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Sight unseen

Christian Kotscher of MetroTech Partners, LLC provides a perspective on where the US is heading in terms of detection and classification

The Ultimate Sensor

The richness of video data makes the camera in many ways the ultimate sensor. The potential of gaining so much contextual information makes camera networks a compelling solution to today's traffic management needs.

Cameras have become so prevalent in metropolitan living primarily because, for those tasked with traffic management or law enforcement, actually being able to investigate a scene as events unfold provides greater context as opposed to looking at dots or exclamation marks on a map. Network managers and operators are most effective when can see the full extent of what is happening so they can prioritise and react with the most efficient use of limited resources.

Digital video is already being used for traffic data purposes in a multitude of ways. Vehicle counting, flow measurement and Automatic License Plate Recognition (ALPR) are all proven technologies which transform visual data into actionable information.

The security market is driving the expansion in camera systems which employ Digital Video Analysis (DVA). Motion detection, tripwires, or abandoned/missing objects are but a few of the data points that are now sensed by DVA computer systems. That list will surely grow as software-based analytic approaches improve. Already the necessary computing power has become much more affordable, increasing the adoption of DVA systems.

The growing investment in digital video surveillance makes particular sense when one considers the potential array of functions that can be obtained from a single sensor. A camera deployed for remote viewing of traffic can also be used to count cars and extrapolate traffic flows. Irregular conditions that are electronically observed and identified via automated video analysis can include accidents, wrong-way drivers, abandoned vehicles and illegal pedestrian activity. The range of information that can be extracted from a network of intelligent cameras will continue to see many years of scientific growth and change.



The potential of gaining so much contextual information makes camera networks a compelling solution

Although video analysis methods result in highly specific information as to the location, speed and even size and colour of vehicles, it is still anonymous data. When coupled with license plate recognition, digital video data can become very specific.

Searching for criminals, abductees, missing people or terror threats are but a few examples of the primary features of the next generation of digital video surveillance. Analytic systems offer advanced search capabilities which give public safety personnel the ability to closely examine those vehicles that match a particular description as opposed to all vehicles in the area. The opportunities

for expanding the science of forensics for security and investigative work are vast.

Archiving important events

Of the principal benefits of advanced video analytics, event bookmarking stands to provide significant advantages. Digital video bookmarking allows for immediate tagging of segments of video in order to review and analyse at a later time. Significant time savings are realised by moving directly to a scene related to an event of interest rather than viewing hours or even days of video.

A 'needle in a haystack' comes to mind when considering how to navigate enormous volumes of video for five minutes of activity. In effect, once an alert is triggered, the video can be both broadcast to appropriate authorities as well as bookmarked as a significant event to be saved for investigative and legal purposes. Given the high volume of video data that is currently coming into a Traffic Management Centre (TMC) or Command & Control Centre (CCC) sophisticated measures must be employed in order to manage information that is designated as critical.

Some video archival systems employ strict chain of custody methods that have proven admissible in US courts. The key elements of a successful networked video system are: event identification (automated alerts with human validation of action and importance); video management (storing only critical video files and providing proper access and security); and a robust evidence chain (in order for video to be used in legal proceedings, this is critical).

Video data should be exploited to achieve more in-depth analysis of an intersection, exit ramp or road segment. Not every location in a sensor network requires intense examination simultaneously; a local authority or jurisdiction can transfer large amounts of information for later offline analysis. It is now possible to deploy mobile, purpose-oriented cameras as well as other sensors in order to gather information for a defined period of time. Lane-specific usage, merging, turns and pedestrian activity are all data points in a very concentrated analysis.

The high level of detail provided by video analysis will bring municipalities closer to the ultimate goal of metropolitan traffic optimisation. The cost savings gained from not having to perform labour-intensive traffic evaluation projects will allow resources to be deployed where they will be most effective. In some cases the cost savings can be considerable.



Integrated Corridor Management

The United States Department of Transportation (USDOT) is currently working with eight pioneer metropolitan areas to develop advanced strategies for reducing congestion.

When announcing the Integrate Corridor Management (ICM) systems initiative, US Secretary of Transportation Mary Peters stated that US industry loses an estimated \$200 billion (€1.36bn) per year due to freight bottlenecks, and drivers waste nearly 4 billion hours of time commuting, and more than 2 billion gallons of fuel, in traffic jams each year.

