iQ-Smart City
SECURITY - SAFETY - SERVICE

A guide on how to maximize the value of your investment in a Smart City System

iOmniscient
High iQ Surveillance

iQ-Smart City
Security, Safety, Service

Other books published by iOmniscient are:
Automated Surveillance: A Guide to Intelligent Video Analysis
A Practical Guide to Face Recognition in a Crowd
A Guide to Camera Selection and Placement for Video Analytics.

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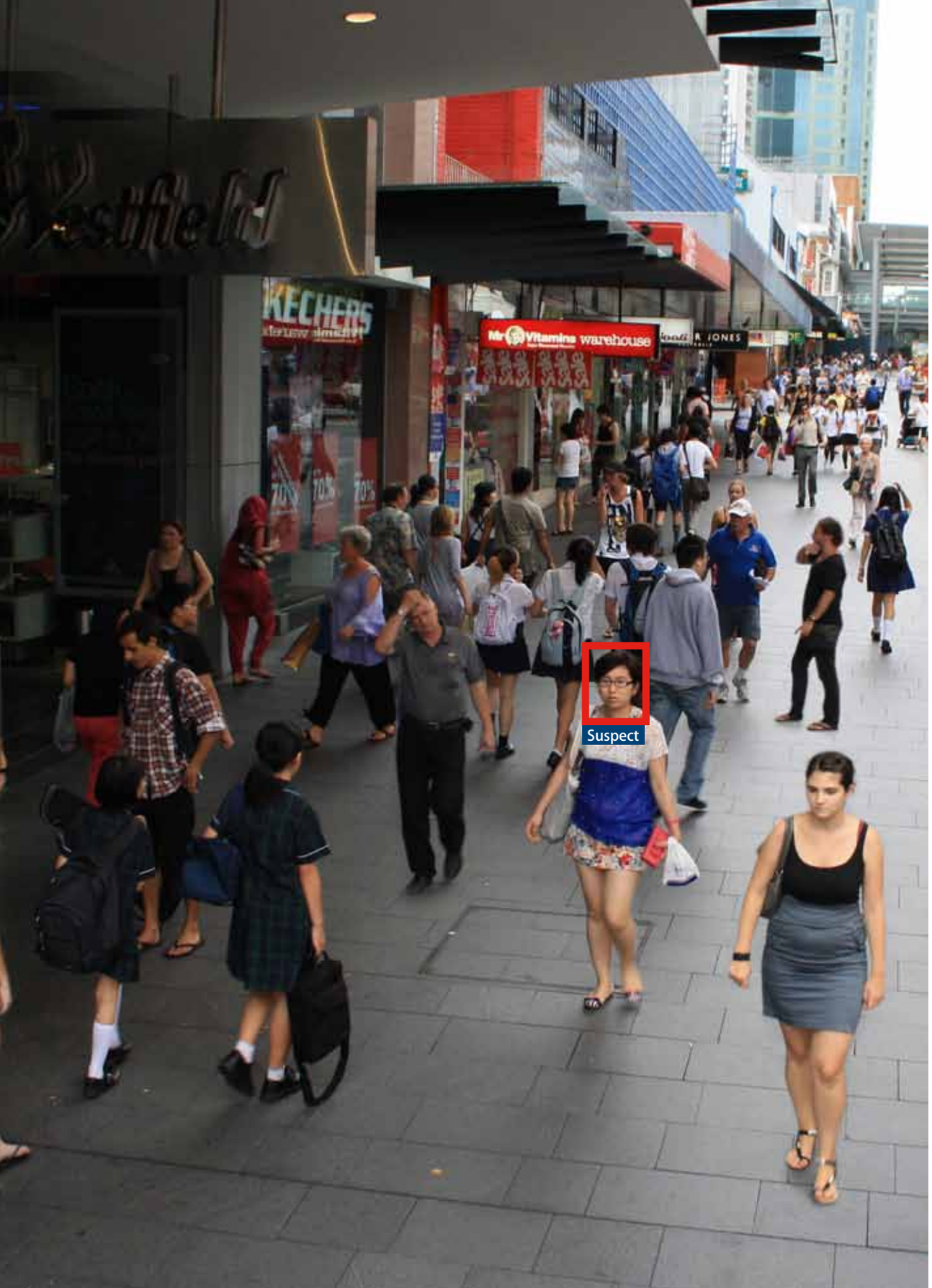


1. Introduction

Most cities build their surveillance systems based on technologies that were available in the past, unaware that Artificial Intelligence based technologies have been evolving rapidly. So far these new technologies have been extensively deployed for specific environments such as road and traffic management, airports, railways, shopping malls, museums and other industries such as banking and oil and gas. iOmniscient has built comprehensive solutions for a total of 30 industries. These include iQ-Rail for the railway industry and iQ-Banks for banking. All the proven capabilities in the various industry solution have now been brought together to provide a solution for the Smart City.

An effective Smart City is one where the information derived from a multitude of different types of sensors from different parts of the city are pulled together so that authorities can ensure the security, safety and enjoyment of its citizens. Consequently it should be possible to reduce the costs and increase the effectiveness of providing services. In a Smart City, the number and severity of accidents and incidents can be reduced through a better understanding of how people behave. When an incident occurs, enhanced information should enable the emergency service providers can respond more quickly and effectively.

Installing thousands of surveillance cameras is not the answer. Studies have shown that an operator watching just two cameras misses half the action after around 10 minutes and sees almost nothing after 20 minutes. Setting up huge and expensive command and control centers cannot on their own ensure that critical incidents are detected. To ensure real time response one requires an Intelligent Video Analysis system that will tell the operator if an event occurs, for example, someone has fallen down on camera 25, someone else has parked

Face Recognition in a crowd. Data sent to nearest policeman to apprehend suspect.

a car illegally on camera 200, a person of interest has just entered the shopping mall and so on. Importantly, only those persons authorized to get specific data should have access to that particular bit of information to protect the privacy of citizens and to ensure that sensitive information does not fall into the wrong hands.

The objective of this document is to put forward a vision of what can be implemented in a modern city using well proven technologies.

An iOmniscient system can provide capabilities that have not been visualized by most city planners.

iQ-Smart City from iOmniscient is a comprehensive portfolio of capabilities for managing the environment where people and vehicular traffic interact in a modern city. By being SMART, the system makes the city SAFE. By being SMART the SERVICES provided to citizens can be enhanced.

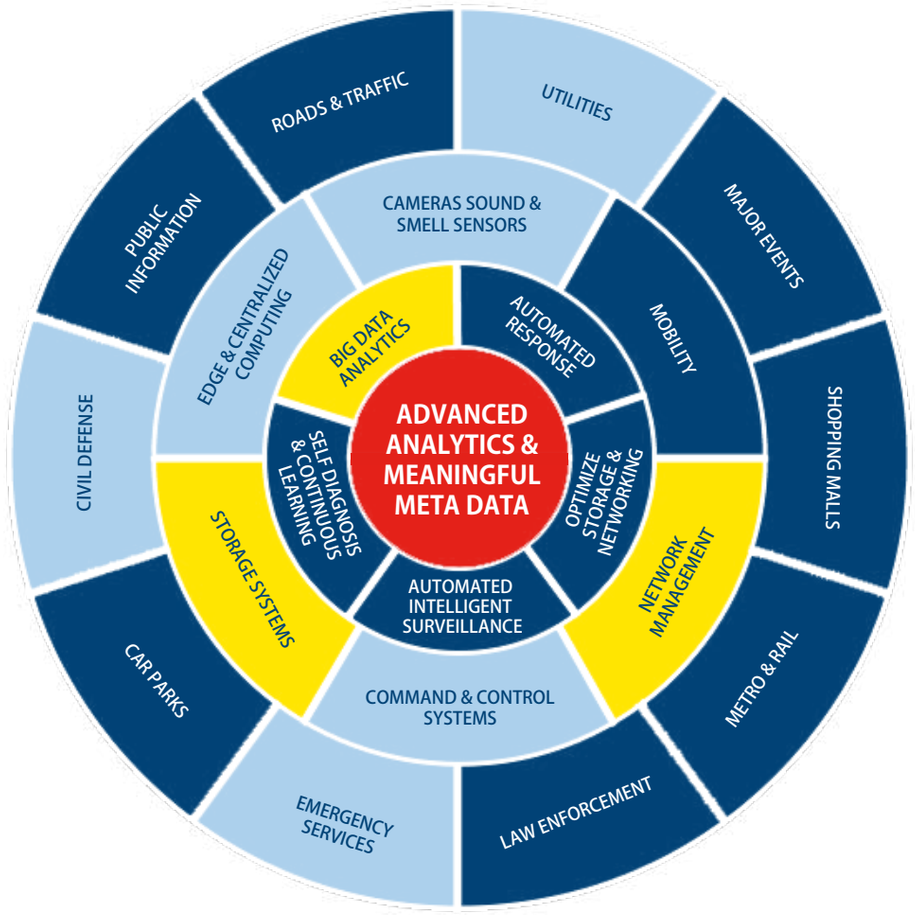
iOmniscient Advanced Video Analytics is a central part of Smart City applications. The technologies described exist today and have all been implemented in a wide range of industries (though not necessarily in a Smart City environment). They are based predominantly on Advanced Video Analytics. iOmniscient also provides analytics based on sound (e.g. detecting gunshots, breaking glass, fights, etc.) and smell (e.g. to detect gas leaks or spray painted graffiti).

The Video Analytics that are described in this book go beyond simple motion-based Video Analysis. It involves behavior analysis, counting in crowds, abandoned object detection in crowded scenes, Face Recognition in crowded scenes and multilingual License Plate Recognition done simultaneously on the same camera. Beyond analytics it involves the concept of a sophisticated Automated Response.

Incorporating Big Data concepts, the iOmniscient iQ-Smart City system is able to process large quantities of unstructured surveillance information to enable the user to manage and respond to a wide range of events in a large city very efficiently and to forecast future requirements, enabling more effective planning.

Most importantly, several of iOmniscient's systems are designed to save money.

A system using iOmniscient's patented iQ-Hawk will in fact cost less than a standard surveillance system, resulting from a large decrease in storage and network bandwidth requirements. The overall system can be several times less expensive than systems designed using traditional technologies. You may not require all these applications immediately. However, knowing that you can upgrade to any of them with a simple license change will ensure your system is not obsolete even before it is implemented.



iOmniscient core technology for Smart Cities
iOmniscient Smart City capabilities
Capabilities provided by both iOmniscient and by partners
Capabilities from partners

At the very heart of a Smart City system is the advanced analytics system that intelligently extracts meaningful information from the variety of sensors. The

sensors could be cameras for video information but they could equally provide sound and smell data for analysis. Further, meaningful intelligence based on the data provided by the sensors is provided to all the other systems that are part of the Safe and Smart City infrastructure. This Meaningful Meta Data is used by a variety of other subsystems to provide information to stakeholders to enable automated responses. This system also sends data to itself to ensure that it is working effectively.

The way iOmniscient technology works with hardware and systems from other partners is shown on page 11.

The core technology at the center of the diagram is provided by iOmniscient. However the infrastructure such as hardware may be supplied by others. Other organizations specialize in particular technologies such as Big Data Analysis and may have a significant role to play in providing meaningful reports and analysis as shown in the next circle. Hence some infrastructure is provided by both iOmniscient and several other companies in partnership.

This infrastructure mentioned in the next circle provides the various capabilities required by the operators of the Smart City. At this level alarms are generated for incidents. Automated Responses can be provided for certain types of event.

The outer ring shows the many stakeholders in the Smart City. These include law enforcement bodies, utilities, commercial interests such as shopping malls and organizers of public events. All these organizations have a role in ensuring that the city is managed safely and securely.

These stakeholders implement infrastructure that can consist of cameras, networks, storage devices and other equipment. Much of this infrastructure may exist already. Many cities have already installed large numbers of cameras and have extensive network bandwidth that has been rolled out. Any new system needs to take account of this legacy infrastructure and incorporate it into its design. Minimizing the overall cost of the systems to the citizens who ultimately pay for them system has to be one of the objectives of a Smart City project.

Different chapters in this book will address most of the elements of this diagram. There will be a discussion of the analytics in the initial sections, followed by some

of the more advanced capabilities such as Automated Response and the use of Big Data concepts to make predictions.

The way the different stakeholders tend to use such systems is also discussed. The final chapter describes what it takes to implement a successful Smart City system. Video Analytics systems are prone to failure if they are implemented without an understanding of these factors.

This book was written to educate our readers on the technologies that are available for creating a Smart and Safe City. There is a bombardment of marketing hype about low end technologies which can confuse users. This book should enable the reader to differentiate between the various technologies available and to choose what is appropriate for them.

iQ-Hawk automatic zoom of abandoned object event. Notification sent to nearest security officer.

2. What Video Analytics can do for Smart Cities

iOmniscient is already recognized as the World's technology leader in Video Analytics for its security and safety applications. It has won numerous International Awards for its technologies including most recently the Global Security Challenge for Crowded Scenes, the Engineers Australia National Engineering Excellence Award and the prestigious IFSEC UK Award for Best CCTV Technology (second time that this award has been given to iOmniscient).

iOmniscient has a global customer base including organizations as diverse as airports from Mexico to Turkey, City Surveillance systems from Kazakhstan to Nanning and railways around the world including the China Fast Train Project.

iOmniscient remains unique for the following reasons:

1. It has the most comprehensive applications in the surveillance industry ranging from behavior analysis to Face Recognition.
2. It is able to cope with crowded scenes which is the biggest challenge in security systems. It has international patents for this application (for object detection in a crowd and Face Recognition in a crowd) which enables the software to operate in complex environments.
3. It has a unique Artificial Intelligence capability called NAMS (Nuisance Alarm Minimization System) which helps to minimize false alarms.
4. It has unique Rapid Automated Response capabilities.
5. It can provide 24x7 support globally. This is through a combination of design (all its systems can be installed and managed remotely) and organizational structure (it has in place 3 support centers strategically located around the world and they ensure that any

issues that come up anywhere at any time can be responded to quickly and effectively).

This book provides further information on the use of iOmniscient software for specific applications to enhance security and safety in cities.

Many cities are implementing smart surveillance systems to improve the safety of their citizens and to enhance the ability of law enforcement agencies to monitor and apprehend offenders who are acting outside the law. Cities use these systems for some of the purposes described below.

Keeping People Safe

The most important priority of city surveillance systems is on the people themselves. The objective is to keep people safe and prevent accidents or criminal activities. Not all activities are easy to detect. For example, it is very difficult to detect if two people are fighting as this can take many different forms. However many associated behaviors can be detected. For instance, if a person falls down as a result of a fight, this can be detected. If a person begins to run suddenly – this too can be detected. If crowds gather suddenly, this could be a symptom of some unusual activity as well. Having a system that can monitor various types of human behavior can help the city's officials ensure the safety of their citizens.

Protecting High Value Buildings and Assets

City surveillance needs can be quite varied. There will be departments that are responsible for protecting building assets. Graffiti and vandalism detection can be an important application for them. Conventional motion detection systems can detect graffiti but they would also detect all the many passersby on a busy street. A smarter system is required to detect the graffiti while ignoring people who are just walking past.

In one European city they had a very severe graffiti problem. Each time the buildings were repainted, the graffiti artists struck again. Repainting buildings can be very expensive and hence the city council had to find a solution. They

put in an iQ-140* level iOmniscient graffiti detection system mounted on a van. The system was able to catch the culprits on the first day after it was installed. The news spread very quickly among graffiti artists and the problem disappeared overnight – at least in their neighborhood.

*The intelligence level of systems and their iQ-Rating is discussed in the next section.

Traffic Monitoring and Management

City surveillance systems can be used to monitor traffic. Often there are special slow speed zones near schools or beside shopping malls and hospitals. Monitoring such locations has previously been very expensive because the detection of speed and the recognition of vehicles required significant civil works such as the digging of roads for the laying of magnetic induction loops as well as very expensive cameras. With modern systems where the Video Analysis system can do everything (recording the event, detection and recognition), the economics have changed and these systems can be widely implemented at a tenth of the cost of the older systems.

Traffic monitoring can also be used to detect areas which get congested along with an analysis of the timing of these events, i.e. by time of day and day of week. This can be used to review traffic management systems to reduce congestion at peak times. These systems also reduce pollution and make cities more sustainable.

iOmniscient offers three packages for managing roads (for tunnels, highways and urban centers respectively). Details on these and other specialized industry packages are available separately.

Enhancing Public Services

Public services including public transport, bicycle paths and pedestrian malls can be enhanced with smart monitoring of these areas for excessive crowding, queues and other problems. The system can highlight if private vehicles travel in lanes designated for buses. City officials can respond in real time to ensure that services to the public are optimized.

Optimizing Sponsorship and other Revenues

Smart surveillance systems provide opportunities for event managers to maximize revenues from advertising in public spaces, both outdoors and indoors, by measuring traffic volumes. Revenues can be generated by managing car parks more efficiently and by being able to demonstrate the value of sponsorship through the promotion of sponsors at strategic locations.

Presenting a Clean City

Smart event applications provide opportunities to monitor graffiti and vandalism and areas where rubbish has been dumped so that the city is presented as a clean and safe place to live.

Traffic Monitoring system for safety.

License Place Recognition for automated infringement notice.

3. Advanced iOmniscient Technologies for iQ-Smart City

Just as with humans, different Video Analysis systems have varying levels of intelligence.

In view of the considerable confusion associated with defining intelligence for video-based surveillance systems, a rating system was developed for various types of intelligence capabilities. The criteria used to define the level of intelligence, essentially relates to how much "thinking" or analysis the system is capable of and the level of difficulty and complexity of its thinking. The system is similar to that used for measuring human intelligence. Just for reference, the average iQ of the human population is 100. Half the population has an iQ of more than 100 while the other half has less.

A surveillance system with a rating below 90 would be classified as a system with very basic or limited intelligence. Between 90 and 110 the system has average intelligence. At an iQ of 120 the system can be considered to be very smart and, above that, the system would be in the genius category.

The chart (page 22) shows the iQ level of various functions. There is a direct correlation between the complexity of analysis provided by systems and the number of companies in the market place that can provide the capability. There are now hundreds of suppliers that provide systems with limited intelligence. At the average level of intelligence there are about a dozen companies worldwide that can provide a robust system.

