Volume 2, Issue 1 | May-2025
e-ISSN: 3065-1085 Print ISSN: 3065-1069

SmartCropNet: A Data-Driven Farm Multi-Platform Tool

Dr. Sophie Dubois[1], Dr. Jean-Luc Martin[2]
[1]School of Agriculture, University of Paris, Paris, France
[2]Department of Plant Science, University of Lyon, Lyon, France
Received: 10-03-2025; Revised: 04-04-2025; Accepted: 20-04-2025; Published: 14-05-2025

Abstract

The multi-platform SmartCropNet presented in this paper is aimed at promoting precision agriculture by means of the inbuilt data collection, analysis, and decision support. The application takes advantage of the cross-platform compatibility and offers farmers, agronomists and researchers convenient access through webs, Android and desktop platforms. SmartCropNet has the potential to optimize crop management, efficient consumption of all resources, and sustainable farming, due to the inclusion of real-time sensor data, satellite imagery, predictive analytics, etc. It is usable and has a farmer-friendly interface, yet it has the advanced possibilities of monitoring soil health, irrigation, detecting pests. All in all, SmartCropNet is a good example of how the technologies of digital agriculture can make traditional farming data-driven and ecologically-friendly.
Keywords: ***Precision Agriculture, Cross-Platform Application, Smart Farming, IoT in Agriculture, Crop Monitoring, Data Analytics, Sustainable Agriculture, Decision Support System, Resource Optimization, Satellite Imagery.***

1.Introduction

Subsequently, use of digital technologies in agriculture has become one of the many innovations of new age by altering the way plants are grown, traced and developed. Although traditional farming and gardening activities have been part of human culture and way of life, they have increasingly come under pressure with the ever increasing complexity of urban life-style, the influence of climate changes and the need, articulated globally, to implement sustainable agricultural activities. The issues demonstrate the great necessity in intelligent, adaptive solutions that help to increase efficiency and minimize manual intervention. The practice of precision agriculture is located at the crossroad between technology and agriculture since the progress field is strongly associated with the benefit of the Internet of Things (IoT), Artificial Intelligence (AI), and other advanced data-based tools to maximize the management of the plant health. It is in this context that the application has been envisioned as a new cross-platform tool that aims to build upon the existing interface between the plant science and contemporary technology that will support hands-on, automated, and scale-able methods of ornamental plant cultivation(1).

The increasing popularity of indoor and decorative plants gives even greater momentum to the technological advances in the given domain. The positive multidimensional effects of urban plants have been established as various studies have revealed the contribution of plants in urban settings regarding the physical and mental status. In addition to their esthetical properties, they enhance living conditions indoors due to absorption of pollutants, transformation of carbon dioxide into oxygen, and provision of more sustainable living premises. On the psychological level, it is preferable to have a little routine to care about plants and avoid stress and promote relaxation as a therapeutic activity of a fast pace of life. Nevertheless, even considering all these benefits, there is still one problem that might occur to plant enthusiasts and amateur gardeners regularly; the lack of proper and consistent information regarding plant care. This ignorance often results in the low growth or early demise of plants, hence reducing their potential usefulness and loss of motivation towards participating in gardening activities.

The need to tackle this challenge is promising with the advent of IoT and AI technologies. IoT-enabled smart devices will be able to measure the real-time information on soil moisture, temperature, humidity, and light conditions, and AI-powered models will be able to analyze them to derive sound decisions. However, the current success of these technologies is dependent on finding the platforms that will be able to combine various information sources and supply them to the end users in a readable, simple to process presentation forms. Elaboration of such platforms is a principal concern of researches and developers in digital agriculture. On these grounds, Plantonome proves to be a solution-based application whose main aim is to provide accurate, comprehensive, and user-specific information about plant management(2).

