Introduction

In 1993, Iteris began developing image processing techniques to detect the presence of vehicles at intersections. These techniques were designed as a replacement technology to the inductive loop sensor. Today, Vantage is one of the leading brands of vehicle detection systems in the world. Traffic applications such as intersection control, highway monitoring, tunnel incident detection and red light enforcement are increasingly utilizing video detection as an alternative and reliable method for detecting or triggering events. This article explains the basic components and functions of a video detection system.

Video Detection System Overview

Image Processors

Modularity should be at the heart of every video detection system enabling flexible system design and configurations. Using the latest technology and full motion video digital signal processing techniques, all video detection systems should be able to offer accurate and reliable performance to detect vehicles in a variety of climatic and lighting conditions. Embedded firmware is specifically tailored for the task without having the need for bulky operating systems or external computers.

Image Processor Module

Video detection modules are available in NEMA or Eurocard module format that can plug directly into most standard detector racks to replace the inductive loop amplifier. Usually, the module is designed as a “Plug and Play” replacement technology for the inductive loop amplifier module. The video detection module will provide the same open collector outputs as the loop amplifier module thereby eliminating any need for traffic signal controller re-programming.

Video detection modules can come in different flavors offering a multitude of options such as:

- Single or dual video input configurations
- Remote programming of processors permitted
- High intensity LEDs showing processor activity
- Compatible with +12VDC or +24VDC power sources
- Multiple virtual zones per camera view
- Multiple output detector channels per video input.
- RS-232 or RS-485 serial port access

Virtual Zones

Video detection is all about virtual zones or defining areas of interest within the camera’s field of view. Generally, the virtual zone is drawn where the inductive loop is, or would have been, placed in the road surface. Each virtual zone is assigned characteristics such as the type of zone (Presence, Delay, Extend, Pulse or Count), its output detector channel,

and other ancillary functions such as occupancy or speed up alarms and wrong way detection notification. The virtual zone can be configured to perform the same functions as an inductive loop. The functional descriptions outlined below may differ slightly from one video detection vendor to another but the results are usually the same.

Presence Detection Zones
This is the most common form of a virtual zone. That is, when the virtual zone detects the presence of a moving object within the zone, it provides a signal on its assigned output detector channel. Nearly all virtual zones are configured for presence detection when used in the intersection control application in conjunction with traffic signal controllers.

Green Input function
When used with presence detection, a Green input function gives the virtual zone added flexibility. This capability allows a virtual zone to have “two conditions” based upon the signal that the traffic signal controller provides. So you could define the virtual zone to be a Presence zone during a Red Phase and during the Green Phase to have a different function such as a Count function. The traffic signal controller provides notification to the video detection system that the Green Phase is activated.

Another example could be where a Count zone is drawn past the stop line and counting of vehicles is required in a particular lane but when the Red Phase is activated, no counting of motion (vehicles traveling sideways or pedestrians) is required. The procedure would call for the virtual zone to be a Count zone when the phase is green and set the virtual zone to be “None” when the phase is red. This flexibility eliminates false counting of vehicles or people as they move through or across the intersection during the Red phase. Clearly, an inductive loop does not suffer this minor annoyance but with simple virtual zone configuration, the problem is eliminated.

Delay Function
The Delay function is used in conjunction with the Green Input. Let's say a virtual zone is drawn in the right turn lane; (in some countries such as the USA, a "Right on Red" is permissible). When the light is red, the virtual zone would provide a delay function for 5 seconds (could be longer, if required). In this instance, a vehicle pulls up in the right hand turn lane and stops while the driver looks to see if it is safe to turn. Once the vehicle is detected, the delay function starts counting down. If the vehicle turns within 5 seconds, no call is placed to the traffic controller and the phasing continues to operate without interruption. However, if the phase is green, then normal presence mode is required and a call is made to the traffic controller immediately thus helping to lengthen the green time.

Extend Function
Extension usually operates in conjunction with advance detection zone placed 75 meters from the crosswalk. In this instance, the video detection system would be programmed to provide extension on the advance virtual zones so they would continue to place a call until the vehicle reached the stop bar and passed through the normal presence detection virtual zones drawn at the stop bar location.

The extension capability goes back to inductive loops. Extension was a form of “band-aid” for poor loop placement in the street. Extension is not that important of a feature with virtual loops because the detection zones can be placed almost anywhere in the field of view and re-drawn until the operator is happy with the virtual zone placement. The in-ground loops cannot be moved so an extension time was added to make the loop "seem" bigger than it really was. Extension is still provided to allow for plug and play video detection systems and minimizes the set up time for the traffic engineer without having to change the traffic signal controller programming.