There are only two or three companies worldwide with offerings that meet the criteria for "Smart" and "Very Smart" systems. At the "Genius" level, because of its international patents, iOmniscient stands alone in providing products in this class.

When applied to video based surveillance systems, storage and retrieval systems would be positioned at the bottom of the scale as having very limited intelligence. At the next level of intelligence we have image enhancement systems which are systems that make the image clearer to see. An auto focus function or a system that eliminates camera shake would fall into this category. There is some basic intelligence involved here but it is still very simple.

iQ-Rating Chart

Intelligence Rating	Level of Intelligence	Potential Capabilities
iQ-10	Not Intelligent at all	Simple storage and retrieval systems
iQ-15	Very Limited	Image enhancement
iQ-20	Very Limited	Health Check
iQ-40	Basic	Image-difference based motion
iQ-60 – 65	Basic	Very Limited Video Motion Detection and counting but with limited ability to deal with false alarms
iQ-80 – 85	Average	Intrusion detection/ counting (involving understanding of what is being detected and sophisticated ability to deal with false alarms)
iQ-100	Average	Object tracking; object detection in relatively empty scene; simple behaviors such as running, loitering
iQ-110	Average	Sophisticated counting (even from angled views) but in a relatively empty scene
iQ-115	Smart	Advanced behavior Analysis such as for slips and falls, crowd gathering
iQ-120	Very Smart	Counting in a crowd
iQ-140	Genius	Object detection in a crowded scene
iQ-180	Genius	Object detection where the object is virtually invisible to the human eye
iQ-Infinity	Super Genius	All of the above at the same time on the same camera

The rating system above is now widely used by some consultants and security analysts as a guideline for measuring the intelligence of video based systems. Systems with the capacity for simple motion detection using image differences would be classed as being of limited or basic intelligence.

At a slightly higher level of intelligence, the system should be smart enough to differentiate between objects using simple techniques and then to recognize simple behaviors such as someone crossing an imaginary line. At the next level, there are systems that can analyze more complex behaviors such as running or loitering. This level of technology is available from several major suppliers and would be classified as having "Average" intelligence.

A smarter system would be able to count people and vehicles accurately. In fact the same system should be able to classify objects (e.g. trucks, cars and bikes) and count each category individually.

An even more sophisticated system is capable of more complex behavior analysis such as the ability to detect slips and falls.

This would be considered to be quite a smart system.

People can fall down for many reasons. They could have been assaulted; they may have had an accident; they may just slip and fall. The system will detect such an event and enable resources to be deployed to help the person. Alarms will not be activated if a person bends down to tie a shoe lace but if the person falls down suddenly, the system will raise an alarm.

This application has been found to be useful in reducing insurance claims. People who get immediate attention and care are less likely to initiate litigation than those who are ignored.

More importantly it ensures that if there is an accident then the victims get immediate help.

Genius systems go beyond the abilities of motion-based systems. They can detect stationary objects in a crowded scene with very long detection times. They can also detect objects that might be invisible to the human eye. iOmniscient has patented technology that enables the detection of abandoned objects in

crowded spaces and complex environments including outdoor environments. It is the only software vendor that has this proven capability.

Cities have a security challenge in detecting abandoned objects in crowded public areas. Given the high volumes of people passing through these areas, there is a very high probability that someone will put a bag down at some point or the other but these bags are probably not dangerous. They are just the normal activity of people moving about in a public space.

The CCTV surveillance system should be able to ignore all the bags that may have been put down for 2 minutes or even 5 minutes and catch only those which have been abandoned for a longer period of time – say 10 minutes or longer. Even 10 minutes may be too short a time but one has to strike the right balance between detecting suspicious objects and ignoring the thousands of bags that everyone puts down momentarily when they are in a public area.

During this time tens, maybe hundreds of people may walk in front of the abandoned bag or object. They may stand in front of it and may totally obscure it from time to time. If the bag or object is still there after the defined detection period the system needs to be able to detect it and raise an alarm.

Theft of cars or items from cars and theft from stores can be a major problem too. The same technology can detect when stores or vehicles are broken into and raise an appropriate alarm. Vandalism and graffiti can be a problem at bus stops and at public buildings. The technology used to detect abandoned bags can also detect graffiti and vandalism even if it occurs in a busy environment with people and vehicles moving about and partially or totally obscuring the problem area for a significant proportion of the time.

It should also be noted that some companies can offer point solutions (e.g. detect one type of behavior). To differentiate between these systems and those that provide a comprehensive solution, the category of iQ-Infinity was defined. In this class, the system has the ability to perform all the analyses described above at the same time on the same camera.

Simple object detection with iQ-100 which is available from many suppliers (Left). Sophisticated object detection in a crowd which is only available from iOmniscient iQ-140, (Right).

Immediate Response with "Jump to Event"

The old method of using Pre and Post Alarm video to determine what happened during an incident has become obsolete because in today's world the incidents themselves are becoming much more complex.

The required information can now be available in real-time from iOmniscient. The "Jump to Event" capability takes information retrieval to a new level of sophistication.

In simpler system, a few seconds of video may be retrieved showing the moments just before and just after the event.

This works when the event is something that happens at a fixed point in time such as a person jumping over a fence. The user can note the moment that this event occurred and store footage from just before and just after this event. This is referred to as Jump to Alarm and virtually all iOmniscient systems can provide this capability.

If the event takes place over an extended period of time, the requirements for Jump to Event can become very complex. For instance, if a bag is abandoned in a crowded scene with a detection time of 10 minutes, the bag has been identified as abandoned and an alarm is triggered by the system after 10 minutes. If the user looks at the video for 30 seconds before and after the alarm, the bag would be seen but without a history of how it got there.

iOmniscient has developed a unique Jump to Event capability associated with an iQ-140 level system that goes way beyond this. It enables the user to jump back to a pre-defined time before the event started. Hence in our example of the abandoned bag, at the press of a button the user can jump back in time not just before the bag was detected but before it was first brought into the scene and abandoned. The user can immediately review both the event and the preceding period of video footage and gain important information on who brought the bag in and the person's current location if he is still within camera view.

Jump to Event takes the user back to the start of the event.

Now consider a scene where there might be ten suspicious bags in the area being viewed. The Jump to Event function should enable the user to click on any one of these bags and "jump back" to the moment when that particular bag was brought into the scene and abandoned.

The user then has the option of archiving the event for later review or discarding the alarm information.

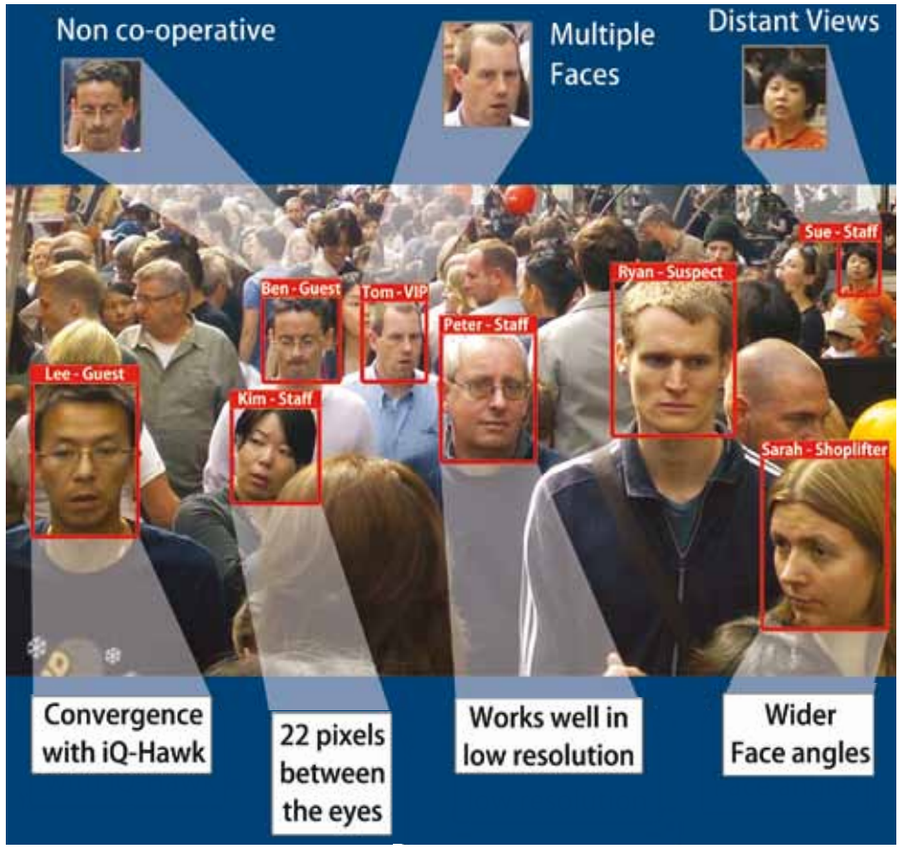
None of the simpler data storage and retrieval systems has such a capability as it is very dependent on the intelligence required to find the bag in the first place. Only a system that can operate at the iQ-140 level and above can actually have a sophisticated Jump to Event function similar to the one described here. This is the domain in which iOmniscient has international patents.

Recognition Technologies

All the technologies described so far are detection technologies. They analyze a wide scene and detect behaviors of humans or vehicles in the scene. There is a parallel Video Analytic technology for the recognition of humans and vehicles.

Face Recognition in a Crowd

The most powerful new technology introduced by iOmniscient within the last 12 months is the world's first Face Recognition in a crowd. Using relatively low resolution video (the system requires only 22 pixels between the eyes) for recognition, the system can recognize people who are non-cooperative, match them against data bases and in general provide a very useful tool for catching persons of interest.



Face Recognition in a crowd.

iOmniscient's Face Recognition System can operate in an uncontrolled environment requiring only 22 pixels between the eyes to perform recognition. The system can cope with variations in pose and expression, head gear, spectacles and facial hair.

The system is not designed as a biometric access control system. Rather its primary use is in surveillance. With its ability to match faces against multiple large database, the system provides a far higher accuracy than the alternative in such situations which is a manual system.

In addition to matching faces against multiple lists of people it can be used to track a person. If person A has been seen on a particular camera and tagged, the system can determine which other cameras A has appeared on and when. This is perhaps the only automated technique available today for tracking people on non-overlapping cameras. In addition to detecting and tracking potential criminals, it could also be used to find lost children at a crowded event.

The system can be used for customer service, to see how long it takes a particular person go travel from Point A to Point B.

It can be used for recognizing witnesses at an accident and to determine where they went if they had not remained at the scene when the police arrived.

The demographic information that can be extracted from the Face Recognition system can have multiple purposes for ensuring the safety and security of citizens.

The accuracy of such systems depends on factors such as the camera type and placement, where the person is looking (the system needs to see both eyes to perform the Face Recognition) and lighting. With large databases the system can consistently outperform humans (who provide the only alternative method of performing these tasks).

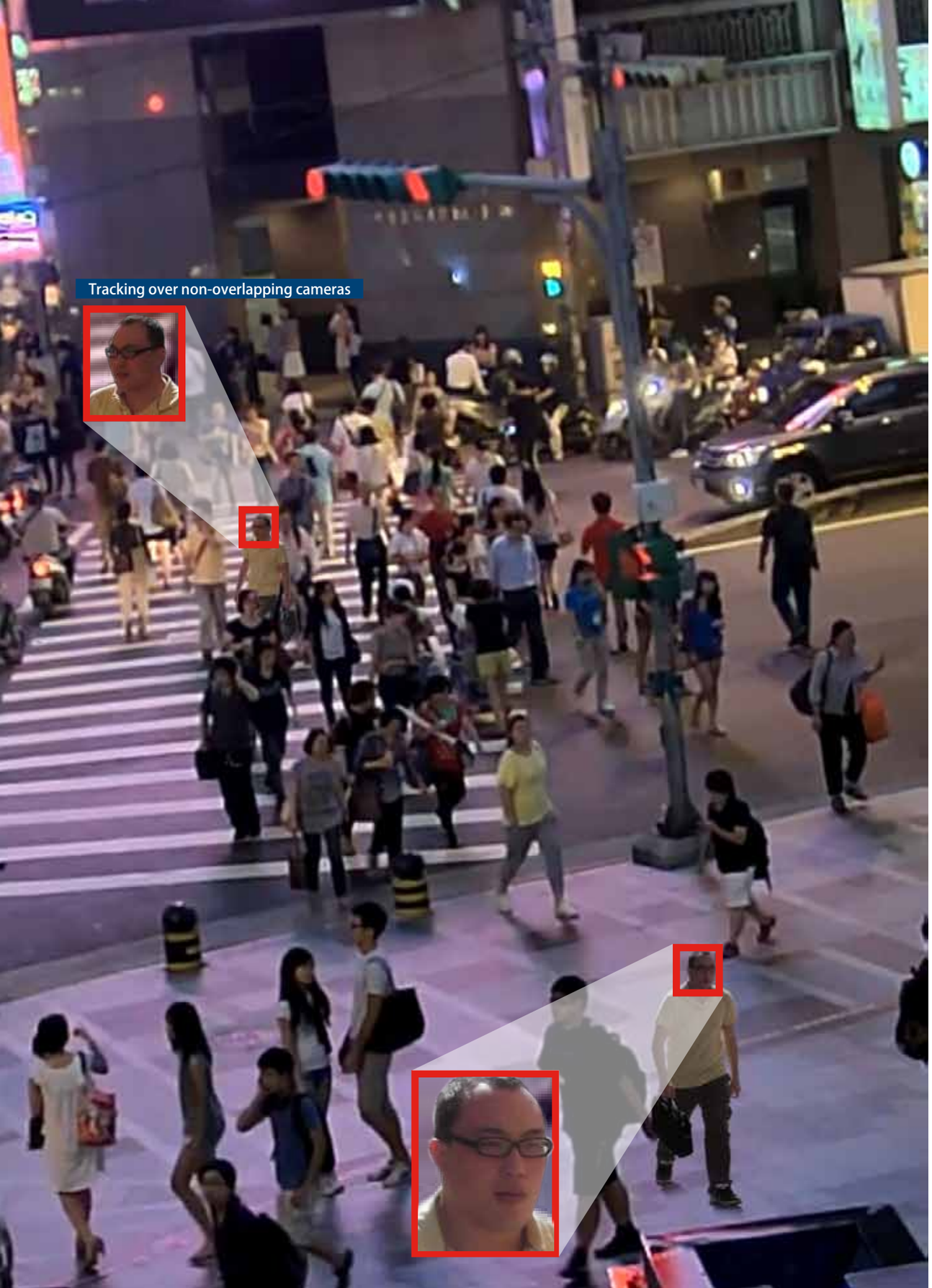
Providing a reasonably accurate match using images that provide only 22 pixels between the eyes, the iOmniscient Face Recognition in a crowd system is demonstrably superior to anything else that is available in the market.

Multi-lingual License Plate Recognition

iOmniscient's License Plate Recognition system can recognize plates from over 100 countries. It does not require any external trigger (e.g. motion induction loops) to recognize that a vehicle is in view and needs to be recognized. It is all done with video. Operating at high accuracy even at high speeds, such an integrated License Plate Recognition system is critical in any Smart City implementation.

Driver Match

The Face Recognition and License Plate Recognition system can be used together. In public car parks vehicles may sometimes be driven out by someone other than the driver who brought the vehicle in. Very often this is a symptom of a vehicle theft. Experience shows that it is often insufficient to use humans at checkpoints to detect such thefts of vehicles. The Driver Match system recognizes the number plate of the vehicle being driven as well as the face of the driver and checks that the driver is the one who is authorized to drive that vehicle.



4. Specialized iOmniscient Video Analytics Capabilities for a Smart City

The core capabilities of a Video Analytic system have been described in the previous chapter along with their iQ levels. In this chapter you will learn how some of these products have been extended for use in Smart Cities. Using its software building blocks, iOmniscient has created new applications that are particularly relevant to the needs of various stakeholders.

As an example, in cities one often has to manage queues. iOmniscient offers a queue management product that uses a combination of the capabilities of the counting products, the crowd management product and the Face Recognition product to provide a capability which provides the user with information such as the average waiting time in the queue, the proportion of people who leave the queue before they get to the end of it and so on.

The main subjects for surveillance in a Smart City are people, vehicles and events. Hence the challenge in a Smart City system is understanding how people and vehicles behave and the types of other events that may occur. In this chapter we provide a few examples to show what is possible.

Applications around People

While occasionally there may be a requirement to protect perimeters and prevent intruders, most Smart City applications are about more complex human behavior. Some interesting applications are described below.

Tracking person of interest using Face Recognition in a crowd. Data automatically sent to nearest police man.

Control of Access to Restricted Areas

Access to important public buildings (and car parks) may need to be controlled. Standard access control systems can be easily defeated. Access cards can be used by unauthorized personnel. Or an unauthorized person may tailgate behind an authorized person.

In such situations iOmniscient's Face Recognition in a crowd system can be used to authenticate that the holder of the access card is indeed its owner. Tailgating can be detected and the faces of the culprits recorded using iOmniscient's Face Detection system. Similar systems exist for controlling the access of vehicles.

Vandalism and Graffiti Detection

The system is able to detect vandalism and graffiti in a crowded scene. Often when graffiti is being sprayed the culprits are performing their art in open view. There may be passersby on the street and the intent would be to ignore these people and to only raise an alarm when new graffiti is seen. This can be achieved using the iQ-140 system. The same is true for vandalism such as the breaking of glass panes or damage to street furniture.

Detection of ATM Skimming Devices

Identity thieves have developed various devices for skimming information off credit cards that people insert into ATMs. These can be very well camouflaged and very difficult to see. iOmniscient's anti-skimming device system (based on iQ-180) can be used to detect such devices. While fraud prevention from ATMs is of particular interest to banks, the catching of identity thieves is usually important to law enforcement authorities so both tend to have an interest in it.

Loitering at Night/ Soliciting

In some jurisdictions law enforcement agencies have an interest in detecting people who may be loitering in an area. They may be car thieves who are checking out vehicles to break into or others who may be soliciting for business. Such behavior can be detected using an iQ-115 system.

