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# AI-Driven Person Detection for Maritime Search and Rescue

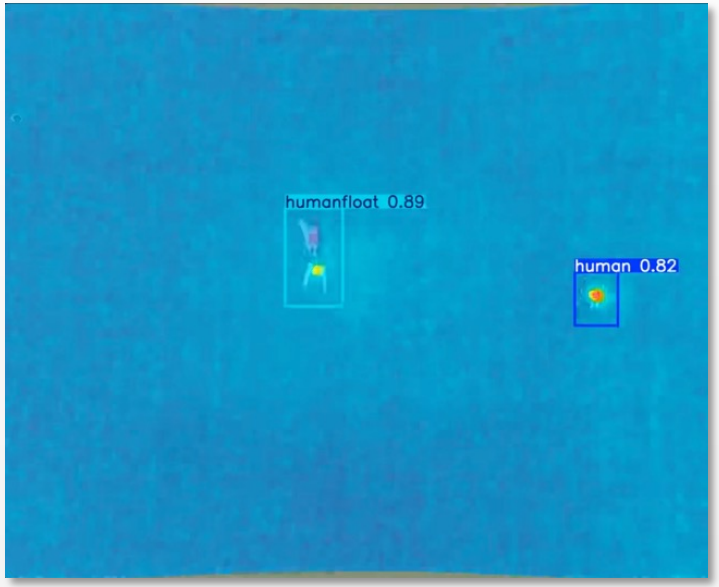
Advanced Real-Time Thermal Imaging with YOLO

October 2025

# Executive Summary

Maritime Search and Rescue (SAR) operations are among the most demanding at sea, where unpredictable conditions, poor visibility, and vast search areas mean survival in a man-overboard situation depends on seconds, not hours. Traditional methods, reliant on human observation, expose rescuers to fatigue and error, often leading to missed detections when time matters most.

This white paper introduces an AI-enabled detection system that uses YOLO-based object detection on thermal drone imagery (iron hot) to enhance real-time SAR effectiveness. Trained on more than 10K manually annotated thermal images, the model demonstrates exceptional precision and recall, achieving near-instant inference suitable for edge deployment. While further work is needed to optimize for hardware and environmental diversity, this research establishes a credible foundation for integrating AI into operational maritime SAR frameworks.




**Key Achievement**: Precision and recall rates of **0.97** and **0.96** respectively, demonstrating near-perfect detection capabilities in controlled conditions.

# The Problem: Why SAR Needs AI

**308**

**MAIB Incidents**

Man-overboard incidents reported between 2015-2023 in UK waters

**40%**

**Fatality Rate**

Percentage of incidents resulting in loss of life

**227**

**US Coast Guard**

Incidents reported in 2023 alone across American waters

Between 2014 and 2023, the UK's Marine Accident Investigation Branch reported 308 man-overboard incidents with a devastating 40% fatality rate. The US Coast Guard reported 227 incidents in 2023 alone, with fatalities consistently linked to delayed detection and response times.

Survival rates plummet dramatically in cold or rough seas, where hypothermia can set in within minutes of immersion. Yet despite these stark statistics and the critical nature of time in SAR operations, detection still relies overwhelmingly upon human observation – from bridge watchkeepers scanning the horizon to helicopter crews conducting visual searches.

> *"Even in technologically advanced navies, detection remains manual, inconsistent, and error-prone. The stakes are clear: time is survival, yet humans remain the weakest link in the SAR chain."*

# Our Research: An AI-Enabled Detection System

This comprehensive study explored how deep learning technologies could augment SAR operations using thermal drone imagery, combining practical maritime expertise with cutting-edge computer vision techniques. The research methodology encompassed multiple critical stages designed to create a robust, real-world applicable detection system.

01

## Data Acquisition

A controlled field trial conducted at Manvers Lake, South Yorkshire, capturing over 70 minutes of high-quality drone thermal footage from 40 participants under various conditions.

02

## Dataset Development

Creation of over 10,000 meticulously annotated thermal images, including humans with and without flotation devices, plus non-human objects such as ducks and swans to rigorously test false-positive resistance.

03

## Model Selection

YOLOv5 chosen for its optimal balance of speed, accuracy, and computational efficiency, making it ideal for edge deployment in resource-constrained maritime environments.

04

## Training & Optimisation

Iterative training progression across datasets of increasing complexity (50 → 1,000 → 5,000 → 10,000 images), with comprehensive hyperparameter tuning and performance evaluation.

05

## Results Analysis

Precision and recall achieved 0.97 and 0.96 respectively at 10,000 images, with substantial improvements in F1 scores and mean Average Precision (mAP) metrics.

# Key Results

## Model Performance Across Dataset Sizes

| Dataset Size | Precision | Recall | mAP@0.5 | mAP@0.5:0.95 |
|---|---|---|---|---|
| 50 | 0.35 | 0.26 | 0.08 | 0.05 |
| 1,000 | 0.63 | 0.41 | 0.16 | 0.09 |
| 5,000 | 0.87 | 0.77 | 0.47 | 0.29 |
| 10,000 | 0.97 | 0.96 | 0.71 | 0.52 |

*mAP@0.5 (mean Average Precision at IoU threshold 0.5) measures the model's detection accuracy when predicted bounding boxes overlap ground-truth boxes by at least 50%. mAP@0.5:0.95 averages this score across thresholds from 0.5 to 0.95 in 0.05 increments, providing more stringent and comprehensive evaluation of overall detection precision.*

In this research, **Precision** represents the proportion of detections that correctly identify a person in the water – how often the system is right when it says it has found someone. **Recall** measures how effectively the system identifies all persons present – how many true cases are successfully detected overall. High Precision reduces false alarms, while high Recall ensures no survivor is overlooked; balancing the two is critical in SAR operations where both missed detections and false positives carry serious consequences.

