Smart Maritime Surveillance System

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MATLAB EXPO 2021

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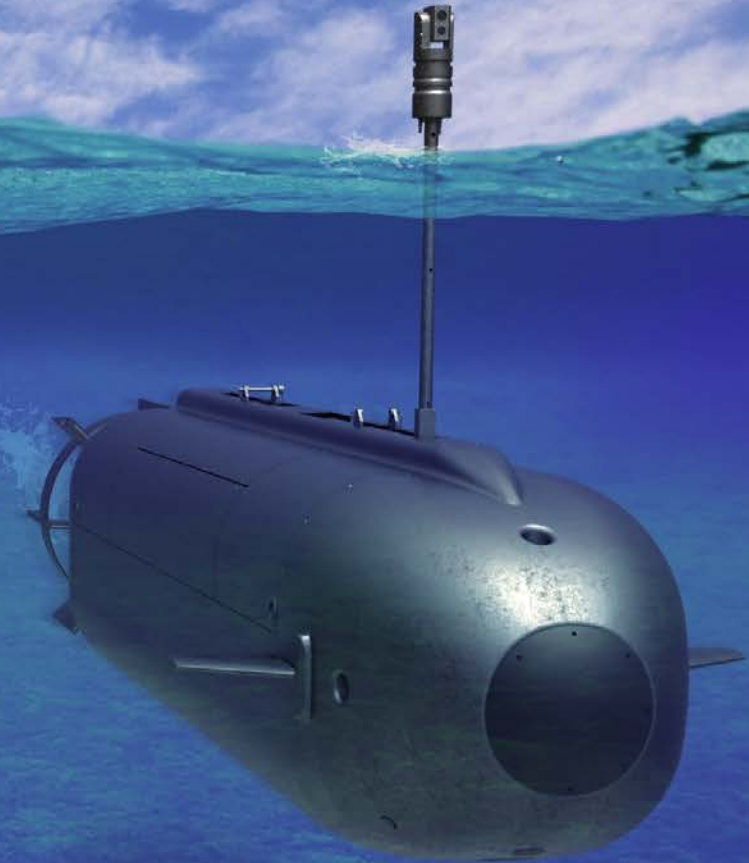
About Me

Role

Command & Control Systems Manager

Education

University of Pisa
Robotics and Automation Engineering

Contact

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o **MATLAB**® user since 2010.

o My team and I currently use **MATLAB® and Simulink**® as base benchmark for our ideas both in DEFENCE and INDUSTRIAL DIVING business lines:

- Dynamic Simulation
- Control Development
- Artificial Intelligence

DRASS Company

DIVING & SIMULATOR

- Midget Submarine
- Compact Submarine
- Swimmer Delivery Vehicle
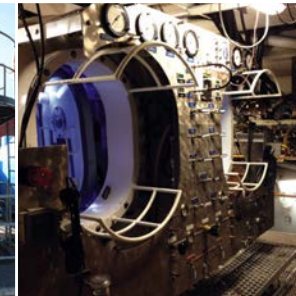
SUBMARINE RESCUE SYSTEMS

- Spares and Components
- Repair and Maintenance
- Training Centre

ENGINEERING & TESTING

- Tunneling Hyperbaric Chambers
- Industrial Pressure Vessels

MEDICAL HOT SERIES & SCUBA

- Deep Diving
- Surface Diving
- Modular Systems

- Resident Rescue System
- Deployable Rescue System
- Submarine Ventilation

- Consultancy
- Laboratory and Experimental

- Medical Hyperbaric Chambers
- Scuba Diving Chambers
- Diving Boats

DEFENCE SOLUTIONS

GLOBAL SERVICE

INDUSTRIAL

Takeaways

o   Speed of dataset creation and management for training and validation

o   Easier Project Exploration (Rapid function implementation & function workflow analysis)

o   Automatic code generation to quick prototype and integration with external environment

o   The power of collaboration with MathWorks

ARTS

Augmented **R**eality **T**racking **S**ystem is an optronic system software for maritime surveillance capable of:

