Improving VTS radar tracking through software development

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The International Association of Lighthouse Authorities (IALA) V-128 Recommendations for Advanced Radars are aimed at improving the clarity of the radar image and track data for Vessel Traffic Service (VTS) operators, to ensure that an accurate, high-resolution representation of the maritime domain and all targets within it, irrespective of size and speed, is available at all times. However, much of today's current radar hardware and software is simply not capable of presenting such a precise and accurate picture due to the noise and clutter returned by the radar signal. This is especially pertinent in today's climate where small, fast moving targets are of much greater importance due to security concerns over possible terrorist threats.

Typical vessel tracking requirements for a port VTS radar may be to detect:

- Vessels in congestion, whose tracks may merge in close proximity
- Vessels that don't follow assigned channels
- Vessels that enter restricted access areas.

A coastal surveillance system must also be capable of detecting:

- Small, high speed targets that could be smugglers or people traffickers
- Boats with unusual moving patterns that could indicate illegal fishing or barter traders
- Boats that move slowly through radar clutter as they may be trying to avoid being seen.

In order to improve detection of such difficult targets and to enable high-resolution real-time vessel tracking for the VTS, Kongsberg Norcontrol IT employs Radar Extractor and Tracker technology within its VTS systems. This is essentially the use of advanced software techniques to extrapolate an even clearer image from the raw radar signal. Radar Extractor and Tracker technology is already in use today but Kongsberg Norcontrol IT has recently developed the system even further in order to enable performance improvements by magnitudes. The result is a new system integrated into Kongsberg Norcontrol IT's C-Scope User Interface that offers nearly four times the sampling resolution available by current generation systems. These improvements enable the difficult targets to be displayed on an operators screen through little investment in hardware – it uses a high end PC and one COTS acquisition card, in addition to a generic radar interface card.

Extracting the right track

It works thus: As the radar rotates and the extractor generates detections, the tracker receives the extracted signals and compares them against an internal track list. Any echoes that are consistent with the behaviour expected from the existing tracks are used to update the tracks, resulting in new positions and velocities. The remaining unassociated echoes are analysed and, if consistent over a number of scans, are used to generate new tracks. This function of association and dynamic filtering is fairly complex because radar echoes can be very variable and can also merge between nearby targets. To determine what returns are consistent with an existing track, and to perform the track itself, the tracker uses a dynamic model that describes the potential behaviour of its tracks.

The Radar Extractor and Tracker's role is to extract and track the radar returns most likely to originate from vessels and other objects of interest. The main function of the extractor is to filter out all signals that represent noise, interference and clutter originating from the sea, rain, fog and reflections, leaving only signals that may be of potential interest. The tracker isolates from these detected signals those that are consistent with its tracking model and outputs a list of tracks. Each track represents a moving or stationary object and comes with a position and velocity in addition to other dynamical data.

The tracker must be able to initiate and correctly update tracks even when they are intermittent due to a low probability of detection, not lose them when they temporarily disappear due to shadowing, not confuse them when they are close to or overlapping with other echoes, and finally properly handle multiplicity when there is coverage overlap between nearby radars.

The radar picture on the right has had the clutter removed by the Extractor & Tracker, revealing a much better definition and cleaner image.

Essentially, the main challenge for the extractor is to detect small objects in the presence of clutter, which is usually expressed as maximising the probability of detection while minimising the false alarm rate. The main challenge for the tracker is to latch onto and not lose existing tracks, and to automatically initiate tracks while minimising false tracks.

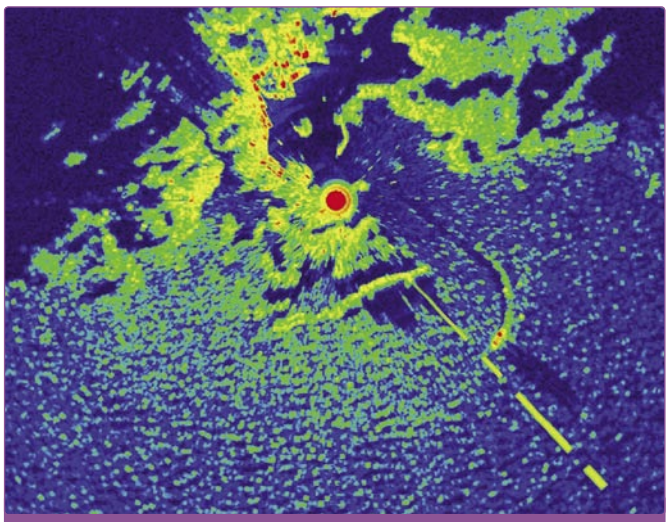
Robust tracking

The C-Scope Extractor and Tracker contains a completely redesigned extractor that significantly improves some of the performance aspects of the existing and competing technology. In particular the sampling resolution and rate have been increased to four channels of 14 bits at 100 MHz, from one single channel of eight bits at 50 MHz. The main benefits of this improved sampling include much higher amplitude resolution that can be carried all the way to the operator for visualization, much more detailed amplitude structure of tracked objects that result in better and more robust tracking and the possibility to do frequency diversity in the extractor instead of requiring an expensive transceiver to do it.

