Smart Maritime Surveillance System

DRASS®
DEFENCESOLUTIONS

Valerio Imbriolo

MATLAB EXPO 2021

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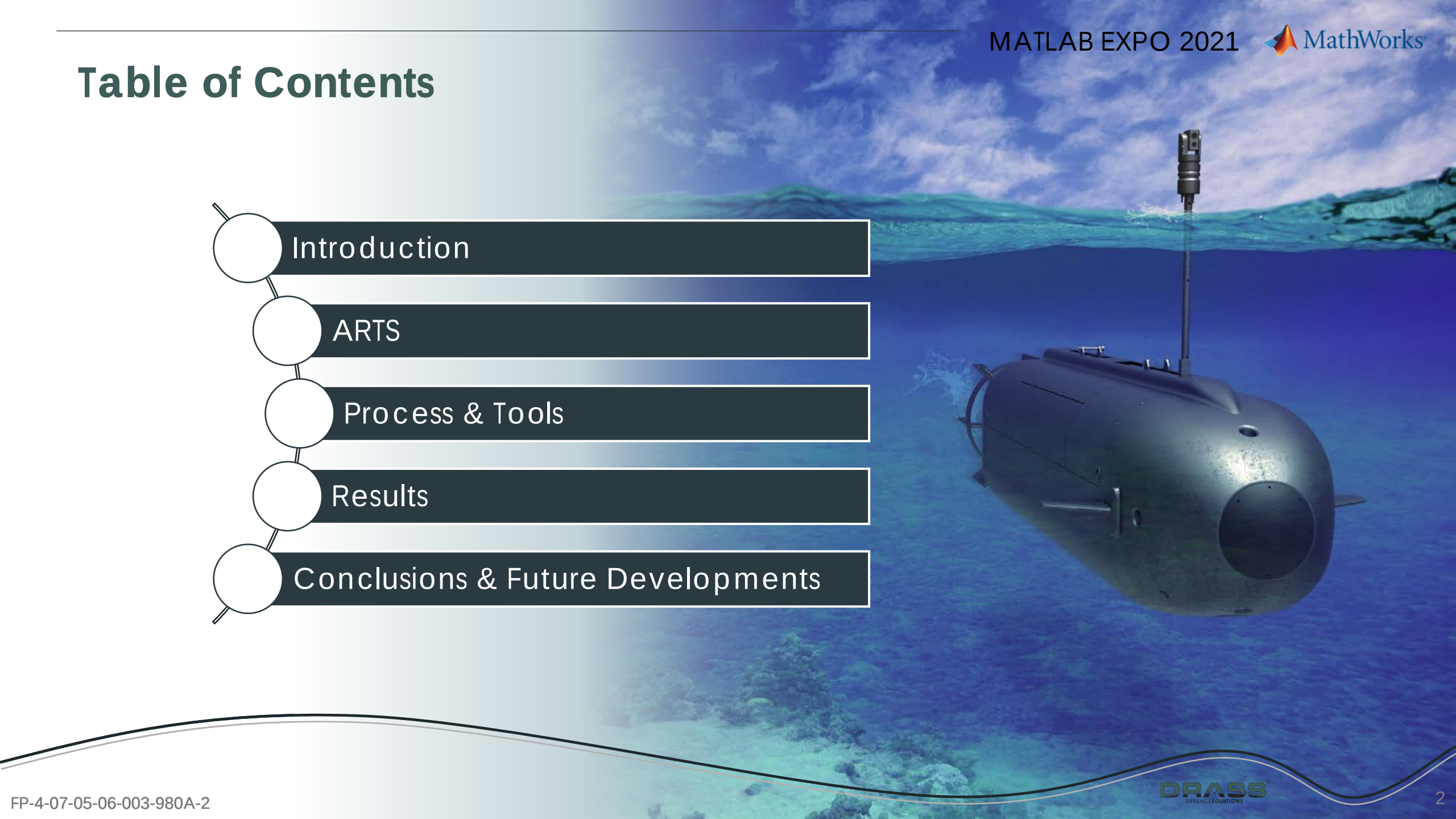

