ULTRA-RAPID OPTRONIC PROCESSOR FOR INSTANTANEOUS ENVISAT/ASAR SCENE OBSERVATION

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1. INTRODUCTION

This paper introduces a real-time compact optronic SAR processor that has the capability to generate ENVISAT/ASAR image swaths of 100 km x 100 km in 10 seconds exhibiting slant plane sampling distances of 4 meters in azimuth and 1 meter in range. It may be instantaneously reconfigured to process data from any of the 7 ASAR image swath modes. In this respect, numerous SAR image sets may be produced immediately on-demand. A rapid SAR processor that also provides fine ground sampling distances in both azimuth and range directions could provide benefits for such applications as landslide and flood monitoring, snow and ice coverage and glacier monitoring.

The optronic SAR processor is compact and lightweight, ideal for on-board processing for interplanetary missions, as well as for SAR system constellations and for Earth monitoring missions with combined sensor payloads. In each case, data bandwidth constraints cause bottlenecks and result in compromises being made between image/area selection, swath size and resolution, especially in the context of the growing number of users. By eliminating the bottleneck, more data is available to more users. Alternatively, the extra available bandwidth may also be partitioned for another on-board sensor, such as a thermal imager, thus providing complementary information to the end user not possible otherwise without the on-board SAR processing capability.

2. OPTRONIC SAR PROCESSING BACKGROUND

Presently, SAR processing is currently performed digitally using any number of algorithms, such the Range/Doppler, Chirp Scaling or Wavenumber [1]. Each algorithm requires involving large amounts of computational processing power, largely due to the two-dimensional fast Fourier transforms (FFTs) used. SAR processing can be also seen as real-time optical demodulation (assuming the Fresnel approximation) and

