TECHNOLOGICAL DEVELOPMENTS FOR ENVIRONMENTAL MONITORING

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SUMMARY

New software and digital hardware technologies combined with the utilisation of Ethernet, the Internet Protocol, and wireless mesh based networks provides the opportunity for monitoring activity at almost any location in the world from any other location in the world. The essential limitation is the availability of power at the location to be monitored, and not the communications infrastructure that might be present there**.**

This paper considers the promise and applicability of the use of recent video technologies for deterrence and evidence gathering of environmental compliance, from the perspective of in house experience. The central theme of this perspective is that intelligent approaches to the gathering of video data are essential in order to avoid being swamped with data that may not merit analysis or storage.

1 DETERRENT EFFECT OF ENVIRONMENTAL MONITORING FOR ENFORCEMENT

Automated video monitoring represents a source of environmental intelligence, allowing the collection of statistical descriptors of salient events, and improved utilisation of resources. The availability of such data may contribute to the strengthening of enforcement systems, but the premise of this paper is that the video monitoring process will have an important contribution to make to deterrence.

A review of empirical research on the effectiveness of monitoring and enforcement of environmental policy in deterring individuals and firms from violating environmental laws or achieving an improved level of environmental performance is presented by Cohen.[1] Studies reported by Cohen show that increased government monitoring and increased enforcement activities resulted in reduced pollution and/ or increased compliance with existing laws. Cohen alludes to the limitation of the performance measures used in environmental deterrence research investigated in that most performance measures used were self-reported. Further, Cohen notes that a finding that increased monitoring leads to increased compliance does not tell us if the marginal cost of increased monitoring is out-weighed by the benefits of increased compliance.

This paper outlines recent technological developments that facilitate the routine gathering of video data for environmental monitoring purposes. These developments are timely because the cost reductions now afforded to the gathering and analysis of the data may enable the *routine* use of video data as deterrence.

2 TECHNOLOGICAL ADVANCES IN VIDEO MONITORING

2.1 Remote Video Monitoring

Remote video monitoring is an enabling ability, which allows monitoring agents to manage and view data from an entire network of video devices from a remote location, quite possibly substantially removed from the site. This is a significant step beyond local alarm monitoring and event management because it allows the observers to be quite removed from the focus of interest, while providing live or archival coverage and visual confirmation of an incident or event.

Detracting from video monitoring, remote or local, are the issues of having to deal with overwhelming quantities of data and the often mind-numbing monitoring staff must perform. Technological developments, largely associated with the availability of inexpensive video acquisition systems and cheap processing of the data that they produce, now allow for the routine 'intelligent' processing of multiple video streams without operator intervention, identifying and recording incidents and events.

2.2 Intelligent Video Monitoring

Intelligent video monitoring embraces the automation of much of the monitoring activity and the archival of only those incidents identified to be of interest. The monitoring activity is intelligent and automatic, intervention being required only for those incidents that may not be classified by the automated process. The available technology is not yet flawless, with some incidents being missed altogether, or producing false-positive, and indeterminate results. In many situations this sub-optimal performance of automated systems is obviously a problem, but in a climate of deterrence, inevitable failings of the system are not a show-stopper.

The contention in this paper is that automated video analysis technology is now sufficiently mature to deliver real value in some environmental compliance applications. Where enforcement and legislative procedure require, human judgement can be bought to those instances where the automated system is inadequate. An important idea here is that the application of this human judgement is facilitated by the automated system being able to highlight incidents and events of interest or uncertainty.

Attitudes are evolving as awareness about the benefits within the limitations of the available technology builds. The extreme view was that it was assumed that video technology could be used to replace staff, but this is true only in the sense that there are limits to the number of cameras/video streams a human can reasonably monitor.

There are limits on a computer's ability to discern successfully real incidents from benign changes in the natural environment, and in consequence, automated video analysis technology is often used to assist operational staff with the mundane elements of the monitoring activity. Indeed the processing algorithms are sometimes purposely set to deliver a high rate of alerts and alarms for human decision-making. Our experience is that it is really the role of the staff that changes. As the technology increases human effectiveness by automating video monitoring to a larger and larger degree, an increasing number of cameras are able to be managed effectively.

