

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

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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.

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

Signature of the supervisor:

Date

ABSTRACT

A pet dog can bring love and companionship to a family or a person. That is a well-known fact among the community. To reduce stress, prevent loneliness, people tend to keep a dog around them. Having a dog or in other words raising a dog is not an easy task. We need to take care of them as well as we get benefits out of them in return. Sometimes taking a pet to a doctor might be a tedious task depending on the person's schedule. Or else it would be hard to have a transport system depending on the size of the dog. And also lack of knowledge on dog's health can be a disaster to prevent long term risky issues. To answer this gap, we initiate a solution which cover almost every aspect that needs to cover in terms of dog's health issues. This solution will offer (smart health tracker which predicts health patterns and suggest activities and prevention methods, dog translator, breeding and predictions based on breeding module, skin related disease identifier and remedy suggestion module).

As per the individual research component, this module will carry out the task of implementing the smart health tracker and prediction-based IOT solutions providing device. This module will mainly cover Heart Rate tracker/ Body temperature tracker and Footstep's tracker. Unlike other devices in the market which provides just the heart rate, Temperature and footsteps, this device will use the above sensor information's for further usage of generating predictions and to identify patterns in dog's health. Identified sensor information will stored in a server where it uses machine learning algorithms to identify patterns in dog's health and generate useful predictions for the usage pet owner. Hence the pet owner will be able to identify abnormal temperature patterns of their dog, is their dog less active as general or especially during a certain period of time. And also, owner will be able to know about the heart rate related issues. This device will be released with an eye catching well synchronized mobile app where the owner can use to know about every detail which the device catches in advance.

Keywords: Sensor information's, prediction-based IOT device, Machine learning, Mobile App

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LIST OF ABBREVIATIONS

- SVM = Support Vector Model

1 INTRODUCTION

1.1 Background Literature

A pet dog can bring love and companionship to a family or a person. That is a well-known fact among the community. To reduce stress, prevent loneliness, people tend to keep a dog around them. Having a dog or in other words, raising a dog is not an easy task. We need to take care of them as well as get benefits out of them in return. Sometimes taking a pet to a doctor might be a tedious task depending on the person's schedule. Or else it would be hard to have a transport system depending on the size of the dog. And also lack of knowledge on dogs' health can be a disaster to prevent long-term risky issues. To answer this gap, we initiate a solution that covers almost every aspect that needs to cover in terms of dog health issues. This solution will offer (smart health tracker which predicts health patterns and suggests activities and prevention methods, dog translator, breeding and predictions based on breeding module, skin-related disease identifier, and remedy suggestion module).

As per the individual research component, this module will carry out the task of implementing the smart health tracker and prediction-based IoT solutions providing devices. This module will mainly cover the Heart Rate tracker/ Body temperature tracker and Footstep's tracker. Unlike other devices in the market which provide just the heart rate, Temperature, and footsteps, this device will use the above sensor information for further usage of generating predictions and to identify patterns in dog's health. Identified sensor information will be stored in a server where it uses machine learning algorithms to identify patterns in a dog's health and generate useful predictions for the usage pet owner. Hence the pet owner will be able to identify abnormal temperature patterns of their dog, is their dog less active in general or especially during a certain period. And also, the owner will be able to know about heart rate-related issues. This device will be released with an eye-catching well synchronized mobile app where the owner can use to know about every detail which the device catches in advance.

As humans, we buy dogs for different purposes in our life. Some raise dogs for their protection, some to prevent loneliness, and also, some people raise dogs to play with their kids. Throughout the pet's life, the dog gives their services to humankind. But sometimes dog's health situation can be a burden to their owners. This happens because of the lack of awareness of the symptoms which owners couldn't identify at the early stages. For humans, we can identify any sort of illness before the actual cause from symptoms. But when it comes to dogs and any other animal which we raise as pets, it's really hard to identify any abnormality in their health statuses.



Figure 1 Walking the Dog

This question still hasn't been answered in the industry properly. Pets and their owners cannot establish a proper communication system among them as humans do with each other with languages. Therefore, when it comes to health issues, owners rarely find any differences or behaviors in their dogs. And another problem is "when to visit a doctor?". Often this question leads to a couple of questions back-to-back, Is this a small issue? Or should I take my dog to the doctor for this certain problem?

These problems mostly arise for, people who have some sort of large breed, which in turn becomes a hassle to take the dog to the doctor. As Sri Lanka is a developing country, we do not find easy access to veterinary doctors near every city. Some pet owners might have to take a couple of extra minutes or hours to visit a Veterinary doctor. Due to all these reasons, the chances of owners neglecting or not seeing minor symptoms which can cause larger health issues are high. To address that we came up with an innovative solution that can easily deliver to every pet owner as a device and a mobile app which will perfectly sync along.

The above solution will provide the owner with the benefits such as measuring and tracking dogs' health statuses whenever required. Especially, this solution will provide predictions and precautions by using daily calculated and measured data. This research

will elaborate detailed information's on how this solution has answered certain questions which every pet owner has faced while raising a dog consecutively. And also, how this solution will make a difference in the pet care community as well as how well this solution will ease the tasks of dog owners.

1.1.1 common issues of pet dog owners

In general, each animals' reaction towards illness is varied. Since humans can't communicate with animals directly, we need to observe them with their behaviors to identify any signal of illness. The only way to find out any difference in their behavior is by observing and paying attention to them carefully. Most indoor pet animals need these types of attention and care especially. There is a huge difference between stray/wild animals and indoor animals. Any living being gets adopted to their precinct. As such, indoor raised dogs need extra more attention, unlike other stray animals, since their internal immunity and other health statuses haven't been exposed to harsh environments. Hence pet owners should be aware of their health statuses often. This is a tedious task. And mainly, for each small issue, visiting the veterinary doctor with their pet would be a hassle. Some dog breeds are large. And some might be overly aggressive. Due to these kinds of reasons, pet owners intentionally try to reduce doctor visits gradually over time. These minor steps which pet owners neglect can be the root causes of major health issues in the long run of their dogs.

1.1.2 what can pet owners do about this?

As we discussed earlier, pet dogs should be paid attention to carefully like any other child. Like humans need good nutrition and intensive exercises to have a good healthy life, dogs require the same. But looking over these tasks and paying more attention might be hectic and a huge burden to a person who is tightly tied to a schedule or a nuclear family. Nevertheless, identifying any internal changes in a dogs' body is almost impossible until the pet shows any unusual behavior. Due to these issues, pet owners might not see symptoms or any illnesses that should be paid attention to in the early stages. Therefore, these neglections and lack of awareness might put that pet dog's life at a risk. Most of the indoor raised dogs are adopted to a certain routine where they eat sleep and relaxed most of the hours in a day. This lifestyle of that dog might lead it to Hyperlipidemia and Diabetes stages. As for the moment, there has been a couple of technologically based

solutions established in the market for this issue. To prevent unnecessary risks from rooting without acknowledging, inventors has delivered smart

5. Would it be easy for you to have a device which can generate your Pet dog's internal health such as (temperature/footsteps (calories)/respiratory levels)?
58 responses

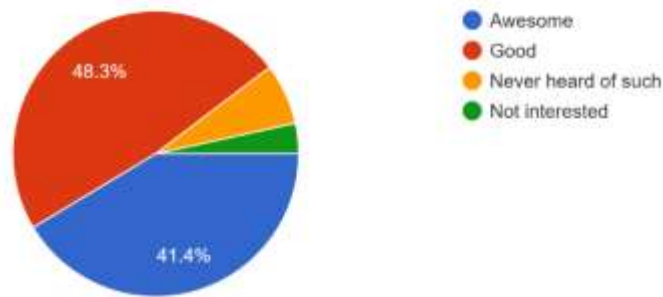


Figure 2 Survey Question -1

tracking systems to the market. These tracking devices have mobile apps which sync along with them.

As per the survey, most of the responders would like to have a device that can track their dog's health. Rather than rushing to a doctor for each symptom, it's better to know your dog. Then pet owners know what exactly is wrong with their pet.

1.1.3 how **do current solutions answer this matter?**

Following solutions which already exist in the market track body temperature, footsteps, and heart rate of the dog [1]. And the sensor information captures by the device will be shown through the mobile app which comes along as a unit. the question which arises from the following solutions is that just information from sensor devices is enough to take an action?

The device and the sensors won't help the owner to identify the real issue of the dog. The device needs to be more innovative to teach about owners' dogs by using the collection of data over a while. With regards to the above response, most of the users like to have a device that can predict and generate more information's through the IoT device.

6. What do you think about a system which can predicts exercises and diet plans by tracking dogs foot steps and heart rate levels for the future health benefits?

58 responses

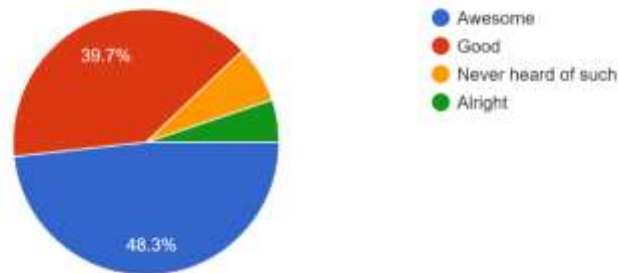


Figure 3 Survey Question -2

There are multiple solutions in the market to track different aspects of a dog's health. For an instance, there are a couple of devices that can measure the body temperature, footsteps, and heart rate of the dogs. But the main concern is what shall the owner do with the device information? The main reason that pet owners fail to identify and take actions for certain illnesses of dogs is not knowing enough information about the procedures. Even though there are apps and devices in the market, there hasn't been any solution that can provide a "**what can you do next?**" answer along with the system. Here are the gaps which I found in the community and can be filled with an innovative and efficient solution [2].

Heart rate tracker which can identify patterns and predicts health statuses and activities accordingly

There are a couple of IoT devices in the market that can measure a dog's heart rate. But these devices have been framed just into showing what is the current heart rate for the moment. This solution will never identify any problems with your dog. To further elaborate how this gap has been affected the pet owners is, the current heart rate can be misleading due to the situation. The normal resting heart rate of a dog usually ranges between 70-120. But this range can be slightly changed according to the weight and height of the dog. Therefore, just by measuring heart rate one time, an owner can't come to any conclusions about the dog's health status. To overcome this issue, pet owners require a device that can take heart rate information daily over a while to identify any pattern of a dog's health.

Temperature tracker which can identify body temperature and inform about abnormal signs during a certain period.

There are devices to track the body temperature of dogs. But as mentioned earlier, there is not much value in calculating current body temperature to come to any conclusion. Here are a couple of factors that can affect the dog's body temperature,

- Environment temperature
- Dehydration
- Consumption of heaty foods

By considering the above factors, pet owners can't straight away come to any conclusion with one-time sensor information. If there's enough information to identify sudden body temperature ranges, an owner can take action accordingly. A device that can store data and identify any patterns, can save lots of dogs from health issues.

Foot's step tracker can identify daily footsteps and suggest exercises according to the daily activity level of the dog.

In general, dogs are very active animals. But this factor can get drastically change according to its environment. Here are some reasons that dogs can be less active,

- No companionship
- Less attention
- Fast foods and process foods can affect dog's health straight away
- Some breeds are less active in general (Bassett Hound, Pug, Great Dane, etc.)

Activeness is one of the main factors which contributes to a long healthy life of a dog. Most of the time dogs stay at home alone without any company. During this period dogs tend to sleep more. This routine can make a dog a less active one. In long run, this issue

8. How often do you take your dog to a walk?

58 responses

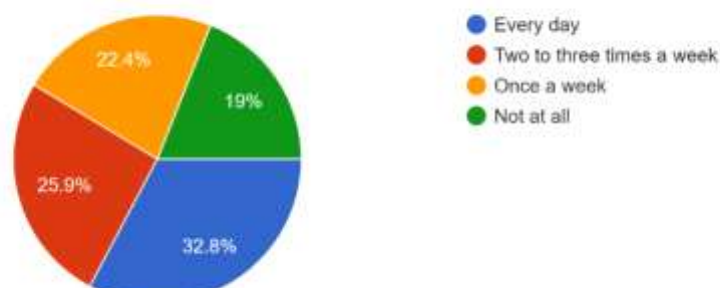


Figure 4 Survey Question -3

can lead to several issues. To prevent those owners can track the footsteps of dogs with current devices in the market. But that won't do the necessary actions which require. These activities should be recorded. And this information can be used to identify how many footsteps that the dog has taken as an average per day and week. If there's a solution that can identify these patterns and suggest exercises for the dog, it can prevent lots of dogs from getting victims of heart diseases.

according to the survey still, there is a portion who do not take their dog to a walk. It is an essential thing for a dog that doesn't have enough space inside the house to walk around. Not just for exercise purposes, taking the dog out is an adventure to do from its perspective. It's because domestic dogs don't get to see the outside of the world more often. Some dogs rarely chance in general, the solutions in the market don't provide the service which pet owners require (providing information that can be used to take action, information's that can educate the pet owner about the dog and its health status). And at the same time, the devices which exist in the market highly rate and very expensive [3].

