DOGODO: IOT BASED ENHANCED MOBILE APPLICATION TO PROVIDE ESSENTIAL HEALTH SERVICES TO DOGS – SMART TRANSLATOR

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October 2021

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Dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science in Information Technology Specializing in Information Technology

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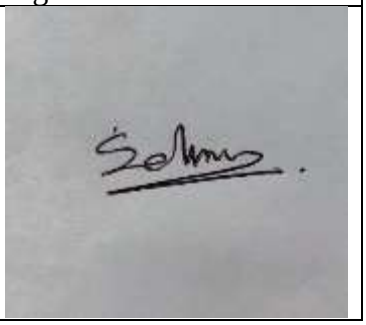
DECLARATION

We declare that this is our work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning, and to the best of our knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Name	Student Id	Signature
SALAY M S	IT18006858	

The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor: Date

ABSTRACT

In a study, we analyzed that there are so many pet lovers especially dog lovers. Most of them take care of their dogs with their experience. What if a dog lover is an armature who has no previous experience with dogs? Here a device with a mobile app has been proposed as a smart assistant which will help dog owners to take better care of their dogs and have a better understanding of their pet dog. The mobile app has four main components. Smart Health Analyzer, Smart translator, breed your pet, and per skincare are the main four components.

As my part, I will be doing the Smart translator which is a component that will help the owner to better understand the dog's mental state and what the dog is trying to communicate. Using a modern machine-learning algorithm, the possible context-specific and individual-specific roles of dog barks were studied. The function of the algorithm was to understand the acoustic characteristics of the barks, collected in various contexts and from different individuals, and then it will help to identify the barking pattern which will output what the dog is trying to communicate. The software will perform this activity by evaluating barks emitted by identified dogs in previously identified contexts.

Keywords: acoustic characteristics of the barks, machine learning, barking patterns, evaluating barks, canine communication

ACKNOWLEDGEMENT/DEDICATION

I want to take this opportunity to express my deepest gratitude to everyone who helped us with the encouragement and support we needed and provide their slightest support. First, we would like to thank Mrs.Disni Sriyarathna, the supervisor, and Mrs.Shalini Rupasinghe who are in charge of our project, for leading us in the right direction to make this project a success.

Our gratitude extends to Dr. Janaka, Lecturer in charge of the research project module, for providing his guidance and constant supervision as well as providing necessary information regarding the project and for their support in completing the project.

Also, we would like to mention the staff and lecturers at the Sri Lankan Institute of Information Technology, who have been provided with the ultimate guide and support for the entire four years. Finally, to support and strengthen our family members and friends who have always been pillars in our success.

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LIST OF ABBREVIATIONS

1. KASL - Kennel Association of Sri Lanka
2. CKC- Ceylon Kennel Club
3. IoT – internet of things
4. ML- machine learning
5. AI- Artificial intelligence
6. Rs. – Sri Lankan rupees
7. Mfcc - Mel-frequency cepstral coefficients
8. ANN- Artificial neural network

1. INTRODUCTION

1.1 Background Literature

Dogs have been the most loyal animal to humans since human evolution. Dogs were domesticated around 15,000 years ago by cavemen. Our ancestors had excessive meat to share. During the ice age, hunters shared their surplus meat with wolves. These wolves eventually became their pets. Dogs are the only animals domesticated by hunters. Other animals were domesticated by farmers after farming was widespread [1]. Since then, dogs have been around humans. Dogs are loyal companions to their masters and intelligent animals. They have crossbreed for generations now and therefore there are so many dog variants in the present. Even though dogs are the most preferred pets around the world lack of knowledge about their pet dog leads to different physical and mental disabilities.

For the well-being of dogs and their dog owners' convenience, many countries have developed innovative IoT-based software, hardware, and smartphone apps for dogs. Even though there are so many alternatives in the market for your dog's well-being it is difficult to procure such equipment from other countries to universal access via a smartphone app, and, worse, it does not help relevant services where appropriate. Also, in some regions, some services are limited and the cost bare can be more than caring for dogs. Therefore, purchasing such technology and maintaining them could be difficult for some dog owners. Through our application "Dogodo" We would like to offer some solutions to some of the problems dog owners may face when having a pet dog.

Like humans, dogs can communicate with each other and with their owners. The difference between a dog and human communication is humans use complex vocalization patterns as their main way of communication medium. When it comes to dogs, they use mainly nonverbal gestures and body language as their main communication medium. Alongside their body language, they use different acoustic barking patterns to communicate. These communication gestures may include communicating by wagging their tales, using different barking sounds and different expressions, and soft bites. Even though body language is the main way of dog communication it is a complicated combination method. To determine what the dog is trying to say the owner needs to crucially observe the entire dog, as well as the situation or the context, to accurately determine what is being conveyed by the dog. To determine what the dog is communicating the owner will need to know the knowledge of body language and accurately identify it. Therefore, in some instances, the dog owner might leave the dog without understanding how to respond to their behavior, breeding, and unique disease-

related concerns relying on their health and behavioral issues. In some of these instances, dog s. Due to the extreme frequent acts of people dumping dogs, the number of abandoned dogs has steadily risen. For example, dogs always wag their tails but a wagging tail does not necessarily mean a friendly dog. A moving tail, just becoming a prominent component of the dog's body language, is frequently observed in most situations. However, if the dog's body is rigid, the ears are back, and the dog is crouching, these additional signs of body language indicate that the dog is in a happy mode. So if we are trying to understand the dog observing the dog and analyzing the situation is a crucial point [2].

Other than trying to determine the dog through body language and gestures understanding acoustic barking sounds is a good way to determine a dog's language and understand what they are communicating with their human owners. When it comes to canine communication there are five groups of common communication, but it is better to note that to respond to a situation dogs can demonstrate other vocalizations that do not belong to any of these canine communication groups. As an example, a dog may display excitement vocalization signals but it may be a response to a stimulus, decide that stimulus is a threat, and switch to aggressive signals, fear signals, or even both. Also, it is better to note that stress can dramatically influence your pet dog's response in each situation [2]**.** These canine communication groups can be described briefly as mentioned below,

a. *Fearful communication:* -
   In a frightening situation, a dog will most likely react to the fearful stimulus with the whole body. The body language of the dog may show up as a combination of several signals. This may appear as the progression of the dog's responses intensifies. He may lick or yawn (even though he is not hungry or exhausted). The dog may keep its mouth tightly closed. The dog may also shake or tremble, lean back or look away to avoid eye contact, to avoid the stimulus that is perceived as frightening. In some instances, the absence of some active signals to the owner may be communicating as much as the active signals. If we look into an example if a dog is not eating any food or treats, avoiding his owner when he reaches the kennel, or freezes on point when seeing him, appearing any kind of "shut down" demonstrations are clear signals of fearful communication [2]

   Note: This kind of behavior has the potential for a dog to switch to aggressive behavior as it tries to defend itself from even its owner. This aggressive behavior may be the presence of the fearful stimulus continues or becomes more threatening

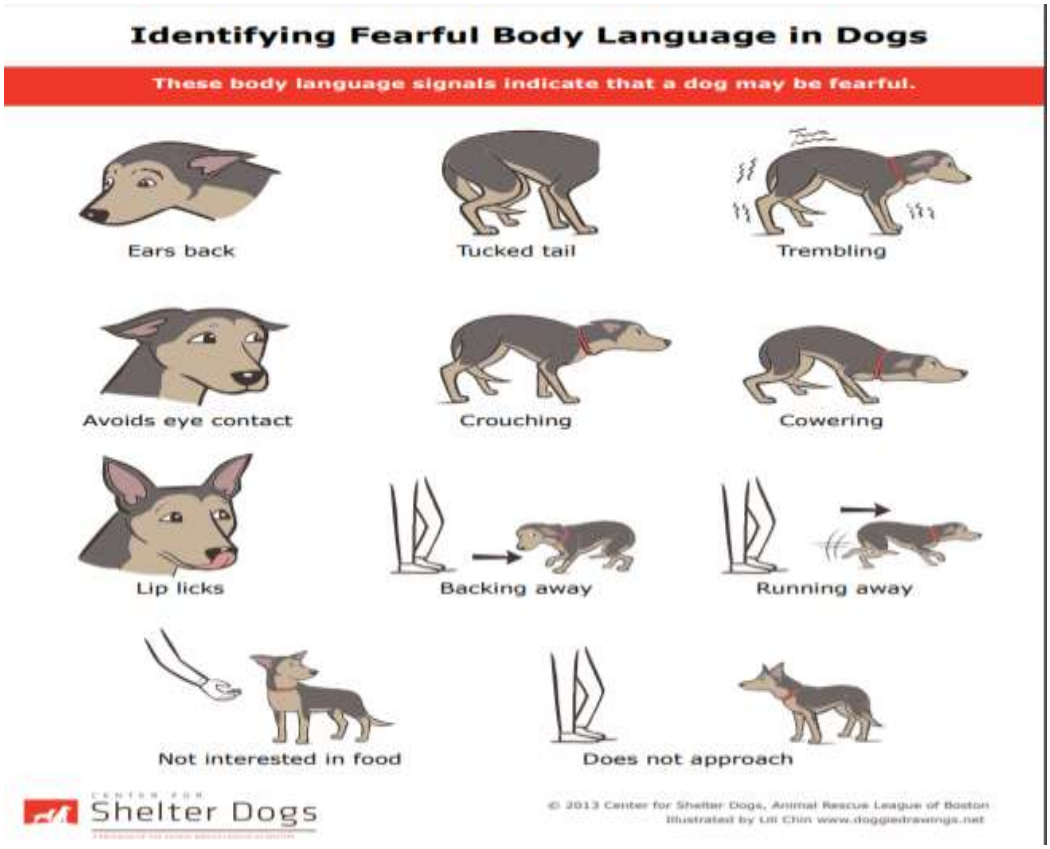

Figure 1:1: A poster of fearful behavior of dogs

b. *Arousal communication: -*

The owners may observe their pet dogs may demonstrate high arousal or excitement behaviors. There are many factors in this exciting behavior that can be demonstrated by the dog. This excitement can be seen due to confinement, dogs in adolescent age, lack of mental and physical outlets, and even due to the personality of the dog. Also, this kind of behavior may be seen due to a response to something or someone the dog likes. As an example, a dog may demonstrate this kind of behavior with a relaxed body, soft eyes, mouth and a wagging tail that jumps up for the owner's attention is a dog that is seeing a favorable person. The dog may also play-bow: rear end in the air, front end lower if the dog is excited about a favorable person or an object (example: toy). However, this kind of behavior can be demonstrated by dogs for unpleasant stimuli such as something they do not like or something the dog does not like, or even in a bad situation. Anxiety signs, such as a low tucked tail or trembling, may combine arousal signals in response to a sign of a problem. These kinds of signals can also be combined with aggressive indications like lunging or barking, as well as apprehensive signals like spinning or pacing [2].

Jumping, mounting, and mouthing are all frequent actions are demonstrated in aroused or excited dogs. Soft mouthing (jaw contact with no or little pressure or pain) or harsh mouthing (jaw interaction with pain and discomfort) orbiting the clothing orbiting of the leash. When a dog is stimulated or aroused, its fur may be standing up straight (pilo-erect), its ears may be front and focused, and the body posture of the dog is erect and upward. The tail of the dog is constantly up and wagging unsteadily, and the eyes are bright and concentrated. The dog may be barking and/or lunging too though [2].

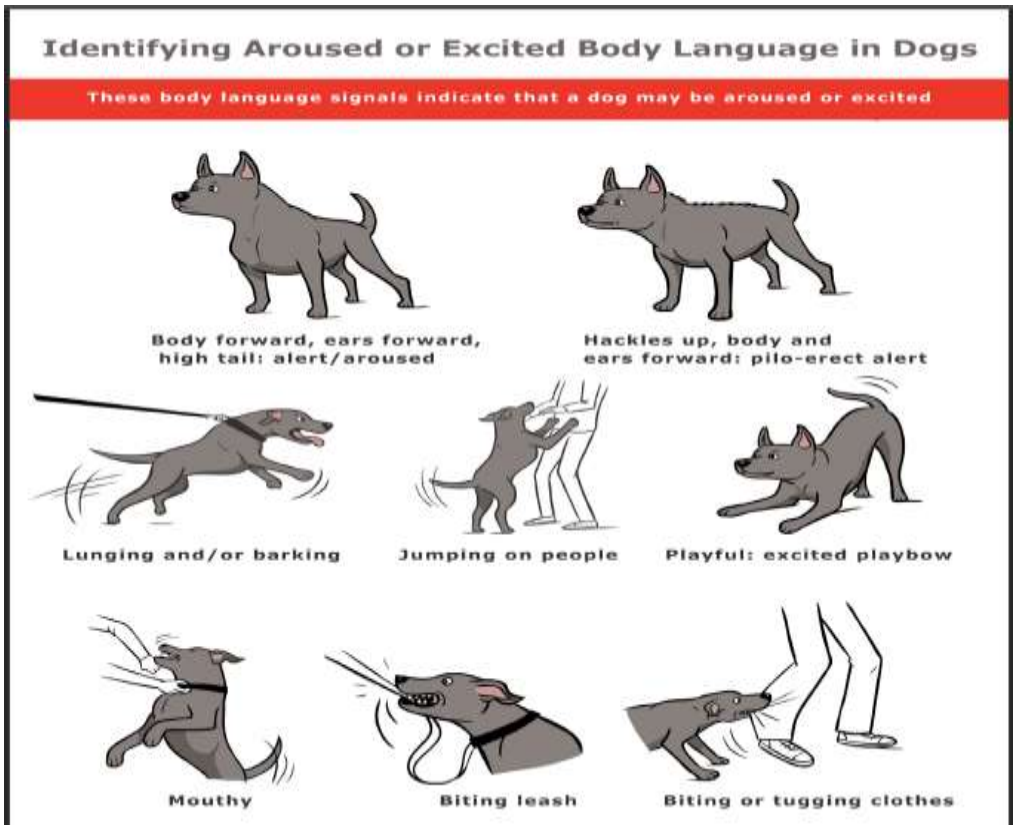

Figure 1:2: aroused communication of dogs

c. *Anxious communication: -*

The main reason a dog can be anxious is its environment. Dogs are usually relaxed animals who live their lives happily, but in some instances, they might become worried. In some situations, dogs who have anxiety about intake can become more agitated. If a dog is nervous, its body language will indicate pacing, heavy panting, and a lack of attention. An anxious dog's body language and a scared dog's body language may resemble the same. If the is anxious it will sweat even though it is not sweaty or perhaps just exercised. In this situation, the dog may pant

excessively, lick his lips even though it is not hungry, yawn even though the dog is not exhausted, and may display a depressed body posture with the dog's ears slightly turned backward. The dog may gently look away, wag its tail, or walk away from people or even the owner. The dog may also drool profusely and sneeze. Anxious dogs are similar to scared dogs, and they may display a lack of actions and they are more likely to display "shut down" gestures [2].

As a result of stress and worry, while at even a shelter your pet dog may exhibit arousal or excitement behaviors due to stress. If your pet dog is nervous in a kennel may circle, pace, bark, or bound off the walls of its kennel [2].

