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Pawsome Detect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection

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Abstract: **-** PAWSOMEDETECT leverages pattern recognition to revolutionize canine age and breed detection. Determining a dog's age and breed from photos has become vital due to rising popularity of dogs as pets and the demand for personalized, data-driven pet care. Traditional methods rely on manual inspection and judgment, prone to errors. Furthermore, mating compatibility among breeds is a consideration for dog owners. This aids users in identifying compatible breeds for mating, increasing successful mating chances. To achieve accurate age and breed, deep learning models are trained on a vast collection of annotated dog photos. These models use Convolutional Neural Networks (CNNs) and transfer learning to improve performance and generalize knowledge, revealing age and breed patterns. Researchers, breeders, and owners can benefit from this data. Following ISO-25010 guidelines, the study confirms the system's accuracy in age and breed determination, as well as its ability to detect user locations for successful mating. It meets response time and resource utilization requirements, ensuring timely operations. In conclusion, "PAWSOMEDETECT" a groundbreaking pattern recognition-based method for accurate age and breed identification in dogs. It provides data-driven solutions for pet care, mating compatibility, and more, benefiting users and dogs. The study's continued enhancements promise even greater accuracy and functionality.

Keywords: Breed Recognition, Data Mining, Dog Age Detection, Pattern Recognition

I. INTRODUCTION

In recent years, there has been a growing emphasis on age and breed estimation in dogs, driven by factors such as veterinary care, animal welfare, and insights into canine genetics. Accurate determination of a dog's age and breed is crucial for health management, disease prevention, and understanding the complex aging process in dogs. Traditionally, estimation relied on subjective assessments of external features like dental attributes and coat condition, but these methods proved imprecise and biased.

Advancements in artificial intelligence (AI), pattern recognition, and data mining have opened new possibilities for refining age and breed estimation models. The use of these techniques allows harnessing massive datasets covering diverse dog breeds, revealing intricate patterns and correlations that were previously undetectable. This progress facilitates the development of more precise models, avoiding the limitations of subjective assessments and contributing to objective age and breed determination.

This groundbreaking advancement in accurate age and breed detection has profound implications across various domains. Veterinarians benefit from a tool that surpasses the limitations of subjective assessments, enabling tailored healthcare plans for individual dogs based on their specific needs and potential health risks. The innovation also holds great potential in transforming adoption procedures in animal shelters. Improved accuracy in determining a dog's age and breed enhances decision-making, leading to stronger matches between dogs and prospective owners, ultimately increasing successful adoptions and reducing mismatched placements.

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To address these challenges, developers propose the study "PawsomeDetect," utilizing Convolutional Neural Networks (CNNs) for accurate canine age and breed detection based on uploaded images. Tripathi (2021), explains that Convolutional Neural Networks (CNNs) represent a robust and effective algorithmic approach for image processing tasks. These networks are currently at the forefront of automated image analysis, offering remarkable capabilities in handling visual data. Employing intricate layers of interconnected nodes, CNNs can automatically detect and learn features from images, enabling them to excel in tasks such as object recognition and classification.

1.1 Objectives

The main aim of this study is to utilize pattern recognition and data mining techniques to create a precise and unbiased model for accurately determining the age and breed of dogs using CNN (Convolutional Neural Network). It offers veterinarians a more precise tool for tailoring healthcare plans to individual dogs, considering their specific age and breed-related needs and potential health risks.

1. To develop a standardized platform in application for storing and accessing the personal and vaccine information, enabling dog owners and veterinarians to easily track and maintain accurate vaccine histories for individual dogs.

2. To implement push notifications on the application that remind the owner to set up and manage their dog's information, such as birthdays and vaccine updates.

3. To integrate a solution for the mobile application that simplifies the process of locating compatible breeding partners and increasing the likelihood of successful mating outcomes for dogs.

1.2 Significance of the Study

The results of the study will provide significant benefits to the following:

1. Veterinary Medicine and Animal Care. Accurate identification of a dog's age and breed is vital in veterinary medicine and animal care to ensure proper healthcare and personalized treatment strategies. The research results can aid veterinarians in more accurately determining the age and breed of dogs, allowing for improved handling of age-related issues and the application of preventive measures.

