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Development of smart pineapple farming assistant mobile application on identifying diseases in MD2 pineapple cultivation

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Abstract

Pineapple (*Ananas comosus*) is a widely cultivated fruit with various commercial varieties, such as MD2, that meet the high demand for sweet and high-quality pineapples. However, MD2 pineapple cultivation in Malaysia faces challenges related to disease management and monitoring that will lead to losses when controlled effectively. This research aimed to identify diseases in MD2 pineapple cultivation in Malaysia. Next, develop a Smart Pineapple Farming Assistant (SPFA) mobile application using image processing. The ADDIE model was employed for application development, which included analysis, design, development, implementation, and evaluation phases that were done in MFL Enterprise pineapple farm based in Segamat, Johor, by collecting sample images and verifying gathered information with an expert. The SPFA application was well -received by users, as indicated by a System Usability Scale (SUS) score of 71.88, demonstrating positive perceptions of usability. The developed application successfully assists smallholders in disease identification, including bacterial heart rot, deep eye, stem breakage, and mealybug wilt, in facilitating timely management actions. The user-friendly interface and design ensure that even users with low technical knowledge can use it. The SPFA mobile application may contribute a lot to the sustainability and productivity of MD2 pineapple cultivation in Malaysia, benefiting not only smallholders but academicians, citizens and the agricultural industry as a whole.

1. Introduction

Ananas comosus, commonly known as pineapple, belongs to the Bromeliaceae family with numerous ornamental species (Filippone, 2022). Originally from South America, pineapples are now cultivated worldwide for various culinary uses (Ware, 2018). In Malaysia, several commercial varieties like Sweet Cayenne, MD-2, N36, and Red Spanish are popular due to high demand (Mohd Ali *et al.*, 2020). The MD2 variety was developed in response to consumer preferences for sweetness, uniformity, and quality (Amar *et al.*, 2015).

Pineapple has many types of varieties that differ in colour, shape, size, and flavour. The famous pineapple varieties that have been cultivated in Malaysia are Sweet Cayenne, MD2 and N36 (Mohd Ali *et al.*, 2020). Pineapple has a high nutritional value that, for sure gives benefits to those who consume it correctly. Pineapple is a good source of carbohydrates, water, dietary fibre, sugars, organic acids, vitamins (such as ascorbic acid, niacin, and thiamine), and minerals (including magnesium, manganese, and copper) (Ancos *et al.*, 2016).

Next, pineapple is a fruit that contains bromelain, a proteolytic enzyme that aids in the digestion process and has therapeutic effects. Bromelain has the potential to be used as an anti-inflammatory, antioxidant, anti-cancer agent, and a substance that protects the heart (Zdrojewicz *et al.*, 2018). In addition, Pineapple's bromelain can also

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be helpful for relieving menstrual issues, which is especially beneficial for women during pregnancy and menstruation by reducing water retention in the body (Khalid *et al.*, 2016).

Malaysia is a major pineapple exporter, but factors like credit access, pineapple variety availability, market proximity, input costs, pineapple prices, and extension services influence its supply (Jaji *et al.*, 2018). The Malaysian Pineapple Industry Board (MPIB) is promoting pineapple cultivation to tap into export opportunities, especially to countries like China (Mail, 2019). Despite high demand, growth and profitability of pineapple cultivation are affected by factors such as light, water, temperature, and nutrients, requiring careful monitoring and management for successful yield (Grunet, 2019).

Currently, smallholders face challenges in identifying diseases affecting their pineapple crops, often due to their diverse backgrounds and lack of agricultural education. Despite their interest in pineapple cultivation driven by increasing global demand due to population growth and health awareness (Sabbe *et al.*, 2009), limited supply presents an opportunity for new smallholders to gain profit from yields.

