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
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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
INTRODUCTION

DRASS Company

DIVING & SIMULATOR
- Deep Diving
- Surface Diving
- Modular Systems

DEFENCE SOLUTIONS
- Midget Submarine
- Compact Submarine
- Swimmer Delivery Vehicle

SUBMARINE RESCUE SYSTEMS
- Resident Rescue System
- Deployable Rescue System
- Submarine Ventilation

ENGINEERING & TESTING
- Spares and Components
- Repair and Maintenance
- Training Centre

GLOBAL SERVICE
- Consultancy
- Laboratory and Experimental

INDUSTRIAL
- Tunneling Hyperbaric Chambers
- Industrial Pressure Vessels

MEDICAL HOT SERIES & SCUBA
- Medical Hyperbaric Chambers
- Scuba Diving Chambers
- Diving Boats

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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
Augmented Reality Tracking System is an optronic system software for maritime surveillance capable of:

- Video Flow Stabilization
- Obstacle Awareness
- Object Detection
- Multi-Spectra Video Merging
Motivation & Goals

Motivations:
1. Low availability of advanced image processing systems in maritime applications
2. Requirement implementation from field scenarios
3. Wide range of maritime applications

Goals:
1. SEA PATROLLING OPERATOR SUPPORT
2. AUTOMATIC THREAT DETECTION
3. ON-BOARD SYSTEM INTEGRATION
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

Implementations by means of KPI

Function workflow management

Code generation

V&V

Parallel Computing Toolbox

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

Process & Tools
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
(Leaning 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**

- Time only manual labeling
  
  3 min/frame × 5000 frame ≈ 249 hrs

- Above process with detector obtained after 16 hrs of work
  
  0.3 sec/frame × 5000 frame ≈ 30 min
  
  30 sec/frame × 5000 frame ≈ 42 hrs

VS.

Checking and discarding incorrect GTs
Speed Up the Process: Intra-Team Exchanges

**LIVE SCRIPTS**
- YOLOv2 from ResNet-50
  - Load Dataset
  - 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
RESULTS

Sensors Merging

Daylight Camera

IR Camera

Light

Label

Person

Refrigerating Sys.
Sensors Merging

Merging

Light

Person

Refrigerating Sys.

Label
Tracking & Obstacle Awareness

Container Ships Detection & Tracking

Obstacle Awareness

Source Video from Singapore Maritime Dataset (SMD)
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