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Light, camera, action and arrest

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LIGHT, CAMERA, ACTION, AND ARREST

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Gun crime is a fast growing problem in the UK and it is important to detect a potential gun crime before an incident occurs. A possible technological and cost-effective approach is to utilise the widespread and endemic installation of CCTV cameras to automatically recognise individuals carrying concealed weapons and so prompt the CCTV operator. Current machine imaging software can identify a range of suspicious behaviours but with varying accuracy and associated false alarms. CCTV operators learn to identify certain cues associated with suspicious behaviour, again with varying accuracy. In a new EPSRC supported research project, MEDUSA sets out to identify both human and machine detected cues of individuals carrying concealed guns and merge these into new software for use by CCTV operators. This paper concentrates on the identification of cues associated with carrying concealed weapons and sets out the ergonomic challenges surrounding such an approach, together with the potential ways to overcome them.

Introduction

The first half of the 2000's have seen the highest levels of recorded gun crime experienced in England and Wales. Between the years ending 31st March 1999 and 31st March 2001, the number of recorded firearms offences (including those involving air weapons) leapt from 13,874 to 17,697 per year (Home Office, 2006). Subsequently, the numbers of these offences have remained relatively steady at between 22,400 and 24,094 per year to the 31st March 2005. (It should be noted that figures after 31st March 2001 may have been inflated by the phasing in of the National Crime Recording Standard, which was adopted across England and Wales on 1st April 2002.)

However, it is important to place these figures in perspective. Firearms offences accounted for just 0.4% of crimes in the year ending 31st March 2005. Thus, official figures suggest that gun crime is a relatively small problem. Even so, a survey by the Control Arms campaign (a joint initiative involving Oxfam, Amnesty International, and IANSA: International Action Network on Small Arms) suggests that fear of gun crime is running high amongst the populace (Control Arms, 2006). It was found that 39% of respondents living in Britain were worried about becoming a victim of armed violence. This figure jumped to 52% in London. Disturbingly, this high level of fear is not necessarily disproportionate to the actual incidence of gun crime. Eleven percent of British respondents reported that they (3%), relatives (3%), or acquaintances (5%) had personally been affected by gun crime in the past five years. Additionally, nearly one in six had seen a gun that they thought was held illegally. This raises the possibility that the streets of Britain are awash with illicit guns.

Using CCTV to tackle gun crime

It appears that the full extent of gun crime in Britain is hidden from the authorities. Assuming that this is the case, how can we rid ourselves of the hidden cache of illicit arms on our streets?

A possible technological and cost-effective approach is to utilise the widespread and endemic installation of CCTV cameras. It is widely reported that Britain is subject to one of the highest levels of camera-based surveillance in the world. There may be as many as 4.2 million cameras in Britain, one for every fourteen people (McCahill & Norris, 2003).

The ability of CCTV to tackle gun crime at present

It is suggested that in order to have a substantial impact on gun crime (or indeed crime in general), the manner in which CCTV is utilised must be changed. At present, CCTV does not appear to be effective at reducing overall crime rates (Gill & Spriggs, 2005). CCTV is typically used to “co-ordinate an appropriate response, and gather evidence that can be used to direct investigations and ensure a swift conviction of offenders” (Brown, 1995). These uses are principally reactive or retrospective. Training guidelines for CCTV operators emphasise *proactive* use, alongside reactive and retrospective activities (Diffley & Wallace, 1998). In the context of gun crime, the ideal proactive solution may be to detect those carrying concealed firearms on our streets and to remove these weapons before they are used.

In principle, present CCTV surveillance practices are capable of achieving this goal. CCTV operators have been observed to proactively search local hot spots for likely criminals at key times, following instinct, experience, and various preconceptions (Norris & Armstrong, 1999). Given that it is possible for people to accurately predict the onset of lawless behaviour via CCTV (Troschianko, Holmes, & Stillman, 2004), this kind of proactive surveillance could prove fruitful. Indeed, Norris and Armstrong (1999) describe a real-life example of effective, proactive surveillance by a CCTV operator (pp. 184 - 185). Additionally, the authors have observed instances in which CCTV operators have proactively spotted suspicious behaviour and brought it to the attention of the police. Subsequent police intervention seemed to have prevented an escalation of criminality. Some of these instances involved the detection of guns.

Unfortunately, the degree to which CCTV is used proactively does not appear adequate to have an effect on national crime rates. This may reflect the exceptional difficulty of the task. Often, just a few CCTV operators are responsible for monitoring the output of hundreds of cameras. They cannot hope to detect every potentially criminal event. Further, human factors place limits on the efficacy of CCTV operator mediated surveillance: the amount of time during which vigilance can be effectively maintained is limited (Tickner & Poulton, 1973); the ability of a person to spot suspicious behaviour is fallible (Troschianko *et al.*, 2004); assignments of suspicion can be based on little more than personal prejudices (Norris & Armstrong, 1999); and boredom or prurience may induce operators to indulge in activities outside of their job description (Norris & Armstrong, 1999; Smith, 2004). With respect to gun crime, the situation is further compounded by the fact that such crimes are relatively rare. This offers CCTV operators little opportunity to learn the indicators of potential gun crime.

Alternatives to the manual detection of gun crime

Intelligent, automatic CCTV systems could address problems associated with data swamping, aberrant profiling, boredom, and voyeurism (Surette, 2005). These technologies are now capable of performing complex, automated, real-time analyses. For instance, a system being trialled in underground railway stations (PRISMATICA) can monitor crowd flow and detect suspicious stationary objects (Velasin, Boghossian, & Vicencio-Silva, 2006). The system is also capable of detecting combinations of motion and location cues that are indicative of

specific behaviours such as loitering, begging, and potential suicides at the track-side (Velasin, Boghossian, Lo, Sun, & Vicencio-Silva, 2005). Perceptrak, employed in the Yonkers district of New York, performs similar analyses at street level (Kanable, 2006). However, the authors are not aware of any intelligent CCTV system for the detection of concealed firearms.