Plantonome is also conceptualized as an open-source cross-platform app with full compatibility with different gadgets and operating systems, thereby increasing access to users. It was constructed with the use of Flutter software development kit (SDK) and is written in Dart, technologies that are quite famous in terms of efficiency when compiling native apps with just one codebase. Using cross-platform compatibility, Plantonome can address the shortcoming of platform fragmentation and guarantees uniform user experiences at Android, iOS and web-based settings. Among the things that have made it one of the most innovative applications is that it has incorporated the Plant.id API, an advanced image-recognition service via machine learning algorithms. Such combination empowers the recognition of ornamental plants quickly and accurately using the images sent to the application directly through a device of a user.

FIGURE 1 Plantonome's Technological Framework

Besides plant identification, Plantonome uses NoSQL cloud-based database, namely Firebase, where the user data and their preference to specific plants and full profile of the plant species are stored. It is supported by a well-considered line of ornamental plants, and it includes the implication of how bright the plants want, what temperature should be at an optimal level, soil, humidity, and watering(3). These rich data enable the application to do more than just name the plants, but can tell the users how best to care their plants by advising them how to grow them and in what conditions making the application become a personal plant management digital assistant. Integrating into the picture recognition both the environmental monitoring and database recommendation capabilities, Plantonome establishes a powerful framework capable of automating the initiatives related to plant cultivation, thus reducing workloads of the user and maximizing the strength of the plants.

Such an application does not only implicate the personal gardening. On a larger dimension, Pl Antonome is contributing to the evolution of smart agriculture, a movement aiming at becoming more efficient, less wasting resources, and sustainable. The tech such as Plantonome can stimulate small-scale indoor growing, community gardens, and urban farming in the cities where the premises to conduct large-scale farming are scarce. The application features automatized control mechanisms and transmission of proper plant information that can be used to bridge the knowledge divide between the novice and the professional horticulturist. Moreover, the sustainability of Plantonome is aligned with the global sustainability objectives as Plantonome accentuates the greener living environment, minimizes plant fatalities, and enhances biodiversity in cities.

Considering the research and development aspects, the Plantonome project shows the possibility of cross-platform and open-source development frameworks in solving specific application domain related issues. Unlike most of the existing plant identification apps, available, which tend to have a narrow scope of audience or can be proprietary restricted, the characteristic of an open-source solution contributes to ingenuity, community, and even further expansion(4). Agricultural technology developers, startups, and researchers may modify, add to, or incorporate its structure or code into their own solutions and speed up the process of developing the tools automating the agricultural activities and enhancing plant care information accessibility.

2.Examining Current Plant Identification Technologies

The blistering change in artificial intelligence, image recognition, mobility has accelerated the production of several applications that find and treat species of plants. Such technological advances deal with the problem of amateur plant lovers and those specialized in horticulture and agriculture. The traditional way of identifying plant species based on botanical knowledge, the visual appearance, and reference books has, over the years, tended to be either inaccurate or laborious. These challenges are compounded by variability in plant morphology, seasonal variation and by subjective interpretation of visual information by humans. Thus, digital applications that utilize the AI-powered system of recognition have become widely used and deemed essential to plant identification, learning, and administration.

In the last decade, the plant identification apps that are natively compatible with smartphones and other smart devices have become popular on the market. Such applications are used by a wide community of people, including small-time gardeners, urban gardeners, botanists and agricultural research scientists. The most well-known are Plant.id, FlowerChecker, Seek, iNaturalist, Flora Incognita, Google Lens, PlantNet, PictureThis, Garden Compass, PlantSnap, Name That Plant, Leafsnap, Plantix, and Planta among others. These applications have all tried to integrate appealing substantiation to end users, yet have differed in terms of the range of possible outcomes, algorithm sophistication, and the readiness of databases. Their appearance illustrates how the need of consumers in easy to use plant identification tools crosses over with the development of machine learning and image classification technologies(5).