Gathering of Groups

At times it may be necessary to know if crowds of a certain size are gathering. This is often the case where a meeting area is only designed to hold a certain number of people.

The iQ-120 system can provide information on the number of people in a given area and it can raise alarms if the number exceeds a given threshold.

Fighting

Fighting is difficult to detect reliably using Video Analytics because the body language of people coming together from different communities can be very different. In some communities people may get very close and hug each other. Therefore attempting to detect fighting can result in a system prone to false alarms based on different social norms. In the next chapter we will discuss Audio Analytics which can complement Video Analytics. By determining that people in the vicinity have noticeably raised their voices the system can be used to detect potential fighting.

Management of Public Spaces

In addition to detecting slips and falls, a key application for the management of public spaces is counting people as they move from one area to another, for example in a shopping mall. Understanding people traffic flows is critical for the running of the shopping precinct. It allows authorities to determine how many people travel along a particular route and retail rentals can be based on this. The retail shops themselves can use traffic counts to determine where to put the chocolates and where to place the milk.

The most important aspect that differentiates "counting" from other security

type applications is that counting can help the user make money whereas all forms of security only result in the spending of money. Marketing departments can find it very easy to justify spending money on counting while security departments may struggle to get the money they need (except after a crisis – management will often spend on security AFTER they have had a major incident). In a city, the local council may wish to count how many people walk through (or drive through) in a particular direction so that they can sell advertising space. Alternatively they may use such information to provide improved services. For instance if a large number of people attempt to cross a road at a certain point it may suggest that they need a foot bridge or a traffic light there.

Counting is usually a statistical activity. Whereas it is valuable to have as accurate a count as possible a small variation is usually not relevant in terms of the information that can be derived from the data.

Counting systems can yield some very interesting information. They can provide information on the routes that people take as they meander through a public space. It is possible to compare traffic information with comparable, previous periods. Using iOmniscient's Face Recognition system it is also possible to understand the demographics of a group of people. The system can provide information on their gender, age and ethnic background which may be used for marketing but also for security purposes. If for instance a young lady or a very old person is walking down a very lonely alley, the system can raise an alarm and alert the police to be keep an eye out for them even though their identity is not known.

Crowd Management

In busy cities, groups of people will inevitably gather and the authorities will want to understand the dynamics of these crowds. They may wish to know when small groups (say of 4 to 5 people) get together. Or they may wish to understand the total number of people in a particular area.

They may also wish to know if known trouble makers or other persons of interest have intermingled with the crowd.

Having accurate information on how a crowd has come together and how it moves can provide the authorities with the means of maintaining orderliness and peace so that citizens can partake of major events without danger.

Tracking People

From time to time the police or other security agencies may be required to track people around the city. It is possible to track a person using the iOmniscient Face Recognition system. The system will search through all the video footage to determine where that face has been seen over the required period of time. If an individual has been spotted in one place it is possible to search through the network to see where he was seen subsequently.

Queue Management

When large numbers of people have to be processed, many queues may need to be formed. iOmniscient's Queue Management System will calculate average waiting times and advise officers if more support is required for those processing the queue.

There are several methods of determining the length of a queue. One technique involves the use of the counting system as a base. In this case one counts how many people enter and leave the queue and based on this their average waiting time can be established. An alternative method is to achieve the same result using Face Recognition to determine how long it takes a particular individual to go from Point A to Point B.

Fever Check

When there is a health crisis (like the SARS crisis) it is important to know if sick and potentially contagious individuals are on the street. iOmniscient's automated Fever Check system can be used for automatically detecting if a person has a fever.

Applications around Vehicles

Speed Detection

Speeding vehicles are always a hazard and occasionally they may be the precursor of a dangerous event. iOmniscient can detect the speed of vehicles and raise an alarm if a vehicle is detected exceeding certain authorized speed limits. Traffic speed can be calculated using several different methods. The speed of every vehicle can be measured individually. The average speed of the traffic can be calculated. The time that it takes a vehicle to go from Point A to Point B can be calculated to provide its average speed which can be important to avoid a situation where vehicles only slow down at “Speed Cameras”.

Automated infringement notice generated using License Plate Recognition due to speeding violation - administered without human intervention.

Tracking Vehicles

Just as humans can be tracked using Face Recognition, vehicles can be tracked using their License Plate.

If vehicle needs to be tracked, the system can locate all the cameras on which that vehicle has been spotted. If there is good coverage of the roads it should be possible to know the exact route that a vehicle has taken.

Applications around Events

An example of an event where there is no human or vehicle involvement is a fire.

Smoke and Fire Detection

Standard smoke and fire detection systems cannot always be used in busy city environments especially if they involve open air situations.

iOmniscient’s video based smoke and fire detection system can be used for very early detection of such events.

There are many inexpensive devices available for detecting smoke in small confined spaces. However these do not work well in large cavernous places or in the open air. For such situations the use of video to analyze the situation provides a faster and more accurate alternative.

Automated traffic warning using congestion detection.

5. Surveillance Using the Other Senses

Video Analytics is based on the sense of sight. Humans have at least four other senses. Today two of these, hearing and smell, can be incorporated into a Smart City system to provide a more comprehensive capability.

Just as a person who cannot see or hear or smell is handicapped in some way, a Smart City system is limited if it cannot receive inputs for sound and smell.

The iOmniscient iQ-Smart City System uses all three senses to provide comprehensive intelligence about the events in the city. Video based analytics has already been discussed. This chapter focuses on Audio and Smell Analytics.

Audio Analytics – iQ-Ear

Sometimes video is not sufficient to categorize an event. Analyzing sound may provide an additional dimension to the analysis. For instance, if a man is seen to fall down it may be because he slipped and fell. However if a gunshot is heard at the same time then it may indicate that the man has been shot.

The iOmniscient Audio Analytics system can analyze a sound. It can differentiate between glass breaking and a gunshot. It can tell if people are conversing normally or if some have raised their voices and are engaged in a vicious argument.

Often video alone cannot provide sufficient information to understand a situation. However combined with an analysis of the sound, the operator may

have a much better understanding of what is happening.

Most modern cameras also incorporate a small loudspeaker in them. It is therefore possible for a recorded message to be played. If for instance a person is standing too close to the edge of a railway platform, the system may advise the person to stand back from the line.

Such a system can also be manually operated. The officer in the command center can speak directly to an offender through the camera. Often people will refrain from suspicious activity if they realize that they are being watched and their images recorded. Talking to them directly may be the best way to let them know that you know.

The Analysis of Smell – iQ-Nose

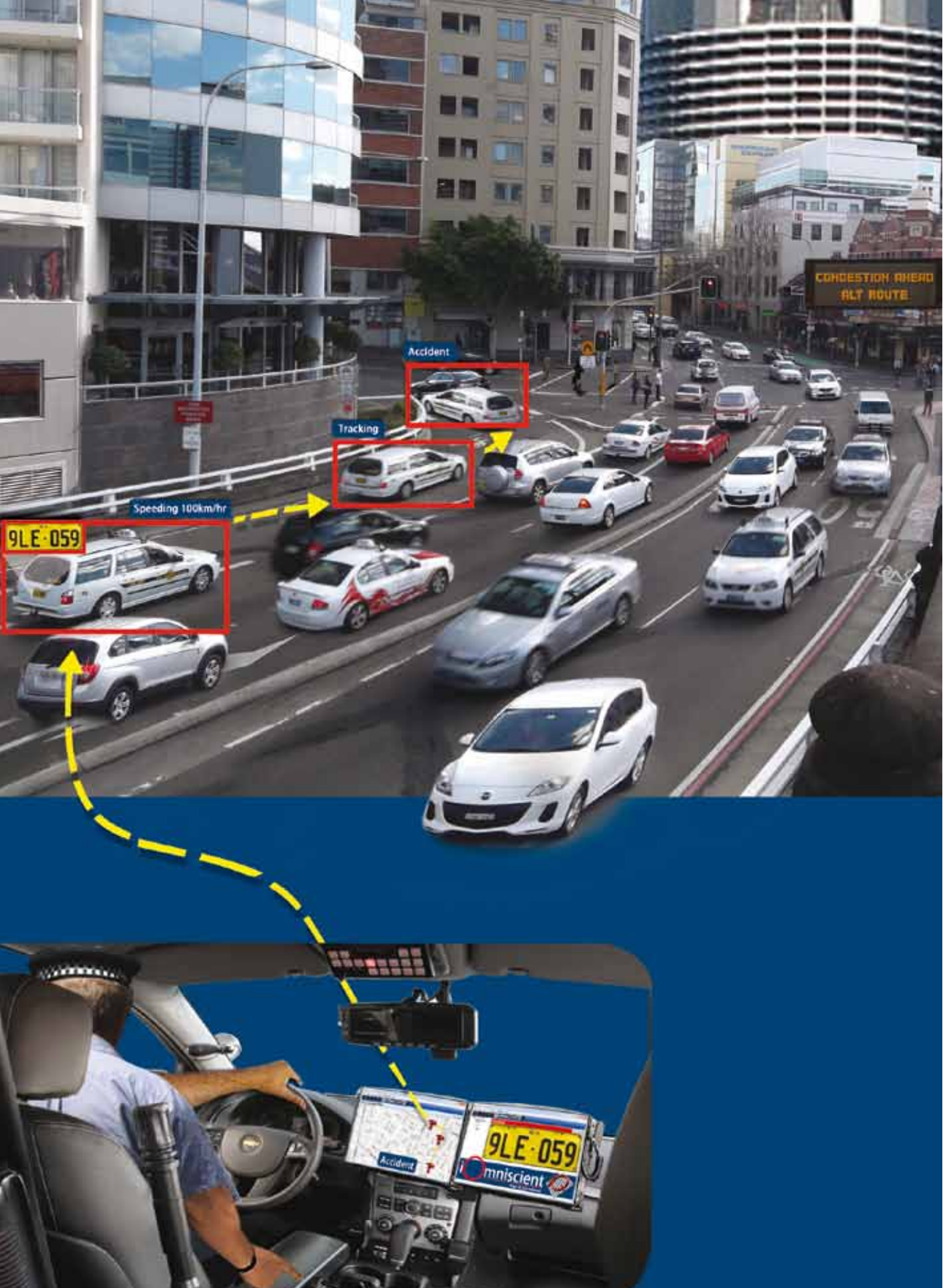
Cameras are the eyes of the system. They can see. The audio system uses a microphone to hear. Humans have a third significant sensor – the nose. There are some things that cannot be seen and may not be heard and for that iOmniscient provides the iQ-Nose system.

Gas leaks are an example of an incident that may not be seen or heard but can possibly be smelt. iQ-Nose can smell and detect a variety of gases at a distance of several hundred meters. If a new chemical has to be detected the system can be trained to smell it.

iQ-Nose can also detect the spraying of graffiti. If a spray can is being used to spray paint the system will detect its presence at a distance of 50 meters (150 feet) or more.

The timely detection of gas leaks or the unusual accumulation of certain gases in a particular location can save lives. Hence this is a very important capability in a Smart City.

iQ-Nose for detecting spray paint graffiti.



Illegal driving alert automatically sent to nearby police vehicles.

6. Automated Intelligent Surveillance

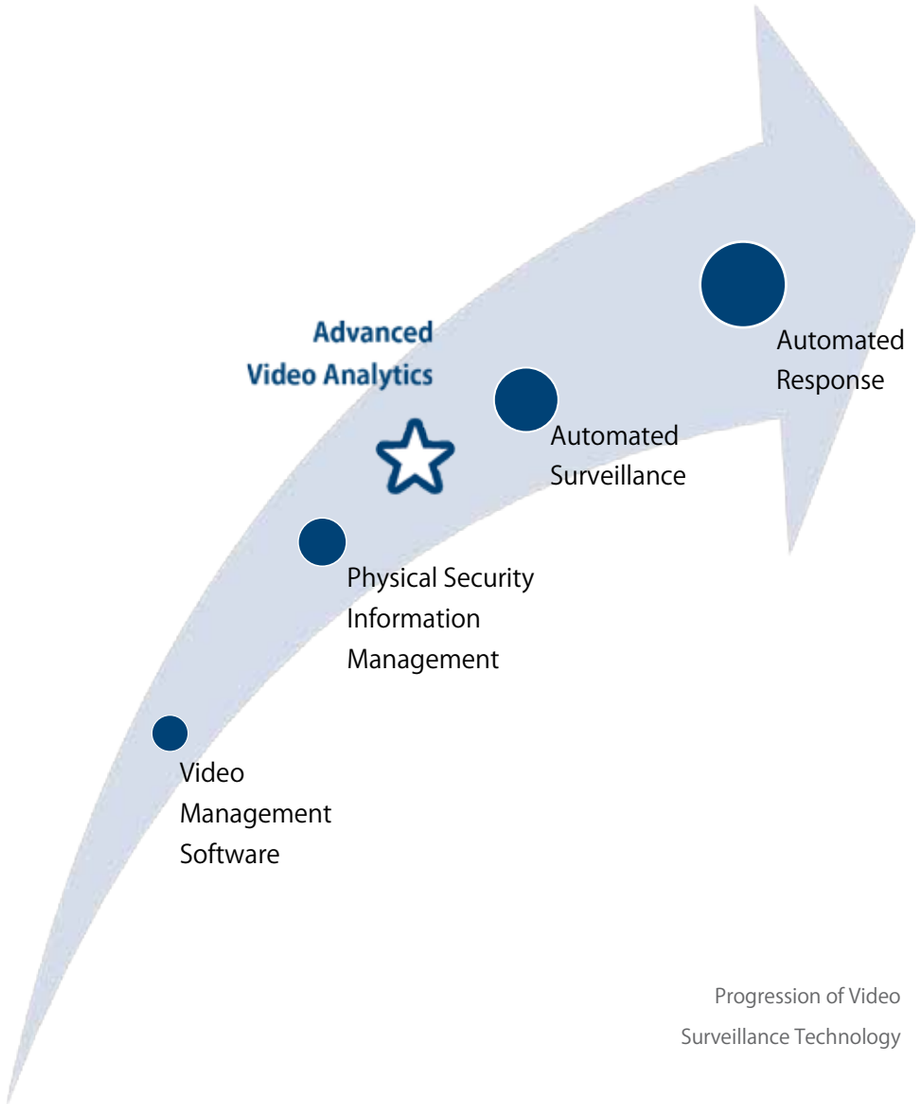
When the industry first started, the main activity was to record surveillance on video. As recording became more distributed the technology was referred to as a Video Management System (VMS).

Over time, information from other sources was brought into the control room. If this information related to a building (e.g. information on temperatures, air-conditioning and lighting), it was called a Building Management System (BMS).

Systems were then developed to list courses of action for particular events. The instructions were really a documentation of processes that the operators were required to take. For instance if a fire was detected, the operators needed to sound the alarm, ring the fire brigade and ask people to gather in a safe area outside the building. Such systems were called Physical Security Information Management (PSIM) systems.

Upto this point there was little or no intelligence in the surveillance system. It was a recording and display system with the ability to provide instructions for the operator. Using the video to analyze and detect certain types of events became known as Video Analytics. In the last few years the most sophisticated Video Analytics companies have also begun to provide recognition systems for vehicles and faces.

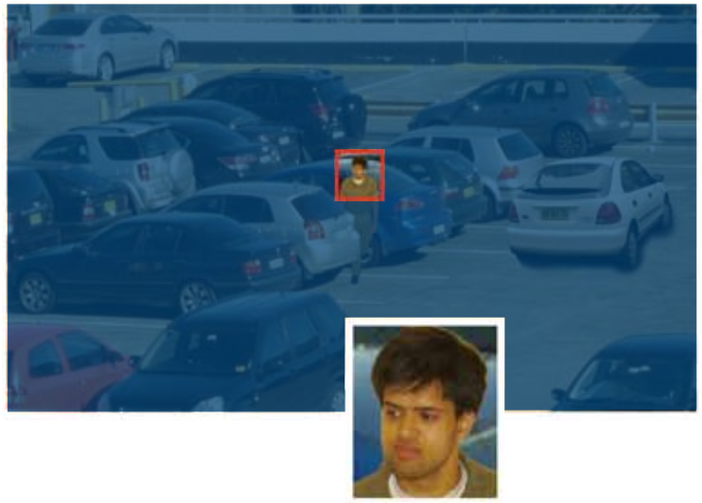
iOmniscient is already recognized as the technology leader in Video Analytics. However it has taken the technology two further steps forward, first with the concept of Automated Surveillance and next with the concept of Automated Response Systems which will be described in the next section.



Progression of Video
Surveillance Technology

Conventional Techniques for Recognizing a Person

In the past, Pan Tilt and Zoom (PTZ) cameras were used when one attempted to perform detection and recognition at the same time. As such, the camera would monitor the total scene. Let us say an event occurred – someone jumped over a fence and entered the area that was being monitored. The PTZ camera could then be zoomed in onto the intruder and with the close-up view, to be recognized.



When a PTZ camera zooms in on a person, the rest of the scene is lost.

Initially this maneuver was done manually. Once detection occurred, the operator would manually zoom in on the individual who had jumped over the fence. It was soon discovered that manual zooming was prone to error. It was very difficult for an individual to accurately zoom onto the target. Even for a skilled operator it was not easy to make the camera close in directly on the targeted person. The task is equivalent to taking aim with a rifle sight. A slight movement of the camera meant that the person was not in the view.

This method was so difficult to use that when a capability was announced for cameras to automatically zoom in on their target, this was readily embraced. With this capability, the camera would detect an intrusion and then it would zoom the PTZ camera to the co-ordinates of the intruder.

This method had one very significant limitation. It was easy to defeat by anyone who was familiar with PTZ cameras. A decoy could be sent in. The camera would zoom in on the decoy and the real intruder could enter the scene from the other side. The next step in this evolution was to use two cameras. A fixed camera was used for detection. If an intrusion occurred, a separate PTZ camera was zoomed onto the intruder to perform recognition. However the first camera would continue detecting and if a second person intruded, he too was detected. Unfortunately the second intruder would not be identified as the PTZ camera would be busy with the first intruder.