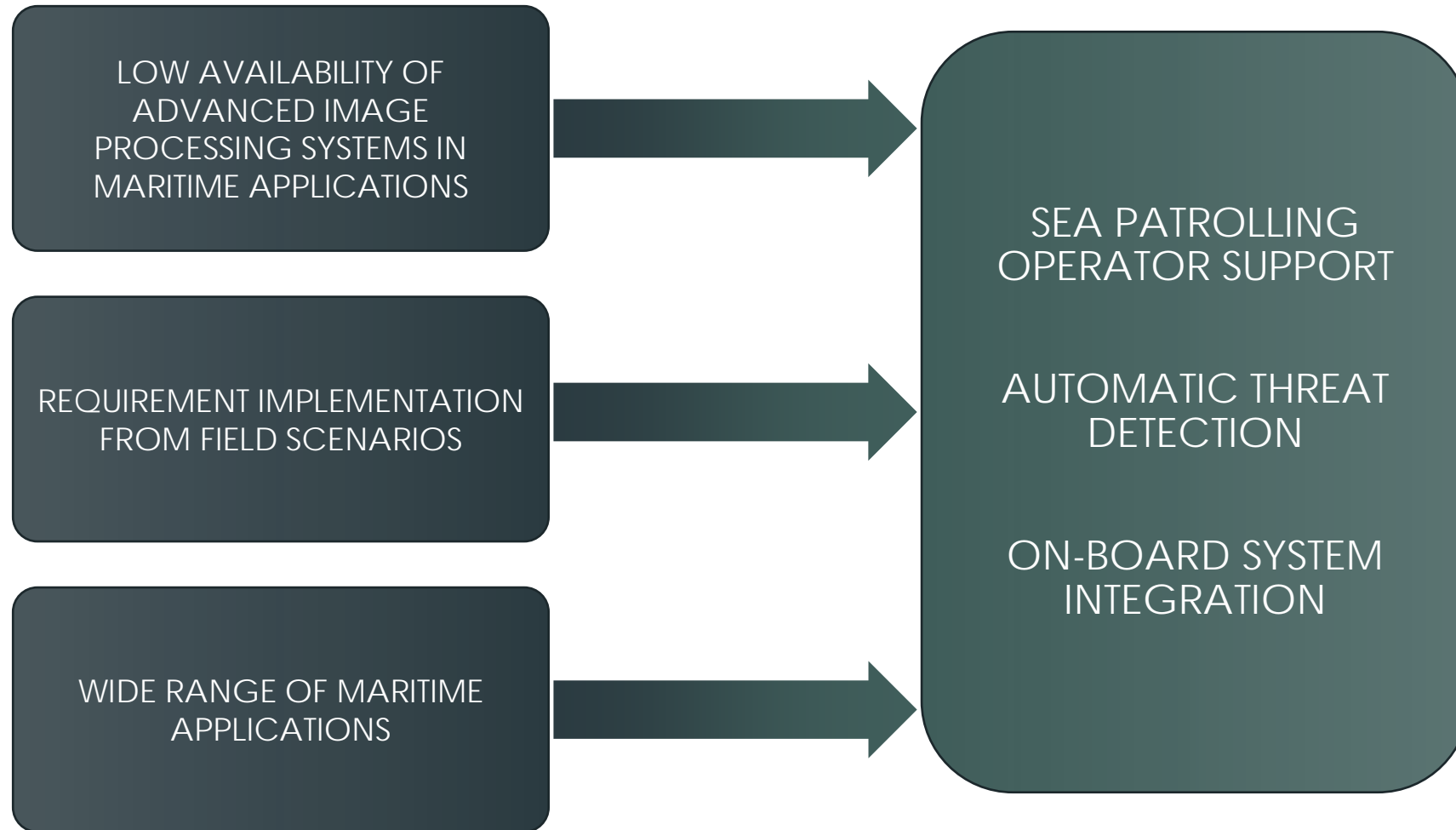Video Flow Stabilization

Obstacle Awareness

Object Detection

Multi-Spectra Video Merging

Motivation & Goals

MOTIVATIONS

- LOW AVAILABILITY OF ADVANCED IMAGE PROCESSING SYSTEMS IN MARITIME APPLICATIONS
- REQUIREMENT IMPLEMENTATION FROM FIELD SCENARIOS
- WIDE RANGE OF MARITIME APPLICATIONS

GOALS

- SEA PATROLLING OPERATOR SUPPORT
- AUTOMATIC THREAT DETECTION
- ON-BOARD SYSTEM INTEGRATION

DRASS
DEFENCESOLUTIONS

Challenges & Solutions

OPEN SEA ENVIRONMENT

Wave Motion
Continuous background changes
Almost total lack of reference points

STATE OF THE ART ALGORITHMS

Two different stabilization algorithms
Tests of different detectors
Frames preprocessing