Virtual Zone Capacity

How many virtual zones can be drawn within the camera’s field of view? A cautionary note should be made here since video detection systems have a finite capacity in terms of processing power, available memory and program function. It is easy for a traffic engineer to create a complex mix of virtual zones that provide multiple functions, Boolean logic for joining and comparing other virtual zones, and output detector contacts. In essence, more virtual zones equate to more processing cycles required to process the additional information. Bear in mind that video is received at 25 (PAL) or 30 (NTSC) frames per second (fps). A well-engineered video detection system should be designed to process ALL received frames AND process all pixels within ALL virtual zones to ensure for a complete and reliable operation. Video detection systems that allow a traffic engineer to configure a higher number of virtual zones without meeting this basic requirement should be viewed as being no different from those offering a lower and more realistic number.

For example, a typical configuration at an intersection or mid block location should not exceed 15-17 virtual zones per camera field of view. Sometimes, a slightly higher number of virtual zones may be required. Therefore, it is reasonable and logical to expect 25-30 virtual zones to be the maximum number permitted. Some video detection vendors suggest it is possible to define up to 99 virtual zones as the maximum permissible configuration. As explained previously, this type of configuration would need to have at least a minimum of three or four times the processing capability of its peers or competitors to function correctly.

Should such specifications be presented, it is recommended to verify the processing power of the product and to obtain a conformance requirement from the manufacturer to ensure full processing capability is maintained at maximum configuration without loss of performance. In real terms, the net result of defining a higher number of virtual zones would be missed frames, missed pixel processing, and at worst, missed processing of virtual zones. Coupled with poor weather conditions, the video detection system would deliver sub-standard performance. The Iteris Edge2 processor module is capable of supporting up to 24 virtual zones with full processing for every configured virtual zone.

Output Detector Channels

Video detection systems normally communicate to other devices by either open output collector channels or by data communication path via RS-232 serial ports or TCP/IP network connections. For most intersection control installations, the easiest and quickest

method is via open collector outputs since loop amplifier modules use the same type of physical connection.

Extension Modules

Normally, video detection modules will have up to 4 output detector channels available. This number conforms to the NEMA standard for 170 input file configurations. Extension modules provide more output detector channels when needed. Usually, they come in 2, Channel 4 Channel or perhaps a 24 Channel model. Extension modules are linked back to a video detection processor module. Each Extension module will have an input and output connector on its faceplate for linking in a daisy-chain fashion. For example; to get 12 output detectors, you would have the following daisy chain:

Extension Modules

PROCESSOR<---->4 Channel Ext module<------->4 Channel Ext module

In the illustration above, the Processor module has 4 outputs and each of the Extension modules have 4 outputs channels making a total of 12 outputs.

The video detection processor and Extension modules can be placed in any order in a standard detector rack. You determine the daisy-chain by linking the modules in the correct order. Typically, you would insert the modules as illustrated above. You can link up to 3 Extension modules creating a total of 16 output detector channels. If you wanted more than 16 output detectors channels, then you would use a high-capacity module like the Iteris Vantage IO Module which gives up to 24 output detector channels. The IO Module is like the 2 or 4 channel Extension module and can be inserted anywhere in the daisy chain.

At the back of the detector rack, you will normally find terminal blocks for the connection of the wires to be connected to the receiving device (traffic controller or data analyzer). The exception would be the high-capacity Extension module. Its output detector channels are normally located on the front faceplate via a DB37 connector or similar.

Output detectors are essentially true logic ground contact closure circuits of +24VDC nominal at 50mA. The receiving device (traffic controller or data analyze) normally outputs +24VDC on its sensors and the video detection processor module provides a true logic ground when the correct condition is met for that circuit.

Communication Modules

Vantage Access™
Vantage eAccess™

Communication modules are multifunction hubs providing connection to several video detection processors enabling remote access and video streaming. Communications modules provide these primary functions:

- Single point of access for many processor modules

- Remote access via modem or TCP/IP
- Built-in hardened modem
- Video streaming via MPEG2 or MPEG4
- Web browser access

Communications modules are essential devices for those requiring remote access via a PSTN or wide area network connection. Typically, a modem connection is fine for remote access to inquire upon the status of the traffic cabinet operation. Today, many more installations are requiring high-speed access to the roadside cabinet in order to view the video from the camera. Communication modules can stream video in MPEG2 or MPEG4 compressed format for viewing on a centrally located PC running Windows Internet Explorer or equivalent. Iteris recently announced the availability if its eAccess communications module for this purpose. Up to 4 Edge2 video detection processor modules can be accessed via an Ethernet connection using a simple PC and web browser support.

