ElectroCap Project Proposal

Altitude-Based Position Control for Meteorological Balloons

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1. Advisors and Mentor

- Scientific Advisor:
- Scientific Co-advisor:
- Coordinator: Luís Caldas de Oliveira
- Mentor:

2. Problem definition

Meteorological balloons are widely used for atmospheric observation, providing valuable data on weather, temperature, humidity, and pressure across different layers of the atmosphere. However, one significant challenge with these balloons is that their movement and location are predominantly dictated by the prevailing winds at various altitudes. This lack of control limits their utility, particularly for fixed-point or targeted area observations, where precise positioning is essential. Consequently, even though meteorological balloons are cost-effective and relatively easy to deploy, their effectiveness is reduced by the inability to accurately steer them or control their geographic location.

3. Solution beneficiaries

The primary users of this solution include meteorologists, environmental researchers, and governmental agencies involved in weather forecasting and climate study. This solution could also benefit agricultural planners, disaster management teams, and academic institutions conducting research on atmospheric dynamics.

4. Technological solution

The proposed solution is an altitude-based position control system for meteorological balloons, enabling them to adjust their horizontal position by leveraging wind currents at different altitudes, but at an early stage we will be focusing first in just trying to adjust the altitude manually. This approach integrates hardware and software for real-time monitoring and control of the balloon.

Technologies Used

• GPS: For real-time tracking of the balloon's position.

• Sensors: To measure pressure, altitude temperature etc.

• Microcontroller: To process data and manage altitude adjustments.

• Altitude Control Mechanisms: Utilizing gas release and ballast adjustment.

• Wireless Communication: To transmit data and allow remote control.

How the Solution Addresses Constraints

• Cost-Effectiveness: Utilizes accessible sensors and systems instead of expensive platforms like drones or satellites.

• Accuracy: Continuously adjusts altitude to align the balloon’s movement with the target.

• Energy Efficiency: Minimizes energy consumption through optimized adjustments and lightweight mechanisms.

5. Competitors and previous work

Competitors

- Weather Balloons (Traditional): Widely used by meteorological agencies and research organizations.
- Unmanned Aerial Vehicles (UAVs/Drones): Used for environmental monitoring and localized data collection.
- Satellites: Provide extensive atmospheric and environmental data across large areas.

6. Solution requirements

- Functionality: Enable horizontal control by selecting the appropriate altitude. Collect and transmit meteorological data in real-time.
- Performance: Positioning accuracy within a buffer zone. Altitude adjustment within a proper time.
- Reliability: Operate autonomously for a couple of days.
- Usability: Simple interface for remote monitoring and adjustments.
- Compatibility: Integrate with standard meteorological tools and Arduino.

7. Technical challenges

- Wind Prediction: Developing an algorithm capable of accurately predicting wind behavior at different altitudes and responding to rapid changes or using the meteorological analysis to dictate where to go.
- Altitude Control: Designing lightweight, efficient, and reliable mechanisms for altitude adjustment (e.g., gas-based or ballast systems).
- System Integration: Synchronizing sensor data, GPS, and control algorithms in real-time.
- Communication: Ensuring stable communication in remote or high-altitude environments.
- Energy Efficiency: Building a system that consumes minimal energy for frequent altitude adjustments.
- Temperature management: Having an appropriate insulation mechanism to protect the electromechanical system.

8. Partners

At the moment we don´t have partners.

9. Testing and validation metrics

- Positioning Accuracy: Evaluate the average distance between the target location and the balloon's actual position.
- Response Time: Measure the time required to adjust the altitude and correct the trajectory.
- Energy Efficiency: Quantify energy consumption per altitude adjustment cycle.
- Data Consistency: Verify the frequency and quality of meteorological data transmission.
- System Reliability: Test the ability to operate continuously without failures over extended periods.
- Geographical Coverage: Assess the effective data collection area over time.

10. Division of labor (I)

Duarte Antunes	Francisco Coelho	Catarina Belchior
Main role	**Main role**	**Main role**
Site development	Site development	Interview and networking
Finding materials	Finding materials	Finding materials
Mechanical Development	Software Development	Mechanical Development

11. Division of labor (II)

João Oliveira	Rodrigo Santiago	
Main role	**Main role**	**Main role**
Finding materials	Finding materials	
Interview and networking	Interview and networking	
Software Development	Mechanical Development	

12. Schedule

Site development : 22 of February – 2 of March

Interview and networking: Starting in the next following weeks.

Mechanical Development: To early to define.

Software Development: To early to define.