2. Animal Shelters and Rescue Organizations. Animal shelters and rescue organizations frequently face uncertainty regarding the ages and breeds of the dogs they rescue. Ensuring reliable age and breed identification is crucial for their proper care, adoption process, and suitable placement. Utilizing pattern recognition and data mining methods, this research can aid these organizations in more precisely estimating the ages and breeds of the rescued dogs. This advancement can enhance their well-being and increase the likelihood of finding them permanent homes that meet their specific needs.

3. Canine Breeders. Accurate age and breed identification holds significant advantages for canine breeders in their breeding endeavors. Having precise knowledge of a dog's age and breed can offer valuable information about its reproductive phase, genetic well-being, and suitability for breeding purposes. By employing pattern recognition and data mining techniques, breeders can enhance their decision-making process when choosing suitable pairs for breeding and maximizing the effectiveness of their breeding programs.
4. Pet Owners. For individuals who own dogs as pets, being aware of their canine companion's age and breed is not only a matter of personal curiosity but also crucial for providing appropriate care and addressing age along with breed-related requirements. The findings of this study can enhance comprehension of the aging process in dogs, enabling pet owners to tailor healthcare practices and make necessary lifestyle modifications. This can lead to improved well-being and increased lifespan for their beloved dogs.
5. Future Research and Development. There is a wide range of practical applications for canine age and breed detection models that future researchers and developers can explore. The knowledge and understanding acquired through this research can serve as a valuable guide for advancing AI-assisted learning applications, bringing benefits to those working in the field of research and development.

1.3 Scope and Delimitation

The study aims to enhance the accuracy and efficiency of determining the age and breed percentage of canines by leveraging advanced pattern recognition and data mining techniques. Specifically, it focuses on the application of image analysis and data feature extraction methods to identify age-related patterns in canine data. Additionally, the study integrates the personal and vaccine information of dogs, push notifications for reminders of the dogs' activities, and finding compatible mating partners considering the given constraints. By combining these techniques, the study endeavors to improve the existing methods of age and breed determination in canines, offering more reliable and precise results.

The study aims to accurately identify a dog's breed and age through uploaded images, considering factors such as size, facial features, body proportions, tail and ear variations, paw details, coat texture, color, and patterns. Close-ups of teeth and documentation of unique body markings or scars are also required for age estimation. However, the study is delimited to age and breed detection specifically for dogs, excluding other species. The research focuses on diverse canine datasets to ensure accuracy and is limited to widely seen dog breeds in the Philippines such as Aspins (Asong Pinoy), Shih Tzu, Poodle, Pug, Pomeranian, Chow Chow, Siberian Husky, Chihuahua, Golden Retriever, Labrador, German Shepherd, and Doberman. The mobile application developed is compatible only with Android OS Version 10 and later. Furthermore, this study aims to determine the optimal distance (1 to 3 feet) for capturing images using a smartphone camera, considering factors like image resolution, lighting conditions, and camera capabilities. The primary focus is on pattern recognition and data mining for improved age and breed detection in canines, but it does not incorporate additional data sources like medical records. Variations in camera hardware, lighting conditions, and dog sizes may influence the ideal distance for image capture.

II. METHODOLOGY

2.1 Research Design

2.1.1 System Architecture

The application is covered by the study's system architecture, which is shown in Figure 3.1 below. It shows how implemented functionalities interact with the hardware, software, and key entities that manage them.