Detector Racks

Vantage V2 Rack™

Detector racks come in a variety of sizes and formats. The main two formats are NEMA and Eurocard. Both are normally installed within the cabinet by the traffic controller cabinet manufacturer. The detector rack provides a module bay for loop amplifier or video detection modules. Detectors racks can be delivered in 3, 4, 5 or 7 slot models.

Sometimes, it is required to offer a standalone unit for data collection or connection to some other type of device such as an input to a Red Light Enforcement system where such equipment does not normally have detector racks. In these instances, many video detection manufacturers supply a standalone rack with integral power supply. The video detection processor can continue to operate in isolation collecting data and storing data until downloaded at the appropriate time.

Iteris offers the Vantage V2 rack, a space-saving solution where a single or dual camera input video detection system is deployed. The V2 rack uses Vantage Edge2 processors and optionally the Edge2 I/O module thus providing application flexibility for standalone or single counting station installations.

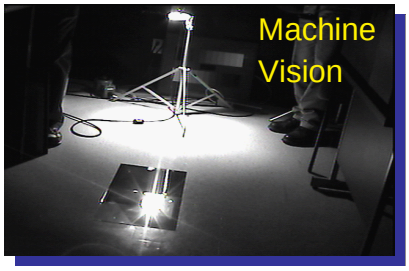
Video Detection Cameras

Vantage Camera™

All cameras are not the same. CCTV cameras are generally designed to offer certain characteristics most suited to visual and depth of field viewing. Enhanced night-rime vision techniques provide images in near darkness which is suitable for operator viewing. One of the disadvantages of such systems is the quality of the image. CCTV images tend to be grainy, or have a “snowstorm” or “Salt and Pepper” look in night time viewing. Essentially, the graininess is due to noise in the video signal.

In contrast, video detection requires a clean video signal with low signal to noise ratio. Remember, the video image processor is trying to determine the shape of an object and detect motion. Noise within the video signal can easily “look” like an object. Compare the two images in the side bar below to see the difference between a normal CCTV camera and a camera that has been optimized for machine vision processing or traffic viewing.

It is recommended that the camera be provided by the video detection manufacturer. While most cameras can be fine-tuned and adjusted through re-configuration of the menu settings, poor video detection performance can sometimes result which may be difficult to overcome. Some cameras are incompatible with video detection systems and cannot be fine-tuned.



Iteris has developed its own range of video cameras to ensure optimal performance is achieved in all situations. The cameras use a sensitive CCD imager to ensure a wider than normal dynamic range, thus improving the system's ability to detect vehicles in low light or abnormal conditions. The Vantage camera assembly includes a weatherproof housing and integral sunshield for outdoor installation. A heater is mounted near the faceplate of the housing to minimize condensation and keep the lens warm for proper operations during periods of cold weather.

Video Detection Applications

Intersection

By using a video detection system to detect the presence and movement of vehicles, traffic engineers can reliably and efficiently monitor, control and manage the operation and synchronization of traffic signals throughout a city.

Responsive mode vehicle detection is one of the most common applications in use today for intersection control. Traditionally, the inductive loop has been the technology of choice for traffic engineers. Today, the traffic engineer can choose from a rich variety of technologies that provide accurate and reliable performance across a broad range of climatic and lighting conditions. Video detection at intersection has seen an explosive growth over the last 5 years. As of January 2006, there are more than 40,000 Vantage systems installed across the world at intersections providing vehicle detection, counting, and red light enforcement functions.

The primary feature and functions of a video detection system should comprise of:

- Superior image stabilization providing reliable detection in extreme windy and poor weather conditions
- Superior shadow rejection providing accurate detection is locations that have sharp shadows or tree-lined roads that cause rapid and changing dark movements in the detection area.
- Fail-safe operation alarms and indicators that inform the traffic signal controller equipment that the video detection system is in either a low contrast or fog condition that would otherwise cause unreliable detection.
- Enhanced night time detection processing to ensure detection of vehicles in a variety of lighting conditions.

