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Video analytics for engine room oil mist detection

Rick Jeffress, *Fike Corporation, USA* rick.jeffress@fike.com

1. OVERVIEW

Significant progress in computer processing, video imaging cameras, and video analytics commonly used for oil mist, smoke, flame, and reflected flame provide a prolific context for new applications in shipboard safety systems.

Existing video surveillance infrastructure and off-the-shelf IP CCTV cameras are utilized, providing an economical, reliable and proven early detection solution with server-based analytics. Video analytics servers include the latest high-speed computer processors, commonly used Windows operating systems and proprietary video analytics software based on artificial intelligence-derived algorithms.

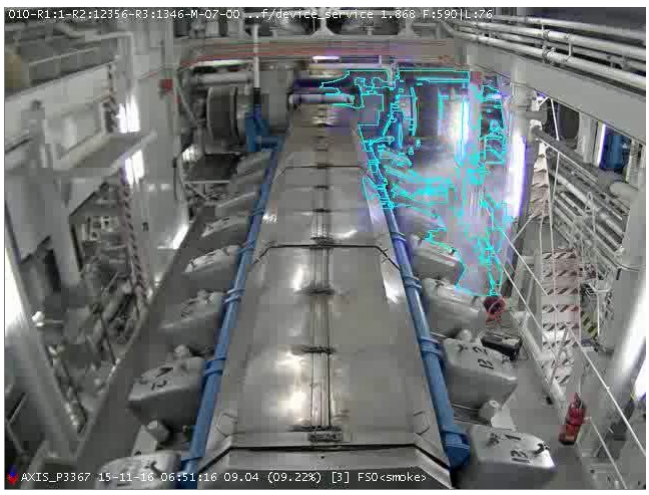
After the Carnival Triumph engine room oil mist fire in 2013, Carnival Corporation collaborated with Fike Corporation to develop a solution to monitor the volume of machinery spaces for atmospheric oil mist with CCTV and video analytics. After over 18 months of shipboard trials and software modifications, a new software product was released including object recognition for false alarm mitigation integrated with the oil mist video analytics, specifically for the shipboard machinery space environment.

Carnival Corp., other cruise and passenger vessels, navies, and cargo ships now include video analytics oil mist detection monitoring machinery space cameras with high power server-based analytics; alarm signals are integrated with the engine automation system and large screen monitors display live video and analytics overlay during a detected event. The crew can easily locate the event area, coordinate the fire-fighting response, or activate and monitor a fire suppression system based on live video information.

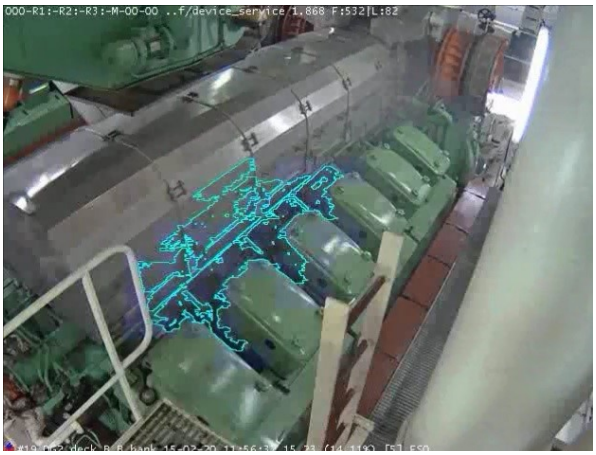
Classification societies see the benefit of this technology as included in the recently published DNVGL-RU-SHIP Pt.6 Ch.5 *Equipment and Design Features* that recommends video analytics as a solution in machinery spaces for “rapid oil mist detection”.

Fike Video Analytics received Safety4Sea and Lloyd’s List North America awards in 2017 for machinery space oil mist detection using video analytics.

Video analytics use for smoke and oil mist detection is restricted to indoor applications as they require stable lighting and a consistent background to evaluate individual pixel light levels for slight changes. Video analytics monitor for smoke and oil mist by tracking the light level of all of the pixels in the camera’s field of view, groups of pixels having a light level change, moving in an organized pattern consistent with learned algorithms will be evaluated and cause system alarm if confirmed.



When an alarm occurs, the software will generate an analytics overlay indicating the outline of the affected pixels on the screen so operators can see the source and movement of the smoke or oil mist.



ONVIF (Open Network Video Interface Forum) profile S is a global, open communication standard for IP (internet protocol) network video cameras and most IP network video cameras on the market are ONVIF S compatible. The Fike video analytics software is ONVIF S compatible, which allows direct plug and play integration of ONVIF S cameras and the Fike software.

Ship engine rooms and machinery spaces are commonly monitored by video cameras with remote viewing in engine control rooms, bridge, staterooms, or other locations. These camera networks will include a network video recorder (NVR) for the recording of video, including software for live monitoring or recorded video viewing. The video analytics servers are similar to network video recorders however include powerful processors to manage the analytics and evaluate the pixel light levels of many cameras simultaneously. The video analytics server software also records video continuously, tracks alarms, and sends live video to viewing software referred to as video management software (VMS). The specific area information and live camera view is available on a per-camera basis at the VMS video monitor.

The server software is commonly connected to, and manages, alarm and fault dry contact relays that change state on an analytics alarm or system fault. System faults include loss of camera communication, dirty or out-of-focus lens, low light level, and other conditions. These relays are commonly monitored by the engine automation system that will alert the crew of a general alarm or fault condition.

