Research Document

Animal Tracker And Health Monitoring Application

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Abstract

Modern culture means people aspire to make every day tasks as simple and efficient as possible which is normally achieved through the addition of technology to the process at hand. The aim of this research document is to outline the technologies and methodologies that would be most applicable for implementing a wearable animal tracker and health information system based on the concept of IoT.

Over the duration of this project possible technologies and hardware such as Raspberry Pi, Arduino, Intel Edison and Intel Galileo boards will be investigated to determine the most suitable for implementing an animal tracker and health information system.

Introduction

The purpose of this project is to create a GPS based system, which can be used for animal tracking. GPS was initially designed for military intelligence to allow the US Navy record their movements across oceans in the 1960's. GPS consists of a network of satellites that orbit the earth and send back data to devices with GPS receivers. The data sent back from the satellites includes a geographical data point, time codes, speed and time from anywhere on the planet.

Agriculture is a sector that is slowly being optimized to produce greater yields and less expenditure through the use of technology. The addition of technology is becoming more prevalent in certain aspects of farming such as dairy where robotic milking machines are becoming more common due to their efficiency and cost saving measures by reducing the amount of man hours required. There are already existing animal wearable's available in the agricultural sector which monitor the animals location and even monitoring their behaviors. Furthermore there are systems available which can inform the farmer via text message when a cow is in heat. (Engineers Journal, 2015)

Often the initial cost outlays for these systems are quite high meaning there is a greater amount of time required along with accurate results, before the user deems it to have been a worthy venture. This can mean farmers are more hesitant on purchasing this type of system without guaranteed results.

Therefore, the aim of this project is to produce an inexpensive and easy to use animal tracking and health monitoring system, which can be used to analyze movement patterns of sick animals to determine the physical source of the problem. For example if you had two animals on the system with Tuberculosis (TB) you could cross-reference their locations to see any common area's in the field where the source of the problem may have occurred.

Existing Herd Management And Equine Devices

DairyMaster MooMonitor

DairyMaster are a dairy equipment production company based in Causeway, Co. Kerry. DairyMaster offer a variety of products, one of which focuses on animal health tracking and reproduction, which is aptly named MooMonitor. MooMonitor is a collar, which is placed around the animals head and records their movement to determine details regarding their eating, resting and general movement habits. Based on this the farmer can gain information relating to each individual animals health. The MooMonitor system works by transmitting its data to a base station, which can be up to one kilometer away. One advantage of the MooMonitor is its long lasting battery, which they state, has up to ten years of battery life. One of the main features of this product and many more on the market is it aims to provide the farmer with data for animal reproduction for use with artificial insemination (AI). The advantage of this feature is the farmer can reduce the length of their calving season by knowing when exactly to apply the AI process to the cow whilst also increasing their overall calving rates. This system can be used on computers, tablets or phones. Furthermore another feature of this system is it sends SMS alerts to the farmer. (DairyMaster)

