Physical Security for Substations and Power Utilities

Critical Infrastructure Security

PureTech Systems
PROTECTING SUBSTATIONS AND POWER UTILITIES

Power utilities worldwide face the continued challenge of finding affordable and effective security solutions to protect assets and personnel. Facilities must actively monitor and respond to theft, unauthorized intrusions, safety events and potential terrorist activities. The ability to monitor a wide range of events over a vast area in varied weather conditions, while accurately identifying potential threats and reacting, is a complicated scenario. These systems need to help detect, deter and facilitate an informed response to a substation or power facility security event. In the United States, this need is furthered by the physical security mandate CIP-014 issued by the North American Electric Reliability Corporation (NERC), calling for identification of security issues, vulnerability assessments and deployment of appropriate processes and systems to address. CIP-104 specifically calls for implemented security plans which include measures to deter, detect, delay, assess, communicate, coordinate and respond to potential physical threats and vulnerabilities. This white paper looks at how a geospatial video management system is uniquely aligned to can address the needs encountered when protecting a critical facility’s perimeter.

AUTOMATED WIDE AREA SURVEILLANCE SYSTEM – OVERVIEW

The PureActiv solution is a geospatial wide area surveillance command and control system designed to detect anomalous situations by analyzing video inputs from cameras and managing a coordinated response to threatening conditions. PureActiv’s unparalleled geospatial technology is uniquely aligned for protection of critical facilities, especially those which have a large physical area, long perimeter or large number of remote sites. PureActiv’s geospatial analytics and command and control are ideal for these types of security situations.

PureActiv provides many innovative features not found in other “intelligent” video systems. These features are enabled through PureActiv’s use of geospatial technology, advanced video analytics, advanced PTZ camera control, and open system architecture. Some of these features include:

- Geographic map based command & control user interface: PureActiv utilizes map-based GIS technology to provide users with enhanced situational awareness, and to automate PTZ camera steering tasks.
- Wide-area surveillance & perimeter intrusion detection: PureActiv integrates with perimeter intrusion systems to provide automated video corroboration of intrusion events without using camera presets, which reduces cost and increases flexibility.
- Advanced scene analysis turns cameras into object detection & tracking sensors.
- Data corroboration from multiple perimeter sensors for maximum probability of detection: A layered approach to security allows one system to compensate for another’s weaknesses.
- Point-and-click interface controls multiple pan-tilt-zoom cameras simultaneously through interaction with both maps and video images.
- Automated policy-based detection rules & alarm notification ensures that the proper responses are carried out for any given type of alarm.
- Self-diagnostic alarm capability: PureActiv can detect and report several types of faults, such as camera and software malfunctions.
- Features are accessible from thick clients, thin clients and mobile devices.
COMMAND AND CONTROL / NVR
The PureActiv Automated Wide Area Surveillance System provides a command and control solution for digital surveillance of remote sites and large outdoor environments. While the security industry has invested a lot of effort into migrating CCTV systems onto digital platforms to ease the burden of managing the volume of video data, minimal attention has been paid to the ergonomics of operators interacting with digital video systems and PTZ cameras. PureActiv addresses this deficiency by providing a geospatial (map-based) user interface to allow simple sensor interaction and an increased situational awareness. The system utilizes camera control technologies to make operators more efficient by automating PTZ camera steering and animating the resulting camera actions on the map, providing operators with accurate visual feedback about where each camera is looking.

The system includes a full featured NVR and stores video data on network devices. When recording video from a digital source, PureActiv stores the stream at its source bitrate. Advanced video grooming algorithms can delete or relocate video based on user-defined policies, including minimum retention, alarm video retention, and maximum retention. NVR functions include features such as multiple fast forward speeds, reverse, frame advance, 30 second skip forward, 6 second skip back, etc. Multiple cameras can be selected and can be played back in sync when reviewing past events.