As humans who love pets, there is one strong factor which everyone misunderstands widely among the society. We often compare wild animals and domestic animals using the same factors and put them into the same caliber thinking both categories are the same. Every living being gets adapted to its environment. And especially,

- Their immune system
- Reaction to the environment changes
- Insect bites
- Foods and liquids

Will be unique and tolerable according to the environment in which they grow. A stray dog that grew in the streets can have a strong immune system while a domestic dog that raised entirely inside a house has a weak one. Due to these reasons, pet owners must be known to some extent to have a dog. But not every pet owner can afford to know each detail before they own one. Raising an animal is a step-by-step process that in return gives experience to the person.

At the puppy stage, every owner gives special care. But this process gradually gets neglected when the dog gets old. As for the normal process for a newborn puppy, a puppy should be taken weekly and monthly to the veterinary doctor until a year. During this

7. How do you rate the process of taking your dog to a doctor to a small issue which can be sorted out by a drug store with correct details?
58 responses

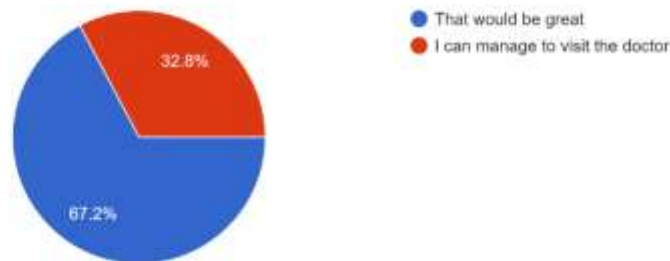


Figure 5 Survey Question -4

period, the puppy gets relevant vaccines and other treatments for growth and health. After the first year, treatments get gradually reduced to long time durations (within the first year every month. After the first year, every 6 months, and so on depending on the doctor's suggestion).

Even though the vital treatment periods are gradually reduced, pet owners should be concerned as usual about their dog's health. But most of the time this factor gets neglect among the community. This neglect can be caused by,

- A busy schedule of the pet owner
- Lack of knowledge about the dog's health
- Thought of giving healthy foods would be just enough
- Dog tend to do activities on their own
- Not seeing any signs of illness from outside

Most of the time these neglects get ended up giving long-term health issues to dogs. With the correct use of technology, these problem gaps can be answered efficiently. Unfortunately, the solutions that have been released to the market hasn't brought up to the point where it can give proper guidance and knowledge to the pet owners. As I mentioned earlier, a device that just measures (temperature, heart rate, and footsteps) does not educate or inform pet owners to take actions which requires for their pet dogs.

Domestic dogs should be paid more attention to carefully. With the current schedules and life patterns of people, it is something difficult to afford. But every problem has its way of solving. Therefore, my research will bring up a solution that can measure a track the internal health of dogs. Especially system will recognize unusual behaviors of the sensor information. And by using that information, the system will provide predictions and suggestions for relevant areas which the service requires. This solution's primary objective is to prevent dogs from diseases and laying a path to a healthy strong life. The main objective of this component is not to provide just a tracking device where its primary target is to display sensor information through a mobile app. This module is simply more than that. Through this module, the IoT device will mainly collect dog's

1. Body Temperature
2. Heart Rates
3. Footsteps

And these data will be collected daily according to the requirement of the pet owner. And collected data will be used along with pre-captured data to identify patterns and predict useful information using machine learning algorithms such as regression. The module will isolate the information sensor wisely to generate useful information for the user. Since there are three different sensors inside the IOT device, collected data will be directed to a real-time database for storage purposes. Once the information is stored inside the database, each sensor information will get tallied with other data to identify any abnormalities among the data. For an instance, if the dog's heart rate gets lower over a certain time, that should be informed to the pet owner through the mobile app with actions that can be taken to prevent unnecessary risks.

As mentioned, each module will provide more information from gathered data using machine learning algorithms. Therefore, the main objective is to provide an innovative useful solution to the pet owner for their dogs.

This device will mainly get attached to a comfortable leash which will get tightened into the body of the dog. The leash will custom made from cushioning (comfortable sponge) and the device will be located under the left leg of the dog. Therefore, the belt won't give unnecessary weight to the dog. Instead, the device information can be captured without any interruption and harm to the dog.

1. Heart rate sensor which helps to identify unusual patterns and predicts health

This is one component of the main IoT device (Smart Health Tracker). This component will mainly focus on tracking the heartbeat rate of the dog. The primary target is to gather

the heartbeat rate of the dog daily to identify any patterns that can cause harm to the dog and to prevent it by taking necessary actions. By using the functionalities of this module, the pet owner (user) can get an overall idea about past week's information's on the dog's heart rate. This module will help users to identify,

- Weekly or monthly heart rate patterns as a diagnosis report along with other sensor information's which can be shared with doctors and drug stores
- Low and high heart rate levels will be informed to the user.
- And also, information's will be shared through the app as suggestions on what users can do about those high and low heart rate levels
- Information's on risky heart rate levels. And especially reasons why it can cause.
- Exercise suggestions to main a good health

2. Body temperature sensor which helps to identify and track normal and irregular temperatures.

This is the second component of the main IoT device (Smart Health Tracker). This component will mainly focus on watching the dog's body temperature daily. This device will be able to identify the high and low temperatures of the dog. The normal body temperature range of dogs is 101 to 102.5 degrees Fahrenheit. but this can be slightly changed according to the environment. Therefore, the solution will gather data daily to distinguish normal body temperatures from abnormal temperatures which the pet owner should be concerned about. This module will help users to identify

- Weekly or monthly Body Temperature patterns as a diagnosis report along with other sensor information's which can be shared with doctors and drug stores
- High and Low body temperatures.
- And also, information will be shared through the app as suggestions on what users can do about those high and low Body temperature levels.
- Information's about remedies for fever

3. Footstep tracker which helps to track the activity level of the dog and suggest exercises to the dog

This is the third component of the main IoT device (Smart Health Tracker). This component will primarily focus on tracking the daily activity levels of the dog. Therefore, this device will be able to identify how many steps dogs have taken [3] within the day. Depending on that, the device can decide whether the dog is an active and healthy one. If the dog hasn't taken any steps which a normal healthy dog would take, the device will suggest and inform the pet owner through the app to take the dog out for a walk. This module will help users to identify,

- Daily and weekly steps that the dog has taken.
- If a dog has taken fewer steps, the app will inform to take the dog out for a walk
- The app will suggest exercises
- Weekly step targets for a dog depending on the weight levels.

To elaborate on the process of this Research Component, we want to get a brief idea about the main divisions and technologies that are getting used to implement the device. Starting from the IoT device, it uses Node MCU technology which has **WIFI and Bluetooth** compatibility. Therefore, the Node MCU chip can bring absolute unique technology which the research project needed the most. And also, the featherweight of the chip will not bother the Dog by giving extra weight on the leash. IoT devices will mainly be based on the NODE MCU chip and relevant sensors will be attached according to the necessity.

Here is a brief idea about how sensor and sensor information will deliver the relevant data to the server.

- The device will be located under the front left leg of the dog (in front of the heart, therefore sensor information's will be more accurate)
- Sensor information's will be recorded using Node MCU and Arduino Uno 3 technology)
- Recorded Sensor information will be directed to the Mongo atlas database to be analyzed further using regression algorithms to identify patterns using Machine learning.
- Sensor information will be analyzed with a preset of data gathered related to Heart Rate/temperatures and footsteps of the Dogs.
- Analyzed data will be shown in the Mobile app for owners' perusal.
- Device location won't be an issue to the dog since it locates under the arm.

Gathered data will be analyzed using Regression analysis methods to identify unique patterns. Identified patterns will get used to generate the health statuses of the dog consecutively (Heart Rate, Temperature, Footsteps).

Here is a summary of how the system flow works,

1. IoT device will be located on the leash of the dog

2. The gathered information will be directed to the Graph QL API.
3. After the API will deliver the information's the server. Small data will be directed to the Firebase database while large ones will be stored in AWS
4. Gathered data will be analyzed using support vector machine algorithms to find out patterns and unique behaviors.
5. Identified patterns will be shared with the responsive web app.

1.2 Research Gap

There are multiple solutions in the market to track different aspects of a dog's health [4]. For an instance, there are a couple of devices that can measure the body temperature, footsteps, and heart rate of the dogs. But the main concern is what shall the owner do with the device information? The main reason that pet owners fail to identify and take actions for certain illnesses of dogs is not knowing enough information about the procedures. Even though there are apps and devices in the market, there hasn't been any solution that can provide a **“what can you do next?”** answer along with the system. Here are the gaps which I found in the community and can be filled with an innovative and efficient solution.

Heart rate tracker which can identify patterns and predicts health statuses and activities accordingly

There are a couple of IoT devices in the market [5] that can measure a dog's heart rate. But these devices have been framed just into showing what is the current heart rate for the moment. This solution will never identify any problems with your dog. To further elaborate how this gap has been affected the pet owners is, the current heart rate can be misleading due to the situation. The normal resting heart rate of a dog usually ranges between 70-120. But this range can be slightly changed according to the weight [1] and height of the dog. Therefore, just by measuring heart rate one time, an owner can't come to any conclusions about the dog's health status. To overcome this issue, pet owners require a device that can take heart rate information daily over a while to identify any pattern of a dog's health.

Temperature tracker which can identify body temperature and inform about abnormal signs during a certain period.

There are devices to track the body temperature of dogs. But as mentioned earlier, there is not much value in calculating current body temperature to come to any conclusion. Here are a couple of factors that can affect the dog's body temperature,

- Sensitivity towards the environment heat changes
- Lack of water consumption
- Consumption of foods that increase the body temperature

By considering the above factors, pet owners can't straight away come to any conclusion with one-time sensor information. If there's enough information to identify sudden body temperature ranges, an owner can take action accordingly [6]. A device that can store data and identify any patterns, can save lots of dogs from health issues.

Foot's step tracker can identify daily footsteps and suggest exercises according to the daily activity level of the dog.

In general, dogs are very active animals. But this factor can get drastically change according to its environment. Here are some reasons that dogs can be less active,

- Dogs tend to play a lot with the owner or some other animal. If they don't get companionship, they tend to become less active and stressed
- When dogs get less attention, they tend to get depressed and anxiety
- Due to the busy routines of the pet owner, they tend to feed fast and process foods for their dogs. This can lead to extreme health risks
- Some breeds are less active in general (Basset Hound, Pug, Great Dane, etc.)

Activeness is one of the main factors which contributes to a long healthy life of a dog. Most of the time dogs stay at home alone without any company. During this period dogs tend to sleep more. This routine can make a dog a less active one. In long run, this issue can lead to several issues. To prevent that owner can track the footsteps of dogs with current devices in the market. But that won't do the necessary actions which require. These activities should be recorded. And this information can be used to identify how many footsteps that the dog has taken as an average per day and week. If there's a solution that can identify these patterns and suggest exercises for the dog, it can prevent lots of dogs from getting victims of heart diseases.

2 RESEARCH PROBLEM

Every living being gets adapted to their environment. Irrespective of the breed, behavior, and capabilities, they get familiar and knowledgeable about their precinct. There are two sides to this matter. In a way, it is an advantage to become knowledgeable about its environment. But being adopted to its environment has its consequences. For example, if we raise any kind of a pet in a domestic environment for a couple of months, it gets adapted to the domestic environment and won't be able to get along with the wild animals and outside. Pet owners need to be aware of their pet's environment and how comfortable the current precinct is to them.

