ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

African Centre for Technology Studies
ACTS
Knowledge for Better Livelihoods

Transforming Africa's Agriculture through artificial intelligence and machine learning

A synthesis of AI4D Africa research projects in agriculture

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Preface

The African Centre for Technology Studies (ACTS) is implementing the Artificial Intelligence for Development in Africa (AI4D) Scholarship Project to foster and nurture talent in responsible Artificial Intelligence (AI) and Machine Learning (ML) in African public universities. The 3-year project, funded by the International Development Research Centre (IDRC) and the Swedish International Development Cooperation Agency (SIDA), aims to meet the growing demand for research and development in responsible Artificial Intelligence (AI) and Machine Learning (ML) in the continent. ACTS is implementing the AI4D Africa scholarship project in partnership with Kwame Nkrumah University of Science & Technology in Ghana; University of Linkoping, Sweden and Université Cheikh Anta Diop de Dakar, Senegal. Other partners include the Regents of the University of California, United States; Human Sciences Research Council and Institute for Humanities in Africa based in South Africa; and the University of Eduardo Mondlane, Mozambique.

Specifically, the project is supporting selected scholars to undertake and successfully complete PhD research in AI and ML in African universities; and early career academics (ECA) to strengthen their research and development capacities in the two areas. Special consideration is given to research projects on responsible AI innovation for sustainable development, gender equity, equitable regional distribution in low-income countries. This initiative is built on the premise that whereas majority of doctoral graduates expect to secure jobs in academic and research, a postdoctoral period is desirable to develop fully-fledged, independent, and competent researchers. Also, there are very few universities in Africa that currently offer MSc and PhD programs in AI and ML. The bulk of the departments, however, do offer MSc and PhD in ICT related courses with some potential to supervise PhD in AI and ML. Apart from supporting research capacities of selected scholars, the programme will enhance the capacities of existing ICT departments to offer MSc and PhD in AI and ML by supporting them with research tools and related infrastructure for AI and ML. This will not only facilitate research activities of Early Career Academics (ECA) but will also be made available to other postgraduate and final year undergraduate students within the departments.

We extend our heartfelt appreciation to the scholars whose dedication has illuminated new paths in the intersection of agriculture and technology. Together, let us look forward to a future where the fruits of AI and ML research blossom into sustainable improvements in agricultural production, touching the lives of individuals and communities across our vibrant continent.

I. AI4D Africa research projects in agriculture

The intersection of agriculture and cutting-edge technologies has ushered in a new era of innovation, transforming traditional farming practices and fostering sustainable agricultural development. This synthesis report encapsulates the culmination of diverse research projects conducted across various regions in Africa, each delving into distinct facets of agricultural challenges and their innovative solutions. As the world grapples with the imperative need to ensure food security, mitigate environmental impact, and enhance agricultural productivity, researchers have fervently explored the realm of artificial intelligence (AI), machine learning, deep learning, geospatial technology, and the Internet of Things (IoT) to revolutionize the agricultural landscape.

The spectrum of research projects covered in this synthesis report spans a wide array of critical agricultural issues. These include the development of intelligent systems for the early detection and management of locust invasions, leveraging AI technologies for stress detection in crops, and enhancing smallholder farmer credit scoring through geospatial technology. Furthermore, the report delves into the domain of disease management, presenting innovative approaches such as AI-enhanced detection and treatment of tomato plant diseases, as well as integrated tools combining AI, IoT, and mobile applications for the early prediction and control of mycotoxins in grains.

The synergy of AI and agricultural sciences has paved the way for groundbreaking advancements, enabling precise agricultural practices, early disease detection, and informed decision-making. Machine learning techniques have been optimized for accurate agricultural yield predictions, ensuring farmers can plan their activities effectively. Additionally, the integration of IoT systems with machine learning algorithms has enabled real-time monitoring of crop conditions, facilitating precision agriculture.

This synthesis report showcases a diverse array of research projects, each contributing to the advancement of agriculture through the integration of artificial intelligence (AI), machine learning, deep learning, geospatial technology, and more. The studies encompass a wide spectrum of agricultural concerns, ranging from pest control to yield prediction, from disease detection to credit scoring, and from inter-farmer interactions to mycotoxin prevention. Together, they represent a collective effort to enhance the efficiency, sustainability, and resilience of agriculture across different regions of Africa.

