

Predicting Adult Dog Temperament Based on Puppy Behaviors: A Machine Learning Approach for Enhancing Canine Welfare

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Abstract

Every year, a higher number of dogs are abandoned or euthanised due to temperament issues and a lack of understanding by owners regarding dog behaviour and training. This research focuses on the potential to make predictions of adult dog temperament based on early puppy behaviours by using a machine learning model. Specifically, the research used guard dog breeds, such as American Bully, American Pit Bull Terrier, and German Shepherd. The study collected dog data and general data from dog owners and used the Random Forest approach to build a predictive model. Users are allowed to input puppy data and receive adult dog temperament predictions in model, which is integrated into a web application. The aims of this web application are to enhance responsible dog ownership and reduce abandonment by offering insights and training recommendations based on predicted outcomes. The model achieved a prediction accuracy of 86% on testing, and it is continually improving, though further refinement is recommended to improve its reliability and applicability across a broader range of breeds. The study contributes to canine welfare by providing a practical solution for predicting temperament outcomes, ultimately helping to reduce shelter populations and euthanasia rates.

Keywords

Dog Temperament Prediction, Canine Welfare, Puppy Behaviour, Machine Learning, Random Forest, Responsible Dog Ownership

1. Introduction

1.1. Background

Currently, a significant number of canines around the world are getting put down

or ending up in shelters even by their owners due to temperament issues. Even the world has an availability of different dog breeds who are most likely to be adopted or petted, in an increasing manner, the number of dogs all around the world is going through tough times related to putting down and sheltering [1]. When purchasing a dog as a pet, attractiveness and likability are the factors that most people focus on [2]. As of today, most dog lovers buy dogs without knowing the requirements and housing conditions. A dog's requirements should always match with their owner's requirements and their housing conditions. Also, it was noted that most dog owners are not training their dogs at early stages and not making time for their dogs [3]. And dog owners must have the knowledge to raise dogs properly regarding the well-being of dogs, which can help to reduce behaviour problems in dogs [4]. The primary matter is canines getting ended up in shelters and getting put down due to behavioural problems arising for the reason of the lack of knowledge in owner's viewpoint regarding dog's requirements, housing conditions and owner's requirements [5]. The result can be fatal as some dogs can get aggressive for strangers, such as new people or animals and even can get aggressive to their owner and family. Then, most of the time, those aggressive dogs will get put down or end up in shelters by those owners. Now, in the animal welfare sector, it's becoming a highly important and considerable matter. After ending up in shelters, dogs can have the risk of homelessness [6]. While investigating the connection between puppy behaviors and adult dog temperament, the research provides knowledge to people and prevents dogs from getting put down and ending up in shelters by providing an innovative solution through predicting adult dog temperament based on puppy behaviors.

There were previous findings available related to temperament of dogs. Previous research was performed for German Shepherd dogs bred for the purpose of Swedish military working dog program and used C-BARQ (Canine Behavioral Assessment and Research Questionnaire) to investigate dog behaviours and experiences. Sudden dummy appearances, structures of frightening floors, human social interactions and noisy sounds were used in T-test (temperament test) to find out the eligibility to grow into military working dogs. The research results showed that behaviours and experiences of puppies in the first 12 months of their life majorly impact for their later temperament [7]. It was found that it's hard to apply standardized dog behavioural tests and also recommended to use standardized dog behavioural tests such as the DMA (Dog Mentality Assessment) or Serpell and Hsu developed method for evaluating guide dog temperament [8]. It was found that previous researchers used different kinds of statistical models. C-BARQ and IFT (In-For-Training), a standardized temperament evaluation used to predict the success of assistance dog training, which resulted in high accuracy rate in a previous research paper [9]. Also, behaviour tests were conducted for the purpose of puppy prediction for the suitability as detection dogs and recommending further validation of behaviour tests for different breeds [10]. Also, previously had a behaviour recognition based on multimodal data, which were collected through a

wearable device and a camera to apply in health monitoring and treatment of dogs [11]. An earlier study reviewed about past research studies relating to different studies of dog temperament and also mentions that most of the studies were focused on Labrador Retrievers and German Shepherd dog breeds [12]. Earlier research was focused on predictive validity of behavioural tests only regarding military working dogs to evaluate relationships among those behaviours [13]. In a past study, they were unable to find proof connecting paw preference to temperament, except that the lateralized dogs outscored ambilateral dogs on a test of stranger-directed aggression [14]. Also, found that specific breed temperament may be triggered by certain mutations in genes, whereas other characteristics may reflect wide range of inherited behaviours of “ancient” lineage or selection by humans for the purpose of particular functional skills [15]. Also, Bennett, Litster, Weng, Walker and Leuscher assessed the effectiveness of evaluation tools, SAFER (Safety Assessment for Evaluating Rehoming) and mAAP (modified version of Assess-A-Pet), in predicting aggression of dogs using 67 dogs and comparing their behaviour histories with the C-BARQ, and discovered that mAAP had better sensitivity and specificity for recognizing aggressive dogs than SAFER. Also, [16] discovered that both these tools were imperfect for predicting aggression. Another earlier research suggested that temperament tests in the previous research were developed without scientific systematic approach. They identified five main key measures (practicality, reliability, purpose, validity, standardization) of a temperament test to influence a new approach [17]. Most of the previous research was done without systematic approaches.

As stated by Shelter Animals Count 2023, which is the national database that collects data from most of the animal shelters in world, the percentage of dogs that were relinquished to shelters by owners was 24% in 2019, 2021, 2022 and 2023 [18]. The percentage of dogs non-live outcomes in shelters was 36% in 2019 and 2021, 44% in 2022 and 47% in 2023 [18].

Related to the temperament and behaviours of dogs, many of the previous researchers have researched dog breeds such as Golden Retrievers [9] [15], Labrador Retrievers [9] [10] [12] [15] and German Shepherd dogs [7] [12] [13] [15]. In the world, there are many more dog breeds available. 200 dog breeds are currently registered in the AKC (American Kennel Club) [19] and over 300 breeds are currently recognized in the UKC (United Kennel Club) [20]. With that gap in mind, other dog breeds like American Bully, American Pit Bull Terrier, etc. related research can be addressed. Also, most researchers have previously focused on companion dogs [3] [9] [17], and military working dogs [7] [13], and there is a lack of research done on other dog categories like guard dogs, service dogs, etc. Based on facts, American Bully [21], American Pit Bull Terrier [22] and German Shepherd [22] [23] dogs can be considered as guard dogs because of their protective qualities. In the United Kingdom (UK), XL Bully [24] [25], Pit Bull Terrier [24] dogs are banned under the Dangerous Dogs Act 1991 [26]. This research focuses on enhancing the well-being of dogs by predicting their adult temperament from their puppy

behaviours and taking steps to give proper training to them, etc. to reduce attacks in public society.