Pineapple cultivation is plagued by various diseases targeting shoot, leaf, root, yield, and crown, each displaying distinct symptoms demanding specific management strategies as in Figure 1. In Malaysia, prevalent diseases include bacterial heart rot and deep eye (Ismail, 2019). There are several diseases that can affect pineapple plants, causing significant damage to the crops and reducing yields. The most common diseases affecting pineapple cultivation are bacterial heart rot, deep eye, stem break, mealybugs, *Rhizopus* rot, internal brown spot, phytophthora root rot, leaf spot, fruit spot, powdery mildew and more. However, this research focuses on bacterial heart rot, deep eye, stem break and mealybugs as in Figure 2.

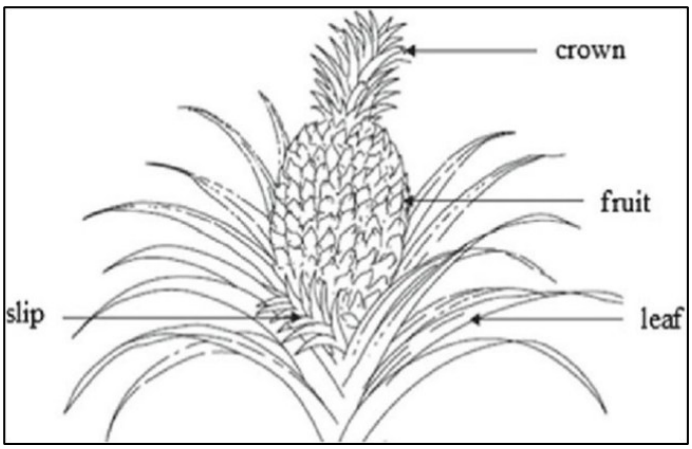

Figure 1. Morphological structures of pineapple (Padzil *et al*., 2020).

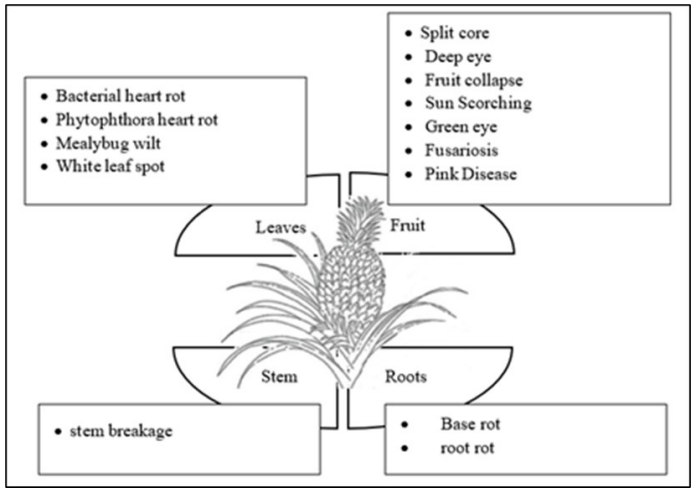

Figure 2. Pineapple disease.

This disease can lead to significant losses in pineapple production by causing rotting and decay of the fruit. Bacterial heart rot disease in pineapples can be identified by the following symptoms in infected plants like a water-soaked lesion in the center of the leaves, browning around the leaf margins and mesophyll tissue, infections at the meristem, apical tissue, and bud shoot also stems that can be easily removed from the base of the plant after a few days of initial infection and as the fruit decays, it emits a strong, unpleasant odour, often described as a rotten or fermented smell (Sidik and Sapak, 2021). Warm, humid weather is ideal for the growth of bacteria and the infection of the bacterial heart rot disease in MD2 pineapple. Rainfall, high humidity, and wounds on the fruit all encourage the spread and growth of the bacterium (Kim *et al.*, 2016).

Failure to control diseases early raises the risk of widespread infestations, leading to stunted growth, wilting, or crop death, translating to substantial losses for smallholders. Effective treatment is crucial as disease-damaged pineapples might become unsellable or their quality downgraded, impacting market price based on fruit quality grades. The key concerns to be addressed and supported by farmers on behalf of decision making to determine net profit for the yield are instructing to remedies for pineapple diseases at the right time, resolving issues during pineapple plantation, and getting guidance from experts in different phases of pineapple cultivation (Bandara *et al*., 2022).

