Caught on Camera: Using Video Analytics to Improve Safety, Security and Operations at Ports
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As 2014 draws to a close, port operators will remember this to be another difficult year. Shipping volumes have yet to fully recover from declines seen during the global financial crisis and many economies remain volatile, driving ports to simultaneously seek efficiencies and increase operational safety and security standards.

While shipping demand is expected to finally pick up in the coming years, the current supply of ships exceeds the demand for moving cargo. Research provider Alphaliner forecasts supply will outpace demand by 3 percentage points over the course of 2014 (based on a 7.6 percent growth in supply and 4.6 percent growth in demand).

Combined with other trends such as increased automation and the shift to dynamic supply chains, this is creating pressure for port operators to evolve their business models while their clients—shipping lines—cut costs to protect their margins.

High performance ports have consistently used technology to improve their operations, enhancing efficiency and lowering manpower requirements, from their rapid adoption of containerization and cargo handling equipment to leveraging information technology to manage vessels and port operations.

An example of innovative technology that can benefit high performance ports is computer vision. Video Analytics have now reached a level of sophistication and maturity, creating an opportunity for ports to meet their highly specific needs, enhancing efficiency and profitability while improving safety and security.

By leveraging the data-driven and predictive approach behind Video Analytics, resource use can be optimized and port efficiency enhanced through a myriad of innovative applications.

Monitoring activity levels throughout the port can reveal bottlenecks and under-utilized areas, which can then be reconfigured to make best use of the available space. Understanding how assets move within the port can deliver insights into their travel patterns leading to route optimization.

Applying the technology to automatically detect and record container identification numbers and stack positions, can increase yard integrity, yielding higher efficiency, while improving safety by reducing man–machine interaction. Such improvements in operations will reduce costs and improve profit margins.

Latent security threats

When it comes to security, ports face reputational risks and the risk of asset destruction. Operating in highly competitive markets, reputational issues have a debilitating commercial impact. Major security risks include smuggling, theft, breaches in cargo control and terrorist attacks.

90% of the world’s trade is carried by sea. A crucial element of global supply chains, shipping remains the most efficient and cost-effective means of international goods transportation. Terrorist strikes on critical infrastructure such as large port facilities can disrupt trade flows, cripple a nation’s economy, cause significant casualties, create potential long-term environmental damage and roil global financial markets.

Accenture believes pervasive monitoring layered with intelligent automated analysis can protect critical infrastructures and deliver a more secure and safer port environment.
Keeping Workers and Assets Safe

With large vessels, bulky cargo, heavy machinery and 24/7 activities, ports can be dangerous and complex environments. In the United Kingdom alone, 212 people were injured at ports in 2012–13 in a range of ways including lifting and handling; slipping, tripping or falling; or being struck by objects. In the longer term, to build a sustainable and attractive business not only for its clients but other key stakeholders such as employees, authorities and shareholders, operators have to demonstrate zero tolerance for personnel incidents and fatalities, tackle health, safety, security and environment (HSSE) challenges facing their businesses and protect their infrastructure and assets.

Any loss of performance in these critical areas can see workers harmed or killed, environmental damage, higher insurance costs and fines from authorities. Such ports not only face losing contracts but also permanently damaging their hard-won reputations as safe, clean and efficient partners to the shipping industry and governments.

A recent Cardiff University study on HSSE in container terminals found that managers recognize the potential dangers posed by machinery and moving vehicles, working on unfamiliar ships and worker’s shift patterns. In response, operators have made efforts to improve, such as ensuring workers receive comprehensive training in health and safety.

However, the study found managers have scope to do more, and significant improvement are required to bring container terminals up to the standards of best practices found in other sectors. This was the case particularly for health reporting, managing outsourcing arrangements and protecting workers in less-developed countries.

At Accenture, we understand it is difficult, yet essential to eliminate safety-related incidents and fatalities and increase security, while improving productivity and managing costs at ports.

One of the main ways ports have sought to achieve HSSE objectives has been to invest in extensive video surveillance systems. However, despite the hundreds of CCTV cameras and other equipment in use, these systems are not always delivering the required results because an estimated 98 percent of video footage is never seen by anyone given the high degree of human monitoring and intervention required. The overwhelming volume of data generated requires smart video analytics solutions in order to deliver insights.
To better harness the power of technology to improve outcomes, Accenture recommends port operators deploy newly available Video Analytics solutions. Video Analytics enables organizations to use computers and big data technologies to analyze, in real time, previously unseen footage from hundreds of video cameras to better understand trends and past problems. An even more valuable application is to use the technology to spot efficiency, safety and security issues in real time as they unfold, allowing rapid and timely interventions.