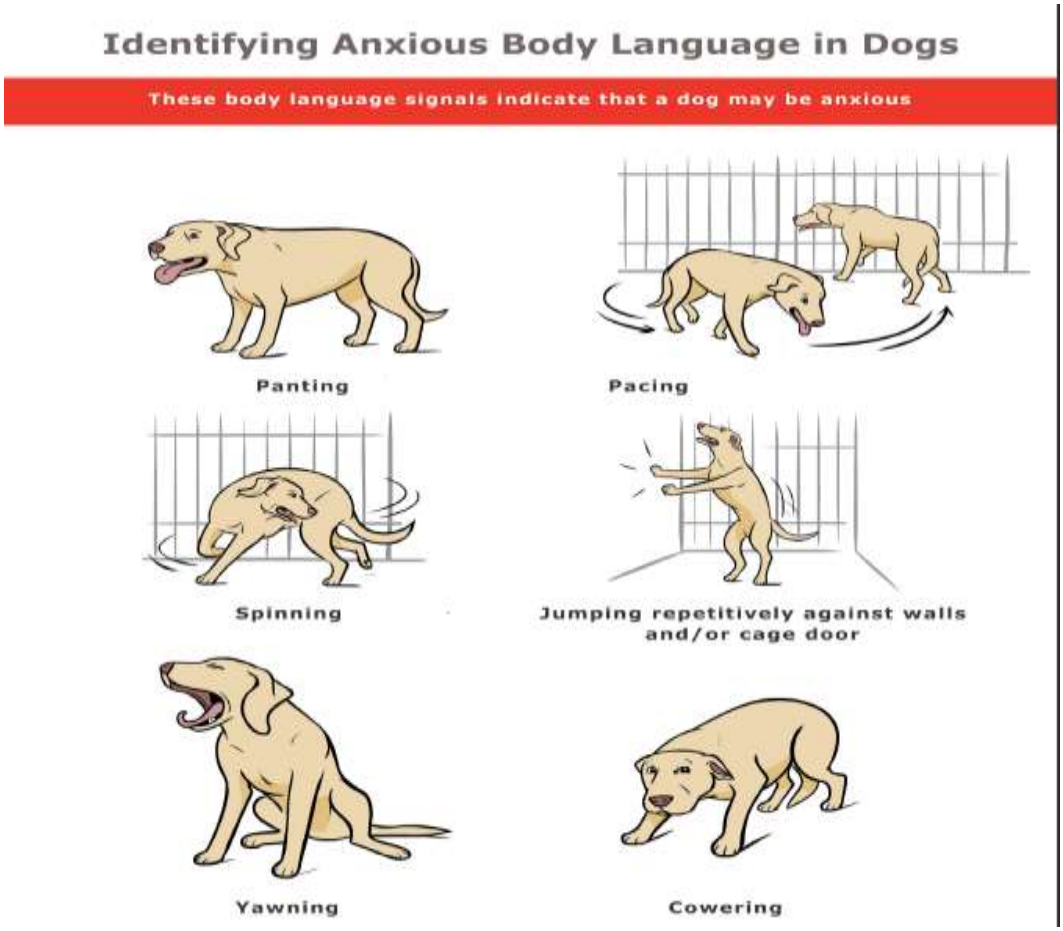

Figure 1:3: Anxious dogs

d. Aggressive communication

Dogs can be aggressive in different situations. This behavior is normal for dogs. In animals' aggression is often triggered by threats. This can see when a hostile human or animal or object approaches. Dogs use aggression to protect themselves from hostile threats. The dog will try to aggressively communicate to the hostile threat to convey that he will defend himself and the position against it.[10]
Even though dogs pose warning vocalizations, and gestures towards the threat they rarely engage physically. As an example, if a hostile threat approaches a dog may stand its ground, growl to the threat or show its teeth towards the threat. In this scenario, if the threat keeps approaching the dog ignoring its warnings the dog may bite. The best approach in such situations is to carefully pay attention to the warning signals of the dog. Also, aggressive signals may come mixed with other signals like fear signals. For example, if a dog is communicating an aggressive signal towards the threat but the owner or stranger misread it as fear and approaches the dog it may lead to a bite. Aggressive communication includes barking, stiffening, or freezing of the body, eyes barking, wide with a lot of white showing (whale eye), wrinkled nose, tense mouth, or curled lips, growling, showing teeth, and air snapping [2].

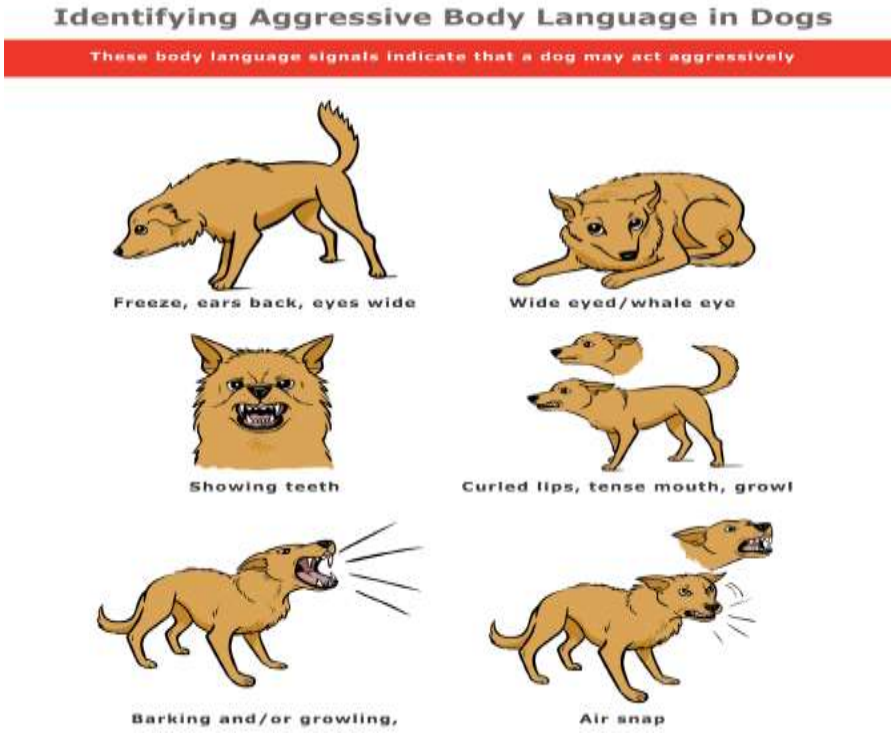

Figure 1:4: Aggressive communication

e. Relaxed communication

If a dog is relaxed it appears its mouth is slightly open and relaxed. It appears almost as if the dog is smiling. The dog's head and ears stay in a neutral position. Its head and eyes are relaxed and soft. The dog may waggle its tail in different directions. The dog may lie down or sit in a “frog-leg position” [2].

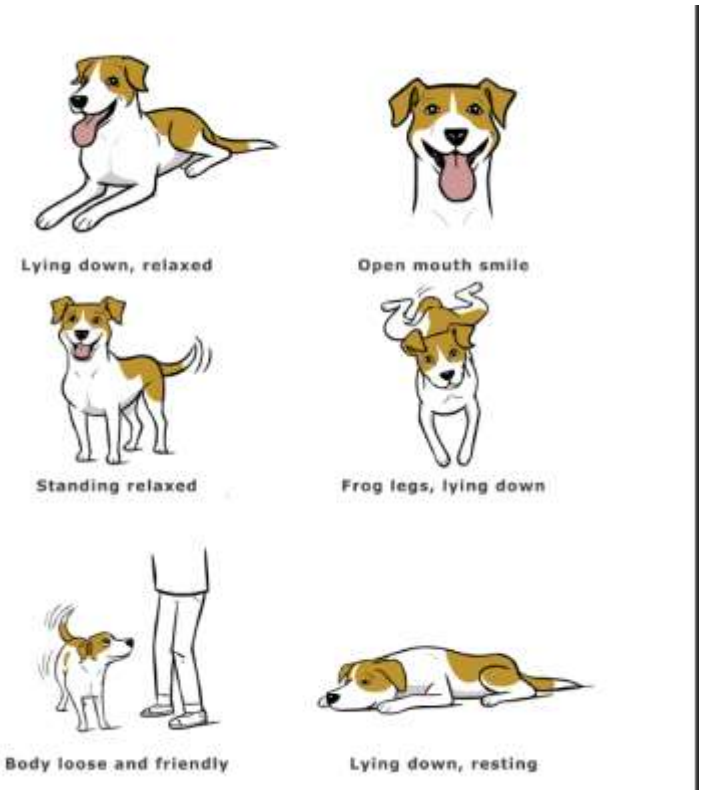

Figure 1:5:realaxed dog

Now in modern days, information communication technology is been applied to solve modern issues. What if to solve the pet dog communicating problem modern information technology concepts like machine learning, artificial intelligence, IoT, and Smartphones can be applied? In Sri Lanka, the KASL- Kennel Association of Sri Lanka offers a device that offers only limited functionality. It contains owner and dog information. This device only provides kind of a identification to the dog and there is no translating functionality.

A dog translator was developed back in 2003 by a Japanese company named “Takara”. The device was called “BowLingual”. This device required a separate device to do the translation. Back when it launched a cost around $120 and the now used unit is around $100 since it is extremely rare and expensive. The company discontinued the device back in 2006 and a new device cannot be purchased now [3]. Another version was launched again “Meowlingual” was only issued for the Japanese market. This was issued only in

the Japanese language. No other versions were released. This device had many issues when identifying sounds and barking patterns [4].

The best and most effective solution that can be purchased is the “BowLingual”.” This device requires carrying an additional device that has only a limited range and needs a considerable amount of time to capture and process acoustic characteristics of the barks due the device has only very limited processing power and the processing is done inside the special device. Other than this limitation this device has other technical limitations as well. A summary can write as below [3],

BowLingual uses custom-built voice-print analysis technology that has been tailored for dog barks. The accuracy of this product is tormented by different conditions and things. Sound interference will occur once the wireless collar-microphone picks up noises created by chain collars and collars with dog tags connected. As a result, the dog owner might believe that the device is malfunctioning and not registering the dog bark properly. In windy conditions, the mike can generally interpret a blow of wind as a bark. Electrical instrumentation and bound radio signals might trigger false readouts. because of enhancements with the U.S. and Canadian versions of the merchandise, these issues area unit a lot of common with the Japanese and South Korean versions [5].

One reviewer of the merchandise stated that "it's not helpful because the translations are not trustworthy and most do not be [6].

There are other mobile apps [7] like ‘Cat and dog translator’, ‘Dog translator simulator’ are just apps for entertainment purposes only which has not been scientifically proven that they could translate.

To solve these problems proposed smart translator will be using a machine-learning algorithm to identify dog bark patterns to understand what the is saying. This will help the owner to get a better idea about the dog. The translator makes the owner and pet more intimate. Dog sound translator system where you record your pup's barks in real-time to find out what they are saying and their feelings (joy, fear, anger, love). The output will be seen in the owner's phone app and no additional device will be required.

To identify the level of dog owners, have a survey was conducted. The survey was created using google docs. Randomly dog owners were chosen around Sri Lanka and the survey was distributed to them through social media such as Facebook, WhatsApp. Also, the survey was emailed to some dog owners as well. The survey had questions to cover our entire group research and here only related to smart translator which is my topic will be evaluated. Around 47 responses were collected from dog owners like Ridgeback, rottweiler, German shepherd, Labrador, beagle, lion shepherd. According to the survey following figure shows the level of knowledge about dogs of dog owners.

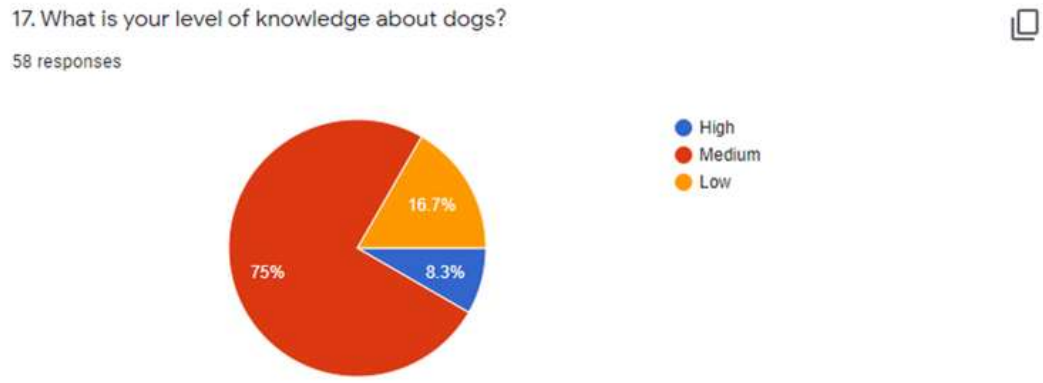

Figure 1:6: Knowledge level of dog owners

According to this graph even though dog owners have been around with their pet dogs for while the level of knowledge of most dog owners is medium. According to the survey, only 8.3% of dog owners think they well know about their pet dog. The majority which is 75.0% is in the medium knowledge level and some are in 15.7% which is a low level.

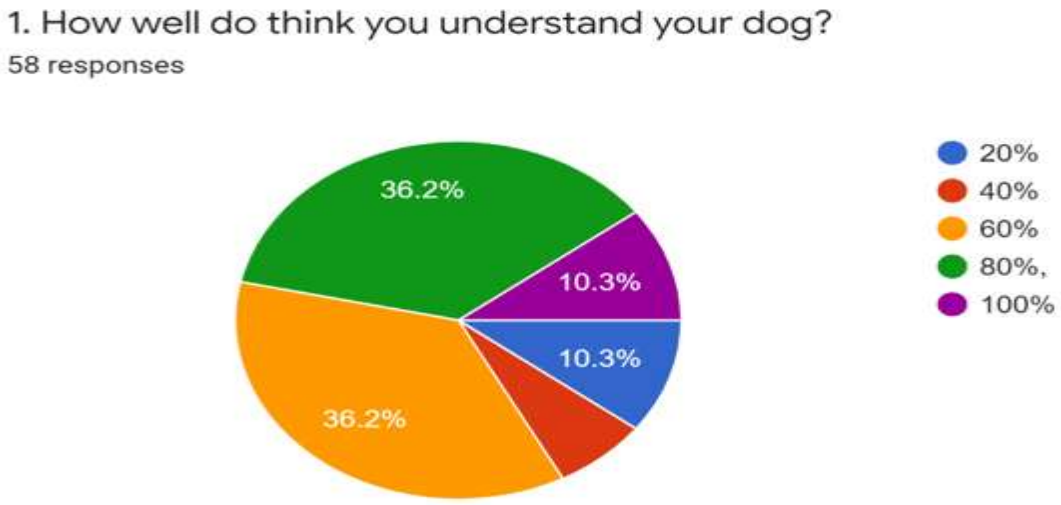

Figure 1:7: How well you understand your dog

According to the above graph, dog owners have indicated their level of understanding of what the dog is communicating. Only 10.3% of dog owners think they can understand their pet dog at an excellent level while 36.2% of owners think they can understand their dog up to a good level. The majority of the communication level is 60.0% or below level according to this graph that indicates most dog owners understand their dog to an average

level. This communication understanding level gap in some instances can lead dog owners to leave the dog without understanding how to respond to their behavior, breeding, and unique disease-related concerns relying on their health and behavioral issues.