This research study focuses on predicting adult dog temperament based on puppy behaviours using Random Forest ML approach and also, found that there is no previous research done on predicting adult dog temperament based on puppy behaviours and experiences using a ML prediction model with Random Forest approach. The study provides users with a solution and the knowledge to develop responsible ownership of dogs and positive human-dog relationships, helping canine welfare by reducing the dog count getting put down and ending up in shelters. This improves the well-being of canines as well as dog owners, also shelters and dog rescue groups through an inventive approach.

1.2. Research Question

RQ: How can adult dog temperament be predicted based on puppy behaviors and experiences to reduce the number of dogs ending up in shelters and being euthanized?

1.3. Research Objective

To predict adult dog temperament based on puppy behaviors and experiences to reduce the number of dogs that end up in shelters or are euthanized.

2. Methods

The main target of the research is to gather dog data and general data from dog owners. With that strategy in mind, data gathered by calling through phone, physically visiting and by Google Surveys, and then used for the analysis process. After gathering of data phase, organized and stored data in an excel sheet as in Comma-Separated Values (CSVs) [27] format which was more suited when feeding to the machine learning model in the model training process. Dataset contained same dogs' adult dog behaviors and puppy behaviors. Dog behaviour attributes such as energy level, shyness/outgoingness, reaction to owner and the family, reaction to new people, behavior around other animals, responsiveness to common commands, specific behavioural issues, and general data attributes such as having other animals at home, having children in home, perform trainings for the dog, each day hours spending with the dog, etc. contributed to predict the adult dog temperament in the solution of the study. Most of these attributes are highly valued key variables to affect dog temperament [4] [28]-[33]. Then, the data preprocessing part done through feature engineering by focusing on categorizing behaviour data and handling missing values to attain the best results. Overall, all the findings provided the training data for the ML predictive model. In the Discussion and Findings section, some of the graphs and charts are displaying processed data related to dogs and their owners. Then, the dataset absorbed into the ML model which uses the Random Forest ML approach that can handle complicated relationships with a medium to large dataset [34] [35]. While Decision Trees approach

is useful but may not capture the complexity of the relationships in the data as effectively in this research because it is good for small, simple and well-structured datasets [35]. While focusing on Neural Networks approach, it typically requires much larger datasets. Also, the training of Neural Networks approach is very time-consuming and can be computationally intensive [36]. The difficulty of interpreting trained models is one of the primary issues with neural networks approach [36]. When comparing with other ML approaches, Random forest approach is fast to train [37]. Random Forest approach can outperform Neural Networks approach over specific cases and also can have advantages when comparing with Neural Networks approach [36]. The Random Forest approach was chosen as the better option for this research project. The model was then trained. After the model training process, it was evaluated. Then the predicting model integrated with a web application. Users can be able to input puppy data into the integrated web application to get adult dog temperament predictions of those puppies. Also additionally, based on the predicted adult dog temperament results, the software provides valuable insights such as recommendations, insights and training plan generators to users. By making better decisions such as perform trainings for the dog, etc. can improve the well-being of their dogs and their relationships [38]. Overall, the solution tool contributes to enhance the well-being of dogs by these strategies.

Below conceptual framework is showcasing the structure for organizing the research process (Figure 1).

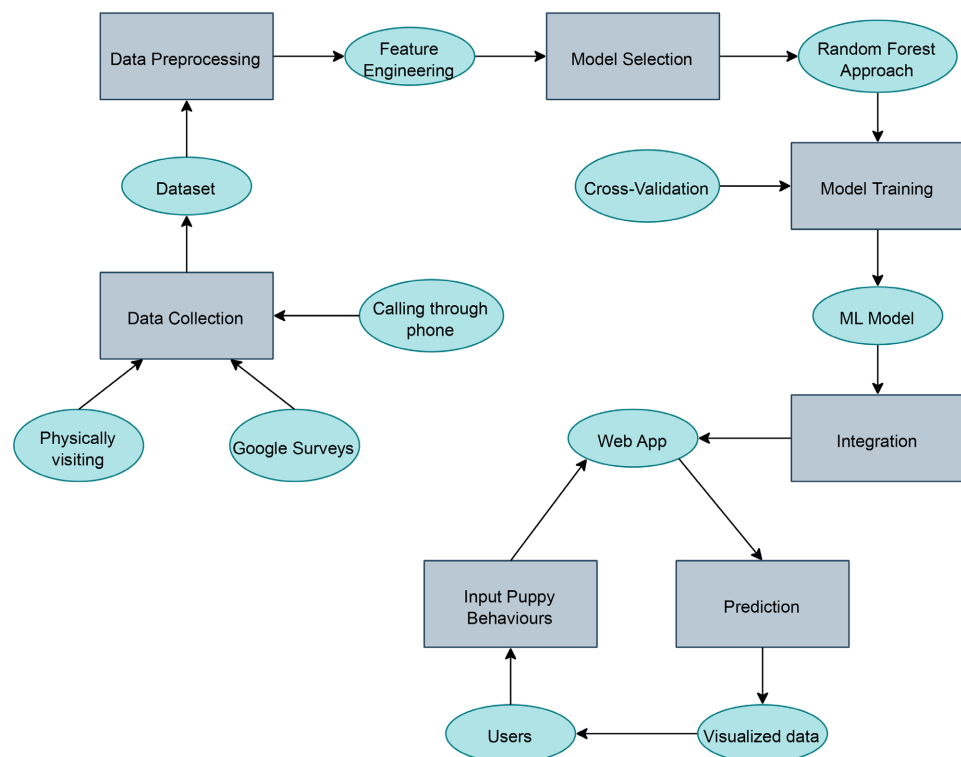


Figure 1. Conceptual framework diagram.

3. Discussion

3.1. Findings

The analysis had a broad area of dog data and general data. In this section, some of the charts and graphs are showcasing processed data related to owners and their dogs.