Model performance improved significantly with dataset size, particularly between 1,000 and 5,000 images. Beyond 10,000, gains plateaued – indicating that data diversity, not quantity, will drive future improvements. These results show that high-accuracy, low-latency detection is achievable without costly infrastructure – making AI-assisted SAR a practical reality for vessels of all sizes.

# Practical Implications for Maritime SAR

The model's high recall and near-real-time inference open new possibilities for maritime operations:

### Enhanced Survivability

Faster, more reliable detections significantly reduce the risk of missed causalities, directly improving survival outcomes in time-critical SAR scenarios. Every second saved in detection translates to improved survival rates.

### Reduced Cognitive Burden

AI augments human operators by intelligently filtering environmental noise and prioritizing genuine detections, allowing SAR personnel to focus their expertise on rescue coordination rather than visual scanning.

### Integration Ready

Designed for deployment on low-power edge devices, the model delivers reliable performance without dependence on high-end GPUs – enabling seamless integration into existing vessel systems.

### Operational Reach

Designed for low-bandwidth environments where connectivity is limited. The system processes data locally, ensuring reliable performance even in remote or disconnected maritime operations.

By combining AI inference with human judgement, the system enhances decision-making when seconds matter.

> *"In SAR, AI won't replace the crew – but it can empower them. When every second matters, intelligent systems extend human capability, turning awareness into action."*

# Challenges & Future Research

Whilst results demonstrate highly promising capabilities, real-world deployment demands comprehensive additional research and development across multiple critical domains. The transition from controlled laboratory conditions to operational maritime environments presents unique challenges requiring systematic investigation.

### Edge Deployment Validation

Live benchmarking on embedded edge devices including Jetson Xavier NX and Jetson Orin platforms, with TensorRT acceleration optimization for real-world power and thermal constraints in maritime environments.

### Environmental Variability

Expanding datasets to encompass fog, rain, wave occlusions, varied salinity conditions, and extreme weather scenarios that commonly challenge SAR operations in operational contexts.

### Interface Development

Advancing the intelligent user interface that delivers actionable alerts and situational awareness without overwhelming operators during high-stress emergency response scenarios.

### Sensor Fusion

Combing thermal imagery with RGB cameras, radar systems, GPS, and AIS data streams to improve detection reliability, enable smart searching and reduce false positives in complex maritime environments.

### Operational Trials

Collaborative testing programmes in genuine SAR conditions to validate performance under operational stress and situational complexities.

# Conclusion

This project conclusively demonstrates that AI-enabled SAR detection is not theoretical. With precision and recall approaching near-perfect scores of 0.97 and 0.96 respectively, YOLO-based models show remarkable potential to outperform conventional human-led methods, offering a genuine step change in maritime safety capabilities.

### Proven Technology

AI detection systems achieve near-perfect accuracy whilst maintaining real-time performance requirements for operational deployment.

### Human Enhancement

Technology augments rather than replaces SAR personnel, dramatically enhancing their decision-making capabilities in critical situations.

### Life-Saving Impact

Faster, more reliable detections directly translate to improved survival outcomes and reduced fatalities in maritime emergencies.

AI will not replace SAR personnel, but it can dramatically enhance their ability to act decisively in life-or-death situations. By bringing artificial intelligence to the “Coal Face” of maritime operations, we can substantially increase survivability rates and deliver the next generation of autonomous, life-saving technologies that maritime professionals desperately need.

The implications extend far beyond individual rescue operations. This technology represents a fundamental shift towards intelligence, data-driven SAR capabilities that can operate consistently in conditions where human performance naturally degrades. As we advance towards operational deployment, the potential to save lives through AI-enhanced detection becomes increasingly tangible.

# Opportunity

With technical validation complete, Coal Face AI is now progressing towards prototyping and live maritime deployment. We are seeking strategic partners, operational collaborators, and innovation investors to help scale this capability and bring AI-driven person detection to real-world SAR operations.

Opportunities include:

- Proof-of-concept trials with maritime and defence partners
- Funding and co-development collaborations
- Integration and licensing discussions for OEM vessel systems

Beyond this project, Coal Face AI welcomes collaboration on innovative ideas of any scale. From early stage concepts to complex technical challenges, we partner with organisations to explore, develop, and deliver practical AI solutions that make a real-world impact.

For partnership or investment enquiries, contact hello@coalface.ai

# About Us

Coal Face AI exists to bring the transformative power of artificial intelligence to the front lines of business and safety-critical operations. Founded by Thomas Wilson, leveraging over 20 years of naval experience combined with an MSc in Computer Science with AI, blending practical maritime expertise with cutting-edge AI capabilities.

Our mission centres on developing AI solutions that work in real-world conditions, not just laboratory environments. We understand that operational success demands more than theoretical performance – it requires systems that perform reliably under pressure, in challenging conditions, and with the lives depending upon them.

## Our Specialisations:

- AI Consultancy
- Bespoke software delivery
- Working with Defence, Maritime and Industry

Get In Touch

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