**REAL-TIME PROCESSING
ON TWO VIDEO FLOWS**

ALGORITHMS OPTIMIZATION

Parallel computing toolbox
Project dependency analysis
MATLAB® Profiler
Slow dynamic speed

**TIGHT DEADLINE
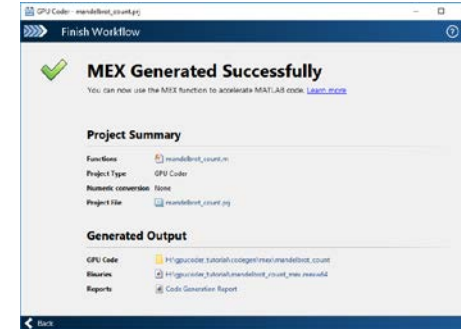MATLAB® CODE INTEGRATION
IN EXTERNAL PROJECT**

GPU Coder & MATLAB Coder
MathWorks SUPPORT

DRASS
DEFENCESOLUTIONS

Process & Tools

Wavelet Toolbox ™
Image Processing Toolbox ™
Deep Learning Toolbox ™
Computer Vision Toolbox ™
Signal Processing Toolbox ™
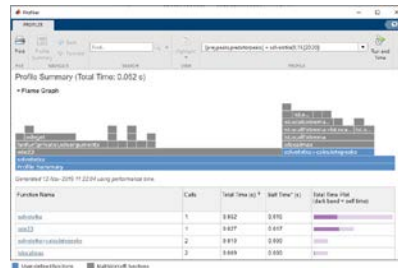

IMPLEMENTATION

RESULT COMPARISON BY MEANS OF KPI
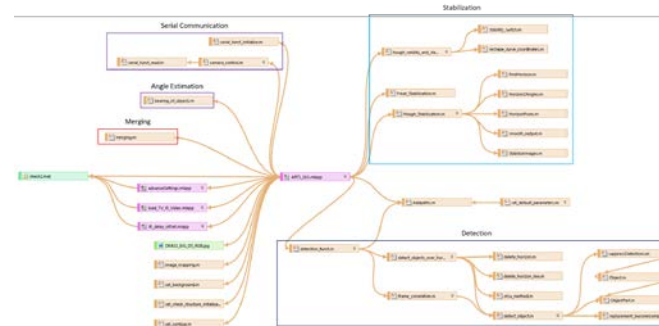
CODE GENERATION

V&V

OPTIMIZATION

FUNCTION WORKFLOW MANAGEMENT

IMPLEMENTATION IN EXTERNAL PROJECT

Parallel Computing Toolbox

Implementation: YOLOv2 Detector

Traditional detection methods are not suitable for unstructured environment

Why YOLOv2?

Its competitors, e.g. R-CNN, are not adequate for real-time processing

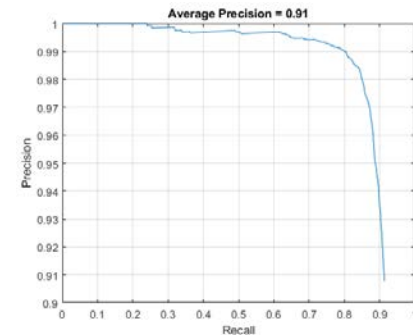Gives great results in different domains
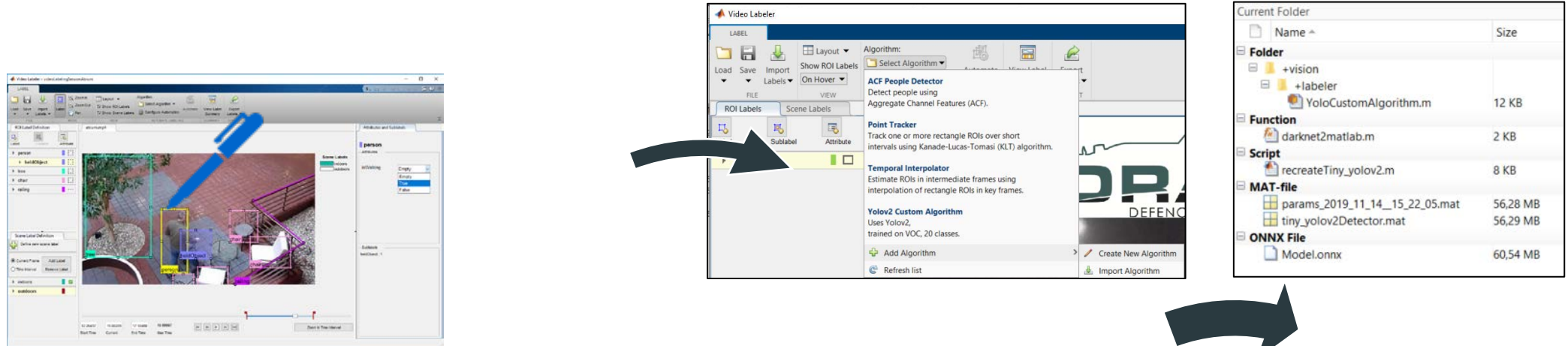
~5000 images/dataset