About Me

Role

Command & Control Systems Manager

Education

University of Pisa
Robotics and Automation Engineering

Contact

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- **MATLAB®** user since 2010.
- 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

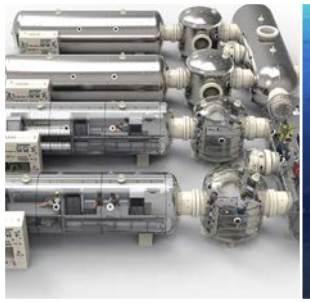
SUBMARINE RESCUE SYSTEMS

- Spares and Components
- Repair and Maintenance
- Training Centre

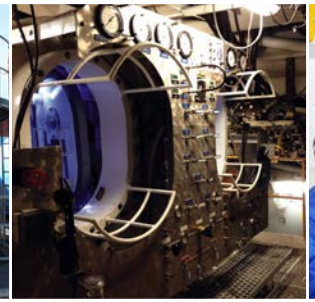
ENGINEERING & TESTING

- Tunneling Hyperbaric Chambers
- Industrial Pressure Vessels

MEDICAL HOT SERIES & SCUBA






- Deep Diving
- Surface Diving
- Modular Systems

DEFENCE SOLUTIONS

- Resident Rescue System
- Deployable Rescue System
- Submarine Ventilation

GLOBAL SERVICE

- Consultancy
- Laboratory and Experimental

INDUSTRIAL

- Medical Hyperbaric Chambers
- Scuba Diving Chambers
- Diving Boats

Takeaways

- Speed of dataset creation and management for training and validation
- Easier Project Exploration (Rapid function implementation & function workflow analysis)
- Automatic code generation to quick prototype and integration with external environment
- The power of collaboration with MathWorks