Data were collected on the dog breeds of American Bully, American Pit Bull Terrier, German Shepherd, Rottweiler, Labrador Retriever and Boxer. The study's aim is on the guard dog category and also because of the low number of responses to several dog breeds, had to drop Labrador Retriever, Rottweiler and Boxer dog breed data. The research then targeted American Bully, American Pit Bull Terrier and German Shepherd guard dog breeds. Forty nine percent of German Shepherd, 28.1 percent of American Pit Bull Terrier and 22.9 percent of American Bully data were analysed in the total of 96 data in the dataset (**Figure 2**). Collected dog data count displayed these guard dog breeds are crucial for the temperament prediction by displaying different patterns regarding the temperament throughout the breeds, had to consider that different breeds have different behaviours. Within the breeds that identified, 60.4 percent of male animals and 39.6 percent of female animals were found. In the real world, both male and female dogs have different temperaments and having data on both genders provide a significant impact to the solution. Because male and female dogs are having different temperaments, the user can understand and determine which dog gender temperament traits are positive or negative at the final result.

2. What is the breed of your dog?

96 responses

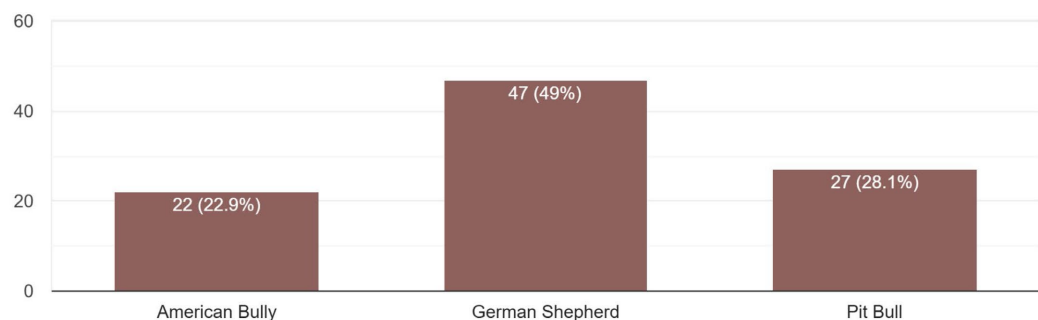


Figure 2. Graph—dog breed.

Dog's energy level was one of the most essential choices because it is a key indicator to the activity level of dogs and by being aware of this trait aids to predict dog temperament [7]. Ninety-nine percent of energy levels were at high, while moderate energy levels were at one percent in the collected dataset (**Figure 3**). Dog's shyness/outgoingness is a main factor in sociability level of dogs. Canines can have confident behaviours, fearful behaviours, etc. [8]. Regarding the research, outgoingness simply spells out that adaptation can be done easily, and

shyness requires more socialization. Outgoingness was at 94.8 percent, while shyness was at 5.2 percent in the gathered dataset. By being aware of this attribute aids to predict dog temperament (Figure 4). In the collected dataset, most of the dogs were friendly to their owner and their family at a percentage of 97.9. Dogs who aggressive towards the owner and family members were very lower at a percentage of 2.1 (Figure 5). When concentrating on the dog's reactions to new people in the gathered dataset, majority of dogs were friendly at a percentage of 59.4, some of the dogs were reserved at 31.3 percent and lesser number of dogs were aggressive at a percentage of 9.4 (Figure 6). And when concentrating on the dog behaviour around other animals in the dataset, majority of dogs were friendly at a percentage of 60.4, some of the dogs were reserved at a percentage of 31.3 and lesser number of dogs were aggressive at a percentage of 8.3 (Figure 7). Friendly reactions indicate positivity of trust and sociability. Reserved reactions indicates neutral action between friendly and aggressiveness but still needs light training. Aggressive reactions indicate negativity and attention required for training [3]. These traits are heavily required for predicting temperament of dogs. Also, the research identified that some dogs had some specific behavioural issues such as aggressiveness that led them to attack new people and other animals sometimes, and very lower number of dogs were aggressive towards their owner and their family. If specific behavioural issues like aggression are discovered, then required to have the attention for training methods. This trait is strongly recommended for predicting temperament of adult dogs in the research solution. When concentrating on responsiveness to common commands trait, most of the dogs were responsive at a percentage of 77.1 and some of the dogs were not responsive to their owners at a percentage of 22.9 which refers to dog obedience and the trainability (Figure 8). This trait is also, strongly aids to predict the adult temperament of dogs. Dog's energy level, shyness/outgoingness, reaction to owner and the family, reaction to new people, behavior around other animals, specific behavioral issues, responsiveness to common commands are key and main ingredients in the study because these traits provide a thorough overview of a dog's early stage which is definitely affecting that dog's adult temperament [8].

5. How would you describe your puppy's energy level?

96 responses

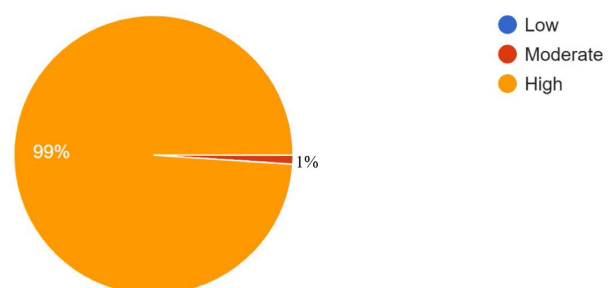


Figure 3. Chart—dog energy level.

7. Is your puppy generally shy or outgoing?
96 responses

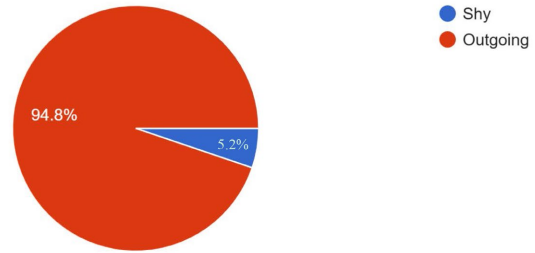


Figure 4. Chart—dog shyness/outgoingness.

9. How does your puppy react to you and your family?
96 responses

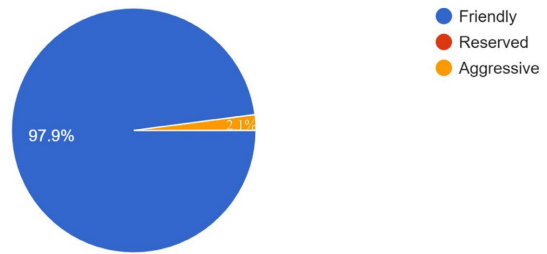


Figure 5. Chart—dog reaction to owner and the family.