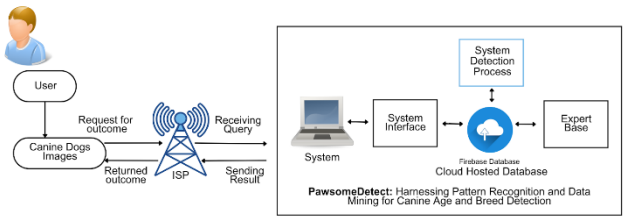

Figure 2.1.1: Pattern Recognition and Data Mining for Canine Age and Breed Detection System Architecture

The PawsomeDetect mobile application uses pattern recognition and data mining to accurately determine a dog's age. It starts by collecting various dog data, including photos and vaccine records. The collected data goes through processing and the release of plans to improve its quality and produce useful plans. Pattern recognition algorithms, machine learning or deep learning models, are then applied to identify patterns and predict age based on the extracted features. PawsomeDetect aims to provide useful information about canine age, to benefit veterinary health care, research and animal welfare.

2.2 Research Development

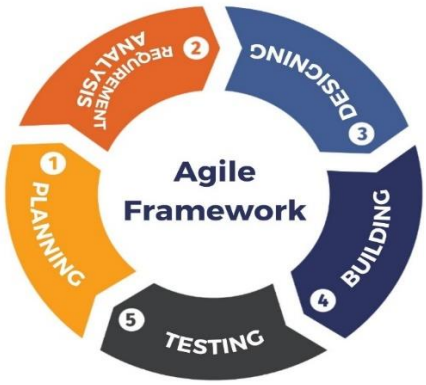

Figure 2.2: AGILE Framework

The AGILE framework is employed as the research development methodology shown in Figure 3.2 to develop study for Pattern Recognition and Data Mining for Canine Age and Breed Detection. It involves various phases such as planning, requirement analysis, building, designing, and testing. As it implements features incrementally through short iterations, resulting in an increasingly refined and tailored pattern recognition and data mining for canine age detection that will synchronize their work, conduct comprehensive testing and quality assurance, and finally deploy the mobile application and provide user training.

2.3 Data Collection

In this study, researchers will collect demographic information from respondents to assess effectiveness across different user segments. The information will be collected using a checklist through Google Forms, benefiting the study by supporting efficient data collection and processing, improving data quality, consistency and reliability in the PawsomeDetect project for canine age detection. Using a checklist to evaluate the mobile application in this survey is useful as it provides a structured and organized approach. It ensures that all relevant topics are covered, uses targeted questions, maintains consistency and helps the respondent focus, and ensures that data is obtained useful in a short period of time.

2.4 Sampling Techniques

Table 2.4.1 Population and Sample

Target Respondents	Population Size	Percentage	Sampling Method
Canine Owners	46	100%	Purposive Sampling

The target respondents for the topic "PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection" would be Canine Owners who are willing to provide information about their dogs' age, along with any relevant data necessary for the study. To get enough data for a useful survey, it is recommended that the respondents would collect a minimum of three hundred (300) respondents. To ensure that the sampling process is purposeful, selection criteria can be applied, such as including respondents of different dog breeds, ages, and geographic regions to capture a representative sample for the study.

2.5 Data Analysis Procedures

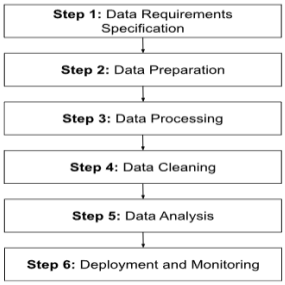

Figure 2.5.1: Data Analysis Procedures

Figure 3.5.1 shows the data analysis procedures for PawsomeDetect includes collecting different datasets of canine images with age markers, data processing by cleaning and adjusting the images, feature extraction using advanced computer vision techniques, machine learning or object learning or deep learning model on the extracted features, and analyzing the performance of the model in support of the test design, interpreting the results by analyzing the lessons learned and analyzing the predicted years, and putting the model to practical use when evaluating its performance and making improvements important. These methods provide a general framework for data analysis and the creation of a canine age detection mobile application using pattern recognition and data collection methods.

2.6 Evaluation

The researchers will employ the International Organization for Standardization (ISO) 25010 evaluation to assess the target respondents. A web-based survey will be utilized to analyze and evaluate the mobile application. In each of the selected ISO 25010 qualities, the researchers will utilize a 5-point Likert Scale as a scaling technique to interpret the numerical value of the gathered data. As Khandelwal (2021) explained, this scaling method provides respondents with five options, including extremes, intermediates, and a neutral opinion. Its versatility allows for the measurement of agreement, likelihood, frequency, importance, quality, and other factors.