ARTS

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

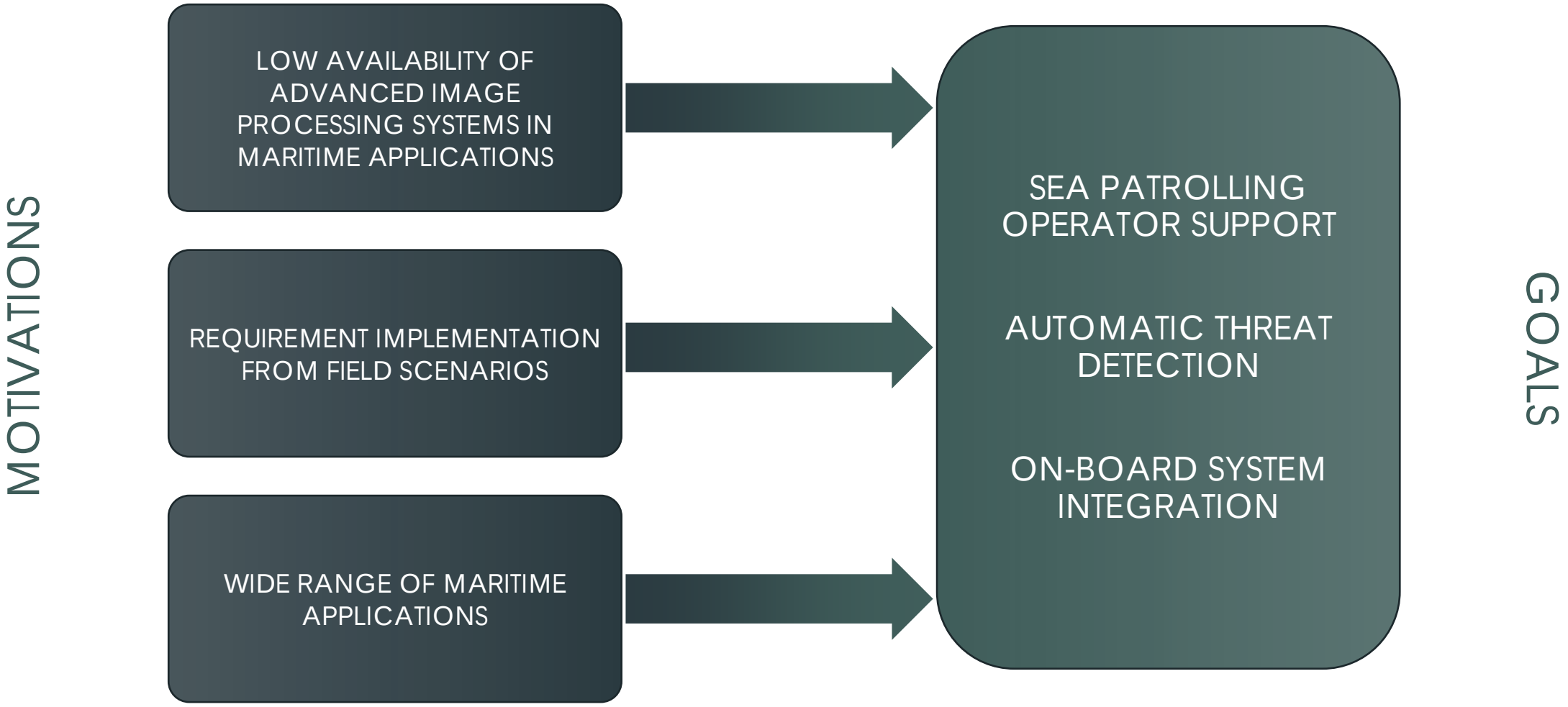
Video Flow Stabilization

Obstacle Awareness

Object Detection

Multi-Spectra Video Merging

Motivation & Goals



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

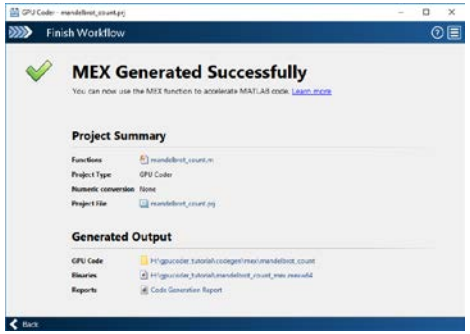
ALGORITHMS OPTIMIZATION
Parallel computing toolbox
Project dependency analysis
MATLAB® Profiler
Slow dynamic speed

TIGHT DEADLINE MATLAB® CODE INTEGRATION IN EXTERNAL PROJECT

GPU Coder & MATLAB Coder MathWorks SUPPORT

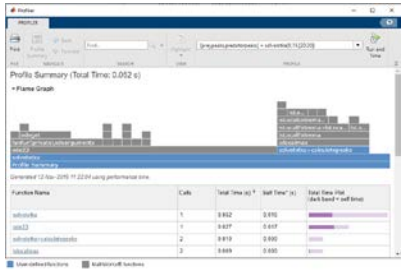
Process & Tools

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



IMPLEMENTATION

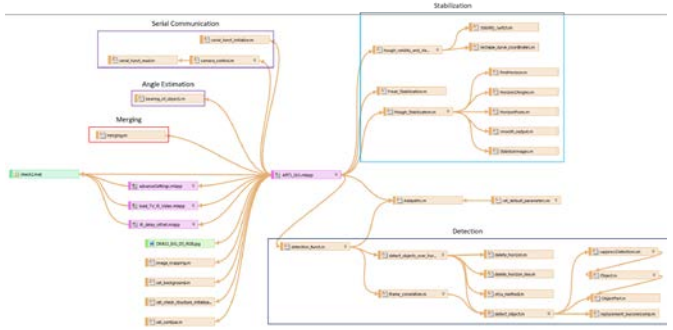
OPTIMIZATION



Parallel Computing Toolbox

RESULT COMPARISON BY MEANS OF KPI

FUNCTION WORKFLOW MANAGEMENT



CODE GENERATION

IMPLEMENTATION IN EXTERNAL PROJECT

Visual Studio

V&V

Implementation: YOLOv2 Detector

Why YOLOv2?

