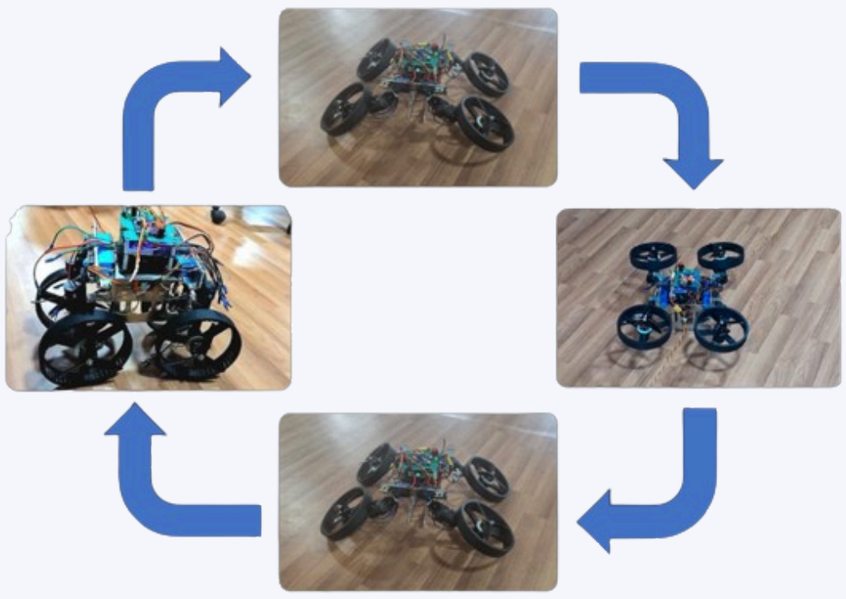
EVOBORNE

An Autonomous Human-friendly Multi-Terrain Scaling Morphobot

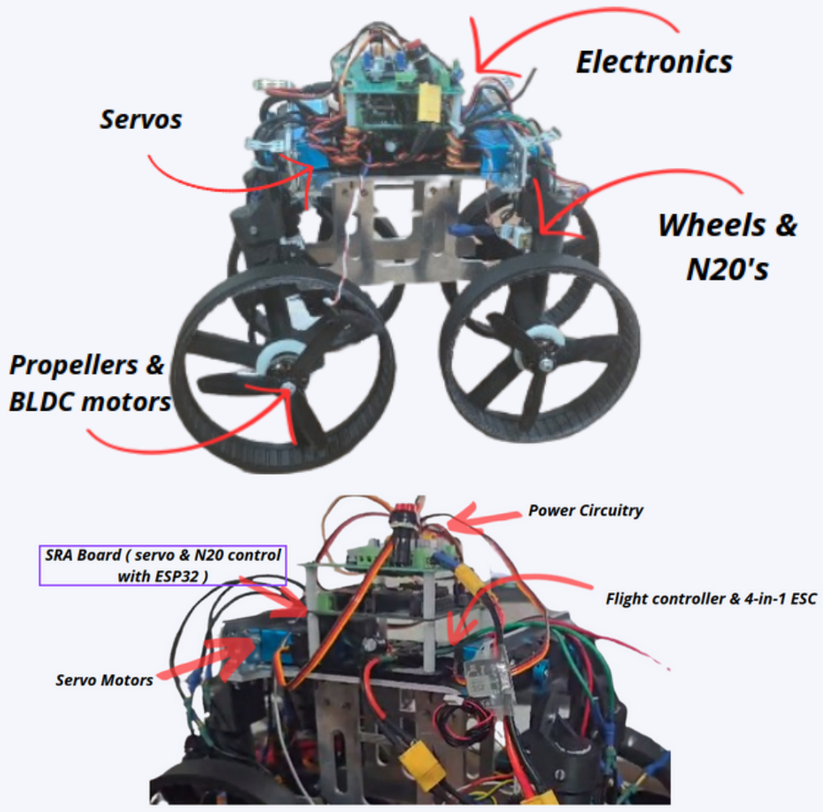


Aim:

We are building a multi-terrain modular robot (EvoBorne, inspired by Morphobot M4) designed to seamlessly adapt to diverse surface and aerial environments, effortlessly transitioning between wheeled locomotion and drone capabilities.. It can navigate as a wheeled robot as well as morph into a drone. Equipped with advanced visual SLAM technology, our robot conducts precise mapping during dry runs in controlled laboratory settings, employing sophisticated path planning algorithms like 3D A-star for optimal navigation. Localization is achieved through vision-based methods, enhancing spatial awareness and accuracy.

Introduction:

The EvoBorne was designed, assembled and tested entirely from scratch in 45 days. was designed, assembled and tested entirely from scratch in 45 days. It has four single DOF arms, thus giving it the capability to act as a limb. The bot comes with a thruster attached to the end of the limbs which provides it with the maneuvering capabilities of a drone. The main feature of the solution is that our bot can change its form as per the conditions. It can be driven on the ground for terrain-based tasks and if the path planner requires its movement in the vertical axis, it morphs into a drone and hovers to a given height. Our solution will include a camera that will be used to map the surroundings; hence, using this data, the bot will ask the user where they want to go, wait for the user's description of the supplied target and direction, confirm the direction, and head there autonomously. Through the integration of our custom-made PCB's and a specialized robot design, we've substantially elevated the robot's functionality, specifically to meet the demands of rescue operations with utmost effectiveness.



