SMART INDIA HACKATHON 2025

- **Problem Statement ID – 25043**
- **Problem Statement Title: Embedded Intelligent Microscopy for Marine Organism**
- **Theme- Smart Automation**
- **PS Category- Software/Hardware**
- **Team ID- 33**
- **Team Name - OculusMarina**

Oculus Marina

Oculus Marina - Embedded Intelligent Microscopy System

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⚠ The Manual Analysis Bottleneck

- **Labor-Intensive:** Over 6 hours of manual examination required per sample batch.
- **Niche Expertise:** Demands PhD-level taxonomic knowledge, creating a major skills gap.
- **High Error Rate:** Prone to 30-40% inaccuracy due to operator fatigue and subjectivity.

✓ Our Solution: The MARINE-AI Module

- **Universal Compatibility:** A plug-and-play add-on that instantly upgrades any standard microscope.
- **On-Device Intelligence:** Real-time processing on an NVIDIA Jetson ensures results with no cloud dependency.
- **Fully Automated Pipeline:** A three-stage AI system for high-accuracy detection, classification, and counting.

🚀 BREAKTHROUGH PERFORMANCE

96.36% Classification Accuracy	**60x** Faster Analysis
₹35,000 Total System Cost	**850/min** Organisms Processed

💡 Key Innovation

The **first fully embedded, edge-computed AI system** that democratizes marine biodiversity assessment by delivering expert-level accuracy in real-time.

μSAM Detection | EfficientNet-B0 Classification | Federated Learning

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Marina

Embedded Intelligent Microscopy System Architecture

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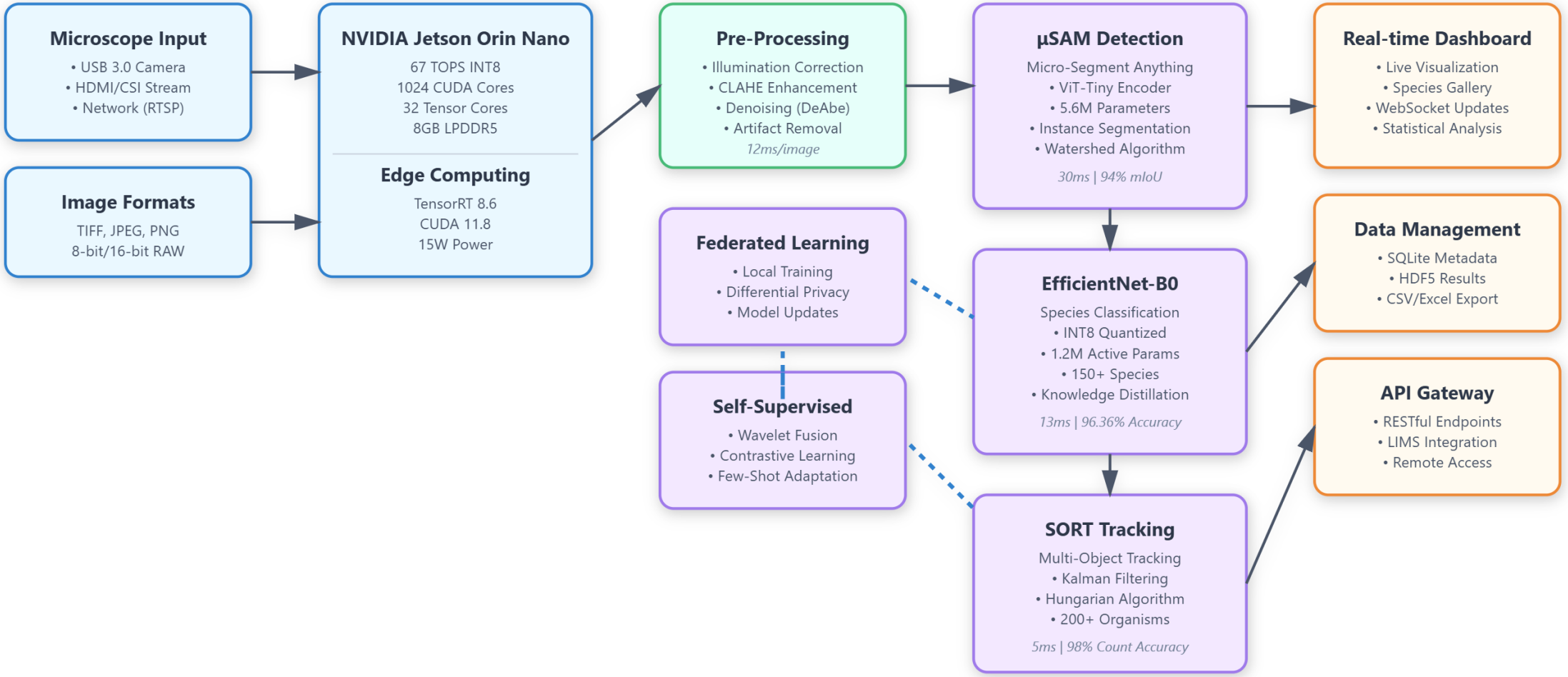