This new technology automates observation of video surveillance cameras, opening up a rich and growing range of functionalities for port operators, from basic intrusion detection and perimeter security capabilities to more sophisticated counting, tracking, and anomaly detection, as well as complex behavioral analysis (see Figure 1).

Figure 1: The art of the possible: a sample of the rich catalogue of Video Analytics functionality
Current deployments in port environments

A growing number of port operators worldwide are already making use of Video Analytics, including Associated British Ports Southampton, Abu Dhabi Ports Corporation, Poland’s Naftoport, Piraeus in Greece, the Port of Singapore Authority, Singapore’s Jurong Port and the Port of Miami and Port Fourchon in the United States.

These pioneers are streamlining operations, enhancing security and improving health and safety by using Video Analytics to:

• raise safety alerts, such as when a person is in a prohibited zone,
• recognize license plates on vehicles,
• identify known offenders using facial recognition,
• detect suspicious or anomalous behaviors,
• overlay information on smart phone camera images (augmented reality),
• analyze past events, including combining footage from multiple cameras,
• counting crowd numbers,
• identify unknown objects and
• monitor traffic flows.

Creating integrated control centers

At the heart of these implementations are integrated control rooms made intelligent by video analytics. These sophisticated environments consolidate and analyze information from a wide range of sources inside and outside the port, giving decision makers actionable insights in a timely fashion (see Figure 2).

By automating manual safety and security processes, usually requiring employees to tediously monitor screens for hours or perform laborious foot patrols over the port’s extensive areas, these centers allow port operators to reduce such labor-intensive operations, allowing workers to be redeployed to higher value activities.

Port of Miami has introduced a sophisticated video management system which incorporates Video Analytics. It has converted its analog CCTV system to a versatile digital video system that can automatically change frame-rate, resolution and image quality according to scheduled or detected events.10

The Port of Singapore Authority is using video management systems and intelligent video analytics to better understand what is happening at its ports to give it a rapid response capability as issues emerge. Its solution supports the port’s existing infrastructure with a 1,100 camera network operating continuously.11

Figure 2: Towards an intelligent and integrated control center

From Video Surveillance
Operator monitoring 20+ screens, showing feeds from 100+ cameras, 98% of video feeds go unseen, 95% of incidents missed after 20 minutes

To Operations Centre
Safety, Security, Operations, Marketing insights
Video analytics help to highlight exceptional events for attention and action.
Business Benefits in the Port Environment

Video Analytics allows port operators to fully reap the benefits of their substantial investments in video and related systems such as sensors, helping them achieve key business goals such as streamlining operations and reducing security and safety incidents.

More efficient operations
To ensure all resources are deployed effectively, port owners need to continually evaluate the productivity and overall functioning of their operations. Operators need to know personnel and machinery are efficiently completing day-to-day tasks. They must keep a close eye on valuable cargo to guard against theft.

To ensure areas are not overcrowded and inefficient, they need to monitor queues and ensure lengths and wait times remain within acceptable ranges. For instance, staff may be avoiding queues by dangerously cutting across crane gantry paths, or walking between shipping containers.

These are messy issues requiring integrated solutions. Video Analytics provides a data-driven and predictive approach, which optimizes resource use and port efficiency. By automatically identifying ‘hot’ and ‘cold’ zones at their facilities, ports can make the best use of available space. By tracking mobile assets and vehicles such as forklifts to identify travel patterns, optimal routes can be plotted and implemented.

In addition, operators can leverage the ability of Video Analytics systems to recognize objects and faces, as well as behaviors such as idle time, unusual movements and unauthorized activities. Using Video Analytics to automatically detect and record vehicle plate numbers can enhance security while applying the technology to detect and record container identification number and its position within stacks will facilitate retrieval and increase yard integrity and efficiency.
Figure 3 – Video Analytics can play a key role in delivering safety, security and operations benefits.

### Nature of port operations
- High manpower requirements
- Stringent Health, Safety & Environment requirements
- High volume of human, vehicular, vessel and machine movements and interactions
- Wide mix of manual and automated activities happening concurrently
- Large sprawling sites with variety of facilities / yards

### Possible Applications of Video Analytics

#### Intrusion / Boundary breach detection
- Restricted area
- Forbidden area
- Perimeter, entry points access control
- Vandalism

#### Person / Object
- Theft alert (store / warehouse)
- Fallen person detection
- Abandoned object
- Loitering
- Strange trajectory pattern alerts, e.g. counter-direction movement