The PTZ camera was usually programmed to follow the largest object in the scene. If a bird flew across the camera view, the PTZ camera would follow the bird (because it is closer and appeared larger) and it would ignore the intruder. Serious users of video surveillance systems have rejected the use of PTZ cameras for this type of detection and zooming because of its inherent limitations.

Automated Surveillance using Higher Resolution Cameras

A really effective solution evolved through the introduction of a totally different technology – megapixel cameras. As megapixel cameras became more widely used, it was evident that by recording an image at a resolution of between 1 and 5 megapixels, the same image could be used for both detection and recognition. Multiple detections and recognitions can be done on the same image view. However megapixel cameras have their own disadvantage. They are incredibly expensive to use because of the computing power required to process the images and the high bandwidth required for transmission. Further, the large, dense, images are expensive to store.

The standard camera image with around 384x288 pixels is equivalent to a 0.1 megapixel image. Using a 1 megapixel camera requires 10 times the computing power over that for the standard camera. A five megapixel camera requires 50 times the computing power. One would also require 50 times the storage capacity and 50 times the band width for transmitting images.

iQ-Hawk (Internationally Patented)

In 2008, iOmniscient developed a technology which it patented that finally solved the issue of the convergence of detection and recognition technologies. A working product called iQ-Hawk based on this patent was introduced to the market around the middle of 2008.

This revolutionary technology involved using a megapixel camera. It performed detection at very low resolution. Because of iOmniscient's powerful detection technologies, this could be achieved even at a very low frame rate (between 2 and 6 frames per second). The system then automatically digitally zoomed in and extracted the face or license plate of the person or vehicle in the incident for recognition in high resolution. It optimized the way detection and recognition are performed at different resolutions to achieve several significant goals.

iQ-Hawk - convergence of detection and recognition simultaneously on the same camera.

iQ-Hawk is the first and only technology which allows multiple detections and recognitions on a single camera without incurring the computing, storage and network bandwidth costs associated with the use of megapixel cameras.

1. Unlike PTZ cameras it cannot be fooled by decoys.
2. Unlike standard megapixel camera based systems it does not require massive computing, storage and networking resources. (When using a 5 megapixel camera the system requires 200 times less computing resources than an equivalent system processing images in the traditional way).
3. It can perform multiple detections (all types and at all iQ-levels) and subsequent recognition (both License Plate and Face Recognition) on the same scene using the same camera.

All this is performed automatically. If 10 events occur concurrently in the scene, the system will recognize the people and vehicles associated with all of them. At last, detection and recognition can finally be achieved on the same camera in a commercially viable way. And it can be done such that it cannot be defeated by someone with a cursory knowledge of how these systems work.

iQ-Hawk reduces the overall cost of the system by reducing storage and network bandwidth requirements by a huge factor.

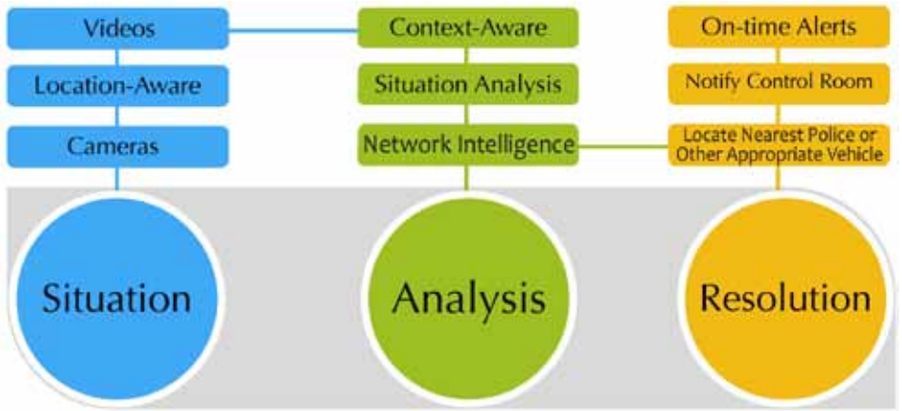
This capability provides the foundation for Automated Surveillance systems. Incidents are automatically detected, People and vehicles involved in the incident can be automatically recognized. This patented capability was the first major technology breakthrough moving the industry beyond simple Video Analytics technology.

Tracking person of interest. Location sent to nearest police man.

7. iOmniscient Automated Response (Internationally Patented)

In surveillance systems the response has usually been left to a human operator. However a human operator may take considerable time to provide a response. His ability to provide an appropriate response is limited by the information that he is able to extract and absorb in a very short period of time under stressful conditions.

iOmniscient has pioneered yet another technology to address this issue – the ability to provide an Automated Response. How the technology works will be described with a real example.



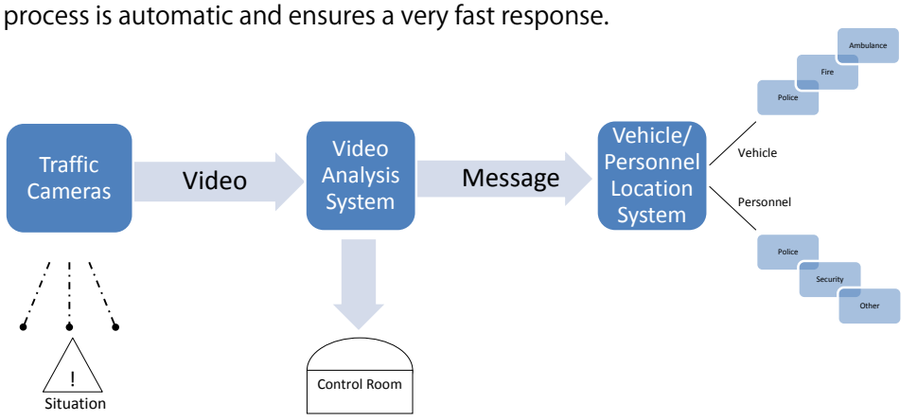
Automated Response information diagram.

For a major Expo in Asia, the city council had the problem that large construction trucks were travelling on narrow streets where they were not allowed. They often got stuck in these streets causing traffic problems. The council set up cameras to detect these trucks and using a GIS system they could locate these trucks on

Automated Response - event is sent directly to nearest policemen.

a Google map. In a traditional system, an operator would then have called the police to check if there was a police vehicle in the vicinity to apprehend the truck. However by the time the operator could locate the police and arrange for a vehicle to be sent, the truck had usually disappeared.

iOmniscient has implemented its Automated Surveillance Action Platform (ASAP) for fast automated response. With this unique patented capability, once the truck is detected, the system searches the Police GPS system to determine if there is a police car in the vicinity. The system automatically sends the information on the truck to the police vehicle with instructions for apprehending it. The whole process is automatic and ensures a very fast response.



Automates Surveillance Action Platform process.

The communication is two-way. If the police vehicle is otherwise engaged and not in a position to respond to the alert, it can advise the system accordingly. The system can then send the information about the event to the next nearest vehicle.

The system is not limited to the police. It can be extended to all emergency services. If there is an accident, the information can be sent to the nearest ambulance. If there is a fire, the nearest fire brigade can be alerted and mobilized.

Operators within Command and Control Centers may have the concern that direct communications between the cameras, the surveillance system and the response teams (e.g. in police vehicles) would diminish their control over their operations. This is easily addressed by providing all the relevant information to the operator for approval or veto.

Hence if the camera sees an accident it can locate the nearest police and ambulance vehicles but rather than sending the information directly to these vehicles, it can send the information on the accident and on the potential responders to the Control Center. Having all the information, the operator is in a position to make an instantaneous decision to proceed according to the recommendations of the system, saving precious time which can save lives in an emergency. The operator is in a position to approve or disapprove the action and remain in full control of the situation.

The level of automation is therefore configurable by the user. The higher the level of automation the higher the speed of response.

The Automated Response System is the latest frontier in tools available to improve the productivity and efficiency of teams involved in improving the security, safety and services available for modern cities.

The system is not limited to use by responders in vehicles. Guards and policemen carrying Smart Phones can be located if they are closest to an incident. The concept is to speed up the response to an incident by automating the process of locating the nearest appropriate responder.

8. iOmniscient Video Utility (Internationally Patented)

Understanding the Stakeholders

There can be many different stakeholders with an interest in a Smart City implementation.

Government entities such as the police, emergency services, civil defense, metro and rail operators, traffic departments, local councils, providers of utilities and others may all have an interest in the services that may be provided.

Private organizations too may have an interest in such a system. They may have installed cameras and other sensors which could be useful to various government authorities.

However sharing videos between organizations has not been easy. Besides the technical issues, there is the question of privacy and the confidentiality of different types of data. Most of these can be addressed as we move towards the concept of a Video Utility.

A Vision of the Utility

Over time, cities will evolve to the concept of a Video Utility - which is very similar to other utilities. Just as it is possible to plug in a fridge or TV into the socket in the wall and access electricity, it is likely to be possible in the future be able to plug into the internet and access video streams from multiple sources. Access may be limited based on the person's authority level. The video information

would be available to the people who require the data when they require it.

Just as very few people generate their own electricity today – most of them are supplied by a public provider - so too different groups will be able to access publicly available video for different purposes.

In fact the real information in the image database lies not in the video images but rather in the meta data associated with the images. Access to the meta data too can be restricted based on authority levels. So for the same image stream a shopping mall may have access to counting information, a paramedic team could be advised if there was a safety incident such as a slip or fall, and the police would be informed if there was a traffic accident.

The cost advantages to all from setting up a common video network for all interested groups can be significant. Not only will the costs for cameras, networks and systems not be duplicated, but systems for protecting the information will also not be duplicated. Initially video utilities will probably be set up within an organization as today different divisions tend to have their own private networks.

In the ultimate scenario, private video will also be accessible for public purpose and vice versa. Consider how this might work. In the case of the bombing incident a few years ago in Bali. A number of terrorists blew themselves up in a crowded restaurant. A large number of people were killed. As the investigation into the bombing progressed, it became evident that many people had taken private videos of the incident. Today mobile phones have video cameras and it is amazing how many people had used their phones to record the event that they were witnessing. However it took a very long time for the authorities to get access to some of these videos from the witnesses who gave evidence. In fact it is not possible to know how many videos were not handed into the police.

Now we know that it is possible to locate quite precisely which phones are in the vicinity of an event. The telecommunications carrier companies have this information and they use it to transmit calls to the correct phones. It is technically possible for an organization like the police to access the video being taken on phones present in the vicinity of an incident at the time when it occurs. Obviously one would need appropriate legislative changes to ensure that the privacy of individuals is protected and that this facility is only used in the public interest

but technically such a scenario is possible today. Such privacy protection may best be achieved by granting access to the meta data rather than to the video images.

Such a system also requires an appropriate costing mechanism to ensure that users pay for what they use.

As we move to the future it will be possible to harness public and private video streams to provide information that is useful to society - especially to those charged with protecting us. The age of the video utility is here. And iOmniscient has built the tools to make this infrastructure work.

9. Brilliant Systems by Design

A robust Video Analytic system must have the most advanced intelligence as well as the capabilities to operate in varied environments with accuracy and high reliability. This does not happen by accident - the strength of the iOmniscient systems come from the effort that is put into their design. The design objective is for each capability to be best-in-class. Some of the key features that have resulted are described here.

Universal Connectivity

Many camera vendors survive by creating very proprietary interfaces to their system. Once a customer has bought their system, they are locked in as they can never purchase any other brand no matter how superior it is as it will not interface with their existing system.

The system must not be proprietary to any camera manufacturer. It must be able to interface with any camera – analog or IP (IP stands for internet protocol and refers to cameras that can be addressed directly over an IP network based on the camera's IP address). iOmniscient has built a Universal Connectivity Module that allows it to interface with almost any camera with little effort. Such a capability is important as the user may change camera types and brands over the years and the system needs to be able to cope with such change.

Users need to be wary about being locked into one supplier for the life of their system.

Automated feedback to traffic light system to reduce queue build-up.

To address this issue, the industry has been attempting to establish standards for interfaces between suppliers. Standards for camera interfaces and for receiving video are now maturing. Standards for Video Analytics are still at a very early stage in their development. This is because there is such a big difference in the capability of different suppliers that it is difficult to establish a standard. A standard set based on the most advanced technologies is unacceptable to those who provide technology with very limited intelligence. On the other hand setting a standard based on the capabilities of the majority of suppliers establishes a very low benchmark and there is effectively no standard for the more advanced capabilities.

The iOmniscient system complies with all standards that exist, the prevalent one being ONVIF. It can receive video in the formats specified and can send alarm information in the required format (at least for those limited types of situations where a standard is defined).

iOmniscient has also built a Universal Connectivity Module that allows it to receive video input even from cameras that do not comply with the standard as long as they use certain basic video streaming protocols. Also, it sends out all alarm information and meta data in an extended form of the existing standard to make sure that this is easy to receive by other systems.

The module has been developed in line with iOmniscient's commitment to openness. The company believes that the customer should always have choice and they should always be able to purchase products on merit and not be forced into ongoing bad decisions because a vendor has succeeded in locking them into a particular product.

Scheduling

In a complex environment a camera may be required to perform different functions at different times or indeed to be set up with different configurations at different times. For instance, from 9am till noon the system may be used for counting but from then on (except on public holidays) it may be required for intrusion detection. The ability to schedule different functions in a robust but sophisticated manner is critical for the effectiveness of a good system.


Understands perspective

Perspective

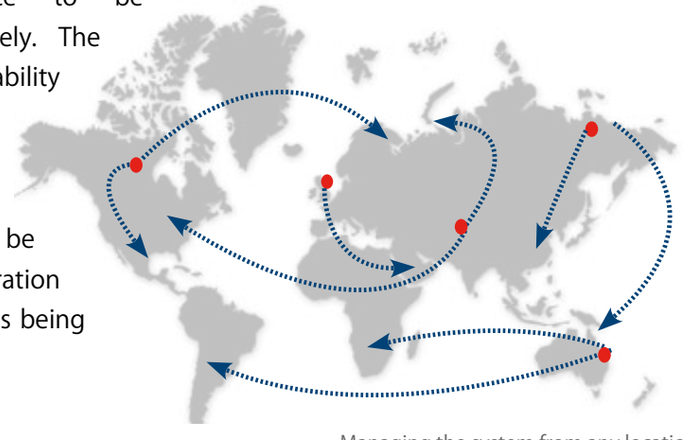
Images from a video are invariably a 2 dimensional representation of a 3 dimensional space. Humans can understand perspective because, with two eyes they can see everything around them in 3D. Systems have to be sufficiently intelligent to understand perspective – to know that a large object in the distance would look much smaller than in the foreground of the image and vice versa.

Auto-archiving

Normally if an event occurs, it should be brought to the attention of the operator who can make a decision on whether to archive that particular footage for later review. If there is no operator available, it should be possible to set the system up so that it can automatically archive any event footage. The amount of time that lapses before the system realizes that there is no human around to intervene must be configurable by the user.

Remote Management

The users of a system may not always be close to events or even near the system used to monitor and analyze the events. They may or may not have the resources to manage and maintain their systems locally. For such situations, the iOmniscient system has been designed to allow implementation, diagnostics and maintenance to be performed remotely. The remote access capability can be used for more than the diagnoses of problems. It can be used for configuration when the system is being implemented.


Managing the system from any location.

Mobile Management

In many situations it may not be possible to continuously monitor the system. There may be insufficient staff to man a command and control center. To ensure that people who need to receive information on events receive this immediately, all iOmniscient systems come with Mobile Client systems that operate on Smart Phones (android). The operator supervisors and senior management can monitor events and manage their system even when they are not inside a control room.

Location Based Knowledge

In a busy city it is not sufficient to be advised when an incident occurs. One also needs to be aware of where it occurs and what resources are available to address the event. For this reason, a good system will know the GPS location for all the cameras. Beyond this it will be aware of the GPS location of all police and emergency vehicles nearest to the incident. If there is a fire, the system will know the location of the nearest fire station and the location of every fire engine. If there is an accident it should know the location of the nearest ambulance.

In certain jurisdictions, the various emergency authorities may not want to initiate an automated response but at least the system can provide vital information to the person co-ordinating the response.

Network Intelligence

So far we have only talked about intelligence as it relates to the images from a particular camera.

The next generation of video management goes beyond the analysis of single images. It involves using the information from multiple cameras to provide the whole network with intelligence.

The best way to visualize Network Intelligence is with an example. Consider a large theme park. At such a venue they have to manage long queues for their various rides and activities. Some of these queues are extremely long. They could, for example, start at the entrance of one building, wind through underground corridors and emerge at a different building. No single camera can see every part of the queue. There are often many entrances to the queue and there may be many points where people leave the queue (perhaps out of frustration).

In order to manage these queues, management requires information like the average waiting time for a person who enters the queue. They also need to know where the queue ends or the length of the queue - especially when all parts of the queue are not visible. Some of this information may also be made visible to the public to help them understand how long they may have to wait.

This is a very good example of an application that requires intelligence that goes beyond the single camera. This type of application requires cameras to be placed strategically at all the entrance and exit points for the queue. Every camera is then used to count the number of people that pass that point. The cameras are also used to determine where the queue ends. The information from all the cameras is pooled together to provide the information that the park management requires. This allows management to open up more service points and to put up electronic signage advising customers of the expected waiting time for their ride.

Traditional suppliers of Video Analysis systems are still focused on analyzing the information from a single camera. Network Intelligence is only available from the most sophisticated providers of Video Analysis.

Boolean Logic

All analytics (video or otherwise) use explicit or implicit rules to determine if certain incidents have occurred. For instance the system can raise an alarm if a person falls down or if a car speeds above the speed limit.

In real life many incidents may occur in some combination and the way in which they are combined can provide more information on the situation. A person falling down may have slipped. However if a gunshot is heard at the same time it is possible that the person has been shot and a different type of response may be appropriate.

This ability to combine rules using AND and OR conjunctions (which involves the concept of Boolean logic) can provide greater insight into a situation and can help the stakeholder to provide a more appropriate response.

User Friendly Displays

The information generated by intelligent systems ultimately needs to be communicated to humans. Humans are known to have short attention spans and a limited ability to pull out key information from huge masses of data. It is therefore important that information is presented to human operators in a manner that is easy for them to absorb and use.