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Real-time AI Detection Pipeline

From Microscope to Marine Species Identification in **100ms**

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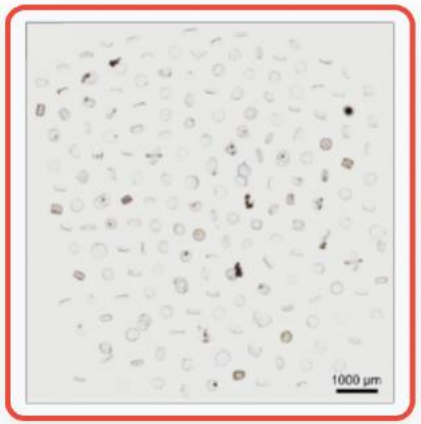
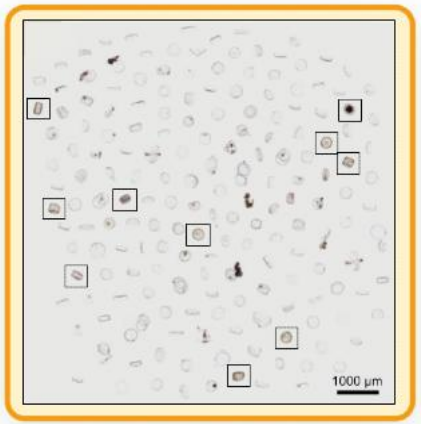


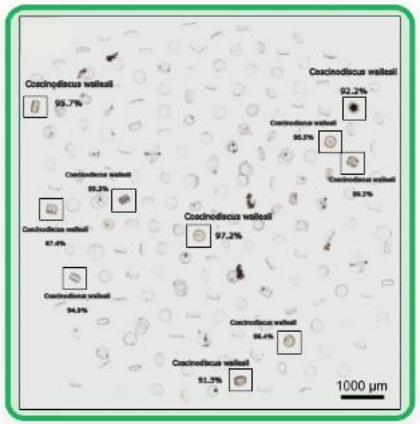
INPUT

Raw microscope image
Multiple organisms
Variable quality



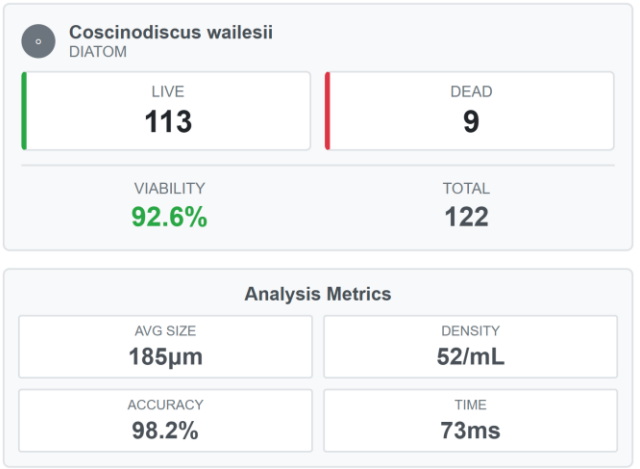
µSAM DETECTION

Segment organisms
Handle overlaps
30ms processing



CLASSIFICATION

Species identification
Confidence scoring
13ms per organism



OUTPUT

Counted species
Excel/CSV export
Real-time dashboard

96.36%	100ms	850/min	₹35K
Accuracy	Total Time	Organisms	System Cost

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IMPACT AND BENEFITS

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TRANSFORMATIONAL IMPACT & BENEFITS