Conversely, a lack of mobile applications for pineapple diseases exists on platforms like Play Store and App Store. Leveraging the widespread use of smartphones with internet connectivity, a mobile application, Smart Pineapple Farming Assistant (SPFA), is developed. This app aims to accurately identify diseases through image processing, overcoming the limitations of visual comparison. By offering timely and precise disease solutions, SPFA could enhance disease

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management for pineapple cultivation.

This research is guided by several key objectives. Firstly, it aims to comprehensively categorise various types of diseases that affect pineapple cultivation and subsequently establish effective management strategies for each identified disease. Secondly, a significant focus of the research involves the creation of the SPFA mobile application. Leveraging image processing technology, this application is designed to monitor and detect diseases within pineapple crops, offering a technologically advanced tool for farmers. Lastly, the research places emphasis on assessing the practicality and effectiveness of the Smart Pineapple Farming Assistant (SPFA) mobile application among its intended users, ensuring its usability aligns with the needs of those who would benefit from its implementation.

2. Materials and methods

The ADDIE model was used in this research, and it is a well-known instructional design model that has been widely used in education and training for many years. It is a systematic approach to the design and development of instructional materials and programs and consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Rossett, 2002).

In the analysis phase, information was gathered through journals, books, e-books, articles, interviews and others. Information gathered included popular diseases that occur in MD2 pineapple in Malaysia, such as bacterial heart rot, deep eye, stem breakage and mealybug wilt. The management and control techniques had also been gathered before being verified by expertise in MFL Enterprise's pineapple farm during a site visit. Other than that, sample images of the related diseases have also been gathered and used in developing the SPFA mobile application. The average picture taken for each disease was between 100-200. The recorded information is then put inside the SPFA mobile application successfully.

Figure 3 shows examples of sample images of bacterial heart rot, deep eye, stem breakage and mealybug wilt diseases that had been taken in the pineapple farm during the site visit. In design phase, User Experience (UX) which to establish a straightforward and easy-to-use navigation system, determining the arrangement and information contained in each screen and deciding on the overall visual appearance and mood of the application as well as User Interface (UI) which visual components of the app, such as colour schemes, font styles, and symbols also their utilization to convey information to the user (Fling, 2009) was created as in Figure 4.

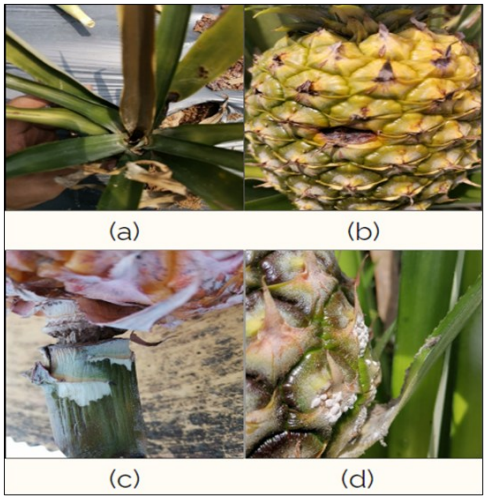

Figure 3. (a) bacterial heart rot, (b) deep eye, (c) stem breakage and (d) mealybug wilt.

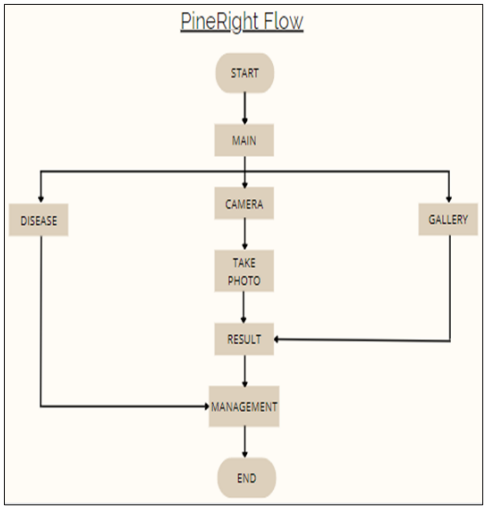

Figure 4. SPFA application flow.

