Autonomous Vertical Farming
Scope of Work (SoW)

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Background:

The concept of vertical farming traces its roots back to the early 20th century when visionaries and agriculturalists first envisioned the possibility of growing crops in multi-story structures. However, it was not until recent decades that vertical farming gained significant attention and became a promising solution to address pressing challenges in traditional agriculture. Those primarily being the massive carbon footprint of traditional agricultural methods.

Farming has evolved significantly over the years, driven by technological advancements, changes in practices, and societal needs. Mechanization during the Industrial Revolution boosted productivity, while the Green Revolution introduced chemical inputs and high-yield crop varieties, revolutionizing food production. In modern times, precision agriculture and data-driven decision-making have further transformed farming practices, optimizing resource usage and sustainability. However, amidst these changes, the fundamental essence of farming remains unchanged - cultivating crops and responsibly stewarding the land to provide nourishment for humanity. The resilience of farming lies in its ability to embrace innovation while upholding its core principles, ensuring a continuous commitment to sustainably feed the world.

Vertical farming has emerged as a promising solution to address the challenges of traditional agriculture, such as limited arable land, climate change, and inefficient resource utilization. Our disruption oriented focus towards tacking problems aims to leverage cutting-edge autonomous capabilities to revolutionize the vertical farming experience. We envision a state-of-the-art vertical farm that will utilize advanced robotics, artificial intelligence, and data-driven automation to optimize crop growth, minimize resource wastage, and maximize productivity.

Project Overview:

The objective of our project is to design and implement an autonomous vertical farm that sets new standards for sustainable and efficient urban agriculture. We want to create a closed-loop system that requires minimal human intervention while achieving optimal yields and producing high-quality crops year-round. The farm will integrate various innovative technologies, which may include but would not be limited to: automated planting, harvesting, climate control, nutrient/ hydration delivery, and pest management, a feasibility study will be conducted in order to inquire about the potential constraints or limitations

Why Now:

The current global landscape presents a compelling case for investing in autonomous vertical farming, making this the opportune moment to embark on such a groundbreaking project:

1. Escalating Food Demand: The world's population continues to grow at an unprecedented rate, projected to reach over 9 billion by 2050. With more mouths to feed, traditional agricultural practices face immense pressure to meet the escalating food demand. An autonomous vertical farm can revolutionize food production by providing a reliable and efficient means of cultivating fresh produce, independent of external factors such as climate and weather conditions. By leveraging innovative technologies, we can substantially increase crop yields and contribute significantly to global food security.

2. Climate Change Impact: Climate change is already affecting traditional agriculture, causing unpredictable weather patterns, extreme temperatures, and water scarcity. Vertical farming, with its closed-loop system, offers climate-controlled environments shielded from external climate fluctuations. Such control over the growing conditions ensures consistent crop production, reduced water consumption, and diminished reliance on arable land. As climate-related challenges intensify, the autonomous vertical farm emerges as a resilient and adaptive solution.

3. Urbanization and Land Scarcity: Rapid urbanization is leading to increased land scarcity, posing a critical challenge to conventional farming practices that rely on vast areas of fertile land. Autonomous vertical farming is inherently space-efficient, enabling cultivation within urban centers or even inside buildings. By utilizing unused or underutilized spaces, such as rooftops or abandoned warehouses, we can transform urban landscapes into thriving centers of agricultural production. This approach also reduces the environmental footprint associated with transportation and storage of perishable goods, promoting a more sustainable urban lifestyle.

4. Technological Advancements: Recent advancements in artificial intelligence, robotics, and data analytics have reached a maturity that makes autonomous vertical farming not just a theoretical concept, but a tangible and feasible reality. The convergence of these cutting-edge technologies enables us to design a sophisticated and integrated system capable of precision agriculture and intelligent resource management. By harnessing the potential of these technologies, we can achieve unprecedented levels of efficiency and productivity in the cultivation of crops.

5. Sustainable Food Systems: With a growing awareness of environmental issues and sustainable practices, consumers are increasingly seeking responsibly sourced and locally grown produce. An autonomous vertical farm aligns perfectly with the vision of a sustainable food system, minimizing carbon footprints, eliminating chemical run-offs, and reducing the use of finite resources like water. The farm's data-driven approach also ensures optimal resource allocation, promoting responsible stewardship of natural resources.

6. Economic Viability: Beyond the social and environmental benefits, autonomous vertical farming holds significant economic potential. As the global demand for fresh produce continues to rise, investing in innovative agricultural technology can create new economic opportunities and foster job growth. Moreover, the reduction in transportation costs and shorter supply chains can improve profit margins and strengthen local economies.