This is the primary challenge for VMS and Command and Control systems. Showing the video image from different cameras is the trivial part of the capability for such systems. For a Video Management System (VMS) or Physical Security Information Management (PSIM) system to present information effectively, it actually has to have the ability to accept the information about events that are occurring and to present this information. This means that the system must have a sophisticated interface for accepting such information from an advanced analytics system.

Unfortunately many systems, while being quite capable of showing videos that come off cameras, have little ability to show what is actually happening in the video. Often they will provide text messages about alarms. Only those systems that have been fully integrated with an advanced Video Analytics system can provide all the information that is available from that system.

Many existing VMS systems maintain a proprietary interface limiting their own ability to interface with advanced Video Analytics systems. The analogy would be with two people who speak in different languages. Let us assume that A speaks Japanese and B speaks English. If A says something to B in Japanese then B can look up a dictionary and translate the words to English and understand them. However there may be some words that just cannot be translated because the concepts do not occur in English. This would mean that B cannot understand that particular concept precisely.

Similarly if the designers of the VMS system have not understood a particular Video Analytics concept their product would have no ability to display the appropriate information. This creates a dilemma. The Video Analytics system can provide increasingly advanced intelligence but this is of little use if it cannot be displayed and communicated to the user by the VMS system.

iOmniscient with its commitment to Openness provides ALL meta data about ALL events in a simple to use standard format. Unfortunately this is not useable by those VMS systems that have proprietary interfaces.

To ensure that all information can be effectively displayed, iOmniscient does offer its own VMS and Command and Control system which has been specifically designed to understand and display ALL the intelligent information that is available from the Video Analytics system.

To provide the operator with context, the display can also be integrated into drawings, plans or maps of the site or into Geographical Information Systems (GIS) that have other information available about the environment. The icons for the sensors can be embedded on the maps or images. These icons are dynamic and they can indicate if there is an alarm on that particular camera or if it is not working effectively.

As a further advance on this concept, some vendors have developed a 3D rendering capability of the type used in video games. Essentially an artist is required to convert a 2D image into a 3D simulation of the environment. This can be quite effective but very expensive to implement for a large network of cameras.

The ultimate requirement of a good display system is to be able to extract all the important information that is available from the analytics system and to display it in a way that is meaningful for the user.

Optimized Storage and Networking

Storage and networking are standard components of any surveillance system and calculating the amount of storage and the bandwidth of the networking

required is normally fairly straight forward.

However, as you will have seen in the section on Automated Intelligent Surveillance, software such as iOmniscient's iQ-Hawk can actually reduce the amount of storage and network bandwidth required.

The savings can be enormous. The storage and networking costs constitute a huge proportion of the total cost of the system – often greater than the cost of the software itself. This can create a situation where a system with iQ-Hawk software will cost less than a system without it. In other words, the cost of the software is much less than the benefits derived from using that software.

As you will see in the last chapter on implementation this is a key reason for selecting the software before one begins to design the hardware infrastructure.

Crowd Monitoring for graffiti and rubbish.

Illegal driving - vehicle travelling in incorrect direction.

10. Surveillance Operation Efficiency

A cost effective surveillance system needs to operate efficiently, ensuring all components are operational, adaptive to its environment and requires minimum intervention by the user.

iQ-Health Check system.

Self Diagnosis & Health Check

In any large network of cameras, on average 20 % will not be operational at any one time. However the user usually does not know which ones are not working until there is an event.

The iOmniscient Health Check system shows the entire system on a dynamic map. The system indicates if a camera is not operational for a number of reasons which can include the simpler applications of detecting tampering or sabotage but also more common but complex problems such as the camera having lost focus or having been moved due to vibrations. The system will even provide a warning if the cameras are working but the images cannot be seen due to bad weather or if the cameras require cleaning.

NAMS – Nuisance Alarm Minimization System

The minimization of false alarms is critical for any video based system. Every iOmniscient product is armed with an Artificial Intelligence based NAMS module. In a recent system test against one of iOmniscient's major US competitors which lasted over a week, both sides achieved similar accuracies for detection. However iOmniscient was differentiated by its ability to cope with the false alarms. The competitor was getting 200 false alarms each night compared to zero from iOmniscient.

Of course it is not possible to eliminate every single false alarm and humans themselves can often be fooled by light changes and mirages. However a good NAMS module is critical for any good Video Analytics system.

Infinite Scalability

Smart City applications can involve thousands of cameras and other sensors. The hardware design must be able to allow the system to scale from a few cameras to thousands. A federated structure is useful. The system on a railway line provides a good example of a federated structure. At each station the station master must receive sufficient information to run his operation effectively. Management at the central control room must also receive the more summarized information that they would require to manage the operation at their level. The system must be able to provide the right level of information for each level of management.

Maintainability

Maintaining a very large distributed network of computers and computing devices can be difficult and expensive if it has not been designed well. Many Edge devices cannot be managed or maintained remotely. All iOmniscient systems are designed to be managed, diagnosed and maintained remotely no matter what the architecture.

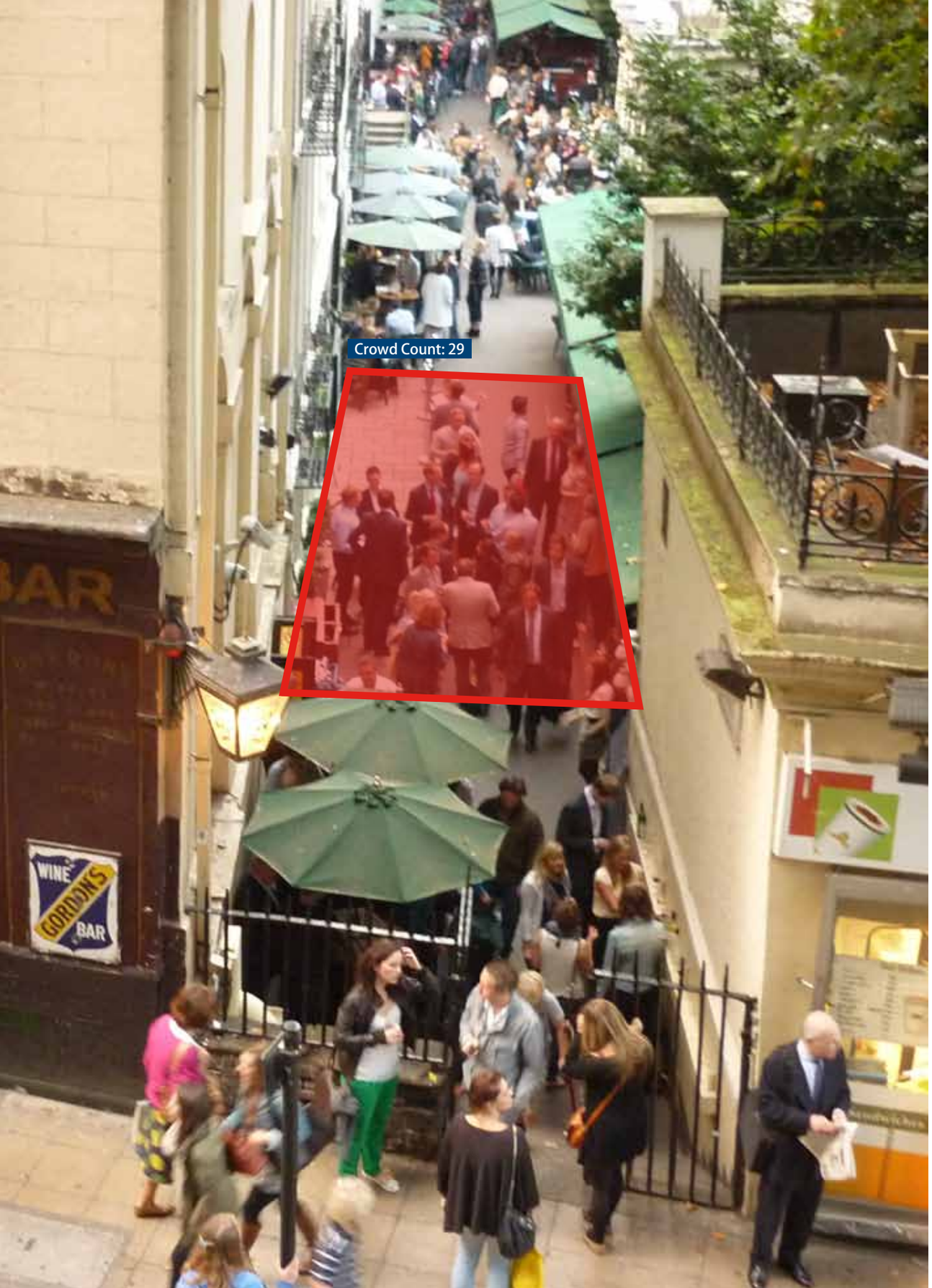
Openness

A comprehensive Smart City system must be designed with totally open architecture which means that the user can choose any supplier for the cameras and for other associated hardware. The user must be free to purchase cameras and computers from any supplier as long as the hardware meets certain minimum specifications and is appropriate for the task.

The investment one makes in a Smart City system must be a long term one. The component that will need to be replaced first is the hardware as the software can evolve and get upgraded. However the hardware will become obsolete or will wear out within a few years. The software must therefore be designed to work not just with the hardware that exists today but with the hardware that may be selected in five or ten years time. Therefore it is imperative that the software is NOT proprietary. It must be totally open to ensure that the best hardware can always be used.

Continuous Learning

The majority of Smart City applications will occur in complex scenes with constantly changing environments. iOmniscient's systems have been designed to continuously learn, understand and adjust to the changes in their environment, for example to light changes and variations caused by slow moving shadows. They can thus cope seamlessly with transitions from cloudy to sunny periods, from day to night and back to day. The system is able to perform this adjustment without manual configuration.



11. Applications for Stakeholders in a Smart City

There are many different areas in a city which require specialized surveillance applications. They may include transport hubs, bus-rail interchanges, car parks, high security buildings, warehouses, maintenance facilities and many other types of facilities. This section summarizes some of the specialized applications available for these areas. Most have been described in the previous sections.

City Surveillance Applications

Security

- Identification and tracking of suspects/criminals even in a crowded and uncontrolled environment.
- Detection of suspicious behaviors (e.g. man-down/fighting, loitering, running, crowd gatherings/formation etc). Be able to automatically IDENTIFY the culprits using many-to-many Face Recognition system.
- Be able to link different events from large number of cameras and to provide full picture and event association for immediate actions.
- Immediate alert for people who wear masks, helmets when entering specific areas (e.g. at money exchanges or near an ATM).
- Recognition of suspicious activities determined by using a combination of video and audio recognition systems. Generate an alert for incidents like gun shots, serious car accidents and screaming sounds.
- Surveillance system health check to prevent camera tampering or sabotage.

Crowd Management. Automatic alert sent to nearest security officer when crowd size exceed limit.

Operations

- Prevent hawkers, posting of advertisements, graffiti and vandalism.
- Data collection before any construction and street planning activities – the use of a counting system to understand the traffic flows and distribution of people/vehicles at different times of the day.

Safety

- Prevent over crowding.
- Detect slips and falls.
- Smoke and fire detection for outdoor environment.

Law Enforcement

- Detect vehicle speeding.
- Prevent illegal parking for all kinds of vehicles or for specific vehicles.
- Prevent vehicles that cross the line at the traffic lights when the light is red.
- Automate the law enforcement and "fining" process for vehicles violating rules using License Plate Recognition system together with iQ-Hawk.

Transport Hubs and/or Bus/Rail Interchanges

Security

- Abandoned objects on the platform or station.
- Face Recognition in crowds.
- Trespassing – wrong way or unauthorized entry.
- Intrusion detection for tunnel, rail yard or tracks.
- Graffiti and vandalism detection.

Operations

- People counting or crowd management.
- Unauthorized access across the turnstile.
- Prevent beggars/homeless people sleeping at the station.
- Site maintenance.

Safety

- Platform safety (yellow safety line detection).
- Detect running/skateboarding/ slip and fall on platform.
- Overcrowding and congestion detection.
- Smoke and fire detection.
- Confirmation of working safety light on passing trains.
- Detection of over-speeding.
- Detection of objects protruding from cargo trains.

Marketing Applications

- Counting.
- Passenger traffic flow measurements.

Public Building Applications - Major Buildings

Security

- Theft prevention system to protect valuable property (e.g. paintings, furniture).
- Graffiti and vandalism detection.
- Detection of suspicious behavior (e.g. running, skateboarding, loitering, wrong way, man-down or attack). It is accompanied with both video and voice recognition system.
- Perimeter protection and intrusion detection to prevent unauthorized access after hours.
- Prevent unauthorized access and tailgating.
- Surveillance system health check to prevent camera tampering or sabotage.

Operations

- Adhere with fire and safety regulations using the crowd management system to understand the occupancy rate in the building.
- Better car park management particularly with the use of counting, License Plate Recognition system, tailgating system, wrong way, parking violation detection etc. Boom gates (used at car parks) can be opened automatically once authorized access (e.g. for VIP or

executives) is confirmed.
- Refer to the details in the car park applications.
- Better resource allocation to cope with busiest time or special events.
- Better property management and to understand the busiest storefront with the use of an accurate people counting system.
- Energy savings – able to understand the occupancy so as to efficiently adjust the electricity usage (e.g. the lights can be dimmed or turned off for areas that no longer have people in them. Additional lights can be turned on when there are more people).

Safety

- Smoke and fire detection, since conventional smoke detection cannot be effective in areas with high ceilings.
- Crowd management and control.
- Detection of water spills.
- Detection of slip and fall for public liability or man-down detection.
- Prevent vehicle speeding at the building entrances and car parks.

Roads and Traffic Monitoring

Security

- Protect bridges and other critical infrastructure – e.g. detect abandoned objects or suspicious objects at the "pylon" or "footing" of bridges.
- Surveillance system health check to prevent camera tampering or sabotage.

Operations

- Traffic management – e.g. vehicle counting, average speed, congestion detection and average waiting time.
- Parking violations and disregard of the "No stopping zone". Use of iQ-Hawk and License Plate Recognition system to automate the law enforcement and fining process for the violating vehicles.
- Efficient traffic light management – can be adjusted dynamically depending on the current traffic situation e.g. allow longer time for pedestrians if there are more pedestrians waiting at the crossroads.
- Smoke and fire detection particularly in tunnel environments.
- Road maintenance – understand the flow and maximum "loading" requirements particularly for the large and heavy vehicles.
- Prevent hawking and begging in prohibited sections or areas.
- Prevent certain vehicle types on certain road sections (e.g. bus lane). This can be used for over-sized vehicles or vehicles whose height may not clear an overpass.

Safety (and for law enforcement)

- Detect speeding vehicles.
- Detect red light violation.
- Respond quickly to accidents – detect accidents, vehicle stopped, "near misses" on the roads or highways.
- Detect "crossing lanes" on double solid lines in tunnel or prohibited sections.
- Incorrect direction on one way roads.
- Collision prevention at level crossings.
- Detect abandoned objects or fallen objects.
- Use of the iQ-Hawk and License Plate Recognition to automate the law enforcement and fining process for the violated vehicles.
- Detect pedestrian jaywalking, skateboarding etc.
- Prevent people crossing major highways or entering the tunnels.
- Use of iQ-Hawk and Face Recognition system to automate the law enforcement and fining process for any unauthorized entry.

Events Management Applications

Security

- Intrusion and perimeter protection.
- Tailgating system for restricted zones.
- Access control using Face Recognition.
- Abandoned object detection.

Operations

- VIP access management.

- Queue management.
- Understand occupancy and ensure that safety regulations are met.
- Speed control.
- Prevention of illegal parking.
- Detection of hawkers and beggars.
- Surveillance system health check to prevent camera tampering or sabotage.

Safety

- Detecting someone who has fallen down.
- Detecting water spills.
- Detecting smoke and fire (since conventional smoke detection systems cannot be effective in areas with high ceilings and outdoors).

Marketing Applications

- Counting to understand the demographics, traffic flows and distribution of people.
- Understand the busiest aisles/ footpaths to allow appropriate advertising campaigns.

High Profile/ Secure Site/ Warehouse Application

Security

- Theft prevention system to protect internal stealing of expensive materials and stock items.
- Perimeter protection and to prevent unauthorized access for the restricted zones at all times or after hours.
- Prevent unauthorized access and tailgating during operating hours – uses tailgating, Face Recognition and License Plate Recognition systems to ensure access to the right people and vehicles while preventing access to others.
- Surveillance system health check to prevent camera tampering or sabotage.

Operations

- Adhere with fire regulation.
- Better car park management particularly at the loading docks for pickup trucks with the use of counting, License Plate Recognition system, tailgating, wrong way, parking violation detection etc.
- Monitor whether workers are on-duty (requires the use of Face Recognition system).

Safety

- Smoke and fire detection whereas conventional smoke detection cannot be effective in areas with high ceilings.
- Adhere with safety guidelines (e.g. to ensure "safety helmet" must be worn by each staff before entering certain areas).
- Detection of water spill.
- Prevent slip and fall.

Secret Services, Defense & Law Enforcement Applications

Security

- Detect and track suspects or criminals accompanied with many-to-many Face Recognition system.
- Detect and track suspicious vehicles.
- Detection of stopped vehicles.
- Detect suspicious behaviors including man-down or attack, loitering, running, crowd gathering etc.
- Perimeter protection along the fence line or intrusion detection at the border (e.g. land or sea).

Operations

- Monitoring of guard attendance at the mission's critical sites using a Face Recognition system.
- Provide both a real time Video Analysis system along with forensic capabilities to process large pre-recorded video.
- Mobile Video Analysis system that can be easily installed and setup.
- Surveillance system health check to prevent camera tampering or sabotage.

Safety

- Protect air force runways to ensure they are clear of obstruction.

Retail Centers and Food Court Applications

Security

- Abandoned objects in a crowd.
- Detect theft in a crowd.
- Trespassing – wrong way or unauthorized entry.
- Graffiti and vandalism detection.
- Tailgating at gates.
- Suspicious behavior.
- Use of the iQ-Hawk and many-to-many Face Recognition systems to automate the law enforcement process to protect staff and customers.
- Detect and track suspects or criminals.
- System health check for camera malfunction or sabotage.