Figure – NVR Functionality
PureActiv permits simultaneous recording, analysis, and live viewing of an unlimited number of cameras. The system can support MJPEG, MPEG4 and H.264 formats from CIF to MEGA-CIF at multiple frame and bit rates, and digitally sign all frames to provide authentication for litigation purposes. PureActiv virtualizes all analog and digital video inputs and provides multiple live video streams for each camera, all with dynamically adjustable and independent compression levels and frame rates to suit client network bandwidth, without affecting recording quality or analytical performance. This means each viewer can set their own frame rate and compression settings independent of other views, recording or analysis functions. PureActiv supports most standard analog camera inputs (NTSC and RS-170 signaling standards), and has native support for interfacing to most IP cameras. Inputs from color, monochrome, infrared and thermal imaging technologies are all accepted.

**USER INTERFACE / GUI**

PureActiv’s map-based user interface is based on GIS style maps, providing latitude, longitude and elevation information for all aspects of the user display. Sensors and detection zones appear on the map in the true geographic location allowing users to easily select, view and control them. This geographical representation, including the actual field of view (FOV) of each camera, has been shown to be one of the quickest ways to convey an overall situational understanding to the security operator. The display consists of three main regions, the video pallet, the map area and the alarm window. Each of these regions can be displayed on a single or multiple monitors. Positioning video pallets on separate monitors enables configuration of video walls.

![PureActiv AlertView Workstation Software Application](image-url)
Alarm conditions from various sensors appear in a standalone window, the location of which is definable by the user. An alarm containing video information, will appear automatically and include an image of the alarm, a looping recorded video, the live camera view and a link the any video sensor associated with the alarm (Such as a second camera performing PTZ Auto Follow). Each alarm provides the ability for the operator system actions including providing a detailed description of the alarm.

The alarm capabilities also highlight geospatial attributes. Whereby an indication of each alarm is placed on the map at the geographic location it occurred. Selecting this icon will automatically display the information for that alarm in the alarm window. Similarly, when viewing an event in the alarm window, the user can select the alarm to automatically center the map interface at the geographical location of the alarm. This provides a very efficient means for the operator to understand the location of the intrusion and the sensors in the immediate locale that can be used to track and assess.

**ADVANCED CAMERA CONTROL**

PureActiv directly interfaces with the majority of PTZ cameras on the market. This provides the operator a simple point-and-click interface within the camera view. “Rubber-banding”, or the ability to draw a window of interest on the video and have the camera zoom to that defined window is also supported. More importantly, combining this use of PTZ feedback and PureActiv’s geospatial capabilities allows the system to provide real-time positional information to operators on map-based GUI, dramatically enhancing situational awareness for operators. This allows users to see on a map, in real time, which direction a PTZ camera is pointing and its current field of view (FOV), as well as, bearing and range to target.

![Figure - Bearing and Range Indication](image)
The use of geospatial map technology allows the unique ability to steer one or more PTZ cameras to look at a specific geographical coordinate. In practical terms, this allows a user to simultaneously steer multiple cameras to view a location by simply clicking on any location on a map, instead of using a joystick. PureActiv further enhances operator effectiveness by allowing them to interact with each video image itself to select objects of interest for detailed inspection. Clicking on an object in a video image will center the camera on that object. Dragging a box around an object will cause the camera both center on the object and zoom into the selected region. These operations are much easier for operators to accomplish than using a traditional joystick control to maneuver PTZ cameras. These control idioms also eliminate common “overshooting” problems encountered when using joystick controls, especially where network latency causes lag between the viewing of a video image and the control signal sent to the camera.

The geospatial characteristics of PureActiv completely eliminates the need for camera-based presets and the use of contact-relay closures from intrusion sensors to steer PTZ cameras to a finite number of different locations. This has several advantages. First, because all camera control is virtualized, all “presets” become software based instead of hardware based, reducing the amount of wiring needed to accomplish automated camera control, and allowing field replacement of cameras without losing their preset programming.