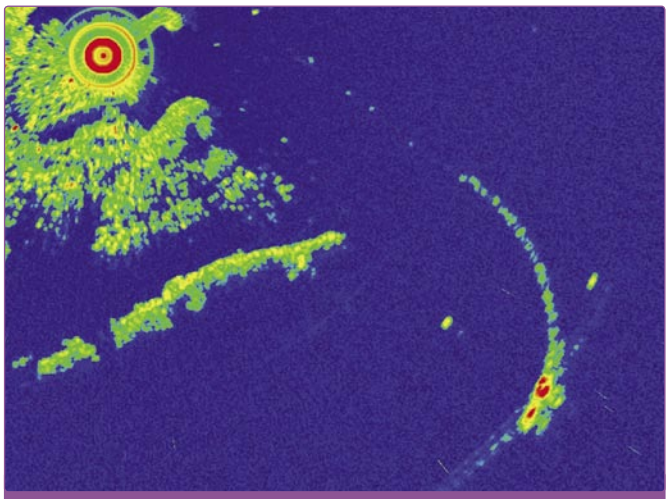
The C-Scope Radar Extractor and Tracker sits at the remote site with the radar antenna and transceiver, and communicates (sending digital video and tracks) with the control centre and the operators via a remote link. The digitised video from the system provides a highly accurate representation of the actual radar video and is processed using advanced algorithms for the standard sequence of steps designed to increase signal-to-noise and more importantly signal to clutter ratio. Two different formats of digital video can be generated for presentation on the VTS Operator Station, namely polygons and fragments, with the resulting radar picture approaching the quality of 'raw video'. The tracking is performed using Kalman filter techniques, which are based on a dynamic mathematical model describing the vessel's movement. This model is used to predict the vessel's behaviour between measurements. Each time a new plot is associated to the target, a position measurement is derived and this measurement is used to correct the state of the dynamic model.

It can provide more control of performance given the specific clutter and noise challenges for the site whilst at the same time improving probability of detection and reduced false alarm rate. It also enhances the vessel tracking robustness of the VTS and reduced track swap and provides better object delineation resulting in additional information for the operators. Essentially, the much improved video presentation can be likened to the jump in quality from analogue terrestrial television to the digital HD era and for ports, authorities and vessels this translates to safer and more secure operation.

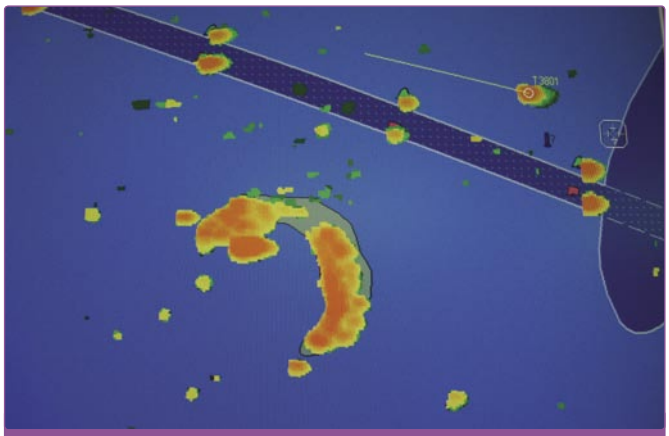
Kongsberg Norcontrol IT's C-Scope Radar Extractor and Tracker is at the MCA's Dover strait traffic separation scheme and at the entrance to the Port of London. The MCA has long been a user of various Kongsberg Norcontrol IT systems and is a forward thinking agency, willing to put technology to use in order to enhance safety and security around Britain's coastline. Having been one of the first Port States to implement a full national AIS network, the MCA is now leading the way in the implementation of this new technology.



It is important to process amplitudes correctly in order to maximise the signal to clutter ratio.



The C-Scope Extractor & Tracker uses improved amplitude resolution to locate properly the centre of mass of the track, which leads to reduced track swap and loss. Here the ferry and the wake are well defined.



High resolution fragments from the C-Scope Extractor & Tracker allow for detailed representations of radar video at the operator consoled while conserving bandwidth from the remote radar site.

ABOUT THE COMPANY

Kongsberg Norcontrol IT is the world's leading VTS, VTMIS, and AIS network solutions provider, with over 170 VTS systems and AIS networks worldwide. Since the delivery of our first VTS system in 1978, Norcontrol VTS systems and AIS networks have been installed in the world's largest and busiest ports, waterways, offshore oil and gas fields, and coastal areas.

ENQUIRIES

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