Operations

- People counting and crowd management.
- Queue management and calculation of average waiting time – for managing customer satisfaction and service in areas with long queues of people.
- Detect and automate the process for understanding the number of taxis at the stand (to call for more taxis if the queue for people has grown to be too long.
- Use of License Plate Recognition to automate vehicle access (particularly for VIPs or senior executives).
- Detect parking violations - Use of iQ-Hawk and the License Plate Recognition system to automate the law enforcement and fining process for the vehicles that are parked illegally.

Safety

- Detect running/skateboarding/slip and fall.
- Overcrowding and congestion detection – adhere to safety regulations.

- Smoke and fire detection where conventional smoke detection cannot be effective in areas with high ceilings.

Metro and Rail Applications

Security

- Abandoned objects on a crowded platform.
- Face Recognition in crowd and in a distance.
- Trespassing – wrong way or unauthorized entry.
- Intrusion detection for tunnel, rail yard or tracks.
- Graffiti and vandalism detection.
- Surveillance health check for any camera malfunction.

Operations

- People counting or crowd management.
- Vending illegal tickets using Face Recognition in a crowd.
- Unauthorized access across the turnstile.
- Prevent beggars/homeless people sleeping at the station.
- Monitor train schedule (License Plate Recognition).
- Parking violation.
- Track maintenance (e.g. loosen/missing plate at the joint of the track).

Safety

- Platform safety (yellow safety line detection).
- Detect running/skateboarding/slip and fall on platform.
- Overcrowding and congestion detection.
- Clear of obstruction or detection of left objects.
- Collision prevention at level crossing.
- Smoke and fire detection.
- Confirmation of working safety light on passing trains.
- Detection and recognize of over-speeding.
- Objects protruding from cargo trains using shape detection.

Car Park Applications

Security

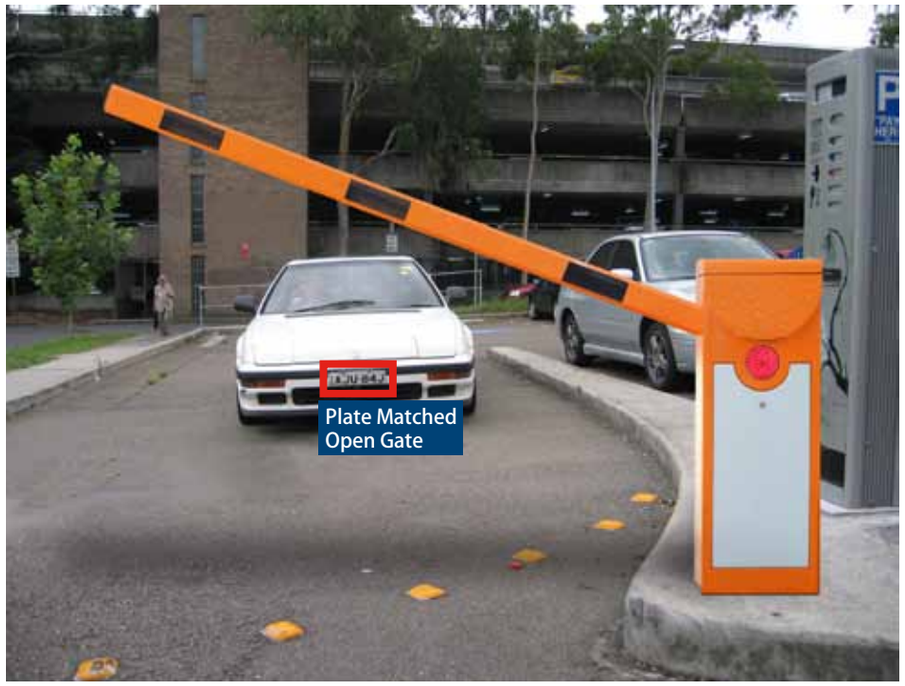
- Protect patrons when the car park is fairly deserted.
- Prevent theft of vehicles and property left inside vehicles (e.g. to match the authorized driver(s) with the vehicle and to alert if an unregistered person is trying to drive the vehicle).
- Identify loitering - particularly a person who is checking out cars (e.g. using Face Recognition to track the suspect/criminals in an uncontrollable and crowded environment).
- Detect if someone falls down through slipping or in a fight.
- Prevent graffiti and vandalism.

Operations

- Increase revenue streams by resetting the meter once vehicles have left. Increase the revenue by understanding the allowed grace period for each vehicle (particularly in the temporary stopping areas without the metering facility).
- Indicate where empty spots are located and guide drivers to the right level and to the right aisle. The same facility can be used to assist car owners to locate their parked car in a huge and multi-storey car park environment by entering specific license plate info on a kiosk.
- Prevent illegal parking in entrances and delivery areas.
- Provision of VIP access.
- Prevent access to blacklisted or unauthorized vehicles.
- Stream the traffic flow by allowing automatic entry for authorized vehicle once the plate information is recognized.
- Enable collection of shopping carts and trolleys left by patrons in a mall.
- Ensure smooth flow of traffic at peak times.
- Prevent tailgating at boom gates.
- Alert at the entrances for vehicles that have exceed height and length restrictions.

Safety

- Prevent vehicles travelling in the wrong direction.
- Prevent vehicles travelling at high speed (the generation of tickets and the administration of fines can be automated using a License Plate Recognition system together with iQ-Hawk).
- Smoke and fire detection (since conventional smoke detection is usually not effective in areas with high ceilings).
- Surveillance system health check to prevent camera tampering and sabotage.



Access Control with License Plate Recognition.

12. Integrating Big Data Intelligence for Smart Cities

iOmniscient has developed the iQ-Smart City application for intelligent city monitoring and surveillance. These systems based on video and other sensors provide intelligent alarms that enable improved safety, traffic monitoring, crowd management and security for city residents. The data generated from surveillance can be used for further analysis, reporting and forecasting, providing city managers and planners with a powerful management tool.

There is a new concept called Big Data management where unstructured data from many systems can be accessed and manipulated to draw out useful information. Traditionally this has only been possible with text data. Meta data from videos and other sensors (which essentially means the data about the data) can also be managed and manipulated in this way. However the task is difficult because most meta data is obtained from unintelligent systems and hence there is a large quantity of meaningless data to be manipulated.

iOmniscient's systems generate what is called Meaningful Meta Data (MMD) which is meta data resulting from preprocessing video to understand what is actually happening in the scene. The more intelligent the Video Analysis, the more meaningful will be the meta data– and of course iOmniscient prides itself on having the most advanced and intelligent Video Analytics in the industry.

Managing Big Data is not done by iOmniscient alone. iOmniscient works in partnership with the major companies offering Big Data analysis to achieve these objectives. This data can be analyzed to provide further intelligence for cities to forecast future requirements and plan and optimize their resources.

Comprehensive vehicle count weekly report.
Big Data analysis can highlight traffic patterns.

For example, event response data from traffic monitoring systems can be used to plan and develop road networks in future, plan public transport and manage traffic flows. This can also enable cities to be smarter, by reducing congestion, reducing noxious emissions and improving the quality of life for residents. It will be possible for cities to levy congestion taxes and estimate expected revenues based on forecasts of traffic flows in various sections of the city at different times of the day and different days of the week.

Crowd management information can be used to plan the patterns of crowd flows by day of the week, time of day and even seasons of the year. This can be used to improve security, provide better facilities such as public toilets and plan public transport by re-locating bus stops, for example.

Information on illegally parked vehicles, traffic violations, queues at bus stops and taxi stands can also assist in alleviating congestion, providing more resources and enhancing the quality of life for citizens of the city.

The data from event and alarm notifications is intelligent "Big Data", that is data that is produced from a wide range of sources that were hitherto not available or easily accessible. Importantly, this is multi-media Big Data, based on video, smell and audio information. Most Big Data from other sources are available as text or, at best, pictures. It is possible to combine the information from multimedia sources with information from other sources in the organization for deeper insights. For example traffic volumes and flows can be combined with maintenance records of roads to optimize road maintenance costs.

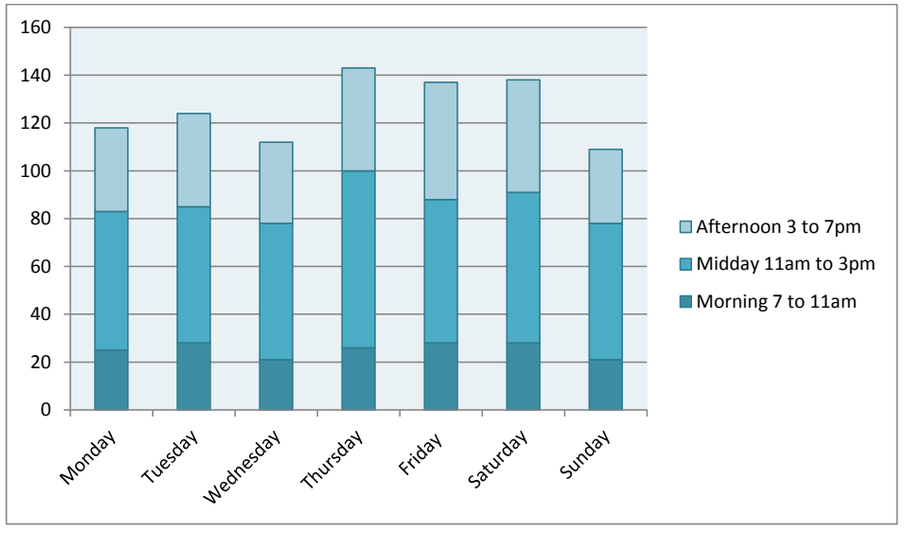
For organizations to maximize the value of their investment in Big Data, it is important for them to know what their ultimate goals are and the questions they need to ask. This will then result in cost effective solutions that will decide their future strategic operational plans. It is important to use this information to provide responses to questions that current conventional databases cannot answer. The best use of Big Data is to provide high quality insights that have hitherto not been available. The multi-media Big Data from iOmniscient is a breakthrough for companies that have not been able to previously access information from this format.

iOmniscient is able to provide Meaningful Meta Data (MMD) for targeted multimedia Big Data analysis rather than large volumes of random data that have limited usefulness. For example, some companies may provide information on every single vehicle that travels on a road individually. This data has limited value and large computing resources would be required to derive any information of value from it. iOmniscient eliminates the need for large volume computing and storage requirements by providing specific information that can be used effectively.

The analysis of very targeted data is called Fast Data where some analysis is attempted in close to real time. An example of this is where vehicle license plates are being read on different cameras across the city. If the same plate is seen on different and relatively distant cameras at the same time, it may indicate that one of the plates is fake.

The applications listed above are just some of the few that are available to capture the next level of intelligence from iOmniscient systems.

The analysis of the intelligent information that is available from event and alarm notifications can be used to provide further information that can enable cities to develop medium and long term responses to enhance their safety and amenities and to optimize the utilization of their resources.



Sample Big Data Report: Analysis of near misses at highway junction by day and time of day.

ATM anti-skimming device system. Automated message sent to bank organization authorities.

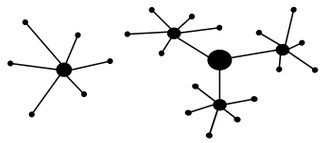
13. Hardware Architecture for iQ-Smart City

Any system that is implemented in a busy city must survive and operate over a long period of time. It must be adaptable to evolving needs as the technology and the expectations of its citizens changes over the years. The system must therefore have a flexible architecture which protects the city's investment in hardware over the next decade and longer.

The hardware and network architecture for a Smart City can be Centralized, Distributed or a hybrid of the two. Centralized architectures are suited to applications where all the information needs to be captured and stored for future retrieval. There are applications, however, where it does not make sense to store all the data as it may impose a heavy load on the network. Examples of these are situations where megapixel cameras are used but incidents are rare and it makes sense to store only the high resolution images from certain incidents centrally. All other information can be stored in a low resolution format.

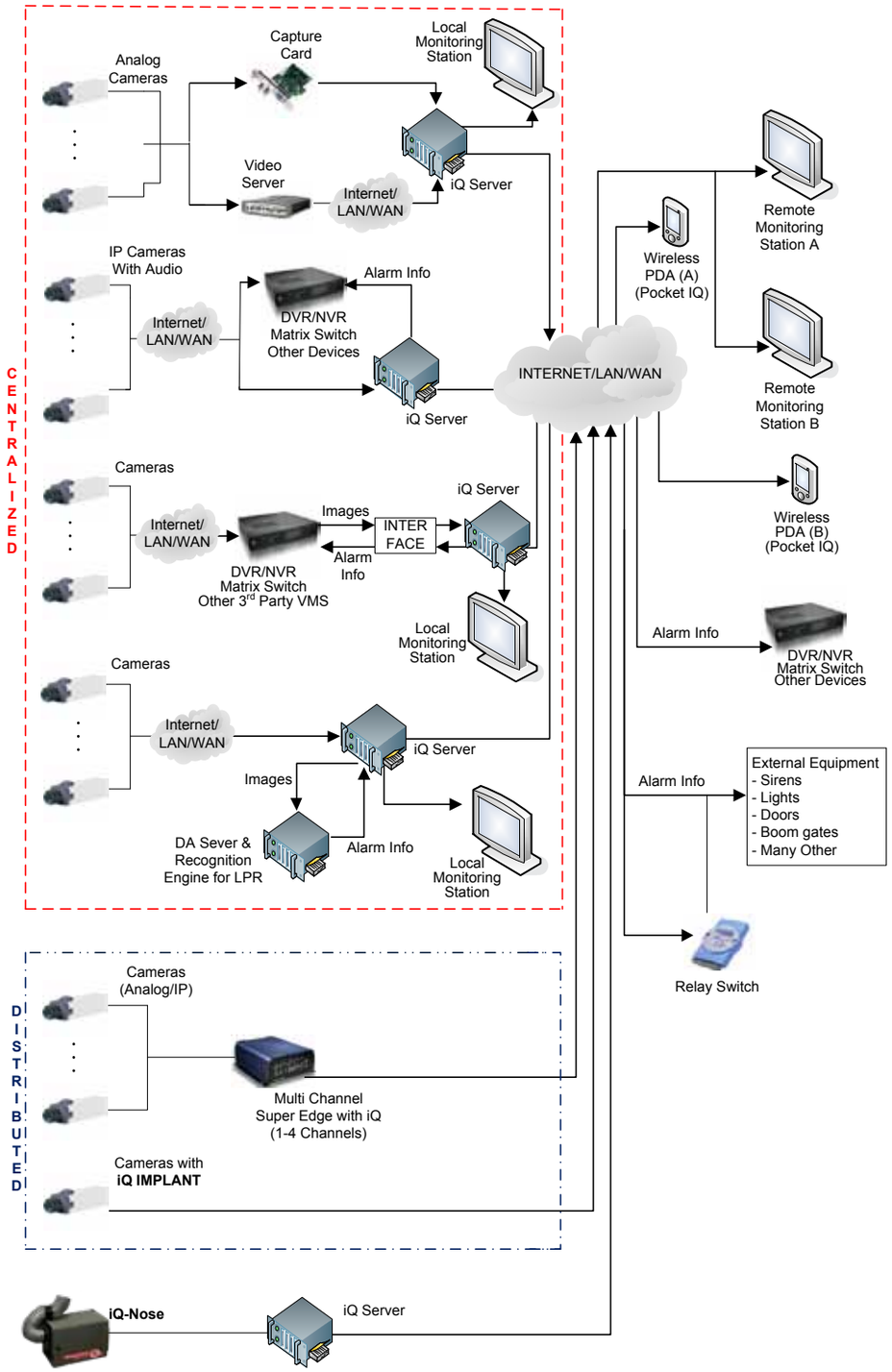
In these situations the analysis can be done on a small computing device placed near or even inside the camera – known as computing at the Edge.

Flexible Architecture



Since a city is a very distributed environment at least a proportion of the surveillance would best be done on Edge devices. These are essentially little computers that sit inside or near the cameras (at the "edge" of the network). The traditional Edge devices that have been available to date just do not have the power to provide all the computing required. Hence iOmniscient, in partnership with Intel, has built a Super Edge device which has the power to process the analytics for 4 cameras at a time in a rugged device.

iOmniscient iQ Series Architecture



The cameras used today will not be the cameras used tomorrow or the day after as the technology evolves. The system must be able to cope with analog or IP cameras (cameras that can be accessed using the internet protocol) without having to change the Edge device.

For that reason, iOmniscient's hardware solution separates the encoding function onto a different device from that which will perform the analytics. Four miniature encoders (or a single 4 channel encoder) can be used in conjunction with a Super Edge device that can handle basic analytics for 4 cameras simultaneously.

Over time, if some analog cameras are replaced with IP cameras, the Super Edge does not have to be replaced as the cameras can connect directly into it via a switch.

The Super Edge itself has many capabilities beyond the normal Edge devices that are generally available on the market. For instance, today's Super Edge can have up to 500 GB of hard disk embedded in it. It is therefore able to operate independently and continue operating even if the network connection is lost for a few hours or even for days or months.

The Super Edge is a fan-less device and therefore can cope with difficult dusty environments. With few moving parts it requires less maintenance.

Super Edge Device

The Super Edge is very powerful compared with the TI chip based edge systems that are available today on the market. While a TI based Edge device can run applications up to iQ-100. The Super Edge can run iQ-Infinity for multiple cameras and also applications such as Face Recognition in a Crowd, License Plate Recognition and iQ-Hawk.

For Smart Cities, the ideal architecture is a hybrid distributed environment which ensures the most appropriate computing platform is used for the application. So some applications can be run at the Edge whilst others are run at a Central location. And they all run with the same effectiveness. The architecture is transparent to the user. This provides great flexibility when implementing

Network Intelligence as opposed to intelligence on single cameras. The Super Edge is the most advanced Edge based device for CCTV today.

The right Cameras for each Job

The cameras are the eyes of the system and the software is the brain.

Whilst iOmniscient prides itself on working with any brand of camera which has a standard interface protocol, it does not mean that every camera is suited for every task.

