Background to Research Project

This research agreement follows the previous collaborative research programs between DST Group and Curtin University. The focus of the previous work were on (1) automatic detection of low observable contacts from panoramic and wide FOV cameras (2008 and 2013) and (2) studying the impact of different visualisation modalities on timely successful detection of targets (2015).

The success of submarine operations is highly dependent on its ability to effectively undertake above water surveillance across the entire electro-optic spectrum in all weather conditions and time of day. From the sensor front end, the sensor-time-space integration of data aims to capture a reliable understanding of the battlespace. With the emergence of non-rotating panoramic masts expected to be of consideration for Project SEA100, the ever increasing volume of data collected from multiple sensors has resulted in a dependency and growing adoption of automated techniques to help improve the efficiency and accuracy of above water contact management for the submarine command team. Automations for feature extraction, machine learning, information fusion and visualisation are designed to augment the decision making process, relieving the image analysis from manually sieving through large volume of data thereby significantly reducing the strain on their time and capabilities and improving the command team response time leading to a regionally superior capability.

**Aims of Research Project**

Recent progress in deep learning techniques has opened up new opportunities for sensor-based visual recognition (LeCun et. al). The main advantages of these methods are that the framework is fully automatic and the underlying features from images can be explicitly learned using a single learning algorithm. Recent advances in deep convolutional neural network (CNN) have allowed thousands of objects to be automatically learned from millions of labelled training images. The capacity of CNNs can be controlled by varying their depth and breadth, and they also make strong and mostly correct assumptions about the nature of images (Krizhevsky et. al). In most scenarios, a deep CNN with an abundance of non-linear computation units is trained on a large-scale dataset and the feed-forward activations at a certain layer are extracted as a feature representation to the next layer. This approach has shown promising performance when transferred to a vast array of target recognition tasks (Stone and Keller).

In this research, the following primary objective activities will be carried out:

1. Investigate the application of CNN (and/or other suitable approaches) for the task of automatic detection of distant maritime surface and air objects of military interest when observed from panoramic EO sensors near the sea surface.
2. Assemble a representative imagery set for training and testing. Investigate if existing imagery data bases can be used, if they can be supplemented with synthetic imagery, and building an unclassified image repository of real world maritime vessels using a multi band camera array installed on the Armaments Jetty at HMAS Stirling together with recording of ships AIS information.
3. Develop and optimise the preferred approach for low observable objects and demonstrate its ROC performance using representative imagery. Determine the effective limits of the approach in terms of minimum pixels on target and contrast with background.
4. Conduct technology forecasting to try and predict how the effectiveness of these approaches are expected to change in the next 10 years.

In this research, the following secondary objective activities will be carried out:

1. Investigating automatic recognition of maritime and air targets from EO sensors using CNN techniques.
2. Investigating information fusion from CNN derived output across multiple EO sensors.
3. Adapting CNN to enable the tracking of moving targets (Nam and Han).

Reference

LeCun Y., Bengio Y. and Hinton G., ‘Deep Learning’, Nature, 521, 436-444, 2015

Krizhevsky A., Sutskever I. and Hinton G., ‘ImageNet Classification with Deep Convolutional Neural Network’, in Proc. of NIPS, 2012

Stone K. and Keller J.M., ‘Convolutional Neural Network Approach for Buried Target Recognition in FL-LWIR Imagery”, SPIE, 2014

Nam H. and Han B., ‘Learning Multi-domain Convolutional Neural Networks for Visual Tracking’, in Proc of CVPR, 2016

**Research Plan, Research Project Reports, and Other Deliverables:**

The University must carry out the Research Project in accordance with the following program:

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| --- | --- | --- |
| Table 2.1 Research Program | | |
| Research Element | Description | Due Date for Completion |
| Project kick-off | Kick-off meeting | By 05 Feb 2017 |
| Phase 1 | Part A: Review of previous work (Shams) and literature review of CNN and/or other promising approaches. Identification of preferred candidate approaches. Initial implementation and testing of approaches.  Part B: Establish representative imagery set for training and testing.  Part C: Research Assistant to Establish defence baseline security clearance | 1 May 2018 |
| Phase 2 | Part A: Implementation, optimisation and evaluation of preferred approach.  Part B: Technology forecasting (inc trends and market forces) | 31 August 2018 |
| Phase 3 | Part A: Investigation of automatic recognition using CNN approaches  Part B: Investigating information fusion from CNN derived output across multiple EO sensors.  Part C: Adapting CNN to enable the tracking of moving targets | 22 December 2018 |

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| Table 2.2 Reports and Other Deliverables Timetable | | | |
| Report or other Deliverable Title | Description | Delivery Format and Location | Due date |
| 1. Project Kick-Off meeting | Kick-off meeting | Meeting at Curtin | By 05 Feb 2017 |
| 2.Project review meeting no. 1 | Progress update of Phase 1 (Part A & B)  Completion of Part C. | Meeting at Curtin. Power point brief or similar. | 1 May 2018 |
| 3.Phase 2 final report and review meeting no. 2 | Final report for Phase 2 (Part A & B) | Meeting at Curtin. Electronic copy forwarded to DST Lead | 31 August 2018 |
| 4.Phase 3 final Report and review meeting no. 3 | Final report for Phase 3 (Part A & B & C) | Meeting at Curtin. Electronic copy forwarded to DST Lead | 22 December 2018 |