Sense from sensing sound (Keynote Address)

Brian G. Ferguson

Maritime Operations Division (Sydney), Defence Science and Technology Organisation

ABSTRACT

Smart acoustic surveillance systems are unattended in their operation and are often deployed in remote areas for the automatic detection, localization, classification and tracking of military activities, which are inherently noisy. Acoustic sensors are appealing because they are passive, affordable, robust, and compact. Methods, with examples, for extracting tactical information from acoustic signals emitted by moving sources (air and ground vehicles) are presented. The methods are based on processing either the narrowband or broadband spectral components of the source's acoustic signature. To demonstrate the scientific principles that underpin the operation of such systems, various signal processing algorithms are applied to real acoustic data from both single and multiple sensors. In one example, the acoustical Doppler effect enables the flight parameters and blade-passage frequencies of turboprop and rotary wing aircraft to be estimated from the time-frequency signal analysis of acoustic data. In the case of a transiting ground vehicle, reliable estimates are provided for the speedometer reading, odometer reading, number of cylinders and range at closest point of approach of the vehicle to the sensor. For wideband processing leading to source motion parameter estimation, phase transform prefiltering is required to suppress the ambiguous peaks in cross-correlograms caused by the presence of strong narrowband lines in the source spectra of air and ground vehicles. In another example, the acoustical Lloyd's mirror effect is used to extract the flight parameters of a jet aircraft. Wideband cross-correlation with differential Doppler compensation is required for the acoustic tracking of high-speed broadband sources such as jets when the sensors are widely separated. Also, weapon firings generate acoustic muzzle blast waves and supersonic projectiles generate ballistic shock waves that propagate in air with spherical and conical wavefronts, respectively. When these wavefronts traverse an acoustic sensor array, the sensor output data are processed to locate the point-of-fire, together with the miss distance and calibre of the bullet. The methods developed for land-based acoustic surveillance using microphone data are also applied to hydrophone data for passive acoustic surveillance of the underwater environment.