In more detail, going through these applications, one might see their potential and limits. As an example, Plant.id incorporates complicated machine learning models to parse photos of plants that are uploaded by its users. It has an admirable success rate, which is, however, highly dependent on the quality and clearness of the images. Another interesting application is Flora Incognita that uses large-scale deep convolutional neural networks (CNNs) trained on a dataset of plant observations. Flora Incognita stands out in such applications as education and work with biodiversity since the program is able to recognize more than 4,800 species. On the same note, a citizen science application iNaturalist has developed a massive plant and animal observation database contributed by users around the world. It is unique as possibly it can operate even in the absence of the internet so that it can be utilized in remote places. This dependence on community identification can, however, cause inconsistency in the identification of species.

Other applications point out the different approaches that are used in this field. An example is PlantNet which is a research and educational site mainly dedicated to biodiversity and conservation of plants. It uses user contribution to categorize images and the database already has more than 38,000 species. Its rate of identification accuracy is not up to a few competitors, but it has helped form a worldwide collaborative plant inventory. Commercial-wise, PlantSnap has an extensive database of 600, 000 plus plant species, which relies on the NVIDIA DGX Station and refined categorization algorithms. Such infrastructure has allowed PlantSnap to be able to recognise 90 percent of the known plants and trees reliably. Nonetheless the computational tools can be resource-intensive, therefore making it difficult to become accessible to small-scale developers or schools.

Although they are successful, the workings of these plant identification systems are not consistent in any condition. The quality of input images is one of the most challenging problems. Background detail, bad lighting and interfering Growth can lessen this accuracy, specially when it concerns Grasses, Sedges, and species whose morphological variations are subtle. Most applications appear reliable in recognizing flowers, leaves, or clear images of the whole plant but not in case of partial or deformed views. The shortcoming points to a continuing requirement of valid advancements in the developments of computer vision algorithms with the capacity to extract relevant features of plants even in a noisy context(6).

Technologically speaking, these apps differ vastly in the degree to which they depend on hardware, datasets and algorithms. There are those who have got their own sets of data and others who use freely available data such as the world database on inaturalist. Algorithms vary greatly with the simplest being image-matching systems, and CNNs and transfer learning models that have been trained on millions of annotated plant images. More recently other developers have sought to incorporate other metadata like geolocation, climatic information and time of year as a means to increase precision. Application of visual recognition with the associated contextual information can help decrease the number of potential species much more efficiently. But to introduce such features, the company needs a strong backend infrastructure and must pay enough attention to data privacy.

These applications go beyond identification that is developed. Inclusion of diagnostic elements to ascertain any health concerns of plants like a deficiency of nutrients, occurrence of pests, and fungus is increasingly being included in platforms. Plantix is another example, but this application operates on the merger of species and the identification of diseases, in this case, agricultural crops and not ornamentals. Such tools help farmers diagnose problems in real time, and so they have a direct role to play in increasing crop yields and resource efficiency, which makes them especially pertinent to the field of precision agriculture as a whole. In the same line, Planta incorporates care recommendations through environmental analysis and notifying its users about water schedules and sunlight requirements. The innovations increase the functional capacity of plant-related app by not only identifying them but also taking the management process to caring and maintaining the plants.

Mainly, the majority of the apps can be accessed through Android and iOS, and the cross-platform support is of various degrees. Others like PlantNet and Flora Incognita have made their application accessible to other operating systems such as HarmonyOS making them be available to more users. Nevertheless, the problem of platform fragmentation aspect remains, where each of the applications has to choose between optimizing the applications to run better or cover as many devices as possible. Besides, approaches to monetization, including subscriptions or premium feature access, restrict their access to the full set of capabilities and often excludes access to their users that cannot afford paid services.