Secondly, and perhaps more importantly, these systems can automatically drive PTZ cameras to look at arbitrary geographic locations based on the location of events. This has tremendous cost-saving implications when monitoring large perimeters. The system can then steer one or more cameras automatically to that location to provide automatic video verification of perimeter alarm events without using any hardware or software presets. This can save thousands of man and equipment hours for installation, configuration, and testing on large perimeters.

INTELLIGENT VIDEO
PureActiv has a number of leading and innovative technologies for video analytics that permit reliable alarming based on object detection and tracking, all designed to eliminate or reduce the false and nuisance alarms traditionally associated with “intelligent” video systems. A common source of false alarms when performing motion and object detection is the motion of the camera itself, either under the control of an operator, or due to wind, weather or vibrations. Pole mounted cameras are particularly prone to low frequency, high amplitude oscillations in even moderate winds or vibration effects, and this can wreak havoc with “intelligent” video systems. To overcome this problem, the usual solution has been to use expensive hardware video stabilizers, or to reinforce the camera mounting, which is also an expensive proposition.

Figure – Video Detection
STABILIZATION
PureActiv solves this problem by stabilizing video images in software. This allows PureActiv geospatial video analytics software to function even in the presence of significant camera motion or vibration. And of course, since the system controls PTZ cameras directly, it knows when an operator is moving the camera, and can turn off video analytics accordingly. When the operator is finished moving the camera, or has left it in an idle position for a certain period of time, the system will return the camera to its unattended monitoring position and resume video analytics. This feature is especially critical in border applications where detection ranges are very long and camera FOVs are very narrow.

BACKGROUND MODELING
Cameras provide a wealth of information. The problem is there is typically too much information for the operator to process and understand in a timely and efficient manner. This is one of the key issues video analytics helps to solve. One of the fundamental features to achieve this is a multi-modal background model. This allows the software to understand what part of the scene is background and what is passing through the scene (intruders, etc). This algorithm addresses normal movement within the scene, such as moving vegetation, changes in lighting conditions, shadows, weather events (rain, snow, fog, moving clouds) as well as atmospheric noise, which occurs often with long range camera views. This is often the most difficult part of the solution...ignoring motion that is not of interest.

OBJECT CLASSIFICATION
Once the background is understood, the resulting objects are further analyzed to provide the operator with those that are of interest, avoiding nuisance objects. PureActiv achieves this by "classifying" objects. This feature takes an object in the video and identifies it as a specific class of object. Object classes may include cars, people, trucks, animals, etc. Objects are classified based on distinguishable features such as aspect ratio, real size, and other key features. The feature of real size is particularly useful and only available on systems, such as PureActiv, that understand a targets geographic location and range from the detecting camera. This classification can then be used as an additional parameter to set up alarms (Alarm on any "car" entering a geographic region). Additionally, the object may be displayed on the map using an icon to represent its class, allowing for better situational awareness. PureActiv comes with a database of standard classes. However, it also has a “learning” mode where it can increase the accuracy of classifying objects or add a new class of objects.
**GEO-REFERENCING**

Geo-referencing refers to understanding how the video and terrain space relate. A system that is geospatially aware relates the image and terrain spaces. The use of an object’s geospatial information is crucial to further define an object and its behavior. Knowing where the object intersects the ground plane not only provides the exact latitude/longitude/elevation, but also the object’s true size and speed, regardless of its direction of movement relative to the camera. This is a key differentiator that allows PureActiv to maintain a high detection rate and low false alarm rate at long distances, which is typical for most border and perimeter applications. This also becomes a key attribute when integrating with third party sensors such as radars, GPS systems and intelligent fences, as discussed later.

**Figure** – Map Based, Object Classification
OBJECT TRACKING
Knowing the objects of interest, their geospatial location and classification, PureActiv now takes this information and track the objects. Objects of interest are highlighted with a bounding box, with the option to show their past track directly on the live video image. The object, represented as an icon representing its class (person, car, truck, boat), is also displayed on the geospatial user interface, showing the object at its current latitude, longitude, and elevation, along with a track of its current path. Through the use of PureActiv’s advanced camera control capabilities and user interface, an operator can then click on the icon on the map to steer one or more PTZ cameras to the object’s location automatically.