#### Anomaly detection
- Smoke alert
- Fire alert

#### Area
- Path analysis within an area (i.e. to support theft detection)
- Absolute population count (overcrowded area)
- Area entrance and exit counts (i.e. from / to warehouse)
- Spatially ‘aware’ cameras

#### Density / Flow
- Area Entrance and exit counts
- Flow control
- Absolute population count
- Group population count
- Traffic density

#### Trip Tracking
- Flow distribution map
- Presence distribution map
- Group-level path analysis

#### Queue Management
- Queue length
- Wait times
- Congestion Level
- Queue overflow detection

#### Demographics
- Gender: Male / female
- Age Group: Children / adults / senior
- Ethnicity
- Mood
Fewer safety incidents
Port operators uphold stringent safety standards, such as:

- enforcing no-go zones such as the 40-feet rule around an operating crane, where trucks are prevented from picking up containers while cranes are moving,
- automated recording of container numbers remove the need for workers to be in proximity with moving machinery to manually record container numbers, thus providing for a safer work environment
- keeping a close eye on how containers and pallets are stacked and stored, to reduce the risk of loads falling on personnel,
- ensuring all personnel don appropriate high-visibility jackets and helmets and
- detecting hazardous vehicular behavior such as unauthorized vehicle entry into safety zones, illegal parking, speeding or incorrect use of roads within the ports.

By ensuring more video surveillance footage is "seen", and intelligently analysing it in real-time, Video Analytics can continually and automatically enforce safety rules by triggering alerts if staff members breach safety no-go zones or if safe distance rules are broken.

Figure 4 summarises how Video Analytics can transform port facilities from a reactive to a highly proactive environment, where safety-related issues can be pre-empted through the use of sophisticated technology.

Figure 4: How Video Analytics can improve safety, security and operations at ports

<table>
<thead>
<tr>
<th>SAFETY</th>
<th>SECURITY</th>
<th>OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Example – Yard floor**
- Restricted / forbidden zones
- Anomaly detection – Smoke & fire
- Overcrowding on working platform
- Fallen person / object
- Vehicle / machine movement
- Incident / response activation

**From Reactive to Proactive and Responsive Safety Enhancement**
- Pro-active monitoring and hazard alerts
- Enhanced activation of incident responses
- Improved HSE performance

**Example – Facility Perimeter / Access**
- Perimeter monitoring / intrusion alert
- Abandoned object
- Suspicious behavior / Sabotage / Vandalism
- Face / Vehicle plate recognition
- Person of interest tracking
- Incident response activation

**From Video Surveillance to Real-time and Cognitive Monitoring to Support Security Enforcement**
- Improved monitoring and intrusion alerts
- Better command, control and response
- Enhanced security performance

**Example – Worksite**
- Worker shortest route analysis
- Yard floor layout optimization
- Footfall / dwell time / density analysis
- Resource monitoring & optimization
- Evacuation scenario modeling & evaluation
- Post-event analysis

**From Status Quo to Predictive Modeling to Optimize Resource Utilization**
- Enhanced insight-driven decision making
- Better resource and asset allocation
- Higher operational efficiencies
Enhanced security

Security threats are multifaceted, encompassing access control, vehicle movements, wrongly delivered containers to incorrect vessels, restricted area intrusions, unauthorized vessel crew disembarkation, theft and contraband cargo.

The scale of these security-related challenges is significant. Many operators fight a losing battle against these ever-increasing threats with foot patrols by guards and basic surveillance.

Video Analytics changes the game from observation to dynamic pervasive real-time cognitive monitoring. Analytics identify suspicious or anomalous activity through advanced biometric technologies such as facial recognition, and intrusions or perimeter breaches.

For example, vessel crew may not have cleared immigration and therefore should be barred from entering the country. By deploying cameras in key locations, the system can alert operators to the presence of such crews and direct them for clearance.

Further Advances in Video Analytics

New technologies such as IP storage are transforming how CCTV data can be collected, stored and used. Cloud-based video surveillance – “video surveillance as a service” (VSaaS) – is set to take the flexibility of CCTV installations to a new level allowing offsite monitoring. And big data technologies can now make unstructured CCTV data searchable and available for analytic processes.

As CCTV goes digital, with major improvements in optics, resolution and frame rates, the quality of data is rising. Crucially, this data can now be seamlessly integrated into the IT infrastructure, where developments in IP networks, bandwidth, processing and storage mean it can be stored and combined with other enterprise data to enable insights that would previously have been impossible.

With increasingly sophisticated algorithms now available, the accuracy of these insights is improving and have for instance surpassed human-ability at facial recognition. People-counting algorithms have also been maturing at pace, and can now count the number of people coming in or out of defined areas with accuracy exceeding 95 percent.