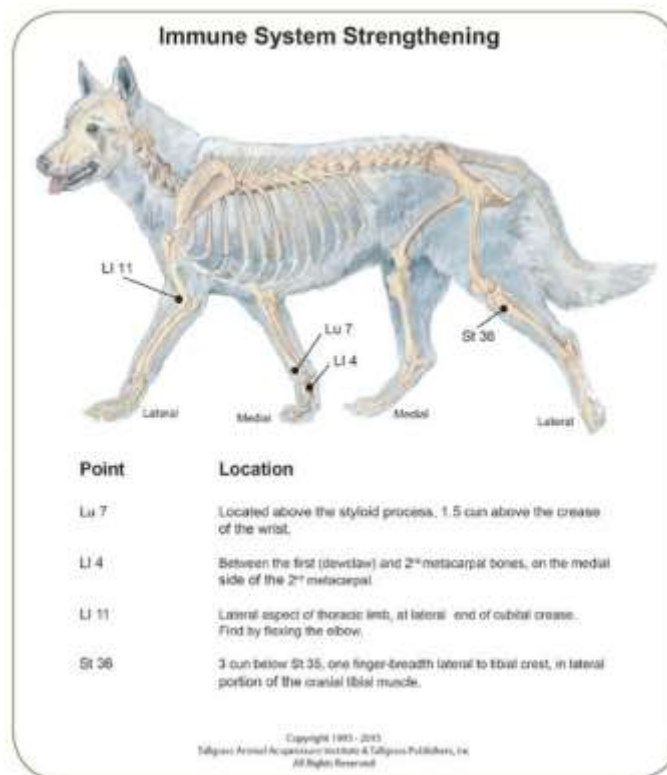


Figure 6 Dogs immune System

2.1 Their immune system

The immunity system is one of the most important parts that pet owners need to be careful about when it comes to their pets' daily routines. Especially what are the foods that they eat and what sort of routines that they follow when it comes to a particular day? For an example, dogs can have a different kind of a routine compared to a cat. Usually, cats like to stay neat and clean and usually in clean surroundings. Therefore, they don't attract

many digestive and immunity-related health issues. For a cat pet owner, it can be an added advantage that comes from the behavior of cat breeds.

But for dogs, it's the other way around dog's sniff and licks pretty about everything, so their bodies have a different method of coping with dirty things. However, this does not negate the need of keeping a dog clean. The most important aspect in strengthening a dog's immune system is maintaining adequate cleanliness. Your dog's immune system has to cope with dirt and germs daily. Of course, some germs and parasites can assist your dog's immune system,

but there should be a healthy balance. Regularly washing your dog will reduce the number of germs in his system, allowing his immune system to focus on more vital battles. Keep in mind, however, that frequently does not imply constantly. Your dog's immune system may become weakened if he is kept excessively clean.



Figure 7 Dogs internal Body Temperature

2.2 Reaction to the environment changes

When the weather gets warmer, some dogs get thrilled, while others seek out cool, shaded locations to relax. While all dogs are exposed to the dangers of hot weather, some dog breeds are more heat resistant than others. Normally when dogs get raised in a colder environment, they tend to get rashes when they move into a warmer environment. Its all due to being adopted to its precinct and being comfortable accordingly

Bulldogs, French Bulldogs, Pugs, and Boston Terriers are brachycephalic breeds that fare best when kept cool in hot weather since they have trouble breathing in high heat. Large breeds, as well as longhaired breeds like the Komondor, Afghan Hound, and Alaskan Malamute, are vulnerable to heat. If you own one of these breeds, you may notice that your dog is less active in hot weather and less inclined to play and engage in other activities

2.3 Insect bites

Ticks and other insects are normal routines for all wild animals. It's because wild animals easily get ticks and other cold-blooded insects from their precinct. Due to that, they carry those insects with them everywhere they go. And also, these insect bites don't give them any diseases especially. Due to being bitten by insects in a daily basis, these wild animals have been adopted to their consequences and abnormal disease which domestic pet gets.

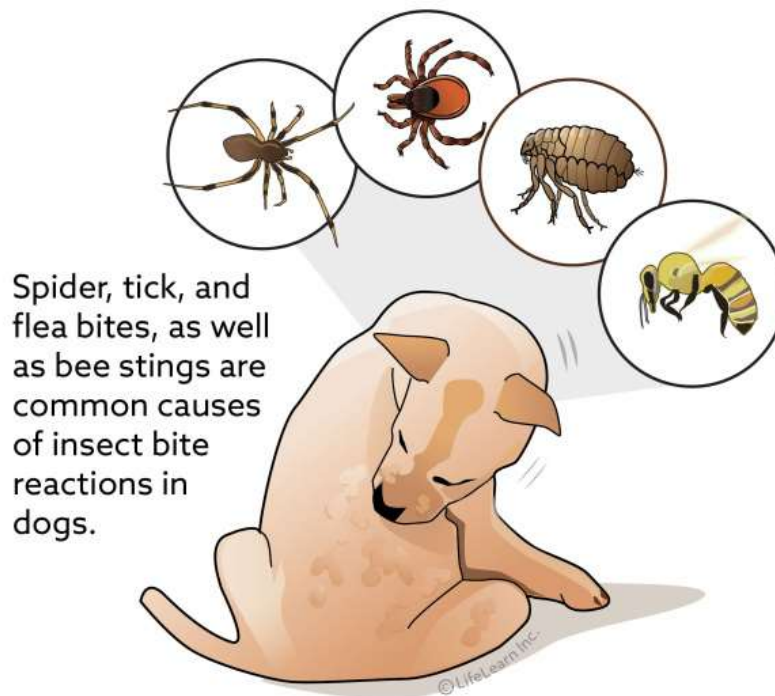


Figure 8 Dogs insect Bites

On the other hand, domestic pets usually tend to get fever frequently due to being bitten by these insects. Due to being raised in a comfortable precinct, domestic animals are uncomfortable with insects such as ticks. Therefore, pet owners need to pay extra attention to their pets daily and need to be very careful when it comes to going for walks on paths filled with grass and sand.

2.4 Foods and liquids

Often wild animals' digestive systems are bulletproof for any kind of food that they consume. Due to not having regular meals by a master, they usually dump dive and consume almost anything edible. Hence wild animals rarely get infections from foods. But on the other hand, domestic animals need to be carefully tracked on what they consume by keeping an eye on the foods that they consume. Its because by being raised in the domestic environment they have sensitive digestive systems most of the time. Therefore, we need to have a proper diet routine for domestic pets at least for a certain amount of period in their life cycle.



Figure 9 Dog Hydration

If we ignore these truths, it can lead to serious health problems for any type of pet. Depending on the environment in which they develop, they will be distinct and acceptable. A stray dog reared on the streets may have a robust immune system, but a domestic dog kept exclusively within a house may have a poor immune system. Because of these factors, dog owners must have some level of education to own a dog. However, not every pet owner can afford to be well-versed in every topic before purchasing a pet.

Raising an animal is a step-by-step process that provides valuable knowledge to the person involved. Every puppy owner provides more attention throughout the puppy stage. However, as the dog ages, this procedure becomes increasingly ignored. A puppy should be taken to the veterinarian weekly and monthly until it is a year old, as is the typical procedure for a newborn dog. Vaccinations and other treatments for growth and health are given to the puppy at this time. Treatments are gradually decreased to long periods after the first year (during the first year, every month).

After the first year, every six months, and so on, as directed by the doctor). Even though the vital treatment periods are gradually reduced, pet owners should be concerned as usual about their dog's health. But most of the time this factor gets neglect among the community. This neglect can be caused by,

2.4.1 A busy schedule of the pet owner

It has been a common fact that people tend to adopt dogs and neglect them after a while. Mostly when the pet is only one year or two years, they take care of the puppy. But most of the pet owners neglect the puppy after two years. The most dangerous side is neglecting

the medical routines of domestic dogs. When dogs raise domestically, owners need to have a solid medical routine to take care of their dogs.

2.4.2 Lack of knowledge about the dog's health

Pet owners need to have some sort of knowledge when it comes to taking responsibility for a dog. Like taking care of a human baby, puppies also need to have special care in the early stages. Especially as aforementioned, puppies need to have diets and medical routines in their early stages. Since we are separating it from its parents, we need to provide the right nutrition which it gets from the mother puppy as milk.

2.4.3 Thought of giving healthy foods would be just enough

Giving healthy foods would not be the only factor when it comes to the health of a dog. Dogs need to be trained and exercised regularly to keep a good cardiovascular system. Unlike wild animals, domestic dogs tend to have fewer active levels daily. But if pet owners feed them more than they required as daily calories, they need to look for cardiovascular issues as well. Domestic dogs tend to get more cardiovascular-related issues due to neglecting exercises and walk frequently [7].

2.4.4 Dog tend to do activities on their own

Domestic dogs tend to have at least two meals a day. In south Asian countries, the main meal always consists of heavy carbohydrates. And also, domestic pets eat what most of the families consume daily. Therefore, pets consume more calories in a day. So, these domestic pets need to take out for long walks to burn those excessive calories. Otherwise, pet owners need to provide them with a proper diet with fewer carbohydrates and more proteins. One of the myths that run around in the society is that when dog walk here and they're in the home precinct would be enough to calculate their activeness in a day. Dogs need to have space to run and walk, but it shouldn't be few minutes like domestic pets do daily.

2.4.4 Not seeing any signs of illness from outside

Pet owners cannot identify each issue of their pets by looking at them externally. It's because not all the symptoms come outside as a side effect to identify the diseases or particular issue. Therefore, pet owners need to be concerned about all the temperature/pulse and heart rate changes of the dogs as well. For that pet owner needs to be educated about the dogs to some extent. This has been a massive issue in society as of now. Pet owners normally care about dogs when they see any symptoms. Otherwise, they won't

put much attention to the dog as they normally should. Due to that, there's a possibility to miss some dangerous issues which pets are suffering day today

Most of the time these neglections get ended up giving long-term health issues to dogs. With the correct use of technology, these problem gaps can be answered efficiently. Unfortunately, the solutions that have been released to the market hasn't brought up to the point where it can give proper guidance and knowledge to the pet owners. As I mentioned earlier, a device that just measures (temperature, heart rate, and footsteps) does not educate or inform pet owners to take actions which requires for their pet dogs.

Domestic dogs should be paid more attention to carefully. With the current schedules and life patterns of people, it is something difficult to afford. But every problem has its way of solving. Therefore, my research will bring up a solution that can measure a track the internal health of dogs. Especially system will recognize unusual behaviors of the sensor information. And by using that information, the system will provide predictions and suggestions for relevant areas which the service requires. This solution's primary objective is to prevent dogs from diseases and laying a path to a healthy strong life.

3 RESEARCH OBJECTIVES

The main objective of this component is not to provide just a tracking device where its primary target is to display sensor information through a mobile app. This module is simply more than that. Through this module, the IoT device will mainly collect dog's

4. Body Temperature
5. Heart Rates
6. Footsteps

And these data will be collected daily according to the requirement of the pet owner. And collected data will be used along with pre-captured data to identify patterns and predict useful information using machine learning algorithms such as regression. The module will isolate the information sensor wisely to generate useful information for the user. Since there are three different sensors inside the IOT device, collected data will be directed to a real-time database for storage purposes. Once the information is stored inside the database, each sensor information will get tallied with other data to identify any abnormalities among the data. For an instance, if the dog's heart rate gets lower over a certain period, that should be informed to the pet owner through the mobile app with actions that can be taken to prevent unnecessary risks.

As mentioned, each module will provide more information from gathered data using machine learning algorithms. Therefore, the main objective is to provide an innovative useful solution to the pet owner for their dogs.



Figure 10 Dogs Leash

This device will mainly get attached to a comfortable leash which will get tightened into the body of the dog. The leash will custom made from cushioning (comfortable sponge) and the device will be located under the left leg of the dog. Therefore, the belt won't give unnecessary weight to the dog. Instead, the device information can be captured without any interruption and harm to the dog.

3.1 Specific objectives

4. Heart rate sensor which helps to identify unusual patterns and predicts health

This is one component of the main IoT device (Smart Health Tracker). This component will mainly focus on tracking the heartbeat rate of the dog [7]. The primary target is to gather the heartbeat rate of the dog daily to identify any patterns that can cause harm to the dog and to prevent it by taking necessary actions. By using the functionalities of this module, the pet owner (user) can get an overall idea about past week's information's on the dog's heart rate. This module will help users to identify,

- Weekly or monthly heart rate patterns as a diagnosis report along with other sensor information's which can be shared with doctors and drug stores
- Low and high heart rate levels will be informed to the user.
- And also, information's will be shared through the app as suggestions on what users can do about those high and low heart rate levels
- Information's on risky heart rate levels. And especially reasons why it can cause.
- Exercise suggestions to main a good health

5. Body temperature sensor which helps to identify and track normal and irregular temperatures.

This is the second component of the main IoT device (Smart Health Tracker). This component will mainly focus on watching the dog's body temperature daily. This device will be able to identify the high and low temperatures of the dog. The normal body temperature range of dogs is 101 to 102.5 degrees Fahrenheit. but this can be slightly changed according to the environment. Therefore, solution will gather data daily to distinguish normal body temperatures from abnormal temperatures which the pet owner should be concerned about. This module will help users to identify,

- Weekly or monthly Body Temperature patterns as a diagnosis report along with other sensor information's which can be shared with doctors and drug stores
- High and Low body temperatures.
- And also, information will be shared through the app as suggestions on what users can do about those high and low Body temperature levels.
- Information's about remedies for fever

6. Footstep tracker which helps to track the activity level of the dog and suggest exercises to the dog

This is the third component of the main IoT device (Smart Health Tracker). This component will primarily focus on tracking the daily activity levels of the dog. Therefore, this device will be able to identify how many steps dogs have taken within the day. Depending on that, the device can decide whether the dog is active and healthy. If the dog hasn't taken any steps which a normal healthy dog would take, the device will suggest and inform the pet owner through the app to take the dog out for a walk. This module will help users to identify,

- Daily and weekly steps which the dog has taken.
- If a dog has taken fewer steps, the app will inform to take the dog out for a walk
- The app will suggest exercises
- Weekly step targets for a dog depending on the weight levels.