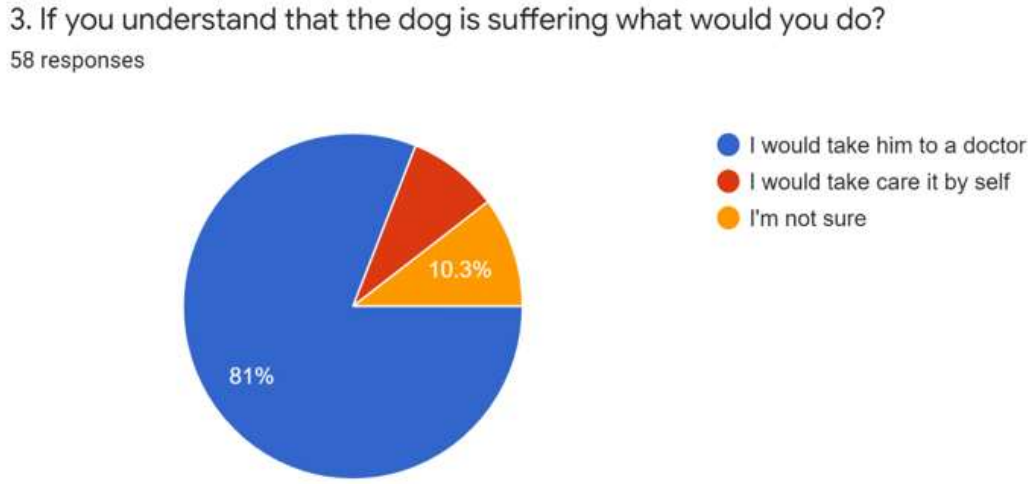

Figure 1:8:If the dog is suffering from an illness/pain

If we refer to the above graph figure, we can observe that majority of the dog owners are willing to attend to their pet dog if the dog is ill or if it is suffering from any kind of pain. To attend in a such manner the dog owner should understand the well should understand what the dog is trying to communicate to the owner. If the dog owner could not capture what the dog is trying to communicate the dog will end suffering or even death.

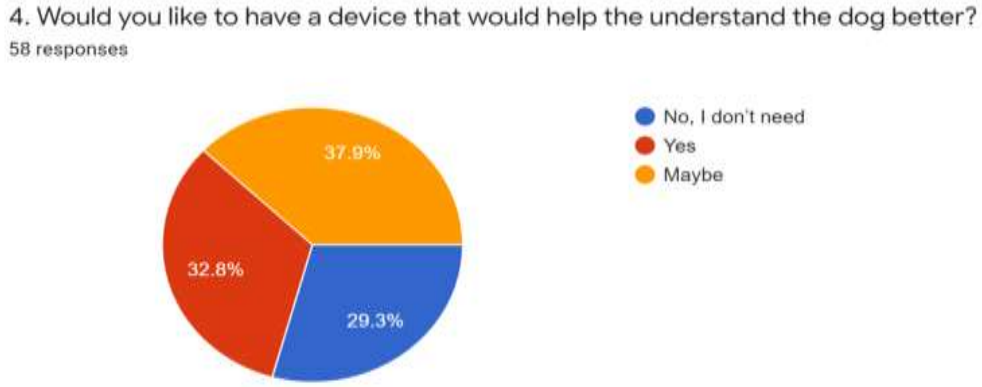

Figure 1:9:If the dog owners is willing to get support from a device

If a situation occurs as such most dog owners are going to face a major problem. According to the above-mentioned graph, we can observe that majority of the dog owners are willing to get assistance from a smart device to better understand their pet dog. Only roughly around 30% of the above dog owners are not willing to put some extra effort to get such a device. 70% of the owners are willing to do so. If a smart assistant could identify the dog barking pattern and output what the dog is exactly trying to communicate the owner could get a better idea of their pet dog. Also, it will help the owner understand the mental state such as Happy, Sad, Hungry, pain, etc. With a help of a device then the owner will be able to attend to the dog adequately.

When taking into consideration all the readings illustrated in the literature survey, it is distinguishable that there is a considerable audience in the society who interested in understanding what their pet dog is trying to communicate to them but due to the lack of knowledge and the experience required most dogs are not aware what the dog trying to communicate. Therefore, they may be not able to properly attend to their pet's physical and mental wants and needs. Especially the mental state and mental requirement. Unlike physical requirements, mental needs cannot be seen physically. These can be identified by only carefully listening to the dog's acoustic characteristics of the barks. Veteran dog owners may be able to identify this based on their experience, but most armature dog owners might not understand this. Due to this reason, most inexperienced dog owners are willing to get all the help they can to understand their dogs better. Therefore, most dog owners don't mind spending few bucks on a device that could help the owner understand their dog better.

Even though there is a clear requirement for a dog translator from dog owners, but when a dog owner seeks such a device that can translate their dog's barks there are very limited dog translator solutions available in the market. As we tested most mobile apps are just simulators [6], [7], [8] which have no actual proper translation, and another available device has many constraints to them.

Today smartphones are so common and almost everyone owns a smartphone. Smartphone has been evolving and this device has been improving to be almost good as modern computers with plenty of processing power but this processing power has not been utilized to understand your pet dog's communication properly. With the help of cloud services, this processing power can be improved further for better analyzing performance. Unlike other translating devices if the smartphone can be used

for translation, no additional device is required to carry and since modern smartphones are powerful devices these translations can be done much more efficiently spending much less time. According to research done by "Molnár, Csaba
Kaplan, Frédéric Roy, Pierre Pachet, François Pongrácz, Péter Dóka, Antal Miklósi, Ádám" on the classification of dog barks: A machine learning approach only on how machine learning algorithm models will work in behavioral science of dogs barking

patterns [9]. It has been only focused on how the algorithm will be behaving and there are no practical implementations. The study results have only focused on some very basic dog barking behavior. With an IoT device, Smartphones, and cloud service no practical implementations have not been tried before on dog barks translating.

1.2 Research Gap

When taking into consideration all the readings illustrated in the literature survey, it is distinguishable that there is a considerable audience in the society who interested in understanding what their pet dog is trying to communicate to them but due to the lack of knowledge and the experience required most dogs are not aware what the dog trying to communicate. Therefore, they may be not able to properly attend to their pet's physical and mental wants and needs. Especially the mental state and mental requirement. Unlike physical requirements, mental needs cannot be seen physically. These can be identified by only carefully listening to the dog's acoustic characteristics of the barks. Veteran dog owners may be able to identify this based on their experience, but most armature dog owners might not understand this. Due to this reason, most inexperienced dog owners are willing to get all the help they can to understand their dogs better. Therefore, most dog owners don't mind spending few bucks on a device that could help the owner understand their dog better.

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2. RESEARCH PROBLEM

Dogs are sensitive, intelligent, social, and loyal animals to their human companions. When someone acquires a dog as a pet it does not come with a manual ‘how to adopt it’? It is all up to the owner to figure it out. If a dog owner is less experienced how to tell whether the dog is happy, hungry, sad, or bored? and what to do about it? In such a situation dog owners may find it difficult to adopt some breeds. These animals love to communicate with their owners. They use different methods to communicate with their owners and get their owner's attention towards them. Also, dog owners are willing to understand what their dog is trying to communicate to them [10]. (According to the above survey results – figure 1.4)

When it comes to dog owners according to the above survey results, we can determine that there are mainly two types of dog owners

1. Less experienced dog owners

   Even though there is no proper definition for ‘experienced’ dog owners these types of dog owners have vast experience and knowledge about dog behavior traits. They have acquired this knowledge by exposing themselves for a long time to their pet dog breed or multiple dog breeds at once. These owners usually can understand canine language, dog’s body language unique gestures, unique vocalizations patterns, accurately identify them. These types of dog owners know the basic principles of dog behavior, why dogs do what they do—including reading meta signals, avoidance behaviors, and displacement behaviors. These owners usually have no issues understanding their dogs accurately.

2. More experienced dog owners

   These types of owners are less experienced dog owners. These less experienced dog owners have very little knowledge of dog behavior traits, gestures, body language, and barking vocalization patterns. According to the survey, we can see that most of these owners are being around their pet dog for less than one year or so. Unlike experienced dog owners, less experienced dog owners don't have a good idea or partially understand what their dog is trying to communicate to them. What if the dog is in pain or the dog needs any special attention, and it snarls in discomfort, but the less experienced dog owner does not understand what the dog is trying to say or knows what to do and just ignores the dog? The dog might face some uncomfortable situations and if it is a critical condition the dog might even face threats to its life. As an example, Beauceron is a breed with high intelligence and hyperactivity. If the owner is not active enough the dog might not be happy.

These kinds of dogs will signal its owner that it needs to walk or do activities but if the owner is not experienced enough or knowledgeable enough the owner might not understand the dog's need. Eventually, it will make the dog unhappy and stressed [10].

If the owner could understand or some experienced dog owner could assist the inexperienced dog owner in understanding their pet dog's wants and needs, they will attend to their pet dog without any hesitation. If someone can understand vital and subtle signs to avoid conflicts with other canines. This is a vital factor as this might involve recognizing behaviors that are prey-driven, defensive, or compulsive. We can identify this by looking at the survey results (figure 1.4). It shows that most owners are willing to give special attention to their dog and they do care a lot about their pet dog. Always seeking help from an experienced dog owner to attend to your dog's wants and needs can be disturbing to both parties. What if a software solution could assist inexperienced dog owners to understand their dog and provide guidance to what kind of steps they need to follow?

If we look at the market for alternative solutions, there are only very few cases where machine-learning techniques have been used in behavioral research on dogs. With a machine learning approach can a dog's acoustic barking patterns be analyzed and assessed to understand the dog better? Can the dog barking pattern translate and be displayed to a smartphone device in real-time?
Compared to human language dog language is less complicated [11]. To translate and interpret canine vocalization patterns such as barks, groans, cries, howls, and whimpers into a language that can be understood by humans, using machine learning and deep learning approaches has not been completed yet. Even though there is some research on dog acoustic bark pattern identification [9] practical implementations of these research conclusions are not available.

With the ever-increasing applications of machine learning and deep learning can it be applied to translation and for vocalization patterns identification? If a dog's acoustic barking patterns are analyzed and assessed most owners will understand exactly what the dog needs. Also, with a help of a pre-trained machine learning model can it be identified? To answer these questions a classifier must be created. To train the model data will be needed to classify on a behavioral approach. Behavioral approaches mostly will be on feasible solutions more than optimal solutions due to their nature of behavior can sometimes be unpredicted. This project involves research into investigating the most efficient, effective way of translating pet dogs' vocal patterns to a smartphone to understand what the dog is communicating and the mental state of the dog such as happy, sad, need to be loved, feared, needs attention.

3. RESEARCH OBJECTIVES

3.1 Main Objective

The main goal of the project represents the overall idea of this research project. Therefore, we have designed our main goal to address solutions to dog-related problems dog owners face from an overall perspective.

We have set out the main goal to be as create an efficient, effective, and easily accessible software solution for dogs' well-being. This software solution should allow dog owners to easily access a wide variety of services for their pet dogs in one place. The proposed solution should make the dog owner's and their dogs' lives much more comfortable. Also, this solution will focus on dogs' health and well-being as major concerns as for many owners this is the most important factor for them.

3.2 Sub Objective

This project has four different components. Each component has its sub-objectives to archive. I will be discussing the sub-objective for my component which is the 'Smart translator'. To make the sub-objective more specific to the component the main focus is to accurately identify canine communication signals and respond to them correctly.

To create an efficient and effective solution that could analyze and translate dog acoustic barking patterns and canine language to human-understandable language with the help of modern technology such as smartphones, machine learning, and deep learning approaches. The device should be able to give the dog owner a better understanding of the pet dog's canine language, unique gestures, unique vocalizations patterns, accurately identify them such as sad, pain, happiness, needs special attention, etc. This should help the dog owner to understand the dog better so the owner could attend to the dog's wants and needs properly without going through any conflicts. The translator should be able to make the dog and the owner more intimate.

3.3 Specific Objectives

- To accurately identify whether your pet dog is under stress.
- To treat and care about the dog in a better manner
- To attend to the dog's wants and needs in a proper manner.
- To understand canine language

- To identify acoustic barking patterns using machine learning and deep learning approaches
- How to respond to dog vocal signals accordingly
- To effectively capture dog barks and analyze them
- To analyze and generate the output with the least delays

4. METHODOLOGY

4.1 System Diagram

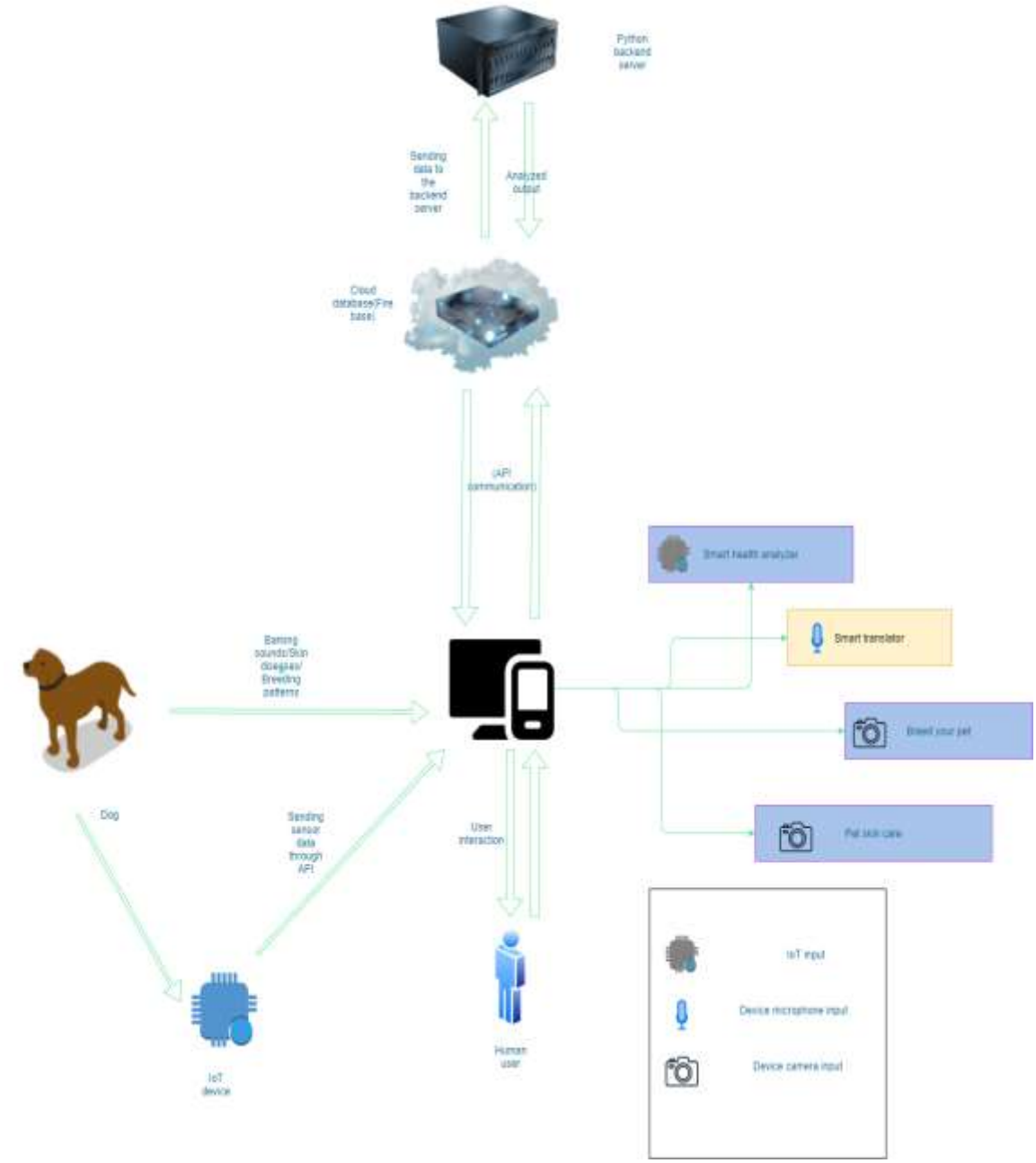

Figure 4:1:Overall system diagram

Note – The highlighted component in yellow (Smart translator) is the component I will be covering in my research