~30000 images/dataset

~12h/training

Training Option Variation (Learning rate, Epochs, Algorithms)

Dataset creation → Dataset Augmentation → Multiple YOLOv2 Training → Network Evaluations

Speed Up the Process: Database Creation

Manual Video Labeling → Training rough YOLOv2 detector → Use Detector in Video Labeler app → Manual incorrect frames discharging → Checking and discarding incorrect GTs

Time only manual labeling

3 min/frame **x** 5000 frame ~= **249 hrs**

VS.

Above process with detector obtained after 16 hrs of work

0,3 sec/frame **x** 5000 frame ~= **30 min**

30 sec/frame **x** 5000 frame ~= **42 hrs**

Speed Up the Process: Intra-Team Exchanges

Performance Evaluation TEAM

MATLAB® and Simulink® TEAM

Visual Studio TEAM

LIVE SCRIPTS

YOLOv2 from ResNet-50
Create a YOLOv2 network from a ResNet-50 CNN.

Load Dataset
Load the data sete extracted from the Singapore clips

```
load('vessel_table.mat')
vehicleDataset = trainingTable;
clear trainingTable
```

The vehicle data is stored in a two-column table, where the first column contains the image file paths and the second column contains the vehicle bounding boxes.

```
% Display first few rows of the data set.
vehicleDataset(1:4,:)
```

ans = 4×2 table

	ImageFilename	Vessel
1	'TrainingData\...	5×4 double
2	'TrainingData\...	5×4 double
3	'TrainingData\...	5×4 double
4	'TrainingData\...	5×4 double

Split the data set into a training set for training the detector, and a test set for evaluating the detector. Select 60% of the data for training. Use the rest for evaluation.

CODE GENERATIONS

o   GPU coder automatically generates from the same function generic .dll or specific .cu code, NVIDIA hardware is available