HerdInsights

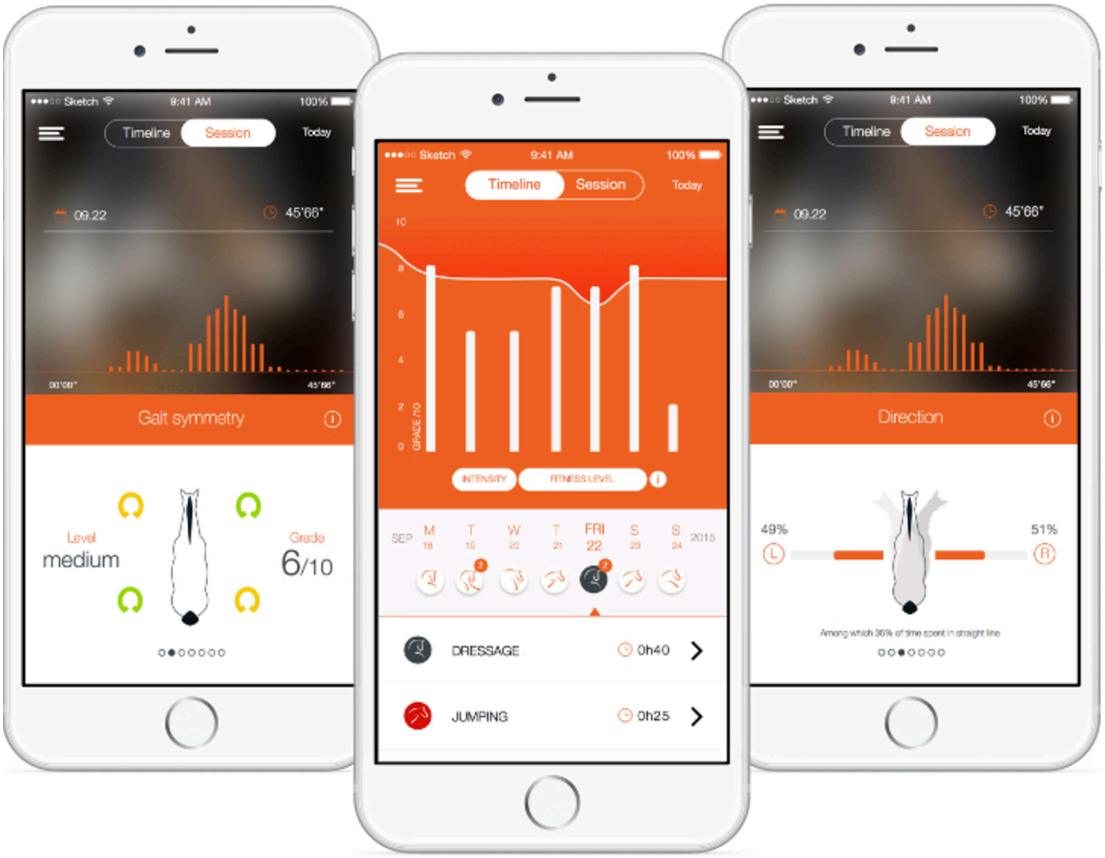
Alanya animal health monitoring provides the HerdInsights system. This system operates in a similar fashion to the MooMonitor system. HerdInsights also use a base station, which can store details of 5000 animals on a single base station. The system is scalable meaning if you meet the maximum 5000 animals on one base station you simply install another base station to cater for the excess. Similarly this system is also available for use with computers, tablets or phones. The HerdInsights system used an RFID tag on the collar to recognize each animal on the system. The HerdInsights system provides similar functionality to that of the MooMonitor in that it sends the farmer SMS alerts informing the farmer when is the best time to apply the AI process to the specified cow. Using this system will provide the farmer with similar results to that of the MooMonitor system. (HerdInsights)

Horse Mote

Horse Mote is a monitoring device specifically designed for use with horses. This system is placed around the horses body in comparison to the two previous systems which places the device around the cows neck. The Horse Mote system is capable of recording information such as the horses body temperature, how much they are sweating, their heart rate and their movement using an accelerometer. (EOIT)