Analytics systems are not just getting more “intelligent”. They are also becoming more affordable, as the cost of image processors and communications systems continues to fall.
Marrying Video Analytics and IoT (Sensors and Wearables)

Developments around bandwidth availability, data storage, computing ability and power consumption are spawning a whole new ecosystem of Internet of Things (IoT).

- Cellular networks and Wi-Fi provide much higher throughput which enables non-traditional communication mechanisms to be enabled over these networks.
- Other channels like Near Field Communications (NFC), Beacons using Bluetooth Low Energy (BTLE) and RFID (Radio Frequency Identification) are becoming more pervasive across the devices ecosystem.
- Electronic memory has become more reliable. Thanks to Moore’s law, these have become exponentially cheaper over the last 30 years.
- There is now an ability to process data inexpensively and at remote locations powered by cloud technologies.
- Sensors are smaller, cheaper and more accurate.

These trends are enabling the IoT ecosystem to add significant value to businesses to monitor productivity and improve efficiency for equipment and also for the labor force via wearables technology.

Example 1
Increased Productivity via IoT Sensors

IoT and wearables – basically sensor technologies – can help ports identify improvement opportunities within, for instance, quayside cargo handling operations. Sensors on ship-based cranes together with a video stream from existing security cameras can accurately measure the process time for each of the following steps of lowering of the crane, cargo being rigged, cargo being lifted, crane swinging towards the quay, cargo being lowered down, cargo being unnrigged and crane being hoisted up again.

Cumulatively, crane based sensors and video analytics can measure the end to end process cycle time and compare it for different types of cargo types.

Figure 5: Cargo Handling Process Time

<table>
<thead>
<tr>
<th>Step Description</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>207</td>
</tr>
<tr>
<td>Hook/crane is lowered</td>
<td>17</td>
</tr>
<tr>
<td>Cargo is rigged by stevedores</td>
<td>81</td>
</tr>
<tr>
<td>Cargo is lifted out of hatch</td>
<td>40</td>
</tr>
<tr>
<td>Crane swings out towards quay</td>
<td>9</td>
</tr>
<tr>
<td>Cargo is lowered down</td>
<td>31</td>
</tr>
<tr>
<td>Cargo is unnrigged from lifting gear</td>
<td>19</td>
</tr>
<tr>
<td>Crane is hoisted up</td>
<td>19</td>
</tr>
</tbody>
</table>
This data when analysed can help improve port throughput in the following ways:

- Improve berth utilization, by understanding the process bottlenecks throughout across quayside operations.
- Drive stevedore efficiency, by providing insights to stevedore productivity through analysing process cycle time information at the step-level, e.g. rigging cargo.
- Increase Equipment efficiency, by determining asset utilisation and idle time through comparing vessel berth duration and equipment activity.
- Increase Equipment efficiency, by identifying ideal vessel characteristics (e.g. cargo mix, dunnage, stowage plans, crane size and number, lifting gear selection) for optimal cargo discharge.

**Example 2**

**Predictive and Preventative Maintenance using On-board Sensors**

Another application of Video Analytics is preventative maintenance for equipment such as cranes. This can be accomplished through the use of thermal cameras’ infra-red imaging to identify hotspots that might be overstressed.

Unfortunately, stand alone, such analysis may be prone to false alerts. When data from on-equipment sensors is correlated with the findings from the video stream, the outcome is significantly more robust. On-board sensors can count the number of cycles to inform engineers when equipment is due for maintenance.

Sensors can also measure the temperature of the equipment and vibration, and cross-reference these against the threshold to warn of much needed maintenance or identify point-of-failures ahead of time. This results in reduced down time, reduced repair and maintenance costs.
Example 3
Yard and Warehouse Space Optimization with Wearable Sensors

Typically, ports have a near-real time understanding of the utilization of space in the open yard and also in warehouses. Via reports coming in from various stevedore gangs, a central repository keeps track of the percentage of utilization of space and allocates cargo to be discharged and stored appropriately.

Unfortunately, cargo is not stored optimally at these locations and there is roughly a 20% discrepancy between what is reported and what actually exists at the yard and warehouse. For instance, some warehouses are reported as full but are actually only at 80% utilization. Similarly sometimes 30% yard space is reported as available but in actuality is closer to 10%.

These discrepancies currently need to be manually reconciled via a walkthrough of each premise multiple times daily. The correction of this discrepancy through optimizing storage is a much more complex task since the stevedore workforce has moved on to other tasks.