11. How does your puppy react to new people?
96 responses

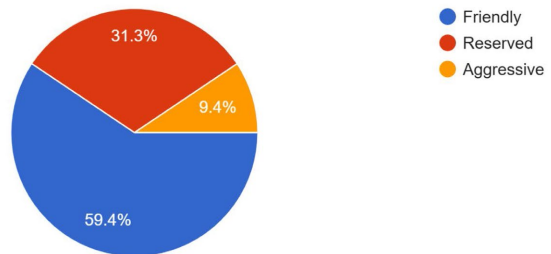


Figure 6. Chart—dog reaction to new people.

13. How does your puppy behave around other animals?
96 responses

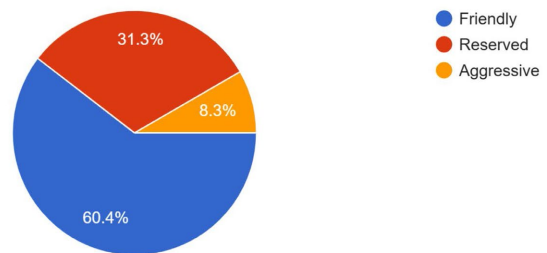


Figure 7. Chart—dog behavior around other animals.

17. Does your puppy responsive to common commands?
96 responses

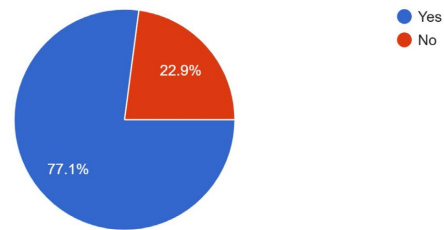


Figure 8. Chart—dog responsiveness to common commands.

Most dogs are living with their owners in suburban areas comparing to rural areas, at 82.3% and 17.7% respectively, according to the dataset. When focusing on home type, 84.4 percent of dogs are living in houses with big yards and 14.6 percent of dogs are living in houses with small yards (Figure 9). There was just only one dog counted as living in an apartment with the owner. It was clear that having no children at home was at 62.5% and having children at home was at 37.5% (Figure 10). Furthermore, having no other animals at home was at 81.3% and having other animals was at 18.8% (Figure 11). These environmental factors such as availability of space, having children and other animals at home are impacting dog’s stress levels and make them crucial attributes to predict adult dog temperament [13]. Other environmental factors such as home type, having children and other animals at home attributes were affecting the adult dog temperament development because housing conditions can affect mental fitness of dogs and coexisting with children and other animals foster relationships and socialization to the temperament of dogs [13].

6. What is your home type?
96 responses

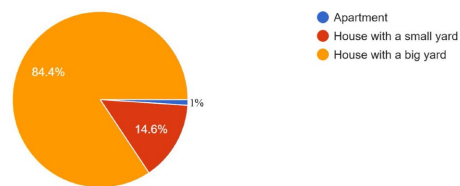


Figure 9. Chart—home type.

7. Do you have children in your home?
96 responses

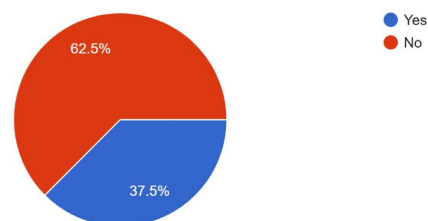


Figure 10. Chart—having children in home.

8. Do you have other animals at home?
96 responses

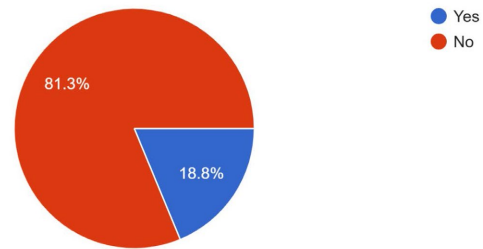


Figure 11. Chart—having other animals at home.

It was evident that most dog owners are spending five hours of time with their dogs on each day, as a percentage of 44.8, while 10 hours, 9 hours, 4 hours, 8 hours, 3 hours, 7 hours, 2 hours, 6 hours were minor contributors at 21.9%, 13.5%, 6.3%, 5.2%, 3.1%, 3.1%, 1%, 1% respectively (Figure 12). Most dog owners were not giving training sessions for their dogs. It was indicated at 71.9%, while owners who give training sessions for their dogs were indicated as 28.1% (Figure 13). Spending time with canines and giving training for them can be a good choice to manage temperament issues or else may arise issues in the future [3]. These attributes directly contribute to strengthen the bond between the owner and the dog [3]. Also, it enhances dog’s behaviors and obedience. These attributes are also influencing for the predicting temperament of dogs.

9. Each day, how many hours do you spend with your dog?
96 responses

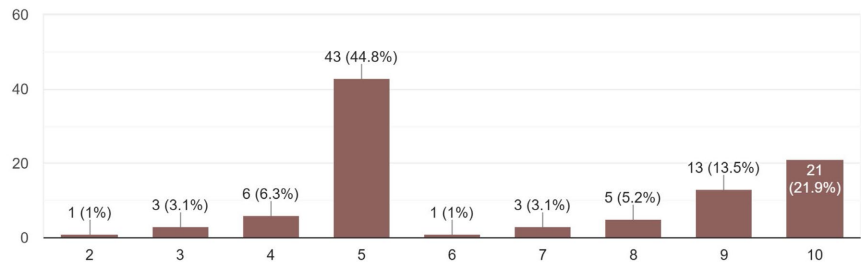


Figure 12. Chart—each day hours spending with the dog.

10. Do you train your dog?
96 responses

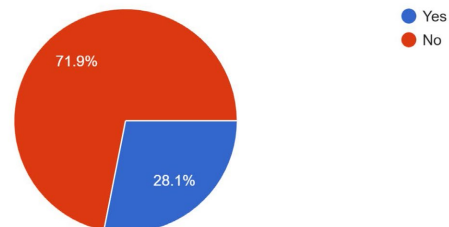


Figure 13. Chart—perform trainings for the dog.

In conclusion, the temperament prediction section is chosen as the main feature of the solution. Furthermore, we decided to add more extra features like providing recommendations, insights and training plan generators based on the predicted adult dog temperament results. Each and every dog owner who provided the data to the research was very concerned regarding behaviours of dogs as dogs mature into adult dogs. That makes the project solution is required to build and will be successful among end users. By understanding dog behaviours properly, dog owners can have positive impact on their dog's well-being.

Following is the diagram explaining the development (Figure 14).