Equisense

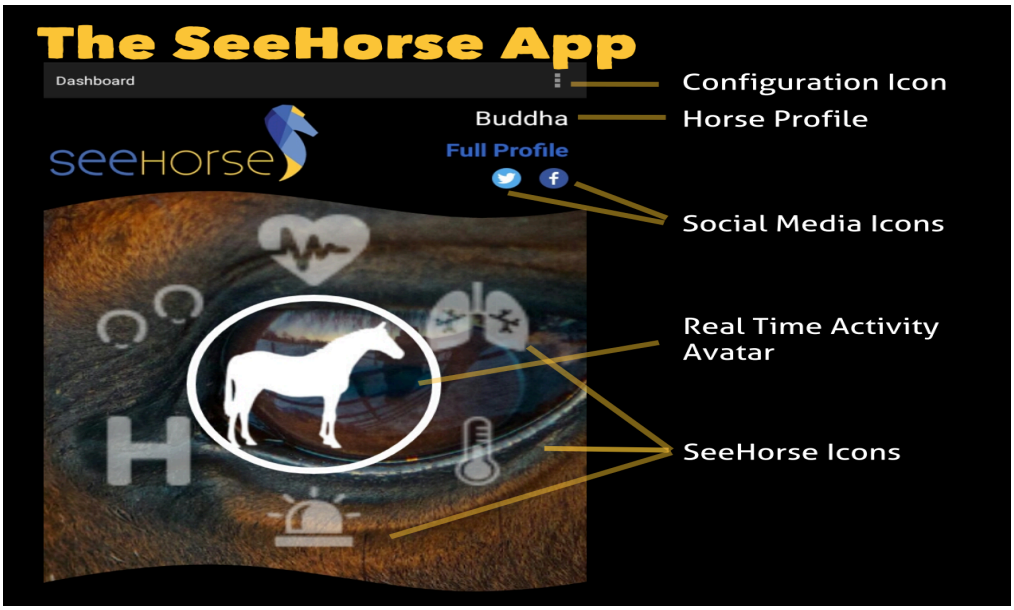
Equisense are a French company who also produce wearable's for monitoring horses health based on their movements. Similarly to the Horse Mote system, Equisense also use an accelerometer to retrieve data relating to the horses movement which they can analyze to determine of the horse is lame. They also record information such as body temperature and the level of sweat being produced by the horse to determine how much strain the animal is under, speed, number of jumps made by the horse and the Cadence produced by the horses movements. Equisense is available on both the android and iOS mobile platforms. Furthermore each tracking device can be used on up to four horses. The device also has a battery life of up to eight hours. Additionally this product costs $329. From viewing their website the application allows the user to schedule training sessions for the horse. It also provides the user with information relating to which direction the horses head is turned most. The app also provides the user with a graphical representation of the horses work intensity as well as its overall fitness level. (Equisense)



SeeHorse

SeeHorse is another horse health and movement monitoring system. This system is very similar to the Equisense system in that it provides the user with similar resources. Information such as the horses heart rate, body temperature, activity levels and movement details are made available to user. One interesting feature

of the SeeHorse system is it comes equipped with a wireless charging pod. The SeeHorse device is more expensive than the Equisense device at $499. The application provided by SeeHorse for their product has a much simpler interface to it. On logging in the user is directed to the dashboard which presents the user with real time data on the horses heart rate in BPM, the number of steps the horse has taken, the horses respiratory rate, temperature and access to previous data that has been previously obtained. The app also provides the user with an alarm functionality where they can set certain criteria that will alert them when the animal is in some distress. (SeeHorse)



Existing GPS Pet Tracking Devices

Pod

Pod is a miniature-tracking device that can be attached to your pets collar that records their activity which can be interfaced through their web application. The Pod device provides its users which information such as your pets location, the time they spend walking, running or at rest. Furthermore the user can set safe zones which will alert the owner when their pet has left this area. The pod can track the animals movements for up to eight hours which it can then synchronize with the mobile application via Bluetooth. The device itself is waterproof and as previously stated miniature with dimensions of 5cm in length and 2.3cm in diameter at a cost of €179. The device also boasts battery life of up to five days depending on usage with a spare interchangeable battery provided. In terms of the application itself it is supported on the android and iOS platform as well as providing a web platform for interfacing with the Pod. (Pod)

Whistle GPS Pet Tracker

The Whistle GPS Pet Tracker is a similar device to the afore mentioned Pod Tracker which provides functions such as recording information about your pets location, the time they spend walking, running or at rest and the device can send alerts to the owners smartphone when their pet leaves their home zone. Again like the Pod Tracker the Whistle GPS Pet Tracker is also waterproof. There are some slight differences between both devices, one of which is the size of the Whistle GPS Pet Tracker that has dimensions of 1.5 x 4.2 x .0.8 inches. Another difference between the two devices is the platforms they support with the Whistle GPS Pet Tracker only available on the android and iOS mobile platforms. Currently this device can be purchased at a cost of $49 which is a sizeable difference in comparison to the price of the Pod Tracker. A convenient function that the Whistle GPS Pet Tracker provides is the ability to add multiple people to the owners account so they can view the animals latest data also. (Whistle)