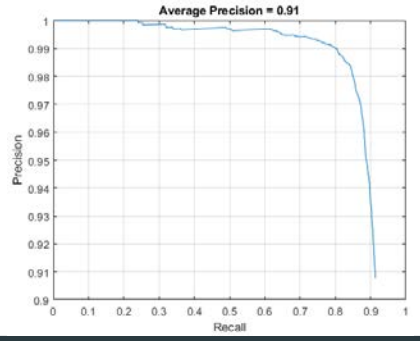
- Traditional detection methods are not suitable for unstructured environment
- Its competitors, e.g. R-CNN, are not adequate for real-time processing
- Gives great results in different domains

~5000 images/dataset

~30000 images/dataset

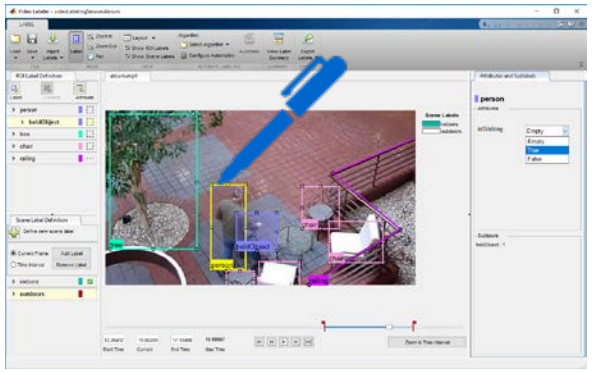
~12h/training

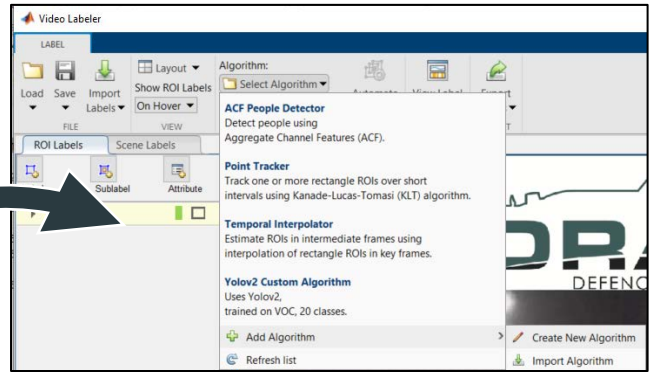
Training Option Variation (Learning rate, Epochs, Algorithms)

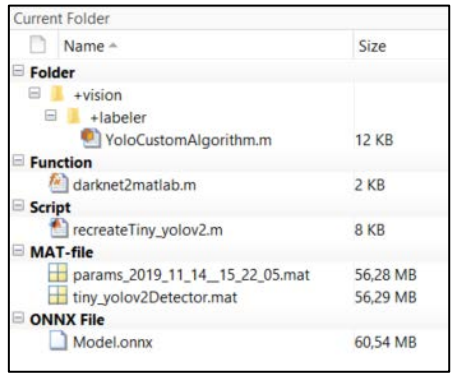


Dataset creation → Dataset Augmentation → Multiple YOLOv2 Training → Network Evaluations

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 → (back to Use Detector in Video Labeler app)

Time only manual labeling

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

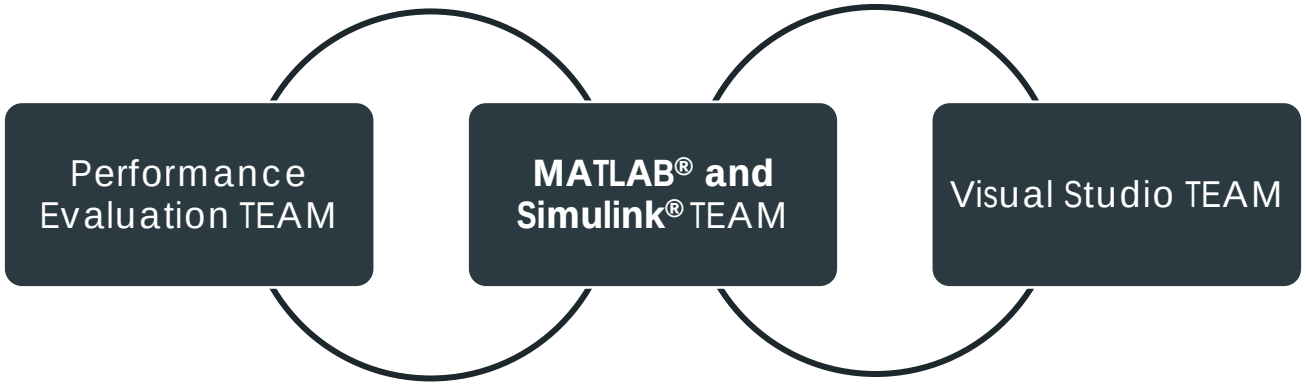
VS.