4 METHODOLOGY

4.1 System Diagram

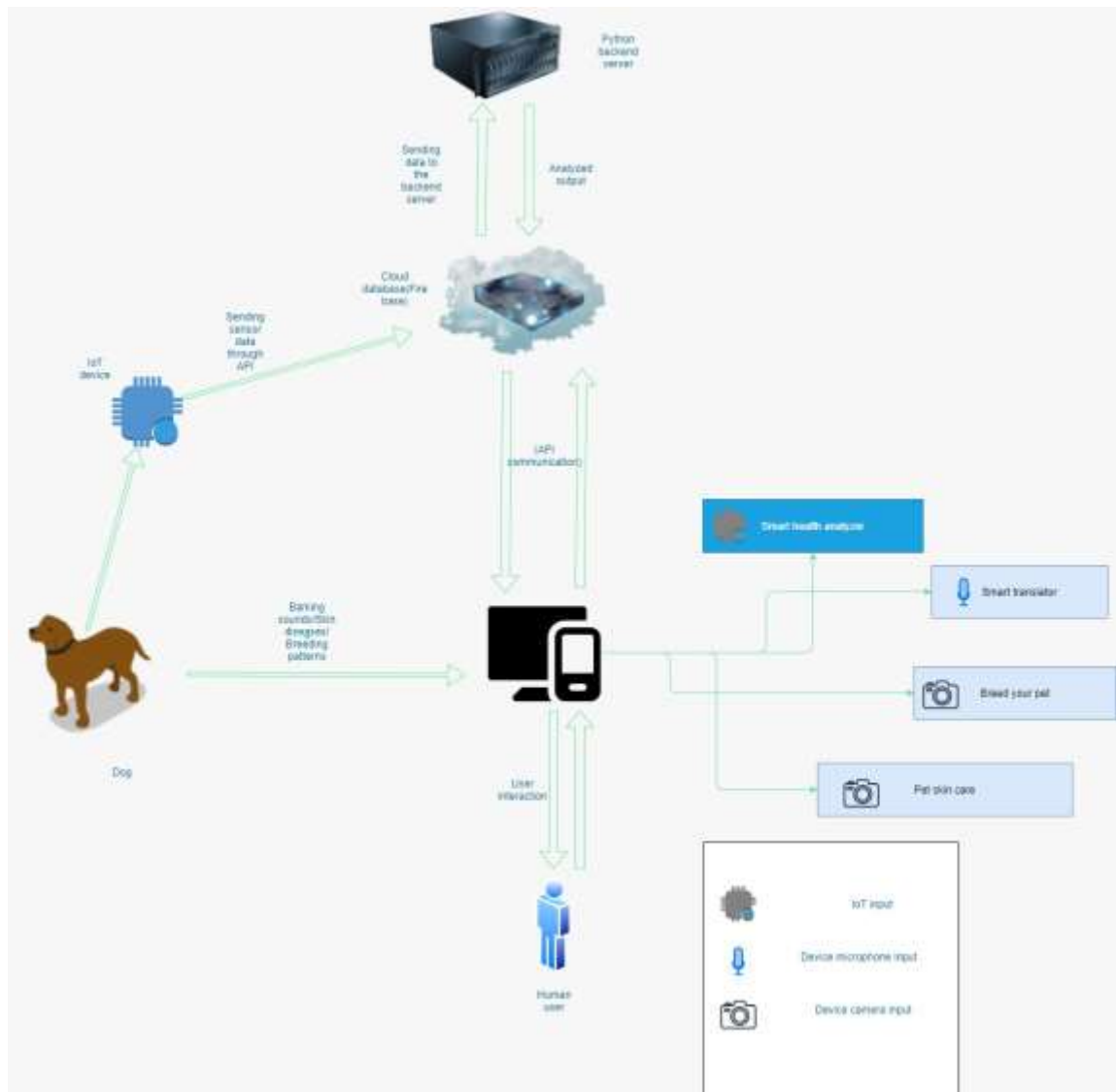


Figure 11 System Diagram

Proposed project is an overall solution that addresses the most common issues which dog owners tend to get daily. Internal health (what are the difficulties and what actions should be taken), Canine language recognition and translations, external issues such as skin diseases, and breeding patterns and breeding outcomes would all have been covered by the proposed system.

The team's primary aim is to highlight essential services that should be included in the mobile app and to deliver smooth services with fewer disruptions.

Also, a service that has never been provided flawlessly and exclusively to dog owners in one go.

Finally, this service will supply IoT devices as well as a supporting environment. eye-catching mobile app to the market.

The solution that Research will Offer

- Smart Tracker with the sensors (Temperature / Heart Rate / Footsteps)
- Supporting Mobile App.
- The device will be attached to a custom-made Body leash.
- Predictions using sensor information's
- Sensor information will be stored to analyze and identify patterns of health.
- Exercise suggestions and Diet plans according to the activity levels of the dog.
- Daily notifications to the owner's smartphone.
- Diagnosis reports can be shown to the doctors and drug stores when necessary.
- Exercise routines and plans

4.2 Individual System Diagram

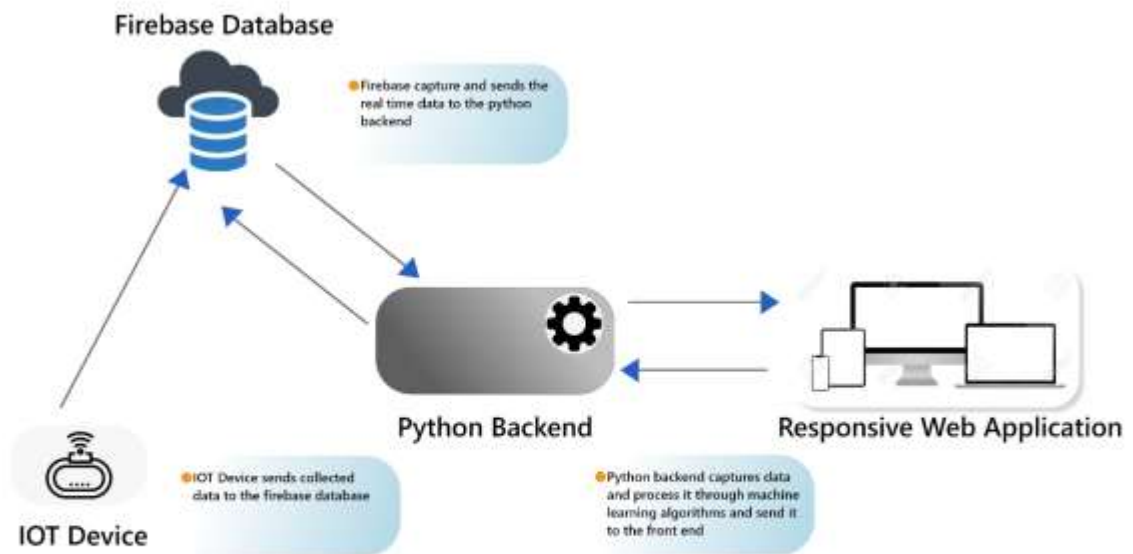


Figure 12 System Diagram personal

There are enough systems in the market to calculate Body temperature, BMI, respiratory levels in humans. But there are only limited systems for animals that have been built to do the same thing. But still, those devices don't deliver the necessary factors such as by using sensor values to predict and analyze health-related issues in dogs. Therefore, one of our primary targets (Smart Health Analyzer) is to use sensor values to predict and analyze data to suggest necessary actions that needed to take by owners for their dogs (time series analysis of body temperature and use of history data values to identify health patterns, same predictions and analysis will be used for heart rate sensor values and calorie related statuses). According to the studies, there have been some products which have been published, without any advanced technologies However this component will mainly tackle down all the other areas which haven't been answered by the industry as of now.

This is an Innovative IoT device that will surpass most of the functionalities which every pet health tracking device would commonly provide in the market. Most of the Health tracking devices would cover (**Pet body temperature, heart rate, respiratory rate, activity level, and ambient conditions**). But those IoT devices don't use the device

analyzed information's in a way **to predict and analyze a dog's health state in advance**, to come up with **diagnosis reports** which can directly share with doctors and drug stores for necessary actions. And also, this app will suggest different kinds of activities for the dog as exercises depending on the data that the device shows.

The app will use Custom made IOT device data to evaluate with pre-processed data and to come up with innovative and valuable suggestions to use for dog health purposes. And also, the following prediction will mainly cover the areas such as suggesting different kinds of activities based on evaluated data (data such as temperature, heart rate, steps taken, respiratory levels (integer values, float values, and strings)) heart rate patterns during the week and what can be suggested for the upcoming week depending on the dog activity level, using historical data, the app can be able to predict body temperature evaluation and different unusual levels.

therefore, this device will bring up the solution to the untapped area. And also, the IoT device will have a fully supported android mobile app component that will sync with the device and elaborate IoT device information in a useful and eye-catching way to the users. This device data will be analyzed using machine learning algorithms to identify patterns that can predict pet's health statuses to identify and report information in an innovative way. And also, the main intention behind this research component is to provide an IoT device as well as a Mobile app both in a reasonable value to the customers. The device will be tested on few selected dogs in the neighborhood which the permission has granted from the owners. And also, these tests will be conducted under the influence and guidance of well-experienced dog trainers.

4.3 IoT Device setup and Sensor positioning

To elaborate on the device and how it is built with different sensors combined, let's look at the sensors and their parts individually. To make this idea a product, there were a couple of sensors took part in this project. Those sensors were,

- Temperature sensor DHT11
- Pulse sensor MAX30100
- Node MCU ESP8266
- Motion Sensor SW420

Here is an explanation about each sensor and what it does exactly in the device,

4.3.1 Temperature sensor DHT11



Figure 13 DHT 11

Above DHT11 sensor are a world-widely used temperature and humidity capturing sensor which comes along with an NTC [8] (Negative temperature coefficient- measure temperature by measuring the resistance of the electrical energy passing through the thermistor which is relative to temperature) to measure temperature. And also, it comes with an 8-bit microcontroller to output the temperature values. Here are some of the significant specifications of the DHT11 temperature and humidity sensor [9],

- It has an operating voltage of 3.5V to 5.5V
- And also operating current of 0.3mA
- It outputs serial data
- This can measure a temperature range of 0°C to 50°C
- Finally, a resolution is for both Temperature and humidity is 16-bit

4.3.2 Pulse sensor MAX30100



Figure 14 MAX30100

MAX30100 is not just a sensor. It's a pulse oximeter and a heart rate monitor sensor solution. This has,

- Two LEDs
- Photodetector
- Optimized optics
- Low noise analog signals to process and capture pulse oximeter and heart rate signals

Here are some of the significant specifications of the MAX30100 [10]sensor,

- MAX30100 operates from 1.8V and 3.3V power supply
- Tiny 5.6mm X 2.8mm X1.2mm 12 pins optically enhance system package
- Ultra-shutdown current (0.7 μ A, typ)
- High SNR Provides Robust Motion Artifact Resilience
- Integrated Ambient Light Cancellation
- High Sample Rate Capability
- Fast Data Output Capability

4.3.3 Node MCU ESP8266



Figure 15 Node MCU

Node MCU ESP8266 is a powerful open-source Lua-based firmware and development board specially targeted for IoT-based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from “Espressif” Systems and hardware which is based on the ESP-12 module [11].

Here are some of the specifications and features of the Node MCU unit,

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

4.3.4 Motion Sensor SW420



Figure 16 SW 420

The vibration sensor module based on the **vibration sensor SW-420** and Comparator LM393 is used to detect vibrations. The threshold can adjust using an onboard potentiometer. During no vibration, the sensor provides Logic Low and when the vibration is detected, the sensor provides Logic High [12].

Here are some of the significant features and specifications of the sensor,

- Operating Voltage: 3.3V to 5V DC
- Operating Current: 15mA
- Using SW-420 normally closed type vibration sensor
- LEDs indicating output and power
- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- With bolt holes for easy installation
- Small, cheap, and easily available

To build this device, there was a significant effort [13] in identifying the sensor behavior and how it can be optimized to get the expected output and functionality. Since we are

dealing with dogs' skin and identifying dog-related internal health issues I had to tweak sensors a little bit further to get the expected accuracy.