Loc8tor Pet GPS

Loc8tor is another company that provide GPS Tracking devices for pets. One such device is their tracker that is designed specifically for dogs. This device functions in a similar manner to the previously mentioned pet trackers by providing the owner with features such as safe zones, current pet location and the pets previously travelled routes. The GPS coordinates obtained by the device are accurate up to five meters. The battery, which is rechargeable has the capability of lasting between 7-10 days depending on usage and alerts the owner when the battery is running low. The device is slightly cheaper than the Pod Tracker at €120.98. Like the Pod Tracker the Loc8tor Pet GPS is available on any mobile device with an internet connection. The Loc8tor gives the owner the opportunity to specify what intervals they want the device to record their pets location which is an advantageous feature. (Loc8tor)

Tabcat

Tabcat is another company that provides GPS Tracking devices for pets. Tabcats device is designed specifically for use with cats. Tabcat differs from the previous devices in how it ascertains the cat's location by using radio frequencies. The device works by directing the owner to their pet using audio and visual signals emitting from the Tabcat handset, which is communicating with the homing tags attached to their cats collar. Tabcat has the ability to locate a cat that is up to 122 meters away. The device comes with an intelligent feature built in that is used to train the owners cat to come home by emitting a beeping sound from the homing tag until the cat returns. The device has an excellent battery life of up to one year. As the directional technology is more accurate than GPS it is precise up to 2.5 inches. Tabcat is an inexpensive option for any cat owner with the basic package costing as little as £69 that comes with two homing tags. (Tabcat)

Kyon

Kyon provide a GPS tracking collar for pets of any type. This device has a similar safe zone functionality as the already mentioned devices. The perimeter for the safe zone is 300ft. If the animal leaves this perimeter the GPS tracking functionality on the device is enabled. The Kyon collar utilizes 3D GPS technology that can inform the owner what level of a building their pet is in for example. Like the Loc8tor Pet GPS tracker this device also has a rechargeable battery (420mAh) which is charged using the Kyon docking station which also acts as a beacon for the collar. The device is also water resistant like many of the previously mentioned pet trackers. The Kyon collar also boasts a battery life of up to 30 days. The collar operates by transmitting data to your phone or docking station which then communicates with the Kyon server. The Kyon collar delivers numerous functions to the owner such as the pacifier operation which prevents your pet from engaging in a fight with another animal by emitting a high frequency sound from the device. (Kyon) (Kyon)

Single Board Computers

When attaching a tracking device to an animal it is essential that it is compact enough not to be an obstruction to the animal but also to be strong enough to withstand any blows to the object itself. To achieve this research will be conducted on single board computers such as Raspberry Pi's, Arduino's and Intel Galileo boards because of their small size but phenomenal power. This research will begin by looking at the Arduino Boards.

Arduino

There are five entry-level boards available from Arduino. They are the Arduino Uno (known as the Genuino Uno outside the USA), Arduino 101, Arduino Pro, Arduino Micro and the Arduino Pro Mini. (Arduino)

- **Arduino Uno:** The Arduino Uno was the first USB Arduino board produced which is based on the ATmega328P. It has 8-bit architecture with a CPU clock speed of 16MHz and an operating voltage of 5 volts. It provides 32 KB flash memory with 2KB SRAM which provides faster data access times. (Arduino)

- **Arduino 101:** The Arduino 101 is an advancement on the Arduino Uno. It boasts 32-bit architecture with a dual core CPU each of which have a clock speed of 32 MHz. Unlike the Arduino Uno, the Arduino 101 has a minimum operating voltage of 3.3V. Similarly to the Arduino Uno the Arduino 101 has 14 I/O pins 4 of which are used for Pulse With Modulation (PWM (Arduino)). The Arduino 101 shows improvements in the volume of storage it offers for example it provides 196KB of flash memory with 24KB of SRAM. (Arduino)

- **Arduino Pro:** The Arduino Pro is a smaller PCB than the previous two products. It has dimensions of 52.07mm x 53.34mm. The Arduino Pro comes in two versions, the 3.3-volt 8MHz version and the 5-volt 16MHz version. With the reduction in physical size comes a decrease in processing power on both versions. Both PCB's offer the same storage with 32KB of flash memory and 2KB of SRAM like the Arduino Uno. (Arduino)

