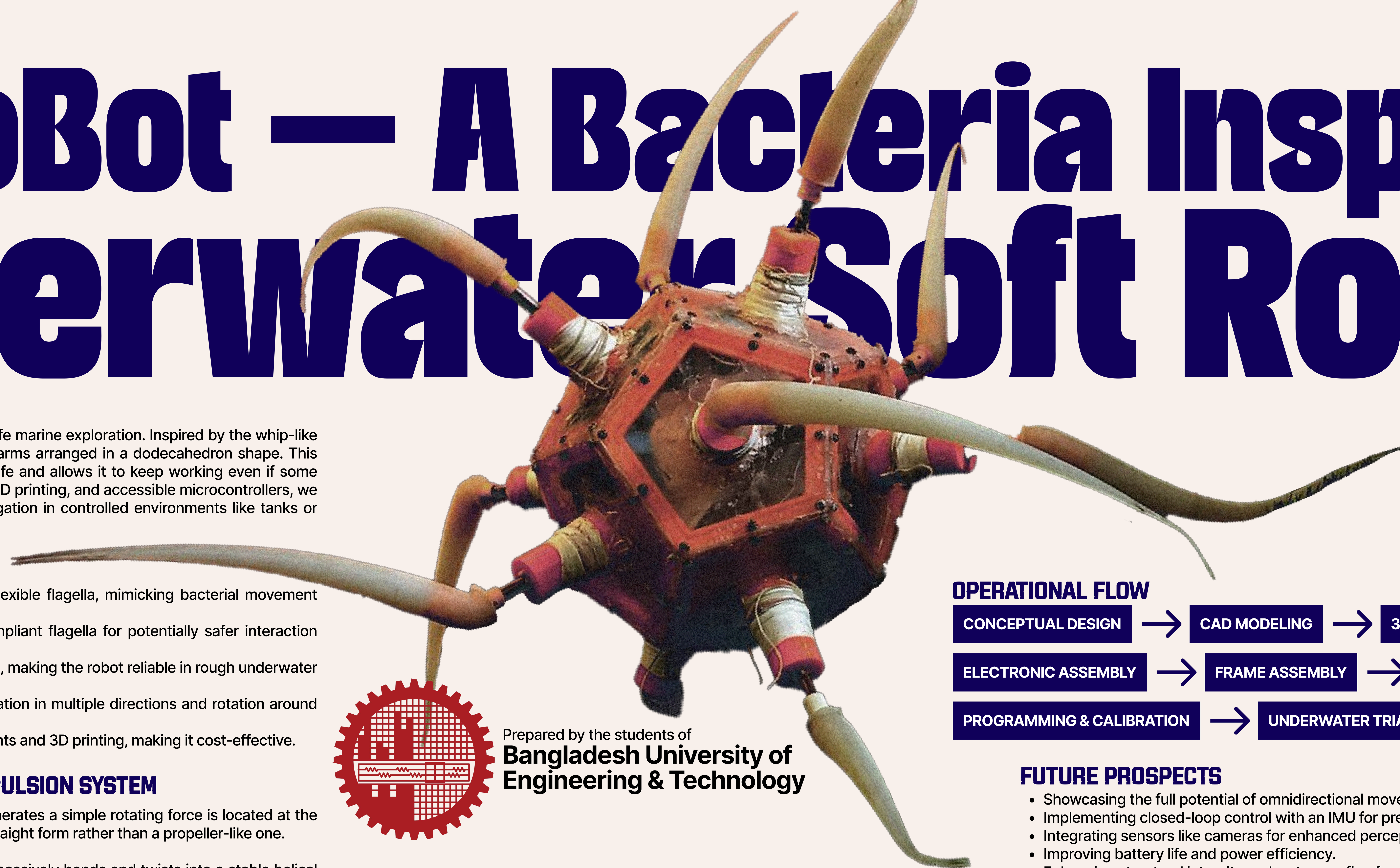
BactoBot — A Bacteria Inspired Underwater Soft Robot



ABSTRACT

BactoBot is a soft underwater robot designed for safe marine exploration. Inspired by the whip-like tails (flagella) of bacteria, BactoBot has 12 flexible arms arranged in a dodecahedron shape. This design makes it gentle for interacting with marine life and allows it to keep working even if some arms break. Utilizing readily available components, 3D printing, and accessible microcontrollers, we developed a bot capable of basic underwater navigation in controlled environments like tanks or pools.