o   The code and the necessary libraries can be integrated with no effort in Visual Studio thanks to *packNGo* **MATLAB®** function
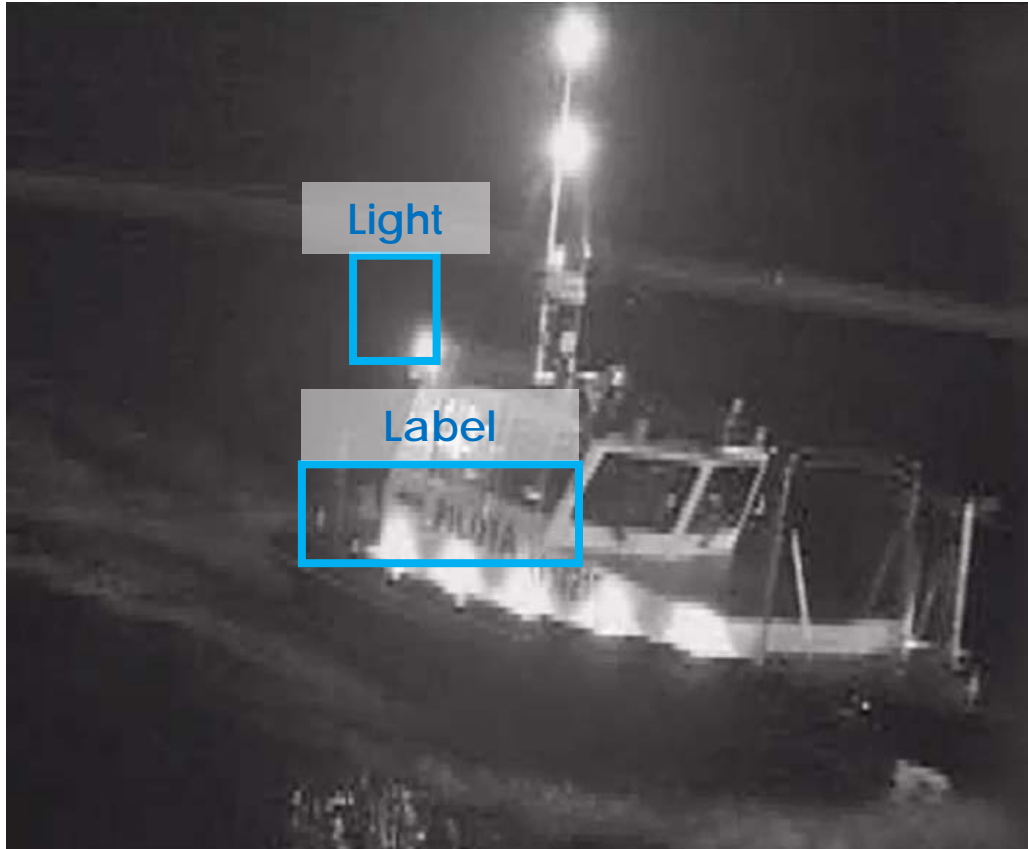
Video Stabilization
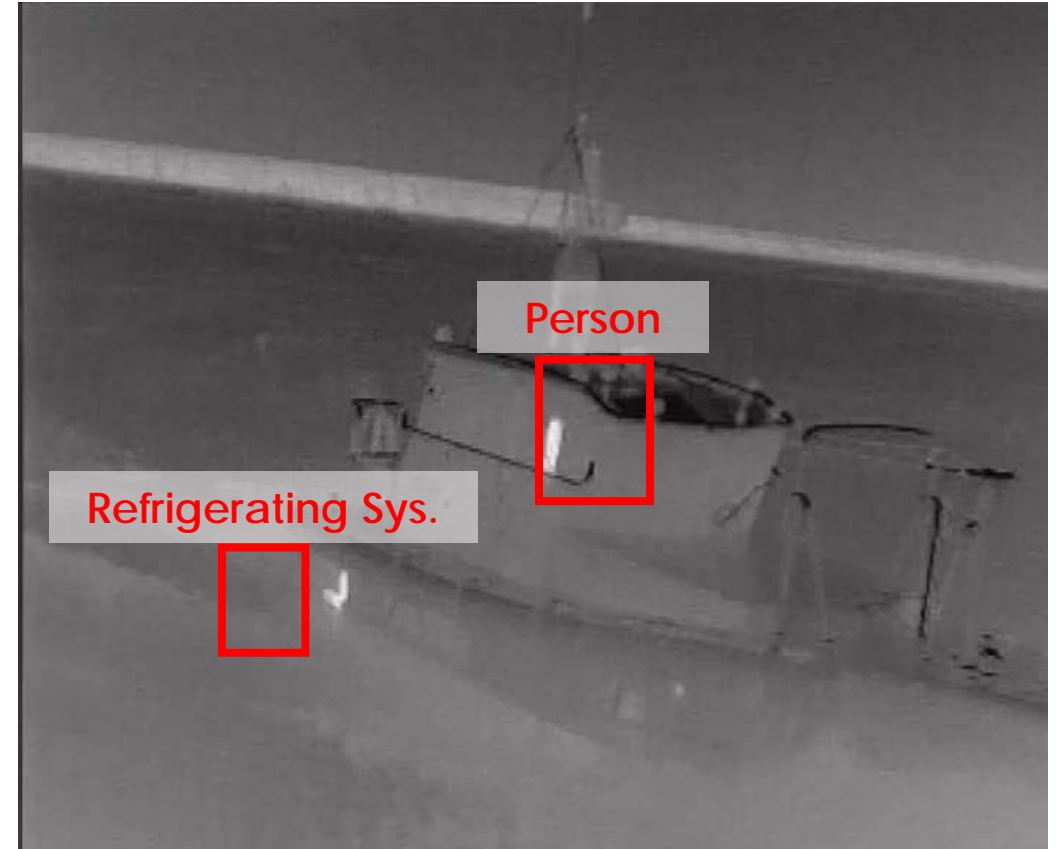
Original Source