What have we done till now?:

- We are currently carefully evaluating every feature of the EvoBorne, which has been designed and assembled.
- The ability to morph into DRONE and QUAD modes, as well as enable terrain driving, is finished while flying is in progress.
- We tested two different flight controllers (Pixhawk 2.4.8 and SpeedyBee F405 V3) with three different autopilot firmwares (PX4, Ardupilot, and Betaflight), but we were still unable to get the expected navigational outcomes in DRONE mode.
- We have used ROS Noetic, which is running on the NVIDIA Jetson Nano for path planning algorithms, to map our workspace lab using the RealSense D435i camera.
- The PCB design, which includes the power circuits for every onboard component and a mounting platform for the ESP32 MCU, onboard Jetson nano, and 4-in-1 ESC, is also ready to be manufactured.
- Our goal is to replace the flight controller with an in-house flight controller that will manage the flight via ESP32. By creating and evaluating a DSHOT protocol for BLDC control, we have already made headway toward this goal.

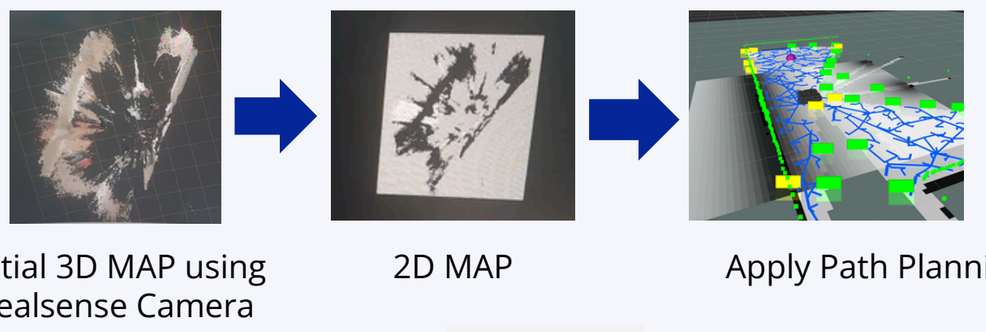


*Image only for representational purpose

Potential:

The EvoBorne exemplifies a groundbreaking leap in efficient movement by seamlessly integrating aerial & terrestrial motion capabilities.

- **Autonomous Navigation :** Ability to map its surroundings and autonomously navigate the terrain, switching modes as and when required.The robot's navigation capabilities need to be rigorously tested and optimized for uneven and challenging terrains.
- **Limbic Flight :** It should maintain normal flight in the event one of the motors/propellers malfunctions. It should do so by compensating the thrust with the other three motors.
- **Design Improvements :** The current design has presented challenges that can be addressed to enhance it further. The propellers and the main body can be encased in a dome-like structure for safety.

Its potential applications span diverse fields such as search and rescue missions, space exploration, agriculture, and disaster response, where robots must navigate challenging and unpredictable terrains with ease.

Problems faced & future actions :

- We had a great deal of difficulty obtaining and producing the chassis, arms, and wheel components as it took weeks for each element to be laser cut or 3D printed.
- Many power-related parts were unavailable at local offline retailers, so we had to order them online and wait days for them to arrive while we assembled the flight controller. This significantly reduced our ability to conduct tests.
- We had to make modifications to our first prototype design since we were running into geometric dimensioning and tolerancing issues and misalignment, which made it difficult for the bot to take off as proper alignment is essential for a successful flight. This caused the flying tests to be postponed until a few weeks after the revised design arrived.
- Inadequate documentation surrounding the Pixhawk board's power management scheme contributed to the event in which an IC burned. In addition to being the cause of the first accident, this incomplete paperwork made it more difficult for us to quickly and correctly identify the damaged parts and replace them.

System Components :

We use SpeedyBee F405 V3 as our main on-board flight controller and a 60 Amp 4-in-1 ESC for controlling the 1700 KV BLDC motors. We have another onboard controller known as the SRA-board , our in-house development board based on ESP32 MCU to handle the servos and N20 motors. The servos are used for morphing/unmorphing and the N20 motors control the wheels for moving on land. It has a custom-designed chassis built keeping in mind the requirements & usage of the robot. A Realsense D435i depth camera is used to map the EvoBorne's surroundings. This data is then processed on the NVIDIA Jetson Nano board . This allows the EvoBorne to effectively perceive its surroundings which is crucial to its motion & stability. The EvoBorne's entire chassis was designed using Solidworks. Although the original plan included utilizing RFIDs from Novanta Inc. for tracking purposes and bearings from Igus, logistical hurdles with importing these items prevented their integration into the project. During flight ,drone control is achieved using a RF remote controller.

Acknowledgements :

- **Multi-Modal Mobility Morphobot (M4)** : *https://www.caltech.edu/about/news/new-bioinspired-robot-flies-rolls-walks-and-more*
- **SLAM with RealSense D435i** : *https://github.com/IntelRealSense/realsense-ros/wiki/SLAM-with-D435i*
- **Society of Robotics and Automation,VJTI:** *https://sravjti.in/*
- **MassRobotics** : *https://www.massrobotics.org/*
- **ESP-Drone** : *https://github.com/espressif/esp-drone*
- **QuillBot Paraphrasing tool**

Github Repository for Evo-Borne:-