AI-BASED FARMER QUERY SUPPORT AND ADVISORY SYSTEM

Supriya Yadav,
Department of Computer Science & Engineering, FoET, University of Lucknow, India.

Pawan Tiwari,
Department of Electrical Engineering, FoET, University of Lucknow, India.

Varalika Dwivedi,
Department of Computer Science & Engineering, FoET, University of Lucknow, India.

Siddharth Singh,
Department of Electronics & Communication Engineering, FoET, University of Lucknow, India.

ABSTRACT

The small farmers in Uttar Pradesh, India, face various issues concerning agriculture, such as the crop diseases, weather inconsistency, lack of expert guidance [14], [21]. Not only do these problems lead to poor performance but they also cause stress amongst. This paper aims to introduce an AI-based query support and advisory platform for farmers. The proposed system enables farmers to receive agriculture advice from experts through natural language processing (NLP) [4] methods by providing information in multiple languages including Bhojpuri, Hindi, and English [4]. Crop diseases were diagnosed using a convolutional neural network (CNN) built on TensorFlow [11] to predict diseases with high accuracy (86.7%) for the crops like tomatoes, potatoes, maize, and chili [5]. The System also takes real-time weather conditions using APIs such as OpenWeatherMap [8] provides personalized suggestions based on past crop history and soil data, and promotes community participation through a credit reward system SathiPoints. The system utilizes the cloud-based computing technique for processing to handle data in real time.

Keywords: *Artificial intelligence in agriculture, farmer advisory system, crop disease detection, voice-based interaction, digital agriculture, farmer mental well-being*

INTRODUCTION

Agriculture in the Indian economy is immensely important, especially in Uttar Pradesh, where a large portion of the population depends on it for their livelihood [14]. Majority farmers in India are small and marginal [14], and they face several constraints, that includes plant disease problem, unpredictable weather, lack of information from agricultural experts, price fluctuations, and unavailability of modern agricultural technology.

First of all, there is an issue of delayed crop disease detection, which may lead to lower yields and economic losses [5]. Secondly, climate change makes it impossible to estimate the water supply and timing for irrigation, sowing, and harvesting [21]. Farmers often struggle to get expert advice on dealing with pests and weeds, mainly because they live far away from agricultural experts.

Several applications have been developed for farmers, such as AgriApp and Kisan Suvidha [1], [3], but many are text-based and not suitable for farmers with limited literacy. For instance, most of the platforms are text-dependent and not suitable for less literate users. Those applications do not provide linguistic and local adaptation.

To overcome the above-stated constraints, this research introduces a farmer advisory system using artificial intelligence. This system uses voice input interface, and community participation to offer digital support in agriculture. The main aim of this study was to increase agricultural efficiency and make appropriate decisions to improve the lives of farmers through digital solutions.

The second reason is that despite technological advancements in information technology, farmers face economic challenges in adopting digital technology. These include inadequate Internet connectivity and the inability to access knowledge about how to use new technology effectively. Agricultural methods practiced in regions like Uttar Pradesh are very much influenced by local environmental factors. Thus, there is a need for an innovative technology that takes into account all these factors.

Another important point is the absence of platforms where various functions are combined into one platform itself. Often, farmers may have to use different programs for getting information about the weather, checking crops for diseases, and even talking to an expert on the issue, which makes the entire process complicated and decreases their involvement. The solution could be developing a platform integrating everything that a farmer needs into one place [20].

LITERATURE SURVEY

Agriculture has experienced remarkable growth in recent years because of innovations in artificial intelligence, computing, and cloud computing [5]. This innovation is geared towards increasing efficiency within the agriculture sector, efficient resource management, and timely decision-making for farmers

A. AI-Based Crop Disease Detection

In recent times, artificial intelligence technology, especially deep learning technology, has found widespread use in disease detection in crops. It is important that convolutional neural networks (CNNs) can be very useful in identifying diseases on plants using image classification techniques [5]. Previous studies have indicated that CNNs can classify diseases accurately based on leaf image recognition. The availability of frameworks like TensorFlow and OpenCV has facilitated the development of image processing and classification algorithms [7], [11]. The main challenge in applying this technology in rural areas comes from environmental factors.

B. Digital Advisory and Voice-Based Systems

There are numerous digital applications that have been developed in order to offer agricultural guidance to farmers. Examples of these applications include AgriApp and Krishi Network, both of which connect farmers with experts who provide guidance on agricultural matters [1], [6]. The disadvantage of such applications can be that they are mainly text-based and hence not easily accessible to farmers who have limited literacy skills. An alternative approach could be to use voice-based solutions such as Google Speech-to-Text and overcome the issue [2].