Here is small anatomy of the sensor diagram and how it is attached with the Node MCU unit when fixing up and building the unit into one piece.

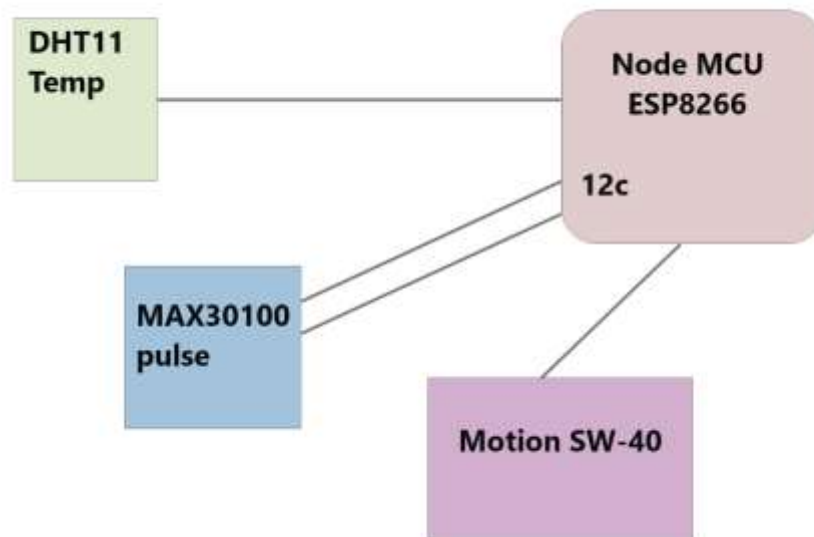


Figure 17 Component Diagram

When capturing the pulse rate of the dog, I had to get the sensor out of the device a little bit further with some extra jump wires to make sure it has enough distance to reach the dog's heart. Normally dogs have rough skin. From the outside, it gives the idea of it's hard to capture the pulse rate by instance from a device like max30100. Nevertheless, dogs have sensitive skin under their arms and especially the heart is located in the left leg of each dog. Therefore, it is easy to capture the pulse rate if the sensor is located under the left leg.

And also, initially, the project had a small block on predicting the pulse rate of dogs that has more fur on their skin. But with the research, we were able to identify that each dog has low fur levels under its arms. Even in **Shepton Daphnis Horsa As known as Dulux breed** has less fur under their chest level.



Figure 18 Diagram Picture One

The device has been mainly built on top of a breadboard to get the strength to the core of the device. And on top of the breadboard node, MCU has been placed accordingly. Node MCU has a built I WIFI chip where we can connect the device straight to the router and sent the sensor details to the desired place as expected. And also, this device has a portable battery that can be separated from the device at any given time and especially with the capability of recharging,

So, this device has brought useability to pet owners at their convenience. Especially when occasions such recharging, the device can be plugged into the USB-B micro type. USB B micro is the most common USB worldwide at the moment. Therefore, without any issue, this device can be charged at any time. And also, once the pet owner charges the device, it can be used for a long time of period since the power consumption of this device is very low.

And especially when talks about the placement of the sensors of the device separately, the main idea which needs to be covered is that the task that the sensor does in the correct place. To elaborate the idea further, please take look at the attached reference picture carefully,



Figure 19 Diagram Picture Two

The Motion detector or rather a vibration detector has been placed next to the main platform of the unit. In other words, the motion detector has been placed right next to the Node MCU to have a stable structure to get its work done. The behavior of the motion detection has been modified to get a unique capture of the dog's activity levels. This particular sensor has a cylinder and a metal ball inside the cylinder to get the vibration in a manner.

To elaborate further, when the dogs do any sort of activity in their daily routine, the metal ball inside the cylinder will collide with the cylinder surface and will make a spark to simulate a digital signal to the Node MCU.

Once the Node MCU gets the signal it is getting recorded as one activity level. Therefore, the device will make the above-mentioned kind of spark when on any vibration to capture and identify the activity of the dog.

And also, to mention specially about the temperature sensor, DHT11 sensor has been strategically placed with the pulse sensor to capture both data simultaneously without any blockers.



Figure 20 Diagram Picture Three

As aforementioned dogs have low fur and relatively sensitive skin under their legs. Therefore, that place is an ideal place to capture the pulse rate and the body temperature of dogs. Normally dogs have a sensible feeling of their heart rate under the left leg. And also, if there are any temperature changes, they can be captured very accurately from that spot. DHT11 sensor comes with plastic from on top of the temperature sensor to avoid unnecessary damage which can happen to the sensor on colliding's and droppings.

Dogs have quick moments and behaviors. They tend to do activities in a quick and hard way. Therefore, as an inventor, I had to put extra care into the device to make it protected.

Finally, the altogether combined product was a successful stable product that can be attached to the dog leash and position under their left leg to capture the temperature, pulse rate, and motions.

This device has an on-off switch that can be used to turn on and off whenever the pet owner wants. And also, upon switching on it, it gives an LED bulb indicator that the device has started and is ready to push data into the firebase. Once the device has started it will send data in 15 seconds time periods and it will keep on updating the firebase with regards to the data it captures on the period.

Once this data captures from the device, it will direct into the python backend which has a support vector machine learning algorithm to do the necessary preprocessing beforehand over to the customer to make decisions in the front end.

4.4 Arduino Logics creation and validation the sensor data

We are not capable of setting up sensors the way we want and capture data in an instance. To build something using IoT devices, we need to tweak its logical codes which come with the Arduino libraries. In this instance, I had to rewrite Arduino logic to identify the way it defaults works and rewrite and adjust the code accordingly the way I wanted it to work for this very project.

Here on this point onwards let's take a look at how each sensor works behind the screen and contribute its core work to the project. Before I move into the explanation, let me give a point-wise idea about the structure which is about to elaborate and the order.

- Firebase setup
- Sensor setup
- Logic setup



Figure 21 Diagram Picture Four

4.4.1 Firebase Setup

```
//firebase-----  
  
#include <ESP8266WiFi.h>  
  
#include <FirebaseArduino.h>  
  
#define FIREBASE_HOST "doggy-project-76215-default-rtdb.firebaseio.com"  
  
#define FIREBASE_AUTH "zaKgPwLThuAjapfqLXpr7TY4eWFGdGCN2EwT60DA"  
  
#define WIFI_SSID "Dialog 4G 221" //WIFI Username  
  
#define WIFI_PASSWORD "*****" //WIFI Password
```

Upon initiating the Arduino logic, the utmost importance is to initiate the connection between the firebase database and the device. As mentioned earlier ESP8266 Node MCU unit comes along with a WIFI chip that can transfer data to any device which has an internet connection. Therefore, to set up the connection, initially, I had to set up the connection with a local router to establish the internet connection

As visible in the code snippet, initially, we need to let know the Arduino IDE that we are using a Node MCU unit by importing and mentioning the particular ESP8266 library. Once the library is imported, we need to establish the firebase library authentication code to establish. Upon establishing, it is needed to add a local router username and password to power up the internet connection to send data to the firebase library.

4.4.2 Sensor Setup

Before setting up the sensor's logic in the Arduino IDE, we need to import libraries that need to function the sensors accordingly. Each sensor comes with a unique library to work with the code loop. Therefore, before setting up we need to import and fix the libraries to each sensor accordingly.

Upon setting up the library we need to make sure each library has the unique updated version which matches with the sensor. Otherwise, the sensor might not deliver the expected outcome.

Since this particular device has three sensor components, each component had a couple of separately unique functioning libraries for each. The only issue had during the development was to set up sensor data delivery according to the Arduino sensor loop.


```
//temp-----  
#include <Adafruit_Sensor.h>  
#include <DHT.h>  
#include <DHT_U.h>  
#define DHTPIN 2  
#define DHTTYPE DHT11  
DHT_Unified dht(DHTPIN, DHTTYPE);
```

```
//motion-----  
#define timeSeconds 10  
const int motionSensor = 14;  
long steps = 0;  
  
ICACHE_RAM_ATTR void detectsMovement() {  
    steps++;  
}
```

```
//pulse-----  
#include <Wire.h>  
#include "MAX30100_PulseOximeter.h"  
PulseOximeter pox;  
float pulseCount = 0;  
int spo = 0;  
  
#if !defined(ESP8266)  
#error This code is designed to run on ESP8266 and ESP8266-based boards! Please check  
your Tools->Board setting.  
#endif
```

Upon identifying and registering all the libraries in the Arduino IDE, the setup can be begun to process the logical code for the unit. When processing the logic code to the entire device there were some blockers that I had to face during the implementation. All the Arduino device commonly runs in a loop. For example, when initiating a logic to the Arduino code we need to adhere to its device default loop code which runs in the background. When setting up additional sensors to the default loop in Node MCU, we need to setups sensors accordingly in the main loop.

Here are some of the logical setups that took part in the code,

```
void setup()
{
  Serial.begin(115200);
  while (!Serial);
  //firebase-----
  // connect to wifi.
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("connecting");
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }
  Serial.println();
  Serial.print("connected: ");
  Serial.println(WiFi.localIP());

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  delay(500);
  //motion-----
  pinMode(motionSensor, INPUT_PULLUP);
  attachInterrupt(digitalPinToInterrupt(motionSensor), detectsMovement, RISING);
```

```

//motion-----
pinMode(motionSensor, INPUT_PULLUP);
attachInterrupt(digitalPinToInterrupt(motionSensor), detectsMovement, RISING);

//temp-----
dht.begin();

sensor_t sensor;
dht.temperature().getSensor(&sensor);
dht.humidity().getSensor(&sensor);
delay(200);

Serial.print(F("\nStarting TimerInterruptTest on ")); Serial.println(ARDUINO_BOARD);
Serial.println(ESP8266_TIMER_INTERRUPT_VERSION);

Serial.print(F("CPU Frequency = ")); Serial.print(F_CPU / 1000000); Serial.println(F("
MHz"));

// Interval in microsecs
if (ITimer.attachInterruptInterval(TIMER_INTERVAL_MS * 1000, TimerHandler))
{
    lastMillis = millis();
    Serial.print(F("Starting ITimer OK, millis() = ")); Serial.println(lastMillis);
}
else
    Serial.println(F("Can't set ITimer correctly. Select another freq. or interval"));

//-----
Serial.print("Initializing pulse oximeter..");

if (!pox.begin()) {
    Serial.println("FAILED");
    for (;;)
} else {

```

When initiating the sensor logic code, I had to follow a couple of steps to bring out the sensor work process into a unique flow. To explain this a little bit further, I will break it down into a couple of segments.

- Streamlining pulse and temperature data capture
- Streamlining motion detection into the default loop in Node MCU

4.4.4 Streamlining pulse and temperature data capture

As mentioned above in the pictures, I have strategically placed both the temperature and pulse sensors next to each other with a jumper wire. It is to capture data without any break when capturing. Node MCU board has a loop in it that runs periodically to execute the code in it. When capturing data, we need to align sensor logic inside the Node MCU default loop without interfering with it. Therefore, pulse and sensor data will capture the rates of the dog 3 to 4 times within 1 second. Those capture data will keep in the cache memory for 15 seconds and it pushed to the firebase every 15 seconds. In this manner, every 15 minutes firebase will capture sensor data which is pushed by the Node MCU. And these sensor data won't affect the Node MCU default running process loop as well.

4.4.5 Streamlining motion detection into the default loop in Node MCU

The only issue which project had was the capturing of motion sensor data in the runtime process. As I mentioned earlier, capturing pulse rate and the temperature was fine with the Node MCU inbuilt loop. But motion sensors had a different way of working. SW-40 sensor works with a vibration unit. It has a cylinder with a metal ball inside. Once there's a movement, this metal ball will collide with the surface of the metal cylinder and will make a spark that turns into the digital-analog count. This counts we can increase by incrementing one by one whenever there's a movement happens. Therefore, the SW-40 sensor works in a different way where it listens to the process of movement s and whenever there's a movement and a spark happens, it will call the Node MCU and inform about the movement and its count.

```
void loop()
{
  Serial.print("Heart rate:"); //Main Loop
  pulseCount = (pox.getHeartRate());
  Serial.print(pulseCount);
  Serial.print("bpm / SpO2:");
  spo = (pox.getSpO2());
  Serial.print(spo);
  Serial.println("% ");
  GETtemp();
  FirebaseUpdate();
  delay(3000);
}
```

4.4.6 Project Data Processing and Python Back end

Before elaborating this process where the device releases the data to firebase and firebase injects data into the machine learning algorithms, let break it down it to a couple of simple steps,

- Data Capture
- Data pre-processing
- The suitable Machine learning algorithm
- Segregating and streaming data into the front end

4.4.6.1 Data Capture

This device has three separate sections which need to be maintained separately. Hence let us have to separate and look into it carefully.