Above process with detector obtained after 16 hrs of work

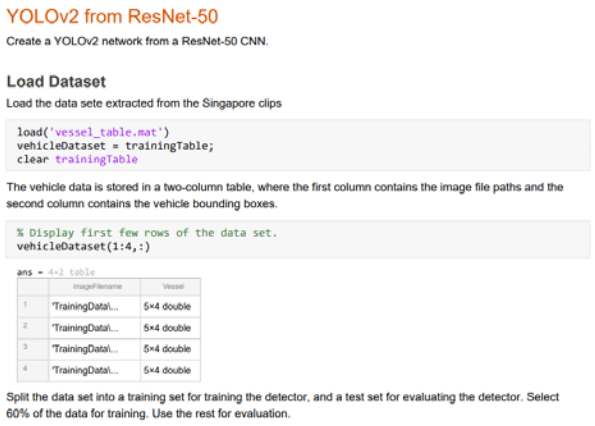
0,3 sec/frame **x** 5000 frame ~= **30 min**

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

Speed Up the Process: Intra-Team Exchanges



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

- GPU coder automatically generates from the same function generic .dll or specific .cu code, NVIDIA hardware is available
- The code and the necessary libraries can be integrated with no effort in Visual Studio thanks to *packNGo* **MATLAB®** function