Ensuring that an image of an appropriate quality is provided to the system for processing will ensure an accurate analysis of the image and to do this one requires a camera with the right characteristics. If the cameras has to see at night it may need to be able see in the infrared or thermal spectrum. The scene may need to be illuminated with an infrared lamp. If vehicles are moving at high speed, the camera would need a high shutter speed to capture the image clearly. Different camera characteristics are required for applications such as Face Recognition, License Plate Recognition, behavior analysis or counting. Hence it is important to understand the objective for a camera before selecting it.

There are many good quality cameras available on the market. But few camera companies have tested their cameras for particular Video Analysis applications and hence they are not able to guarantee whether a particular application is fit for a particular purpose. This is where companies like AnalyticsReady come in. Their cameras are designed and built for a particular application. They guarantee that their cameras would work in a particular situation.

Megapixel versus PTZ Cameras

As has already been noted PTZ cameras are easily defeated. They also have many moving parts which makes them expensive to maintain. However if they are already installed, they can be used for Video Analytic systems as long as they are in a fixed position when the Video Analysis is being performed.

However for new sites it does not make sense to use PTZ cameras. Megapixel cameras today can provide the quality of image required at a lower price and they can be used for Video Analytics. Operators have no ability to watch thousands of cameras. Hence cameras without intelligence are only useful after an event. For them to be useful in a pre-emptive manner they need to be armed with intelligence. Megapixel cameras are far more useful than PTZ cameras for this purpose.

Thermal and Infrared Cameras

Ultimately all cameras require light to see. But the light does not have to be visible for humans. Camera sensors today are sensitive to infrared light and even to heat.

If a camera needs to see at night it must have a sensor that is either very sensitive to light such that it can see even in very low light or it must have a sensor that can see in the infrared range. To see in the infrared spectrum one usually needs to illuminate the area with infrared light which has a longer wavelength than visible light and is invisible to humans.

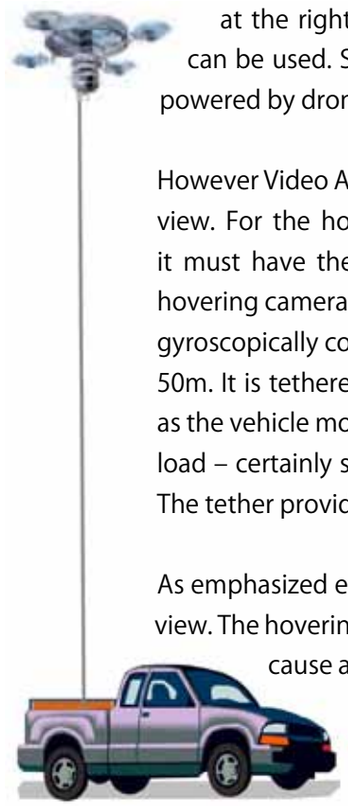
There are several types of chips used in cameras that are sensitive to Infrared light. Some are more sensitive than others and it is important, specially for applications such as License Plate Recognition at night, that one uses camera with the appropriate sensor.

Thermal cameras can see energy in the thermal spectrum. In other words they can see heat. They can tell the difference between warm bodies and inanimate objects. They are very useful for seeing a human at relatively long distances. However the image quality is usually insufficient to do any level of recognition on the person. Thermal cameras are much more expensive than other types of cameras but they can be particularly useful for seeing in the dark over long distances.

Specialized Cameras

Hovering Cameras

For major public events where huge crowds gather, it may be necessary to have a camera to view the scene from a height. Such events occur sporadically and it is usually not possible to have a fixed camera located at exactly the right place at the right time. To address this need, a hovering camera can be used. Several brands of hovering cameras are available powered by drone helicopter type devices.



However Video Analytics today only works on cameras with a fixed view. For the hovering camera to be useful for Video Analytics it must have the ability to provide a steady unmoving view. A hovering camera is available from AnalyticsReady that can fly on a gyroscopically controlled drone helicopter. It operates at or below 50m. It is tethered to a vehicle on the road below and can move as the vehicle moves. The drone helicopter can carry quite a heavy load – certainly sufficient to carry a large camera and illuminator. The tether provides two-way communication as well as power.

As emphasized earlier, Video Analysis does require a fixed camera view. The hovering camera's small movements may be sufficient to cause a Video Analysis system to give false readings. The analytics system has to compensate for these small movements so as to be able to use such a hovering camera effectively.

Hovering camera for crowd monitoring

360 Degree Cameras

As innovation in camera technology continues, new types of cameras appear on the market. One such camera is the 360 degree camera which can see in all directions. The older versions of this technology used four cameras pointing in different directions and their images were stitched together.

Newer cameras use fish-eye lenses that can see in all directions. However the lens tends to distort the images. De-warping software is usually supplied by the camera manufacturer to remove the distortion.

As these are fixed cameras, the undistorted images can be used for Video Analysis.

Other Sensors

Video requires images. Audio analysis requires sensors that will pick up sound. Smell analytics requires sensors that will sense the molecules of the gas and register their "smell".

Many cameras today come with a microphone and a loudspeaker. This allows any sound that occurs in the vicinity of the camera to be heard and analyzed.

Smell sensors today operate independently from cameras. But the information gathered can be closely tied to the information that is collected from cameras and audio sensors.

Just as humans have five senses and can use these in combination, Smart City systems can now have three sensors that can work together to provide a more comprehensive view of what is happening in the area.

Power from the Sun and Wind

All electronic devices draw power and sometimes it is very difficult to provide power in remote locations (such as on a freeway). Solar and wind powered cameras are now available which can operate independently in such remote locations. There is no difference in their capability other than that they draw their power from a different source. Of course the power unit must be sized to provide sufficient power for the device to operate.

14. iOmniscient's Services

Many of the world's top Integrators have selected iOmniscient as their preferred supplier.

iOmniscient's products excel by design. The company has a focus on ensuring that its products are designed to evolve and improve. Its products are designed to be scalable, flexible, open and maintainable. Its products are designed to meet the specific practical needs of its various customers.

But iOmniscient's focus is not just on products. The company has a culture of committing to its customer's success. Fulfilling the customer's need and ensuring satisfaction with the result is a key objective for all employees.

With three strategically placed support centers around the world, the company can provide 24x7 support to its customers. Internal processes ensure that outstanding issues are passed on between support centers to ensure that they are continuously worked on till they are resolved.

In addition, there are five special language support centers that can cope with issues in languages other than English namely Arabic, Spanish, Chinese, Hindi and Korean. All products are maintained through a comprehensive set of ongoing maintenance options which include regular software updates and upgrades and guaranteed response times for problems.

The company provides a wide range of Professional Services to assist the customer from the first step of analyzing risks, though system and network design and camera placement to implementation, training and configuration.

Graffiti detection for a clean city.

iOmniscient succeeds because it does not merely build good products. It designs them to meet the specific needs of the industry it serves, it focuses on providing extraordinary support to its customers with people who enjoy providing good service and it makes sure that the user has a very tangible return on investment.

Car Park Monitoring. Information provided at entrance to car park.

15. Maximizing the Return on Investment from your Smart City System

A Smart City System is a major investment for the stakeholders. There are several factors that affect how the return can be maximized.

The normal assumption is that minimizing the cost of the system is the best way of maximizing the return. Unfortunately getting the cheapest system usually results in the implementation of a system that does not meet the objectives of the stakeholders. It is better to have no system than to have spent a significant amount of money on a system that is ineffective.

Minimizing Cost by Design

And an effective system does not have to be more expensive. It is only more expensive if it is not well designed.

For instance, as we saw in the chapter on Automated Surveillance, the use of iQ-Hawk can reduce the cost of storage and network bandwidth by such a significant amount that even after adding the cost of the software, the overall cost of the solution would be much lower. Of course to achieve this benefit the whole system has to be designed taking into account the advanced capabilities of iQ-Hawk. If the system is designed using conventional assumptions then these cost reduction benefits would not be realized.

Therefore the lowest cost software may not result in the lowest cost system. The overall cost of the system is what is important rather than the cost of any one component.

Automatic jump back to event capability and automated Face Recognition using iQ-Hawk.

Other architectural assumptions can also affect the cost of the system. Systems are often designed as Centralized or Decentralized and this is usually based on the technology provided by the vendor. If the vendor provides an Edge based solution there will be a propensity to design a decentralized solution and vice versa. Since the iOmniscient solution is available both in a server based centralized architecture and in a Super Edge based decentralized one the actual design can be one that is most appropriate for meeting the objectives of the stakeholders. The most cost effective systems are hybrid systems such as those available from iOmniscient as they provides the flexibility for different user groups to use different architecture to meet their objectives in the most cost effective manner without compromising the overall design of the system.

As we have seen some tasks are better performed centrally and others work better when distributed. If the architecture is not the constraining factor then the overall cost can also be minimized.

Irrespective of the architecture the level of intelligence available on the system will have a drastic impact on the effectiveness of the system. A system that is incapable of working in a crowded system will merely give an unacceptably high number of false alarms in that type of situation. Selecting software with the right iQ level for the task to be performed is the most critical factor in determining the value of the system.

Having the right Cameras and other Infrastructure

Users will often spend significant amounts on cameras which may not be appropriate for the job at hand and these may be placed in positions that are not appropriate either. There are numerous examples of cameras being installed with inappropriate views. Cameras for counting systems have been installed outside elevator doors where people wait causing false counts when moving the camera a short distance away would have provided a perfect counting view. Cameras have been installed for License Plate Recognition even when they do not have an adequate shutter speed and where they have inappropriate filters to cope with oncoming headlights. Networks have been put in place with insufficient bandwidth to transfer the video generated by the installed cameras.

This results in significant wasted investment. In the next chapter we will discuss the right process to ensure that such waste is minimized.

Maximizing Return on Capital

The difference in price between the most effective product and one that barely works can be significant. But the difference in utility is infinite. If one feels that one cannot afford to purchase a product that can do the job effectively it may make more sense not to purchase a product at all, as ineffective products just provide an illusion of security and safety.

A well designed system can achieve multiple objectives using different types of sensors and indeed can achieve multiple objectives on each camera.

The effectiveness of a product cannot always be measured in absolute terms. If due to poor camera placement or a very difficult environment a product can achieve 70% accuracy in a particular situation, it may still be far more accurate than the alternative which may be a human attempting to achieve the same objectives.

There are many components in a Smart City system and the intelligence software constitutes a very small proportion of the total cost. It is however the core of the system. It is critical to select the best available core as the return on the entire system can be compromised if the core does not work effectively.

Operational Efficiency

The capital costs of the system are not the only costs that the users will incur. There are many operational costs in using a sophisticated system.

If it takes a long time for the system to provide answers required by the user it reduces his efficiency. If the system cannot function effectively when there is no one around in the control room that can affect efficiency. If a large part of the system is not operational for any reason that can affect efficiency. Reduced operational efficiency reduces the value of the system to the user.

iOmniscient has designed several features just to improve operational efficiency. The Jump to Event function is designed to answer the question about when first started and who was involved.

The Automated Surveillance Capability of iQ-Hawk provides immediate information about people and vehicles involved in an incident. Without such a system operators may spend hours (or even days) attempting to extract the data from unrelated systems.

The Auto-archive function and the availability of information on mobile devices ensure that the system can continue to operate even when the control room is not manned.

The Automated Response Capability can enable the Police and other emergency teams to arrive at the scene of an accident or crime much faster than would be otherwise possible improving efficiency and possibly having an impact in a situation where a few minutes can be the difference between life and death for the people involved.

The iQ-Health Check system can advise the user if part of the system stops functioning.

Maximizing Uptime

Every time the system is down and not operational the user is not receiving the value that he should be expecting from the system. Therefore maximizing uptime is critical. To achieve this, the software and hardware has to be reliable and it is important to know when it is not working so that it can be immediately fixed.

Reliability comes from using good quality hardware and software. It can be enhanced through the use of redundant components.

Knowing that parts of the system are not functioning because they have broken down can be established fairly easily. The iQ-Health Check system can make the user aware of the system not functioning correctly even due to external factors

such as too much rain or a spider's web blinding the camera or movement of the camera due to vibrations.

The user can reasonably expect both the Systems Integrator and the suppliers to offer a level of service and ongoing support for fixing problems that is commensurate with the requirements.

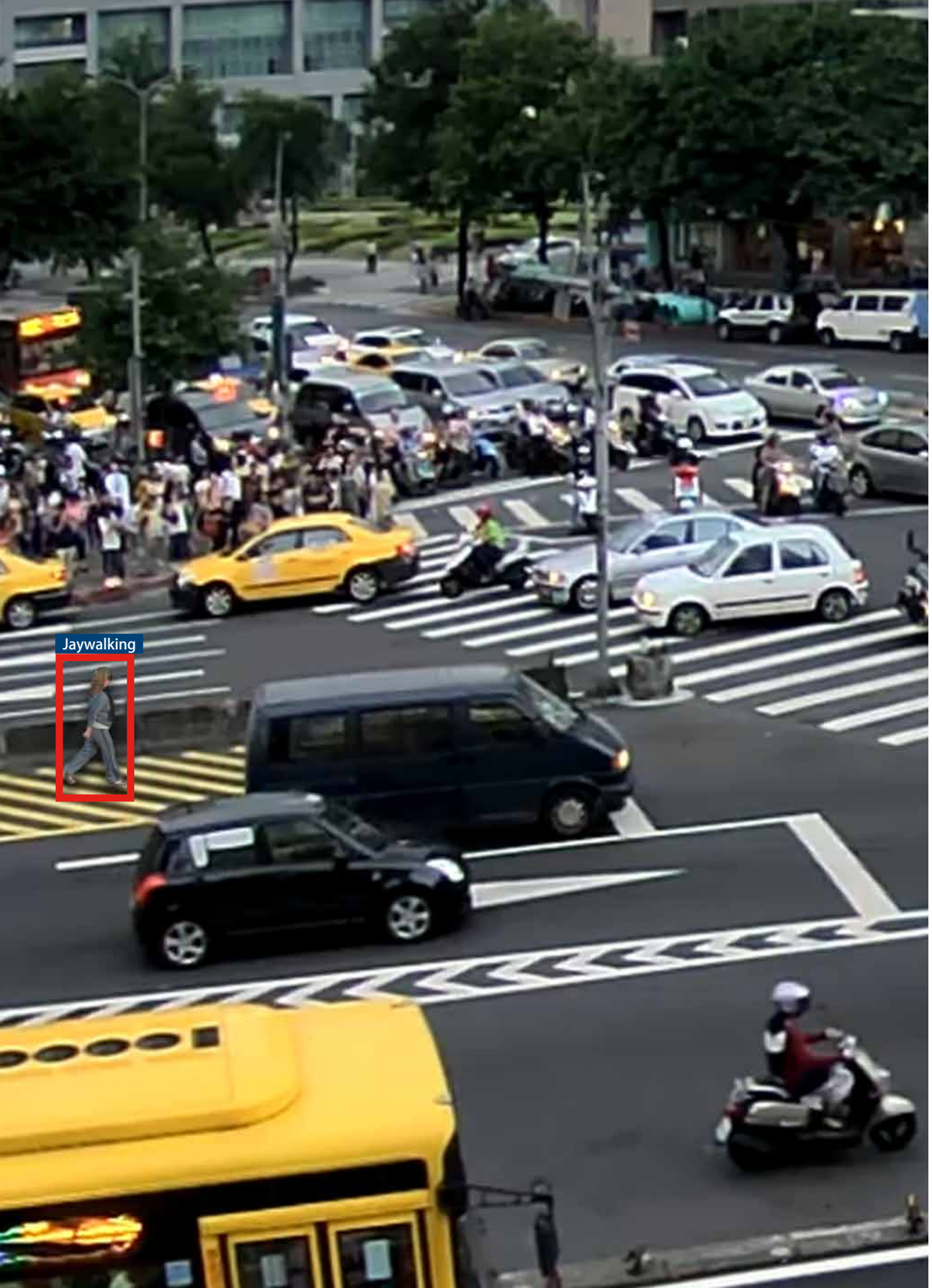
Overcoming Obsolescence

The technology is advancing rapidly. Computing hardware and cameras can become obsolete and unusable in just a few years. Software improves even more rapidly and within a year a system can be overtaken by new advances.

For this reason iOmniscient offers an ongoing product update service to ensure that the system is continuously upgraded. In ten years time the hardware may have collapsed and been replaced several times but the software should be as new as if it was bought that very day.

The key to achieving this goal is that software must always be both forward and backward compatible with itself. It must be able interface with products with which it could interface before while developing new interfaces for new devices and new products. This can only be achieved through strategic design. Very few products can achieve this goal. iOmniscient products are designed to be forward and backward compatible across versions because the objective is to eliminated obsolescence.

Throughout the book we have emphasized the importance of openness and pointed out the negatives associated with products that attempt to lock users in with proprietary interfaces. Nowhere is this more important than when one is attempting to reduce the risk of obsolescence. If a user is locked in to one supplier it is impossible to take advantage of the latest improvements in technology. These are not the monopoly of any one supplier. A commitment to open architectures and interfaces is the foundation to ensuring a system can take advantage of the technologies as they improve.



16. Implementing a Smart City System Successfully

A Smart City surveillance system will be successful if the objectives of the user are clearly defined at the start of the project.

A Smart City surveillance system is usually implemented as a measure to reduce safety and security risks to the people of the city.

A successful system will provide the right information in a timely manner for emergencies, automating all standard events and allowing sufficient time for humans to make a judgment on the more unique, special events.

Therefore, it is important to establish the objective of the system as early as possible using a systematic risk assessment to identify and assess the risks and the best measures to mitigate these risks.

Defining System Objectives

The best method for defining the system objectives is to perform a systematic risk assessment to ensure that the right problems are being solved. There are numerous examples of cameras that have been installed pointing in the wrong direction or indeed where they are in the wrong place. The priority risks lay unattended while systems are installed to solve the wrong problem.

There is now an international standard for Risk Analysis (ISO31000). iOmniscient can provide a service for a comprehensive Risk Analysis for any environment.

Big Data analysis to highlight areas prone to jaywalking.

Once the key risks have been identified and their consequences understood, it is important to prioritize them.

Prioritize the Objectives

Prioritization of risks and therefore the objectives of the system ensures that the investment is made to address the most important objectives first.

