Sentry*Scope*™

Achieving Ultra-high Resolution Video Surveillance through Linescan Camera Technology

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Introduction

Everybody knows the problem. An incident occurs that requires review of stored video. Security personnel bring up images of the incident and zoom into an area of interest. Unfortunately, the image is too blurry to be of use, such as the example in Figure 1.

Figure 1 – Conventional CCTV image of an unidentified bank robber

Today's CCTV solutions for video surveillance provide a resolution of 640 x 480 pixels per frame. In order to confidently identify people in stored video, resolution must approach 40 pixels per foot. Dividing 640 x 480 pixels by 40 pixels per foot yields a maximum field of view of 16 x 12 feet. This means that unless the surveillance camera is pointed in the correct direction, zoomed into an area no larger than 16' x 12', and at the exact time the incident occurred, the stored video will be useless in terms of assisting in the resolution of a crime.

The introduction of digital video recorders (DVRs) has exacerbated this problem. To save storage, DVRs can be set up to reduce the image size to 320 x 240 pixels. This shrinks the usable field of view to as little as 8' wide, if faces and other details are to be recognized.

Mega-pixel IP color cameras are now becoming available. However actual resolution is only 1/3rd of the total pixel count. The 4:3 aspect ratio is not suitable for large areas, with much of the actual image covering unneeded area. Finally network video recorders NVRs) have become available for these cameras. But many challenges remain concerning network bandwidth utilization and storage capacity for the larger image sizes. Strategies to reduce the frame rate and image size to decrease network utilization and storage usage are likely to be employed.

There is a need for much higher resolution capabilities to overcome the limitations of today's CCTV products. This paper will provide an overview of the use of linescan camera technology to achieve ultra-high resolution video surveillance over large areas,

how it is implemented in Sentry*Scope*, and target markets for this breakthrough technology.

Video Surveillance Segmentation

In order to understand where linescan camera technology might fit into the video surveillance market, it is important to segment video surveillance operations. There are three general ways in which video surveillance operations can be implemented:

1) Well-manned – In a well-manned operation, operators are present with full concentration on the video monitors. If pan/tilt/zoom (PTZ) features are being utilized, operators are present to control the cameras. If an incident occurs, personnel can be dispatched immediately to handle the situation. Excellent security is provided, but with a high manpower requirement.
2) Partially-manned – In this operation, security personnel are present but do not have 100% focus on the monitors. For instance, there may be too many cameras to monitor, personnel may be called away to perform patrol duty, live monitoring may only occur during certain hours of the day, and so on. In any case, many incidents will not be noticed by the operators as they occur and are only brought to light at a later time. The recorded video is often of little use, since the camera was not positioned correctly to view the incident.
3) Un-manned – In an un-manned operation video is stored for later review. This is the lowest manpower alternative; however, PTZ technology cannot be used since no one is present to reposition or zoom the cameras. The entire region must be constantly monitored with the available fixed cameras.

Today's CCTV solutions are suited for well-manned operations. Camera resolution is not critical because personnel are present to view the monitors and take immediate action if necessary. However, once security personnel are away from their monitors or people are not available to dispatch, the limitations of today's CCTV products become apparent. Camera resolution is absolutely critical in partially and un-manned operations. Stored video will be reviewed to assist in the investigation and resolution of crime. Faces, small items such as license plates and weapons, and suspicious activity must be able to be identified in the surveillance record.

Achieving Ultra-High Resolution Using Linescan Technology

Linescan camera technology has been in use for many years in non-security applications. Linescan imaging uses a single line of pixels (also called a vertical scan line) to build up images of moving objects. One of the most common uses of linescan cameras is to inspect products proceeding along a production line, such as electronic assemblies and news print. Linescan cameras build up high resolution images of these products allowing very fine analysis of defects. Other common applications include processing bar codes for postal sorting and space photography.