KEY FEATURES

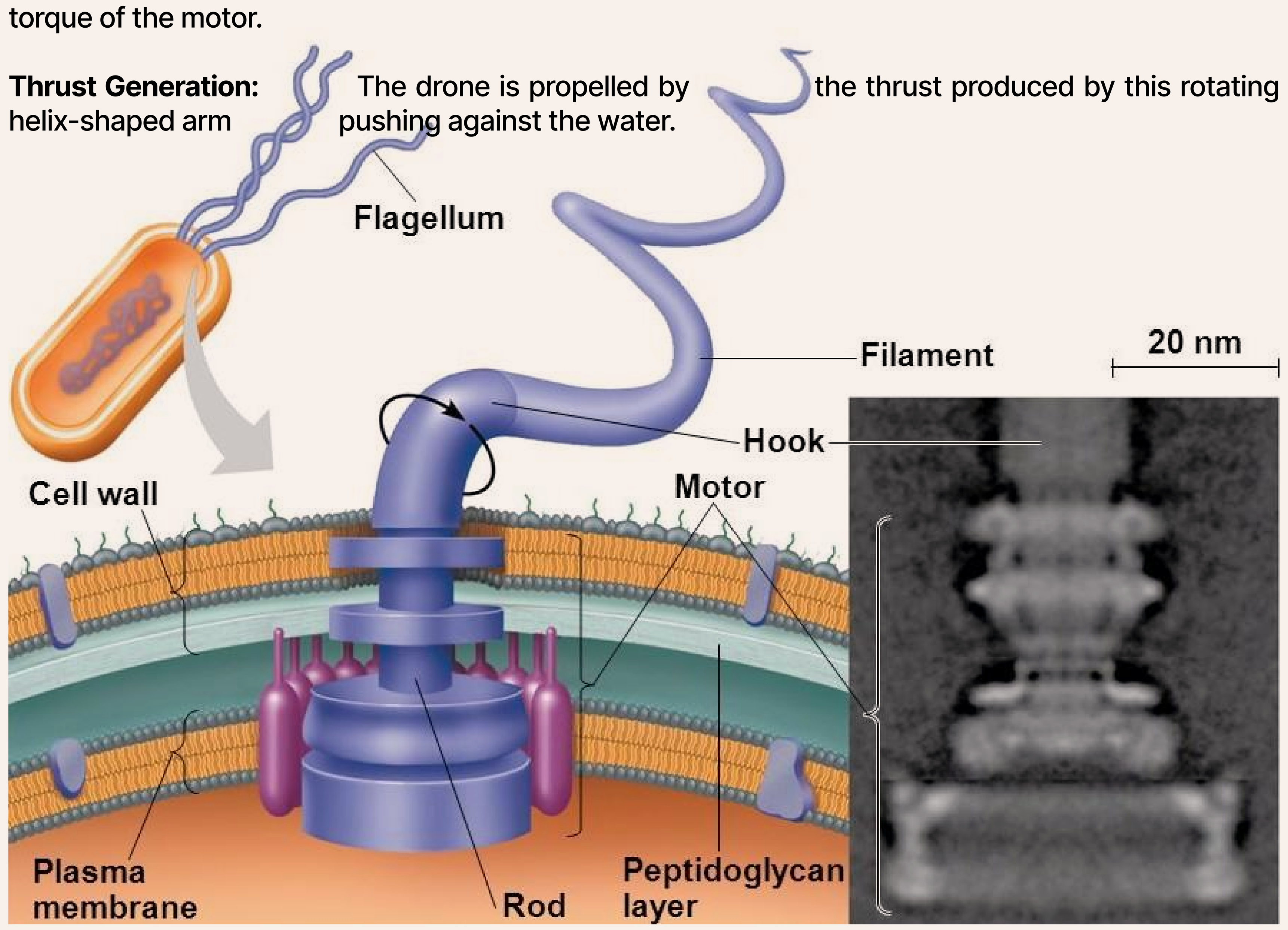
- **Bacteria-Inspired Propulsion:** Utilizes rotating flexible flagella, mimicking bacterial movement for efficient underwater thrust.
- **Soft Robotics Approach:** Incorporates soft, compliant flagella for potentially safer interaction with the environment.
- **Redundancy:** If one arm fails, others compensate, making the robot reliable in rough underwater environments.
- **Omnidirectional Movement:** Designed for translation in multiple directions and rotation around its axis.
- **Low-Cost & DIY:** Built using accessible components and 3D printing, making it cost-effective.

HOW IT WORKS: A FLAGELLAR PROPULSION SYSTEM

Simple Rotation, Complex Motion: A motor that generates a simple rotating force is located at the base of each soft arm. At first, the arm itself has a straight form rather than a propeller-like one.

Passive Deformation of Soft Arm: The flexible arm passively bends and twists into a stable helical shape as the motor spins it in the water. This is due to the hydrodynamic force of the water and the torque of the motor.

Thrust Generation: The drone is propelled by the thrust produced by this rotating helix-shaped arm pushing against the water.



Prepared by the students of
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OPERATIONAL FLOW

CONCEPTUAL DESIGN → CAD MODELING → 3D PRINTING PARTS → ELECTRONIC ASSEMBLY → FRAME ASSEMBLY → WATERPROOFING & TESTING → PROGRAMMING & CALIBRATION → UNDERWATER TRIALS

KEY COMPONENTS & MATERIALS

Microcontroller: Arduino Mega 2560	Motor Driver: BTS 7960 43A	Motors: 12x High Torque DC Geared Motors
Battery: 3300mAh 11.1V 3S Lipo Battery	Power Management: On/Off Slide Switch	Body Structure: 3D Printed Frame (PETG)
Front Faceplate: Acrylic Sheet	Flexible Flagella: Molded Soft Silicone Rubber (Food Grade)	Others: Breadboard, Wiring, Waterproofing Sealants, ballast

CHALLENGES & LIMITATIONS

Waterproofing: Achieving a reliable and watertight seal for all 12 rotating shafts and the main structural body was extremely challenging, especially while working within a limited budget. This was our primary and most persistent engineering challenge throughout development.

Control System: Our current control system is open-loop, meaning we can issue commands to the motors, but the robot receives no feedback on its actual position or orientation. This lack of sensory input causes the system to gradually drift, reducing overall precision.

Buoyancy & Ballast: Precisely adjusting the robot to achieve neutral buoyancy is a slow and iterative process, involving repeated trial and error with different ballast weight configurations. Even small changes in hardware or conditions can require re-balancing.

FUTURE PROSPECTS

- Showcasing the full potential of omnidirectional movement capabilities.
- Implementing closed-loop control with an IMU for precise navigation.
- Integrating sensors like cameras for enhanced perception.
- Improving battery life and power efficiency.
- Enhancing structural integrity and waterproofing for deeper operation.
- Developing autonomous navigation capabilities.

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