3.Methods

The methodology of the development of Plantonome can be described as well-organised and multi-disciplinary in the approach, a combination of software engineering concepts, artificial intelligence, and agricultural informatics. Its approach was contingent to be technically capable and implementable in practice and cross-platform compatibility and real-time plant identification was the specific focus. In contrast to conventional farming equipment, that are usually based on hard and sometimes on manual procedures, Plantonome is a software-based tool using cloud computing, image detection and elastic databases to satisfy the changing requirements of both a plant-kind admirer and agricultural scholars(7).

Strategy of Cross-Platform Apps

Among the first design decisions of the methodology one could note the decision to adopt a cross-platform approach to development. The ecosystem of mobile applications across the globe has become completely fragmented whereby Android controls almost three quarters of market share and iOS controls the greater bulk of the other share. Developing independent native applications per platform would have been a great duplication of efforts, unique programming languages and would have comprised of more costs to maintain. Rather, they chose the Flutter, an open source framework by Google that enables them to develop multiple platform applications with a single code base. The efficiency of Flutter is that it brings near-native performance and allows massive reduction in development time. This was strengthened by its compatibility with Dart programming language that has clean syntax and high performance services.

Another reason why the Flutter framework was so well suited to the Plantonome is the modularity that its flexibility provides, since the project needed to be able to play fluidly with multimedia (uploading images of plants), as well as to read and write databases, and to run sensor-based mechanisms. The framework also included features like hot reload which helped in quickly testing out features during the development stage because when dealing with a complex real-time application, that is an important consideration during fine-tuning. Flutter had better rendering functionality compared to other options such as React Native or Ionic and this rendering was through the Skia based graphics engine that enabled the team to create visually attractive as well as responsive interfaces across a wide range of devices.

Architectural considerations and state management Activities Architectural considerations: Challenge: The biomechanical model has to comply with the demands of the business and not the other way round. The challenges are two-fold: leading to the final state management change is the business strategy and following the final state change is the business strategy. Activities This is not a state management calculation but an architectural consideration and in decision making.

Data flow and application state go hand in hand in the development of a plant identification application to acquire responsiveness. The architecture of Plantonome was layered in modules and the user interface layer, business logic and data layer were separated to enhance easier maintainability. State management libraries were used in order to process the continuous flow of interactions with the program- uploading the photos of the plants, retrieving the species information, changing the user preferences.

Two designs BloC (Business Logic Component) and Provider were also taken into consideration. Although BloC is based on streams and reactive programming to pull the business logic out of the interface, Provider will enable a slimmer and simpler framework that is easier to understand when it will apply to small to medium applications. Plantonome has selected Provider due to its simplicity and efficiency that calls in rebuilding only those widgets that have changed. This targeted update process lowered computations and the application can be more powerful on mid-range smartphones with low resources.

The outcome is a system that is capable of responding to up to the minute data changes, or suggestions regarding taking of care of the plant, and not cause slowdown or the depletion of device resources. Such regards to state management signify the interest of the developers to create an application that will be not only technically powerful but available to the users without specific knowledge.

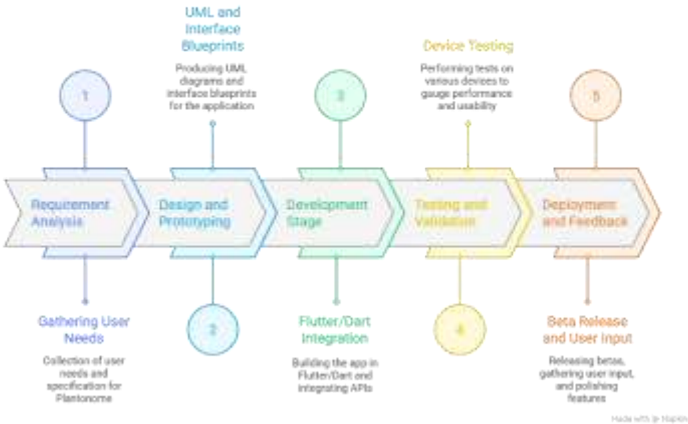

FIGURE 2 Plantonome Development Methodology

Plant Identification Engine: Plant.id API CatResource

Plant.id API is a dedicated AI (artificial intelligence) service dedicated to plant recognition that sits at the core of Plantonome operation. Instead of starting to create a customized recognition model, which has to resort to an enormous supply of annotated data and huge computing equipment, they utilized this API to shorten the development time without compromising the accuracy.