In the development phase, the image processing model was trained by using deep learning at first, as shown in Figure 5, before being imported into the "Android Studio" to develop a mobile application called SPFA, as shown in Figure 6. There was some coding done in this phase. Once the application was developed, it was then imported into a smartphone for some testing and repaired.

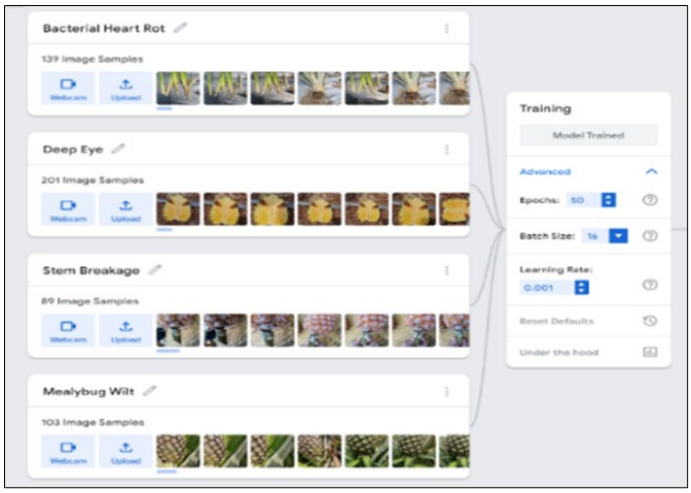

Figure 5. SPFA training model.

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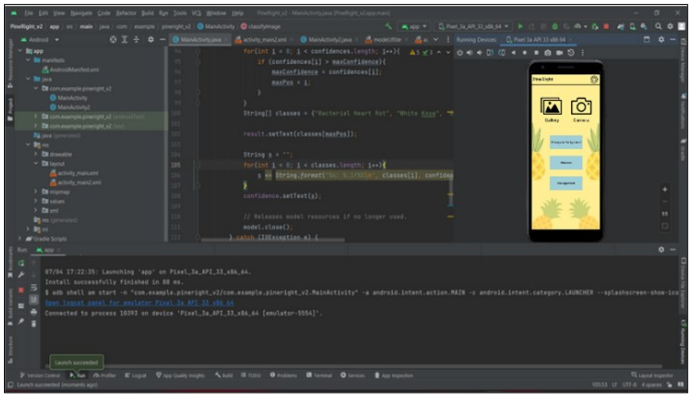

Figure 6. Coding in Android Studio.

Figure 7 shows the interface of SPFA mobile application that consists of settings, gallery, camera, pineapple background, diseases and management. In the implementation phase, the SPFA mobile application was implemented as shown in Figure 6 in MFL Enterprise located in Segamat, Johor and has also been approved its usability by the pineapple expert who had a certificate from Malaysian Pineapple Industry Board (MPIB).

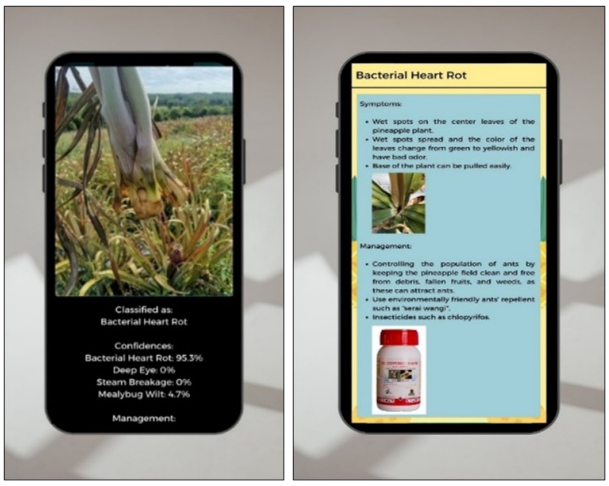

Figure 7. SPFA Interface.

