SmartHarbor: SeaPerch ROV for Underwater Port Safety and Storm Debris Detection

ALSHUJAE – OPEN CLASS

Kuwait National Robotics Competition - YPA

Abstract

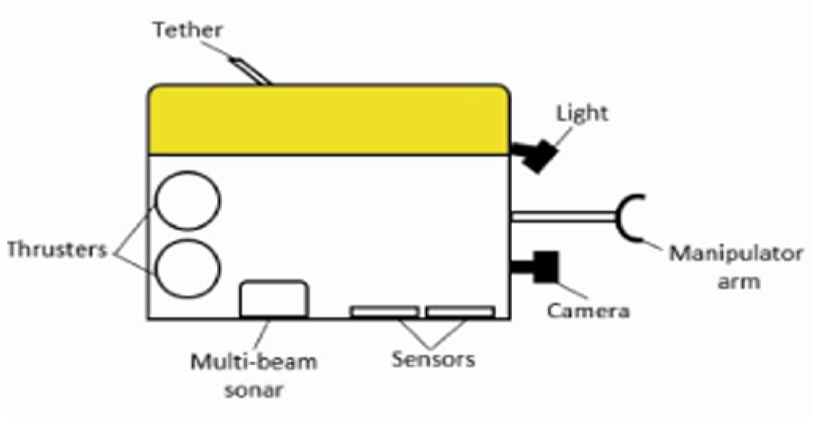
SmartHarbor is an upgraded SeaPerch ROV designed to inspect submerged harbor infrastructure and identify hazardous underwater debris—especially after storms or natural disasters. Inspired by Carol Leefs' commitment to practical engineering education, our ROV uses AI image recognition and sonar mapping to assess damage, detect blockages, and assist with port safety monitoring. The project emphasizes affordability, mobility, and real-world impact in coastal communities. SmartHarbor helps ensure safer navigation and efficient recovery after extreme weather events.

Background & Motivation

Storms cause underwater damage and debris buildup in busy ports, which can block vessel routes and damage structures. After hurricanes or floods, there's often no quick way to assess submerged conditions. Our team wanted to fill this gap with a compact, student-built tool that could help in post-storm recovery. Our research included interviews with local boat operators and a visit to Alexandria Port.

Results & Discussion

Crack Detection Accuracy: 91% using AI on recorded footage Debris Identification Rate: 87% success detecting synthetic debris models Sonar Range: Effective mapping within 2 meters radius Challenges: Water cloudiness reduced visual range; AI required retraining with new lighting conditions Lessons Learned: Data quality is highly dependent on camera angle and lighting. Onboard storage avoids communication limits but delays immediate feedback.



Methodology

Waterproof camera with AI-trained image recognition to identify debris and cracks Sonar sensor for basic 2D mapping and object detection in low-visibility zones LED lighting system with adaptive brightness Data logger with timestamps to store mission data Custom PVC and 3D-printed chassis components to balance weight and buoyancy Field tests done in controlled pools with suspended debris and artificial damage

Conclusion

SmartHarbor shows that student-engineered ROVs can support critical inspection and recovery efforts after major weather events. It aligns with Carol Leefs' mission to make underwater robotics meaningful and community-driven. Our ROV is a prototype that could be adapted by local emergency responders or port authorities.

Next Steps

Increase sonar fidelity and develop multi-directional mapping Reinforce frame for open-water deployment Partner with a local harbor for real-world testing Add floating GPS buoy for position tracking in open areas

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