- **Temperature Data**

When it comes to dog breeds there are three categories in a high-level view. Small breed / medium breed and the large breed. These three categories have the same kind of temperature levels in their body. Therefore, it's easy to identify any anomalies in their body heat levels, if there are any sudden changes.

For example, to make this project a success, I individually met the lead doctor of Air Force (**Sky pet veterinary Hospital**) veterinary hospital, and discuss the different body heat levels of the dogs with data. So, I was able to identify that each size breed maintains a body heat of **101.0 to 102.5°F (38.3 to 39.2°C)**. So, a healthy dog always maintains the body heat in the range of Fahrenheit 101 to 102. But if the count fluctuates crossing the range, it'll be one of these symptoms,

- Higher than the range – Fever
- Lower than the range – hypothermia

- **Pulse rate Data**

When it comes to the pulse rate of dogs, we need to specially distinguish the dog breed by their size. The reason is that depending on the size dog body heart rate can be changed. For example, a large breed can maintain a low heart rate compared to a small dog. Therefore, before proceeding with the project, I took a step to finalize data gathering by meeting the lead doctor of the Air force veterinary hospital. With regards to the discussion that I had with the doctors; I was able to identify the difference in the heart rate levels of each dog.

Here the separation as mentioned above,

- Small Breed (90 – 120 bpm)
- Medium Breed (70 – 110 bpm)
- Large Breed (60 – 90 bpm)

As per the discussion I had with the doctor, a healthy dog has to maintain the mentioned heart rate daily. If there's a fluctuation, the pet owner needs to be aware and need to seek a doctor immediately.

- **Motion Detection (Activity and footsteps)**

In this project, motion detection happens on a real-time basis like the other two sensors. But these data won't get directed to the machine learning algorithm to fall into data pre-processing. The primary objective is to capture the activity level of the dog and send it to the front end for the pet owner's perusal.

4.4.6.2 Data preprocessing

For the above-mentioned data gathering, I mainly contacted the lead doctor of the air force veterinary hospital and collected the relevant data which needs to be trained to identify any fluctuation and abnormality in the dogs' daily lifestyle.

When experimenting with the right machine-learning algorithm to be used, I was able to identify that there are a couple of ways and a couple of algorithms that can be used to do this process efficiently.

For example, to identify and analyze heart rates and temperature levels of the dog, we can use,

- Anomaly detection algorithm
- Support vector model algorithm
- Gaussian Naive Bayes algorithm
- Random forest algorithm

Even though there are a couple of algorithms to use to optimize the research objective, I had to use the best out of these algorithms. But without the training and tweaking, I was able to identify that the support vector model is the best algorithm to use in this project.

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import os

for dirname, _, filenames in os.walk('/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

Initially, we need to get the data into the system which is been captured by the IoT device. In this case, we need to get the data by the firebase since the data has been pushed to the firebase from the Node MCU.

To elaborate this process further,

- Once the data captured from the IoT device

- It will send the data to the firebase immediately as I mentioned earlier in 15 seconds time frames
- Once the data has been captured by the firebase, it will send down the data to the python back end which runs the support vector model to do the necessary procurements of the data.

```
target = "output"
predictors = [col for col in fin.columns if col != target]

X_train, X_test, y_train, y_test = train_test_split(fin[predictors],
                                                    fin[target],
                                                    test_size = 0.25,
                                                    random_state = 42)

cv3 = KFold(n_splits = 3, shuffle = True, random_state = 42)
cv5 = KFold(n_splits = 5, shuffle = True, random_state = 42)
cv10 = KFold(n_splits = 10, shuffle = True, random_state = 42)

def cv_model(model, X = X_train, y = y_train, cv = cv5):
    return cross_val_score(model, X, y, scoring = "accuracy", cv = cv, n
    _jobs = -1).mean()
```

Since a set of data has been already trained accordingly with the right amount of data. It takes the device delivered and data and put that into the model. So, the model is already trained, it will take the data from the device and deliver the output in an instance without delaying to the front end.

Support vector model has been fed with a stack of data which is related to the temperature and heart rate levels which have been taken with the correct pieces of advice from the lead doctors. Therefore, model has taken these data and separated them into two models where it can take one set of data for the training and another set of data for the testing.

```

logreg = LogisticRegression(random_state = 42)
svc = SVC(random_state=42, probability = True)
gnb = GaussianNB()
rfc = RandomForestClassifier(random_state = 42)
knn = KNeighborsClassifier(n_jobs = -1)
lgb = lgb.LGBMClassifier(random_state = 42, n_jobs = 1)
dtc = DecisionTreeClassifier(random_state = 42)
xgb = xgb.XGBClassifier(random_state = 42, n_jobs = -
1, use_label_encoder = False, eval_metric = "logloss")

vc_logreg_svc_rfc_knn = VotingClassifier([("logreg", logreg), ("svc", svc),
("rfc", rfc), ("knn", knn)],
voting = "soft")
vc_logreg_svc_knn = VotingClassifier([("logreg", logreg), ("svc", svc),
("knn", knn)],
voting = "soft")
vc_logreg_svc = VotingClassifier([("logreg", logreg), ("svc", svc)],
voting = "soft")
vc_all = VotingClassifier([("logreg", logreg), ("svc", svc), ("gnb", gnb),
("rfc", rfc), ("knn", knn),
("lgb", lgb), ("dtc", dtc), ("xgb", xgb)],
voting = "soft")

train_accuracy = {}
test_accuracy = {}
cv_score3 = {}
cv_score5 = {}
cv_score10 = {}

models = {
    "LogisticRegression": logreg,
    "SupportVectorMachine": svc,
    "GaussianNaiveBayes": gnb,
    "RandomForest": rfc,
    "KNN": knn,
    "LightGBM": lgb,
    "DecisionTree": dtc,
    "XGBoost": xgb,
    "VotingClassifier (All Models)": vc_all,
    "VotingClassifier (Logreg-SVC)": vc_logreg_svc,
    "VotingClassifier (Logreg-SVC-KNN)": vc_logreg_svc_knn,
    "VotingClassifier (Logreg-SVC-RFC-KNN)": vc_logreg_svc_rfc_knn
}

```

```

for name, model in models.items():
    model.fit(X_train2, y_train)
    train_preds = model.predict(X_train2)
    test_preds = model.predict(X_test2)

    train_accuracy[name] = accuracy_score(train_preds, y_train).round(4)
    test_accuracy[name] = accuracy_score(test_preds, y_test).round(4)
    cv_score3[name] = cv_model(model, X_train2, y_train, cv = cv3).round
(4)
    cv_score5[name] = cv_model(model, X_train2, y_train, cv = cv5).round
(4)
    cv_score10[name] = cv_model(model, X_train2, y_train, cv = cv10).rou
nd(4)

scores = pd.DataFrame([train_accuracy, test_accuracy, cv_score3, cv_scor
e5, cv_score10],
                      index = ["TrainAccuracy", "TestAccuracy", "3FoldCV
Score", "5FoldCVScore", "10FoldCVScore"]).T

```

4.4.6.3 Suitable Machine Learning Algorithm

- **Support Vector Model**

SVM support vector machine is a supervised machine learning algorithm that can be used for both classification and regression requirements. In the Smart health analyzer project, we can identify two components that capture dog heart rate and pulse rate levels. In this case, what we are mainly targeting is to identify fluctuations in the range of heart rate and give temperature levels. Therefore, classification can be used to optimize the project objectives.

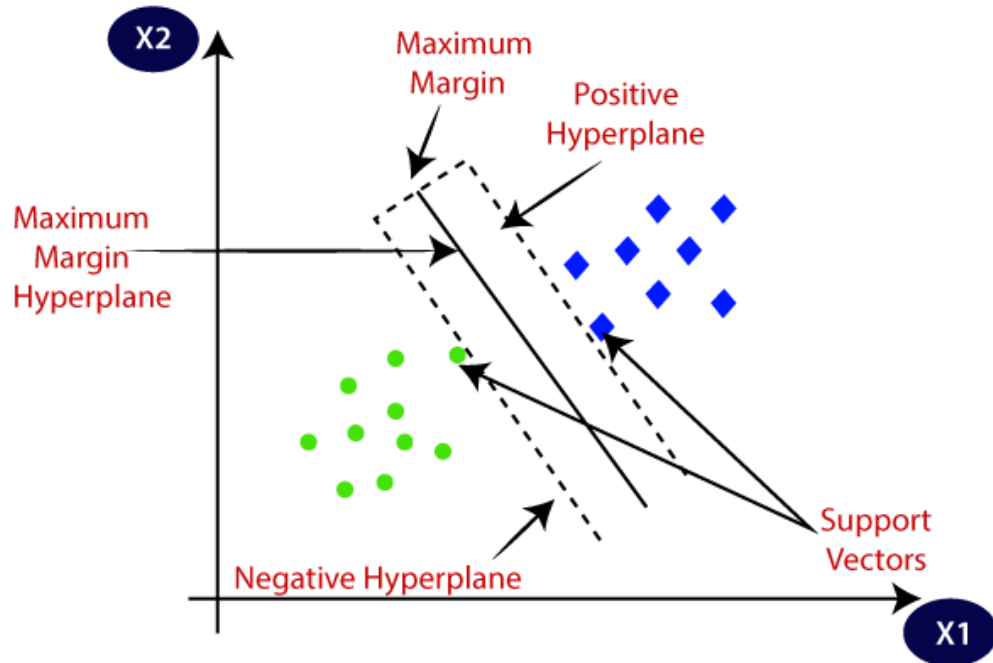


Figure 22 Support Vector Algorithm

○ Support Vector Machine Algorithm

$$\text{if } w^T x + b = 1 \quad y +$$

$$\text{if } w^T x + b = -1 \quad y -$$

$$(w^T x + b)y_+ = (1)y_+$$

$$(w^T x + b)y_- = (-1)y_-$$

$$y_+ = 1, y_- = -1$$

$$(w^T x + b)y_+ = (1)(1)$$

$$(w^T x + b)y_- = (-1)(-1)$$

$$y_i (w^T x + b) = 1$$

$$y_i = \{y_+, y_-\}$$

In order to give a brief explanation to the above equation, if all points we have checked in the condition,

If a point(x) $y_i \cdot (w \cdot x + b) = 1$

Point=support vector

Classified correctly save parameters

else if > 1 :

Classified correctly save parameters

else:

classified incorrectly adjust parameters

4.5 Commercialization of the Product



Figure 23 Commercial

- The targeted Audience will be dog owners mainly

This project has been mainly targeted space in the community. We have seen this requirement earlier with the pet owners where it has been a hassle to take their dogs to the vet hospital for each symptom even it's a small one. This project has mainly tapped into the pet owner's lifestyle directly. With the device and the mobile-first approached web application has made everything easier for pet owners to get educated and gather information about their dogs at convenience. Therefore, this solution doesn't need to be marketed exceptionally to land in the community since it is addressing a community issue.

- The app will be mainly promoted through social media

As mentioned above this project does not need any emphasized marketing in the media. But with the privilege of free marketing on social media, we can have an organic campaign in especially Facebook, Instagram, Twitter, and all the other existing platforms. Without spending much money, we can target all the audience and gain organic growth within a small amount of period.

- Initial audience reach will be targeted as an organic growth without boosting

Since the project is addressing a community issue, we can target the pet owners in the first phase. For any product, there has to be a need in the community. Therefore, the idea of this project can be delivered among the pet owners at first. Since there's a requirement for an all-in-one service that can address dog internal and external health, attention can be gain through social media platforms easily.

- The device can be shared among supermarkets, accessory shops, and drug stores where dog owners usually roam

Once the product is well established in the market, the device can be delivered to any supermarket in Sri Lanka. Normally all the food-related products can be found in any supermarket in Sri Lanka. And also, most of the pet owners tend to search dog-related products in the supermarkets in Sri Lanka. Therefore, this IoT device can be placed in Sri Lankan supermarkets for a better reach.

- A leash is highly comfortable to the dog since it is made out of fabric and sponge cushioning's

Since the IoT device is getting attached to the dog leash, the leash will be separately made with the usage of sponges. A leash will be made with strong fabric and for the comfortability of the dog leash will be cushioned perfectly.