In the evaluation phase, a questionnaire was chosen as the primary method of gathering data, and Google Forms was used to create and distribute the survey. The questionnaire consisted of two sections, namely Demographic Information and System Usability Scale (SUS). A total of 53 respondents participated in the survey and provided valuable insights into their preferences and expectations from the SPFA mobile application.

3. Results and discussion

The SUS score is computed by aggregating the individual scores provided by participants for each statement in the SUS questionnaire. Additionally, the average score for each statement will be calculated to identify specific areas of strengths and weaknesses in the SPFA app's usability (Brooke, 1995).

The scores for all statements are then summed, and the result is multiplied by 2.5. This sum is then divided by the total number of participants to obtain an overall system usability score ranging from 0 to 100. A SUS score above 68 would be considered above average, while anything below 68 is below average (Brooke, 1995).

Figure 8 show the result from this study where in the demographic part, in terms of gender (Item 1), 75.5% of respondents were male, attributed to the sector's physical demands. In age distribution (Item 2), 18-25-year-olds constituted the majority (39.6%), while legal restrictions prevented respondents below 18 due to educational priorities. Occupations (Item 3) varied widely, with students (24.5%) and labourers (20.8%) leading. The

	Timestamp	1. Gender	2. Age / U	3. Occupa	4. Educati	5. Years o	1. I think tl	2. I found	3. I thought	4. I think tl	5. I found	6. I thought	7. I would	8. I found	9. I felt vei	10. I need	SUS Raw Score	SUS Final Score
15	6/27/2023	Female / F	More than	Pengurus	Diploma /	More than	4	2	4	2	5	2	4	2	3	2	30	75
16	6/27/2023	Female / F	More than	Petani	Degree / I	Less than	3	3	3	3	3	3	3	3	3	3	20	50
17	6/27/2023	Male / Lel	More than	Jurutera	Degree / I	Less than	4	3	4	5	4	3	4	2	4	4	23	57.5
18	6/27/2023	Male / Lel	More than	Petani	SPM	Between 4	3	4	2	4	3	3	4	2	4	3	20	50
19	6/27/2023	Male / Lel	Between 1	Student / I	Degree / I	Less than	4	4	5	2	5	5	3	3	5	4	24	60
20	6/27/2023	Male / Lel	Between 1	Student / I	Degree / I	Less than	5	2	5	1	5	1	5	1	5	1	39	97.5
21	6/27/2023	Male / Lel	More than	Kakitanga	SPM	Less than	4	3	3	3	4	3	4	3	4	4	23	57.5
22	6/27/2023	Male / Lel	More than	Kakitanga	SPM	More than	3	2	4	3	4	2	4	2	4	3	27	67.5
23	6/27/2023	Female / F	More than	Kakitanga	Diploma /	Between 4	5	2	5	5	5	3	5	1	5	5	29	72.5
24	6/27/2023	Male / Lel	Between 2	Kakitanga	Diploma /	Less than	4	2	4	4	4	2	4	2	4	2	28	70