4.2 System Overview

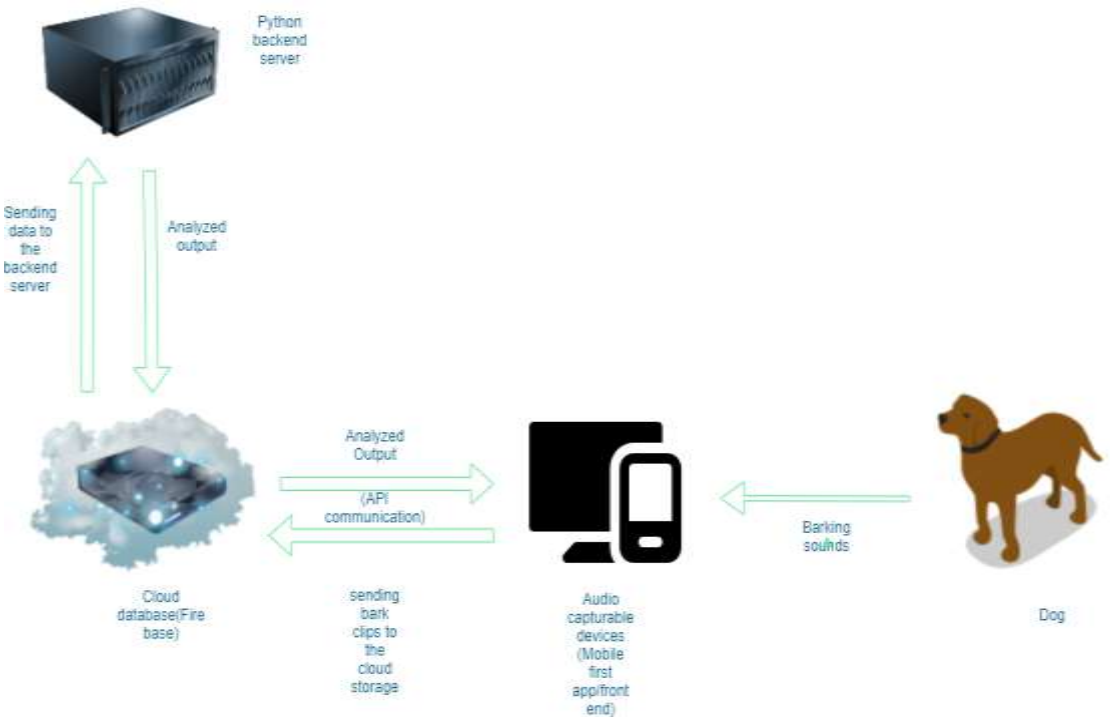

Figure 4:2:Smart translator

Dogodo is an overall solution that addresses most of the dog owner issues. The proposed system will mainly cover the relevant areas that are supposed to be covered to full fill the pet owners' expectations by providing the necessary services (Such as Internal Health (what are the issues and what actions should be taken), Canine language recognition, and translations, external issues such as skin diseases, and breeding patterns and breeding outcomes). Team priority is to emphasize necessary services that should be included in the mobile application and provide fluid services with fewer interruptions. And also, a service that has been never issued perfectly and solely to the Dog owners in a one go. Finally, this service will provide both IoT devices and a supportive eye-catching mobile app to the market.

The app works as a personal assistant, especially for new dog owners. The mobile has four main components.

- Smart health tracker
- Smart translator

- Breed your pet
- Pet skincare

Each component assesses four different areas that a dog owner might face when having a pet dog.

- **Smart health tracker**

  According to studies, the majority of animal-related health concerns are caused by a lack of activity or adequate diet. Domesticated animals suffer from cardiac problems as a result of a lack of exercise in their everyday activities. Furthermore, the health of these dogs may be jeopardized as a result of being ignored or having undiagnosed illnesses. This study was primarily concerned with addressing these symptoms at an early stage to give essential treatments and eliminate symptoms that might lead to severe health problems in the long term. According to research, tracking a dog's body temperature and heart rate can assist owners to receive a high-level perspective of the dog's health state.

  As per this research, the expectation is to provide an all-in-one IoT-based solution that can be used to identify body temperature, heart rate, and the footsteps of a dog at any given time. The solution will be provided as an IOT device where it can be attached to the leash.
  The gadget will be placed beneath the dog's left leg. The provided solution will be synchronized with a one-of-a-kind completely responsive mobile app. As a result, all information obtained from the IoT device will be shown in a way on the mobile device for the dog owners' review. The major expectation of the given solutions is to supply calculated and measurable thoughts about the dog's present heart rate, body temperature, and footfall. Also, what precisely can be done with such knowledge to improve a dog's health?

- **Breed your pet**

  .
  In the case of domestic dog breeders, some of them have a basic knowledge of dogs, but many do not but most of the time people who have basic knowledge about dogs do not have the updated knowledge about Medication and food recommendations. Using this component we are providing a solution to some of the major problems faced by dog owners. Here are four key pointers in moving your pet owners forward.

The first issue that pet owners have is finding a mate for those who want to cross their dog, which has become a difficult process in recent years. However, this component of the smartphone application is intended to notify pet owners that other dog owners are trying to cross their pets. Pet owners may save a lot of time by doing this, which they can then use to find a companion using other ways.

Furthermore, they are attempting to determine the appearance of a newborn pet by crossing their pet dog with another dog. People are very eager to know what the mixed breed of two dogs is if the pure breed cross is the same as the parent breed. This will assist you in determining the solutions. You may use this program to determine what sort of pet will result from cross-breeding dogs.

Also, one of the most common problems people face is not knowing the medical routine and food routine that should be given to puppies at an early age. Using this component pet owners can learn about medical routing and food routing properly to attend to these newborn pets.

- **Pet skincare**

The last component helps the user to understand which skin disease the dog is suffering from. The owner must take a photo of the disease and let the app analyze the image after predicted the disease as a minor or major issue. Based on image observations, the app will output the skin-related disease.

Efficient methods developed with deep learning have provided impartiality and high accuracy in identifying skin diseases in the past years. This research gives dog owners a system developed using Android to detect a dog's skin diseases such as Ticks, Redness, Shedding and Hair Loss, Rashes, Dry or flaky skin, Mange (Mites), Fleas, Swelling, Lumps, Hot spot, and wounds using an image processing algorithm. As well as promote accurate, cost-effective, and timely treatment using a chatbot. In addition, the component offers diagnoses and treatment without the need to contact veterinaries, which is particularly desired when the illness is infectious, or the dogs have another contagious disease. On the other aspect, it is not feasible to proceed with deep networks on resource-constrained devices (E.g., mobile phones). Therefore, lightweight network designs have been proposed in the literature. However, only a few mobile applications have been developed to identify dogs' skin diseases using colored images using lightweight networks.
Moreover, only a few skin diseases have been treated in those applications. Furthermore, they do not perform as well as deep network models, particularly when it comes to pattern identification. Therefore, in this study, a novel model has been created using a mobile-based application. The proposed K-means algorithm,

Canny Edge Detection technique, Deep Convolutional Neural Network, Morphological image processing technique using Non- Linear Regression, and mobile-based app chatbot to enhance the user experience for identifying skin diseases of pet dogs. The study aims to propose and develop an intelligent expert system for classifying skin diseases in dogs. In earlier research, we explored skin diseases identification using a conventional machine learning algorithm. By conventional machine learning method, we meant a computational approach for skin diseases classification that includes various stages, and classification is done using manually derived characteristics. In this study, we have studied the classification accuracy of the convolutional neural network, a part of the deep neural network.

- **Smart Translator**

  This is the component I will be covering in this research as my part.
  Now in modern days, information communication technology has been applied to solve modern issues. What if to solve the pet dog communicating problem modern information technology concepts like machine learning, artificial intelligence, and Smartphones can be applied.
  The smart translator is a compound that will help the owner better understand the dog and what the dog is trying to communicate. Using a modern machine-learning algorithm, the possible context-specific and individual-specific roles of dog barks were studied. The function of the algorithm was to understand the acoustic characteristics of the barks, collected in various contexts and from different individuals, and then it will help to identify the barking pattern which will output what the dog is trying to communicate. The software will perform this activity by evaluating barks emitted by identified dogs in previously identified contexts. humans can categorize various barks and associate them with appropriate emotional content by merely listening to them. Humans with different dog experience levels showed similar trends in the categorization of the possible inner state of the given barking dog. According to a study, we have shown that human perception of the motivational state in dogs is influenced by acoustic parameters in the barks

4.3 Data Source and Collection

Barks of serval dog breeds have been used here as the source for dog sound clips. The main data source for sound clip extraction is “Audioset” by Google [12]. This dataset consists of 13,705 data that belong to different types of dog breeds around the world. Due to the lack of computing resources to train and handle a such large dataset we have only selected some breeds for research. We have selected the most common dog breeds in Sri Lanka. This survey was done by one of the popular e-commerce platforms in Sri Lanka “ikman.lk” [13]. These results have been archived by analyzing the most sold dog breeds on the e-commerce platform. We have chosen 7 dog breeds for this research. Rottweiler,Boxer,Golden Retriever,Beagle,German Shepherd,Doberman Pinscher,Dalmatian are the most commen dog breeds in Sri Lanka accrding to the ‘Ïkman.lk” e-commerce platform and we have chosen the same for this research. Only these dog breeds have been extracted from the dataset.

However, the recorded data set has not considered the male to female sex ratio as a parameter. Therefore this dataset includes a mix of acoustic bark clips of male and female dogs. The age range for the dog breeds is 3- 4 years. The total sample size of barks analyzed is 400 bark clips. Additionally, 100 clips have been added as background noise. This is done to increase the accuracy of the model. By adding background noise the model will be able to determine dog vocalization patterns even in a noisy background environment [14].

4.4 Preparation of Sound Material

Sound clips were made and trimmed using Wavepad sound editor. To reduce the noise in the sound clip and normalize them Wavepad normalization option was utilized the bit rate of sound clips has been set to 1536kbps.

As each recording contained up to three or four barks, individual bark sounds were manually segmented and extracted. The final process of this resulted in individual 400 acoustic dog clips. These clips only contain single bark

4.5 Exploratory Data Analysis

All bark clips have been recorded in 4 different behavioral contexts. Those are Stranger, Angry, Sad, and Pain. All this voice clip data has been extracted from the google audio set which already has been classified. These categories have been chosen under the main four canine vocalizations dogs perform [2] .

Those categories can be listed and compared to the dataset as mentioned below,

- Aggressive communication-Angry
- Anxious communication-Pain
- Fearful communication -Sad
- Arousal communication-Stranger

Sound consists of two types of audio waves. mono waves and stereo waves. Mono wave consists only one wave and stereo waves consist of two waves. A sound clip can be displayed in a spectrogram. Here when it comes to the model training model compares the input voice sound clip. According to each sound category, all bark sound vocalizations have their unique waveform

I. Aggressive communication (Angry)

Angry (N=100)- An aggressive threatening behavior performed by dogs. This is a low guttural vocalization. Dogs may be aggressive in a variety of situations. This is typical dog behavior. Threats frequently cause aggressiveness in animals. When a hostile people, animal, or item approaches, this can detect it. Aggression is used by dogs to defend themselves against hostile dangers. The dog will try to communicate aggressively with the hostile danger to signal that he would protect himself and the position against it [2].

Even though dogs provide warning vocalizations and gestures in the direction of the threat, they rarely engage physically. For instance, if a hostile threat comes, a dog may hold its ground, growl, or flash its fangs at the threat. In this case, if the danger continues to approach the dog while disregarding its warnings, the dog may bite. In such cases, paying close attention to the dog's warning indications is the best strategy. Furthermore, aggressive impulses may be combined with other signals such as fear signals. For example, if a dog communicates an aggressive signal toward a threat but the owner or stranger misinterprets it as fear and approaches the dog, it may result in a bite. Barking, stiffening, or freezing of the body, eyes barking, wide with a lot of white showing (whale eye), wrinkled nose, tight mouth, or curled lips, growling, displaying teeth, and air snapping are all examples of aggressive communication [2].

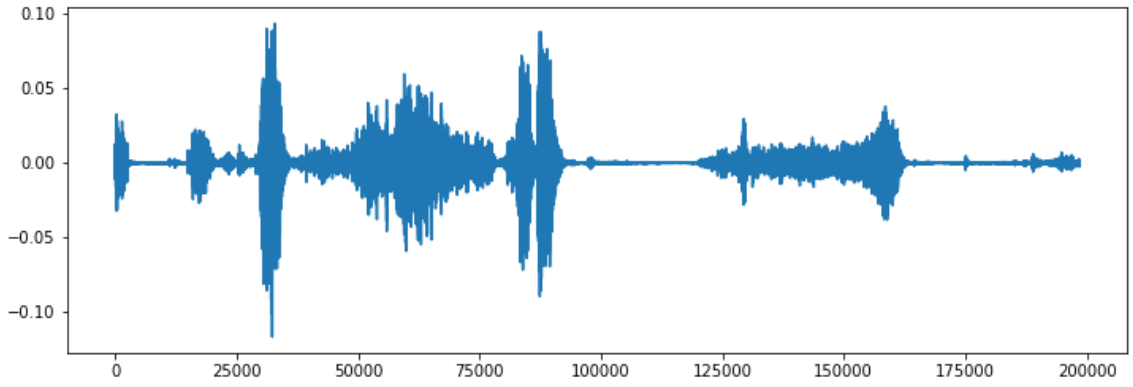

Figure 4:5:1 Angry vocalization mono form

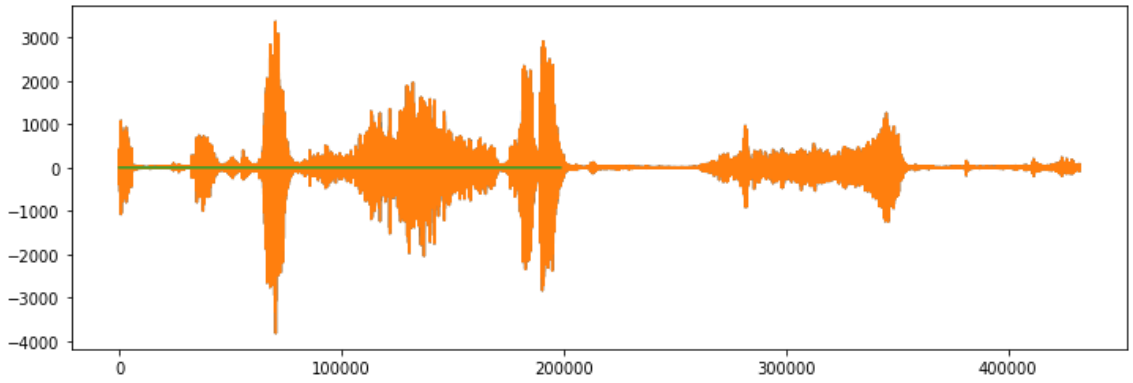

Figure 4:5:2 Angry vocalization stereo form

II. Anxious communication (Pain)

Pain (N=100)- This is a muted vocalization indicated by a dog. Indicates submission or pain. The major cause of a dog's anxiety is its environment. Dogs are mostly calm creatures who enjoy happy lives, although they can get concerned in certain situations. Dogs who are anxious about eating might get agitated in particular settings. When a dog is frightened, its body language will show pacing, excessive panting, and a lack of focus. The body language of an anxious dog and that of a terrified dog may be similar. If the is nervous, it will sweat even if it is not sweaty or has only recently exercised. In this scenario, the dog may pant excessively, lick his lips despite not being hungry, yawn while not being weary, and adopt a sad body posture with his ears slightly turned backward. The dog may softly avert its gaze, wag its tail, or even move away from others or even the owner. The dog may also sneeze and slobber heavily. Anxious dogs, like terrified dogs, may exhibit a lack of movements and are more prone to make "shut down" signals [2].