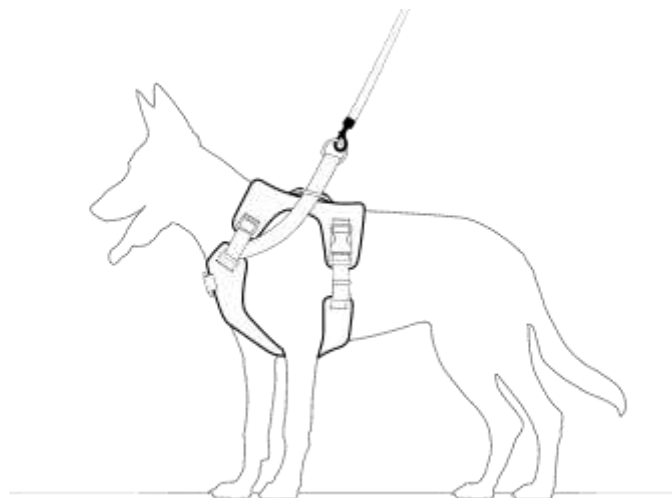


Figure 24 Dogs leash Two

- Device usages will be printed and posted at vet hospitals under the permission for awareness

Most of the Sri Lankan veterinary hospitals have poster board which has commercial and information about dog breeding ads. Therefore, we can use the board by spending a small amount of money to get a better reach. Since most of the pet owners come to vet hospitals at least once a month, this post-board method can be useful to spread the awareness in a greater reach.

- And also, targeting to get the help of brand ambassadors such to embark to spread the awareness.

Sri Lanka has south Asian best Dog community help ambassador embark. Not just embarks Sri Lanka couple of more dogs help foundation which has island-wide reach in the pet owner's community. These foundations can be useful to deliver the project as a better marketing strategy. For example, embark does a foundation campaign twice a year where a lot of dog's owners participate. As a team, we can participate in those campaigns to market the device to pet owners with permission. Since all the pet owners and not pet owners come to the campaigns like this, the project can get a better reach within a day.

5 TESTING & IMPLEMENTATION



Figure 25 Testing and Implementation

- Testing will be mainly implemented on neighbors' dogs.

Smart Health Analyzer is a small portable device that can take anywhere. And also, since the device comes with a leash, it is easy to hand over the entire system to another pet owner to check the device out. And also, it's easy to set up the device for the pet owners since it's getting automatically connected to the WIFI router. Once the system gets connected to the WIFI router, the pet owner can simply switch on the device and test it out on the dog.

- Implementations will be carefully organized under the owner's supervision.

The device is completely harmless to the dog. And also, the leash has been made with cushioned fabric to make it much more comfortable for the dog. For the initial stage, I will personally volunteer to set up the device on the dog for the pet owner. But as I mentioned above earlier, the device does not put much weight or do any harm to the dog.

- The smart device will be handed over to the owner for two days.

For the pilot project, the smart device will be hand over to each pet owner for two days to test out. On the first day, we will help the test owner to set up the device on the dog and transfer the necessary knowledge that the owner requires to know to get the maximum out of the device. once the pet owner knows to carry out the test alone, we are handing over the device to get the information for two days.

- Selected owners who have a couple of dogs will get two to three days to use the device to get information.

If the particular dog owner who has a couple of dogs gets additional more days to keep the device during the pilot project. Therefore, pet owners can keep the device and test it out on each dog for a day to identify their pulse rates / Temperature levels and Activity levels during a day. After that, they continue the same process for each dog. If they need an additional one or two days to test out, they can request.

- Setup guides will be delivered to the owners

The pilot project team will be volunteering to help out the dog owners to set up the device. And also, the team will offer a manual that has instructions to carry out the setup without any guidance or to clear our any concerns as well.

6 RESULTS & DISCUSSION

6.1 Results

Here are some of the test cases that were carried out to make sure the main functionalities meet the desired expectations

Test case 01

Table 1 Test Case 1

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/	Firefox	Pass	[Sandagomi 4.29 P.M. 04/10/2021] Launch successful
2.	Enter user credentials and enter log in button	Email id: sandagomi.v.i@gmail.com Password:123456	Dashboard view	Dashboard view	Firefox	Pass	[Sandagomi 4.30 P.M. 04/10/2021] Log in successful

Test case 02

Table 2 Test Case 2

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/	Firefox	Pass	[Sandagomi 4.35 P.M. 04/10/2021] Launch successful
2.	Enter valid mail and invalid password and enter log in button	Email id: sandagomi.v.i@gmail.com Password:12345678	Incorrect user name or password	Incorrect user name or password	Firefox	Pass	[Sandagomi 4.39 P.M. 04/10/2021] Log in unsuccessful
3.	Enter invalid mail and valid password and enter log in button	Email id: sandagomi@gmail.com Password:123456	Incorrect user name or password	Incorrect user name or password	Firefox	Pass	[Sandagomi 4.45 P.M. 04/10/2021] Log in unsuccessful

Test case 03

Table 3 Test Case 3

Test Scenario ID	Voice input-02	Test Case ID	02-A				
Test Case Description	Pulse rate	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Pulse rate capture 4. Dog owner- sandagomi 5. Experience- 12 years	Post-Requisite	Great Dane breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Firefox	Pass	[Sandagomi 5.05 P.M. 04/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Pulse Rate	Pulse rate	Firefox	Pass	[Sandagomi 5.10 P.M. 04/10/2021] Correct prediction]
3	Click ‘log out’	N/A	Log in screen	Log in screen	Firefox	Pass	[sandagomi 5.10 P.M. 04/10/2021] Log out successful]

Test case 04

Table 4 Test Case 4

Test Scenario ID	Voice input-02	Test Case ID	02-B				
Test Case Description	Pulse rate	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Pulse rate capture 4. Dog owner- sandagomi 5. Experience- 12 years	Post-Requisite	Log out from the system Ridgeback breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Firefox	Pass	[Sandagomi 5.15 P.M. 04/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Pulse Rate	Pulse rate	Firefox	Pass	[Sandagomi 5.20 P.M. 04/10/2021] Correct prediction]
3	Click ‘log out’	N/A	Log in screen	Log in screen	Firefox	Pass	[Sandagomi 5.25 P.M. 04/10/2021] Log out successful]

Test case 05

Table 5 Test Case 5

Test Scenario ID	Voice input-03	Test Case ID	03-A				
Test Case Description	Temperature capture	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Temperature capture 4. Dog owner- sandagomi 5. Experience- 12 years	Post-Requisite	Log out from the system Great Dane Breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Google chrome	Pass	[Sandagomi 5.30 P.M. 04/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Temperature	Temperature	Google chrome	Pass	[Sandagomi 5.35 P.M. 04/10/2021] Correct prediction]
3	Click ‘Back’	N/A	Main menu	Main menu	Google chrome	Pass	[Sandagomi 5.40 P.M. 04/10/2021] Navigation successful]

Test case 06

Table 6 Test Case 6

Test Scenario ID	Voice input-03	Test Case ID	03-B				
Test Case Description	Temperature capture	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Temperature capture 4. Dog owner- sandagomi 5. Experience- 12 years	Post-Requisite	Log out from the system Ridgeback Breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Google chrome	Pass	[Sandagomi 6.30 P.M. 05/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Temperature	Temperature	Google chrome	Pass	[Sandagomi 6.35 P.M. 05/10/2021] Correct prediction]
3	Click 'Back '	N/A	Main Menu	Main menu	Google chrome	Pass	[Sandagomi 6.40 P.M. 05/10/2021] Navigation successful]

Test case 07

Table 7 Test Case 7

Test Scenario ID	Voice input-04	Test Case ID	04-A				
Test Case Description	Motion sensor capture	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Motion sensor 4. Dog owner-sandagomi 5. Experience- 12 years	Post-Requisite	Great Dane Breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Google chrome	Pass	[Sandagomi 10.30 A.M. 07/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Motion Capture	Motion Capture	Google chrome	Pass	[Sandagomi 10.35 A.M. 05/10/2021] Sound recording]
4	Click ‘Back ’	N/A	Main menu	Main menu	Google chrome	Pass	[Sandagomi 10.45 A.M. 07/10/2021] Correct prediction]

Test case 08

Table 8 Test Case 8

Test Scenario ID	Voice input-04	Test Case ID	04-A				
Test Case Description	Motion sensor capture	Test Priority	Medium				
Pre-Requisite	1. The user should be logged in 2. IoT device should be connected 3. Motion sensor 4. Dog owner- sandagomi 5. Experience- 12 years	Post-Requisite	RidgeBack Breed				
Test Execution Steps:							
S.No	Action	Inputs	Expected Output	Actual Output	Test Browser	Test Result	Test Comments
1.	Select Smart Health Analyzer	N/A	Smart Health Analyzer	Smart Health Analyzer	Google chrome	Pass	[Sandagomi 11.00 A.M. 07/10/2021] Navigation successful
2.	A device placed in the dog	N/A	Motion Capture	Motion Capture	Google chrome	Pass	[Sandagomi 11.05 A.M. 05/10/2021] Sound recording]
4	Click ‘Back ’	N/A	Main menu	Main menu	Google chrome	Fail	[Sandagomi 10.15 A.M. 07/10/2021] Incorrect prediction]

6.2 Research Findings



Figure 26 Diagram Picture Five

As expected, I was able to make a device that is less weight and comfortable to carry for the dog. Initially, I was under the impression with the sensor and the breadboard weights it will be difficult for the dogs to carry such a device with the leash attached to it. And also to point out this device has been made strategically to replace sensors if there's any issue occurs. Not only for the sensors but Node MCU mainboard can also be replaced at any given time if there are any issues occurs in the future.

Here are some of the benefits of the device,

- Sensors are renewable and can be replaced with updated sensors without any issue.
- Mainboard of the device which Node MCU can be replaced. Therefore, the system won't get affected even if there's a shortage on the board.
- The device can be rechargeable at any time and no need to replace the battery.
- The device will be covered with a hard plastic shell and it will be waterproof.

This device can be placed on any size of a dog. Since the device is getting attached to a leash, irrespective of the dog size the device can be attached to any dog. MAX30100 sensor can track pulse rates on rough skins as well. Since the sensor has two led bulbs that can send the infrared lights to the skin, we can track the pulse rate without any issue.

Initially, doubt arises with the fur density whether it's possible to get the pulse rates tracked. Due to the technology of the sensor, it was easy to track it down. And also, all the dogs have less fur under the left arm. Therefore, it is easy to capture the temperature and pulse rate by placing the sensor under the arm.

6.3 Discussion

When it comes to Pulse rates and temperature rates and motion detections, it works differently in each dog. Especially when the dogs get categorized as small breed, medium breed, and large breed. And also, when predicting and validating certain ranges, especially in different scales support vector model gave the best results as expected. For this particular project to capture sensor information we can use two machine learning algorithms,

1. Anomaly Detection algorithm
2. Support vector model

Nevertheless, support vector model is best to capture outliers in a range of data. Therefore, even for upcoming projects which are dealing with a range of numbers, a support vector machine learning model is highly recommended.

The more you increase the set of data as the numbers of pulse rates and temperature rates in each class the model may be able to predict correctly than the current accuracy level. To train and identify normal levels and distinguish fever and other symptoms, we add normal data as well. If we can increase the number of normal and healthy rates of dogs of pulse rates and heart rates classes respectively, we have to increase the number of unhealthy pulse rates and temperature rates as classes as well.

For motion detection, we didn't use machine learning specifically since it has a real-time data capturing process. Nevertheless, we add some healthy dogs' daily activity levels to measure out a benchmark which each and every dog can be followed with the guidance of their pet owners.

Here are some of the guidance to carry out when predicting and training a model as mentioned above

- As much as we predict correct data, we need to feed bad data to the model as well. For example, it is not enough just to feed healthy dog's pulse rates and temperature rates to the system to identify better predictions

- Also, use the set of data as 60% to 40% percentages of chunks to train and test
- 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.
- Finally, Gradient clipping can be done to control gradient explodes.

7 CONCLUSIONS

As per the research, we were able to identify that most pet owners cant distinguish and identify smaller symptoms that arise in their dogs' internal bodies without a help of a device. As per the usual routines of the pet owners, we always wait until the end of the month or until the given date to visit pet doctors to talk about the behavior of the dogs in certain periods.

But with this device, pet owners can straight away identify even a small temperature change in their dog's internal body. And also, by keeping an eye on daily pulse rates, dog owners can track down whether their dogs have or suffering from cardiovascular system issues.

We have developed a simple straightforward solution that can be turned on by a small switch and can be used at any given time of the day without an issue. And also, since this system has been attached to a comfortable leash, the device can be worn by the dogs without any issue and harm. The device has been trained by data which has been taken by Sri Lankan registered professional Lead veterinary doctors in the Air force. Since we were able to get correct data out from Air force databases, we were able to get higher accuracy levels in the training model without any issue.

