PRECISION AGRICULTURE: AI, IOT, AND WLAN-ENABLED CROP MONITORING AND DISEASE DETECTION IN GHANA'S AGRICULTURAL SECTOR

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Project Summary

In response to the persistent challenges faced by Ghana's agriculture sector, ranging from crop diseases and inefficient resource usage to limited digital access in rural areas, our team developed an AI-powered, IoT-integrated crop monitoring and disease detection system. The goal was to deliver a low-cost, internet-free solution that empowers smallholder farmers to make timely, data-driven decisions to boost yield and sustainability.

Methodology

We adopted a multi-layered design approach, integrating hardware, AI, and network infrastructure into a unified system:

- **IoT Hardware Integration**: We deployed HALISENSE soil sensors connected to ESP8266 WiFi modules and RS485 communication lines for long-range, noise-resistant data transmission. A Raspberry Pi served as the local edge server, processing data in real-time without internet.
- **AI & Machine Learning:** For disease detection, we fine-tuned lightweight versions of EfficientNet B0 and V2-S models, ensuring accurate crop classification with minimal computing power. Our pipeline included automated preprocessing, training, and evaluation, fully compatible with edge deployment and Google Colab for reproducibility.
- **Mobile App (Nnɔbae Boafo)**: We built an offline-capable app that visualizes sensor data, AI predictions, and provides crop-specific recommendations. It also features CropAI, a domain-specific assistant trained to respond to farmer queries.

- **Drone Imaging Integration**: We used the DJI Mini Pro 3 drone to capture high-resolution crop images for disease classification. Data was tiled, analyzed locally, and presented with actionable insights using the raspberry Pi.
- **Network Design**: A custom 10,000-acre WLAN infrastructure enabled communication between all devices, ensuring full system functionality even in off-grid locations. (For testing purpose the bandwidth was reduced to 0.5 acre)

Challenges Overcome

- **Power Constraints:** To overcome energy limitations, we optimized power usage with deep sleep modes, reducing sensor hub consumption to under 0.75mAh/hour, making solar-powered deployment viable.
- **Connectivity in Remote Areas:** We bypassed internet dependency by designing the system around offline WLAN connectivity and local edge processing on Raspberry Pi.
- **Image Quality & Noise Handling:** Poor lighting or motion blur during image capture was addressed through Mixup data augmentation and robust model selection strategies.
- **Hardware Compatibility:** Integrating components like HALISENSE, ESP8266, and RS485 into a single communication loop required custom PCB design and firmware tuning.

Outcomes Achieved

- **High Accuracy Disease Detection:** Our models achieved up to 96% accuracy (Cashew), maintaining strong performance across all five crops with <50ms inference time.
- **Affordable, Scalable System:** We prioritized low-cost components, ensuring the system is accessible to smallholder farmers without sacrificing performance.
- **Offline Functionality Across 10,000 Acres:** The entire platform, from sensors and drones to mobile app, runs without internet, enabling use in Ghana's most underserved farming regions.
- **Empowering Local Agriculture:** With its ease of use, tailored recommendations, and Text-to-speech, **Nnɔbae Boafo** bridges the digital divide and strengthens food security efforts.

Conclusion

This project demonstrates how locally driven AI and IoT innovation can solve real-world problems in African agriculture. By designing with Ghana's rural realities in mind, we have created a system that's not only technically sound but socially impactful, laying the groundwork for scalable, sustainable farming across the region.