25	6/27/2023	Male / Lel	Between 1	Student / I	Degree / I	Less than	5	3	3	4	5	2	4	1	5	3	29	72.5
26	6/27/2023	Male / Lel	Between 1	Labor / Bu	Degree / I	Less than	5	1	5	2	5	2	5	1	5	2	37	92.5
27	6/27/2023	Female / F	Between 1	Student / I	Degree / I	Less than	5	1	5	1	4	2	5	1	5	1	38	95
28	6/27/2023	Male / Lel	Between 2	Supervisc	Degree / I	Between 4	5	1	5	1	5	1	5	1	5	1	40	100
29	6/27/2023	Male / Lel	Between 2	Supervisc	Degree / I	Between 4	5	2	5	1	4	1	5	1	5	2	37	92.5
30	6/27/2023	Male / Lel	Between 1	Labor / Bu	Diploma /	Less than	3	1	3	3	3	3	3	3	3	3	22	55
31	6/27/2023	Female / F	Between 2	Kerani	Diploma /	Between 4	4	2	4	2	4	2	5	2	4	3	30	75
32	6/27/2023	Female / F	Between 1	Kerani	Diploma /	Between 4	5	1	5	1	4	1	5	2	3	3	34	85
33	6/27/2023	Male / Lel	Between 1	Labor / Bu	SPM	Less than	4	2	4	2	4	2	4	2	4	3	29	72.5
34	6/27/2023	Male / Lel	Between 2	Labor / Bu	SPM	Between 4	4	2	5	3	4	3	5	2	4	2	30	75
35	6/27/2023	Male / Lel	Between 2	Labor / Bu	Tiada	Between 8	4	2	4	2	4	2	4	2	4	2	30	75
36	6/27/2023	Male / Lel	Between 2	Labor / Bu	Tiada	Between 8	4	2	4	2	4	2	4	2	4	2	30	75
37	6/27/2023	Male / Lel	Between 1	Labor / Bu	SPM	Between 4	4	2	4	3	5	3	4	2	5	3	29	72.5
38	6/27/2023	Male / Lel	Between 1	Labor / Bu	SPM	Between 4	4	2	4	2	3	3	5	1	4	1	31	77.5
39	6/27/2023	Female / F	More than	Guru	Degree / I	Less than	4	2	5	1	5	1	4	1	4	2	35	87.5
40	6/27/2023	Female / F	More than	Guru	Master	Less than	5	2	5	1	4	3	4	1	5	2	34	85
41	6/27/2023	Female / F	More than	Guru	Degree / I	Less than	5	2	4	2	4	3	5	2	5	3	31	77.5
42	6/27/2023	Male / Lel	Between 1	Supervisc	Diploma /	Between 4	5	2	4	1	4	2	4	1	3	2	32	80
43	6/27/2023	Female / F	More than	Pesara	SPM	Less than	4	3	3	3	3	3	3	2	4	5	21	52.5
44	6/27/2023	Male / Lel	More than	Pesara	SPM	Less than	5	2	3	3	4	3	5	2	3	3	27	67.5
45	6/27/2023	Male / Lel	Between 2	Labor / Bu	SPM	Between 4	4	1	5	2	4	2	3	3	4	3	29	72.5
46	6/27/2023	Male / Lel	Between 2	Labor / Bu	SPM	Between 4	4	2	5	3	5	3	4	2	3	3	28	70
47	6/27/2023	Male / Lel	Between 2	Labor / Bu	Tiada	Between 8	4	3	4	2	5	2	4	3	4	3	28	70
48	6/27/2023	Female / F	Between 2	Kakitanga	Diploma /	Less than	4	2	4	2	5	1	4	2	4	1	33	82.5
49	6/27/2023	Male / Lel	More than	Sendiri	SPM	Less than	3	3	2	4	5	2	3	1	4	4	23	57.5
50	6/27/2023	Female / F	Between 1	Student / I	Diploma /	Less than	4	2	4	2	4	2	4	2	4	2	30	75
51	6/27/2023	Male / Lel	More than	Pekebun	SPM	Between 4	4	2	4	2	5	2	3	2	4	4	28	70
52	6/27/2023	Male / Lel	More than	Peneroka	SPM	More than	4	2	3	4	3	2	5	2	5	2	28	70
53	6/27/2023	Male / Lel	Between 2	Peneroka	Diploma /	Less than	4	2	5	2	5	1	5	1	5	2	36	90
54	6/27/2023	Male / Lel	More than	Kakitanga	Diploma /	Between 8	5	2	5	3	3	1	4	2	5	2	32	80
55																AVERAGE	28.75	71.875

Figure 8. Result.

