Smart Marine Cleanup Robot

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Abstract

The sea, once a cradle of life and a mirror of the sky, is now stained with the dark fingerprints of human carelessness. Oil spills float like silent poison, choking marine life and clouding the water with sorrow. These black tides don't just harm creatures beneath the surface, they ripple into our lives, damaging nature, health, and hope. To heal this wound, we created a robot that gently glides across the water's surface, carrying a cellulose sponge that drinks in the oil but leaves the water untouched. And like a helping hand, it sprays a safe dispersant to break the oil's grip before collecting it. Our project is a step toward giving the sea its breath back, quietly, gently, and sustainably.

Background

Marine oil pollution is one of the most serious environmental threats, as it forms a barrier on the water's surface that blocks sunlight and reduces oxygen levels. This leads to the suffocation of marine organisms and the destruction of vital ecosystems such as coral reefs.

In our project, we focused on safe and effective techniques to address this type of pollution by using two main materials:

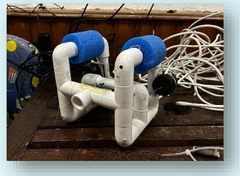
•**Tween 80:** A chemical dispersant commonly used in the food and pharmaceutical industries, making it low in toxicity and environmentally safe. It works by reducing the surface tension of the oil, breaking large oil slicks into smaller droplets that can be more easily absorbed or biodegraded by microorganisms.

•**Cellulose sponge**: Made from natural plant-based fibers, it has the ability to selectively absorb oil without taking in water, due to its hydrophobic and oleophilic properties. It is also biodegradable, making it an eco-friendly option.

By integrating these two components into a surface-walking marine robot, the project provides a highly efficient, environmentally responsible solution for oil spill cleanup—contributing to sustainable efforts in marine environmental protection.

Methodology

To address the issue of marine oil spills, we applied the Engineering Design Process (EDP) as a structured framework for developing our solution. The process included five key phases:



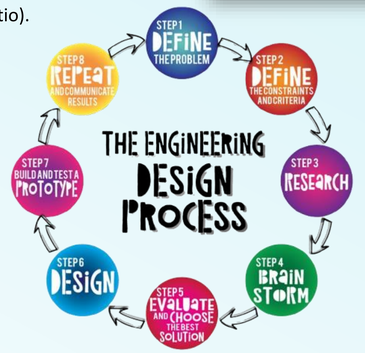
1. Problem Identification & Research
- Studied the environmental effects of oil spills.
- Defined our goal: build a robot that removes surface oil using eco-friendly methods.

2. Ideation & Planning
- Designed a SeaPerch-based robot with:
- Cellulose sponge for selective oil absorption.
- Sprayer system applying a low-toxicity Tween 80 + water dispersant (1:10 ratio).

3. Design & Simulation
- Built the layout in TinkerCAD.
- Modeled robot behavior in SeaPerch environment.
- Optimized sponge & sprayer placement for surface efficiency.

4. Prototype & Testing
- Assembled robot using affordable materials.
- Tested in a simulated spill to evaluate:
- Oil absorption rate
- Dispersant coverage
- Combined removal efficiency
- Stability and movement

5. Iteration & Improvement
- Refined sponge & sprayer placement.
- Enhanced oil detection and energy use.



Discussion

The robot showed strong potential in cleaning up oil spills using a mix of physical absorption and chemical dispersion. The cellulose sponge effectively absorbed oil without taking in water, while the Tween 80 and water dispersant helped break down the oil into smaller droplets, making cleanup easier and faster. Combining both methods improved overall performance. The system worked well in testing, though some challenges included sponge saturation and making sure the sprayer covered the oil evenly. With some small improvements, this robot could become a powerful, eco-friendly tool for protecting marine environments.

Conclusion

After we finished the design, it presents a creative and environmentally friendly way to address marine oil pollution: it is meant to walk on the sea's surface carrying an oil-absorbing sponge. The robot can actively remove oil spills from the surface of the ocean by combining mobility, stability on water, and effective absorption technologies, so lowering environmental damage and safeguarding of marine life. Its capacity to run fleets or independently lets scalable deployment in case of an emergency spill or as a preventative cleaning tool in crowded maritime environments. This idea not only helps to clean the oceans but also marks a progress in environmental preservation and sustainable marine technologies

Next Steps

The next steps for developing the robot begin with researching suitable materials specifically oil-absorbing, water-repellent sponges and lightweight, buoyant structures that allow it to move across the sea surface. This is followed by designing and building a small-scale prototype that can balance on water while effectively collecting oil. The robot will be equipped with navigation tools such as GPS and oil-detection sensors to enable smart movement and targeting of pollution zones. Afterward, it will undergo controlled testing to refine its stability, absorption capacity, and efficiency. An environmental safety assessment will ensure it poses no harm to marine ecosystems and complies with regulatory standards. Once validated, the robot will be deployed in real-world pilot trials to demonstrate its performance, paving the way for large-scale production and collaborations

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