Voice-based solutions [2] would allow farmers to engage in conversation with the software by simply speaking out loud rather than having to read and type text. This is especially helpful for farmers with limited literacy, as it simplifies communication and reduces the learning barrier. Eventually, such systems can improve user confidence, encourage wider adoption, and ensure that more farmers can benefit from digital agricultural support. Studies show that digital advisory systems improve farmer decision-making and behaviour [16], [19].

C. Gamification and Community Engagement

Gamification improves engagement and participation in digital platforms. Research indicates that community-driven advisory systems enhance knowledge sharing among farmers [13], [17]. For example, in the agriculture and farming sector, gamification could be used to motivate farmers to engage in knowledge exchange and discussion within the agriculture community. But, even when such potential exists, fewer platforms have used such techniques or created engagement structures among farmers. Hence, there is a need for platforms that combine advisory services and gamified user experience in order to engage with a large majority [20].

From the available literature, even though solutions already exist to help with plant disease detection, advice provision, and voice interface technology, most platforms do not integrate all of them with localization and community engagement aspects. Therefore, the goal of this paper will be to create a platform that will solve this problem.

The existing solutions in digital agriculture have contributed positively to agricultural development but numerous issues have emerged with these platforms. The primary one is that of creating one solution for different needs. Current solutions in digital agriculture might have only solved one particular problem, while there is a need to design an inclusive solution that solves several problems at once. Secondly, there is a need to regionalize and customize the solutions according to the region, especially Uttar Pradesh.

The third important gap is that no attention is paid to the psychological health of farmers [21]. Although technology may offer solutions that can increase efficiency and improve production, it fails to recognize the psychological issues that farmers face. Financial stresses, crop failure, lack of social support systems may lead to psychological disorders that usually go unnoticed. There are no gamification or socialization features incorporated in any digital platform that makes the process more interesting and engaging.

SYSTEM DESIGN AND IMPLEMENTATION

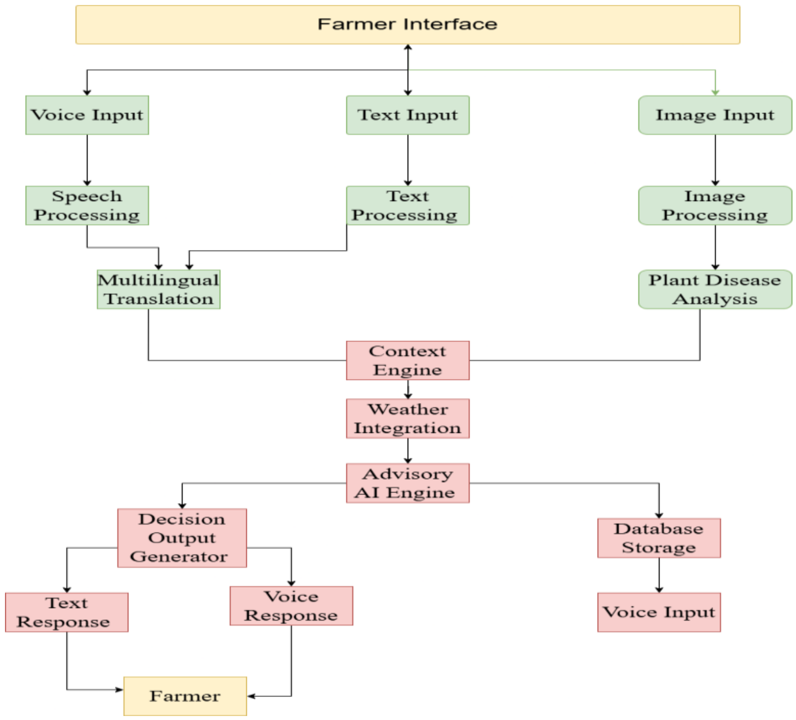
A. Architecture Overview

The proposed system adopts an architecture that consists of different modules to ensure smooth functioning of the system. React Native is going to act as the front end of the technology stack for making sure that the users can use this on all mobile operating systems. Node.js will be used for developing the back end for processing the requests of the users as well as working with APIs. User information, data about crops, and interactions performed through the app will be stored in PostgreSQL databases. External APIs such as weather services (OpenWeatherMap [8]) and speech recognition (Google Speech-to-Text [2]) are integrated.