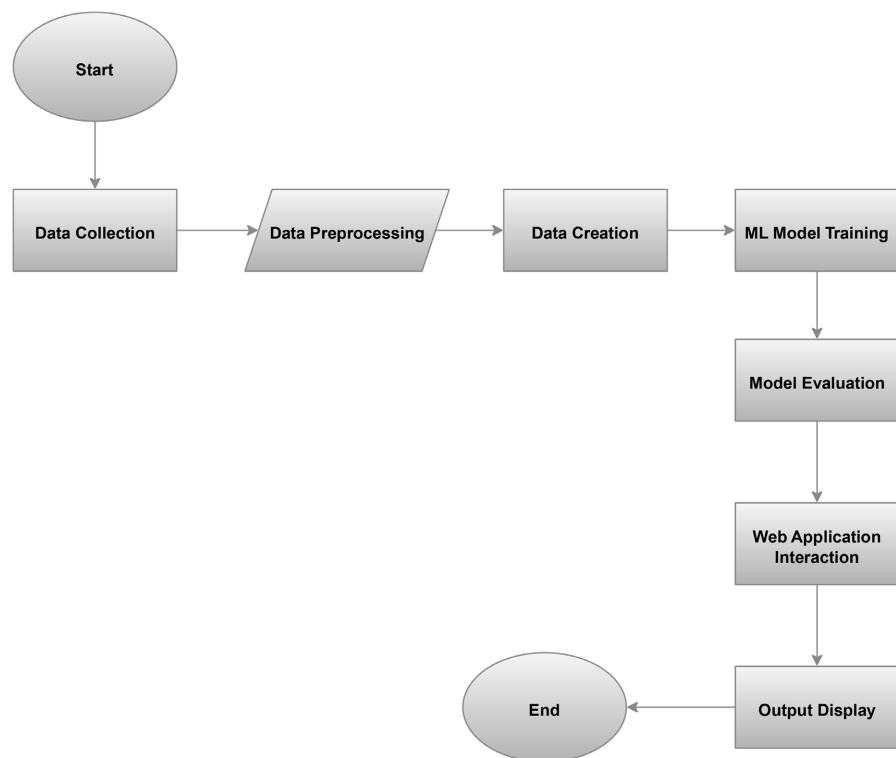


Figure 14. Flowchart diagram.

3.2. Software Development

Frontend application, backend application, machine learning model and database acted as the main units in the software architecture that the study followed. In the frontend application, interactive interfaces were designed using React library to handle client-side interactions. Integrated with the Python ML model, backend is implemented using Flask (Python) framework and Node.js to handle server-side interactions. The machine learning model is the unit that is responsible for the adult dog prediction based on early puppy behavior data and the model was trained using dog data and general data in the dataset that was collected from dog owners. The model is implemented primarily using Python programming language. Data pre-processing part is done through feature engineering by focusing on categorizing behaviour data and handling missing values. In the process, split data into training

(80%) and testing (20%) sets. Trained the model using Random Forest ML approach because Random Forest approach is more suitable to handle complex relationships with a medium-large dataset, as encountered in this research. Also, performed hyperparameter tuning and evaluated the model to enhance the accuracy to fulfill the expectations of the study. After saving and loading the model, predicted the target values. After implementing the ML model, integration of the model to the backend application process happened. MongoDB Atlas cloud database is used to perform CRUD operations for software data and model parameters. After all processes were done, to validate the finalized software solution, tests were conducted and found issues were instantly addressed and fixed.

Below use case diagram is showcasing the features and scope of the software (**Figure 15**).

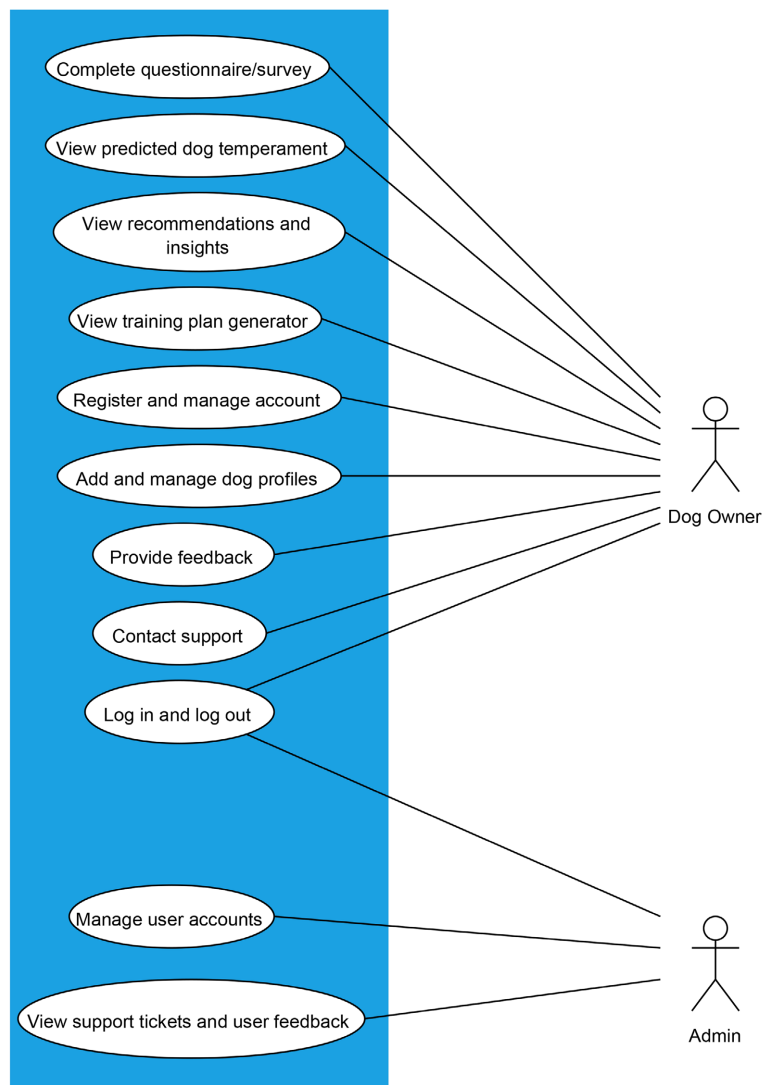


Figure 15. Use case diagram.

Below is the solution logo (**Figure 16**).



Figure 16. Solution logo.

Below screenshots are showcasing user interfaces in the software.

User should be able to register to the app using the sign-up screen (Figure 17).