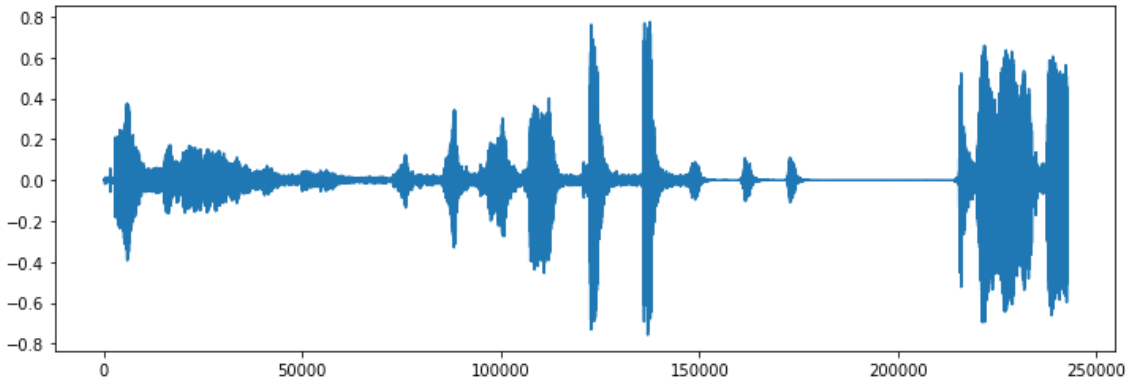

Figure 4:3:3 pain vocalization mono form

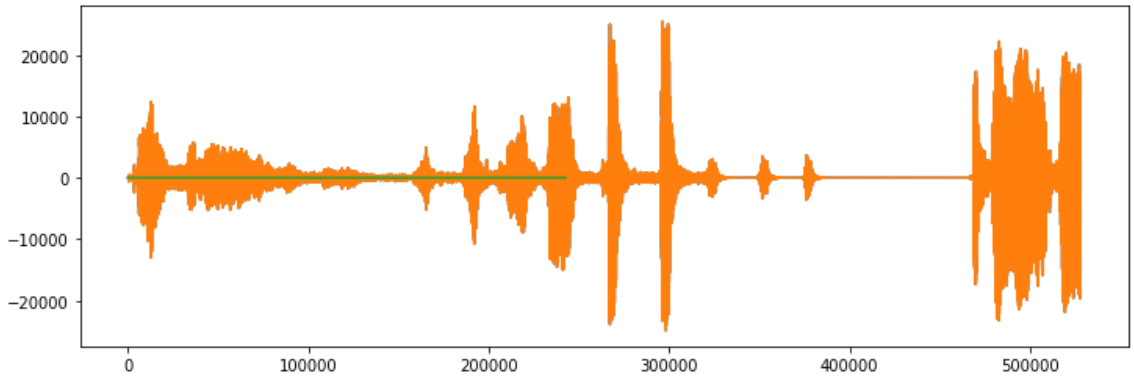

Figure 4:5:4 pain vocalization stereo form

III. Fearful communication (Sad)

Sad (N=120)- This is a long plaintive cry performed by a dog. In a terrifying circumstance, a dog would most likely react to the fearful stimuli with the whole body. The body language of the dog may show itself as a mix of many signals. This may emerge when the development of the dogâ€TMs responses intensifies. He may lick or yawn (even when he is neither hungry nor weary) (even though he is not hungry or exhausted). The dog may keep its jaws securely clenched. The dog may also shiver or quiver, lean back or turn away to avoid eye contact, to escape the stimulus that is viewed as threatening. In certain situations, the lack of some active signals to the owner may be conveying as much as the active ones. In certain situations, the lack of some active signals to the owner may be conveying as much as the active signals. If a dog is not eating any food or rewards, avoids his owner when he arrives at the kennel, or freezes on point at seeing him, these are all evident signs of frightening communication [2].

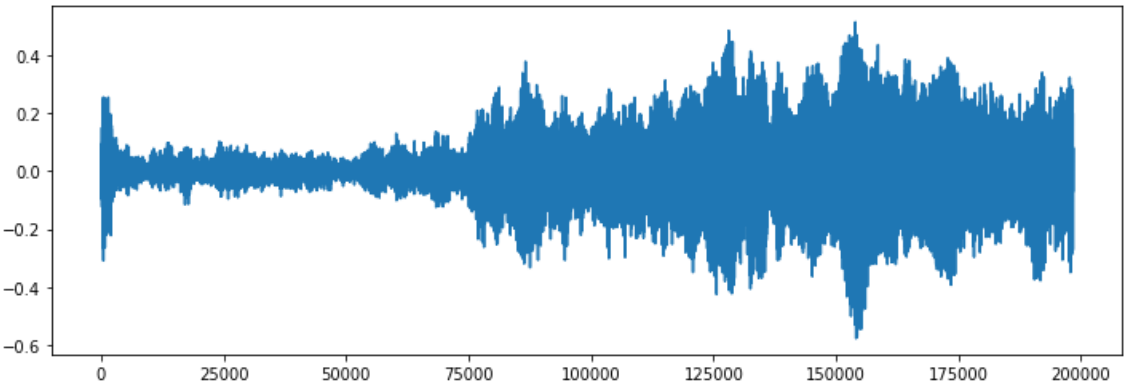

Figure 4:5:5 Sad vocalization mono form

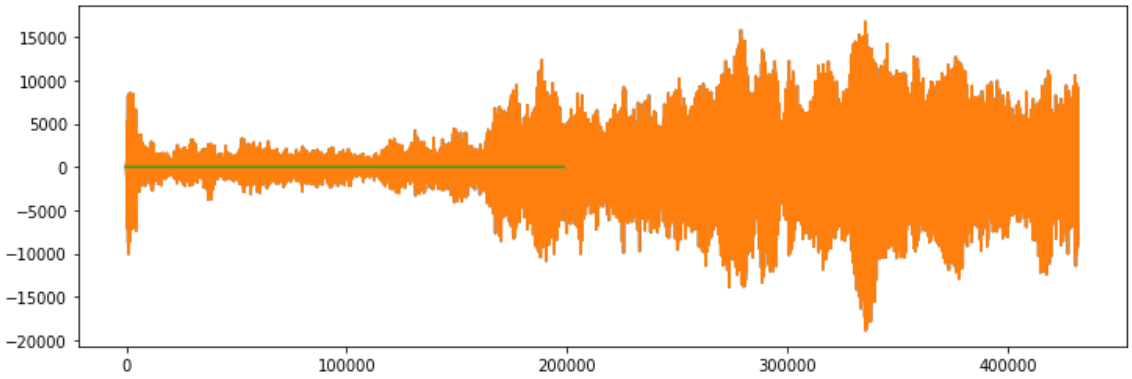

Figure 4:5:6 Sad vocalization stereo form

IV. Arousal communication-(Stranger)

Stranger(N=111) - The principle way of communication of dogs. All sound clip consists of 10 seconds of barking. In this scenario, a stranger appears front of the dog and it starts responding to the stranger with a casual bark. Pet owners may notice their pets exhibiting high arousal or exciting behaviors. Several elements might be shown by the dog in this fascinating activity. This enthusiasm can be noticed as a result of confinement, dogs in adolescence, a lack of mental and physical outlets, and even the dog's personality. This type of behavior may also be perceived as a reaction to something or someone the dog likes. For example, a dog with a relaxed body, soft eyes, mouth, and a wagging tail that jumps up for the owner's attention is a dog that is viewing a positive human. If the dog feels thrilled about a positive person or item, the dog may also play-bow rear end in the air, front end lower (example: toy). However, dogs can exhibit this type of behavior in response to unpleasant stimuli such as something they do not like or something the dog does not like, or even in a poor circumstance. Anxiety indicators, such as a low tucked tail or trembling, may mix with arousal signals in reaction to a problem indication. These signs

can also be coupled with aggressive indicators like lunging or barking, as well as anxious indications such as spinning or pacing [2].

Jumping, mounting, and mouthing are all common behaviors seen in aroused or agitated dogs. Soft mouthing (jaw contact with little or little pressure or pain) or severe mouthing (jaw interaction with pain and discomfort) circling the clothes orbiting the leash. When a dog is stimulated or aroused, its fur may stand up straight (pilo-upright), its ears may be front and concentrated, and the dog's body posture is erect and upward. The dog's tail is always up and wagging unsteadily, and its eyes are bright and focused. However, the dog may also be barking and/or lunging [2].

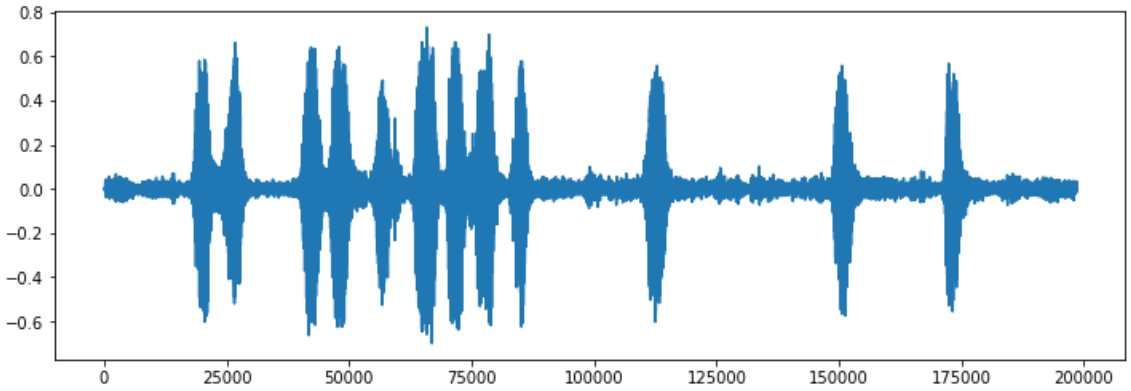

Figure 4:5:7 bark vocalization mono form

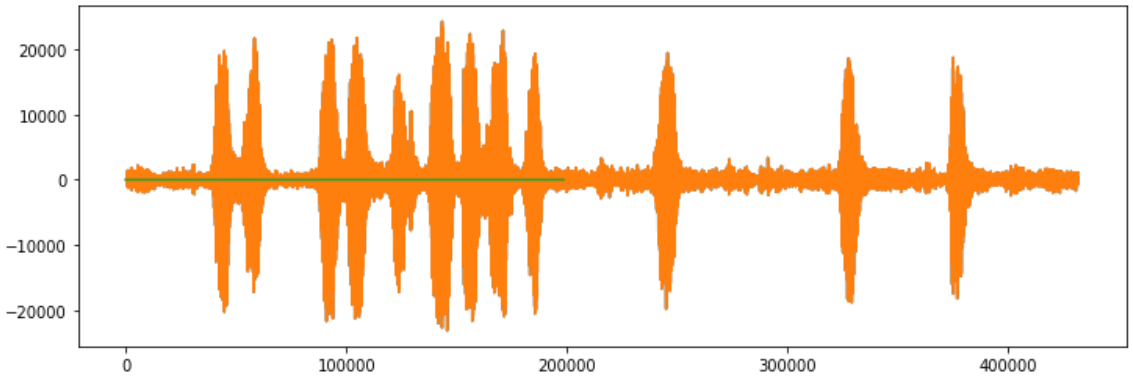

Figure 4:5:8 Bark vocalization stereo form

4.6 Data Pre-Processing

To process and analyze data we use a python library called “librosa”.

librosa

”librosa” contains the building blocks for music and audio data analysis. With the help of librosa, we are capable of reading audio signals, find the sample rate of audio samples, determine how many channels are in the audio file, and converting mono or stereo channels into the mono audio channel. Signal converting is done by mapping the audio data into a -1/+1 array. Also, Whatever the sample rate is librosa will just read the audio file and convert it to a 22050 Hz sample rate.

Example:

```
[0.         0.         0.         ... 0.0321897  0.03172747
0.03313958]
```

Mfccs

Here we will be using Mel-frequency Cepstral Coefficients(MFCC) from the audio samples. The MFCC summarises the frequency distribution across the window size, so it is possible to analyze both the frequency and time characteristics of the sound.

Mfcc audio parameters can be listed as mentioned below, [15]

- Mel Frequency Cepstral Coefficients

I. FFT length: The FFT size
II. Low frequency: Lowest band edge of Mel-scale filterbanks
III. High frequency: Highest band edge of Mel-scale filterbanks
IV. Frame stride: The step between the successive frame in seconds
V. Filter number: The number of triangular filters applied to the spectrogram
VI. Window size: The size of the sliding window for local cepstral mean normalization. Windows size must be odd.
VII. Number of coefficients: Number of cepstral coefficients to keep after applying Discrete Cosine Transform

- Pre-emphasis

I. Shift: The pre-emphasis shift value to roll over the input signal
II. Coefficient: The pre-emphasizing coefficient to apply to the input signal (0 equals to no filtering)

In sound processing, MFCC performs the following steps to process a sound clip and uniquely identify it. First, it takes the signal and Fourier transforms it. Then the signal is mapped according to the powers of the spectrogram obtained onto the Mel scale. This is done using triangular overlapping windows or cosine overlapping windows. Then it takes the each of Mel frequencies respective to the log value. As it was a signal it takes

the discrete cosine transform of the list of Mel log powers. The resulting spectrum is the MFCC aptitudes. The algorithm can be shown below,

$$(\omega) = f(w) = \int_{-\infty}^{\infty} f(x)_e^{-i\omega} f(x)e - i\omega x \, dx$$

The fast fourior algorhitem

$$F(\omega) = f(w) = \int_{-\infty}^{\infty} f(x)_e^{-i\omega} f(x)e - i\omega x \, dx$$

Suppose we are creating a filter to eliminate low frequencies and retain high frequencies. When we are processing a signal, the terminology is called an ideal high pass filter. So we'll specify a box-shaped frequency response with cutoff frequency ωc:

$$F(\omega) = 0 \; |\omega| \leq \omega c$$

$$1 \; |\omega| > \omega c$$

The impulse response is the inverse Fourier transform of the frequency response. There fore,

$$\begin{aligned} f(x) &= \frac{1}{2\pi}\int_{-\omega_c}^{\omega_c} e^{i\omega x}\, d\omega \\ &= \frac{1}{2\pi}\frac{e^{i\omega x}}{ix}\Big|_{\omega=-\omega_c}^{\omega_c} \\ &= \frac{1}{\pi x}\frac{e^{i\omega_c x} - e^{-i\omega_c x}}{2i} \\ &= \frac{\sin\omega_c x}{\pi x} \qquad \text{since } \sin\theta = \frac{e^{i\theta} - e^{-i\theta}}{2i} \\ &= \frac{\omega_c}{\pi}\text{sinc}(\frac{\omega_c}{\pi}x) \end{aligned}$$

where sinc(x) = sin(πx)/(πx). For antialiasing with unit-spaced samples, the

cut off frequency to equal the Nyquist frequency, so ωc = π.