Table 2.6.1 ISO Characteristics used for System Quality Evaluation

Characteristics		1	2	3	4	5
Functional Suitability	**Functional Completeness** - The PawsomeDetect mobile application covers all necessary functions and tasks for canine age and breed detection objectives. **Functional Correctness** - The PawsomeDetect mobile application produces accurate results for canine age and breed detection. **Functional Appropriateness** - The PawsomeDetect mobile application supports and facilitates the needs and objectives of canine age and breed detection.					
Performance Efficiency	**Time Behaviour** - The PawsomeDetect mobile application meets response and processing time requirements for timely canine age and breed detection operations. **Resource Utilization** - The PawsomeDetect mobile application effectively uses the necessary resources while performing canine age and breed detection functions. **Capacity** - The PawsomeDetect mobile application can handle the expected workload and specified limits for canine age and breed detection.					
Usability	**Appropriateness Recognizability** - The mobile application's interface helps users determine its suitability for canine age and breed detection needs. **Learnability** - The mobile application enables users to quickly learn and use it for canine age and breed detection. **Operability** - The mobile application is easy to operate and control for canine age and breed detection. **User Interface Aesthetics** - The PawsomeDetect mobile application has a visually appealing and user-friendly interface for canine age and breed detection. **Accessibility** - The PawsomeDetect mobile application is accessible to users with diverse characteristics and capabilities for canine age and breed detection.					
Reliability	**Maturity** - The PawsomeDetect mobile application meets the reliability needs for normal operation of canine age and breed detection. **Availability** - The PawsomeDetect mobile application is operational and accessible as required for canine age and breed detection tasks.					

Overall Feedback (Not Required)

Please share any challenges or difficulties you encountered while using the PawsomeDetect Mobile Application.

Description: Rest assured that the researchers are dedicated to addressing challenges that users have encountered in order to continuously enhance the overall user experience.

Table 2.6.2 provides an analysis of the evaluation. The developers will be using a Likert scale. A Likert scale is a rating scale that helps to interpret the user's perception of the mobile application's functionality and usability. It allows the developers to gather data from the users and assess their perception of the mobile

application's quality, which helps to identify areas that need improvement. application's quality, which helps to identify areas that need improvement.

Table 2.6.2 The five-point Likert Scale to Interpret Evaluation Results

Criteria	Numerical Value
Very Satisfied	4.21 - 5.00
Satisfied	3.41 - 4.20
Neutral	2.61 - 3.40
Dissatisfied	1.81 - 2.60
Very Dissatisfied	1.00 - 1.80

Researchers will use a five-point Likert scale to interpret data for Pattern Recognition and Data Mining in Canine Age and Breed Detection. This scale, widely used for evaluating the mobile app and gathering opinions, offers options from Very Satisfied to Very Dissatisfied, capturing a range of preferences with a balanced distribution. Its moderate granularity provides enough variation for accurate feedback without overwhelming choices, ensuring efficient data collection and analysis. The Likert scale offers a user-friendly experience, allowing quick feedback on application features.

III. RESULTS AND DISCUSSIONS

3.1 Results

The evaluation of the PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application was conducted by the developers, who assessed its functionality, performance efficiency, usability, and reliability based on ISO-25010 standards. The evaluation questionnaire was completed by 46 respondents, and the data collected from their responses is presented in the following section.