Here is an example of the accuracy level which we could take from the model,

SupportVectorMachine	0.8987	0.8816	0.8282	0.8634	0.8374
----------------------	--------	--------	--------	--------	--------

As of now, the device has been built to monitor the following tasks successfully,

Current System	Future Work that can be implemented
<ul style="list-style-type: none">• Pulse rates of the dogs of any size (small/Medium/large breed)• The temperature of the dogs of any size (small/Medium/large breed)• Activity levels of a dog. (This captures daily steps and activities that the dog does)• Analyze and predict the heart rates of the dog. (Whether it's in the normal ranger or needs to pay medical attention)• Analyze and predict the pulse rates of the dog. (Whether it's in the normal	<ul style="list-style-type: none">• If anyone is interested in taking this project furthermore to the next level, they can work on a device that can get blood-related predictions. (For example, blood sugar levels/ cholesterol levels, etc.)

<p>ranger or needs to pay medical attention)</p> <ul style="list-style-type: none"> • Daily activity levels analyzer and informs about how active the dog is • Supplies diet routines for the dog depending on the size of the breed. • Supplies exercise routines for the dog depending on the activity levels of the dog. • Downloadable PDF format of diet routines. • Downloadable PDF format of the exercise routines. 	
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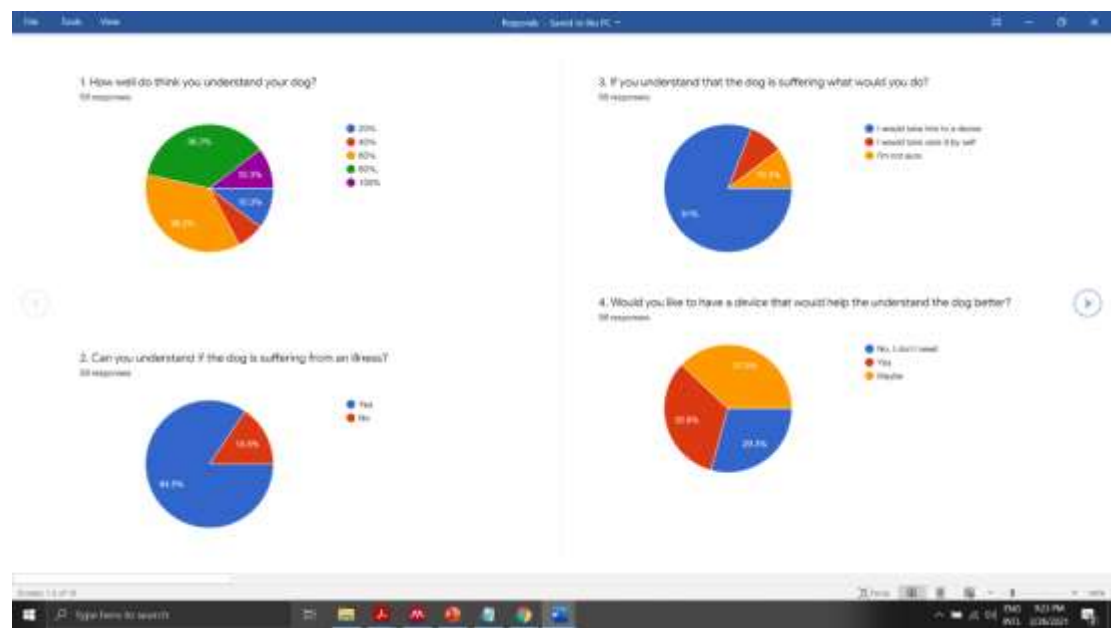
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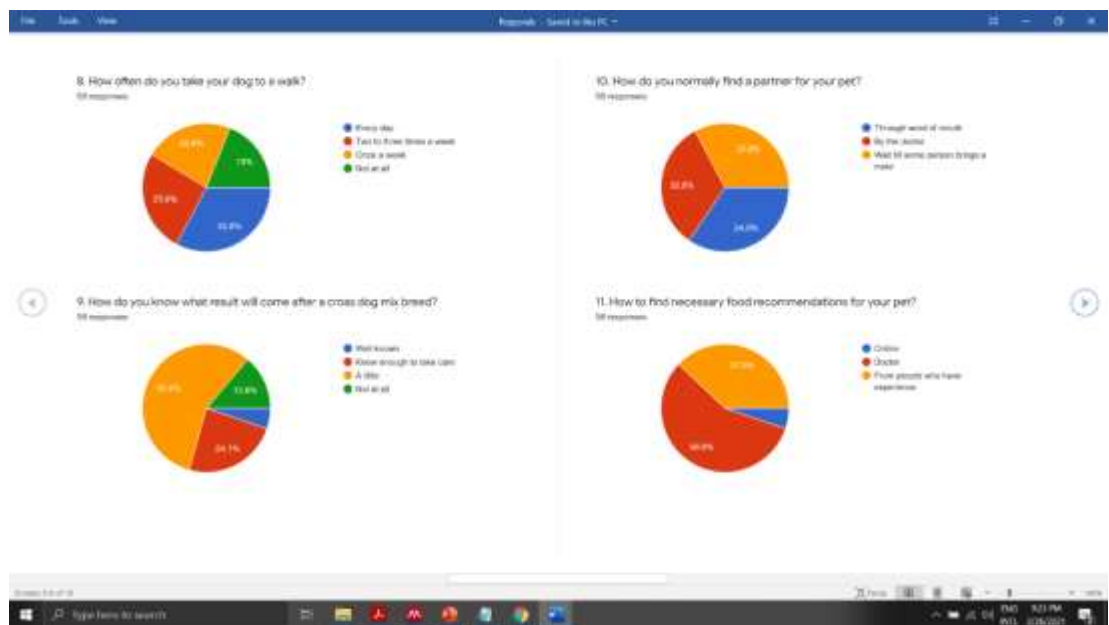
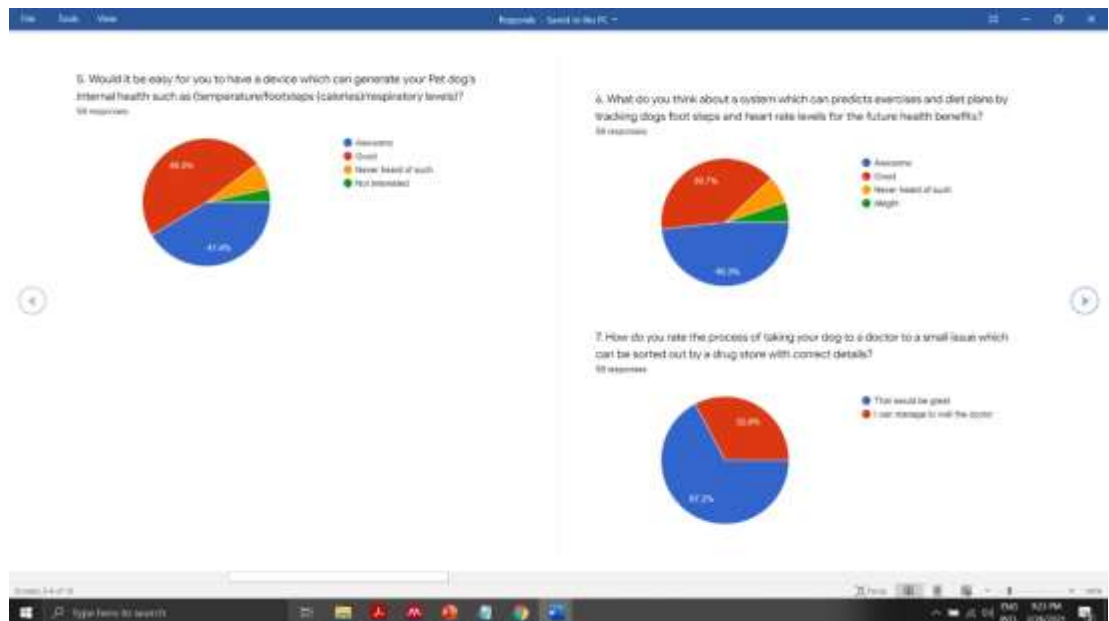
GLOSSARY

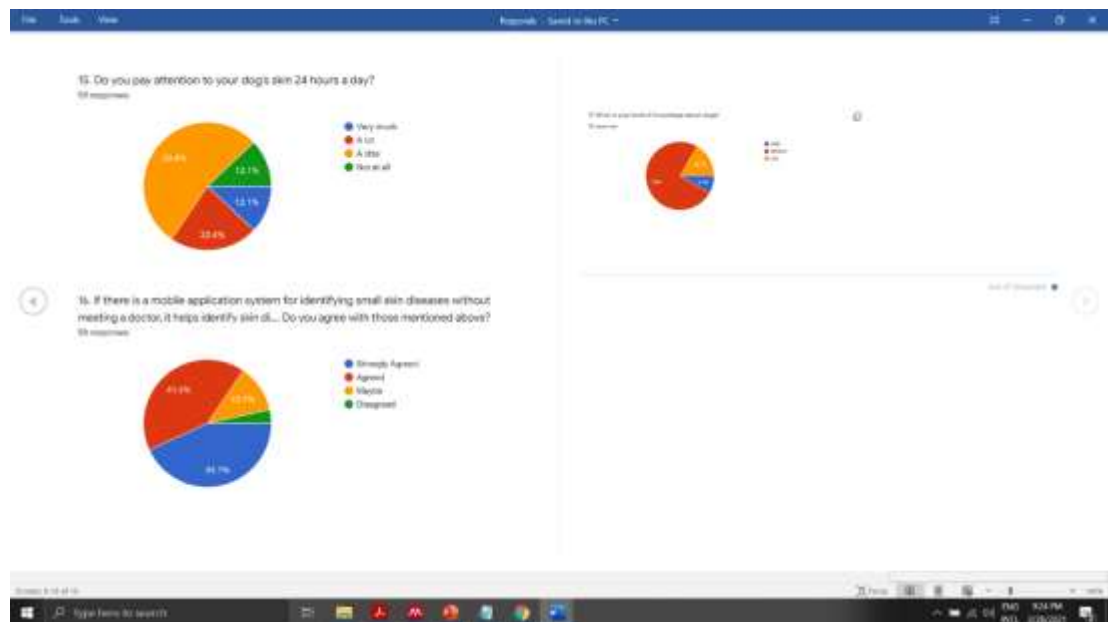
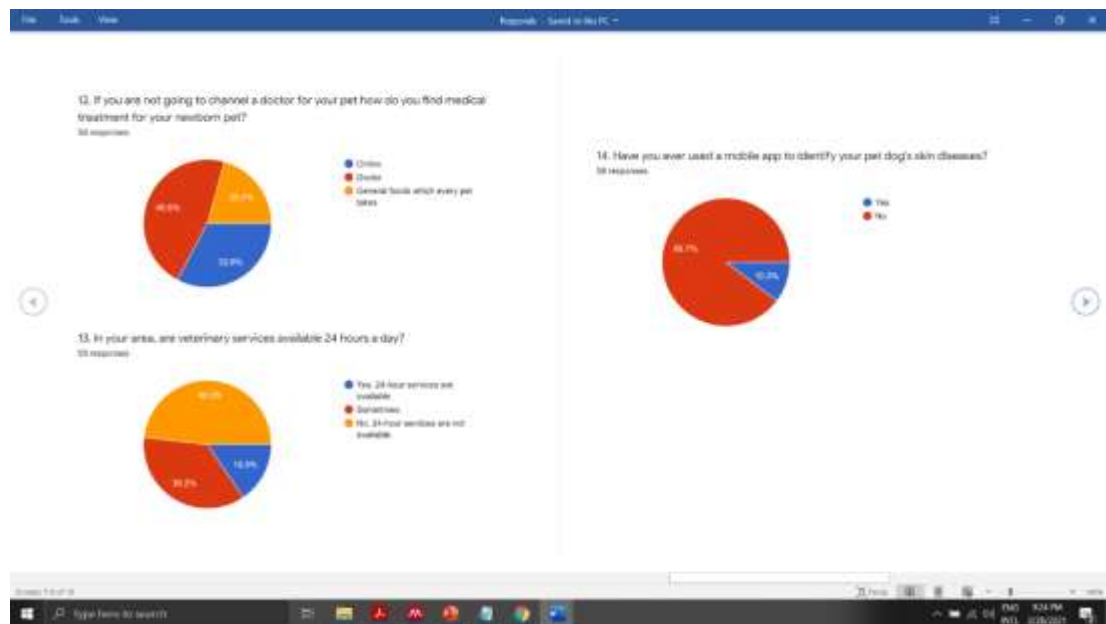
Node MCU = Node Micro Controller Unit

APPENDICES

Appendix A: Complete questionnaire results







Appendix B: User Interfaces