Plant.id utilizes deep convolutional neural networks (CNNs) which are trained over the data sets like FlowerChecker set. The algorithms can identify more than 12,000 species of flowers and shrubs, trees, and lichens. Plantonome allows one to choose an image that is in his/her gallery or take it in real time. The API thereafter goes through this image, matches it to its wide database and provides results which include the most likely species identification and confidence scores.

In addition to the identification, metadata (in the form of time and place) can also be included to increase precision. As an illustration, some species can only be located in a particular geographical area or only once a season. Including such surrounding data, Plantonome is useful in giving predictions with a higher level of credibility, which promotes more application in urban gardening applications where the diversity of plants is high.

Database and Cloud Connection to Firebase

The second main principle of the methodology of Plantonome is the cloud-based data management registry using Firebase Firestore. Firebase, the scalable NoSQL database, provided by Google, was selected because of its capability to synchronize in real-time across the devices. This aspect guaranteed that user information, including book marks, tastes, and environment configurations remained the same irrespective of access mode, either smart phones, tablets, or PC.

The database was categorized in two leading sets:

- Plants collection acts as a common resource of the information about the ornamental plants available to all the users.
- User-specific collections, where histories of personal plant care, plant preferences, and individual-specific garden planning are saved.

Such a dual structure enabled Plantonome to strike the right balance between universal knowledge and intimately experienced experiences. In addition, the linking of the firebase with the authentication functions allowed safe authentication to be conducted and hence the user data was not compromised. Being able to commercially distinguish its pricing model (consisting of a free Spark plan and a scalable Blaze plan allowing it to cater to small projects and projects with higher number of users, respectively), it was especially advantageous to have it in an open-source application, such as Plantonome.

Ornamental Plants Dataset

Another feature that clearly defines Plantonome is its dependence on a unique set of data on ornamental plants that were constructed. The data contained in this dataset gives critical background that cannot be restricted to identifying species. It contains the information including the ideal light exposure, toleration of temperature, soil type, moisture needs, poison contents, and humidity conditions.

In this case, the data tables might show that Achimenes hybrids prefer indirect light and moderate humidity, whereas Abutilon hybridum can only be used in direct sunlight and less warmth during the nighttime. The ability to factor in such granular information allows the application to recommend approaches to care occasional yet realistic, and actionable and being species-specific. That is one of the reasons why it can be of use to not only hobbyists but also urban farmers who need to maximize produce in small spaces.

SDLC

The development strategy was phased model:

- Requirement Analysis Requirements Analysis is collection of user needs and specification.
- Design and Prototyping-producing UML diagrams and interface blueprints.
- Development Stage: Build the app in Flutter /Dart and integrate APIs.
- Testing and Validation – performing tests in succession on different devices to gauge execution, user-friendliness as well as identification effectiveness.
- Deployment and Feedback relief of betas, gathering user-input, polishing features.
- This lifecycle stressed on the constant build up and thus accounting that the end outcome application should be in line with the expectations of the user yet it was to be technically intact.

4.Results

Plant Identification Precision

The very essence of utility of Plantonome is the fact that it can easily identify and single out species of ornamental plants. In a controlled testing phase, the app performed with an identification performance of 94.64%, which can be evaluated to be on par with currently available commercial plant recognition applications. This finding was obtained by taking advantage of the Plant.id API which is based on convolutional neural networks pre-trained on large datasets.