The report delves into the intricacies of research endeavors spanning regions from Benin to Rwanda and Mozambique to Tanzania. Each research project not only represents a testament to the ingenuity of the scientific community but also offers tangible solutions to some of the most pressing challenges faced by farmers and agricultural stakeholders in Africa. Through collaborative efforts, innovative technologies, and interdisciplinary approaches, these research initiatives signify a significant step towards sustainable agricultural practices, fostering resilience, and ensuring food security in the face of evolving environmental and economic landscapes. The knowledge distilled within these pages not only informs the current discourse in agricultural technology but also lays the foundation for future research, policy-making, and implementation efforts, shaping a more sustainable and prosperous future for African agriculture.

II. Socio-economic significance of the research projects

The ever-evolving landscape of agricultural research, a multitude of groundbreaking projects are underway, each with the potential to redefine the way we approach farming, food security, and environmental sustainability. These initiatives delve deep into the realms of artificial intelligence, machine learning, geospatial technology, and IoT systems, among others, aiming to address pressing challenges faced by agricultural communities around the world. The AI4D Africa Scholarship projects focusing on agriculture has illuminated a promising path for Africa, one that leads towards substantial socio-economic transformation. By harnessing the power of technology, these initiatives offer tangible solutions to age-old challenges, promising not only improved agricultural practices but also profound impacts on the socio-economic fabric of the continent. These research projects are outlined below:

Early warning and prediction

Early warning system for locust invasion

By predicting locust movements, farmers can take proactive measures to protect their crops, preserving livelihoods and food security. By predicting and managing locust invasions using AI technologies, farmers can safeguard their crops. Preserved harvests translate to stable incomes, reducing economic vulnerability and enhancing financial security for communities. Early warning systems, where the integration of artificial intelligence technologies has paved the way for swift and accurate detection of locust invasions. By predicting and managing the spread of these destructive pests, agricultural communities can safeguard their crops, ensuring stable yields and food security for their regions.

Agricultural yield prediction

Through the optimization of machine learning techniques, accurate predictions regarding agricultural yields are made possible. This knowledge aids farmers in planning their harvests, optimizing resources, and maximizing productivity. Accurate yield predictions empower farmers to plan effectively. Predictable harvests lead to better market strategies, enabling farmers to negotiate better prices, increasing their income and overall financial stability. This not only aids farmers in making informed decisions regarding their crops but also contributes to overall food production, bridging the gap between supply and demand.

Predicting disease vector abundance

The practical application of advanced statistical methods, such as random forest regression, facilitates the prediction of disease vector abundance in livestock pastures. This knowledge has the potential of empowering livestock farmers to take proactive measures, reducing the risks associated with disease vectors and ensuring the health and well-being of their animals.

Crop Management

Stress detection in tomatoes

In Benin, a deep learning model is being developed to detect stress in tomato plants. By identifying signs of distress early on, farmers can intervene, ensuring healthier crops and higher yields. Early detection of stress in crops ensures healthier yields. Healthy harvests mean more produce to sell, boosting incomes for farmers and strengthening local economies. By identifying stress factors early on, farmers can implement targeted interventions, thus preserving the vitality and productivity of their crops.

Intelligent crop disease management

In Niger, intelligent systems have been devised to manage agricultural crop diseases sustainably. By implementing targeted treatments, farmers can minimize losses and promote the health of their crops, contributing to food security. Effective disease management preserves crops, ensuring a stable food supply. Increased agricultural output not only meets local demand but also creates surplus for trade, enhancing economic resilience. The use of artificial intelligence can help in mitigating crop losses, promoting resilience and stability in the face of changing environmental conditions.

Mitigating crop losses using AI

The use of AI technology in Cape Verde is expected to significantly reduce crop losses. By identifying and addressing potential risks early, farmers can safeguard their harvests, ensuring a stable food supply. Reduced crop losses mean more produce reaches the market. Increased supply can stabilize prices, benefiting consumers and providing consistent income for farmers, thereby improving their economic well-being. By swiftly identifying and treating diseases, farmers can protect their crops from devastating losses, thereby securing their livelihoods and contributing to a more stable food supply.

AI enhanced detection and treatment of tomato diseases

Deep learning techniques are applied for the early detection of crop diseases. Timely identification allows farmers to take preventive measures, mitigating the impact of diseases on their crops. Early disease detection saves crops and resources. Preserving harvests ensures market supply, supporting farmers' livelihoods and bolstering local economies. Early disease detection preserves crops and ensures higher yields. Increased agricultural output not only fulfills local demand but also creates surplus for export, bolstering national economies.

Precision Agriculture using IoT

In Rwanda, IoT systems and machine learning techniques are combined to monitor crop conditions and predict yields accurately. This precision agriculture approach optimizes resource usage and ensures sustainable farming practices. Precision agriculture maximizes resources. Efficient use of water, fertilizers, and energy increases profit margins, promoting economic growth in agricultural communities. Precise monitoring allows for optimized resource use. Efficient farming translates into higher profits, offering farmers financial stability and fostering economic growth at the local level.

Advanced agricultural monitoring in Mozambique

In Vilankulo, Mozambique, researchers have employed statistical and physically based hyperspectral and multispectral reflectance modeling. This approach enhances agricultural monitoring, providing valuable insights for effective farm management. This research project focuses on integrating statistical and physically based models to analyze hyperspectral and multispectral reflectance data for agricultural monitoring. By combining advanced remote sensing techniques and statistical methods, the study aims to provide detailed insights into agricultural landscapes, crop health, and environmental conditions.

Random forest regression for predicting the abundance of disease-carrying tick species

The research project aims to investigate the practical application of random forest regression for predicting the abundance of Rhipicephalus appendiculatus - a disease-carrying tick species - in permanent livestock pastures. By utilizing advanced computational techniques, the study seeks to enhance our understanding of disease vector dynamics and improve predictive models to assist in disease control efforts. By combining cutting-edge technology with ecological insights to benefit various stakeholders, ranging from farmers and veterinarians to public health authorities and the broader scientific community, the research has the potential of improving our ability to predict disease vector abundance, the outcomes of this study have the potential to make a significant impact on livestock health and public well-being.

Post-harvest management

Mycotoxin Control in Grains

The integrated AI, IoT, and mobile app-based tool developed in Tanzania for the early prediction and control of mycotoxins in maize and peanuts crops. This innovative solution safeguards food safety and ensures the quality of agricultural produce. Controlled mycotoxin levels ensure safe produce. Safe products meet international standards, opening avenues for exports, strengthening trade relationships, and boosting national economies. By addressing food safety concerns at an early stage, these technologies play a crucial role in ensuring the quality and safety of agricultural produce.

Credit Scoring

Geospatial farmer credit scoring

Geospatial technology is harnessed to assess the creditworthiness of smallholder farmers. This approach facilitates access to financial resources, enabling farmers to invest in their farms and improve their livelihoods. Improved access to credit for smallholder farmers enables them to invest in their farms. Financial stability fosters economic growth, creating job opportunities and enhancing the overall prosperity of communities. Precise location data enables financial institutions to extend credit to farmers, empowering them to invest in their agricultural practices, enhance productivity, and improve their livelihoods.

Shared knowledge and improved practices

Farmer-to-farmer interactions in small scale dairy farming

Multi-agent models are utilized to facilitate learning recommendations and improve farmer-to-farmer interactions in small-scale dairy farming. Knowledge sharing among farmers enhances practices and fosters a sense of community. Enhanced interactions lead to shared knowledge and improved practices. Efficient farming methods increase productivity, boosting incomes for farmers and strengthening local economies

III. Conclusion

The diverse topics covered in this synthesis report reflect the dynamic landscape of agricultural research in Africa and the growing role of technology in addressing critical issues. Together, these projects offer a comprehensive view of the transformative potential of technology in agriculture and underscore the importance of ongoing research and innovation to ensure a sustainable and prosperous future for the continent.

These innovative agricultural research projects offer far-reaching benefits to multiple stakeholders. By bolstering agricultural productivity, stabilizing incomes, and fostering economic growth at the local, national, and international levels, they pave the way for a brighter, more prosperous future for Africa. The transformative impact of these initiatives extends beyond farms, promising a ripple effect of economic empowerment and enhanced well-being for communities across the continent. By leveraging AI, machine learning, deep learning, geospatial technology, and IoT, these initiatives empower farmers, enhance food security, and pave the way for a sustainable agricultural future in Africa. Through ongoing research and innovation, these advancements will continue to shape the agricultural landscape, improving the lives of farmers and communities across the continent.

Finally, these research projects signify a collective effort to revolutionize agriculture, making it more efficient, sustainable, and resilient. The potential benefits encompass not only increased agricultural productivity and food security but also economic empowerment for farmers, environmental conservation, and overall societal progress. As these initiatives continue to unfold, they hold the promise of ushering in a new era in agriculture, where science and technology work hand in hand to shape a more sustainable and prosperous future for all.

However, successful implementation of findings of these research projects relies on a collaborative approach involving farmers, researchers, governments, and agricultural extension services. Education, training, and community engagement are key components of translating these innovative solutions into practical benefits for agricultural communities, ensuring sustainable farming practices and improved livelihoods for farmers.

IV. Key Recommendations

These recommendations are tailored to each specific project's findings, but they all share a common goal: to translate research insights into tangible benefits for farmers and agricultural communities while promoting sustainability, productivity, and resilience in agriculture. Some of the key recommendations

Collaboration

Collaboration between governments, research institutions, and local farmers is vital to establish a comprehensive network for efficient information dissemination and response. Based on research findings, agricultural research institutions and seed providers can collaborate to develop and distribute crop varieties that are resistant to prevalent pests and diseases. Farmers' cooperatives and community organizations can disseminate information about these varieties, encouraging their widespread cultivation, For example, financial literacy programs can educate farmers about the importance of credit scores and how geospatial data contributes to their creditworthiness. Therefore, establishing partnerships between banks, technology providers, and farmers' cooperatives can streamline the credit application process, making it more accessible and transparent.

Training and Education

Agricultural extension services can play a pivotal role in translating these predictions into actionable insights, guiding farmers on optimal planting times, irrigation, and crop management practices. Training programs on disease vector identification, breeding site management, and vector control methods can enhance farmers' capacity to manage disease vectors effectively. Regular veterinary visits and disease monitoring can provide valuable data for the development of accurate predictive models, aiding in timely interventions and disease prevention.

Educating farmers on recognizing stress indicators and implementing stress-reducing measures can significantly enhance crop yields. Workshops, training programs, and knowledge-sharing platforms can empower farmers with the necessary skills to identify and address stress factors effectively Training local agricultural officers and farmers on how to use these systems can also enhance disease surveillance, early detection, and effective treatment. Also, training programs on effective communication and cooperation can enhance farmer-to-farmer interactions, leading to improved practices and productivity.

Promoting knowledge exchange among farmers

Accessible mobile applications or hotlines can facilitate real-time communication between farmers and agricultural experts, enabling prompt disease management strategies. Establishing farmers' cooperatives or community-based organizations can facilitate knowledge exchange and collective problem-solving. There is also need to facilitate knowledge sharing among farmers on disease prevention and treatment. Collaborate with government agencies to implement AI-based agricultural resilience

strategies; and creation of platforms for knowledge sharing and feedback among farmers.

Promoting Adoption of AI and ML technologies

Creating awareness about agricultural technologies in AI and ML is critical for fostering sustainable, efficient, and productive agricultural practices. It not only benefits farmers but also contributes to global food security, economic development, and environmental conservation. Public awareness and education play a pivotal role in ensuring the successful adoption and integration of these technologies in agriculture.

Formulation of appropriate policies

Appropriate policies are necessary to ensure the responsible, equitable, and sustainable adoption of AI and ML technologies in agriculture. By addressing regulatory, ethical, accessibility, and environmental concerns, well-crafted policies can pave the way for the successful integration of these technologies into agricultural practices, benefiting farmers, consumers, and society as a whole.

VI. Synopsis of AI4D Africa Scholarship research studies in agriculture

This synthesis report provides an overview of thirteen research projects that harness the power of artificial intelligence (AI), machine learning, deep learning, geospatial technology, and the Internet of Things (IoT) to revolutionize farming practices and ensure sustainable development as outlined below:

1. A framework for an early warning system for the management of the spread of locust invasion based on artificial intelligence technologies

Name: Brian Halubanza

University: The University of Zambia

Country: Zambia

Gender: Male

Supervisor: Prof. Jackson Phiri
University of Zambia

Overview

This research project aims to develop an AI-based early warning system for locust invasion in Africa can provide timely and accurate information, assisting in proactive measures, reducing the impact of locust infestations on agriculture, and enabling more efficient locust management strategies. This research study aims to explore how IoT, Geospatial, cloud computing and machine learning technologies can be used to detect African Migratory Locust (AML) invasion. The specific objectives are to:

i. identify challenges faced by farmers and government in controlling AML invasion using existing early warning models;

ii. explore how IoT, Geospatial, cloud computing and machine learning technologies can be used to detect AML invasion;

iii. design and implement an early warning system framework for AML Invasion.

The study expects to improve the accuracy in forecasting the potential areas of locust infestation, enhance knowledge and skills in the application of AI technologies for locust management, and increase agricultural productivity in affected areas.

2. Optimization of machine learning techniques for agricultural yield prediction (prediction)

Name: Souand Peace Gloria Tahi

University: University of Abomey-Calavi

Country: Benin

Gender: Female

Supervisor: Prof. Romain Glele
University of Abomey-Calavi

Overview

This research study focuses on maize's plants (Zea mays) as a basis for bidirectional analysis. It focuses on the weather and fertilization pattern using growth and yield parameters and also yield prediction from weather and fertilization scenarios. Early prediction of maize yield allows for early identification of potential production shortfalls or surpluses. This information is vital for policymakers and stakeholders to take proactive measures to ensure food security, such as implementing appropriate agricultural policies, managing imports and exports, and initiating interventions to address any anticipated food shortage. The study sets out to:

i. determine algorithms associated with pre-generated weather characteristics using maize yield data cultivated in real environments;

ii. assess the effect of pre-generated weather characteristics and fertilization levels on the growth parameters and the yield of maize;

iii. assess the performances of Ensemble Learning techniques compared with other Machine learning methods for the yield maize prediction;

iv. assess the effect of variation of hyper-parameters on the performance metrics of the main machine learning methods and compute the final optimization technique of maize.