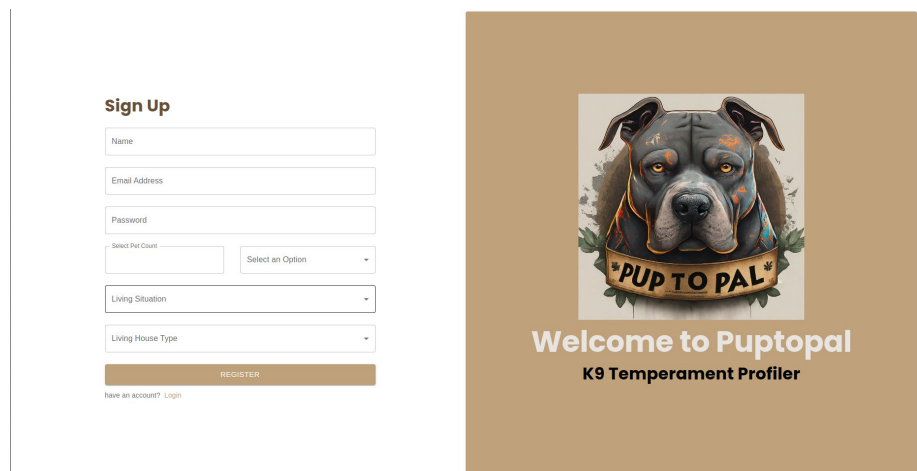


Figure 17. Sign-up.

User should be able to log in to the app using the login screen (Figure 18).

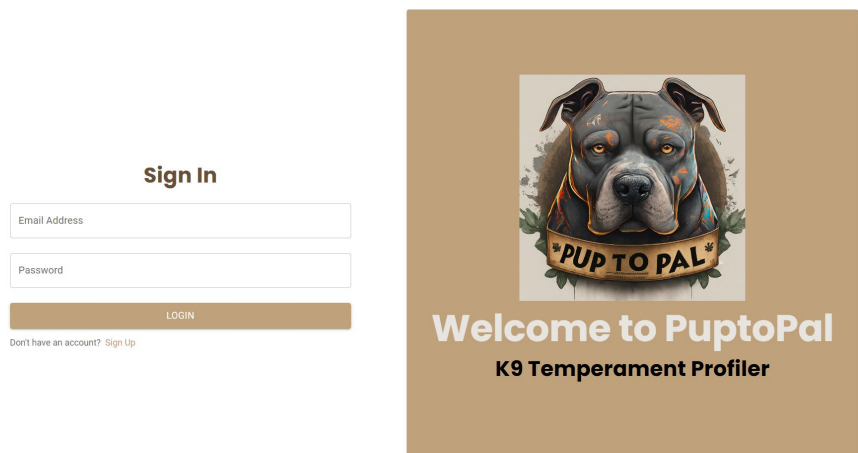


Figure 18. Login.

User should be able to see dogs that are added to dog profile section in the dashboard (Figure 19).



Figure 19. Dashboard.

User should be able to view and update their user profile (Figure 20).

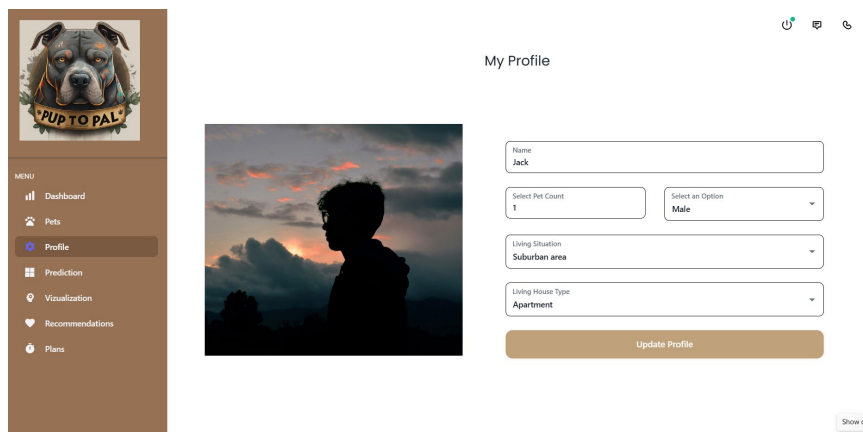


Figure 20. User account.

User should be able to add dog profiles to their account (Figure 21).

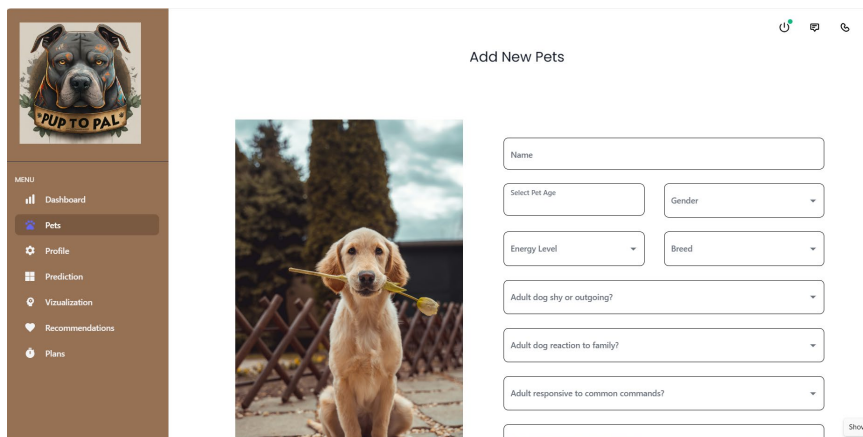


Figure 21. Add dog profiles.

User should be able to answer the questions regarding puppies asked from the app to predict the adult dog temperament (Figure 22).

Figure 22. Survey questionnaire for the prediction.

User should be able to see the predicted adult dog temperament after answering to the questions (Figure 23).

Figure 23. Predicted results.

User should be able to view visualization section regarding their dog information (Figure 24).

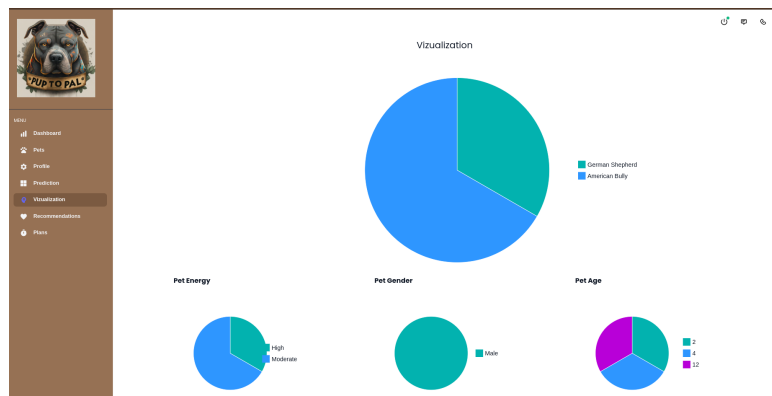


Figure 24. Visualization.

