Development and Evaluation of a Low-Cost, 3D-Printed Robotic Head for Plant Monitoring in Greenhouse Environments

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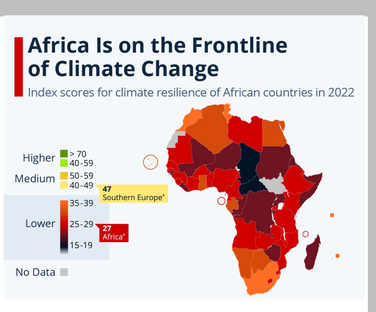
Introduction

Sub-Saharan Africa is grappling with critical challenges in food security, exacerbated by an increasing population and climatic unpredictability such as droughts and flooding [1]. Traditional farming practices may benefit from innovative, climate-resilient agricultural Kenya's adoption remains low often due to high setup costs and limited technical know-how.

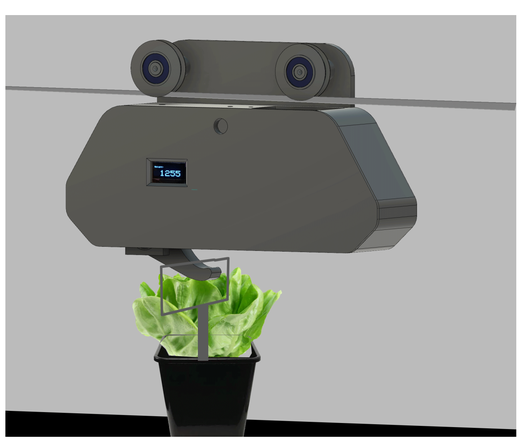
Why it Matters



Food Security Concerns in Sub-Saharan Africa
Crop care involves repetitive and time-consuming tasks which can be automated [2].
Climate-related Challenges in Farming
Limited Adoption of Greenhouse Technology in Kenya [3]

Objectives

An Affordable Automated Crop Care Approach for Small-Scale Farms in Sub-Saharan Africa
The aim of this research is to evaluate the effectiveness and extensibility of a low-cost, 3D-printed, robotically-controlled head for monitoring and managing plants in a simulated greenhouse environment.



Research Question(s)

"How effective and extensible is a low-cost, 3D-printed, robotically-controlled head for monitoring and managing plant care in a simulated greenhouse environment?"

Sub-Questions
What weighing accuracy can be expected?
Movement Efficiency, e.g. slippage, derailment, cable sag
Design Modularity: how easily can other sensors be added
Cost-effectiveness and Adaptability; Built and maintained locally?

References

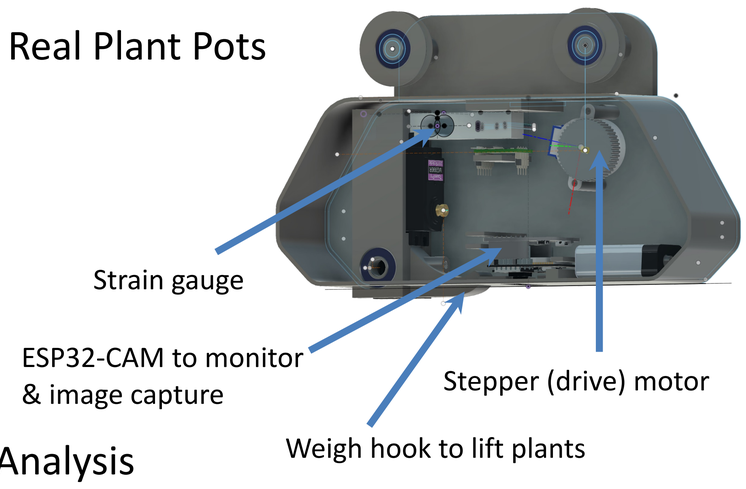
[1] M. Armstrong. "Africa Is on the Frontline of Climate Change." statista.com. https://www.statista.com/chart/28136/index-scores-for-climate-resilience-of-african-countries/
[2] G. Bagagiolo, G. Matranga, E. Cavallo, and N. Pampuro, "Greenhouse Robots: Ultimate Solutions to Improve Automation in Protected Cropping Systems—A Review," Sustainability, vol. 14, no. 11, doi: 10.3390/su14116436.
[3] Sanzua L. J , Saha H. M , Mwafaida J , "Status of Greenhouse Farming in the Coastal Humid Climatic Region of Kenya," Universal Journal of Agricultural Research, Vol. 6, No. 5, pp. 165 - 172, 2018. DOI: 10.13189/ujar.2018.060504.

Methodology

Experimental Design
- Controlled Simulation with Real Plant Pots

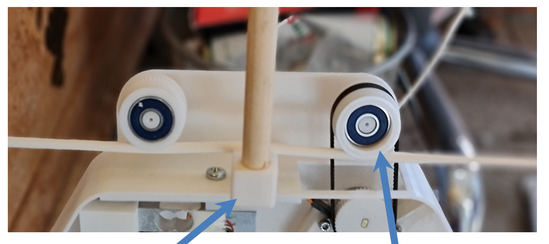
Data Collection
- Weighing Accuracy
- Movement Efficiency
- Modularity Assessment
- Cost and Adaptability

Data Analysis
- Statistical Analysis
- Feasibility and Modularity Analysis
- Cost-Benefit Analysis



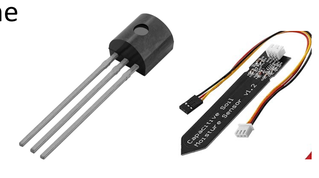
Preliminary Findings

Weighing System
Comparative analysis with calibrated kitchen scales
Movement Efficiency
Time taken for movement along the overhead wire track.
Modularity and Extensibility
Discussion on the ease of adding functionalities like humidity sensors, cameras, etc.
Cost and Adaptability
Cost analysis and potential for real-world applications.



Sub Future Work/Conclusions and Outlook

Other sensor modules, how easily can the head unit be upgraded?



Collaborate and work with farmers on the ground to establish need (if any).
Extending functionalities to include more plant health variables such as soil moisture and temperature.
Exploring the addition of watering and nutrient-feeding systems.

Evaluate in live settings, to test for factors such as humidity, dust, accuracy and ease of track installation

Collaborators

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