BEHAVIORS
PureActiv’s ability to classify objects in relationship to environmentally changing backgrounds and then track those objects within the video space provides the basis to perform behavioral analytics. Behavioral Analytics is the ability to identify typical security behaviors or situations. This includes behaviors such as detecting a stopped vehicle, detecting when a crowd is forming or dispersing, loitering, identifying left-behind objects or an item being removed. The ability to allow the system to automatically monitor for behavioral events, further reduces the workload of the operator and allows them to manage more sensors in a more efficient manner. This workforce multiplier effect could allow a security person to effectively manage a set of sensors for a longer period of time, or allow them to monitor a greater number of sensors at one time.
ALARM CAPABILITIES

Once video analytics has classified (Human, Car, Truck, Small boat, etc) and tracked an object, alarm conditions can be established based on specific attributes including: its classification, areas of interest, target speed, target direction, times of interest, length of time target remains in the scene, specific behaviors and other attributes. This is a tremendous aid to the operator and helps to filter out a huge number of targets that are not important to the operator. Below is an illustration of a person detected alarm generated by the PureActiv system. The alarm itself includes indication on both the camera view and the map view, along with specific information about the detection: time, location, camera, classification (object type), etc. These features are available on all types of video sources, including infrared and thermal cameras. PureActiv’s video analytics also provide diagnostic capabilities, such as detecting possible camera tampering due to lens blockage or gross physical movement.
PureActiv automatically assigns metadata to all video it manages. This allows for detailed analysis of the video and associated parameters. Metadata also provides a basis for rapid forensic searches on large amounts of video data. Metadata is assigned to each frame of video and includes information such as time, date,
latitude/longitude, camera information, object tracks and object attributes. The software is designed to easily accommodate new metadata as it becomes available. Digital signing is also part of the metadata functionality, whereby each frame is digitally signed and authenticated during playback. Likewise, exported video is authenticated as an entire collection of frames, further securing the integrity of the video. Metadata can be reviewed through the use of the PureActiv video player. Metadata is available for viewing on a frame by frame basis.

PTZ AUTO FOLLOWING

PureActiv also has the ability to perform autonomous PTZ following or PTZ Auto Follow. This feature continuously steers a Pan-Tilt-Zoom camera to maintain a view of an intruder. The advanced tracking is not impacted by posture changes, occlusion of the target by trees or poles, changes in target speed, direction or even sudden stops. Although this feature can receive a cue by many third party devices, this tracking is not to be confused with other types of camera following which is restricted to tracking within the view of a secondary fixed camera. PureTech’s algorithm allows for automated control of pan, tilt and zoom, keeping the target centered in the field of view throughout the entire coverage area of the PTZ camera. This feature essentially allows for “hands-free” camera tracking when an intrusion or event occurs.

PTZ Auto Follow augments many other technologies and sensors. Any sensor that can detect an intrusion and provide location information can be used as a cue for PureActiv to slew the camera to the location of the
 intrusion, find the intruder, then engage PTZ Auto Follow. Typical border and perimeter sensors that fall into this category include radar, intelligent fences, access control points, proximity sensors, GPS systems and fixed cameras enabled with video analytics. Additionally, the operator may choose to control the camera manually and upon finding a subject of interest, they may manually engage PTZ Auto Follow. The combination of detection, identification and subsequent tracking is very powerful and is available on both IP and analog type PTZ cameras.

In some cases, when a PTZ camera is slewed to a point of intrusion, it may determine that the intruder is not in the camera view. This can also occur if the camera has a very narrow field of view, if the intruder is moving very quickly or due to margin of errors in detecting and positioning sensors. In these situations, PureActiv can invoke its “Scan to Target” feature, whereby the camera is commanded to scan the surrounding area in attempt to locate the intruder. Detection algorithms are invoked during the camera movement, and if the intruder is found, the system will automatically engage PTZ Auto Follow and begin following.