Table 3.1.1 Demographic Profile of the Dog Owner Respondents

Study Variables	Variable Levels	Frequency (f)	Percentage (%)
Age	13	1	2.2%
	14	1	2.2%
	15	1	2.2%
	17	1	2.2%
	18	4	8.7%
	19	3	6.5%
	20	13	28.3%
	21	11	23.9%
	22	5	10.9%
	23	1	2.2%
	24	2	4.3%
	26	1	2.2%
	30	1	2.2%
	52	1	2.2%
	Total	**46**	**100%**
Dogs Owned	1 - 3	41	89.1%
	4 - 6	3	6.5%
	7 - 10	2	4.3%
	Total	**46**	**100%**

The study analyzes dog owners' demographics based on age (across different generations) and the number of dogs they own. Table 3.1.1 reveals valuable insights, categorizing owners by age and assessing their evaluation of the

mobile app. The data on the number of dogs owned adds essential context, highlighting a significant portion of participants owning multiple dogs.

Table 3.1.2 Overall Mean for Characteristics in ISO 25010 Evaluation

Criteria	Mean	Interpretation
Functional Suitability	4.58	Very Satisfied
Performance Efficiency	4.46	Very Satisfied
Usability	4.63	Very Satisfied
Reliability	4.61	Very Satisfied
Overall Mean	**4.57**	**Very Satisfied**

Table 3.1.2 indicates high satisfaction levels for the Pawsome Detect mobile app across ISO 25010 Evaluation Characteristics. Noteworthy scores include 4.58 for functional suitability, 4.46 for performance efficiency, 4.63 for usability, and 4.61 for reliability, all reflecting a "Very Satisfied" result. With an overall mean score of 4.57, the system demonstrates excellence in meeting user requirements, emphasizing its suitability, efficiency, user-friendliness, and reliability. Positive feedback from respondents reinforces the system's success in achieving its objectives effectively.

Using this 5-point Likert scale, the respondents were able to answer the following questions:

Table 3.1.3 The five-point Likert Scale

Response Categories	Numerical Value
Strongly Agree	5
Agree	4
Neither Agree or Disagree	3
Disagree	2
Strongly Disagree	1

Respondents' Demographic Profile

Question 1: Indicate your age

The participants' age distribution from 13 years of age up to 52 years of age has allowed the researchers to categorize dog owners on how they evaluate the mobile application. Including this data is crucial for understanding and addressing age-related preferences, usability, and needs. It helps define the target audience, improve the user experience, and benchmark the application against industry standards or competitors. This age-related information ensures the application effectively caters to a diverse user base, enhancing overall satisfaction.

Question 2: How many dogs do you have?

The data on the number of dogs owned has provided essential context. The researchers' findings indicate that a significant portion of participants own multiple dogs ranging from 1-10. Understanding the number of dogs ensures that the application caters effectively to the needs of both single-dog and multiple-dog owners, ultimately enhancing user satisfaction.

3.2 Evaluation Results

The software quality model specified in ISO 25010:2011 was used by the study's developers. This study aims to evaluate the system in terms of the following attributes: Functional Suitability, Performance Efficiency, Usability, and Reliability.

Functional Suitability:

Functional Completeness: The PawsomeDetect mobile application covers all necessary functions and tasks for canine age and breed detection objectives.

The results show that out of 46 respondents: 34 (73.9%) of the users Strongly Agreed, and 10 (21.7%) agreed. On the other hand, there is 1 (2.2%) who has a neutral stance while and 1 (2.2%) disagreed. This suggested a strong consensus on the application's effectiveness in achieving the objectives.

Functional Correctness: The PawsomeDetect mobile application produces accurate results for canine age and breed detection.

The results of whether the respondents think that the system's evaluation of the functional correctness in age and breed detection suggest that out of the 46 respondents, 37 of them (or 80.4% of the total respondents) strongly agree that the system produces accurate results for detecting dog's age and breed, while 7 people, or 15.2% of the total respondents, said they agree. On the other hand, 1 person, which is 2.2% of the total respondents, has a neutral stance while 1 person strongly disagreed.

Functional Appropriateness: The PawsomeDetect mobile application supports and facilitates the needs and objectives of canine age and breed detection.

The data reveals a strong consensus among respondents, with 33 (71.7%) strongly agreeing that the application effectively supports the needs and objectives of canine and breed detection, indicating high satisfaction. Additionally, 11 (23.9%) respondents agree, while 1 (2.2%) respondent disagrees, and 1 (2.2%) has a neutral stance, suggesting widespread approval of the application's appropriateness in fulfilling facilitating the objectives.