Feature extraction using mfccs

Using the Mel-frequency Cepstral Coefficients(MFCC) from the audio samples, MFCC summarises the frequency distribution across the window size, so it is possible to analyze both the frequency and time characteristics of the sound. These audio representations will allow us to identify features for classification

```
def features_extractor(file):
    audio, sample_rate = librosa.load(file_name, res_type='kaiser_f
ast')
    mfccs_features = librosa.feature.mfcc(y=audio, sr=sample_rate,
n_mfcc=40)
    mfccs_scaled_features = np.mean(mfccs_features.T,axis=0)

    return mfccs_scaled_features
extracted_features=[]


for index_num,row in tqdm(metadata.iterrows()):
    file_name = os.path.join(os.path.abspath(audio_dataset_path),'f
old'+str(row["fold"])+'/',str(row["slice_file_name"]))
    final_class_labels=row["class"]
    data=features_extractor(file_name)
    extracted_features.append([data,final_class_labels])
```

The above function will load audio files and extract features. First using the' `librosa.load` it will load the audio file. Then it will extract two features, Audio, and the sample rate. Then 'librosa' is going to assign these parameters into mfccs using '`librosa.feature.mfcc`'. Finally, to get the mfccs scaled features we will be doing a mean on the transpose on the parameters extracted. This is done to one audio file. To iterate it to all audio files we are using a 'for' loop. Then we using the 'append' function we were able to list down data and class labels respectively

After following these steps we were able to extract independent and dependent features separately. Once the iteration is done we need to convert this to a data frame. Then we can extract independent and dependent features

```
### converting extracted_features to Pandas dataframe
extracted_features_df=pd.DataFrame(extracted_features,columns=['fea
ture','class'])
extracted_features_df.head()

### Split the dataset into independent and dependent dataset
X=np.array(extracted_features_df['feature'].tolist())
y=np.array(extracted_features_df['class'].tolist())

y_train.shape
(336, 5)
```

Since we have five classes (including the background noise) we have got 5 features here. Now we can do the train-test split, to split the dataset. The test size for the dataset has been set to 30% (0.3) and the train size for the dataset has been set to 70%(0.7). The random state for this split will be 1.

```
### Train Test Split
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.3,ra
ndom_state=1)
```

Once the splitting is done we can go for the model creation.

4.7 Model Creation

To create an ANN model we will be using the following libraries from 'TensorFlow and 'SK-learn'.Also, we will be adam optimizer for optimization purposes.

```
#model Creation
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense,Dropout,Activation,Flatte
n
from tensorflow.keras.optimizers import Adam
from sklearn import metrics
```

ANN-Artificial neural networks

Artificial neural networks also called neural networks are based on animal brain neural network patterns. These neural networks are computing systems that are similar to biological neural networks. This is a base model of the loosely coupled biological brain.These neural network cosist of multiple layers of neurons

```
model=Sequential()
###first layer
model.add(Dense(100,input_shape=(5,)))
model.add(Activation('relu'))
model.add(Dropout(0.5))
###second layer
model.add(Dense(200))
model.add(Activation('relu'))
model.add(Dropout(0.5))
###third layer
```

```
model.add(Dense(100))
model.add(Activation('relu'))
model.add(Dropout(0.5))

###final layer
model.add(Dense(num_labels))
model.add(Activation('softmax'))
```

First Layer

First, with respect to the no of features, the `input_shape` has been set to five (5). The first layer of neurons has a density of 100 neurons. The activation function has been set to 'relu.' Then we can set the dropout to 0.5. Setting the dropout layer is important as it will prevent overfitting. During the training time, the drop-out layer randomly sets input units to 0 with a frequency of rate at each step. This only drops in the training time and no drop-out is done during interference.

Second Layer

The first layer of neurons has a density of 200 neurons. The activation function will be the same as the first layer. Then we can set the dropout to 0.5. Setting the dropout layer is important as it will prevent overfitting similar to the first layer.

Third Layer

Similar to the second layer but the third layer has a density of 100 neurons. Other characteristics are all similar to the second layer.

Final Layer

This is the output layer of the artificial neural network. Here the '`num_labels`' is equal to the number of features. The activation function will be '`softmax`' as this is a multiclass classification problem.

The summary of the model can be viewed as mentioned below,

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 100)               4100
_________________________________________________________________
activation (Activation)      (None, 100)               0
_________________________________________________________________
dropout (Dropout)            (None, 100)               0
_________________________________________________________________
dense_1 (Dense)              (None, 200)               20200
```

```
_________________________________________________________________
activation_1 (Activation)    (None, 200)               0
_________________________________________________________________
dropout_1 (Dropout)          (None, 200)               0
_________________________________________________________________
dense_2 (Dense)              (None, 100)               20100
_________________________________________________________________
activation_2 (Activation)    (None, 100)               0
_________________________________________________________________
dropout_2 (Dropout)          (None, 100)               0
_________________________________________________________________
dense_3 (Dense)              (None, 5)                 505
_________________________________________________________________
activation_3 (Activation)    (None, 5)                 0
=================================================================
Total params: 44,905
Trainable params: 44,905
Non-trainable params: 0
```

Then we can compile the model. To compile the model we need to set the following parameters.

```
loss='categorical_crossentropy'
metrics=['accuracy']
optimizer='adam'
```

Once these parameters are set we can train the model.

4.8 Training the model

```
## Training my model
from tensorflow. keras.callbacks import ModelCheckpoint
from datetime import datetime

num_epochs = 30
num_batch_size = 15

checkpointer = ModelCheckpoint(filepath='saved_models/audio_classif
ication.hdf5',
                               verbose=1, save_best_only=True)
start = datetime.now()

model.fit(X_train, y_train, batch_size=num_batch_size, epochs=num_e
pochs, validation_data=(X_test, y_test), callbacks=[checkpointer],
verbose=1)
```

```
duration = datetime.now() - start
print("Training completed in time: ", duration)
```

From the TensorFlow Keras library, I have imported '`ModelCheckpoint`' to save the model for future use. Since this is not a large dataset the number of epochs for this training session will be 30. For a small data set, it is better to set the number of epochs between 25-30. If it is a large data set we can set our no of epochs to a large number. If the data set is large and the number of epochs is more than 30 it may lead to overfitting of the model. Since relatively the data set is not that large we can set the batch size to 15. If we increase the batch size we can see the model will overfit and cause accuracy problems [16].

Then we can declare the checkpoint using the libraries we imported previously. Using this checkpoint function we can save this model fd5 format for future use.

```
Epoch 00040: val_loss did not improve from 1.44346
Training completed in time:  0:00:05.883772
```

Optimizing the model

To find the optimal solution, the model had to be trained multiple times by changing the following parameters

1. number of epochs

2. batch size

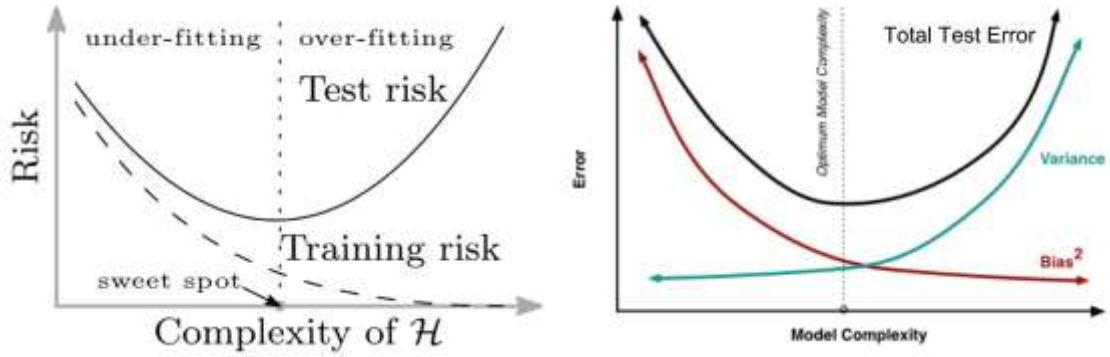

Figure 4:8:1 optimal solution

According to this graph, we can see that without hitting overfitting or underfitting we need to find the optimal solution. For that, we need to change the number of epochs and the batch size parameters iteratively until the variance and the bias is balanced. The following table shows the results of the accuracy variants with respect to the number of epochs and batch size.

Note: only one parameter has been changed at once

When the number of epochs is a constant,

Number of epochs	Batch size	Accuracy variance
100	30	35%
100	25	38%
100	20	41%
100	15	45%
100	10	45%

Table 1 : Model optimization number of epochs constant

Even though batch size decreases the accuracy has not changed due it has reached the optimum point.

When the batch size is constant,

Number of epochs	Batch size	Accuracy variance
90	10	48%
80	10	55%
70	10	58%
60	10	65%
50	10	73%
40	10	78%
30	10	80%
20	10	80%

Table 2:Model optimization batch size is a constant

Even though the number of epochs decreases the accuracy has not changed due it has reached the optimum point. After finding this optimal solution I was able to save the model with these parameters.

```
In [182]: test_accuracy=model.evaluate(X_test,y_test,verbose=0)
          print(test_accuracy[1])

          0.8002289533615112
```

Figure 4:8:2Optimal solution accuracy

Once the model is optimized I was able to use the model for testing purposes. To test the model following steps were carried out.

- Preprocess the new audio data
- Predict the classes
- The inverse transform your Predicted Label

```
filename="/content/drive/MyDrive/Research/Recording (2).m4a"
audio, sample_rate = librosa.load(filename, res_type='kaiser_fast')

mfccs_features = librosa.feature.mfcc(y=audio, sr=sample_rate, n_mf
cc=40)
mfccs_scaled_features = np.mean(mfccs_features.T,axis=0)

print(mfccs_scaled_features)
mfccs_scaled_features=mfccs_scaled_features.reshape(1,-1)
print(mfccs_scaled_features)
print(mfccs_scaled_features.shape)
predicted_label=model.predict_classes(mfccs_scaled_features)
print(predicted_label)
prediction_class = labelencoder.inverse_transform(predicted_label)
prediction_class
```

```
prediction_class = labelencoder.inverse_transform(predicted_label)
prediction_class

C:\ProgramData\Anaconda3\lib\site-packages\librosa\core\audio.py:165: UserWarning: PySoundFile failed. Trying audioread instea
d.
  warnings.warn("PySoundFile failed. Trying audioread instead.")