User should be able to receive recommendations based on their adult dog temperament (**Figure 25**).

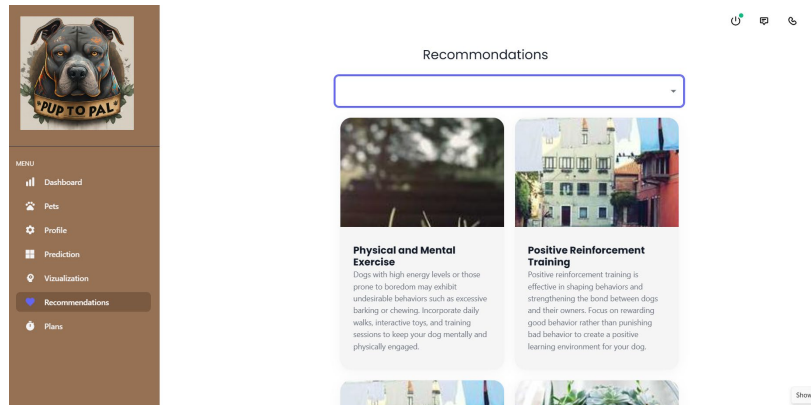


Figure 25. Recommendation.

User should be able to receive training plans based on their adult dog temperament (**Figure 26**).

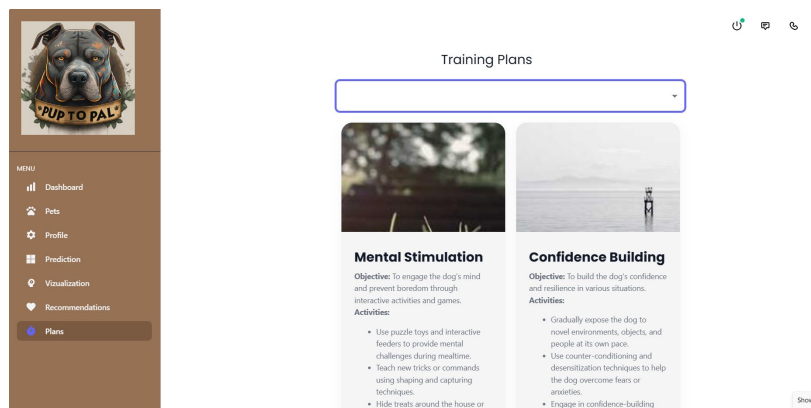


Figure 26. Training plans.

User should be able to give feedback regarding the app solution (**Figure 27**).

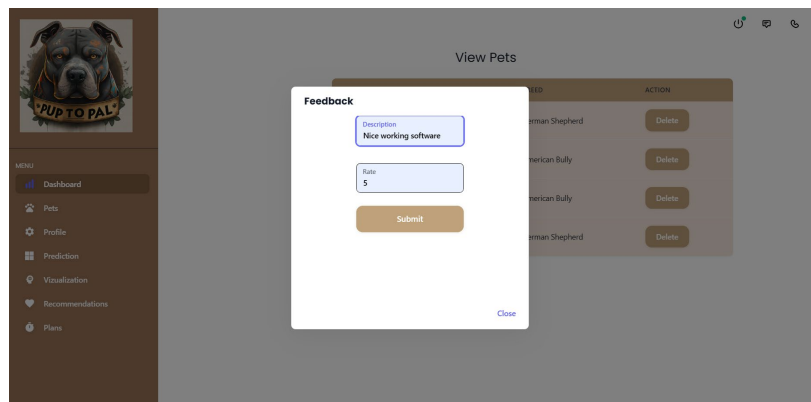


Figure 27. User feedback.

User should be able to submit support tickets regarding the app solution (Figure 28).

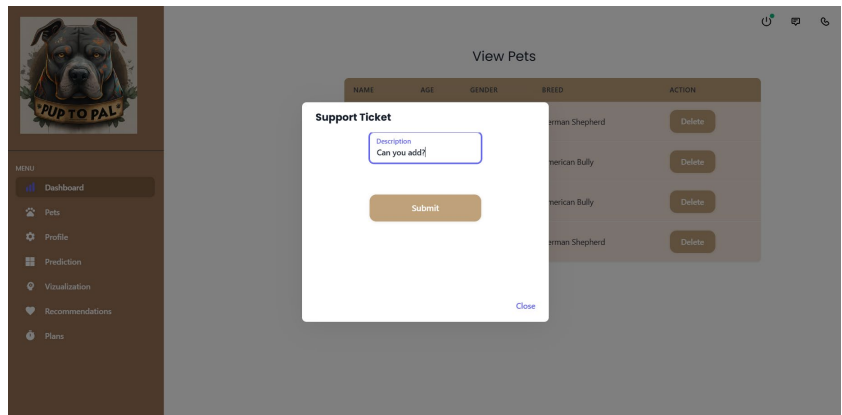


Figure 28. User support tickets.

Admin should be able to manage user accounts (Figure 29).

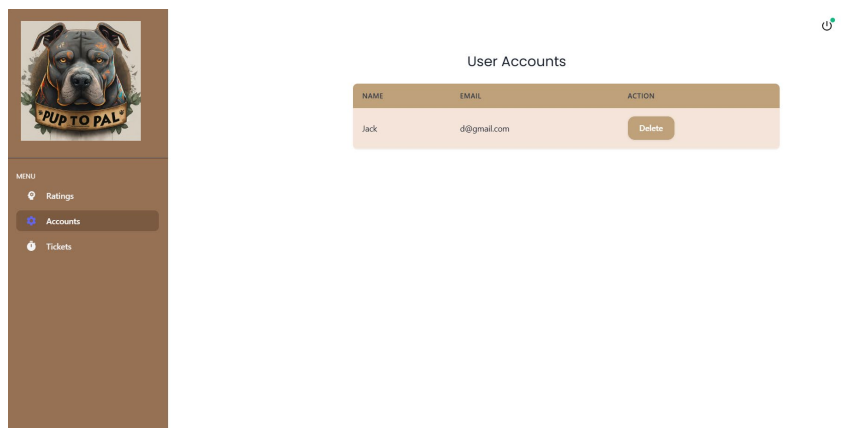


Figure 29. Admin view—user accounts.

Admin should be able to manage user feedback (Figure 30).