**Figure** – Detection, Classification with Geo-Location, Camera Auto Follow

**REMOTE ACCESS TO VIDEO AND ALARMS**

In addition to a PC-based client, PureActiv provides several other ways to interact with the system. One of the popular methods is the ability to email alarm information. This includes an image of the alarm and may be sent to mobile devices (BlackBerries, iPhones, Androids), as well as, PC based email clients. Email notification can be set up to specific people, distribution list and alarms themselves. For example, only alarms occurring on a specific set of cameras can be sent to a specific security person.
The system also includes a first responder capability on the Android platform, whereby a first responder or security personnel can take a photo with his android device and submit it to the PureActiv system as an alarm or informational notification. The resulting image will appear as a regular alarm in PureActiv and on the map-based display, visible to all operators, and will include the image, the exact location of the photo and any description to user supplies. At that point, any operator may click on the map based alarm icon and instantly swing a camera to the scene to further investigate.

Finally, PureActiv also provides for a web based client, where users can access the live cameras and alarm information, without the need for client software. This option does not include the map-based aspects of the PC-client, but is very useful in sharing video and alarm information with 3rd parties, such as local police and authorities.

**FORENSIC SEARCH**

Digital storage of video provides for seamless searching of video through forensic analysis or date-time queries for each camera, whether the video is stored locally or centrally. PureActiv’s advanced searches allow a user to add forensic analysis capabilities to the query, such as looking for motion or objects in certain parts of the camera’s field of view, or looking for objects that meet certain size, speed, or directional criteria. An example may be searching for movement within a specific keep out zone. Search results are returned as thumbnail images which can then be exported as video clips in AVI file format. This search feature saves operators’ valuable time over the traditional method of fast forwarding through recorded video.
Figure - Forensic Video Search

Figure – Alarm Management / Search
ACCESS CONTROL INTEGRATION

PureActiv interfaces with third party access control systems to provide alarm inputs, automatic video call-up, camera control, GIS command and control displays, and forensic video review. Integration features include association of access control alarms with live and recorded video, PTZ camera control, and alarm locations displayed on the GIS map.

PERIMETER INTRUSION SENSORS

Because of advanced camera steering capabilities and geospatial technology, PureActiv is also an ideal platform for providing visual verification and secondary detection using video analytics of perimeter intrusion events. Use of a fence detection system, such as Southwest Microwave’s Intrepid, and ground surveillance radars can provide positional perimeter intrusion accuracy within a few meters. These integrations provide the capability to map the location of an alarm on the perimeter to an actual latitude, longitude, and elevation, and can even take into account non-linear sensor deployments and changes in elevation. The system is easily configured by placing the location of the sensor on a map so that the system can automatically relate the positions of camera to the sensor. Once an alarm is received from a perimeter intrusion device, the system can automatically steer one or more PTZ cameras to the location of the intrusion. At that point, an operator can take control of the camera to manually verify the alarm, or the system can turn on its object tracking capability and raise a second alarm if it detects subsequent movement at the perimeter location.

INTEGRATION WITH OTHER SYSTEMS

PureActiv was designed to easily integrate with industry specific command and control. It provides reusable software components and an XML interface that allow key features to be quickly incorporated into 3rd Party Command and Control systems. Key features such as bi-directional alarm sharing, live and recorded video, target tracks, and camera steering can be seamlessly accessed within the 3rd Party Command and Control application.

Because PureActiv contains both software and hardware methods for receiving alarms from third party systems, it can interact and add value for the following:

- Other alarm systems. PureActiv can automatically steer cameras to provide corroboration of these alarms. Still video images and video clips can be stored or referenced with the alarm.
- Vehicle gate systems,
- Access Control Systems,
- GPS systems,
- Directional audio devices and camera illumination or deterrent sources (white light, laser, IR), and
- Maintenance Support systems. PureActiv supports SNMP protocols.
EDGE DEVICE – MANAGED BANDWIDTH

PureActiv may be deployed as a server-based or edge device-based architecture or a combination. The Scene Analyzer edge device operates with PureTech’s PureActiv Wide-Area Surveillance System and can monitor, detect and report on multiple types of threats. The Scene Analyzer can also act as a stand-alone remote sensor, detecting and reporting threats or seamlessly integrating into your current enterprise surveillance solution. In addition to state-of-the-art video surveillance, the Scene Analyzer also offers many integrated capabilities. External I/O allows for the integration of devices such as fence detection systems, gates, locks, lights and local alarms. These devices can be used as input logic for smart threat detection or can be activated by PureActiv based on the identification of a threat.