[-2.2145137e+02  1.0647595e+02 -4.0290585e+01  1.4129481e+01
 -1.1710290e+01  1.9335449e+01 -1.2857929e+01 -1.6397915e+00
 -7.8254805e+00  2.8445737e+00 -1.1003942e+01  8.2042770e+00
 -1.0479798e+01 -8.6976118e+00 -7.1040735e+00 -1.0514242e+01
 -1.8436327e+01 -5.5986695e+00 -5.7399611e+00 -1.1576040e+01
 -1.0727984e+01 -1.1435496e+01 -7.9377217e+00 -1.6215829e+00
 -2.0026221e+00 -2.9836619e+00 -1.3749297e+00  1.3522311e-01
  2.1645477e+00 -3.8719127e+00 -5.5651507e+00  5.6104078e+00
 -9.1747866e+00  6.1285257e-01 -8.0318747e+00 -4.4871283e+00
 -6.0952263e+00 -8.5139618e+00 -6.4854484e+00 -3.5003810e+00]
[[-2.2145137e+02  1.0647595e+02 -4.0290585e+01  1.4129481e+01
  -1.1710290e+01  1.9335449e+01 -1.2857929e+01 -1.6397915e+00
  -7.8254805e+00  2.8445737e+00 -1.1003942e+01  8.2042770e+00
  -1.0479798e+01 -8.6976118e+00 -7.1040735e+00 -1.0514242e+01
  -1.8436327e+01 -5.5986695e+00 -5.7399611e+00 -1.1576040e+01
  -1.0727984e+01 -1.1435496e+01 -7.9377217e+00 -1.6215829e+00
  -2.0026221e+00 -2.9836619e+00 -1.3749297e+00  1.3522311e-01
   2.1645477e+00 -3.8719127e+00 -5.5651507e+00  5.6104078e+00
  -9.1747866e+00  6.1285257e-01 -8.0318747e+00 -4.4871283e+00
  -6.0952263e+00 -8.5139618e+00 -6.4854484e+00 -3.5003810e+00]]
(1, 40)
[2]
Out[34]: array(['Sad'], dtype='<U8')
```

Figure 4:8:3 Model prediction results

4.9 Commercialization Aspects of the Product

Target audience

This product will be mainly targeted toward the less experienced dog owners but any dog owner can use purchase and use this product. The proposed solution comes as a package. The IoT device and the software solution. Even without the IoT device, the customer can still use some service of the software solution.

Benefits to end-users

- Less experienced dog owners can understand what the dog is trying to communicate
- The product will suggest dog owner what to do according to the dog's response
- This will help increase less experienced dog owner's knowledge about the dog
- Less experienced dog owners don't want to seek well-experienced dog owners help to understand the dogs
- The user can access the product's service at any time they want
- Without purchasing the IoT device the dog owner can still use the product.

Advertising and commercialization

- The app will mainly be marketed through social media such as Facebook, Instagram.
- On Facebook and Instagram, separate pages will be created and posted will be posted as advertisements.
- Also, Google advertisement services will be used if necessary to publish on google services.
- On youtube, a separate page will be created to market the product. The entire product and capabilities will be demonstrated via videos.
- The IoT device will be available to purchase through supermarkets, Kennel clubs in Sri Lanka, and dog products selling shops.
- A website will be created to publish the IoT and software solution product specifications.
- Posters will be created and posted where the IoT device is available to purchase.

5. Implementation, Testing Results & Discussion

The main objective of this phase is to test all components of the system and to evaluate the system whether meets all the functional and non-functional requirements of dow owners gathered. Also, to test the system for a bug-free experience. To test the behavior and performance of the product there are different levels of testing.

Unit testing

In this phase, we will be testing individual components of the product. Each component will be tested separately.

Integration testing

In this phase, we will be testing the integrated components and the interdependency of components. Also, the data flow from one model to another will be checked.

System testing

Here we will be testing the complete system whether it full fill all functional and non-functional requirements.

Acceptance testing

Acceptance testing is the final step of the testing phase. This is done by user or client debuggers usually. Client debugging involves the identification of localized implementation errors or bugs from a program or system. Also, these localization errors and bugs need to be removed. Concerning this, a web system should be evaluated by stakeholders for accessibility preferences. These stakeholders can be administrators, IT technicians, and dependents of the dog owner who will be using the app.

Once the system is running it is important to develop a strategy to maintain the system. From time to time it is better to debug the system for security vulnerabilities, performance checking, and out-of-date information.

5.1 Results

Following test cases are some of the test cases that we used to test the 'Smart translator' component. Due to the prevailing pandemic situation, we could only carry out limited test cases on limited test subjects (Dogs),

Test case 01

Test Scenario ID	Login-01	**Test Case ID**	Login 1-A
Test Case Description	Login -positive test case	**Test Priority**	High priority
Pre-Requisite	The user should have a valid user account	**Post-Requisite**	N/A

Test Execution Steps:

S. No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Launch application	Cmd:npm start	Launch http://localhost:3000/	http://localhost:3000/	Google chrome	Pass	[Salman 4.29 P.M. 04/10/2021] Launch successful
2.	Enter user credentials and enter log in button	Email id: abc@gmail.com Password: 123	Dashboard view	Dashboard view	Google chrome	Pass	[Salman 4.30 P.M. 04/10/2021] Log in successful

Table 3:Test case 1

Test case 02

Test Scenario ID	Login-01	**Test Case ID**	Login 1-B
Test Case Description	Login -Negative test case	**Test Priority**	High
Pre-Requisite	N/A	**Post-Requisite**	N/A

Test Execution Steps:

S. No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Launch application	Cmd:npm start	Launch http://localhost:3000/	http://localhost:3000/	Google chrome	Pass	[Salman 4.35 P.M. 04/10/2021] Launch successful
2.	Enter valid mail and invalid password and enter log in button	Email id: abc@gmail.com Password:456	Incorrect user name or password	Incorrect user name or password	Google chrome	Pass	[Salman 4.39 P.M. 04/10/2021] Log in unsuccessful
3.	Enter invalid mail and valid password and enter log in button	Email id: abcd@gmail.com Password:123	Incorrect user name or password	Incorrect user name or password	Google chrome	Pass	[Salman 4.45 P.M. 04/10/2021] Log in unsuccessful

Table 4:Test case 2

Test case 03

Test Scenario ID	Voice input-02	**Test Case ID**	02-A
Test Case Description	Voice input - positive test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. A voice clip of an angry dog 3. Breed- Labrador 4. Dog owner- Shashini Chethana 5. Experience- 12 years 6. Background noise- Quiet	**Post-Requisite**	

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Shashini Chethana 5.05 P.M. 04/10/2021] Navigation successful
2.	Select 'Choose file'	Angrily labeled Bark clip	Angry	Angry	Google chrome	Pass	[Shashini Chethana 5.10 P.M. 04/10/2021] Correct prediction]
3	Click 'log out'	N/A	Log in screen	Log in screen	Google chrome	Pass	[Shashini Chethana 5.10 P.M. 04/10/2021] Log out successful]

Table 5: Test case 3

Test case 04

Test Scenario ID	Voice input-02	**Test Case ID**	02-B
Test Case Description	Voice input - Negative test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. A voice clip of an angry dog 3. Breed- Labrador 4. Dog owner- Shashini Chethana 5. Experience- 12 years 6. Background noise- Loud	**Post-Requisite**	

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Shashini Chethana 5.15 P.M. 04/10/2021] Navigation successful
2.	Select 'Choose file'	Stranger labeled bark clip	Stranger	Stranger	Google chrome	Pass	[Shashini Chethana 5.20 P.M. 04/10/2021] Correct prediction]
3	Click the log out button	N/A	Log in screen	Log in screen	Google chrome	Pass	[Shashini Chethana 5.25 P.M. 04/10/2021] Log out successful]

Table 6:Test case 4

Test case 05

Test Scenario ID	Voice input-03	**Test Case ID**	03-A
Test Case Description	Voice input - Negative test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. A pre-recorded voice clip of a sad dog 3. Breed- German Sheperd 4. Dog owner- Gihan Ravindrajith 5. Experience- 4 years 6. Background noise- Neutral	**Post-Requisite**	The user should log out from the system

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Gihan 5.30 P.M. 04/10/2021] Navigation successful
2.	Select 'Choose file'	Howling labeled bark clip	Sad	Sad	Google chrome	Pass	[Gihan 5.35 P.M. 04/10/2021] Correct prediction]
3	Click 'Back'	N/A	Main menu	Main menu	Google chrome	Pass	[Gihan 5.40 P.M. 04/10/2021] Navigation successful]

Table 7:Test case 5

Test case 06

Test Scenario ID	Voice input-03	**Test Case ID**	03-B
Test Case Description	Voice input - Negative test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. A pre-recorded voice clip of a sad dog 3. Breed- German Sheperd 4. Dog owner- Gihan Ravindrajith 5. Experience- 4 years 6. Background noise- Loud	**Post-Requisite**	The user should log out from the system

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Gihan 6.30 P.M. 05/10/2021] Navigation successful
2.	Select 'Choose file'	Howling labeled bark clip	Sad	Sad	Google chrome	Pass	[Gihan 6.35 P.M. 05/10/2021] Correct prediction]
3	Click 'Back '	N/A	Main Menu	Main menu	Google chrome	Pass	[Gihan 6.40 P.M. 05/10/2021] Navigation successful]

Table 8:Test case 6

Test case 07

Test Scenario ID	Voice input-04	**Test Case ID**	04-A
Test Case Description	Microphone input -Positive test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. Breed- German Sheperd 3. Dog owner- Gihan Ravindrajith 5. Experience- 4 years 6. Background noise- Neutral	**Post-Requisite**	The user should log out from the system

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Gihan 10.30 A.M. 07/10/2021] Navigation successful
2.	Click 'start' To record	A dog cry(pain) sound clip	Start recording sound	Start recording sound	Google chrome	Pass	[Gihan 10.35 A.M. 05/10/2021] Sound recording]
3	Click 'stop '	N/A	Stop recording sound and it will be saved	Stop recording sound and it will be saved	Google chrome	Pass	[Gihan 10.40 A.M. 07/10/2021] Sound clip saved]
4	Select 'Choose file'	Recorded sound clip	Pain	Pain	Google chrome	Pass	[Gihan 10.45 A.M. 07/10/2021] Correct prediction]

Table 9:Test case 7

Test case 08

Test Scenario ID	Voice input-04	**Test Case ID**	04-A
Test Case Description	Microphone input -Negative test case	**Test Priority**	Medium
Pre-Requisite	1. The user should be logged in 2. Breed- German Sheperd 3. Dog owner- Gihan Ravindrajith 5. Experience- 4 years 6. Background noise- Loud	**Post-Requisite**	The user should log out from the system

Test Execution Steps:

S.No	**Action**	**Inputs**	**Expected Output**	**Actual Output**	**Test Browser**	**Test Result**	**Test Comments**
1.	Select 'Smart translator and enter	N/A	Smart translator UI	Smart translator UI	Google chrome	Pass	[Gihan 11.00 A.M. 07/10/2021] Navigation successful
2.	Click 'start' To record	A dog cry(pain) sound clip	Start recording sound	Start recording sound	Google chrome	Pass	[Gihan 11.05 A.M. 05/10/2021] Sound recording]
3	Click 'stop '	N/A	Stop recording sound and it will be saved	Stop recording sound and it will be saved	Google chrome	Pass	[Gihan 11.10 A.M. 07/10/2021] Sound clip saved]
4	Select 'Choose file'	Recorded sound clip	Pain	Background	Google chrome	Fail	[Gihan 10.15 A.M. 07/10/2021] Incorrect prediction]

Table 10:Test case 8

5.2 Research Findings

The main discussion goal we will be focusing on here is to evaluate the system with its requirements and fix existing bugs. Here we have mainly focus on how the dog bark classification algorithm (ANN) performed against various kinds of environments, against different dog breeds, and in various devices. The following table shows a summarization of the above test case results. For each breed, a test case has been executed 10 times. The test score is given out of 10 based on device output. Each correct prediction will earn 1 point.

Note: Windy situation was simulated using a table fan. The table fan created a windy situation and under the situation, microphone recordings were performed. To generate

Dog breed: Labrador

Condition	Stranger	Angry	Pain	Sad
Windy	9/10	8/10	9/10	9/10
High background noise	8/10	8/10	5/10	8/10
Low background noise	9/10	9/10	9/10	9/10

Table 11:Labrador findings

Dog breed: German Shepard

Condition	Stranger	Angry	Pain	Sad
Windy	9/10	9/10	9/10	9/10
High background noise	9/10	8/10	6/10	9/10
Low background noise	9/10	9/10	9/10	9/10

Table 12: German Shepard findings

Due to the prevailing covid 19 pandemic situation, we could only perform test cases on limited dog breeds. We performed those tests on Labarodor and German Sheperd. According to the above test results, we can see that a high windy situation may disrupt the

microphone recording of a device. This may result in incorrect predictions. In our case, the model was able to correctly predict 9/10 in a windy situation. Also, predictions have been tested in low background situations and high background situations. In low background situations, the model tends to perform as expected with high accuracy predictions. In high background situations high vocalizations barking patterns like Angry, Stranger, and Sad do not vary much as low background situations. However, 'Pain' which is a low vocalization bark pattern prediction has some drop inaccuracy. In the low background noise for both breeds 9/10, the model was able to predict correctly. In the high background noise, low vocalizations may have problems ower coming high background noise. Therefore the model has not been able to correctly determine the dog's vocalization.

5.3 Discussion

We have found that the model is performing differently in different situations. When it comes to a prediction we were able to examine that for a microphone input-based device background noise is a very important factor. Background noise can disrupt the pet dog's bark vocalization and even in some scenarios, it may overcome the dog's sound and lead to incorrect predictions. Even though to train the model we have used around 500 sound clips the model did face difficulties identifying the sound correctly.

If we increase the number of dog bark clips in each class the model may be able to predict correctly. To train the model we used dog sound clips without background noise but we did add some clips for background noise. If we can increase the number of sound clips in bark classes respectively we have to increase the number of clips in the background class as well.

Additional other than just adding pure Sad, Angry, stranger, and pain clips to classes without any background noise we can use dog sound clips with some background noise so the model will be able to distinguish correctly. While training the model and preparing the data to increase accuracy we need to focus on the following points.

- We need to analyze the validation data for bad predictions(errors).
- Also, we need to focus on dead nodes on the artificial neural network. It is better if we could keep the dead node count noted.
- The data set need to be shuffled. This can be done manually or automatically (Programmatically)
- Balancing the data set as much as possible is important.

- Also, the data set should be normalized for error-free predictions. Activations should be monitored. When normalizing we can use batch normalization, layer normalization, zero centered normalization, or normally distributed.
- Gradient clipping can be done to control gradient explodes.

6. CONCLUSIONS

We have found that using machine learning algorithms and deep learning algorithms dog vocalization patterns can distinguish correctly. This relative software experience is given by ‘Dogodo Smart Translator ’can be compared to a well-experienced dog owner assisting a less experienced dog owner to accurately identify canine language and gestures. The proposed system mainly works with canine language. Also, in each canine response, the system suggests a response to the dog owner. When comparing each class against human identification in ‘Stranger’ and ‘Angry’ situations humans could identify them faster than the algorithm. In ‘Sad’ and ‘Pain’ identification the algorithm outperformed human predictions. On average the algorithm could perform with 80% accuracy in all contexts. The dog bark acoustic bark pattern recognition study looked at the variables acquired by the deep convolutional neural network for the multi-class classification problem. A multi-Classifier was applied to classify the extracted features for the classification objective. After 5-fold cross-validation, the multi-class classifier achieves an overall accuracy of 80.21 percentage with an error rate of 19.79.

```
In [182]: test_accuracy=model.evaluate(X_test,y_test,verbose=0)
          print(test_accuracy[1])