- **Arduino Pro Mini:** The Arduino Pro Mini is a more compact version of the Arduino Pro. Similar to the Arduino Pro it offers a 3.3-volt 8MHz version and the 5-volt 16MHz version. Both PCBs are based on 8-bit architecture. Like the Arduino Pro and Arduino Uno, the Arduino Pro Mini offers 32KB and 2KB SRAM. (Arduino)

- **Arduino Micro:** The Arduino Micro is the smallest board that Arduino offer. It boasts 8-bit architecture with an operating voltage of 5-volts. Its CPU operates at 16MHz. It also provides the user with a built in micro-USB connection. In terms of storage it is similar to the majority of the

previously mentioned boards with 32KB flash memory and but with 2.5KB of SRAM. (Arduino)

Intel Galileo

There is only one Intel Galileo board currently available, Intel Galileo Gen 2. The Intel Galileo board is the first Arduino certified board based on Intel Architecture. Note: The first generation Intel Galileo board is no longer in production.

- **Intel Galileo:** The Intel Galileo Gen 2 board provides a sizeable increase in power and performance compared to the previously mentioned Arduino boards. The board is based on 32-bit Intel architecture It comes equipped with 256MB DDR3 RAM with 512KB of SRAM. It also boasts 8MB onboard flash storage with the capability of adding an extra 32GB via microSD card. (Intel)

Raspberry Pi

The Raspberry pi series are possibly the most well known single board computers out of the three, potentially due to the vast quantity of accessories and information available to their users. There are currently five Raspberry Pi's available, they are the Raspberry Pi 1 Model A+, the Raspberry Pi Zero, the Raspberry Pi 1 Model B+, the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.

- **Raspberry Pi 1 Model A+:** The Raspberry Pi 1 Model A+ superseded the Raspberry Pi Model A in November 2014. The board has an operating voltage of 5 volts and comes equipped with a microSD expansion slot, one USB slot, one headphone jack as well as a HDMI port. This model has 512MB RAM. (Adafruit)
- **Raspberry Pi Zero:** The Raspberry Pi Zero is a physically smaller board than the Raspberry Pi 1 Model A+ but it has very similar components and power. Like the Raspberry Pi 1 Model A+ it also has an operating voltage of 5 volts. It comes equipped with a 1 GHz single core CPU, 512MB RAM, a mini HDMI port, two micro USB slots and a microSD card slot for external storage. (Adafruit)
- **Raspberry Pi 1 Model B+:** The Raspberry Pi 1 Model B+ incorporates everything the previously mentioned boards have and more. It has an operating voltage of 5 volts, provides four USB ports, a new Ethernet port, a headphone jack as well as a microSD card socket. Similarly it has 512MB of RAM but it has a smaller CPU, which is rated at 700MHz. (Adafruit)
- **Raspberry Pi 2 Model B:** The Raspberry Pi 2 Model B represents another milestone for single board computers with regards to its hardware. This board comes equipped with 1GB of RAM accompanied by a quad core ARMv7 CPU. Similarly to the previously mentioned Raspberry Pi this board also contains a HDMI port, a headphone jack, a microSD card slot, an Ethernet port and a micro USB slot. (Adafruit)
- **Raspberry Pi 3 Model B:** The Raspberry Pi 3 Model B is their most technically advanced single board computer yet. It possesses a quad core 64-bit ARMv8 CPU rated at 1.2GHz. Another new feature is its built in Wi-

Fi chip along with the built in Bluetooth adapter. This board also has an operating voltage of 5 volts like the previous Raspberry Pi boards. It also boast 1GB of ram like the previously mentioned model. (Adafruit)

Intel Edison

The Intel Edison board was designed to aid developers with regards to the Internet of Things. The main difference between the Intel Edison and the other previously mentioned boards is that it is a System on a Chip (SoC).