Development was performed on various images that were collected in built-in datasets and actual pictures of users. The results also showed that the model works best when instances depicting some clear images of the leaves, flowers or the whole plants were present. On the other hand, situations such as use of cluttered backgrounds, bad lightning, or partial obstructions at times caused less confidence in the identity. However, its general quality makes Plantonome a very trustworthy app in the hands of non-professionals and amateurs who want to recognize the plant as quickly as possible without having to be knowledgeable in botany.

Cross-Platformicity / Cross-Platform Responsiveness

One peculiarity of Plantonome is that it is cross-platform and this is done by means of the Flutter framework. Android (version 5.0 and above), iOS, and web-based testing have revealed the responsiveness and the same visual richness within operating systems.

Performance metrics measured the use of the CPU, and how much memory and time it takes to load an application. Plantonome showed high resource management so that although it was running on mid-level hardware, it was not crash or slow. Facilitating the user interface and rendering it without any frame drops or lag on tasks involving a lot of interaction, e.g. uploading photos or viewing real-time plant care recommendations, was made possible thanks to Flutter, which utilizes a graphics rendering engine known as Skia.

With regards to responsiveness, average latency time between the upload of the image and consequent plant identification output was less than a couple of seconds in the stable internet circumstance. This high level of processing improves the usability aspect, as Plantonome is faster and less optimized with respect to the much slower recognition and reading applications.

The User Experience as well as Usable Feedback

The testing was an essential factor of the user validation. The stated participants were rogue gardeners, school children, and urban dwellers, whose knowledge concerning horticulture were of mixed quality. Parameters such as ease of use, interface design, information clarity and overall satisfaction were some of the parameters to be used in gathering feedback.

Most of the users commended Plantonome on its ease of navigation and the fact that its interface itself is easy to use, and that has been made achievable by the use of Flutter features dictated by the widget-based nature. The addition of a custom dashboard, in which customers are ab in a position to monitor their stored plants and further customized care-related reminders proved to be a hit. Moreover, incorporation of Firebase had a sufficient capability to synchronize across devices with ease such that some users had an ability to access their saved data irrespective of the involved platform.

There were also positive comments. A segment of the respondents have shown interest in enhancing the applicability of the application on edible crops and medicinal species as well. Other proposals included the offline operation, where the existing usage is greatly reliant on an internet connection in case of access to the Plant.id API and Firebase database. Such analysis offers future improvement possibilities.

Scalability/ Cloud Integration

The domination of Plantonome as Firebase-based real-time NoSQL cloud database was verified on stressing it by simulating user loads. The system was very stable in the event of simultaneous usage and data synchronization instabilities were not experienced. The two-layer type including a global plant database and individual collections created by different users was useful in terms of the need to reach the point between the universal and individual experience.

Scalability tests also proved that the platform would be able to support an increasingly larger user base without experiencing a significant loss in performance. The system was also viable to be implemented in research and commercial settings since the pricing of Firebase was also flexible. This was evidenced in the results, which highlight the significance of cloud-based infrastructure in facilitating the operation of Plantonome that is not limited to local devices.

Analysis of Ornamental Plant Dataset

One of the most important elements of the success of Plantonome is that specialized ornamental plants data was used. Users claimed that the species specific care instructions which include the brightness, humidity, soil and watering cycle elements were very beneficial in the application especially when compared to other identification only based applications.

Achimenes hybrid is an example of such a species, because, upon identification the system not only identified the species, it also included detailed instructions on the kind of light it should be exposed to and the level of moisture it should have in the soil. This dual functionality recognition and customized direction was considered as a differentiating advantage and used to give Plantonome edge over others.

Horticulture experts also conducted a verification similar to that of data set comprehensiveness, assuring that the recommendations (plant-wise) are correct. Though the already defined dataset is oriented on ornamental plants, the construction of its structure warrants extension to agricultural crops, which would become the next route toward precision farming in the future.