The system will have AI modules for performing image-based disease detection and processing users' voice commands. The cloud will provide the necessary computational power to perform the assigned functions. The system will use external APIs, such as weather services and speech recognition software to expand its functionality.

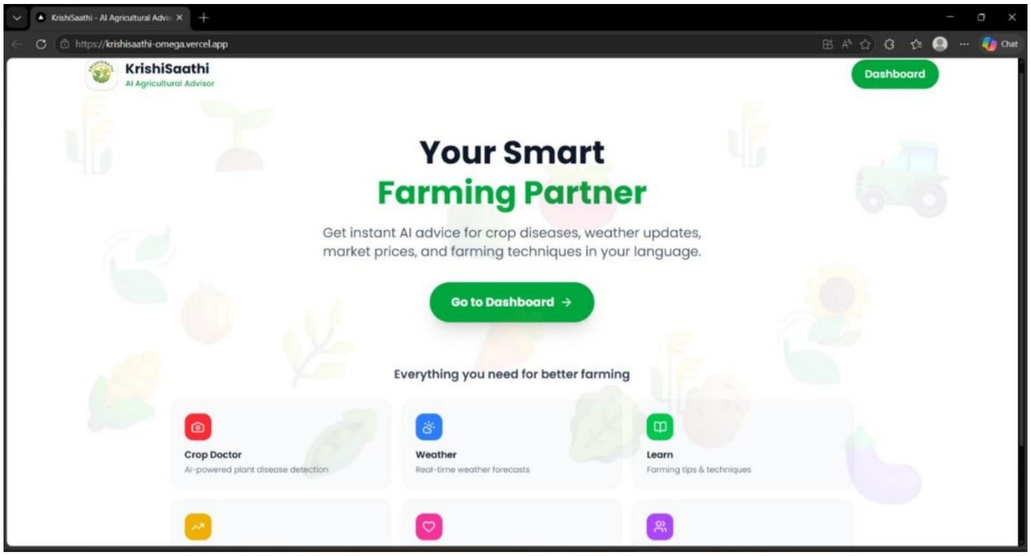
Cloud computing enables real-time processing and scalability [20]. The adoption of cloud computing technology has played a major role in ensuring the effectiveness of the proposed app. For instance, the use of cloud computing will enable the delegation of certain processes, such as processing images and performing NLP tasks to the cloud. In this regard, the requirement for the hardware of user devices will be minimized. As the number of users grows, cloud computing will help to scale the system efficiently.

The security and safety of the user's information are also considered during the design phase of the system. The user data, which include information on the crops and interaction history, are safely stored in the database through the proper use of authentication techniques. Frontend-to-backend communication is also encrypted for safety purposes.



B. User Interface Design

The design philosophy of the user interface revolves around the simplicity and ease of use of the system. The design ideology behind the user interface lies in its simplicity and convenience. Voice-first technology is adopted to decrease the necessity to type input into the system, thus facilitating access for those users who do not know how to write in a certain script [2]. The interface utilizes large icons, minimal text, and convenient navigation.