- **Intel Galileo:** The Intel Edison board comes equipped with a dual core Intel Atom CPU rated at 500MHz. It also has 1GB DDR3 RAM and 4GB onboard flash storage. Unlike the majority of the previously mentioned boards the Intel Edison has an operating voltage of 3.3 volts to 4.5 volts. This is by far the smallest board of all with dimensions of 35mm x 25mm x 4mm. (Adafruit)

Comparisons

Model	CPU	RAM	Storage	Built in Expandable Storage	Cost	Operating Voltage	Built in USB Ports
Arduino Uno	8-bit Architecture. 16MHz	2KB SRAM	32KB Flash Storage	No	€20.00	5 volts	No
Arduino 101	32-bit ARC Dual Core Architecture. 32MHz	24KB SRAM	196KB Flash Storage	No	€28.65	3.3 volts	No
Arduino Pro	8-bit or 16bit Architecture. 8MHz or 16MHz	2KB SRAM	32KB Flash Storage	No	€13.60	3.3 volts or 5 volts	No
Arduino Pro Mini	8-bit Architecture. 8MHz or 16MHz	2KB SRAM	32KB Flash Storage	No	€9.05	3.3 volts or 5 volts	No
Arduino Micro	8-bit Architecture. 16MHz	2.5KB SRAM	32KB Flash Storage	No	€18.00	5 volts	No

Model	CPU	RAM	Storage	Built in Expandable Storage	Cost	Operating Voltage	Built in USB Ports
Intel Galileo Generation 2	32-bit Intel Architecture. 400MHz	256MB DDR3. 512KB SRAM	8MB Flash Storage	Yes. Up to 32GB	€72.70	3.3 volts or 5 volts	No

Model	CPU	RAM	Storage	Built in Expandable Storage	Cost	Operating Voltage	Built in USB Ports
Raspberry Pi 1 Model A+	ARM 700MHz	512MB		Yes. Up to 32GB	€22.69	5 volts	Yes (1)
Raspberry Pi Zero	1 GHz single core	512MB		Yes. Up to 32GB	€4.55	5 volts	Yes (2 micro USB slots)
Raspberry Pi 1 Model B+	Broadcom SoC running at 700MHz	512MB		Yes. Up to 32GB	€27.24	Powered by 5 volt but operates at 3.3V	Yes (4 USB slots)
Raspberry Pi 2 Model B	Quad Core ARMv7 CPU @ 900MHz.	1GB		Yes. Up to 32GB	€36.33	5 volts	Yes (4 USB slots)
Raspberry Pi 3 Model B	Quad Core ARMv8 64-bit CPU @ 1.2GHz.	1GB		Yes. Up to 32GB	€36.33	5 volts	Yes (4 USB slots)

Model	CPU	RAM	Storage	Built in Expandable Storage	Cost	Operating Voltage	Built in USB Ports
Intel Edison	Dual Core Intel Atom @ 500MHz.	1GB	4GB Flash Storage	Requires a breakout board	€72.70	3.3 volts to 4.5 volts	No

Supported Technologies

Selecting the technologies to implement a project with is possibly the most important choice of all. Fortunately, with major technical advances in recent years, the choice of what languages to use for implementation is not as restricted as it once was with single board computers.

Raspberry Pi

The Raspberry Pi boards offer a wide range of compatible programming languages such as Python, Java, C, Scratch, C++, Ruby which are preinstalled on the Raspberry Pi by default. It is also possible to use languages such as HTML, JavaScript, Erlang and Perl as well as any other languages that can compile on ARMv6 and ARMv7 architecture. (Dikmans, 2015)

Arduino

The Arduino board has its own programming language that is made of a subset of C and C++ functions. Compared to the Raspberry Pi boards the language selection is much more limited. Due to the Arduinos small language selection research regarding this series of single board computers will cease. (Arduino)

Intel Galileo Generation 2

The Intel Galileo Gen 2 offers a wide variety of compatible programming languages like the Raspberry Pi boards. Languages such as C, C++, Python, HTML5, JavaScript and Node.js are a selection of languages that are programmable on the Intel Galileo board. (Intel)

