Towards Inverse Synthetic Aperture Radar (ISAR) for Small Sea Vessels

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What is ISAR?

- Technique that produces cross range dependent doppler frequencies
Applications of ISAR

- Produces a radar image of the target
- Non-cooperative target recognition (NCTR)

Photo of the impala

ISAR movie of an Impala

Photo of large ship

ISAR of large ship

Credit: Telephonics APS-143B (V)3
Block diagram for ISAR processing

\( S_r(t) = e^{-j/4s} \int \int h(x', y') e^{-j/2\pi (px - qy)} \, dx \, dy \)

1. Radar transmit signal
2. Radar receiver

Range alignment

- Compensated Range profiles
- Uncompensated Range profiles

Doppler shift

- Compensated Doppler
- Uncompensated Doppler

Dwell time

- Autofocus techniques

Polar reformatting

FFT processing

Single image over processing interval

JFT processing

Several images over processing interval

JFT can be used to deal effectively with non-uniform rotation that is not compensated by doing perfect range alignment and perfect autofocusing. See paper on Evolutionary Adaptive Wavelet Transforms (EAWT)
Identification of new ideas

- Old classification algorithms do not exploit the persistent surveillance capability of the newly proposed Awarenet radar
  - No context, no ability to improve over time

- Development of new classification algorithms that improve their performance over time
  - Takes into account that target can be observed for a long period of time
  - Same mistake would not occur twice.

- Joint motion compensation and classification algorithms
  - All previous work in the literature looked at these algorithms separately. Can information from the motion compensation stage be used to improve the classification of targets?
Real ISAR Experiments in Arniston 2006

- Fynmeet tracking radar
- Small fishing vessels at sea
- Data captured
  - Radar data
  - GPS data
  - INS/3D motion data – Mti sensor

- Processing tools were developed
- Motion compensation was applied (AUTOCLEAN)
Issues with AUTOCLEAN

- AUTOCLEAN (motion compensation – ISAR)
  - Assumes RCS of scatterers constant throughout processing interval
  - Assumes position of scatterers are fixed throughout processing interval

If not satisfied

Leads to a blurred ISAR image
Effects I don’t yet understand

- Effect of complex 3D motion on ISAR blurring
  - Literature deals with target being confined to 2D space

- Effect of multipath on ISAR blurring/ghosting effects

- Complex scattering
  - Diffraction from the edges of the sea vessel
  - Walking scatterers

- Sea clutter

Cannot isolate why the ISAR image is blurring from processing real data
Building the mathematical system model

- Develop quaternion 3D model
- Extend model: Dual quaternions
- Learn quaternion algebra
- Learn dual quaternions
- Extend model: Dual quaternions
- Multipath modelling
- Incorporate multipath
- Incorporate complex scattering
- Sea clutter models
- Incorporate sea clutter model
- EM backscatter
- Radar Conference 2007
- Start

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Summary and conclusions

- Introduction to the concept of ISAR and applications
- Signal Processing steps needed for ISAR
- Identification of new work
- Recording and analysing radar data
- “Issues I don’t yet understand”: sensitivity analysis is required
- Way forward: building the mathematical system model
Questions?