Stabilized Source

Sensors Merging
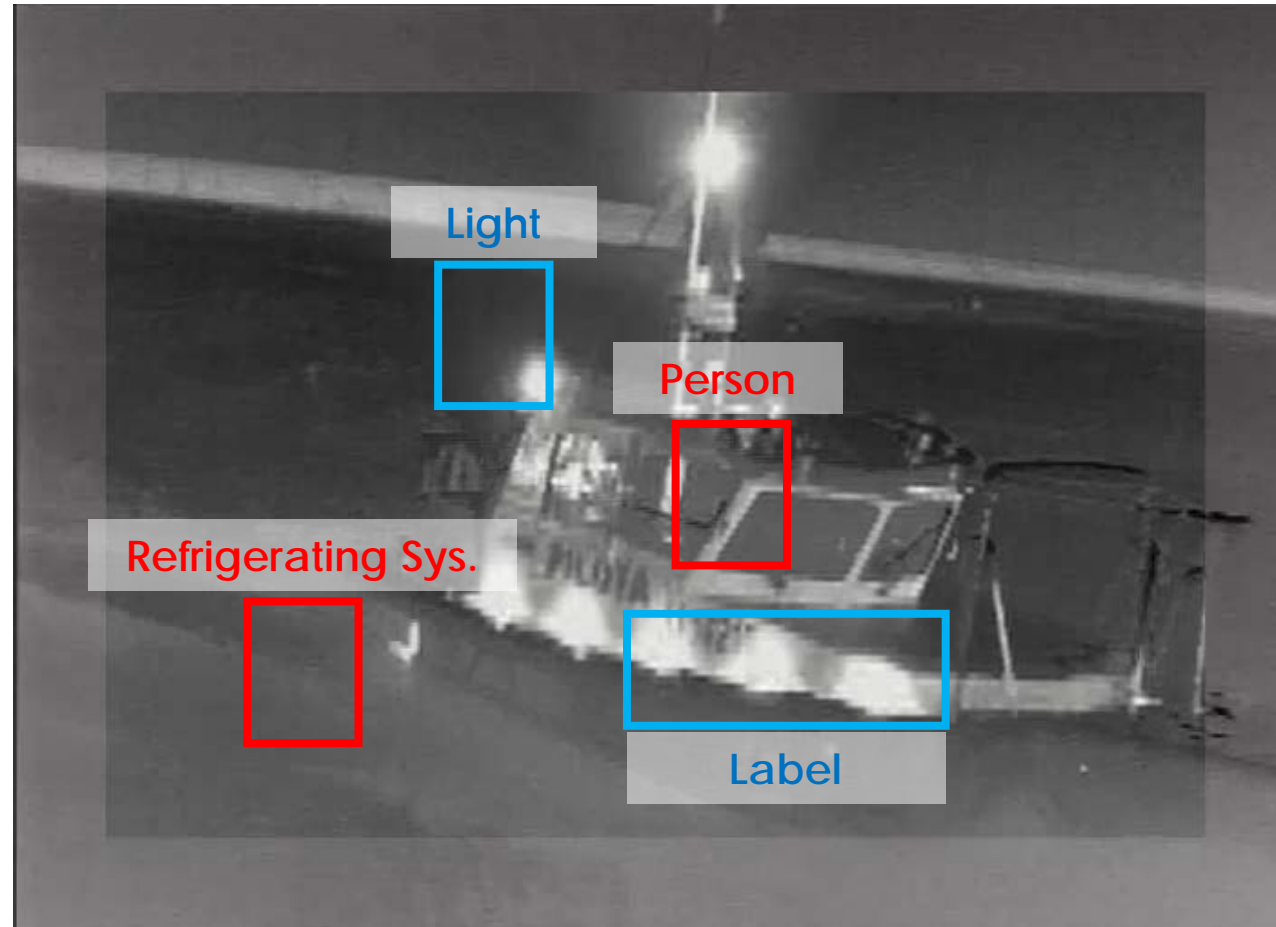
Daylight Camera

IR Camera

Sensors Merging

Merging

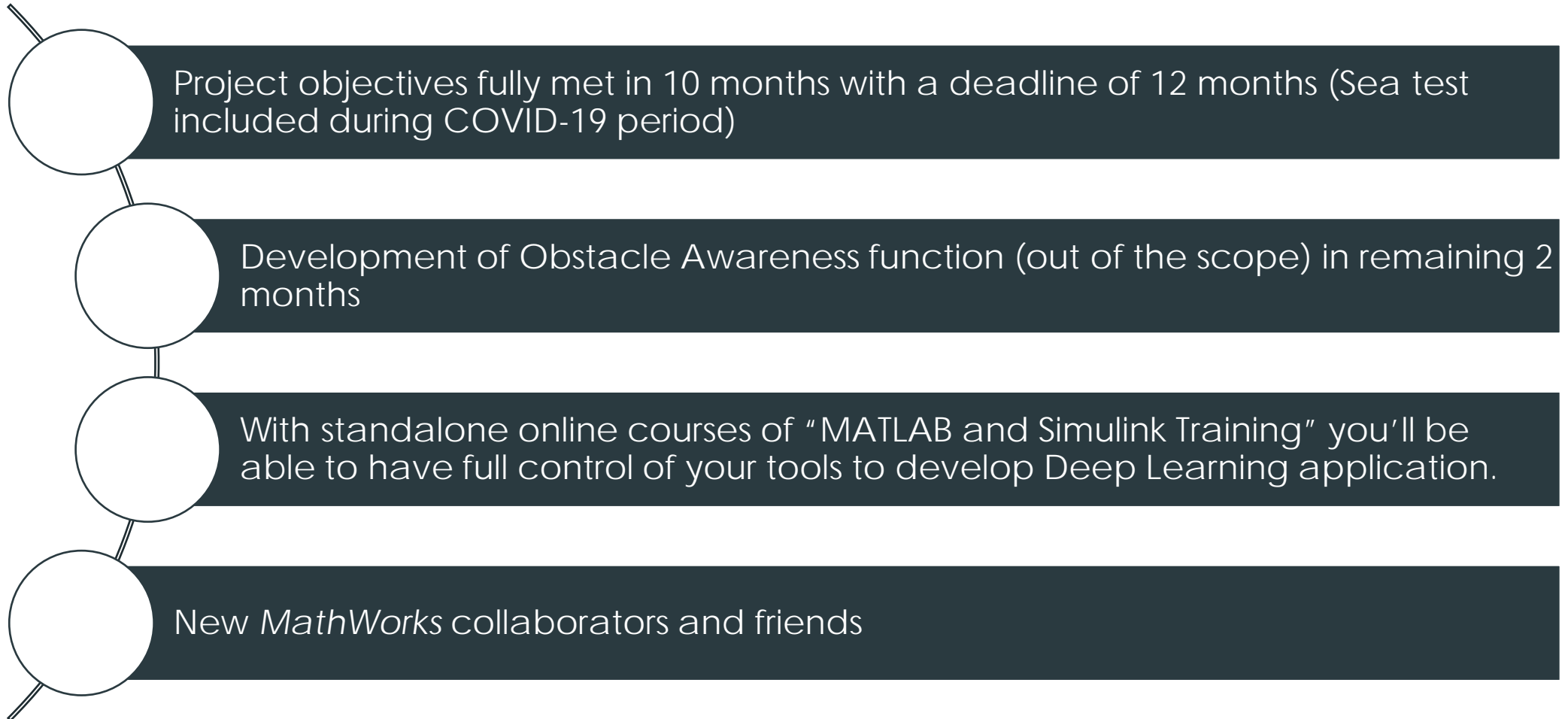# Tracking & Obstacle Awareness

Container Ships Detection & Tracking

Source Video from Singapore Maritime Dataset (SMD)

Obstacle Awareness

Conclusions

Project objectives fully met in 10 months with a deadline of 12 months (Sea test included during COVID-19 period)

Development of Obstacle Awareness function (out of the scope) in remaining 2 months

With standalone online courses of "MATLAB and Simulink Training" you'll be able to have full control of your tools to develop Deep Learning application.

New *MathWorks* collaborators and friends

Future Developments

Increase the number of identified objects

YOLOv2 (and YOLOv3) training on thermal and merged target dataset

Sensors Fusion: AIS, GPS & CMS integration

Integration of 3D maritime complex scenario for close loop simulation

Thank You for your kind attention