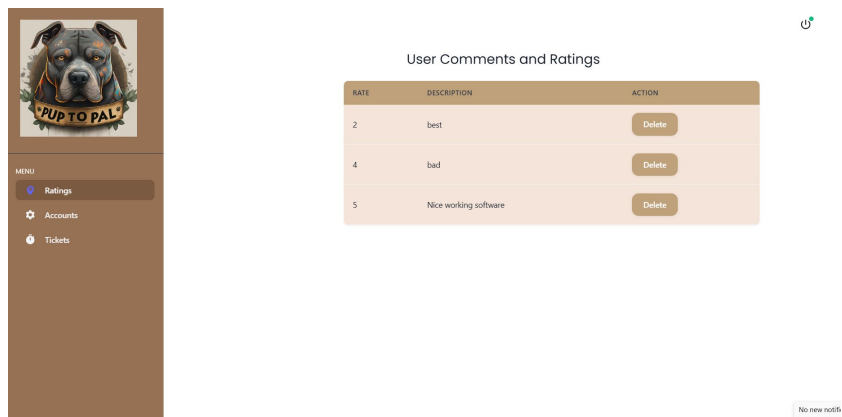


Figure 30. Admin view—user feedback.

Admin should be able to manage user support tickets (**Figure 31**).

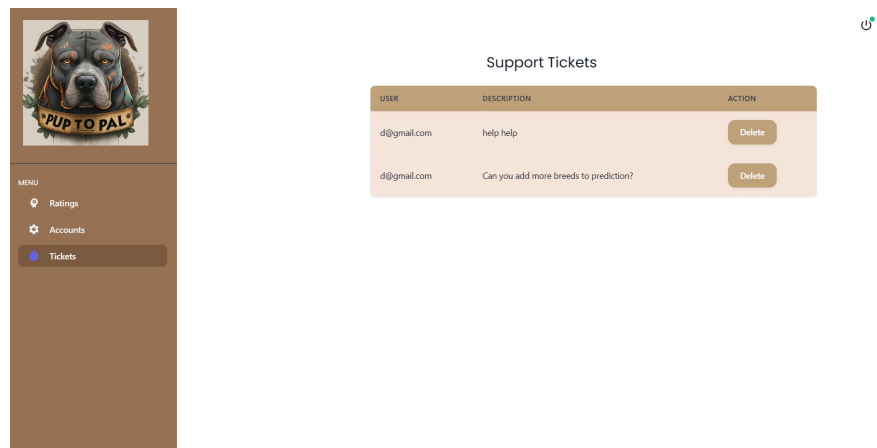


Figure 31. Admin view—support tickets.

The finalized software solution provides adult dog temperament based on puppy behaviours to the users so they can understand dog behaviours and make decisions related to the well-being of dogs. Finally, the software can be able to give valuable insights to users to improve public safety, increase adoption rates and reduce costs regarding shelters and animal control units.

4. Limitations

However, there seem to be expected limitations.

- When data is collected from dog owners, the given data may not be centered on facts, but instead, they are focused on the owner's personal feelings or beliefs, resulting in a messy dataset.
- Current research focused on three specific breeds of guard dogs (American Bully, American Pit Bull Terrier, and German Shepherd) to predict adult dog temperament. That being the case, prediction results may fail to act on behalf of all dog breeds.
- Dog behaviours can be dynamic and can be changed over time due to unforeseen environmental circumstances.

5. Future Recommendations

In order to enhance the productiveness of adult dog temperament prediction, below recommendations are proposed for the issues that were identified.

Continuous improvement and evaluation of the model:

Recommendation: Integrate with more advanced machine learning approaches to enhance the accuracy and strengthen the model. Make use of more efficient feedback loops to validate the model [39]. Also, it could include other extra factors like genetic variances to examine the connection with dog behaviours [32] [40].

Implementation: Establish connections with specialists and experts in the field to verify implementations and evaluations.

Continuous data collection and integration:

Recommendation: Integrate systematic methods to gather data in real-time using applications for smartphones or using wearable devices [11]. Integrate newly acquired data, which will contain a broad range of dog behaviours and environmental conditions to the model.

Implementation: Engage in interactions with dog owners, breeders, shelters, etc., in order to gather diverse and rich data. Develop user-friendly applications to expand participation and share data.

6. Conclusions

In the research study, the research question addressed is how to predict adult dog temperament based on puppy behaviours and experiences to reduce the count of dogs getting ending up in shelters and getting put down. The study covered and made a lot of effort to show it as a considerable work in the subjective areas. Using the Random Forest approach, the ML model was able to predict the temperament of adult dogs with 86% of good performance accuracy based on puppy behaviours and is continually improving.

The study has demonstrated that it is feasible to predict adult dog temperament based on puppy behaviours and experiences. By analysing and examining factors like dog breed, dog gender, energy level, shyness/outgoingness, reaction to owner and the family, reaction to new people, behavior around other animals, specific behavioral issues, responsiveness to common commands, home type, having children in home, having other animals at home, each day hours spending with the dog, perform training for the dog, etc., most of which are highly valued key variables to affect dog temperament, develop a machine learning prediction model with Random Forest approach to predict and provide adult dog temperament to users. This can help users to understand and address potential temperament issues of dogs with better decisions in early stages, like performing training sessions for their dogs and making enough time for their dogs. This can improve their bond with dogs and can lead the path to reducing the count of dogs ending up in shelters or getting put down due to behavioural issues. Also, with the help of the tool, users who are willing to buy or adopt dogs can get the understanding and then can choose and get a suitable dog based on their requirements. Shelters and dog rescue groups can also use the tool as a solution to predict adult dog temperament and find suitable adopters by matching predicted dog temperament. This can reduce the count of dogs who are homeless or living in shelters and find them a happy home. Tracking dog behaviour data from puppy to adulthood provided greater value by allowing us to get the knowledge of how puppy behaviours change over time. The solution tool also offers users with recommendations, insights and training plans for the predicted results to make informed and better decisions regarding whether managing an existing dog or choosing a new dog. Although the research study has made a considerable amount of work towards the adult dog temperament prediction, there are some areas that still need to be addressed. Further studies could address on enhanced

prediction models via much larger and more diverse datasets. Furthermore, the research should continuously prioritize on the well-being of dogs and any other innovative approaches to fulfill needs regarding the welfare of dogs.

In conclusion, the research is a major step towards the understanding of dog temperament and behaviours to promote responsible dog ownerships. To enhance positive human-dog relationships and well-being of dogs, we could further continue to accelerate the field of canine behaviour using modern and innovative approaches.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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