In order to adapt linescan technology to video surveillance the vertical scan line must be swept across the field of view to build up the image. Figure 2 shows one way this can be implemented:

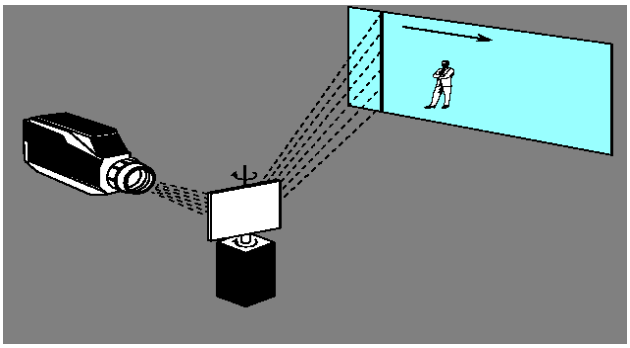

Figure 2 – A rotating mirror moves the vertical scan line across the field of view

The linescan camera views the field of view through a mirror mounted on a shaft/motor assembly. As the mirror rotates, it sweeps the line across the field of view collecting many scan lines to form the image.

Sentry*Scope*, from Spectrum San Diego. Inc., utilizes a 2,048 vertical pixel CCD. Each vertical scan line therefore contains 2,048 pixels. Using a high precision optical assembly, the mirror sweeps the scan line across the field of view collecting up to 10,240 vertical scan lines for a total of nearly 21 million pixels in a single image.

How Much Resolution Do You Need?

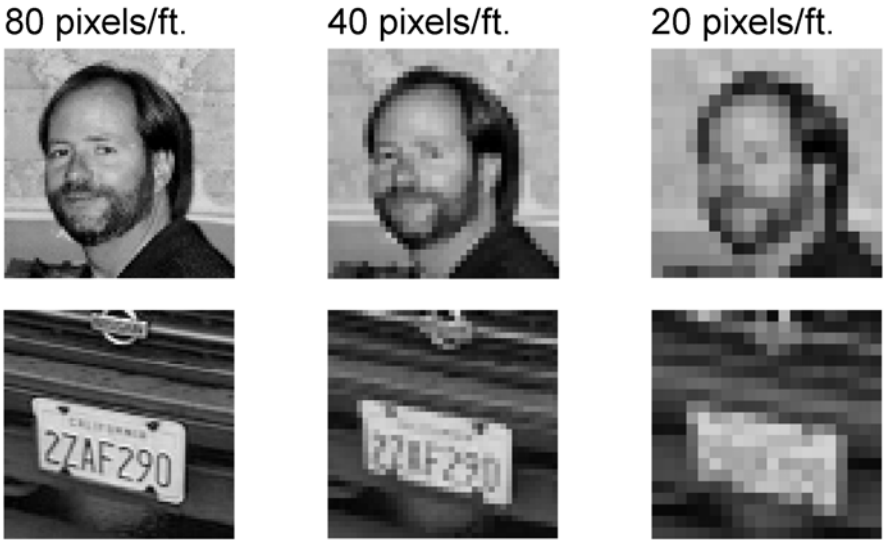

Figure 3 – Surveillance video requires 40-80 pixels/ft to recognize faces and key details

As shown in Figure 3, at 20 pixels per foot, recognizing faces is difficult at best. At, 40 pixels per foot faces become identifiable but smaller detail such as a license plate is difficult to read. At 80 pixels per foot, faces and small detail become identifiable.

As an example, suppose a large parking lot is the application and license plates are required to be identified. Sentry*Scope* captures up to 10,240 pixels in the horizontal direction. Dividing 10,240 pixels by 80 pixels per foot yields a field of view 125 ft wide covered by a single camera. The entire area is covered 100% of the time in ultra-high resolution. This gives security personnel a detailed record of activity that can be viewed immediately or analyzed at a later time.

Trade-offs

Color is often regarded as being critical in well-manned applications. However in partially and un-manned applications, where Sentry*Scope* is designed to operate, resolution is more important. In general, a color camera has 3-4 times lower resolution than a black and white camera with the same number of pixels. In order to achieve the highest resolution possible, Sentry*Scope* operates in black and white.

Today's CCTV cameras produce thirty (30) frames per second, which can be viewed on a monitor to provide "real-time" surveillance. Most extended play analog VCRs and the newer DVRs have the ability to reduce the frame rate to 1-4 frames/second to maximize storage. Because of the extremely high number of pixels captured in a linescan implementation, a typical rate of one image per second is achieved by Sentry*Scope*.