The greatest concentration of congestion is often along critical corridors that link residential areas with business centres, sports arenas and shopping areas. New road construction alone will not solve the growing problem of congestion; according to the USDOT, travel demand on the US's roadways is outpacing new freeway capacity by a factor of five.

Sensors are the most basic elements of corridor management. Many existing sensors already provide vast amounts of disparate data which give the command centre detailed overviews of expressways and mass transit.



However, that is not enough to optimise a corridor. To a great extent, operational personnel require information on arterial roads with details and resolution reaching down to the intersection level.

The cost of deploying loop or radar sensors in so many widely distributed locations is prohibitive. The complexity of even simple four-way intersections cannot be effectively analysed with traditional roadway sensors. Digital video is in many ways the best solution with which to obtain the detailed information needed to understand not only the current status but also the long-term trends.

Privacy and GPS models

GPS has reached the point of mass adoption around the globe and will be a key asset for both ICM as well as other traffic management approaches. The business of collecting commercial and commuter information is another matter entirely. GPS technology is proven and, putting aside limitations in urban canyons and some specific remote regions, most metropolitan areas have high-quality wireless and location data that can be brought into an ICM system.

The floating vehicle data model has made great strides in Europe and can provide a good visualisation of where commercial vehicles are experiencing congestion. Some success has also been made in determining similar GPS data from the Location-Based Services (LBS) on cellular phones. This method has faced issues in the US due to the lack of support from the quickly consolidating wireless phone industry.

A cautious view of privacy has kept this approach from becoming mainstream. Eventually, however, a business model will prevail which enables willing subscribers to sign up for traffic and other services where their location data is monitored. Once that happens, GPS and LBS will play a significant role in ICM.

Managing disparate data

Many different data types are required to provide a complete view of an integrated corridor. Each sensor type has both advantages and disadvantages (Table 1). Key to understanding regional sensor data is complex multi-dimensional analytics on every available data source no matter the sensor type.

Such approaches provide a rich contextual view of the corridor at large by combining the differing data sets to uncover as-yet-unseen information hidden in the chaos of modern traffic. The sheer volume of information requires significant computing power in order to operate on the sensor data with the sole purpose of maintaining an acute awareness of the health of the network.

Several techniques are currently in varying levels of development which utilise analytical procedures that can provide results in mere minutes and seconds. More traditional traffic research methods once required weeks or months to complete.

A significant challenge lies in managing video data (or subsets of such information) that is deemed critical and thus useful to analyzing a particular segment of traffic. Software systems designed to reduce the amount of video information that operators need to review are available.

Some software providers declare reductions in the sheer volume of critical video that must be stored for extended periods of time. Just a mere 30 days of video data for a large city can lead to storage requirements of several petabytes. It is critical to store only that video data which is of long-term value to the traffic management system in addition to those municipal agencies with an interest in such information.

Political leaders are always examining methods to encourage and empower agencies to work together in an effort to share infrastructure such as networks of sensors.



These efforts in the direction of enhanced mutual aid provide informational benefit to everyone involved. Mutual aid between municipal agencies offers the greatest value to constituents while reducing operational redundancies. Such progressive methods allow organisational departments to work together more closely on a daily basis.

Acting on the Information

In addition to deploying the specialised sensor network, ICM requires the right enterprise computing architecture to consume, monitor, and control the vast amounts of data generated. Once a clear picture of the network's health can be viewed in a real-time environment, the system will have to be tuned for tolerance and priorities.

Some segments will have precedent over other to ensure the most optimal use of the corridor assets. An ICM system must have the flexibility to adapt to new information and to highlight only that which is most important for the TMC operators to address.

This will require enterprise computing services that will allow systems to be customised to fit the unique need for each metro area that adopts ICM. A Service Oriented Architecture (SOA) will allow agile scalability for future growth.

The TMC of the future?

Technology has advanced so rapidly in the last few years that system integrators hardly have time to adjust before the 'Next Big Thing' demands attention. Today, that technology is Digital Video Analytics operating on advanced sensor networks and comes with benefits as well as challenges. By planning ahead for the expanded capabilities of DVA and the growing number of cameras, agencies are able to avoid the significant investment in systems that can overwhelm personnel and quickly grow obsolete in relation to the original purpose. -

Mr. Kotscher founded MetroTech Partners in 2007 to develop Advanced Analytical Software for Intelligent Transportation Systems.

Kotscher@MetroTech-Partners.com

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