Range Alignment for ISAR Imaging of Sea Vessels

By Azhar Ebrahim

1. Introduction

This project covers range alignment for inverse synthetic aperture radar (ISAR) imaging of sea vessels. Radar concepts as well radar signal processing concepts were investigated. Subsequently, ISAR concepts were looked at before a focus on range alignment algorithms was placed.

The rationale behind the study was to review the range alignment techniques found in the literature and to assess the strengths and weaknesses of the techniques. Furthermore, the study was done to determine the performance of range alignment algorithms across different datasets.

2. Objectives

The objectives of this report are listed as follows:

·Review range alignment algorithms in the literature.
·Implement range alignment algorithms on the measured data to understand their strengths and weaknesses.
·Compare the range alignment performance for different algorithms on different datasets.

3. Results

Figure 1 : Image of the Zayaan Vessel

An image of the one maritime vessel is shown in Fig 1. The ship is known as the Zayaan Vessel. The commercial fishing boat is 9m in length, and 3m in width and has a mast with height [3.5m 7m]. The dataset consists of 4473 High Range Resolution (HRR) profiles, each with 96 range bins. A Spanish vessel was the other ship used.

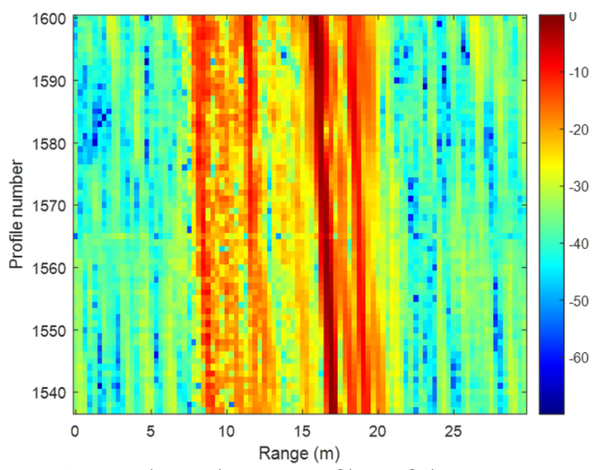

Figure 2 : Unaligned HRR profiles of the Zayaan Vessel

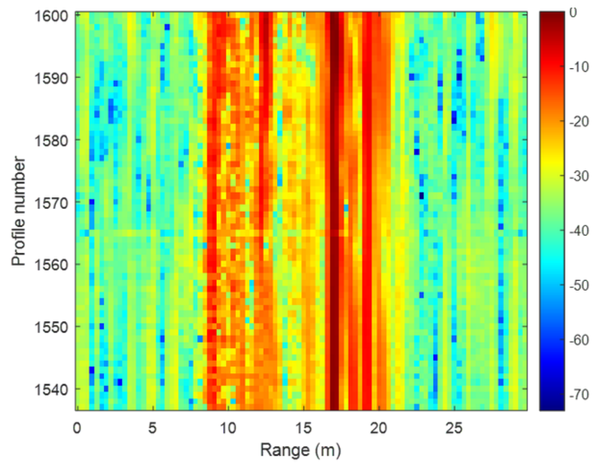

Figure 3 : Aligned HRR profiles of the Zayaan Vessel

The HRR plot for profiles 1536:1599 is shown in Fig 2. The profiles are clearly unaligned due to the linear migration of scatterers through the HRR profiles. In Fig 3 the profiles are aligned using the sub-integer, envelope correlation, single reference profile algorithm.

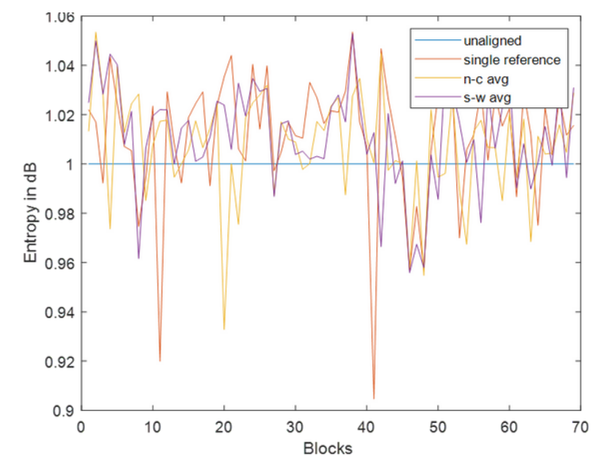

Figure 4 : Aligned HRR profiles of the Zayaan Vessel

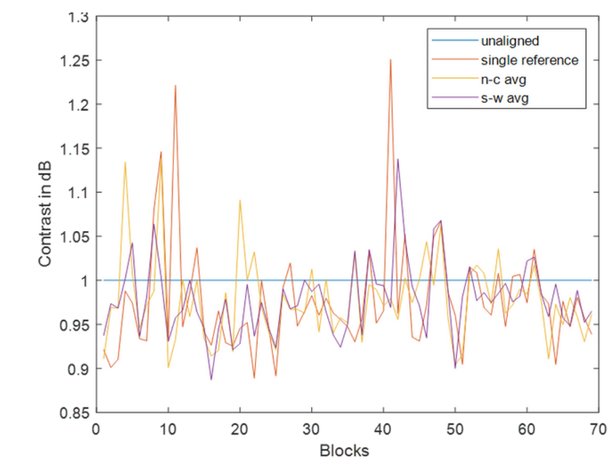

Figure 4 : Aligned HRR profiles of the Zayaan Vessel

In Fig 4 the normalised contrast values are shown for different blocks of data and in Fig 5 the normalised entropy values are shown. These were the measures used to assess performance. The values are shown for the sub-integer shift algorithms.

4. Conclusions

8 algorithms were explored, all related to envelope correlation. This was further split into integer shift techniques and sub-integer shift techniques. A discussion of the strengths and weaknesses of these algorithms was conferred. The quality of these techniques was assessed by qualitative measures as well as quantitative measures such as contrast and entropy. As expected, the different techniques had different performances.

For the most part, the performance of the algorithms was consistent across both datasets, apart from a few minor differences. The single reference profile sub-integer shift algorithm produced the best results for the data blocks analysed, across the two datasets.

The CSIR dataset was rich in information and the variation in performance of different algorithms, across different blocks of data could be accurately concluded. The single reference profile algorithm integer shift was the best among the integer shift algorithms. With the sub-integer shift algorithms, no algorithm was consistently better than the others.

Acknowledgements

Developed with: MATLAB

Github Link to code:

Data provided by: CSIR Touching lives through innovation

Information:

Student number:
EBRAZH001

Email:
EBRAZH001@myuct.ac.za

Supervisor:
Dr. M.Y. Abdul Gaffar

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad