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Machine Learning Approaches for Pest and Insect Management in Forest Scenario: An Outlook

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Forests are nature's most efficient complex ecological system and vulnerable resources of valuable products which contribute to the sustainable development of communities. In the current scenario of climate change, forest became susceptible to major issues such as diseases, insects, pests and their unpredictable pest outbreaks. The sustainable management and protection of this natural environment from insect, pest, diseases, human interference and unwanted disturbances is vital and needs new tools to find insight and effective management. Computer vision is good at spotting disorder and efficient pre-requisite tool for insect pest management. Hence, introduction of Artificial Intelligence (AI) and Machine Learning (ML) techniques could be an alternate advanced precision approach to detect and control the herbivorous insect pests at an early stage to avoid huge damage to forest and continuous indiscriminate usage of the chemical pesticides. This is an opportunity which benefits farmers, state forest departments, Forest Development Corporation, forest and private nurseries, wood-based industries, paper and pulp industries etc.

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1. INTRODUCTION

Forests are essential for weather regulation that provide a spread of treasured products, such as timber, fuelwood, fiber and non-wooden forest products to a growing human population and make a contribution to the livelihoods of rural communities. They are considered as “carbon sinks”. They provide critical and diverse ecosystem services such as supporting biodiversity conservation, combating land degradation, soil erosion and desertification, protecting watersheds, reducing risk due to natural disasters, regulating climate change mitigation, enhancing carbon sequestration, poverty eradication, economy enhancement and income generation which gain people economically, emotionally and socially. Forest encompasses 40 % of the global terrestrial superficial composed of approximately 3.04 trillion forest trees of which most are innate tree species and a minor portion of profitable plantation, industrial forestry (that plays a vital part in national financial prudence) and plantation forestry with amazing tree species prevails [1-3]. Trees are crucially essential for climate regulation. Loss of nearby tree habitats causes decline in pollinator numbers thereby decrease in agriculture production. Such forest trees are progressively menace by means of numerous abiotic and biotic factors. It is anticipated that due to increased stress (climate change), forests will become susceptible to insects.

Within the present-day situation, global climate alteration is having notable impacts on forests viz., expansion of insect species stages, invasion and expansion of alien insect species and increased frequency of woodland fires. Of which, herbivorous insects are necessary components of natural forest ecosystems which could affect and be stricken by forest [4]. Forest is persistent even though their health and power are affected by the natural disturbances along with fire, climatic variation, pests and diseases. Climate change can affect pests and the damage they purpose with the aid of: directly impacting their development, survival, reproduction and unfold; altering host defenses and susceptibility; and in a roundabout way impacting the relationships between pests, their surroundings and other species which include natural enemies, competitors and mutualists. Bugs and diseases have giant influence at the fitness of forests, bushes outdoor forests and different wooded lands. They adversely have an effect on tree increase, vigor and survival, the yield and nice of timber and non-timber products, wildlife habitat, endeavor, aesthetics and cultural values. Forestland affected by insects has been predicted to be forty times larger than other causes [5,6]. Forests /plantations need to be managed to minimize the risks and impacts of unwanted disturbances.

Conservation of these prone assets from insect pests requires reliable data on their bio-ecology, distribution, their impacts on wooded area ecosystems and appropriate manage measures. Globally most effective little complete, quantitative information is to be had on insect-pests, even though plenty qualitative facts on insect-pests and sicknesses occurs in nearby and national level. Subsequently, a deep know-how of the complicated relationships between a changing weather, forests and forest pests is vital to enable the ones in forest health protection and management to assume and put together for adjustments in pest behaviors, outbreaks and invasions. Climate change and increased extreme weather will cause alterations in the insect’s lifecycles, host range and augment their virulence thereby becoming significant driver to change the forest ecosystem. In addition, non-native invasive species that spread widely causes severe threat to forest health across the nation. For effective management and conservation of this natural multipurpose forest from insect, pest and diseases an advanced intelligent agent-based new tools are needs preemptive control measures for effective management and pests’ prediction system at an early stage. To achieve this goal application of Artificial Intelligence (AI) and Machine Learning approach (ML) tools would be of great importance.

Underneath such circumstance, artificial intelligence (AI) that encompasses an array of strategies and frameworks in conjunction with Machine Learning (ML) a looming powerful tool for forest insect pest control. Machine learning algorithms interpret vast datasets, analyze the input and result data, from the dataset it built the system model from which it predict future outcomes. ML along with Artificial Neural Networks (ANNs) have been extensively used to detect insect pests. Various ML algorithms are

beneficial in insect pest management of different crops. ML shifts pest control strategies from reactive to proactive, reduces wide spread pesticide use, economic sustainability, ecosystems protection, healthy environment and promoting biodiversity. Karar *et al*. [7] proposed a cellular utility to classify 5 training modern day insect pests the usage of deep modern day in cloud computing. Chen *et al*. [8] proposed an embedded drone device and deep brand new to recognize bugs in a tree. Li *et al*. [9] studied 5 state- of- the- art deep trendy architectures for photo reputation trendy ten classes trendy crop pests. Thenmozhi and Reddy [10] proposed a stepped forward deep convolutional community, outperforming exceptional-tuned models in insect pest reputation. Computer imaginative and prescient is right at recognizing problems and using aerial vehicles which includes drones make it possible to automate spraying latest pesticides uniformly throughout an area.

1. Machine learning approach

Machine Learning (ML), a major area under Artificial Intelligence is creation of computational algorithms to classify and predict the behaviours of data set using the train data with high accuracy and speed which have been proved worthwhile. ML construct algorithms to interpret and analyze both the input and result data without simply following the instructions on that data. Some of the machine learning algorithms viz. Neural Networks ((ANN, CNN, R-CNN), Support Vector Machines, Decision Tree, Regression Analysis, *K*-means clustering, Logistic regression and Bayesian belief network have been used for insect pest management.

Support Vector Machines, Decision Tree, Naive Bayes algorithm were used to detect and classify the disease through obtaining patterns of input data i.e., effective consideration of all factors (soil quality, crop rotation cycle, seed quality etc.) and historic/satellite/sensor field data. These efficient, fast interpreting algorithms will help plant scientist for effective and affordable automated insect detection.

2. Importance and application

- Growing performance of time, labour and sources.
- Enhancing environmental sustainability.
- Making useful resource allocation smarter.
- Imparting real-time tracking to promote extra health and satisfactory of produce [11].

Prospective areas of entomology for application of AI& ML

- Taxonomic studies (identity and category of insects, phenotype quantification, knowledge evolutionary versions in species)
- Ecological research (Spatial and temporal distribution of insects, understanding adjustments in insect biomass, abundance and diversity, reading dietary ecology of insects, estimating microhabitat characters)
- Pest management (pest identification, class, tracking, manage, developing pest warning and prediction systems and biosecurity) [12].

3. Steps in Artificial Intelligence & Machine Learning

a. Detection of pest

Detection of pests of plant life can be automatic by means of using image reputation generation based on deep studying. Series of real-time photos of bugs on unique plantations. They then based totally the detection and coarse counting approach on YOLO object detection, and the class and first-rate counting on Support Vector Machines (SVM) the usage of international capabilities [13]. While all will set and performed, their computer vision model would able to identify exclusive bugs with nearly 90% accuracy. To expect the incidence of pest use of deep getting to know YOLOv3 for photo reputation to attain the place of pest and analyze the environmental facts from climate stations through Long Short-Term Memory (LSTM).

Computer vision systems and photo processing using artificial intelligence techniques i.e., machine gaining knowledge of and Artificial Neural Networks (ANNs) had been widely used to locate insect pests. Faster place-based totally Convolution Neural Networks (quicker R-CNN) are a unified deep CNN for goal detection and identification in pix which include feature detection, candidate local generation, nearby image category, and location refinement. In order to classify insect pests, four machine learning techniques, namely artificial neural network (ANN), Support Vector Machines (SVM), K-Nearest Neighbours (KNN), Naïve Bayes (NB) and Faster R- CNN model would be of better choice to achieve highest accuracy rates of 90%. Deep learning module is responsible for image

processing to detect and classify pests using Faster R-CNN and cloud computing system approach [14]. Extraordinary synthetic Intelligence based mobile apps had been advanced and released for identity of insect pests on specific plants e.g., E-SAP, Plantix [15].

b. Population density, damage and spray threshold

Regression and K-manner clustering might be applied to evaluate the density. ANN and SVM would be implemented for assessing the dame as a result of the insect. MODIS (slight decision Imaging Spectro radiometer) together with remote sensing snap shots with guide Vector Machines would be a higher desire to expect the damage ability [16]. To are expecting the geographic distribution of organizations of polyphagous plant pests, synthetic neural networks can be used, the usage of weather variables as predictors, synthetic neural community fashions, might be as compared with binary logistic models for predicting insect distribution.

c. Control measures

Nowadays, artificial Intelligence (AI) techniques have been used for precision control of insect pests. Drones are unmanned aerial vehicles widely used in various disciplines. It works at the principle of AI. Drones are used for spraying of pesticides to manipulate insect pest effectively over a larger vicinity. Unmanned aerial motors (UAVS) geared up with computer imaginative and prescient AI make it possible to automate spraying of insecticides uniformly across an area [17]. This considerably reduces the risk of contaminating plants, humans, animals and water resources and help in insect pest control efficaciously. Use of chemo and bio sensors would usefully resource in IPM, very especially on Push-Pull approach. Device getting to know algorithms (selection Tree, Naïve Bayes, Random woodland, AdaBoost, help Vector gadget) and one statistical method (Logistic regression) (classifiers) will be used to expand models to forecast insecticide software decisions for pests and ailment manipulate, by predicting whether pest tracking results might be above or under a spray threshold.

d. Limitations of Machine Learning

1. Whilst in comparison to people, machines can't examine exclusive realities and adopt to it. Every problem is precise and requires steady improvement and education of latest algorithms, much like how every day new sort of clever phones are being advanced.
2. It requires huge antique for set of rules training database.
3. Whilst dataset is small, extra mistakes may be noticed due to much less training cycle. While dataset is big but has much less variability, this leads to low accuracy because actual-time scenarios are complex with excessive versions.
4. Requires excessive high-quality pictures to teach the algorithm.
5. Developmental cost is excessive.
6. Absence of adequate research in the application of robotics in agricultural entomology.

4. Challenges of AI

The challenges that need improvement for this significant advance pest management method includes accuracy, reliability, real-time detection, data quantity, data quality and species diversity. Developing methods that can adapt to different pests is challenging due to the factors like identifying non-pests as pest, failing to detect pests, huge data requirement which is expensive and time-consuming, imbalanced data set and species diversity (method developed for one pest may not be operative for others). The other challenges include

- How effective is this on ground over the ongoing conventional technologies.
- How cost effectiveness.
- What is the time gain for detection and control?
- The terrain where these technologies are to be deployed and best utilized
- Difficulties in use of these tools in remote areas.
- How effective has this been in agriculture /horticulture plantation management?

2. CONCLUSION

Protection of forestry as of insect pests and diseases is an essential portion of sustainable forest administration, since insect pests are causing havoc to forest bio resources which are essential for sustainable livelihood of all living organisms. Smart modern technologies such as integrating artificial intelligence and machine learning will help in forecasting and timely management of pests and diseases effectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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