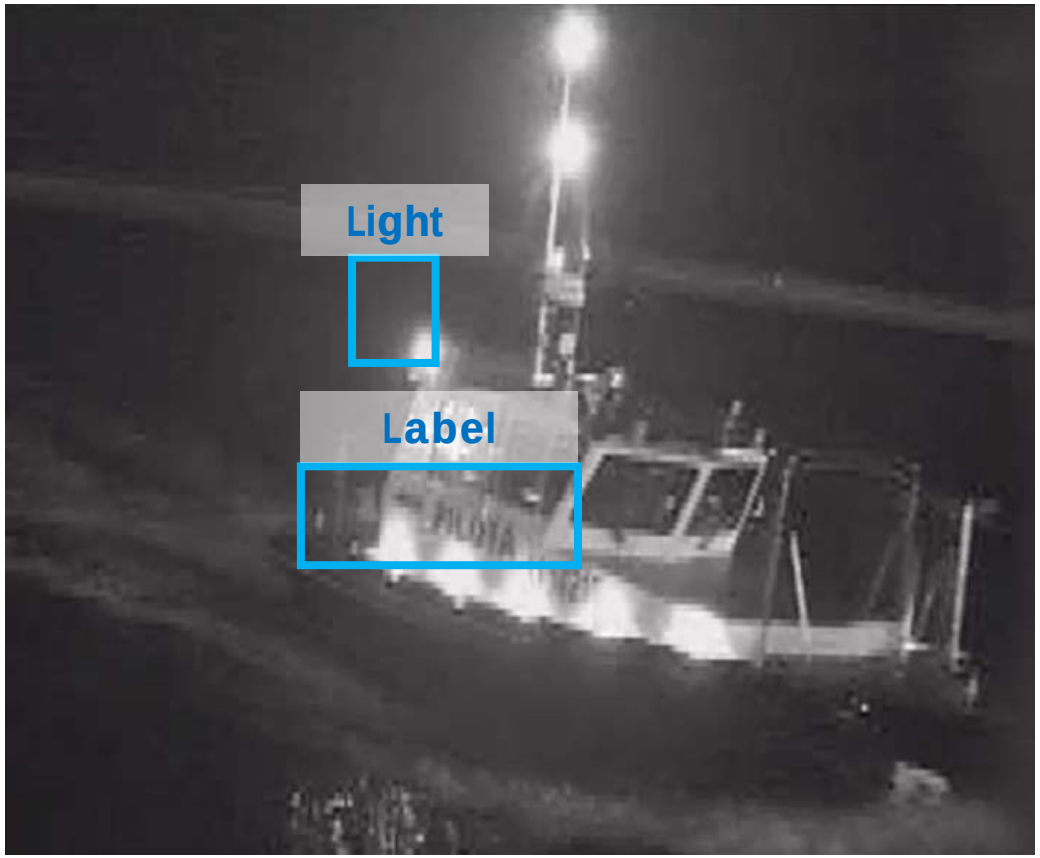
Video Stabilization

Original Source

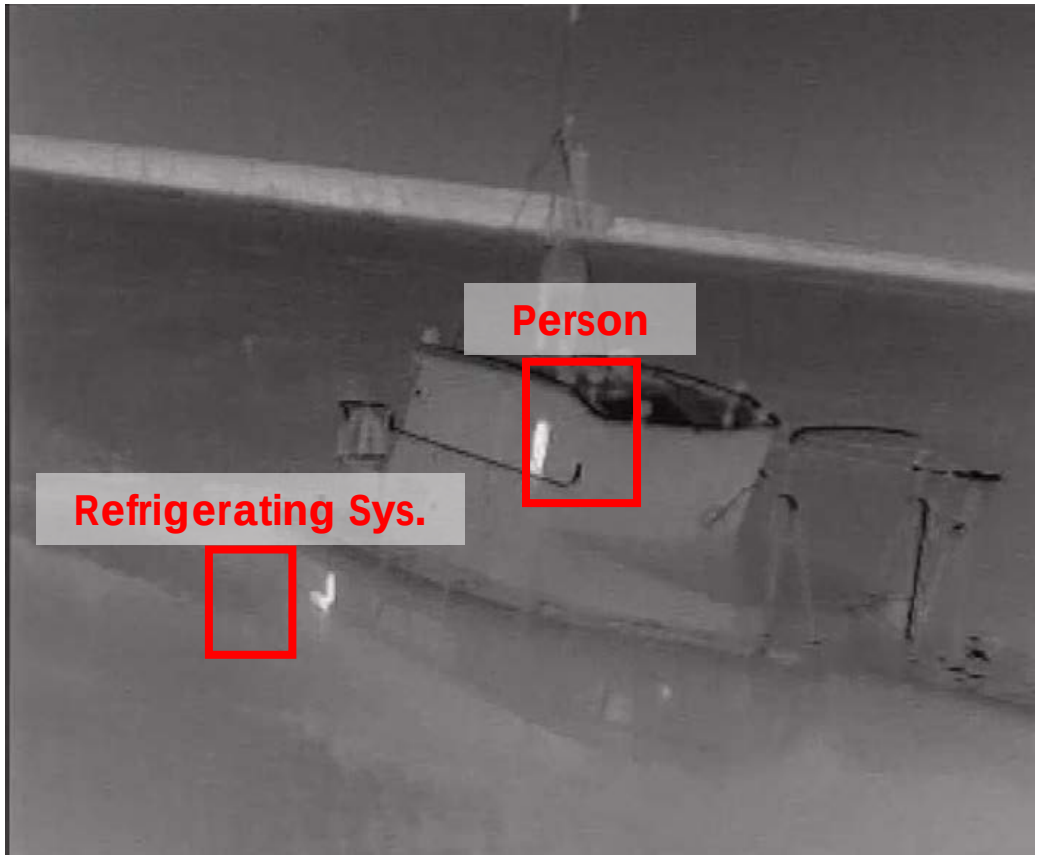
Stabilized Source