MEDUSA (Multi Environment Deployable Universal Software Application) will bring the advantages of intelligent CCTV technologies to bear upon the problem of gun crime. The intention is to produce a system that will constantly analyse the live feed from CCTV cameras for evidence of the visible precursors of gun crime. As such, it will circumvent problems associated with data swamping, boredom, and voyeurism. Only salient information will be brought to the attention of the operator. Additionally, cues that are effective indicators of gun crime will be derived empirically. This addresses concerns surrounding the influence of personal prejudice on surveillance practices. It may also allay fears that malignancies associated with human mediated surveillance will be enshrined in computer code (e.g., Graham, 2005). Further, a programme of work dedicated to amassing an archive of real-life CCTV footage of gun crime will address problems associated with the relative rarity of these crimes.

It is noted that intelligent CCTV systems do not always meet the desired standards of efficacy. A case in point is FaceIt, a CCTV-mediated, automatic face recognition system which was deployed in the London borough of Newham, in 1998 (Dupont, 1999). The system was designed to compare faces captured on CCTV with those of wanted persons, but it does not appear to work in practice (Norris, 2003). Similarly, DEVASTA employed image analysis algorithms to automatically detect aggressive behaviour via CCTV. It was piloted in a Dutch railway station in January 2002, but a high rate of false alarms prevented the software from being adopted permanently (Dubbeld, 2005).

It is hoped that the application of scientific rigour in deriving cues to gun crime, alongside an ability to learn new cues, will ensure that MEDUSA is accurate. MEDUSA aims to combine two approaches. Psychological techniques will be used to elucidate the visual cues used by CCTV operators to detect potential gun crime in real-life CCTV footage, tapping into the expertise of CCTV operators. These human elicited cues will be combined with the latest digital image processing algorithms in object detection, motion tracking, and machine learning.

Thus, MEDUSA will be able to detect gun crime from the outset, whilst proceeding to learn the idiosyncrasies of gun crime in each area to which it is deployed. As the system will monitor all live feeds, constantly, the machine learning of new cues could occur apace.

Visual cues to gun crime

It has already been noted that CCTV operators can predict the occurrence of crime on the basis of visual information alone (*cf.*, Norris & Armstrong, 1999; Troscianko *et al.*, 2004). Further, instances where this ability relates to gun crime have been observed by the authors, although it is not certain whether the visual cues used are specific to gun crime. It is posited that any visual precursors to gun crime will manifest in two principal ways: the direct, physical consequences of carrying a gun; and behavioural traits associated with the intention to commit gun crime.

Direct, physical consequences of carrying a gun

The direct, physical consequences of carrying a gun could relate to the shape and size of the gun, or its mode of operation. The shape of the gun may be visible through clothing. Additionally, carrying a gun may physically impact upon gait, stance, or posture. Indeed,

movement cues associated with gait are incredibly informative; it is possible that they can even reveal information about individual identity (Stevenage, Nixon, & Vince, 1999).

However, ergonomists note that firearms vary widely with regard to form and operation (Hancock, Hendrick, Hornick, & Paradis, 2006). Thus, the actions involved in preparing to fire a gun or the physical consequences of carrying a gun could vary extensively. This may make it difficult to derive a definitive set of cues for the direct, physical consequences of carrying a gun, although any such cues might be indicative of the particular gun to be used. Consequently, behavioural cues to the intention to commit a gun crime could prove especially important.

Behavioural cues to gun crime

The existence of a “powerful and early-emerging cognitive system for discerning intentions” has been suggested (Baldwin & Baird, 2001). This system has a strong visual element, reinforcing the potential for behavioural cues to intention to be conveyed via CCTV. It may also have universal, perceptual elements. For instance, the derivation of intention from motion is possible across disparate cultures, using abstract, visual cues alone, (Barrett, Todd, Miller, & Blythe, 2005). Further, when shown real-life CCTV footage of the events leading to a lawless act, it has been found that experts and naive participants are equally adept at predicting whether something “bad” will happen (Troscianko *et al*, 2004). This indicates that visual, behavioural cues to the intention to commit crime may operate at a perceptual level, and that they are detectable via CCTV. It is conceivable that these findings will extend to the intention to commit gun crime. Behavioural cues may even distinguish between different types of gun crime (*e.g.*, intent to fire and mere threat, or air weapons and actual firearms).

Thus, the visual processing of intent appears to have both cognitive and perceptual aspects. Consciousness pervades low-level, perceptual processes to a lesser degree than high-level, cognitive processes. This raises the possibility of the existence of both overt and covert, visual cues to gun crime. Overt cues are those which CCTV operators are consciously aware of using. They are likely to be employed at the higher, cognitive level of visual processing. In contrast, covert cues are those which CCTV operators are not consciously aware of using. They are likely to contribute to a lower, perceptual level of visual processing. Psychological experimentation could make these covert cues explicit, enabling MEDUSA to exploit them in its software. Such cues have not been considered in intelligent CCTV systems to date.

Summary

MEDUSA seeks to reduce the occurrence of gun crime by bringing the advantages of intelligent CCTV systems to bear upon the problem. The efficacy of the system will rest upon combining the best aspects of human and machine-based factors in order to detect the visual precursors of gun crime, using existing CCTV surveillance networks. MEDUSA will be capable of tailoring its gun crime detection algorithms to the idiosyncrasies of each region to which it is deployed.

Acknowledgement

This research is supported by the EPSRC.

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