Technology Strategy Board
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CODED APERTURE IMAGING AND OPTICAL CORRELATION

Cambridge Correlators / MBDA / University of Sheffield

The need

Coded Aperture Imaging (CAI) is a lensless imaging technique used predominantly in astronomy to produce sharp images. However, with current software-based methods, there is significant post processing time involved in reconstructing the original image.

Fourier optical processing has been used classically for optical pattern recognition, where patterns/images are compared in terms of their visual similarity and alignment. The same system architecture may be used to perform a process analogous to the post processing involved in reconstructing the image in the CAI method.

This Internship aimed to implement a CAI system with Fourier optical processing.

The outcomes

Two methods were developed that allowed the CAI deconvolution process to be performed with both of the classical correlator architectures – the 4-f Matched Filter and Joint Transform Correlator. Based on these models, a blueprint covering the hardware design aspects and parameters was created, for both the encoding and reconstruction stages of the CAI system. It is hoped that the resulting report will lead to the development of a prototype CAI sensor in the future.

CAI also underpins a number of other related applications and may have the potential to eliminate some of the intermediate processing steps in, for example, Automatic Target Recognition (ATR). The use of a dynamic input, using the same liquid crystal technology as employed in Cambridge Correlators' systems, adds significant possibilities through advanced functionality.

The project presented the student with the chance to apply knowledge gained during his PhD on lensless imaging, to the previously unconnected area of Fourier optical correlation. Whilst gaining a valuable introduction to the field, the intern also benefited from the practical experience of real problem solving by implementing his ideas in hardware.

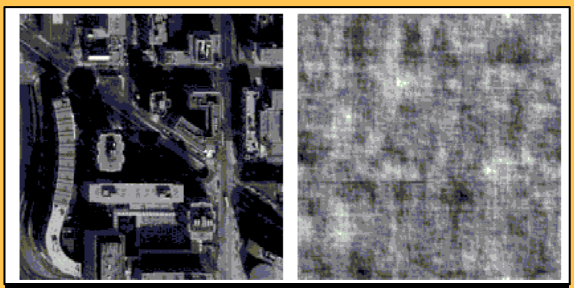
"The project has been extremely useful for all the parties involved. Bringing the fields of lensless imaging and Fourier optics together through the internship has brought about several new concepts that we will be developing further."

Nick New
Cambridge Correlators

Technical summary

Cambridge Correlators (CC) is a university start-up company developing very high resolution, high speed, parallel optical processing systems based upon the principles of Fourier Optics. MBDA and CC are examining where this technology may apply in a range of missile system problems.

The primary function of this project was to look at the potential application of optical processing to missile system functions. Down-selection identified functions and techniques to which the CC technology could bring the most benefits and resulted in CAI being chosen for detailed study.



Typical aerial image Encoded image

CC optical correlator technology has the potential to enable CAI post processing to be performed in the optical domain at frame rates which have hitherto been impossible.

A comprehensive analysis was conducted using Matlab to simulate the optical system, based upon Fourier and diffraction theory to model the propagation of light through the system and phase hologram generation. The analysis considered actual device constraints and attributes, as well as optical effects such as the diffraction encountered when using micron-range pixel sizes in the dynamic aperture array.

Methods were developed for optimal reconstruction of the input images and preliminary testing was performed in hardware for comparison with the mathematical models. These models incorporated the physical dimensions and effects of using the liquid crystal input device and the propagation of the light towards the camera sensor.

"Working on this project has provided me with valuable insight into the nature of scientific research outside academia. The practical skills acquired during this internship and the corresponding exposure are invaluable for the final phase of my PhD and my career as a scientist."

Tega Edo
University of Sheffield

"Tega has had an excellent opportunity to widen his knowledge of image processing methods. His exposure to a different problem has strengthened his scientific, technical, and analytical capabilities."

John Rodenburg
University of Sheffield

This internship was part of the Underpinning Defence Mathematics programme, a joint initiative of the UK Ministry of Defence and the Knowledge Transfer Network (KTN) for Industrial Mathematics. The KTN works to exploit mathematics as an engine for innovation. It is supported by the Technology Strategy Board, in its role as the UK's national innovation agency, and the Engineering and Physical Sciences Research Council, in its role as the main UK government agency for funding research and training in the physical sciences.

EPSRC
Engineering and Physical Sciences Research Council

Project Details

Partners
Cambridge Correlators / MBDA
University of Sheffield

Project investment
£15,000

Intern
Tega Edo

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