The study expects to enhance food security and agricultural policies, improved accuracy and reliability of yield predictions and also skills in the application of optimized machine learning techniques for yield prediction.

3. Application of deep Learning model on stress detection of tomato in Benin

Name: Seton Calmette Ariane Houetohossou

University: University of Abomey-Calavi

Country: Benin

Gender: Female

Supervisor: Prof. Romain Glele
University of Abomey-Calavi

Overview

The application of deep learning models for stress detection in tomato plants in Benin can provide valuable insights into plant health and enable timely intervention. By applying deep learning models for stress detection in tomato plants in Benin, farmers and agricultural stakeholders can benefit from early identification of stress conditions, allowing for timely interventions such as irrigation adjustments, nutrient supplementation, disease management, or pest control. This approach can help optimize tomato plant health, improve yields, and enhance overall agricultural productivity. This study aims to:

i. determine the sources of stress on fruits and vegetables especially tomato plants using deep machine learning;

ii. empirically compare the performance of the main Deep Learning techniques used to detect plants stresses;

iii. build a scalable Deep Learning model with potential to detect climate-based stresses on tomato plants;

iv. develop a scalable Deep Learning model with potential l to detect disease based-stresses on tomato plants.

The findings of the study are expected to help improve the accuracy in identifying various stress factors affecting tomato plants, improve farmers income by increased tomato yields enhance decision-making capabilities, enabling farmers to optimize resource allocation and apply targeted treatments

4. Leveraging geospatial technology for smallholder farmer credit scoring

Name: Susan Okeyo

University: University of Nairobi

Country: Kenya

Gender: Female

Supervisor: Prof. Galcano Mulaku
University of Nairobi

Overview

Financial exclusion has a major impact on small holder farmers in Kenya. Credit history is often required by financial institutions to evaluate the risk of a potential borrower before making lending decisions. Most farmers face hindrances when they want to access credit facilities to fund their farming activities. To overcome these challenges and reduce financial exclusion, there is need to investigate how non-financial data which is not related to a person's financial activities can be used in credit scoring. There is no known study in Kenya that has sought to investigate and demonstrate how geospatial technologies can leverage farm credit scoring. Hence to break this cycle, this research seeks to fill the above gaps and at the same time answer the following: how can geospatial technologies, be used to leverage credit scoring for farmers? To demonstrate how geospatial technology can be used to leverage farm credit scoring for the benefit of small holder farmers, the study aims to:

i. identify the small holder farms in the study areas;

ii. determine the extent of small holder farmer financial exclusion;

iii. develop a new farmer credit scoring approach that includes remotely sensed crop data.

The study expects to enhance credit access for small holder farmers, improve risk assessment for smallholder farmers and financial inclusion among smallholder farmers in Kenya.

5. Development of an intelligent system for the management of agricultural crop diseases for sustainable development in Niger

Name: Atsu Alagah Komlavi

University: Abdou Moumouni University of Niamey

Country: Niger

Gender: Male

Prof. Harouna Naroua

Overview

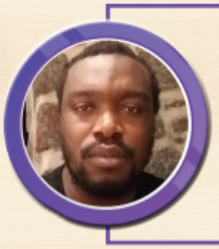
In recent years, detection systems of plant diseases have become increasingly reliable mainly because of advancement in technology, specifically artificial intelligence and machine learning. As a result, it is important to compare the performance of these technologies with a view to determining which methods appropriately require improvement. Like other algorithms, convolutional neural networks (CNN) in addition to their noted high performance, have countless architectures on which it is possible to make modifications that can lead to much higher performance. Hence the fundamental question of proposing a new CNN architecture leading to even higher performance. In the same way, it is possible to act on the different methods of preprocessing and extraction of the characteristic vectors in order to improve the performance of the classical artificial learning algorithms. The study aims to:

i. establish an intelligent system to solve the problems of diagnosis of existing plant pathologies;

ii. develop and implement a new architecture of convolutional neural network.

It is expected that Empower farmers with valuable knowledge and resources to effectively address crop diseases and promote sustainable agricultural practices, provide evidence-based policy recommendations for disease management strategies, resource allocation, and agricultural policies aimed at sustainable development in Niger and also increase crop yields, and ensure long-term agricultural sustainability.

6. Practical use of random forest regression for predicting disease vector abundance: application to the abundance of rhipicephalus appendiculatus in permanent livestock pastures.



Name: Mushagalusa Ciza

University: University of Abomey-Calavi

Country: Benin

Gender: Male

Prof. Romain Glele

Overview

The Rhipicephalus appendiculatus tick complex has been associated with several emerging diseases in Africa mostly through ecosystem modifications. Using accurate methods to identify factors driving tick abundance is primordial for tick-borne diseases control. The Poisson distribution remains the widely used distribution for modeling count data in many research areas despite the violation of its property that the mean and variance are equal. To overcome the poisson distribution limitation, a variety of models have been introduced. However, count data models do not detect the presence of complex non-linear interactions between predictors and the response variable. Therefore, new modeling approaches, different from traditional techniques, are needed to improve predictive models' accuracy for count data sets. In the last two decades, machine learning (ML) methods have gained more popularity compared to classical methods in many applied sciences, including agriculture and epidemiology. Their performance often exceeds that of traditional statistical techniques, and in some cases, traditional techniques simply aren't appropriate. The main target of this work is to contribute to the improvement of RF regression accuracy in statistics and ecological niche assessment of disease vectors. Specifically this study will strive to:

i. assess the influence of data features and over-dispersion on RF regression parameters setting;

ii. evaluate RF regression accuracy compared to count data classical methods;

iii. assess the performance of different resampling algorithms in RF regression for over-dispersed outcomes with different levels of multicollinearity among covariates;

iv. estimate the predictive power of RF in comparison to Generalized Linear Models, and other ML algorithms in predicting ticks abundance on grazed permanent pasture.

Study findings will help development of effective disease management and control by public health officials, policymakers, and stakeholders and enhance understanding of the complex relationships between environmental factors and vector populations.

7. The use of artificial intelligence in mitigating crop losses in Cape Verde

Name: Dr Sonia Semedo

University: University of Cabo Verde

Country: Cape Verde

Gender: Female

Overview

This research projects is focused on monitoring crop growth and, with the help of artificial intelligence, detect and identify potential pests that are affecting crops and alert farmers in a timely manner in an attempt to mitigate agricultural loses. This study is an attempt to answer the question: How can we use artificial intelligence to mitigate/ prevent crop losses in Cape Verde? To achieve this goal, it is important to note that the application of artificial intelligence requires a comprehensive and integrated database, training and validation models in addition to applications protocols. In the context of this study, Cape Verde does not have database on crops and pests that affect them, which is a big challenge. Hence the objectives of the study are to:

i. Assess the feasibility, accuracy, and effectiveness of AI tools in mitigating crop losses and improving overall agricultural productivity in Cape Verde;

ii. analyze the economic viability, social acceptance, and environmental sustainability of using AI in Cape Verde's farming practices;

iii. develop a comprehensive and integrated database on pests and diseases for crops in Cape;

iv. develop models for training and validation of artificial intelligence tools for mitigating crop loses in Cape Verde;

v. raise awareness on the potential of AI in agriculture among researchers, farmers, policymakers, and other stakeholders in Cape Verde.

The study expects to develop a practical AI-based tools and systems tailored to the needs of farmers in Cape Verde, improve crop monitoring and disease detection capabilities in Cape Verde with a view to enhancing agricultural productivity and resilience in Cape Verde. In addition, the study hopes to increase incomes, improve livelihoods and food security for farmers in Cape Verde.

8. An AI enhanced detection and treatment of tomato plant diseases in Africa

Name: Dr Ugochi Adaku Okengwu

University: University of Port Harcourt

Country: Nigeria

Gender: Female

Overview

This research will adopts the Convolutional Neural Network (CNN) deep learning model which is a deep learning algorithm which can take in an input image and assign importance. The ability of the CNN to understand the visual content of the input image makes it suitable for recognizing minute variation between the classes (Raju & Thirunavukkarasu, 2020). This power of CNN makes it a good choice to address image classification problems with multiple classes. Verma and Jain (2019) showed that CNN outperformed other machine learning tools significantly during image classification. Si et al (2020) developed a novel method for identifying coal and rock based on a deep CNN. Viral diseases have been considered as an economically important biotic factor hindering profitable tomato production both during the wet and dry seasons in Nigeria. The increase in the number of virus diseases causing significant yield losses on tomato is of great concern and these vary from one location to another. Crop diseases have significant implications for the achievement of SDG 1 and 2 in Nigeria, as many people are still engaged in agriculture. The study focuses on 4 objectives:

i. create robust data repository of tomatoes diseases and possible solutions;

ii. develop machine learning model for detecting tomatoes virus disease and recommending possible solutions;

iii. design mobile android and web application to implement the predictive model;

iv. develop action plan and outreach for output deployment by organizing farmers training, publicity drive and dissemination of information.

The study expects to improve the accuracy and speed of disease detection, enhanced disease diagnosis and identification, create AI-powered decision support systems for tomato plant disease management. It will also support sustainable and cost-effective solutions for tomato plant disease management and reduced crop losses thus increasing agricultural productivity and improving food security.

9. Statistical and physically based hyperspectral and multispectral reflectance modelling for agricultural monitoring: A case study in Vilankulo, Mozambique

Name: Dr Sosdito Mananze

University: Eduardo Mondlane University - Higher School of Rural Development

Country: Mozambique

Gender: Male

Overview

Implementation of strategic initiatives for the structural transformation of agriculture in Mozambique, there has been an increase in cultivated areas and in the level of use of agricultural inputs. For example, in the 2020/2021 agricultural campaign, the National Program for the Integration of Family Agriculture into Value Chains, SUSTENTA, made available around 300,000 technological packages to small farmers, supporting them in increasing the areas of cultivation, the level of use of agricultural inputs and, consequently, to increase their production in different cultures (MADER, 2021). In this context, it is urgent to develop innovative tools conducive to the establishment of robust, economically competitive, socially responsible and environmentally efficient production systems. These tools should be able to monitor the cultivation areas and provide timely information that gives the farmer greater decision-making capacity; localized application and, in the appropriate amount and time of inputs and/or interventions necessary to sustain high productivity, thus contributing to the preservation of the environment, namely carbon sequestration. In this context, this research aims to develop AI algorithms for optimizing the control of weeds, diseases, pests and crop irrigation in Mozambique. This study specifically aims to:

i. Calibrate and validate an AI algorithm for identifying diseases in tomato crops by June 2024;

ii. Calibrate and validate an AI algorithm for identifying pests in corn until June 2024;

iii. Calibrate and validate an AI algorithm for optimizing irrigation in corn and tomato crops by June 2024

The study expects to generate more accurate models for monitoring agricultural systems using hyperspectral and multispectral reflectance data and better understanding of the spectral signatures of agricultural crops and their relationship to various agricultural parameters

10. Leveraging multi-agent models for learning recommendations and improvement of farmer-to-farmer interactions in small scale dairy(farmer support)

Name: Dr. Devotha Nyambo
University: Nelson Mandela African Institution of Science and Technology
Country: Tanzania
Gender: Female

Overview

Governments employ extension officers who support farmers with advisory, animal health management and breeding services among others. However, there is an imbalance between available extension workers and farmers to be served, leaving a service gap in smallholder dairy production. Although Governments have put up strategies for increased milk yield, on-going initiatives have left behind the power of data, emerging technologies in artificial intelligence (AI) and mobile computing. Studies have shown that deploying a sufficient ground force for extension service to smallholder farmers is cost prohibitive. This makes the case for a digital extension model to be the most viable option. Nonetheless, AI provide approaches for simulating the real world to test results/outcomes of various interventions before they are deployed. Researchers are yet to embrace the power of data driven multi-agent models where agents can better learn based on data from the real world. The proposed research envisages to leverage real data to construct and improve multi-agent models for their output to be used in development of an end user mobile application for farmer-to-farmer learning.

The main objective of this research project is to develop intelligent multi-agent models for learning recommendation and improvement of farmer-to farmer learning for increase in milk yield. The proposed research will accomplish the following specific objectives:

i. collect data on management choices, constraints and milk yield and defining requirements for the mobile application for peer-to-peer learning tool; 2.

ii. develop a complete dataset by cleaning, sorting and labelling on-farm management and milk data based on 6 dairy production clusters;

iii. develop data-driven agent-based models and simulate peer to-peer farmer learning and networking for increase in milk yield;

iv. develop end user mobile applications for farmer peer-to-peer learning.

This study expects to enhance knowledge sharing among farmers, improved decision-making capabilities, resulting in more efficient and effective farming practices. This will support the adoption of improved farming techniques, leading to increased productivity, sustainability, and profitability.

11. Crop conditions monitoring and yield prediction using IoT systems and machine learning techniques for precision agriculture (Case study of maize in Rwanda)

Name: Dr. Frederic Nzanywayingoma
University: University of Rwanda
Country: Rwanda
Gender: Male

Overview

The general objective of this project is to increase crop yield by using emerging technologies in order to fight against food insecurity. Basically, with the use of IoT tools in precision agriculture the ability to analyse each plant's condition individually improves; and as consequence, errors that are usually found with agronomists when sampling small areas of the field are minimized. This project aims to provide quality services to farmers with the deployment of IoT tools and the use of ML skills; thus, the responsible authority and farmers will get notifications in due course concerning the health and yield of the crop. From the given information right decisions and measures will be taken. The research projects aims to:

i. develop an autonomous UAV imagery crop conditioning system to detect FAW;

ii. design IoT System integrated with machine learning technics for crop stress localization system;

iii. design an IoT system for ground truth information;

iv. detect crop diseases in early stages hence increase crop yield by using ML techniques;

v. assess and analyze crop health and help in prediction of crop yield using ML techniques.

Findings from this research project could potentially improve crop disease detection, increase crop yield/quality as well as reduce costs associated with crop production, mitigate against environmental impact and enhance agricultural sustainability.

12. Deep learning techniques for early detection of crop diseases(Early detection)

Name: Dr. Neema Mduma

University: The Nelson Mandela African Institution of Science and Technology

Country: Tanzania

Gender: Female

Overview

Despite the fact that the agricultural sector is the national economic development priority in most countries in sub-Saharan Africa, crop diseases have been the challenge affecting major food security crops. The current state of data collection and disease diagnosis is transitioning from disease identification using visible symptoms to the use of data-driven solutions applying machine learning and computer vision techniques. However, the image data previously collected have not been sufficiently curated, prepared and shared with the wider machine learning community. Moreover, by the time-image data is captured, diseases have already manifested in different parts of the plant and little can be done to salvage the situation. The efforts on data collection workable solutions for early diseases detection are still limited, biased and the data is not reproducible. Therefore, it is crucial that more datasets made available to increase the adoption of machine learning research and spur innovations to address food security. The main objective of this research is to develop deep learning techniques for early detection of crop diseases specifically by:

i. assessing farmers knowledge on crop diseases diagnosis;

ii. collecting image data in the identified study sites;

iii. extracting features of the collected image data;

iv. developing, evaluating and deploying a model for detection of crop diseases.

The research expects to improved crop disease detection, crop yields and quality as well as cost savings while also enhancing sustainable agricultural practices.

13. An integrated AI, IoT and mobile App based tool for early-prediction and control of mycotoxin in grains case-study: maize and peanuts crops in Tanzania

Name: Dr. Judith Keebisilo Leo

University: Nelson Mandela African Institution of Science and Technology

Country: Tanzania

Gender: Female

Overview

Tanzania is among the SSA countries whose economy depends on agriculture, accounting for 60% of the Gross Domestic Products (GDP), 90% of the countries' rural employment, and 85% of recorded export earnings (DTMA 2012). Major food crops grown in these countries are grains including maize, peanuts, and rice crops which contribute to major per capita calories consumed. These crops have the potential to upsurge small-scale producers' (SSPs) incomes, reduce poverty and assist close the food gap (FAO and IFAD, 2005). Despite their potentials for SSPs and the economic development of SSA countries at large, there is still a lack of precise and cost-effective mechanisms for early-warning analysis, prediction, and control of food-poisoning in grains hence its agricultural economic development has remained lower in Tanzania. While peanuts and maize are important crops with both economic and nutritional significance in tropical and subtropical regions, their vulnerability to aflatoxin contamination makes them unsuitable for consumption. This research study aims at assessing the aflatoxin contamination of locally stored and processed maize and peanut in Tanzania then develop a precise and cost-effective tool for early analysis, prediction, monitoring, and control of aflatoxin using emerging technologies including AI, Internet of Things, and Mobile Applications. The main objectives are to:

i. identify requirements and recruit a group of small-scale farmers and entrepreneurs especially women-farmers who are dealing with maize and peanut crops agricultural and mycotoxin experts;

ii. collect, review and validate the identified requirements with the assistance of the recruited small-scale farmers and entrepreneurs' groups and agricultural and mycotoxin experts:

iii. design, develop and evaluate an integrated AI, IoT, and Mobile-App based Tool for Early-Prediction and Control of Mycotoxin in Maize and Peanut crops.

This research hopes to improve early detection and prediction of mycotoxin contamination in maize and peanut crops, enhance crop management practices through the integrated tool and empower farmers and stakeholders with accessible and user-friendly information. It will also help develop adaptable solutions that can be applied to other regions and grain types beyond maize and peanuts while also promote sustainable farming practices, reduce mycotoxin contamination and improve crop productivity.

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