Traffic and maintenance engineers should look for these basic requirements within a video detection system. Also look at the company and ensure it is focused on delivering quality product through timely releases of new and improved firmware and hardware. Video detection systems are being enhanced continuously through better algorithms, improved technology and proven field experience.

Highway Monitoring

Video detection has matured into a proven technology that allows engineers to broaden the range of applications to include pedestrian and bicycle detection, incident detection, ramp metering, highway monitoring and much more. Currently, all of these applications use the cost effective technology of video image processing

Video detection for highway monitoring has several benefits such as simplified installation, accurate recording, and the availability of video for surveillance purposes. As with all above ground technologies, careful placement of the detector equipment is critical for good results.

The Vantage Express application is specifically designed to perform reliably and accurately in a variety of climatic and lighting conditions. For optimum performance, Iteris recommends the following:

- The camera should be fitted with a wide angle lens for better viewing.
- Optimum positioning of the camera is over the lanes pointing downwards at around 45 degrees. Up to 4 lanes is recommended.
- Traffic is monitored as it moves away from the camera to prevent glare/headlamp issues.
- The camera should be placed at least 12 meters high. The higher the better to eliminate occlusion.

The types of data collected can be classified as:

- Vehicle Counts (per lane)
- Average Vehicle Speeds (MPH/KPH per lane)
- Average Headway (per lane)
- Average Gap (per lane)
- Vehicle Classification by Length (per lane)
- Lane Occupancy
- Wrong Way Vehicle Incident Detection
- Low Visibility Alarm
- User -defined alarm thresholds based upon occupancy, speed and counts etc.
- User Defined Data Collection Intervals (in increments 20 Sec. to 1 Hour)

Information retrieval can be performed using one of two methods:

- Collection by video detection software application
- Collection by Traffic Managements Center application

Most video detection manufacturers will provide some form of a host application that will connect with one or more remote video detection systems. This application will normally poll, load or retrieve configuration data and may allow video streaming, archiving and alarm reporting.

Iteris provides a Windows application called Vantage Remote Access Software (VRAS). VRAS provides a simple method for data retrieval and remote configuration. It can display low-resolution video of the target area and allows the operator to reconfigure zones and other video detection parameters. VRAS allows the operator to retrieve the collected data from the video processor modules and to store the data in ASCII files for offline processing or insertion into spreadsheets etc.

Additionally, the data can be retrieved by using the customer's Traffic Management System. This method usually involves some integration of the video detection systems' communications protocol into the customer's application. Iteris provides the necessary parameters and command flow to enable the customer's Traffic Management System to extract the information from the Vantage Edge2 processor. All output from the Vantage processor is in a structured ASCII text format.

The Iteris - Vantage Benefits

The Vantage design goal was to produce a product that was easy to install and easy to configure. Typically, video detection cameras are mounted on lighting arms or gantries so the camera's field of view is in line with the lanes being monitored. The video imaging processor is located in the roadside cabinet and is connected to a traffic controller. Video signals may also be transmitted back to the traffic management center for other applications.

Easy to Install

All Vantage equipment is supplied ready to go with all the accessories needed to install and bring the system into operation quickly with the minimum of fuss. The image processor modules are “Plug and Play” and insert into a variety of detector racks. All Vantage equipment uses standard RJ45 patch cords and RS-232 serial connections to facilitate communications between a variety of equipment thus minimizing the need for your field personnel to carry expensive specialized equipment, materials and tools.

Easy to Configure

Got a mouse? That's all you need to configure the Vantage video detection system. Just plug the mouse into the USB port and activate the unique built-in Vantage menu. From this menu you can quickly create and define up to 24 virtual zones that are comparable the function and operation of inductive loops. Within minutes, you can define an approach consisting of several virtual zones to cover the straight through, left or right turn pocket and advance detection zones. Once configured, just disconnect the mouse and let the system carry on detecting thus minimizing the on-site time of your personnel.

Easy to Use

The Vantage menu system is easy to learn and use in a variety of applications whether it be intersection control, ramp metering or highway monitoring. The same menu is used throughout the range of our products thus minimizing the training and learning time for your installation personnel.

Easy to Maintain

All Iteris manufactured products are solid-state-technology requiring little or no maintenance during normal operation. Periodic maintenance is required to ensure the camera lens is kept reasonably clean. Other than that, expect a lower life cycle cost to you compared with inductive loops thus allowing more available productive time for your field personnel.

For further, please contact:
Melvyn Haxby
International Business Development Manager
Iteris, Inc.
mjh@iteris.com
www.iteris.com