Robustness and Error Processing of Systems

Robustness testing targeted testing how Plantonome addressed misuses and failed to deal with data errors, or edge case usage. The online program was able to handle situations in which the users posted ambiguous or low quality photos by reporting the confidence values and requesting further input. This aspect offered transparency, whereby users would evaluate the reliability of every identification outcome instead of using binary outputs of correct and incorrect.

Also, Plantonome required no internet connection to re-access data since it memorized the data that was accessed before in other form of handling instead of offline. This aspect partially solved the problems of connectivity because although full offline recognition was not possible it was still somewhat present. The well managed error handling system made such instances of crashing or distractions very minimal keeping the stability in touch.

Comparative Study against the Background Applications

Plantonome was benchmarked to the main competitors of the project which include PlantSnap, PlantNet, and Flora Incognita so as to verify itself in the competitive market. Although other apps hold more databases, like PlantSnap, the advantage of Plantonome is its usefulness in the balance of accuracy, usability, and instructions of actionable care.

As opposed to the identification-only instruments, Plantonome will incorporate the Internet-of-Things (IoT) readiness and cross-platform synchronization, which make the device relevant to the overall objectives of digital agriculture. It also gives freedom of adaptation and durability that researchers and companies in their early stages may require since such elements are not easily found in other platforms with proprietary licenses.

5.Conclusion

Plantonome as a developed tool implies the relevant step toward the integration of digital technology and agriculture, as well as horticultural routine and plant-related care, providing an innovative solution to plant identification and management. Its cross-platform availability, compatibility with image recognition powered by AI, and use of an advanced cloud-based system can show how software applications may turn the daily routine of plant management into a data-power environment with smooth operation. Plantonome is a more than a recognition tool that not only accurately identifies a user-specific plant but also offers a species-specific catalog of care recommendations so that users have the power to keep their plants in the best shape possible.

Key Achievements

In this respect, one of the most commendable achievements of Plantonome is the balance between the technical complexity of the product and usability. Using Flutter framework and Dart programming language helped the application to have an efficient development cycle with performance optimization in Android, iOS, and web development. This move enabled the developers to create maximum outreach and accessibility with no loss in responsiveness or image quality.

It is also significant to mention the incorporation of the Plant.id API, which supplied the application with the exceptionally precise plant recognition engine. On the basis of an identification accuracy of 94.64%, Plantonome can be considered equal to or outcompeting a number of prominent plant identification applications. In contrast to many competitors though, Plantonome goes far beyond recognition and shows actionable care guidance based on its curated ornamental plants catalogue. This two-fold focus is crucial by the fact that it will not only enable the user to identify the plants but also to cultivate them in the best way possible.

Also, the implementation of Firebase as cloud-based database led to the creation of flexible and safe environment when working with data and synchronization. This combination of world data with organized collections permitted collective knowledge with individual experiences and the application was applicable to various groups of users between amateur gardeners and researchers.

Wider Agricultural and Horticultural Value

There are wider implications of agriculture and horticulture including the following:

Along with its direct appropriateness to the needs of those interested in plants, Plantonome has larger implications in terms of precision agriculture and urban horticulture. Roof settlements, community gardens, and green areas in cities can be promoted using applications such as Plantonome which when used indoors can present a low-intensity indoor farming option. Through presenting quality, real-time plant data the application reduces the entry threshold to potential growers who might not have the formal knowledge of horticulture encouraging greater plant care and sustainability culture.

Besides, the structure of Plantonome indicates how AI-based agricultural apps can help achieve the sustainability challenges. The application enables accurate care advice to correct over-watering or other irregularities, leading to the unnecessary waste of resources and healthier growth of the plants. Such efficiencies on the scale can fit objectives across the globe to resource optimization, biodiversity preservation and environment-friendly practices.

The identified limitations during evaluation Limitations Identified During Evaluation

Although the results of Plantonome look encouraging, a number of limitations have been noticed in the course of testing and validation. The biggest thing first: the application is still linked to the internet connection since both Plant.id API and firebase need an online connection. Those in areas with low connectivity might find it hard to exploit the features of the application to a maximum. Despite the partial offline capabilities enabled by use of cached data, operating in full offline recognition is an area that can use some further improvement.