Performance Efficiency:

Time Behavior: The prediction, input of data and search for applicants are all processed quickly and without any delays.

The data indicates a strong consensus among respondents, with 31 (67.4%) strongly agreeing that the application effectively meets these time-related requirements, demonstrating high satisfaction. Additionally, 12 (26.1%) respondents agree, while 2 (4.3%) respondents have a neutral stance, and 1 (2.2%) respondent disagrees, suggesting widespread approval of the application's ability to perform timely operations.

Resource Utilization - The PawsomeDetect mobile application effectively uses the necessary resources while performing canine age and breed detection functions.

The data shows a strong consensus among respondents, with 30 (65.2%) strongly agreeing that the application effectively utilizes resources, indicating high satisfaction. Additionally, 14 (30.4 %) respondents agree, while 1 (2.2%) respondent disagrees, and 1 (2.2%) has a neutral stance, suggesting widespread approval of the application's resource-efficient performance.

Capacity - The PawsomeDetect mobile application can handle the expected workload and specified limits for canine age and breed detection.

The data reflects a strong consensus among respondents, with 29 (63%) strongly agreeing that the application can effectively handle the workload, indicating high satisfaction. Additionally, 14 (30.4%) respondents agree, while 2 (4.3%) respondents have a neutral stance, and 1 (2.2%) respondent disagrees, suggesting widespread approval of the application's capacity to meet workload and limit requirements.

Usability:

Appropriateness Recognizability - The mobile application's interface helps users determine its suitability for canine age and breed detection needs.

It reveals a strong consensus among respondents, with 36 (78.3%) strongly agreeing and 9 (19.6%) agreeing that the application's interface effectively communicates its suitability, demonstrating high satisfaction. While 1 (2.2%) respondent disagrees, the overall feedback highlights the application's ability to clearly convey its appropriateness for the intended purpose.

Learnability - The mobile application enables users to quickly learn and use it for canine age and breed detection.

The data reveals a strong consensus among respondents, with 36 (78.3%) strongly agreeing that the application is easy to learn and use, indicating high satisfaction. Additionally, 9 (19.6%) respondents agree, while 1 (2.2%) respondent disagrees, suggesting widespread approval of the application's user-friendly design and ease of adoption.

Operability - The mobile application is easy to operate and control for canine age and breed detection.

The data showcases a strong consensus among respondents, with 37 (80.4%) strongly agreeing that the application is easy to operate and control, indicating high satisfaction. Additionally, 7 (15.2%) respondents agree, while 1 (2.2%) respondent disagrees, and 1 (2.2%) has a neutral stance, suggesting widespread approval of the application's user-friendly and efficient design.

User Interface Aesthetics - The PawsomeDetect mobile application has a visually appealing and user-friendly interface for canine age and breed detection.

Respondents' feedback indicates a strong consensus, with 38 (82.6%) strongly agreeing and 7 (15.2%) agreeing that the application boasts a visually appealing and user-friendly interface, demonstrating high user satisfaction. Only 1 (2.2%) respondent disagrees, highlighting the overall positive perception of the application's aesthetic qualities.

Accessibility - The PawsomeDetect mobile application is accessible to users with diverse characteristics and capabilities for canine age and breed detection.

It shows a strong consensus among respondents, with 34 (73.9%) strongly agreeing and 10 (21.7%) agreeing that the application is accessible to users with diverse characteristics and capabilities, reflecting high satisfaction. While 1 (2.2%) respondent disagrees and 1 (2.2%) remains neutral, the data highlights the positive perception of the application's inclusivity and accessibility features.

Reliability:

Maturity - The PawsomeDetect mobile application meets the reliability needs for normal operation of canine age and breed detection.

Upon gathering the data, it reflects that there are 34 (73.9%) respondents who strongly agree that the application can meet the reliability that is needed for normal operations. Additionally, 11 (23.9%) respondents agree, while 1 (2.2%) respondent disagrees, suggesting widespread approval of the application's capacity to meet certain requirements.