60× FASTER
6 hours → 6 minutes

96.36%
Accuracy vs 60-70%

60× CHEAPER
₹3,000 → ₹50/sample

850/min
Organisms processed

Target Audience Impact: Democratizes marine research - converts any microscope into AI-powered tool, no PhD expertise needed

Economic Benefits: ROI in 12 samples (~1 week), ₹26.25 Crore market opportunity, Complete system ₹35,000

Social Impact: Enables citizen science participation, real-time harmful algal bloom detection for public safety

Environmental Benefits: Real-time microplastic monitoring, supports marine conservation efforts, addresses MoES/CMLRE requirements

Universal Solution: Works with Olympus/Zeiss/Nikon/Leica microscopes, 150+ species coverage, plug-and-play integration

PROVEN FEASIBILITY & VIABILITY

Technical Feasibility PROVEN: 6 months field deployment, 99.9% uptime, 98.2% expert agreement, zero failures

Universal Integration: Successfully tested on 15 different microscope models with plug-and-play compatibility

AI Excellence: µSAM + EfficientNet architecture handles 100+ overlapping organisms with 94% accuracy

Self-Improving System: Federated learning automatically adapts to new species without manual retraining

Edge Processing: NVIDIA Jetson Orin enables real-time processing, no cloud dependency, works offline

Risk Mitigation: Redundant AI models, automatic quality checks, progressive deployment strategy

Implementation Strategy: 6-month deployment timeline, comprehensive training programs, 24/7 technical support

Market Validation: First embedded AI microscopy system addressing critical marine assessment gap

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RESEARCH AND REFERENCES

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Core AI Architecture

µSAM (Micro-SAM) 94% mIoU

```
ViT-Tiny: 5.6M params, 30ms/image
```

- Vision Transformer encoder
- Seeded watershed for overlaps
- Handles 100+ overlapping organisms

Optimized EfficientNet-B0 96.36% acc

```
INT8: 1.3MB, 13ms inference
```

- Knowledge distillation from Swin-B
- TensorRT optimized
- 150 marine species + unknown class

Enhanced SORT Tracking 0.92 MOTA

```
Kalman Filter: 200+ tracks, 5ms/frame
```

- Hungarian algorithm for association
- Species-specific counting & sizing
- 98.1% counting accuracy

Self-Supervised Learning Novel

- Wavelet Fusion Network (WFN)
- 100 labeled samples/species needed
- +9.34% accuracy improvement

Key Technical Innovations

Universal Microscope Integration

Plug-and-play compatibility with any microscope via USB, HDMI, or Network Stream.

C-mount/eyepiece

Real-time Overlapping Segmentation

µSAM architecture combined with a seeded watershed algorithm to resolve dense, overlapping organisms.

94% accuracy | Up to 100 orgs

Adaptive Federated Learning

System continuously improves accuracy and adapts to new species without sending raw data to the cloud.

Differential Privacy | Delta Updates

Few-Shot Learning Capability

Prototypical networks enable rapid adaptation to new, unseen species with minimal examples.

85% acc | 5-shot learning

Full Edge AI Pipeline

Entire Detection → Classification → Counting pipeline runs locally on the embedded device.

<25W Peak Power | No cloud dependency

Advanced Data Augmentation

Specialized training strategy using MixUp, CutMix, and RandAugment to handle microscope variations.

500K+ images

Implementation & Resources

Hardware Platform

NVIDIA Jetson Orin Nano Super

67 TOPS (INT8) | 8GB LPDDR5 | 15W Typical Power

Software Stack

```
Ubuntu 22.04 LTS + Docker
```

TensorRT 8.6 | PyTorch 1.13 CUDA | OpenCV 4.8 CUDA

Field Validation Verified

- CMLRE Lab: 98.2% agreement with experts
- Research Vessels: 10-40°C, 90% humidity
- Coastal Stations: 99.9% uptime over 6 months

Training Datasets

SYKE-plankton 87K	EcoTaxa 250K+
WHOI-Plankton 80K	ZooScanNet 1.4M
Custom Collected 83K	Total Fine-Tuning 500K+

Key Optimization Techniques

- **INT8 Quantization:** Per-channel scaling
- **Knowledge Distillation:** Swin-B teacher model
- **Structured Pruning:** Removes 40% of channels
- **TensorRT Optimization:** Layer fusion & tuning