          0.8002289533615112
```

Figure 6:1:Model accuracy

The System extracts and converts canine language into human understandable text-based outputs.

According to [9] humans can identify most dogs ‘Stranger’ and ‘Angry’ bark patterns accurately. In ‘Pain’ and ‘Sad’ humans have problems correctly identifying them. We concluded that the reason for these findings latter context of each bark is less similar to each other. As an example, ‘Stranger’ and ‘Angry’ are similar bark patterns and they are commonly performed by dogs. Most individuals could accurately identify these bark patterns. ‘Sad’ and ‘Pain’ are relatively uncommon bark vocalization bark patterns performed by dogs.

To perform ‘Pain’ or ‘Sad’ dogs should face special environments. There fore a dog owner may not identify it properly. For example, A hyperactive dog breed that needs outdoor exercise a lot may not get that due to the owner’s lack of knowledge about the dog breed. Therefore the dog might be stressed and sad. With this proposed solution the owner could overcome this.

Also, we discovered that the model behaves differently in different scenarios. In terms of prediction, we were able to determine that background noise is a significant component for a microphone input-based device. Background noise can interfere with a pet dog's bark vocalization and, in certain cases, may even overpower the dog's sound, resulting in erroneous predictions. Even though we utilized about 500 sound samples to train the model, the model had difficulty properly recognizing the sound.

If the number of dog bark clips in each class is increased, the model may be able to predict accurately. We utilized dog sound samples with no background noise to train the model, however, we did include some clips with background noise. If we can raise the number of sound clips in the bark classes, we must also increase the number of clips in the backdrop class.

In addition to adding pure Sad, Angry, Stranger, and Pain clips to classes with no background noise, we may utilize dog sound clips with some background noise to ensure the model accurately distinguishes.

As future work, this can be extended to understanding deeper contexts of canine communication. In this research, we have only covered the basic aspects of canine communication and limited dog bark vocalizations. This can be extended to deeper dog communication with different dog sounds. For example, this research only covers the basic aspects of canine communication such as ‘Stranger’, ‘Pain’,’ Sad’ and ‘Angry ’. This could be extended to more complex identification such as ‘Dog is in Pain due wound’ or ‘Dog is sad due to lack of owner’s attention. This system can also be further developed to identify mixed signals. For example, aggressive signals may come mixed with other signals like fear signals. For example, if a dog is communicating an aggressive signal towards the threat but the owner or stranger misread it as fear and approaches the dog it may lead to a bite. To prevent this kind of situation the system can be developed and enhanced. For that, we will need to train the model again with these kinds of mixed audio data signals. The data set need to be larger and complex. We can do this by adding more sound clips and more classes to the dataset.

Also, in this research, we have only focused on the most common breeds of Sri Lanka due to the easy accessibility of test subjects. This can be extended to more dog breeds. This can be even extended to puppies as they communicate different vocalization patterns.

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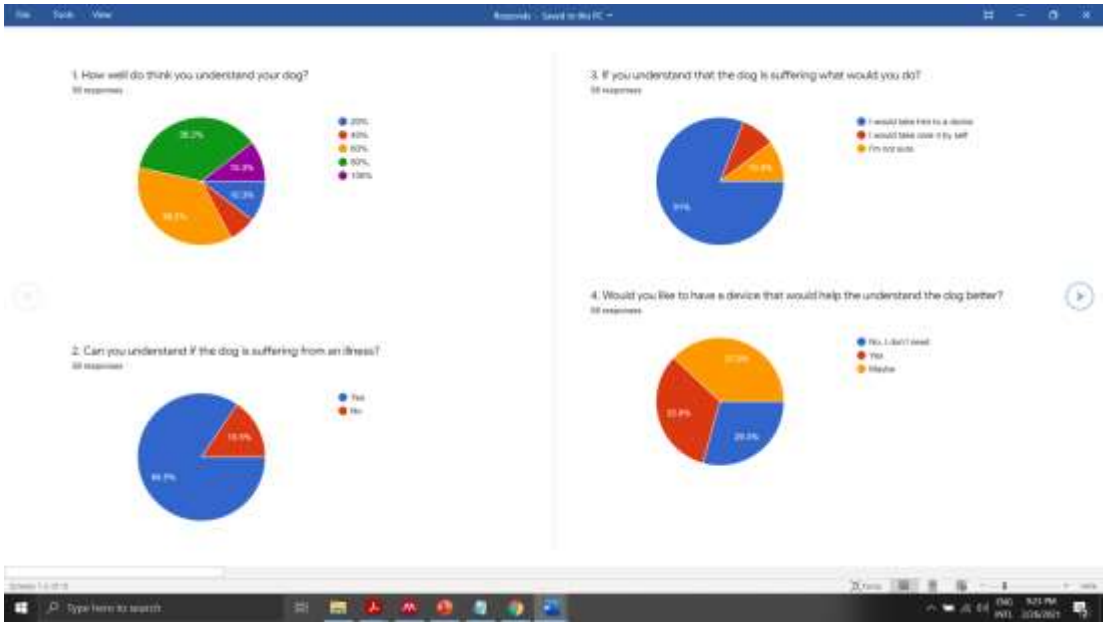
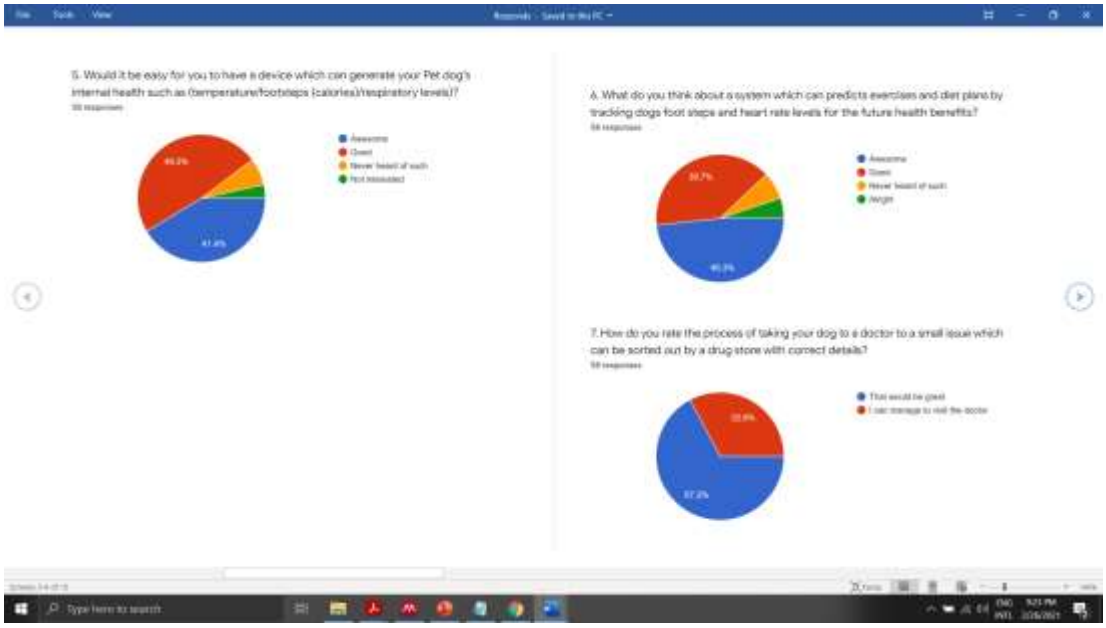
GLOSSARY

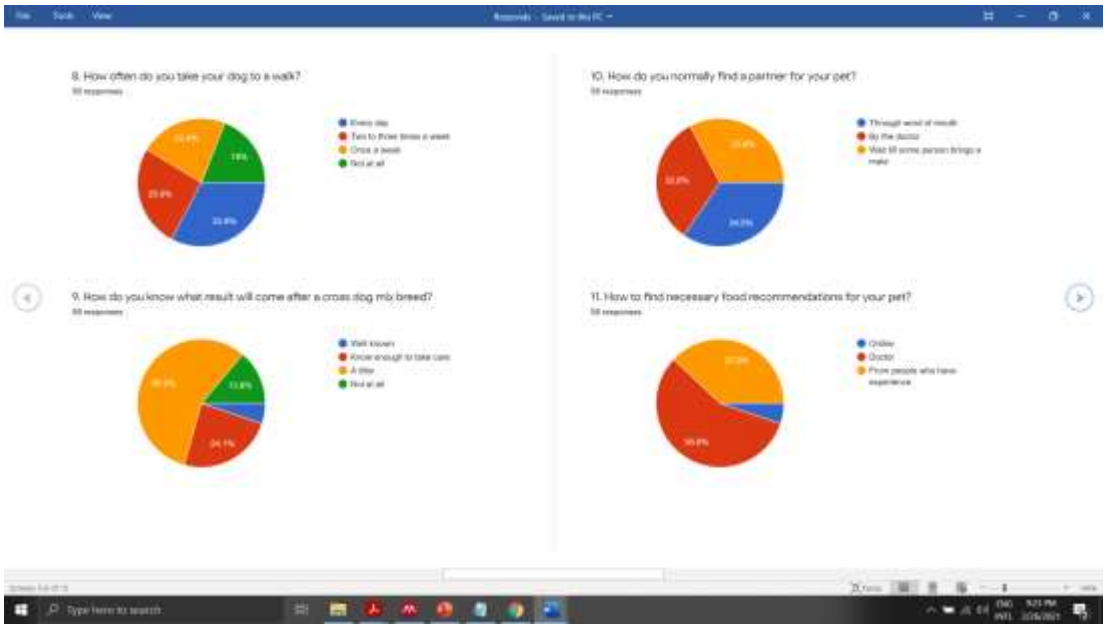
1. Canine - Relating to or resembling a dog or dogs
2. Acoustic- The branch of physics concerned with the properties of sound.

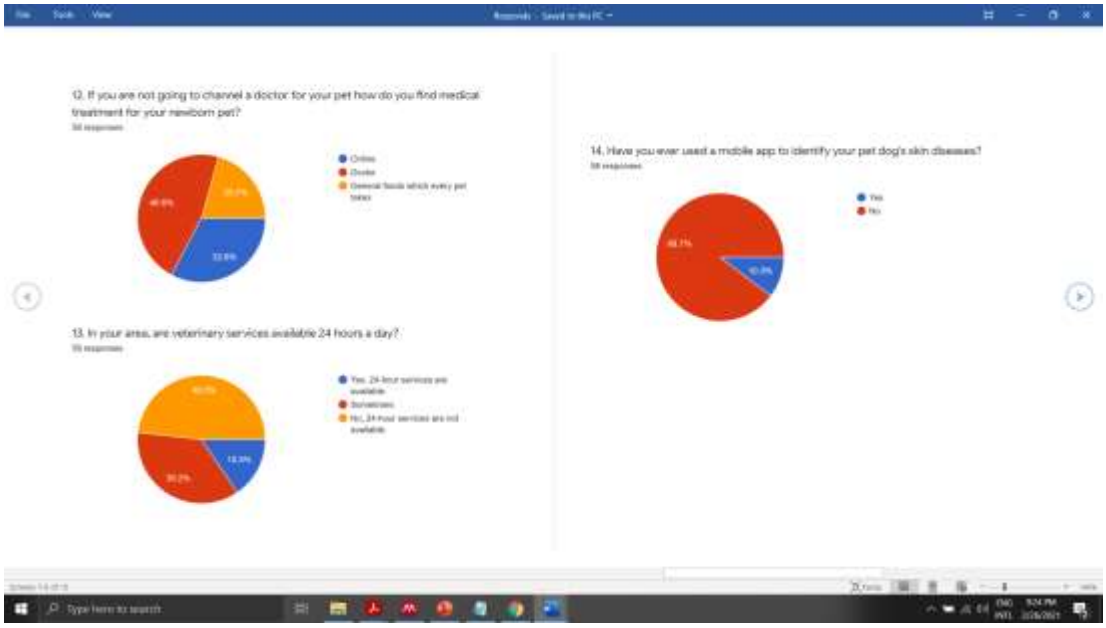
APPENDICES

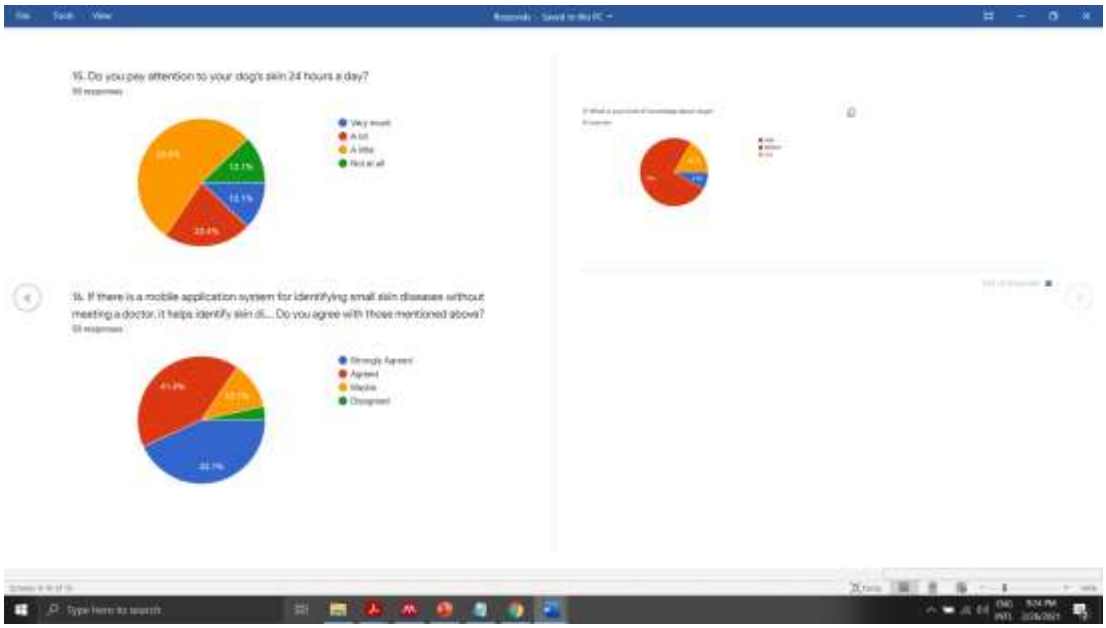
Appendix A: Complete questionnaire results



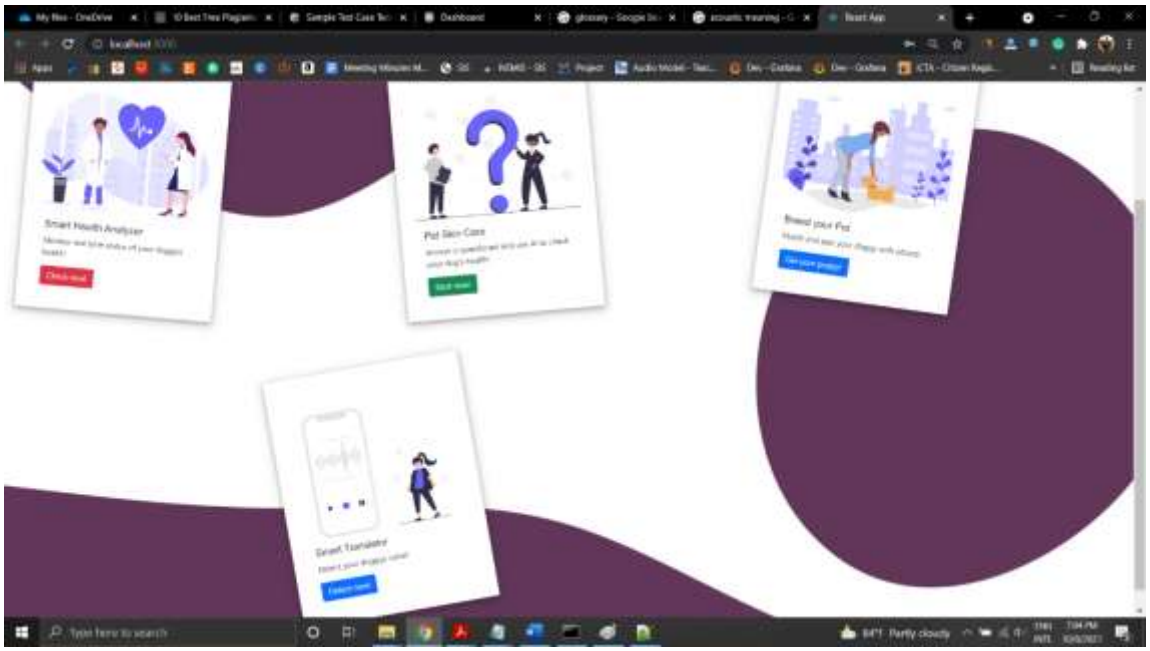


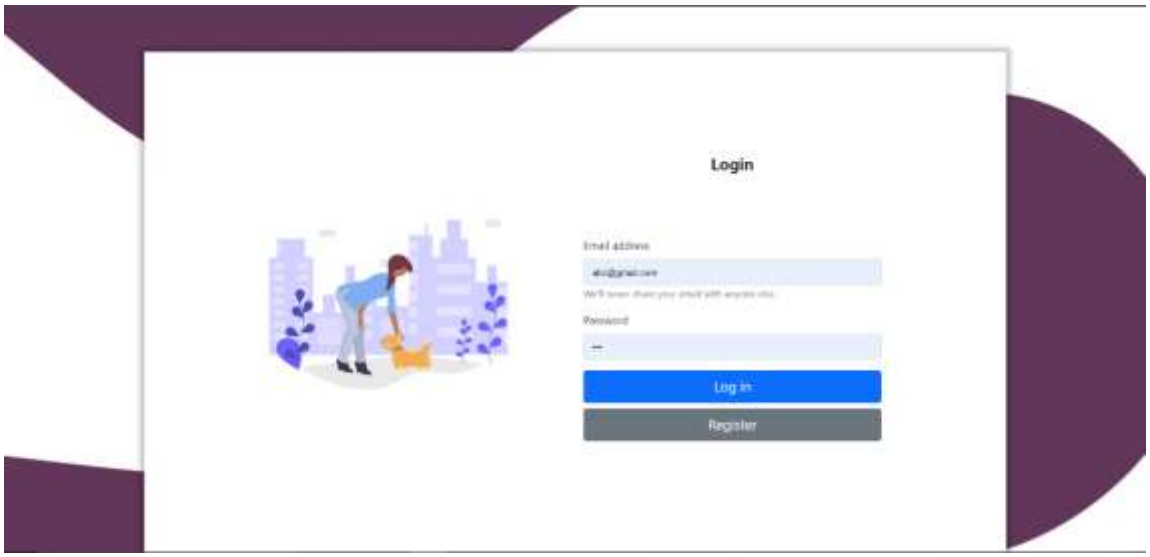

8. How often do you take your dog to a walk?
10. How do you normally find a partner for your pet?
9. How do you know what result will come after a cross dog mix breed?
11. How to find necessary food recommendations for your pet?

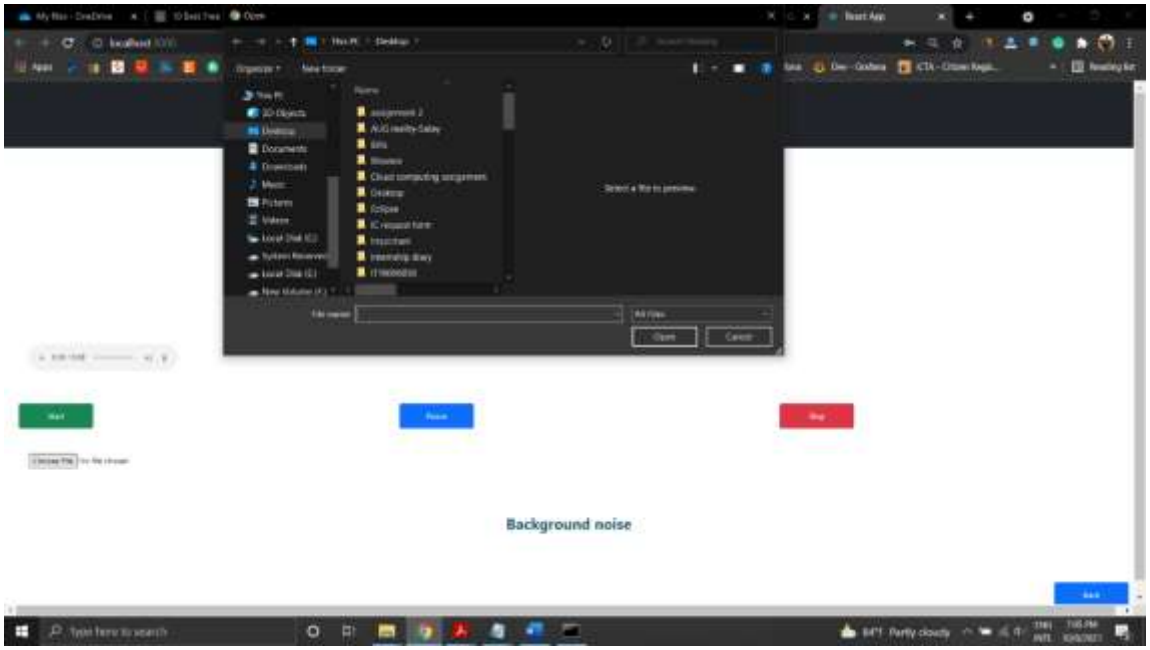

12. If you are not going to channel a doctor for your pet how do you find medical treatment for your newborn pet?
14. Have you ever used a mobile app to identify your pet dog's skin diseases?
13. In your area, are veterinary services available 24 hours a day?



Appendix B: User Interfaces




Login
Email address
Password
Log in
Register


Background noise

Appendix C: Plagiarism check