Second, the size of the existing ornamental plants dataset, although substantial as it applies to ornamental species, omits edible crops, medicinal plants, and agriculture staples. This limits the use of the application in farmers and other professionals in precision farming where food crops are very important to take care of. However, an increase in the amount of data would not only increase the number of people using the service but also make Plantonome more relevant in rural, as well as commercial sense.

e-ISSN: 3065-1085 Print ISSN: 3065-1069

Third, despite the good performance being accompanied by high accuracy of recognition, the performance is nonetheless sensitive to image quality and background complexity. Challenging scenarios like dim light, congested vegetation or semi-obstacles can lessen the level of confidence. This is an important aspect that future iterations should improve on to make the algorithms more robust with regard to combating such challenges.

Future Directions

In the future, there are several improvement and growth options with Plantonome. The usage of IoT-enabled sensors to enable real time monitoring of environmental parameters like soil moisture, air temperature, and humidity is one of the promising avenues. Platonome has the potential to turn into a complete automated plant care system that could automate irrigation, lighting, and ventilation of smart gardens by processing an existing application data along with the sensor readings.

Second, it is the possibility to increase the size of the datasets and incorporate agricultural crops, herbs, and medicinal plants. This would make the application applicable to professional farmers and researchers in the field of agriculture as well as consumers of the hobby. Further enhancements to the role of Plantonome may be as a broader diagnostic tool as diseases of plants, pests, and nutrient shortages may be found and reported.

In addition, extending offline functions would be more accommodative of the project to the rural population that has low internet accessibility. With lightweight models used to recognize common species trained on-device, Plantonome has the potential to offer at least functional levels of the app even in conditions without a reliable connection.

Lastly, developing a community-based knowledge platform would open up the potential of Plantonome. Allowing users to contribute their own plant data, experiences and related observations, the application might form an environment of collaboration that simultaneously builds its database, and promotes citizen science.

Final Reflections

To summarize, Plantonome is not a mere application; it is a software demonstration of the digitalization of the agricultural and horticultural processes. Its success with regards to accuracy in identifying plants, ease of use, and cross platform consistency points to the success that it has achieved so far and its shortcomings help to point out the potential opportunities which can lead to new innovations.

Tools such as Plantonome will be critical in enabling individuals and communities to live much more sustainable lives and to apply smart agriculture to grow their crops when the demand of both increases. Both in city apartments, neighborhood gardens and on professional farms, Plantonome demonstrates how much scientific expertise can be combined with the easy availability of a digital application.

Acknowledgement: Nil

Conflicts of interest

The authors have no conflicts of interest to declare

References

1. Wolfert S, Ge L, Verdouw C, Bogaardt MJ. Big data in smart farming – a review. Agricultural Systems. 2017;153:69–80.
2. Liakos KG, Busato P, Moshou D, Pearson S, Bochtis D. Machine learning in agriculture: a review. Sensors. 2018;18(8):2674–2699.
3. Kamilaris A, Prenafeta-Boldú FX. Deep learning in agriculture: a survey. Computers and Electronics in Agriculture. 2018;147:70–90.
4. Zhang C, Kovacs JM. The application of small unmanned aerial systems for precision agriculture: a review. Precision Agriculture. 2012;13(6):693–712.
5. Khoa TQ, Man NH. IoT-based smart agriculture: architecture, applications, and challenges. Wireless Personal Communications. 2020;113(3):1407–1432.
6. Shadrin D, Shadrina A. Cloud-based platforms for smart farming: opportunities and challenges. Future Internet. 2021;13(9):237–249.
7. Ray PP. Internet of things for smart agriculture: technologies, practices, and future direction. Journal of Ambient Intelligence and Smart Environments. 2017;9(4):395–420.