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SPFA app's diverse user base influenced this range. Education levels (Item 4) leaned towards degrees (32.1%) and SPM qualifications (30.2%). Experience (Item 5) showed that those with under 3 years' experience (50.9%) were prominent, mainly students. These findings collectively provide a comprehensive view of the demographic landscape within the plantation sector.

The study assessed user perceptions using the System Usability Scale (SUS). Participants showed positive attitudes towards frequent system use (Item 1), with 52.8% agreeing and 28.3% strongly agreeing. Regarding complexity (Item 2), 56.6% disagreed, and 20.8% were neutral. Ease-of-use (Item 3) received 34% agreement and 45.3% strong agreement. Technical support (Item 4) saw 35.8% disagreement and 15.1% strong disagreement. Integration of functions (Item 5) garnered 47.2% agreement and 37.7% strong agreement. Inconsistency (Item 6) had 43.4% disagreement and 9.4% agreement. Ease of learning (Item 7) showed 49.1% agreement and 37.7% strong agreement. Cumbersome use (Item 8) had 50.9% disagreement and 1.9% agreement. Confidence in use (Item 9) saw 45.3% agreement and 34% strong agreement. Learning needs (Item 10) had 30.2% disagreement and 13.2% strong disagreement. The findings illuminated user perspectives on various system aspects.

The average System Usability Scale (SUS) final score of 71.88 indicates a generally positive perception of the system's usability among the participants. The SUS is a widely recognised and reliable tool for assessing user satisfaction and ease of use. With an average score of 71.88, it suggests that, on average, the participants found the system to be relatively usable and user-friendly. Overall, the average SUS final score of 71.88 indicates a satisfactory level of user satisfaction with the system's usability

The SPFA application offers various benefits to different user groups. Firstly, for pineapple farmers, the application provides efficient disease management tools, addressing challenges in disease control. By enabling smallholders to identify diseases like bacterial heart rot and deep eye, farmers can promptly diagnose issues and apply appropriate solutions, enhancing farm monitoring and leading to improved crop yields and income.

Secondly, SPFA serves as a valuable educational resource for academicians. It furnishes accurate information for educators to impart to students, enhancing learning experiences through interactive elements. Furthermore, the app offers real-world examples of pineapple disease, aiding students' comprehension of the subject matter.

Moreover, SPFA is a valuable resource for citizens engaged in pineapple cultivation. It equips them with information to identify diseases early, preventing severe and costly outbreaks. The application also provides guidance on disease prevention and management, aiding in maintaining healthy pineapple crops and increasing yields. By minimising the need for expensive treatments and reducing losses, SPFA contributes to sustaining livelihoods in the pineapple cultivation sector.

4. Conclusion

In conclusion, the developed SPFA mobile application has successfully met its objectives of assisting users, particularly smallholders, in identifying diseases which are Bacterial Heart Rot, Deep Eye, Stem Breakage and Mealybug Wilt and managing them in MD2 pineapple cultivation. The application has proven to be a valuable tool in the agricultural sector, providing crucial support to cultivators in disease identification and management. By utilising the application, smallholders can efficiently identify related diseases affecting MD2 pineapple crops, enabling them to take timely and appropriate actions to mitigate the spread and minimise the negative impact on their cultivation. The application's user-friendly interface and intuitive design make it accessible and easy to navigate, ensuring that even users with limited technical knowledge can benefit from its functionalities. The developed application has proven to be a valuable resource for smallholders in identifying diseases and managing them effectively in MD2 pineapple cultivation. Its user-friendly interface, comprehensive disease database, and widespread accessibility contribute to its success in meeting the objectives and supporting the needs of smallholders. This application stands as a significant technological advancement that aids in the sustainability and productivity of MD2 pineapple cultivation, benefiting smallholders and the agricultural industry as a whole.

Conflict of interest

The authors declare no conflict of interest.

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