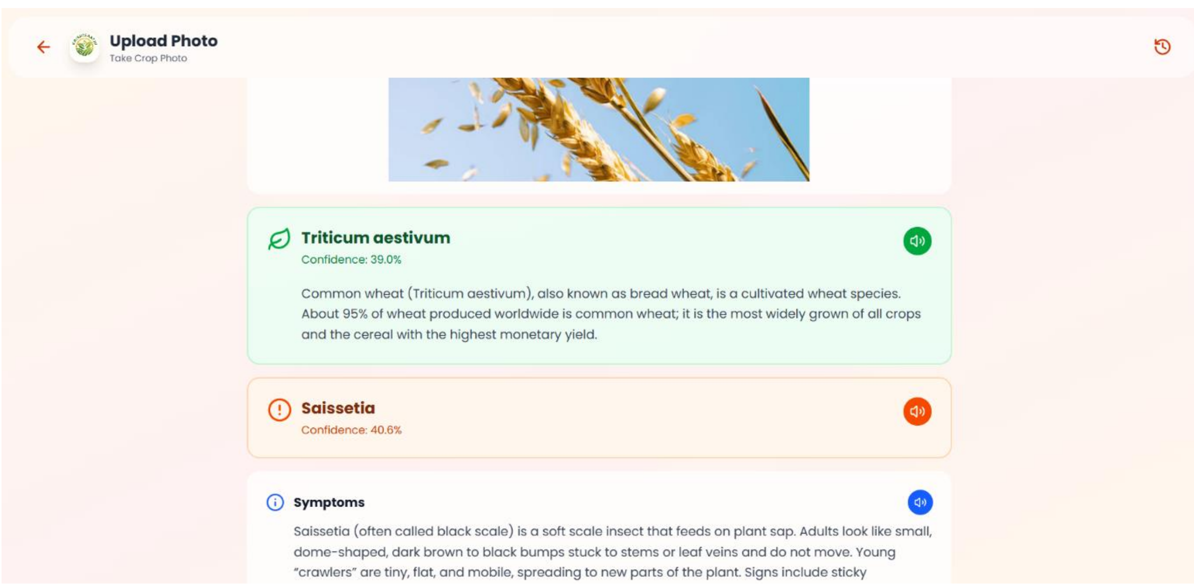


C. AI-Based Disease Detection

For the implementation of the crop disease detection module, a CNN model created using TensorFlow is employed [11]. Image pre-processing is done using OpenCV [7], including resizing, normalization, and denoising. Afterward, the images are given as input into the CNN model for prediction, and the output includes the name of the disease, its probability value, and possible treatment. For the training of the model, not only public datasets are employed but also field datasets.

In order to boost the performance of the model, the use of both public and field datasets is made to enrich the variety of data. Techniques such as rotations, flips, and scaling can be applied to the dataset to prevent the problem of overfitting. Supervised learning is the approach used for training the model using the CNN algorithm. Hyperparameter tuning is also performed.

The model not only makes predictions, but it also gives confidence scores alongside the prediction. For instance, when the confidence score is low, the recommendation will be to consult experts via the application.



D. Voice Interaction and Personalization

The voice interaction system uses speech recognition technology [2] to transcribe the queries. The NLP algorithms [4] will assist in deciphering the intention of the query and provide answers accordingly. Suggestions are made based on information about the weather condition, type of soil, and previous crop types. It will assist the farmers in receiving suitable suggestions related to irrigation, pest control, and cropping patterns.

E. Gamification and Community Integration

The system introduces reward-based engagement (SathiPoints). Studies show gamification improves participation and knowledge exchange [13]. The platform offers an incentivization program in the form of SathiPoints, through which users receive points as rewards for using the website. Farmers earn points by posting questions, sharing information, and helping fellow farmers. A discussion forum is added within the website to enable peer-to-peer interaction.

RESULTS AND DISCUSSION

The proposed system was evaluated through a prototype implementation in rural farms. In terms of crop disease detection, the model based on CNN technology provided accuracy of 86.7%, precision of 84.9%, recall rate of 85.2%, and F1-score of 85.0%. This shows that the implemented model is effective in the identification of the crop diseases [5].

In terms of language recognition by the voice assistant, a recognition accuracy of 91.3% was recorded [2]. This showed that the implemented technology worked well in dealing with different languages. Users gave positive feedback on the use of voice commands since this helped improve usability for illiterate users.

Finally, gamification helped improve user engagement where farmers actively participated in community activities and exchange of information. It is apparent that integrating various components within one platform can provide significant benefits for users [16].

Aside from the quantitative analysis, qualitative feedback was also gathered from the users through interactions with the prototype. They noted that the voice-based technology greatly improved the ease of use as compared to existing text-based technology. Furthermore, another factor that contributed to increased ease of use was the opportunity to communicate using their native language, thus reducing the learning curve. Gamification also increased the application's appeal, as users were actively involved in discussions and trying to earn SathiPoints. Clearly, introducing features that provide rewards in applications makes users utilize such applications.

