gun related crime, especially.

In social human interaction, emotional intelligence plays an essential role as it includes the human ability to attribute mental states to other people in order to make sense of and predict other people's behaviour. Building social, affective intelligence into an automated video surveillance would imply making the CCTV system more emotionally intelligent in the sense of recognising affective and mental states of people captured on CCTV cameras which might enable the system to more correctly predict human actions.

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