Low-Cost Virtual Fencing for Livestock Management

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Traditional vs Virtual Fence

Efficient livestock management is crucial for agricultural productivity. Traditional physical fencing methods are expensive and environmentally invasive. This innovative virtual fencing system provides a cost-effective and scalable alternative. Features include:

- GPS for precise geolocation,
- Wi-Fi and LoRa for robust, long-range wireless communication,
- IMU and temperature sensor for health monitoring,
- User interface for real-time track and control.

GPS-Based Livestock Tracking

The system utilizes the Adafruit Flora Wearable Ultimate GPS Module for real-time, precise geolocation. It accurately captures longitude, latitude, and altitude data, essential for monitoring livestock over varied landscapes. Utilizing UART communication with the Raspberry Pi Pico W, the system enforces virtual boundaries, thereby eliminating the need for physical fences, reducing both costs and environmental impact.

Behavior and Health Monitoring

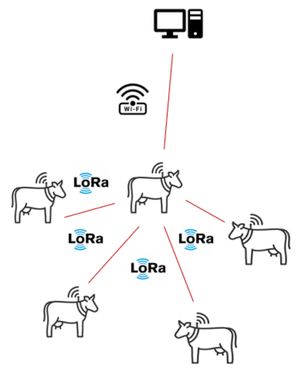
- The virtual fencing system utilizes incorporates an Inertial Measurement Unit (IMU) to accurately monitor livestock orientation and movements, essential for behavioral analysis.
- The Raspberry Pi Pico W is equipped with a temperature sensor to measure surface temperatures, providing vital health indicators.

These integrated technologies ensure comprehensive real-time monitoring, allowing for immediate interventions and enhanced livestock management.

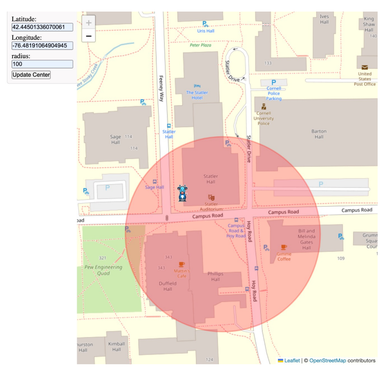
Wireless Communication

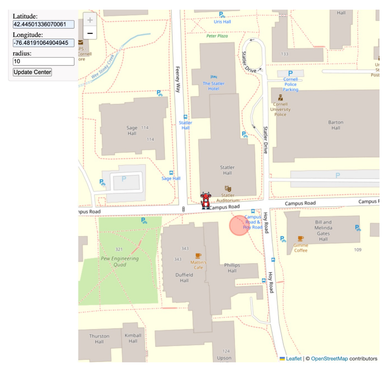
In current version, this currently establishes a connection via Wi-Fi and uses WebSocket for a robust two-way communication session between the user's browser and the Raspberry Pi Pico W. This setup ensures seamless real-time transmission of sensor data directly to the user's PC.

In the future, we plan to implement a wireless sensor network utilizing a dual-network strategy. This network will primarily use LoRa to connect each peripheral sensor device to a central gateway device, enhancing local data transmission efficiency. The gateway device will then leverage the Wi-Fi capabilities of the Raspberry Pi Pico W to aggregate and relay data from all connected sensors to the user interface, further optimizing the system for extensive livestock monitoring.



User-Friendly Web Interface

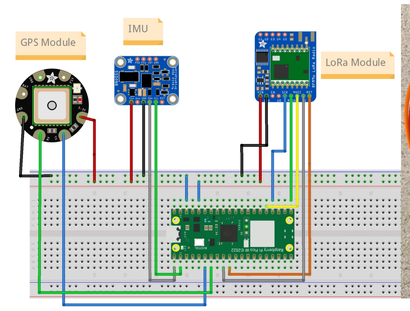


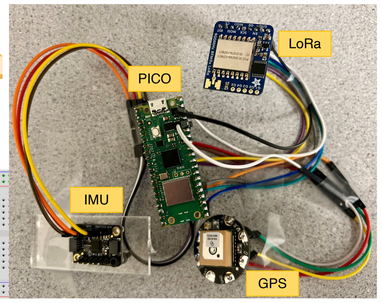


The system features an intuitive web interface that allows farmers to easily configure and monitor virtual fencing for livestock. Through this interface:

- The geofenced area can be established by defining a central point and specifying its radius.
- The location of each animal is dynamically shown on a live map, with blue indicating animals within the boundary and red signaling those outside the boundary.
- Real-time data are displayed in line charts, showing movement patterns and health status.

Layout





Summary

The project exemplifies a revolutionary advancement in livestock management.

- By integrating advanced GPS tracking, motion detection via an IMU, and crucial temperature monitoring into a single wearable device, we have created a virtual fencing system that is both cost-effective and environmentally friendly.
- Utilizing Wi-Fi technology, the system efficiently transmits data over long distances to a central user interface
- The user interface provides a real-time, interactive map and essential health statistics of each animal, empowering farmers with actionable insights.

The whole system demonstrates a sustainable model of agriculture technology that enhances productivity while conserving natural ecosystems.

Future Work

- **Expand Network Capabilities**: Integrate LoRa technology to establish a robust wireless sensor network, enhancing connectivity across extensive farm areas.
- **Advanced Geofencing**: Develop capabilities to support multiple and diverse geofencing configurations, allowing for customized boundary settings tailored to varying pastoral layouts.
- **Enhanced Health Monitoring**: Broaden the scope of health monitoring features to include additional vital signs and behavioral indicators, facilitating comprehensive livestock health management.
- **Proactive Herd Management**: Implement stimulus-response mechanisms that gently guide animals back within geofence boundaries, reducing the risk of straying without distressing the livestock.

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