Prioritise what's important

CCTV The Vanaheim project is developing the next generation of intelligent surveillance networks — these are able to prioritise information shown to operating staff and provide long-term data on passenger behaviour.

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The pilot installation of networked CCTV with intelligent analysis went live in the Torino metro control centre in March.

From a single camera and monitor to complex CCTV networks with hundreds of cameras and video recorders, surveillance systems are a feature of daily life in shopping centres, car parks and other public spaces. However, when dealing with large-scale infrastructure such as a metro network, the primary role of CCTV is usually to handle specific security issues, such as intrusion detection on the running lines or ex-post incident investigation. But they are less routinely used for real-time monitoring, or to collect statistics on passenger activities and behaviour patterns. Indeed, most of the time, most video footage from large surveillance networks is never watched.

Underpinned by €3·7m in funding from the EU's FP7 research programme, the €5·5m Vanaheim project is developing and integrating innovative video analysis modules into the CCTV networks already used by the metro operators in Paris (RATP) and Torino (GTT). Its multidisciplinary team comprises eight partners — four research institutes, two suppliers plus the two public transport operators — from six different countries (p55). Using their complementary skills, supported by an advisory board of specialists in fields such as surveillance ethics, the partners are examining three specific application areas:

- automatic sensor selection for intelligent video wall management;
- human-centred monitoring;
- long-term data collection for operational analysis and planning.

Since its inception in February 2010, the project has combined the video analytics elements of these three workstreams to create an intelligent 'video wall' tool, and installed an automated video surveillance system in GTT's metro control centre in Torino as a proof of concept exercise. The final stages of the project, which is due to conclude in July 2013, envisage a larger installation on the Paris metro, with further demonstration exercises presented to a wider audience in a live setting.

Automatic sensor selection

In the case of Torino metro, 28 monitors are used in the control room to supervise more than 1 100 cameras, so the probability of watching the right streams at the right time is therefore close to zero. Moreover, vigilance studies show that operators who spend hours 'screen gazing' at static scenes tend to become less attentive. They are thus likely to miss low-frequency events such as a passenger falling or a violent dispute, which reduces the overall effectiveness of CCTV.

Vanaheim seeks to meet the need for automated content-based selection tools that feed the most informative and/or relevant data streams to the operator. Different unsupervised activity algorithms have been developed to capture recurrent activities from long recordings; these algorithms are also able to provide 'abnormality measures' that can be used to filter the content displayed in the control room.

This functionality can be extended further to integrate multiple video streams, perhaps covering an entire metro station from entrance foyer to platform level. These streams are then compared and ranked by the level of abnormal behaviour patterns detected in each, with the most 'unusual' then displayed on the operator's priority screen (Fig 1).

The automated selection tool can highlight behavioural anomalies within a large tranche of footage. For example, when applied to more than 200 h of video from eight cameras on the Torino metro, it identified people using the escalators in the wrong direction, a crowd gathering around someone who had tripped and fallen, and passengers who were apparently lost.

Some phenomena which are statistically rare, but not necessarily abnormal, can also be identified. While this could be problematic for a preventative system (such as intrusion or abandoned object detection), the presence of a non-abnormal event is much less so in the case of video streaming. Here the objective is not to generate an alarm, but to prioritise one or more streams where all can be described as 'normal'.

Human-centred monitoring

In a second research thread, various scene analysis algorithms were

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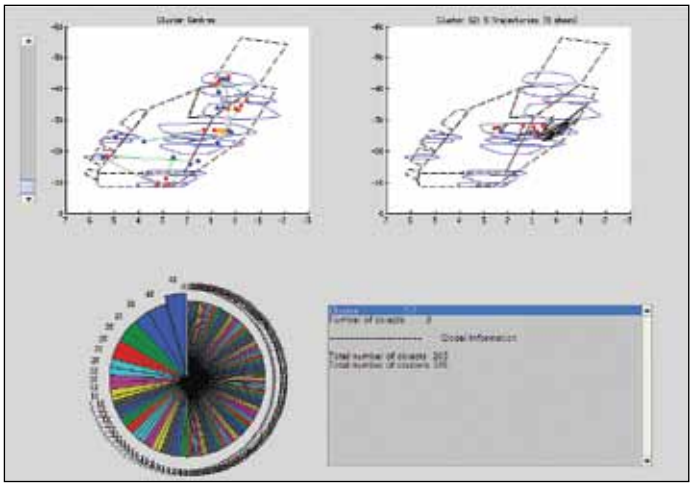

Fig 1. Algorithm-driven 'abnormality ratings' provide a continuous measure of unusual events. Here a person is falling in the top right of the screen, and people are gathering around them; this event does not correspond to recurrent activities.

Fig 3. An offline analysis tool categorises the streamed data into three subsets to highlight activity zones, types of behaviour, and activity metrics.

investigated. These range from human and group monitoring to left luggage detection, using people counting and flow estimation analysis at different locations in GTT's stations.

Human detection. Efficient and reliable detection of people in a station environment is undertaken through assessment of appearance and spatio-temporal features. A human/non-human classifier is then used to confirm the selection.

Static luggage detection. This algorithm relies on a multi-layer background subtraction method by distinguishing recent layers from older, long-term background layers and foreground zones. It is enhanced by a human detection algorithm to remove false alarms caused by people waiting, and hence remaining static for quite some time.

Group detection and behaviour analysis. This algorithm performs real-time group detection and tracking corresponding to predefined behaviours of interest. The group detection and tracking method works first by tracking mobile objects and then grouping them recursively over time. It also assesses spatial and temporal group coherence, using factors such as proximity and walking pace and direction.

Flow monitoring. Several crowd characterisation approaches have been developed to monitor crowds or large flows of people. These include counting the number of people crossing a particular boundary point, for example at an escalator, or monitoring the occupancy level of a specific space, such as a platform (Fig 2).

Situation reporting. The suite of software and hardware that provides estimates of passenger location, flow and numbers is then used to feed a situational reporting tool. The location data is 'back projected' in real time onto an infrastructure map of the Torino metro network, providing the operator with a dynamic view of occupancy and passenger behaviour.

Long-term planning

The Vanaheim partners have also sought to maximise the long-term benefits of smart CCTV. Such macro-level analysis can plot trends of behaviour across the network, using algorithms to plot patterns through historical data. This in turn enables the operator to attain a deeper understanding about how the metro is used. The project team developed three specific tasks which would allow such patterns to be detected. The first was to identify the regions of each surveillance zone which saw most passenger activity (for example, the section of platform where passengers were most likely to congregate); the second was to collate types of activity that are most typical in each zone of a station; and the third was to look at how these activities could be logged, classified and quantified statistically (Fig 3).

The results have been used to create a Video Management Solution, where all the analytics modules developed for the project have been integrated. The user of the system can launch any available algorithm, select the audio or video stream to assess, and configure the video wall graphical overlay to highlight the output data. VMS is now being used to process 26 live video streams from one GTT station.

Vanaheim partners

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Far right: Fig 2. Passenger flow monitoring at an escalator records and counts each person crossing a virtual boundary.

Right: Vanaheim user desktop and control interface.