Video analytics together with sensors/wearable devices can resolve this issue in real-time and without additional human supervision. Ports usually have cameras installed in warehouses to prevent theft and enable security and safety. The video feed from these existing devices can additionally be used for the detection of storage and discharge of cargo which can then be used to reconcile reports with reality.

In addition, the stevedore gang can be informed in real-time via wearable sensors that cargo is not being stored optimally in real-time. For instance, if steel coils can be stacked up to three tiers based on the storage factor and the stevedore workforce has only stacked up to two or has over stacked, an alert can be sent in real-time to the sensor so that corrective action can be taken. This optimizes the utilization of space, prevents damage to the cargo and eliminates discrepancies between reports and actuals.

Example 4
Workforce Management & Safety using Wearable Sensors

Ports usually assign gangs of stevedores to specific tasks on a day-by-day basis. Sometimes assignment of the workforce to these tasks is managed hourly. It is important to track the location of the gangs to ensure productivity and safety.

A combination of video analytics and wearable sensors like GPS, communication modules and a touch-screen can effectively track the location of the stevedore gangs to ensure that the task is being executed.

Video analytics and wearable sensors can also work together to ensure that when a worker enters a controlled/hazardous area, a notification to turn around or to take precautionary measures like wearing a hard-hat is provided. This is done seamlessly and automatically.

Facial recognition via CCTV video analytics coupled with the detection of on-body sensors can make access to sensitive areas of the port even more secure. This two-factor security mechanism also enables the automatic log of time in and time out, enabling accountability and crowd management in sensitive locations.
At Accenture, our deep understanding of the ports business has allowed us to design and develop solutions for companies in the industry to maximize business performance and profits.

While video analytics is available today and offers many potential benefits, deploying an effective system in complex environments such as ports require careful planning, a deep understanding of ports’ business environment, and a strong management and knowledge of the wide range of providers involved, to deliver performance and the desired business outcomes from your investment (see Figure 7).

Other industries from public transport, security to retail have successfully leveraged Video Analytics with Accenture’s help. Port operators too can enjoy the improved performance and safety.

Figure 7: Accenture Video Analytics Service Platform
Helping a French Public Safety Agency use Analytics to drive effective police solutions¹⁵

Alarms initiated by Accenture’s Video Analytics platform saw an effective and coordinated response which brought benefits to public safety officers. In 2014, 502 people, an 11.6% increase, were supported by aid stations in various areas and 154, an increase of 28.3%, were sent to hospital by emergency services. Three adults and 13 children who were lost were successfully reunited with their families.

The French police also used the system to manage security contraventions. In a fair, traders who had begun to set up their stalls in restricted zones were easily identified and relocated before any major congestion could occur.

Singapore Government – Safe City Test Bed¹⁶

Through the use of Accenture’s Video Analytics and its user-friendly applications, a test bed was created to help predict crowd behaviour, coordinate resources, respond to incidents and collaborate more effectively across agencies to facilitate public transport.

High crowd activity, crowd size estimation and object detection were successfully executed with a greater than 85% accuracy. Crowd size estimation in Singapore’s busy City Hall metro station made use of five already existing CCTV cameras, while Accenture’s crowd simulation model was used to predict crowd movement through this station during the 2013 Formula 1 Grand Prix in Singapore.
Accenture's capabilities

Accenture is ideally placed to play the important role of systems integrator, with our track record in developing and implementing Video Analytics solutions.

Accenture believes that pervasive monitoring layered with intelligent automated analytics delivers a more secure and safer digital port environment. We bring together leading technology partners to develop customized solutions for your operations, including video analytics service providers, video management system providers, video camera manufacturers and network providers.

For those already equipped with a video surveillance infrastructure, it is a key priority for us to maintain and enhance the value of your existing investments in video, networking and data systems.

Maximising the use of the ports’ existing telecommunication networks and integrating new Internet Protocol (IP) Surveillance technologies extends the benefits of networking capabilities to digital CCTV. The improved search capability, higher quality images which suffer no degradation with time, the ability to record and play simultaneously, and data compression for improved storage, is leveraged by the network to allow remote viewing and control, offsite secure data storage, ease of distribution and an ability to connect to email and other communications systems for automatic alerts.

Accenture will help you build a scalable system to facilitate incremental installations as an important element of future-proofing your investments, to maintain your standard of security and operational efficiency as the port expands.

At Accenture, we understand the ports business and we are a partner that operators can rely on for the long-term.
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Contact us
Peter Goh
peter.goh@accenture.com
Adil Antia
adil.hoshang.antia@accenture.com
Cyrille Bataller
cyrille.bataller@accenture.com
Ani Bhalekar
ani.bhalekar@accenture.com

About Accenture
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Accenture 2014