When integrated into an enterprise surveillance system, such as the PureActiv Wide-Area Surveillance System, Scene Analyzer lets the system scale video much more affordably. Offloading image processing allows your network video server to receive a higher number of inputs—helping save money. PureActiv Scene Analyzer also removes the need to stream video all the time, and therefore requires less network bandwidth and less storage. Scene Analyzer can be programmed to store information until such time that it is requested, or continuously send information. It may also be programmed to only send text information, jpeg alarm images, video clips of events, or full frame rate video.

NETWORK TOPOLOGY - ARCHITECTURE AND SCALABILITY

PureActiv utilizes a distributed client/server architecture. Video digitizing, analytics, and camera control systems can be placed on the edge of the network near the input terminations for the cameras and intrusion sensors or centralized.

This hierarchical architecture allows for maximum scalability, permitting access to view and control cameras from any location, while reducing the risks of network data congestion. Each server is typically capable of supporting two simultaneous gigabit Ethernet connections. Remote desktop capability is also supported.

The following shows an example system architecture for a typical wide-area surveillance installation. The system is extremely flexible based on the specific coverage required and the additional types of sensor systems desired for integration (access control, fence detection, etc.).
EXAMPLE SITE DETAILS

The following illustration shows how PureActiv might be installed to protect the exterior of a facility requiring a high level of security. This is an example layout; a more detailed analysis is conducted for each site to insure the proper coverage for specific object types, speeds, etc.

Highlights:
- Fixed Cameras utilized as virtual fence to protect surrounding perimeter from approaching humans
- Fence intrusion system to detect persons crawling over or cutting fence
- PTZ cameras integrated with fence detection system. Allows for visual verification of fence alarm.
- General surveillance PTZs to track threats or monitor different regions based on time of day, alarm conditions and threat level.

Figure – Example System Architectures – Server Based

Figure - Example System Architectures – Scene Analyzer Based (Edge Device)
Figure – Example Site Layout
NEXT STEPS FROM PURETECH SYSTEMS

Case Study – Substation Physical Security: There are many solutions to help power utilities address physical security concerns identified as part of NERC CIP-014.

Substation Security Automation: The challenge power utilities worldwide are facing is finding an affordable solution, which can help detect, deter and facilitate an informed response to a substation security event. This article describes how tech

8 Things to Consider When Designing a Camera Perimeter: There are many guidelines that have been released that provide information as to the type of security measures that should be considered when protecting these facilities. However, the details involved with making these measures a reality are often missing. This paper presents 8 things to consider when designing a camera-based security system, or when reviewing your existing one.

Tailgating Vulnerability at Substations: One vulnerability of substation access control is the fact that it can control opening a gate when an access card is presented, but it cannot control how many people or vehicles actually enter behind the authorized card holder. This article addresses this CIP vulnerability referred to as “tailgating” or “piggybacking.”

About PureTech Systems
PureTech Systems Inc. is a manufacturer of wide-area perimeter surveillance software solutions including internally developed outdoor video analytics, PTZ Auto Follow, multi-sensor integration and a map-based (real object size) command and control. It is offered to fortune 1000 firms, military, petro-chemical, water and electric utilities, seaports, airports and federal, state and local governments. With headquarters in Phoenix Arizona, PureTech Systems serves national and international markets. To find out more about PureTech Systems Inc. visit our website at www.puretechsystems.com, follow us on Twitter @PureTechSystems or sign up for our email list.