Sensors Merging

Daylight Camera

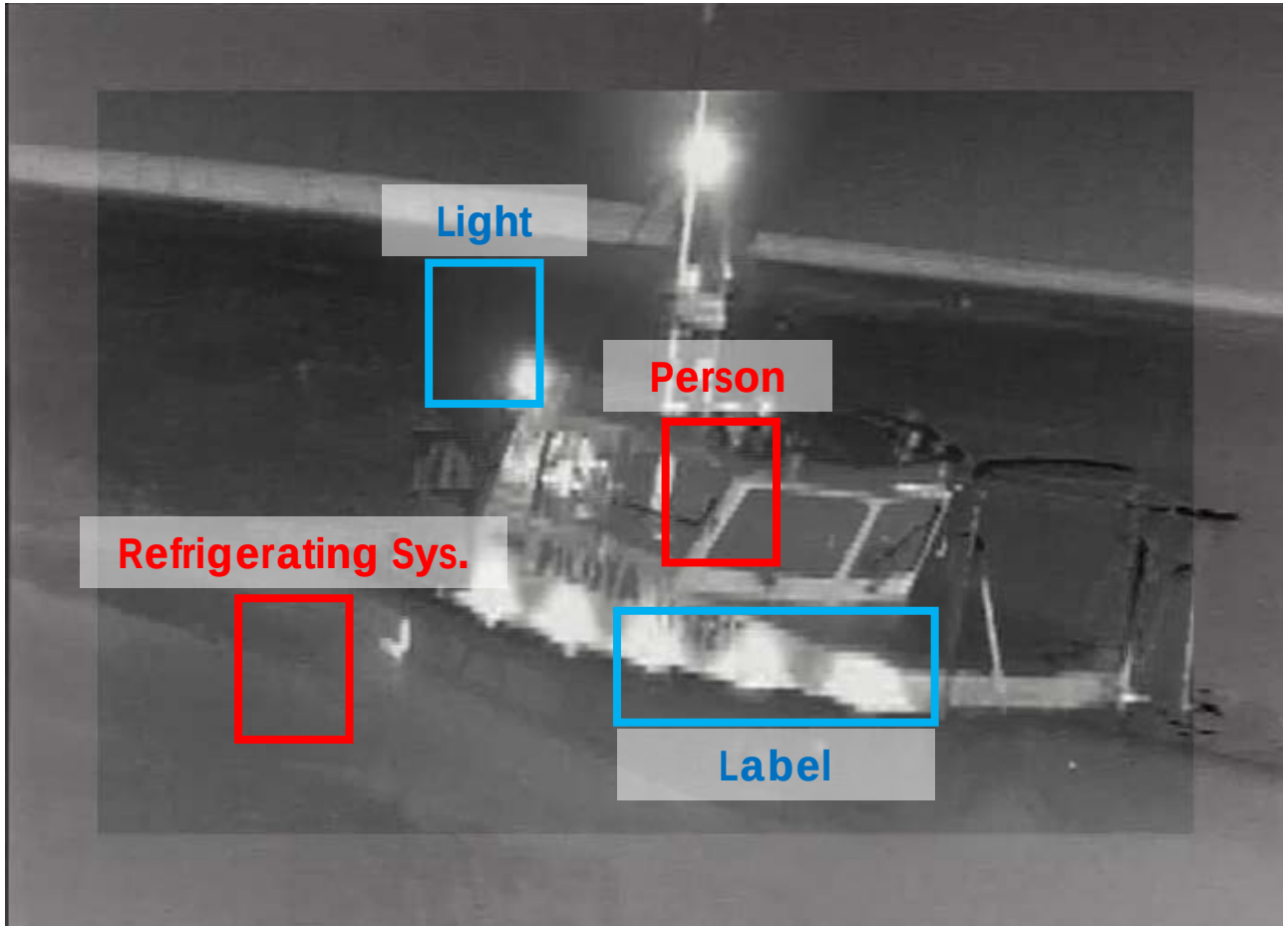


IR Camera



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