Skip to content

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- Department
- Air Force
- Army
- Navy
- Minister

DSTO

- Home
- News
- Events
- Research
- Collaboration
- Publications
- Gallery
- Careers
- Contacts

Search this site ... Go

- All
- Air
- Land
- Maritime

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Underwater Acoustic Imaging: Rapid Signal Processing

Scientific & Technical Report

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As part of Australian defence policy to counter sea mines, the need has been recognised for an enhanced capability to identify objects that have been classified as minelike. Because the medium is often too turbid for optical methods to work, DSTO is working with Australian industry to develop a high-resolution underwater acoustic (sonar) imaging system, intended to 'see' detail of size 1 mm at a range of 1 m. The system has successfully passed the concept demonstrator stage.

This report reviews options for the signal processing phase of the innovation plan. The processing for the present design involves, for each of volume pixels (voxels), a summation of 4000 voltages, one from each sensor element, taken from that element's voltage stream at the appropriate time. It therefore appears that at least operations are required; for a combination of reasons, the expected figure becomes nine times that number. Thus a 1 Gflops computer (floating point operations per second) would require 30 hours to produce the image, unacceptably long by far. (Note also that further overheads are required in a practical computer, yielding yet another factor of say 2.)

However it may be possible to greatly reduce the computation time needed. Thus the problem is to determine how to calculate the full three-dimensional image in the shortest time or, if that time is too long to be useful, to develop the best strategy for obtaining an image over a reduced volume embracing the object of interest.

A hierarchical structure of options is developed in an attempt to capture all possibilities. At the top level, three approaches are identified. First, the use of appropriate hardware, such as computers with parallelism, or the use of an optical analogue. Second, a reduction in the number of operations (a 'software' solution). And third, the defining of a suitable reduced goal, which appears to come down to the imaging of a subvolume of the original volume. Each of these three approaches is subdivided into suboptions; these are discussed in detail to bring out difficulties and advantages.

In the third approach, one is likely to aim for a subvolume that is a slice about the front surface of the target, restricted further to an angular sector chosen from prior information as containing the strongest clues to mine identification. This approach can yield a dramatic reduction in computing time, but it is not clear that it reliably yields the subvolume (in terms both of the range and of the direction) that is

needed for mine identification.

Within the third approach, a method that apparently images all the front surface of the target in a usefully short time is described.

Back to the top

Publication Types

- All
- Scientific & Technical Reports
- Journal Articles
- Corporate Publications
- Historical Publications

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- Last modified: 23 August 2005
-
- Privacy policy
- Site map