Compression of Raw SAR Data

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Introduction

Synthetic aperture radar (SAR) is the only imaging system that can provide high resolution images of wide areas in all weather conditions, during the day or night, it is used for various military and science applications. Many organisations use SAR for numerous land applications including: agriculture monitoring, earth resource monitoring, climate science, digital elevation modelling, flood mapping, oceanography, derivation of elevation models after natural disasters and human geography [1],[2]. SAR also has military applications which include intelligence gathering, remote sensing, reconnaissance and gathering target information required in military operations.

A very popular research topic and industry trend is unmanned aerial vehicles (UAV). The advantages of a UAV system include lower risk in terms of human fatigue, lower cost and timely operations. A local project showing these and other advantages of a UAV system is the AREND project [3], where a UAV was designed by groups of South African and international students to address the important problem of poaching in the Kruger National Park.

Major international organisations developing UAVs include Lockheed Martin and NASA. Not only do they focus on UAVs, but they have integrated SAR systems into UAVs. Sandia National Laboratories has been decreasing the size of sensors over the past twenty years in order to deliver smaller, lighter and less expensive systems to be implemented on small UAVs for tactical missions [4]. Yet, Sandia is still implementing SAR systems on large platforms since large platforms provide more processing power and bandwidth which maximize the radar's performance [4]. The CSIR also has along history in working on SAR systems and has in the past developed a roof SAR system [6]. The CSIR is currently working along with DST to develop a UAVSAR system that could later be taken to space.

Since the volume of data is ever increasing, decreasing the volume of data to be processed is the problem to be addressed. Finding ways in which raw SAR data can be compressed to reduce the volume of data to the rest of the system is an important investigation as it would make wide-swath, high-resolution SAR systems for smaller platforms possible. In 2014 the Army Contracting Command at Natick contracted IMSAR to develop small, lightweight SAR systems for small UAVs that have to be launched near the front lines [6]. The NanoSAR B system produces high-quality radar images at a rate of 6.5 Mbps [6]. Before transmitting to the ground station the real-time SAR data is compressed by onboard firmware. Efficient compression of SAR data is required since SAR technology is moving towards being multi-band, multi-polarized, very high resolution with more than one mode of operation [7]. All of these factors contribute to very large volume SAR systems while the downlink channels and on-board storage capacity remain limited [7].

Aim of study

The main objective is to compress the large volume of data at the output of the ADCs as can be seen in Figure 1. In order to achieve the research objective, the following research questions must be addressed.

- What algorithms will be suitable to compress raw SAR data?
  - What are the characteristics of raw SAR data?
- How effective is the algorithm in compressing raw SAR data?
  - What are the metrics to valuate the suitability/effectiveness of a compression algorithm?
- What is the effect of the compression on the quality of the SAR image?
  - What metrics can be used to evaluate the quality of a SAR image?

Method

To find a solution to the research problem, the following process will be followed.

1. Determining the unique characteristics of raw SAR data.
2. Determining the metrics to evaluate the effectiveness of a compression algorithm.
3. Establishing metrics to evaluate the quality of a SAR image.
4. Performing an extended theoretical study on previously published research.
5. Implementing a possible solution from the literature.
6. Performing experiments to validate the published results.
7. Testing the performance of the implemented solution when application-specific test data are used.
8. Implementing an altered solution that is application specific.
9. Performing verification experiments to evaluate the performance of the implemented solution.

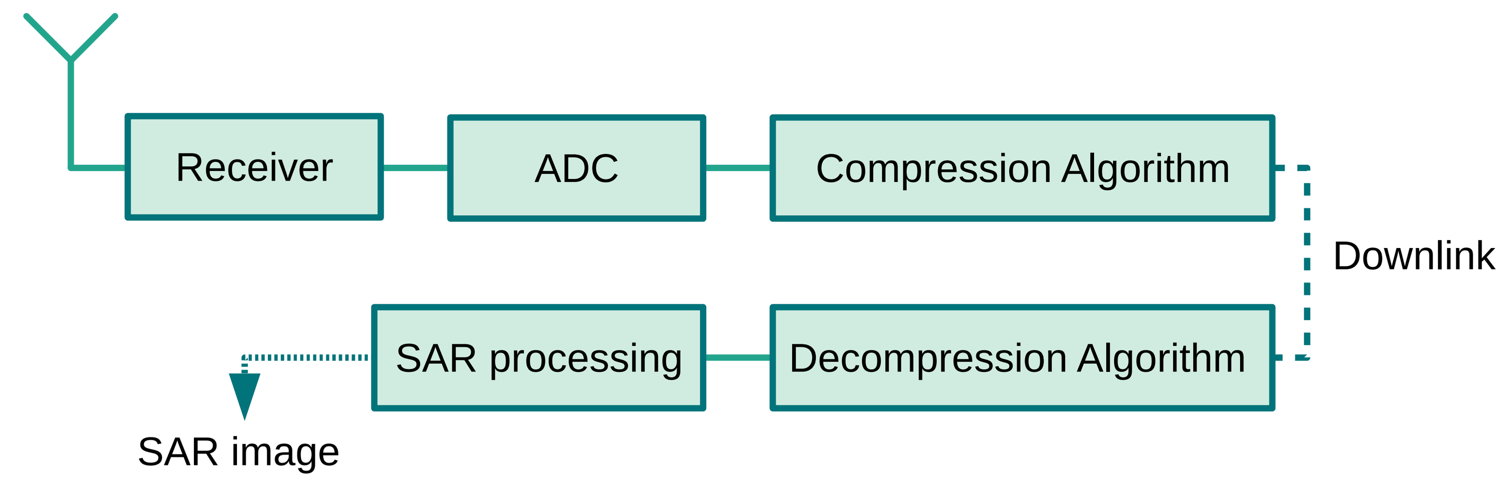

Figure 1. Block diagram of a modern SAR system, showing at what stage the compression algorithm will be implemented.

Conclusion

An important characteristic of modern space-borne SAR systems and small UAVSAR systems is that the acquired data is not processed on the platform, but transmitted to a ground station for processing. Thus, the main constraints in the design of these SAR systems are the unavailability of a downlink with a high data rate and the immense storage capacity required [7]. If these constraints can be addressed, it would lead to smaller, lighter and less expensive SAR systems for a variety of applications. In order to address the problem of large data volumes on board a SAR system, an efficient compression algorithm will be investigated and implemented.

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