Airborne Oil Spill Remote Sensing

Remote sensing of oil spills in conjunction with their prevention and combat has long since evolved into a key element for the protection of the marine environment. The impact of oil spills caused by ship traffic and platform discharges has induced decision makers worldwide to establish airborne pollution surveillance services.<P>

Assuming state-of-the-artsurveillance equipment onboard the aircraft, these services can provide (1) flexible overviews of survey areas with regard to marine pollution and sea traffic, (2) quick assessments of oil spill sites, and (3) deterrence of potential polluters. Airborne pollution surveillance has proven to be an indispensable tool for the detection of oil spills and support of response actions. Modern maritime patrol aircraft are often equipped with surveillance subsystems dedicated to (1) pollution surveillance, and (2) traffic surveillance. This article deals with the latest pollution sensors, advanced data processing, platforms and benefits derived from combining pollution and traffic surveillance data.
The maritime surveillance community can benefit from a number of specialised oil spill remote sensors. These sensors have become well established during the last three decades. Since the mid-1990s, there are new approaches to handling multi-sensor oil spill data, especially in terms of fusion and geospatial information systems (GIS) integration.

Existing Sensor Technology

Airborne oil spill remote sensing is normally divided into two different modes of operation: far-range detection and near-range monitoring. Far-range detection is based on using airborne imaging X-band radar systems, which usually cover swaths of several tens of kilometres. Suspicious structures detected by airborne radar are subsequently investigated on-site using near-range sensors. Near-range monitoring of oil spills includes mapping of relative and absolute oil layer thickness, as well as classification of the type of oil. This mode of operation is typically limited to swaths of several hundreds of metres at flight altitudes in the range of 300–1,000 metres. There are a number of well-established near-range sensors, such as infrared (IR)/ ultraviolet (UV) line scanners, visible line scanners, camera systems, microwave radiometers (MWRs) and laser fluorosensors (LFSs).

Oil Spill Detection

Far-range detection of oil spills is usually performed by side-looking airborne radar (SLAR), which is a cloud-penetrating X-band radar technique of real aperture type. At an aircraft altitude of about 300 metres, SLAR systems usually have a cross-track coverage between 60 and 80 kilometres (see Figure 1). Oil spill detection using airborne radar is generally based on the principle that oil spills, as well as biogenic surface films (even monomolecular films) and hydrodynamic effects, may reduce the radar back-scatter due to dampening of gravity-capillary waves of the sea surface.

Basic Mapping

Basic mapping of local characteristics of oil spills is normally carried out using IR/UV line scanners. These devices are bi-spectral cross-track scanning sensors that are sensitive in the thermal IR (8–14 microns) and the near-UV (320–380 nanometres) ranges. IR/UV line scanners are capable of mapping relative oil thickness within a swath of about 500 metres at a platform altitude of 1,000 feet. In the thermal IR, oil spills can be detected if the oil layer thickness exceeds approximately 10 microns, and in the near-UV the lower limit of detection is approximately equal to 0.01 micron.

Advanced Sensors

LFSs and MWRs are still the only sensors that allow measurements of oil film thickness, and LFSs can remotely classify the oil. LFSs are based on high-power UV lasers that send short laser pulses (5–20 nanoseconds) towards the water surface. The laser-induced fluorescence and back-scatter are received by a telescope and analysed with regard to oil class and film thickness.
MWRs are across-track scanning microwave spectrometers that are capable of detecting and mapping oil layers exceeding a thickness of a few tens of microns. Furthermore, these devices are capable of mapping oil layer thickness in the range from 50 to 3,000 microns.

MEDUSA

The two German maritime surveillance aircraft of Dornier 228-212 type and the three new Spanish maritime surveillance aircraft of EADS-CASA CN-235 type are examples of platforms that have been equipped by OPTIMARE with all the above-mentioned types of sensors. Both types of platforms are equipped with OPTIMARE's network-based MEDUSA system for real-time acquisition and processing of pollution data. Since 2001, there has been further development with respect to new sensors and new data processing capabilities such as automated image segmentation, data fusion, geo-referenced mapping and GIS integration. Basic data processing capabilities include colour-bar adjustment, GIS capability, tagging of geo-objects, distance measurements, bearing measurements, polygon drawing and creation of pollution reports.

OSSAS

The development of the Oil Spill Scene Analysis System (OSSAS) has shown that implementation of specific image segmentation and data fusion algorithms can increase the usability of the multi-sensor system. One feature of OSSAS is the automated extraction of features from IR/UV imagery, such as the area of the oil spill, the centre of its area and specific size parameters (see Figure 5). Another feature is the creation of segment maps that show the principal elements of an oil spill, i.e. the oil-covered area as well as the area of intermediate and large oil thickness. OSSAS is also capable of merging IR, UV and LFS data into a single composite thickness map. OSSAS prevents the system operator from being overwhelmed by the incoming flow of multi-source information.

Data Distribution

Remotely sensed pollution imagery, as well as data products derived by OSSAS, can be easily relayed by satellite communication (SATCOM) or direct data downlink to response vessels or shore-based situation centres. These data products can be further distributed along with satellite and in situ data using specifically dedicated internet-based GIS, which is a modern aspect in marine crisis management. Two examples of projects that deal with the development of such systems are the European Community projects DISMAR and InterRisk.

Surveillance Modes

While airborne maritime pollution surveillance comprises all remote sensing techniques described above, airborne maritime traffic - surveillance includes operation of forward-looking IR (FLIR) devices, automatic identification system (AIS) transponders and maritime surveillance radars. Accordingly, modern maritime patrol aircraft are often equipped with surveillance subsystems dedicated to (1) pollution surveillance, and (2) traffic surveillance.

Integrated Approach

One suitable approach for merging pollution surveillance with traffic surveillance may be the AIS technique as it provides, among other things, geo-location and identity of vessels in the survey area. Geo-locations of vessels are also available through maritime surveillance sensors such as FLIR, using its geo-locating capability, maritime surveillance radar and any pollution sensor. In other words, AIS is considered a suitable basis of the bi-directional coupling between maritime pollution surveillance and maritime traffic surveillance. Continuous storage of pollution and AIS data allows direct linking of remotely sensed vessel signatures to the corresponding identity at any point in time during the mission. Direct identification of polluters is possible if the pollution signature in the sensor image is spatially associated with the ship’s signature. If not, historical AIS data and oil drift models permit the analysis of the spatial relationship between the pollution signature and existing ship trajectories.

Summary

Modern airborne maritime surveillance systems often comprise subsystems that are dedicated to (1) pollution surveillance, and (2) traffic surveillance. Making real-time acquisition and processing of multi-source remote sensing data onboard airborne platforms possible. Newly developed algorithmic frameworks for automated analysis and fusion of multi-source pollution data can increase the value of the pollution surveillance component. The combination of pollution surveillance with maritime traffic surveillance by using AIS offers promising perspectives in maritime surveillance.

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