In light of these factors, the timing for implementing an autonomous vertical farm is ideal. By seizing this opportunity, our disruptive technology club can lead the charge in redefining the future of agriculture, ensuring sustainable food production, and making a lasting positive impact on the world.

MVP (Minimum Viable Product) by End of Year:

By the end of the year, we will produce a functional prototype of an autonomous vertical farm with the following key features. The following list provides potential prototype features in order of importance (a weighted evaluation matrix will be utilized to tier feature selection once a team is assembled):

1) Autonomous watering system
2) Integrated climate control system to regulate temperature, humidity, and lighting.
3) AI-powered nutrient delivery system, ensuring precise and optimized distribution.
4) Remote monitoring and control interface for farm management.
5) Data-driven pest management system, reducing the need for pesticides.

Methods:

To achieve the MVP, we will follow a rigorous and systematic approach:

Research & Development: Conduct in-depth research on existing vertical farming methods and autonomous technologies. Identify the most suitable crops for initial implementation and study their growth requirements.

Prototyping: Begin the design and development of the autonomous systems, starting with one core component at a time. Regularly test and iterate each prototype to optimize performance.

Integration: Integrate the developed subsystems into a cohesive, functioning autonomous vertical farm. Ensure seamless communication and coordination among all components.

Testing & Iteration: Conduct extensive testing in controlled environments to validate the farm's performance and identify areas for improvement. Implement necessary iterations to enhance efficiency and reliability.

Scaling & Optimization: Once the MVP is achieved, focus on optimizing resource usage and scaling up the farm to accommodate more crop varieties and increase overall productivity.

Potential Bill of Materials for Prototyping/ MVP

- Rasberry Pi/ Arduino for servo control
- Servo motors to regulate delivery systems
- Sensors (humidity, pressure, electrochemical) in order to measure system conditions)
- PVC Piping
    - ~5mm piping for fluid transport
    - ~1ft piping for structure creation
- Hot Glue Guns/ Glue
- Lumber for construction
- Soil
- Seeds
- Fertilizer

Timeline:

Month 1: *Research & Development*
Conduct in-depth research on existing vertical farming methods and autonomous technologies.
Identify the most suitable crops for initial implementation and study their growth requirements.
Month 2: *Prototyping*
Begin the design and development of the autonomous systems, starting with core components.
Rapidly create functional prototypes for automated planting and harvesting.
Month 3: *Integration & Testing*
Integrate the developed subsystems into a cohesive, functioning autonomous vertical farm.
Conduct initial testing in controlled environments to identify any major issues.
Month 4: *Iteration & Optimization*
Implement necessary improvements based on the initial testing results.
Focus on optimizing the performance of the autonomous systems.
Month 5: *Scaling & Expansion*
Expand the range of crops that can be grown autonomously.
Enhance the farm's capacity to accommodate more plants.
Month 6: *AI Integration & Fine-tuning*
Implement an AI-powered nutrient delivery and climate control system.
Fine-tune the AI algorithms to ensure optimal resource utilization.
Month 7: Full Automation & Testing
Aim for full automation in planting, harvesting, nutrient delivery, and pest management.
Conduct extensive testing to validate the entire autonomous vertical farm system.
Month 8: Final Refinements & Completion
Address any remaining issues and make final refinements to the system.
Complete the autonomous vertical farm and prepare for a successful launch.

By following this accelerated timeline, we will complete the project within 8 months, delivering a functional and advanced autonomous vertical farm that showcases our club's ability to drive disruptive innovation in the field of urban agriculture.

Due to the complexity and innovative nature of the project, we may need to prioritize certain features over others to meet the timeline. If necessary, we may focus solely on the core autonomous watering and nutrient delivery system to ensure its successful implementation within the given timeframe.

Onboarding:

To get our team up to speed with relevant details as quickly as possible, we will organize the following onboarding plan:

Reading Materials: Preparing documents to be shared with the team in order to brief team members on

Workshops and Seminars: Conduct specialized workshops and seminars which may be lead by experts in vertical farming, robotics, and AI to familiarize the team with the fundamental principles and challenges in these domains.

Training and Skill Development: Identify specific skill gaps within the team and provide training sessions to enhance their capabilities in areas crucial to the project's success.

Hands-on Experience: Encourage team members to gain hands-on experience by visiting Queen's design bays to observe the various tools at our disposal.

Collaborative Learning: Facilitate regular brainstorming sessions and knowledge-sharing meetings within the team to foster a collaborative learning environment.

Conclusion

In summation, we aim to create an autonomous vertical farm that will significantly impact the future of urban agriculture and contribute to sustainable food production in a world with growing demands and limited resources.