2.3 Intelligent Algorithms for Video Analysis

Intelligent video analysis is often triggered by motion detection. Motion detection is a fairly mature technology that is often provided free, or integrated within many video acquisition devices. The general approach to motion detection is simply to measure the number of pixels that change between successive video frames. It is usually possible, and sometimes a requirement, to set the level of alerting, perhaps if 15% of the pixels change from frame to frame. A further refinement may enable the definition of the amount by which a pixel needs to change before a 'real' change is indicated: perhaps more than 10% of its previous value (after normalisation). Many of the recent advances in intelligent video processing are built on complex algorithms that identify and filter out video "noise" that presents in the form of unimportant pixel changes. Regular motion detection has clear limitations when used outdoors, for example when trees and bushes blowing in the wind might trigger false alarms. There has, accordingly, been substantial development to avoid false alarms and to produce more robust algorithms. Such algorithms sometimes rely on the classification of shapes and objects in the field of view once a significant change in pixels is detected. Different algorithms use different methods to differentiate and classify shapes and objects, as appropriate for particular applications. The classification in turns leads to the possibility of developing a profile of the normal behaviour of the object, and an alert may be generated or recording is commenced only when the behaviour of the object departs from the normal profile. Indeed much of the effort in setting up an intelligent system for the automated analysis of video is in developing an appropriate profile of the object(s) of interest.

Through the use of profiling software, monitoring agencies are able to more easily track unexpected and questionable activities. Output may take the form of reports ranging from a count of the number of incidents in a time-period through to assisted retrieval – perhaps in the form of a web link – of all incidents in chronological order.

Historically, incidents would require to be observed in real-time by personnel monitoring the video feeds. The important distinction is that measurements and statistics may now be obtained without operator intervention.

More than the availability of inexpensive video cameras, the recent drop in prices of pan-tilt-zoom -capable cameras has made pan-tilt-zoom functionality more commonly available. pan-tilt-zoom functionality increases possibilities for the intelligent automated analysis of incidents as pan-tilt-zoom (and static 360° cameras) may be programmed to automatically zoom in and follow a particular object once it has been detected. Algorithms have been developed that will latch on to an object and follow the object through complex environments. In instances of cross-over and temporary obscuration of the object algorithms are available to predict where the object will be, and in the event that the object does not reappear as anticipated, to back off and look for the object in the wider scene.

2.4 Management

Instead of disparate video monitoring systems, which are monitored locally, a remote monitoring network may be configured to support a wide-area monitoring facility. The data store, or data stores, may be linked to a management network to provide functional requirements such as simultaneous multi-site monitoring and the retention of archival data, video recording and playback, bi-directional communication (*e.g.* pan-tilt-zoom commands) and the distribution of real time video to local agencies, as required.

If an alarm is generated, a video image of the site location may be automatically routed to a monitoring agent. Monitoring agents may then visually confirm the nature of the alarm and alert local agencies following verification. The significant change from what has gone before is that the monitoring agent is now concerned only with incident verification, without the requirement for continuously monitoring the video sources.

2.5 Reporting

Real-time analysis enables an alarm and a response, as deployed in traditional CCTV networks. However there is also analysis that monitors the environment over days or months, such as, for example, animal counting, fish catches, bird nests, movement pattern analysis, duration of activities and waiting times between activities, *etc.* The output may be presented in report form, and not necessarily as video data although this may be retained for evidential use.

In addition to statistical summaries generated daily, weekly or monthly, reports may contain web hyperlinks to video and still images providing visual documentation of events captured. Weekly summaries of an activity at a particular location may be sent by e-mail.

2.6 Smart Cameras

Modern video cameras feature monitoring enhancements such as megapixel image quality, built-in motion detection, alarm management, web-enabled controls, and encryption for secure communication. A more recent trend is to run the video analysis on the video acquisition device itself, with the advantage that the entire video stream does not require transmission over the network for processing, with only significant events being sent over the network for storage.

These 'smart cameras' perform the video processing directly inside the camera to create an all-in-one embedded device.[2]

3 CONCLUSION

Early adopters of the intelligent video technology were big enterprises and high-risk environments such as governments and transportation, particularly airports. There was also significant uptake in the banking sector, where security issues are a particular consideration.

As the use of video for monitoring grows and matures, intelligent video analysis will become routine and may even be bundled into cameras as an integral part of their operations. Where an extensive network, of video cameras already exists, these are able to be added to an intelligent processing network for less than the cost of purchase and installation of replacement systems.

Intelligent video analysis will facilitate the audits of large-scale, 24/7 monitoring operations, contributing to both deterrence and evidence gathering in environmentally sensitive locations. As such, intelligent video analysis has an important contribution to make to the monitoring of environmental compliance.

4 REFERENCES

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