However there is a need for further identifying details, such as color of clothes or car, and additional information on the actual event that Sentry*Scope* may miss because of the frame rate. Spectrum San Diego has developed a color overlay feature called Sentry*Chroma* to provide security personnel this critical information. Sentry*Chroma* is a separate 3 mega-pixel color camera operating at up to 12 frames per second. Tools are provided to ensure Sentry*Chroma* is looking at the exact field of view as Sentry*Scope*. Both video streams are run into the recorder and the integrated into the user interface such that security personnel can easily switch back and forth. In this manner security personnel get the best of both worlds, the incredible zoom capabilities of Sentry*Scope* and color and faster frame rate information from Sentry*Chroma*.

There are four key performance elements in the Sentry*Scope* architecture that limit the frame rate:

1) Processing power and I/O rate of the image processing engine in the camera
2) Motor/mirror assembly used to sweep the scan line across the field of view
3) Data interface from the camera to the recording device
4) Processing power and I/O rate of the recording device

The image processing engine in Sentry*Scope* is based on the Analog Devices BlackFin digital signal processing (DSP) chip. The scanning assembly, custom designed by

Spectrum San Diego, uses advanced digital control to provide the extremely high accuracy and precision required by the application. A Fast Ethernet link between the camera and PC provides a data transfer capability of 100 million bits per second, just sufficient to transmit the compressed ultra-high resolution data stream. Finally, the personal computer operates at 2 gigahertz or higher, with a storage capacity of up to 2 Terabytes. These components were carefully selected to provide the highest performance at the targeted price point for the product. As technology evolves and the cost inevitably comes down, the performance of Sentry*Scope* will likely be even greater.

Target Markets

New, higher priced technology usually gets purchased by early adopters. The target application for Sentry*Scope* is a large area that cannot be monitored 100% of the time with existing CCTV cameras and where personnel are not available to take immediate action in case of an incident. At one image per second in black and white, monitoring live images probably will not be the most common use of the product. Partially manned and un-manned operations, where review of stored images is a regular occurrence, are the probable most common uses. High-end niches where unsolved crime and terrorist acts could be catastrophic are likely to be early adopters, including:

Local and federal government facilities and agencies
Airports
Ground transportation terminals
Utilities
Ports and harbors
Entertainment (theme parks, stadiums, arenas)
Local and federal law enforcement facilities
Toll booths (cars coming to a stop)
Busy intersections (cars coming to a stop)
Casinos
Large retail

Possible camera locations include parking lots, perimeter areas, entry and exit points, inside locations for an overall view, or other locations where 100% coverage of the area is required in ultra-high resolution.

However, Sentry*Scope* is also a good fit in what might be considered an application more suited for today's CCTV products. There might be certain critical regions or trouble spots in an area where unsolved crime has occurred or that are vulnerable. Sentry*Scope* would be an appropriate addition to the current CCTV installation giving security personnel the best of both worlds: (1) high frame rate, color coverage with low resolution, plus (2) slower frame rate, ultra-high resolution coverage of the critical area(s).

Desired Results

What can security personnel expect to see with Sentry*Scope*? When reviewing stored images, ultra-high resolution yields zooming capabilities as demonstrated in Figure 4:

Figure 4 – SentryScope provides monitoring of large areas with ultra-high resolution zooms of small regions

Faces can be clearly identified and license plates can be read. Conventional CCTV shows you that *someone* was at the scene. Sentry*Scope* lets you identify the person and prove it in court.

Conclusion

There is no easy way to perform an apples-to-apples equipment cost comparison of Sentry*Scope* and conventional CCTV. There are too many variables to take into account when designing a video surveillance solution. It is safe to say that Sentry*Scope* can take the place of more than one conventional CCTV camera with PTZ capabilities in manned operations. In un-manned and partially manned applications, SentryScope could replace several fixed conventional CCTV cameras.

One possible way to decide whether or not Sentry*Scope* is right for you is to consider the benefits of ultra-high resolution coverage of large areas:

Reduced installation and maintenance expense with fewer cameras

Increased productivity of security personnel through reduction in the number of monitors and image streams to view live and/or review at a later date

Faster analysis and resolution of crime

The deciding factor very well may be that if you have critical areas that must be covered 100% of the time in ultra-high resolution, Sentry*Scope* can give you performance that no conventional CCTV camera can begin to match.