Availability - The PawsomeDetect mobile application is operational and accessible as required for canine age and breed detection tasks.

The data indicates a strong consensus among respondents, with 36 (78.3%) strongly agreeing and 9 (19.6%) agreeing that the application is operational and accessible as required for the application’s tasks, demonstrating high satisfaction. While 1 (2.2%) respondent disagrees, the overall feedback underscores the application's reliability and accessibility as needed for its intended functions.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Findings

After conducting the demonstration and assessment of the "PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection," the mobile application underwent assessment through an online survey conducted via Google Forms. This survey was completed by a total of forty-six (46) respondents, selected through Purposive Sampling, which included dog owners, aligning with the ISO 25010 standards. The primary findings can be summarized as follows:

1. The PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application had a mean functional sustainability score of 4.58, which is evaluated as Very Satisfied.

2. The PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application achieved a mean performance efficiency score of 4.46, which equates to Very Satisfied.

3. The PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application scored a mean usability score of 4.63, which equates to Very Satisfied.

4. The PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application achieved a mean reliability score of 4.61, which is recognized as Very Satisfied.

5. The PawsomeDetect: Harnessing Pattern Recognition and Data Mining for Canine Age and Breed Detection mobile application obtained an average rating of 4.57 across all four criteria, which is considered Very Satisfied.

4.2 Conclusions

1. The research, directed at using pattern recognition and data mining techniques for ascertaining canine age and breed percentage via Convolutional Neural Network (CNN), has proven successful. This incorporation of CNN technology equips veterinarians with a precise tool for tailoring healthcare plans based on individual dogs' age and specific breed.

2. Establishment of a standardized platform for the storage and retrieval of personal and vaccine information has exhibited high efficacy. The "Very Satisfied" rating obtained from the evaluation underscores the application's success in providing a user-friendly interface for dog owners. This facilitates the seamless management of accurate vaccine histories for their pets.

3. The incorporation of push notifications introduces a valuable feature, reminding owners to update vital information such as birthdays and vaccine schedules. This enhancement contributes to increased user engagement and reinforces the application's overall efficacy in supporting responsible pet ownership.

4. Integrating a solution for the mobile application that simplifies the process of locating compatible breeding partners, aligns with the broader objective of promoting successful mating outcomes for dogs.

5. The PawsomeDetect app not only simplifies vaccine tracking but also encourages responsible pet care. Positive feedback aligning with ISO 25010 standards highlights its practicality and usability, laying a robust foundation for standardized vaccine information and emphasizing the project's potential impact on pet healthcare and data-driven analysis.

4.2 Recommendations

Based on the outcomes of the researchers' findings, tests, and evaluations, the following recommendations were offered to upcoming researchers and proponents embarking on similar projects:

1. To enhance the precision of a dog age and breed determination model using pattern recognition and data mining through CNN, it is recommended to explore more data sources, expand the mobile app's breed database to include a diverse range of breeds, and provide regular updates to cover emerging or less common breeds. This ensures a comprehensive and inclusive tool for accurate age and breed identification.

2. To advance the research, standardize formats for personal and vaccine data, explore regulatory compliance for data protection and veterinary standards, consider technological solutions like databases or blockchain for data integrity, and conduct a pilot program for real-world testing and user feedback. These steps aim to create a user-centric platform for managing dog health information with a focus on functionality, accessibility, and security.

3. Create a user-friendly interface for personalized healthcare reminders, covering vaccine appointments and check-ups. Enhance the application by including multimedia content, like articles and videos, to educate dog owners on broader pet wellness. This approach promotes an informed and engaged pet owner community beyond just vaccine tracking.

4. Analyze genetic databases for dog breeds, emphasizing compatibility for successful mating. Integrate this data into the mobile app's breeding partner matching system for accurate and effective dog mating outcomes. Collaborate with geneticists or veterinary experts to validate and refine the algorithm for improved results.

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