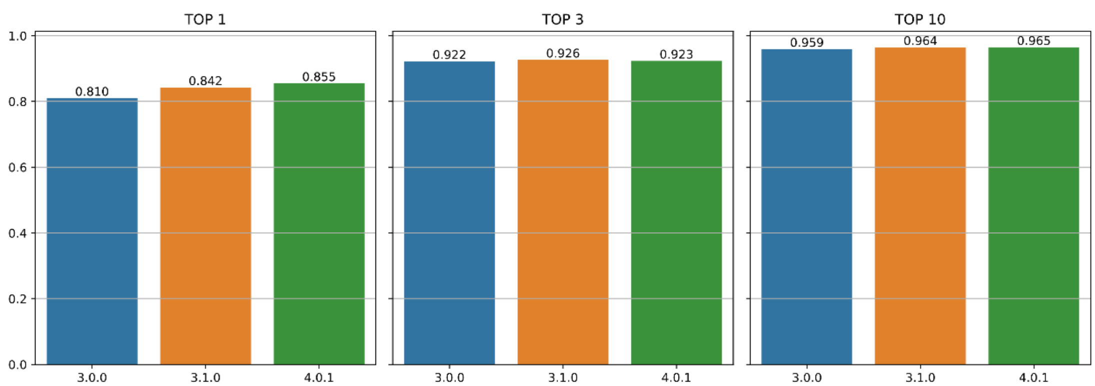


Fig 4: Accuracy comparison of AI plant disease detection models. Source: Adapted from Kindwise [12]

CHALLENGES AND FUTURE WORK

However, despite having some positive outcomes, this method faces several constraints. Firstly, its functioning is greatly hindered by the lack of internet connection and dependency on external APIs such as weather services [8]. Secondly, regional accents can affect the quality of speech recognition [2]. Thirdly, the set of training data used for building the algorithm of detecting the disease is quite small.

The next obstacle lies in the necessity to use third-party services such as weather forecasts and the speech recognition engine. Recommendations will always be accurate depending on the quality of these external sources. For example, forecasts can fail to predict exact climatic changes in particular places. The same way, speech recognition engines can face issues when it comes to differences in pronunciation.

Lastly, scalability can pose additional challenges for the working of the application. Managing lots of concurrent users is quite difficult due to the need to use proper resource management techniques and optimization processes.

FUTURE SCOPE

The present work is a foundation upon which several future research and development can be pursued. A primary direction that involves enhancing offline capabilities through the deployment of lightweight machine learning frameworks such as TensorFlow Lite [11]. Such an implementation can enable on-device inference in low-connectivity village areas, thereby addressing the infrastructural limitations frequently encountered in rural agricultural settings.

Further versions of this system are expected to expand the present scope by covering not only tomatoes but also other crops that might be affected by the late blight disease [5]. Such a feat will be made possible by creating an extensive database that caters to different kinds of crops and an elaborate categorization of plant disease.

As far as methodology is concerned, the use of advanced machine learning algorithms such as transfer learning and reinforcement learning will bring great excitement. The potential of using transfer learning, for example, lies in its ability to allow the reuse of knowledge gained from one domain to another, especially in relation to crop diseases, whereas reinforcement learning may help improve the classifier's prediction by learning from experience.

The issues of accessibility and inclusiveness represent yet another crucial aspect to consider in future research and development. The improvements in the realm of automatic speech recognition with regard to dialects and resource-poor languages will allow the use of the technology by users who speak different languages.

Lastly, the coverage of the proposed system can be broadened from disease diagnosis to cover other aspects of decision support systems. Inclusion of forecasting models for market prices and logistics analysis would give farmers an edge to make better decisions concerning harvesting, distribution, and marketing of their produce.

CONCLUSION

The suggested AI-powered Farmer Advisory System highlights the power of integration of various technological tools to solve practical problems in agriculture. With an ability to detect crop diseases, interact in different languages, provide recommendations, and connect with others, the platform represents a holistic approach to solving issues faced by small farmers. It is evident from the findings that not only does the platform increase agricultural output but also user participation and accessibility to the services provided.

Feature / Platform	Plantix	Kisan Suvidha	Krishi Network	AgriApp	KrishiSathi
AI Disease Detection	Yes	No	No	No	Yes
Multilingual Voice Support	No	No	No	No	Yes
Hyperlocal Weather Forecast	No	Yes	No	Yes	Yes
Personalized Advisory	No	No	Yes	Yes	Yes
Community interaction	No	No	Yes	Yes	Yes

Gamification	No	No	No	No	Yes
Mental Health Support	No	No	No	No	Yes
Govt Scheme Access	Yes	Yes	No	No	Yes
Image-Based Crop Diagnosis	Yes	No	No	No	Yes
Voice-first Interface	No	No	No	No	Yes

Apart from technical benefits, it can be noted that the development positively impacts the quality of life of farmers through uncertainty management and timely assistance. Community communication and game mechanisms contribute to a more collaborative environment, which promotes sharing valuable experience among users. Further evolution of digital agriculture will help create similar solutions that could help bridge the gap between technologically advanced world and rural communities.

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