Once the user has an understanding of the risks to be addressed, it is important to select the most appropriate risk mitigation strategies. These may not involve the use of cameras. There may be risks that can only be addressed by other methods such as the presence of an armed guard or a lock on a door.

The systematic risk assessment will assist the user in deciding where surveillance and automation technology is required and the reasons for this decision. This will ensure that the most appropriate technology is used to achieve specific purposes.

In security the onion principle is important. According to this principle, it is best to have layers of protection just like the layers within an onion. If one layer of protection is defeated, there are still several levels of defense that have to be overcome. No single technology will solve all problems. However many technologies can work together to provide a secure and safe environment.

Having prioritized the risks it is important to determine the types of event where an automated response is appropriate and where human intervention may be necessary. Many situations which were previously responded to by humans are simple to automate leaving the human with the bandwidth to address more complex tasks.

Once the objectives have been determined, there are two important elements to implementing a successful system.

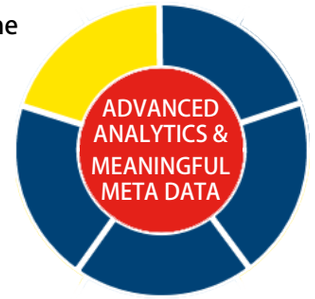
1. Following a disciplined implementation process.
2. Selecting the right suppliers for software systems, hardware and implementation services (the Systems Integrator)

Disciplined Implementation Process

To implement a successful Smart City system one has to follow a 4 step process as follows:

1. Select the appropriate software to meet the objectives of the Smart City surveillance system.
2. Select the cameras and other hardware infrastructure.
3. Select the Systems Integrator.
4. Implement the system with appropriate camera placement and test the outcome to ensure the objectives are met.

Step 1: Select the appropriate software to meet the objectives of the smart city surveillance system.



It is important to identify and select the software that would be most suited to addressing the objective of the system. This determines the core of the Smart City System.

Step 2: Select the cameras and other system hardware infrastructure.

As a next step, the user should identify the sensors that should be used. These include the cameras. Without going through this process the organization may select inappropriate cameras for the required task and place them incorrectly for the applications. Of course the software would then not work optimally.

Once the cameras have been selected the next step is to select the computers, storage and networking infrastructure and ensure it is appropriate to the software to be used.

Step 3: Select the Systems Integrator.

Next, it is important to select the Systems Integrator who has the capability of bringing all the components of the solution together.

Step 4: Implement the System.

The final step is to proceed to implement the system. Cameras and sensors need to be placed as per the directions of the supplier of the Video Analytics (not the camera vendor).

It is also important for the user to establish a test plan to ensure that all the objectives of the system are met once the system has been implemented.

Frequent Mistakes in Implementation

Unfortunately many users of such systems have started with Step 2. First they have selected the cameras and even installed them without determining if they are the appropriate cameras and whether they are placed correctly for the application.

Some users have selected the Systems Integrator at Step 3. They have hoped that this organization will implement a working system. However without going through the previous steps the Integrator has little chance of implementing a system that actually meets the needs to the user.

When a system fails to deliver the results the fingers are pointed in all directions – except at the core problem which is that the user has not followed the disciplined approach that has been prescribed.

Questions you should ask your Vendors

Smart City systems are large and complex with many suppliers involved. The key suppliers are:

1. The software suppliers.
2. The hardware suppliers.
3. The System Integrator.

Most Smart City systems are implemented by a Systems Integrator. These companies acquire the software and hardware for the surveillance system and manage the integration of these to implement the system. It is important that the purchaser understands and specifies the requirements of their system especially for a Smart City project.

The user needs to ensure:

1. The system requirements are clearly specified. iOmniscient can provide sample specification documents to help the user with this exercise.
2. The selected software and hardware solution will meet these requirements.
3. The selected software and hardware is delivered and implemented (not a cheaper less effective alternative).

The user has a test plan to ensure that the system delivers the required capabilities in a realistic complex environment and the objectives of the system are met. Sample test plans are available from iOmniscient.

System Objectives

1. Does the system achieve the objectives of the key stakeholders of the system?

Intelligence Levels

1. What is the iQ-Rating of the systems being offered?
2. Does the system have the ability to operate at higher levels of iQ? Or is what is being offered as smart as the system gets?
3. Is the software so smart at optimizing resources that a system with the software can be less expensive than a system without the software?
4. Is the system the most advanced that is available to date? A comparison with the iQ-Rating Chart would confirm this.
5. How robust is the system? This can be determined by establishing if similar systems have been operational for long periods of time.
6. How committed is the supplier to enhancing capabilities in future

to ensure the system does not become obsolete?

7. Does the system use other sense including noise and smell?
8. Is it necessary to implement record all video all the time? Most advanced systems may record video only for events and for their verification. In very few situations does all video have to be recorded and archived for long periods of time.
9. Can a single system provide all the capabilities required (including Face Recognition in a crowd, License Plate Recognition, Automated Response and Audio and Smell Analytics? Remember that interfaces between different suppliers are often the weakest link in the system.

Face and License Plate Detection and Recognition

1. Can the system perform Face Detection and Recognition in crowded and complex environments?
2. Can the system recognize vehicles and people based on the events that it has detected?
3. Can the system track people and vehicles from camera to camera?

Jump to Event and determining the identity of the person involved in an incident

1. For complex events that might take some considerable time, can the system go back to before that event commenced at the press of a single button and recognize the person who was involved? (Consider an event such as a person abandoning a bag for ten minutes. Can the system recall the video of the person bringing the bag into the scene)?
2. Once the start of an event has been determined can the system automatically identify the person or vehicle (or other object) involved in that event?

Automated and Mobile Response for Emergency Management

1. Can the system automatically show the human operator where events are happening on a map of the environment?
2. Can an operator view all events on a Smart Phone and can these be archived and managed from this device?
3. Can the system locate the nearest responder (e.g. police car, ambulance, fire brigade) and automatically advise them of an incident?

Big Data Capability

1. Does the software generate Meaningful Meta Data?
2. Can this data be used to provide reporting, analysis and forecasting capabilities?
3. Can the system pull together unstructured information from a variety of different sources and use it to understand the environment and predict future events?

System Cost Effectiveness, Reliability and Efficiency

Some questions to ensure that the system operates cost effectively and with a minimum of human intervention are:

1. Can the system intelligently store information of interest or does it simply record all video footage?
2. Can important information (such as faces and number plates) be stored in higher resolution than other irrelevant details
3. Does the system know if it is not working or if the cameras cannot see properly?
4. Can the system be scheduled to perform different functions on a camera at different times?
5. Does the system have a Nuisance Alarm Minimization System (NAMS) capability?
6. Does the system have a Universal Connectivity Module?
7. Can the system be configured, implemented and maintained

remotely?
8. Can the system operate as an Intelligent Network rather than just as a smart camera?

Software Selection

Some questions to ask when selecting the software vendor for the Smart City surveillance system are:

1. Can the technology actually meet the objectives of the surveillance system?
2. Is the proposed solution comprehensive enough so that the number of interfaces to other vendors is minimized?
3. Is Video Analytics the core business? This is a very specialized field and many organizations and many software suppliers are relatively inexperienced. Ensure you are working with an expert in the field who has been around for a long time.
4. Is the software supplier knowledgeable? Make sure your supplier is recognized as knowledgeable in the field. Have they published significant books, guides or other information that demonstrates their knowledge?
5. Is the software supplier committed to openness? Engaging a vendor with proprietary interfaces which do not work openly with others will greatly restrict the user in the long term.
6. Is the software robust? Has it been implemented in a large number of different circumstances? There are many new players who are essentially attempting to commercialize university projects. The resultant products tend not to be sufficiently robust in meeting the real user requirements.

Hardware Selection

Some questions to ask when selecting the hardware vendor for the Smart City system are:

1. Can the camera vendor commit that the selected cameras are suited for the Video Analytics that have to be used?
2. Is the vendor able to provide the other sensors needed to enhance the capability of the overall system?
3. Does computer hardware meet the specification required for the Video Analytics and is there sufficient network bandwidth for the system to perform adequately?
4. Is the vendor able to supply hardware required for the mobility and Automated Response applications?
5. Has all the hardware been certified by the supplier of the analytics as being fit for use and suited to the objectives?-

Systems Integrator

Some questions to ask when selecting the Systems Integrator for Smart City surveillance system are:

1. Is the Systems Integrator experienced in the implementation of smart surveillance systems?
2. Make sure their experience is not limited to implementing simple VMS/ DVR systems.
3. Has the Integrator developed a test plan that has been approved by all the stakeholders and which meets all the objectives for the system?
4. Has the Integrator been certified as trained by the supplier of the Video Analytics?
5. Are training and documentation provided?
6. Does the user have a commissioning plan that covers everything that has to be implemented including the advanced VA, Automated Surveillance and Automated Response?

Appendix: Examples of Big Data Analysis

Application	Smart Function	Big Data Reporting Capability
Security and Safety on the Streets		
Street Security	Identification and tracking of suspects/ criminals even in a crowded and uncontrolled environment	Automated processes for detection for fast response by law enforcement and subsequent reporting and analysis
Street Security	Detection of suspicious behaviors (e.g. man-down/fighting, loitering, running, crowding. Be able to automatically IDENTIFY the culprits using many-to-many Face Recognition system	Automated processes for detection for fast response by law enforcement and subsequent reporting and analysis
Street Security	Linking of different events from large number of cameras to provide comprehensive information for immediate action	Automated processes for detection for fast response by law enforcement and subsequent reporting and analysis
Street Security	Immediate Alert for people who wear masks, helmets when entering specific areas (e.g. the money exchangers or near an ATM)	Automated processes for detection for fast response by law enforcement and subsequent reporting and analysis
Street Security	Recognition of suspicious activities determined by using a combination of video and voice recognition systems. Generate an alert for incidents like gun shots, serious car accidents etc.	Automated processes for detection for fast response by law enforcement and subsequent reporting and analysis
Street Security	Surveillance system health check to prevent camera tampering or sabotage	Automated processes for detection for response by city maintenance and subsequent reporting and analysis
Security		
Security	Face Detection & Recognition in a crowd and in an uncontrolled complex terminal environment	Reporting and analysis of location, timing etc. of events
Security	Abandoned objects	Reporting and analysis of location, timing etc. of events
Access Control	Trespassing, Wrong way and Tailgating	Reporting and analysis of location, timing etc. of events

Debris on the road can be detected even when significantly obscured. Automatical traffic warning generated.

Application	Smart Function	Big Data Reporting Capability
Access Control	Suspicious behavior, loitering, etc. in restricted areas	Reporting and analysis of location, timing etc. of events
Access Control	Intrusion detection into prohibited areas	Reporting and analysis of location, timing etc. of events
Operations		
VIP Security Management	Monitoring of access around nominated areas where VIPs will be located, suspicious behaviors, crowding etc.	Real-time monitoring and subsequent analysis of incidents to enable optimized resource deployment and improved VIP security
Queue Management	Monitoring of lengths of queues and waiting times to improve customer services	Analysis of wait times for passengers by day/time, enable optimized resource deployment and improved customer service
Retail and Pedestrian Traffic Areas	People counting and crowd management, loitering	Analysis of people numbers by day/ time, enable better forecasting and planning for services and optimized rental for retail tenants
Retail and Pedestrian Traffic Areas	Vandalism/Graffiti detection	Reporting and analysis of location, timing etc. of events to enable improved security
Retail and Pedestrian Traffic Areas	Surveillance System Health Check to prevent camera tampering or sabotage	Reporting and analysis of location, timing etc. of events to enable improved security
Retail and Pedestrian Traffic Areas	Abandoned object detection, lost & found, etc. in passenger drop off, Bus depots or Taxi stands	Reporting and analysis of location, timing etc. of events to enable improved security and safety
Main Vehicle Traffic Areas	Vehicle counting and crowd management	Reporting and analysis of location, timing etc. of events for better traffic management, taxi queue management etc.
Public Spaces	Theft Prevention of public furniture, art works etc.	Reporting and analysis of location, timing etc. of events for improved security
Public Spaces and Important Buildings	Use Automatic License Plate Recognition (ALPR) to record and register all vehicles entering/ leaving pickup/drop off areas	Reporting and analysis of location, timing etc. of events for improved security
Protecting Important Buildings and Places		
Protecting Prominent Buildings and Landmarks	Detect hawkers, graffiti activities or vandalism	Automated processes for detection for response by city maintenance and subsequent reporting and analysis
Protecting Prominent Buildings and Landmarks	Perimeter Protection along the boundary to detect unauthorized entry etc.	Reporting and analysis of location, timing etc. of events for improved security and safety

Application	Smart Function	Big Data Reporting Capability
Protecting Prominent Buildings and Landmarks	Detection of any abandoned objects on the perimeter of the building or landmark	Reporting and analysis of location, timing etc. of events for improved safety
Safety		
Public Space Safety	Use Video monitoring to detect, respond to and prevent running, skateboarding, slip and fall	Reporting and analysis of location, timing etc. of events for improved security
Public Space Safety	Overcrowding and congestion detection – adhere to safety regulations	Reporting and analysis of locations and numbers of people where there is overcrowding including timing, frequency etc. of events for improved management of the spaces
Public Space Safety	Smoke and fire detection	Raise alarm for quick response and subsequent reporting and analysis of location, timing etc. of events for safety and security
Public Space Safety	Detection of abandoned objects, especially around prominent building or open spaces and plazas	Reporting and analysis of location, timing etc. of events for improved security
Road Traffic Monitoring and Management		
Traffic Flow	Monitoring and measurement of traffic volumes and flows	Reporting and analysis of traffic flows & traffic patterns to introduce effective traffic management especially during major events
Traffic Flow	Detect traffic congestion resulting from vehicles stopped or major accidents	Reporting and analysis of location, timing etc. of events for improved traffic management
Traffic Violations	Detect traffic violations e.g. for vehicle stopping at no standing zone, vehicles speeding, red light violations etc.	Reporting and analysis of location, timing etc. of events for improved traffic management
Traffic Violations	Law enforcement by detecting prohibited (e.g. stolen) vehicles using Automatic License Plate Recognition (ALPR) system	Automated processes for detection and issue of law/traffic infringement notices and subsequent reporting and analysis
Law Enforcement	Automate law enforcement by converging detection and identification technologies iQ-Hawk	Automated processes for detection and issue of traffic infringement notices and subsequent reporting and analysis
Law Enforcement	Track nominated vehicle based on plate, color and driver information with Automatic License Plate Recognition (ALPR) system	Automated processes for detection and follow up by police to facilitate apprehension and subsequent reporting and analysis
Access Control	Allow / disallow vehicle access using Automatic License Plate Recognition (ALPR) system into high-security buildings and car parks	Automated processes for detection and issue of traffic infringement notices and subsequent reporting and analysis
Law Enforcement	Monitor time spent on nominated locations at specific pickup/drop off areas, taxi stands, etc.	Automated processes for detection and issue of traffic infringement notices and subsequent reporting and analysis

Application	Smart Function	Big Data Reporting Capability
Car Park Management		
Car Park Security	Enhance car park security (e.g. loitering or suspicious behaviors)	Reporting and analysis of location, timing etc. of events for improved traffic management
Car Park Security	Prevent vehicle being stolen – e.g. to match owner to the car using ALPR and Face Recognition	Automated processes for detection and law enforcement and subsequent reporting and analysis
Car Park Customer Services	Enhance car park management using Video Analysis to guide to the empty spot	Automated processes for detection and advice to customer (e.g. via mobile phone)
Car Park Customer Services	Assist car owner to locate his/ her parked car using License Plate information in a big car park	Automated processes for detection and advice to customer (e.g. via mobile phone)
Car Park Management	To increase the revenue by resetting the parking meter once the car has left the spot	Automated processes for detection and re-setting of parking meter and subsequent reporting for analysis of additional revenue captured
Car Park Management	Increase the revenue by understanding the allowed grace period for each vehicle (particularly in the temporary stopping areas without the metering facility)	Automated processes for detection and reporting of volumes and timing of events for analysis of revenue foregone.
Optimizing Revenues for Sponsors and Advertisers		
Measurement of Foot and Vehicular Traffic	Optimizes revenues based on traffic volumes	Monitoring and reporting of traffic volumes – people and vehicles- to demonstrate cost/.benefits to sponsors and advertisers
Transport Hubs and Related Services		
Transport Hubs – bus terminals, taxi stands, transport interchanges etc.	Monitor crowding, queues, traffic flows at bus depots, taxi stands and other transport hubs	Reporting and analysis of location, timing etc. of events for improved security and safety
Planning for Sustainable City living		
Traffic Flows		Analysis of traffic flows prior to major developments
Alternative Transport Use e.g. bicycles		Analysis of numbers of movements along various city routes
People Movements		Analysis of people flows prior to major developments

About iOmniscient

iOmniscient is the technology leader in Video Analytics with an unmatched capability in analyzing realistic, complex and crowded spaces using its internationally patented technologies such as Non-motion Detection that are not available from anyone else.

iOmniscient provides the most comprehensive suite of Detection, Recognition and Automated Surveillance and Response Systems, from simple intrusion and counting systems to unique object detection in a crowd, multi-lingual License Plate Recognition & the world's first non-cooperative Face Recognition for crowded scenes. Several of its capabilities (including the ability to perform abandoned object and theft detection and the ability to perform detection and recognition simultaneously on the same camera) are internationally patented.

All iOmniscient systems are armed with its Artificial Intelligence based Nuisance Alarm Minimization System (NAMS) to help eliminate false alarms while maintaining detection accuracy. With its extensive industry experience, the company has also developed over 30 unique industry solutions.

iOmniscient has won many international awards, including the IFSEC "Best CCTV System of the Year" for its Face Recognition in a crowd and the Global Security Challenge for Crowded Scenes.

With its global footprint and distributed support centers, iOmniscient can provide 24x7 worldwide support and professional services to ensure that customers can successfully implement their Video Analytics systems.

With over 35,000 licenses sold, customers in many industries around the world use iOmniscient.

As a pioneer in Video Analytics with over 10 years of commercial experience, iOmniscient is dedicated to maintaining its global leadership by continuing to develop revolutionary and intelligent surveillance technology.

For more information about Smart Cities, please visit www.iqsmartcity.com.
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