In some cases, the alarm and fault signals, as well as live video, have been integrated into ships' damage control systems such as by Martec of Italy and ship-wide CCTV VMS systems such as commonly-used Milestone software that can receive alarm signals and display analytics overlay along with the security camera video.

2. SYSTEM CONFIGURATION

Prior to installing a system onboard a ship, the hazard areas where oil mist release can occur are identified and camera locations evaluated based on the best view of the proposed monitored equipment and away from potential damage or obstruction from pipes or other machinery. The next steps are to determine monitoring station locations and server size based on the quantity of cameras.

The cameras are mounted, Ethernet wire installed, and run through powered network switches, then to the server and monitoring locations, thereby creating a network. In some cases, the cameras, servers, relays, and monitoring stations are connected to an existing ship-wide network.

The alarm/fault relay module is also connected via a network switch and commonly located near the ship engine automation panel, wiring interconnections and programming of the automation equipment and labeling of alarms are then completed. Relays are commonly monitored with a closed-on-power position to assure fault is shown if the relay loses power.

Table 1- Sample Shipboard Video Analytics Oil Mist Detection Specification

High fire risk machinery required by SOLAS to be protected by a local application water mist fire suppression system must also be monitored by the following:

1. Closed-Circuit Television (CCTV) system
2. CCTV smoke oil mist and fire analytic system (FIKE).

Oil leak detection and CCTV coverage including smoke and fire analytics, must include at least the following spaces and equipment:

Space / Equipment	Surveillance Coverage
Diesel Generators and Diesel Propulsion Engines	Cylinder heads and exhaust manifolds Fuel supply and return line modules (general area coverage above the deck plates where flexible hoses/pipes and filters are located)
Oil Fired Boilers	Boiler front/burner
Incinerator Room	Burners and Silos
Purifiers and fuel modules	Purifiers and fuel modules – general coverage
Emergency Diesel Generator and Auxiliary Emergency Diesel Generator (where fitted)	Diesel Engine – general coverage (CCTV only)

CCTV cameras and monitors must produce color images and be of sufficient resolution to ensure easy identification of abnormal conditions such as oil mist/spray, smoke or flames.

Programming of the analytics VMS consists of two steps, adding the server, cameras, and relay then configuring the analytics on a per-camera view basis. The video analytics VMS is similar to other CCTV security software and technicians will see many similarities when adding the equipment. The analytics software is configured by a factory-trained technician, experienced with shipboard equipment monitoring of engines, fuel lines, incinerators, and fuel separation equipment.

Our goal is to configure the software to detect and alarm from oil mist or smoke, while avoiding false alarms from crewmembers working or moving throughout the space. Video analytics software has many setting options to allow for early detection and avoid false alarms.

One option is by targeting specific areas by programming virtual alarm zones within the camera view where, if smoke or oil mist enters the zone, an alarm occurs. The virtual zones can be any shape or size and usually located above hazard equipment. The video analytics is monitoring and tracking all movement within each camera's view, however, the oil mist or smoke signature must enter the alarm zone for the system to alarm.

Operator settings are available, such as "maintenance mode" to avoid false alarms while the crew is working on top of engines or other monitored equipment. The operator enables maintenance mode for a specific camera and period of time in minutes that disables smoke and oil mist detection. A countdown will begin, when the countdown expires the system will disable maintenance mode and resume detection.

Testing of video analytics systems is recommended by a video analytics software company representative or factory-trained technicians on an annual basis, similar to other marine safety systems. Initial testing is commonly accomplished with a fog machine to confirm the system is tracking the mist and alarming in the configured zones along with correct video and ship's automation system annunciation. Space airflow can also be evaluated by the mist movement to assure sufficient alarm zones are in place to catch mist migration. Semi-annual or monthly testing can be accomplished by the ship's crew.

A test tool is available from the video analytics software company including an instructional video and a video of an actual flame that can be held in front of the camera to generate a flame alarm and confirm analytics operation as well as correct signaling functions.

3. OTHER SHIPBOARD VIDEO ANALYTICS APPLICATIONS

The same video analytics used in marine applications for engine room atmospheric oil mist, smoke, flame, and reflected flame detection is currently under evaluation in the LASH FIRE, EU funded project by the Research Institute of Sweden (RISE) for fire and smoke detection in RORO closed vehicle decks.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814975.

Due to the high rate of fires on RORO ships, fire and smoke detection technologies, including video analytics, are being evaluated for effectiveness of early detection of fires on enclosed vehicle decks. The technology may offer a faster response, including live video as actionable information regarding location, size and type of fire, increasing the effectiveness of firefighting operations and safety of crew.

Off the shelf IP video cameras are becoming increasingly common in RORO vehicle decks, monitoring of these cameras in a similar manner to machinery spaces with video analytics can allow use of digital technology for early fire detection and increase actionable, situational awareness.

4. INTEGRATION WITH OTHER TECHNOLOGIES

New electro-optical flame detectors, required by classification societies for monitoring of engines now include high definition video cameras that can also be monitored by video analytics, combining the two technologies for early detection in a single device.The Fike IR3HD multi-spectrum infrared flame detector, also evaluated by the LASH FIRE project for open and weather deck fire detection, includes an IP HD embedded ONVIF S video camera that can be connected to a camera LAN and monitored with video analytics in the same manner as any other ONVIF S IP camera.

Fike IR3HD Flame Detector