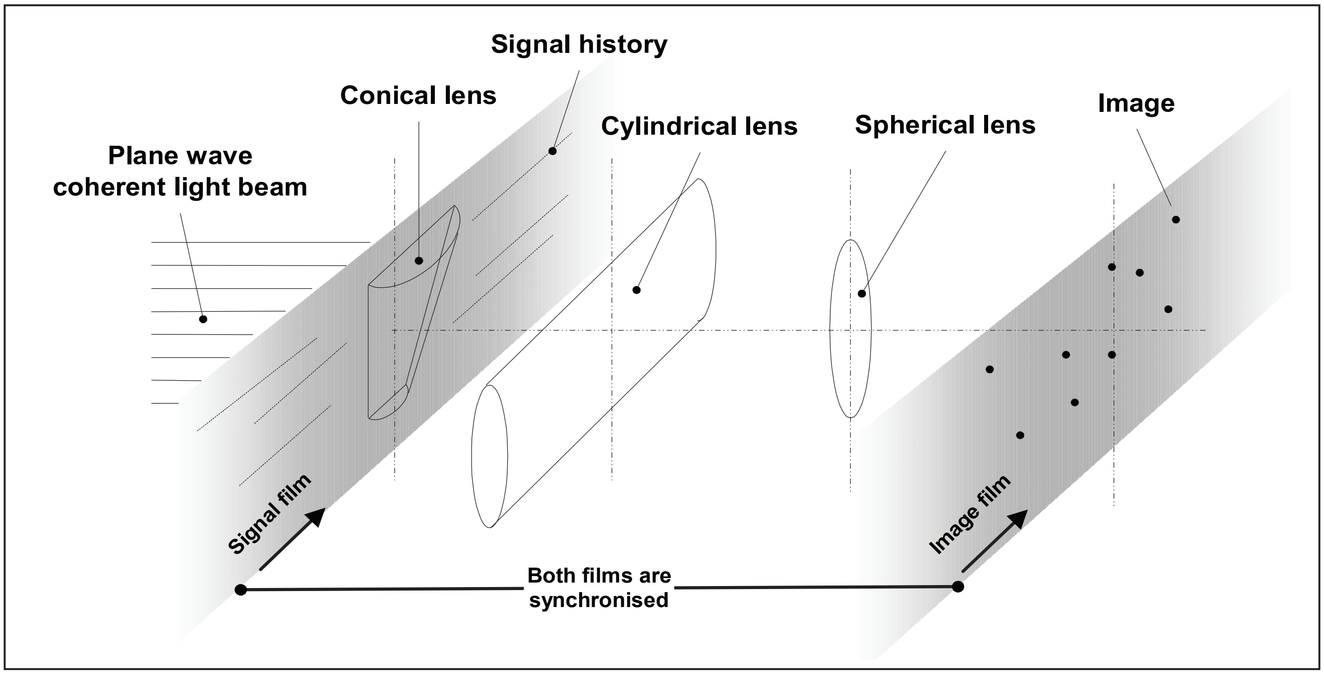

Figure 1: Original Optical SAR Processing Concept

therefore the processing 'algorithms' may be performed with lenses and thus provides inherent parallel computing capabilities [2]. Figure 1 demonstrates the concept behind optical SAR processing that was the original method employed until the 1980s [3]. The signal film used for recording the history in the first stage, light from the Cathode Ray Tube (CRT), is used as an input for the processor. The reconstructed SAR image is recorded on another film. Today, the availability of high resolution spatial light modulators (SLM) gives to the optronic processor advantages, such as reprogrammability, that were not available when photographic film was used as the recording medium. An SLM is basically a two-dimensional transmissive electronically addressable display on which images or data can be imaged.

3. OPTRONIC SAR PROCESSOR

The optronic processor is shown in Figure 2. High definition, 1920 x 1080 pixel, spatial light modulators are used to encode complex SAR raw data in amplitude and phase. A CMOS camera, located at the output is also high definition. The processor mass is 6.1 kg and its size is 630 mm x 207 mm x 140 mm (L x H x W). The total power consumption (not optimized) is 15.6 W.

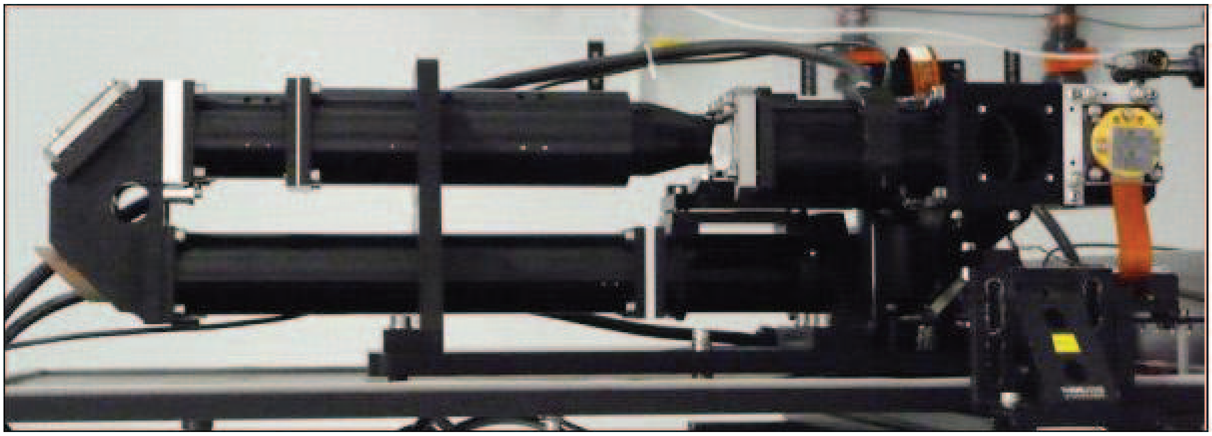

Figure 2: Optronic SAR Processor

4. REAL-TIME CAPABILITIES

Given specific ASAR system parameters, the total number of points generated per second may be calculated. For a nominal mid-range ENVISAT/ASAR data set (e.g., swath IS4) the generated throughput is calculated to be approximately 10 megasamples/second. From the SAR system parameters, the azimuth and slant range pulse compression ratios are calculated from which the minimum number of frames per second required to process the incoming raw data without bottleneck. The required frames per second for an optical processor employing an SLM with dimensions 1920 x 1080 pixels is deduced to be 59 frames/second. The current prototype frame rate capability is 60 frames/second thus providing real-time processing capabilities. The total processing time for a full ASAR scene of 5200 range samples and 20,000 azimuth lines is 10 seconds.

5. ENVISAT / ASAR IMAGE RESULTS

ENVISAT / ASAR images from a part of The Netherlands were processed. The swath mode was IS2 and the PRF was 1652 Hz. Figure 3 shows a section block of the total image and it can be seen that optronically processed image (right) is comparable to final Envisat image magnitude single-look (IMS) product (left). It can be seen in the figure that the optronically generated image has a finer sampling distance as compared to the IMS product, resulting in improved feature definition.

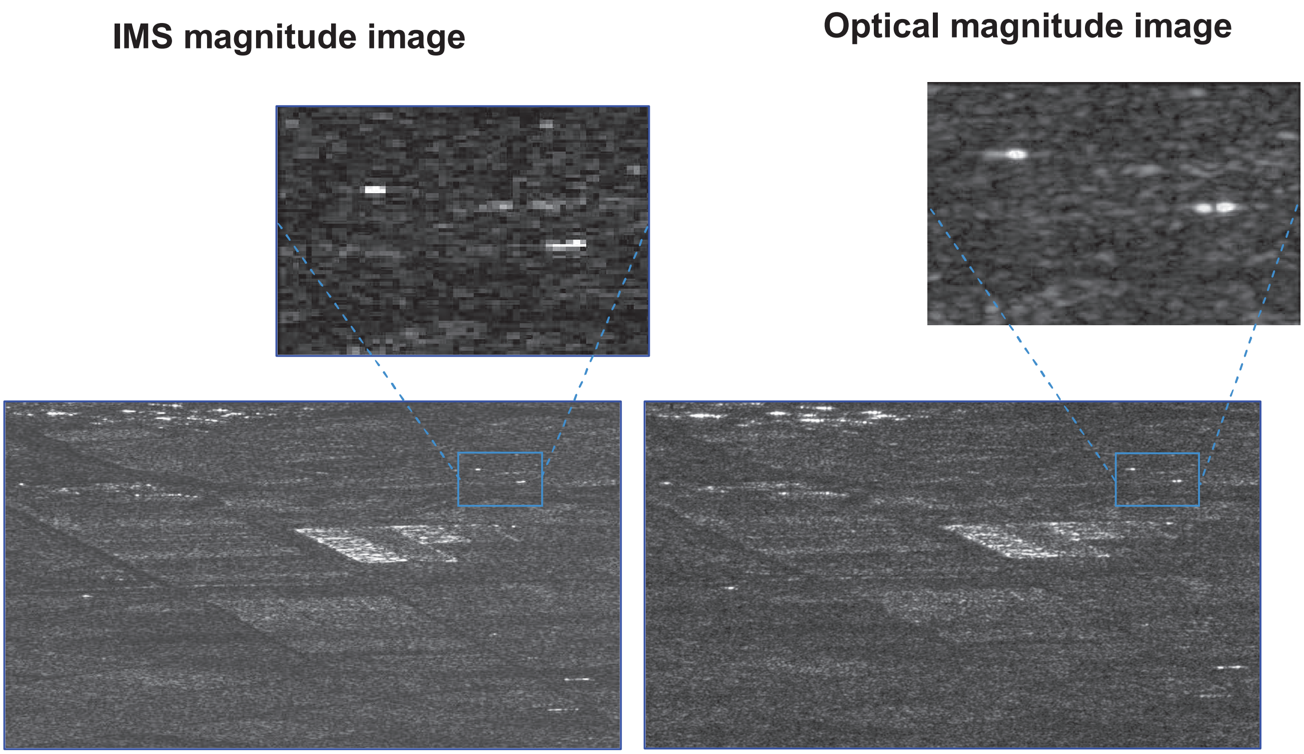

Figure 3: Optronically Processed Image (left) and Envisat IMS product (right).

6. CONCLUSIONS AND FUTURE IMPROVEMENTS

This paper introduces a real-time optronic processor suitable for on-demand SAR image generation. The compact, lightweight prototype has the capability to process high image quality ENVISAT / ASAR images within seconds. The processor shows enhanced sampling distances compared to IMS product. The near-future processing potential is further estimated to be 116 times the actual real-time capabilities demonstrated, given current commercially available SLMs. Considering that the prototype built handles today's throughput in real-time, these technology improvements allow for near-future optronic processors to handle user demands for finer sampling and larger swath SAR systems.

7. REFERENCES

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