Intel Edison

The Intel Edison offers the same range of potential programming languages as the Galileo Gen 2 board does with C, C++, Python, HTML5, JavaScript and Node.js all compatible with the Intel Galileo. (Intel)

Raspberry Pi vs. Intel Galileo Generation 2 vs. Intel Edison

Raspberry Pi Power Requirements

As part of this comparison the aim is to outline the boards with the least amount of power consumption, most documentation and also the widest range of accessories that can be used on them. The following table illustrates the power requirements for a selection of the Raspberry Pi boards. (Raspberry Pi)

Product	Recommended PSU current capacity	Maximum total USB peripheral current draw	Typical bare-board active current consumption
Raspberry Pi Model A+	700mA	500mA	180mA
Raspberry Pi Model B+	1.8A	600mA/1.2A (switchable)	330mA
Raspberry Pi 2 Model B	1.8A	600mA/1.2A (switchable)	
Raspberry Pi 3 Model B	2.5A	1.2A	~400mA

The power requirements for the Raspberry Pi Zero under certain conditions are as follows (Raspberry Pi):

	Zero (Amps)
Boot	0.20
	0.15
Idle	0.10
Video playback (H.264)	0.23
	0.16
Stress	0.35
	0.23

In terms of powering the Raspberry Pi the best option may be to install a small battery pack with the Raspberry Pi board which is charged using solar powered sensors that are attached to the strap on the cows neck.

Intel Galileo Gen 2 Power Requirements

The output power for the Intel Galileo board with no additional accessories attached is displayed in the table below: (Intel, 2016)

Voltage (V)	Current (A)	Power (W)
7	0.379	2.653
8	0.329	2.632
9	0.294	2.646
10	0.264	2.64
11	0.24	2.64
12	0.221	2.652
13	0.205	2.665
14	0.191	2.674

Intel Edison Power Requirements

The power consumption for the Intel Edison below was taken with the Wi-Fi disabled. The power consumption of the Intel Edison is visibly lower than the Galileo board whilst also being slightly less than the Raspberry Pi Zero. (Intel, 2016)

Voltage [V]	Current [A]	Power [W]
7	0.069	0.483
8	0.055	0.44
9	0.05	0.45
10	0.047	0.47
11	0.046	0.506
12	0.043	0.516
13	0.041	0.533
14	0.038	0.532
15	0.036	0.54

Manufactured GPS Units

There are some notable disadvantages to implementing an animal tracker using a single board computer. One of the main disadvantages of using these computers is providing them with adequate power to be able to collect and transmit the data to the database. There are battery packs available that would be able to supply the single board computers enough power to operate for a short time but then the problem of size is introduced. It should be a priority that the device sits comfortably on the animal but with the addition of battery packs and cases this will become more of a problem.

An alternative to these disadvantages is to use an already manufactured GPS tracker that could be utilized to attain the GPS coordinates of the animal and transmit the data to a database. One possible alternative is the NanoTracker which is manufactured by Round Solutions.

NanoTracker

The NanoTracker is a small portable GPS device that can in theory be used to track anything form vehicles to animals. One major advantage of this device is its compact size of 60mm x 33mm x 13mm when the case is on the device. The device comes with a built in 350 mAh lithium polymer battery that is charged via a micro USB interface. The device is based on cellular technology with a nano SIM required for the device to operate.

The device allows developers to enable/disable certain functionalities based on their individual needs. These functionalities are as follows:

- Geofencing allows the developer to define certain areas where the tracking device leave without a notification being sent via SMS.
- The device has a built in Wellness function that will send an alert when the device hasn't moved for some predefined length of time.
- The device comes with a panic button functionality that can be disabled depending on the purpose of the devices usage.

The device transmits the data via a HTTP Post. The transmitted data contains information such as longitude, latitude, speed, date, time and battery voltage. The device contains an onboard accelerometer which is used to detect when there is any movement as well as for power saving measures.

The NanoTracker is quite a configurable device. It is possible to configure the intervals between data transmissions. The datasheet for the device states that obtaining and transmitting the device position every five seconds will require the battery to be charged after approximately two hours whereas if the device is configured to transmit the data every thirty minutes the battery will last approximately 43 hours.

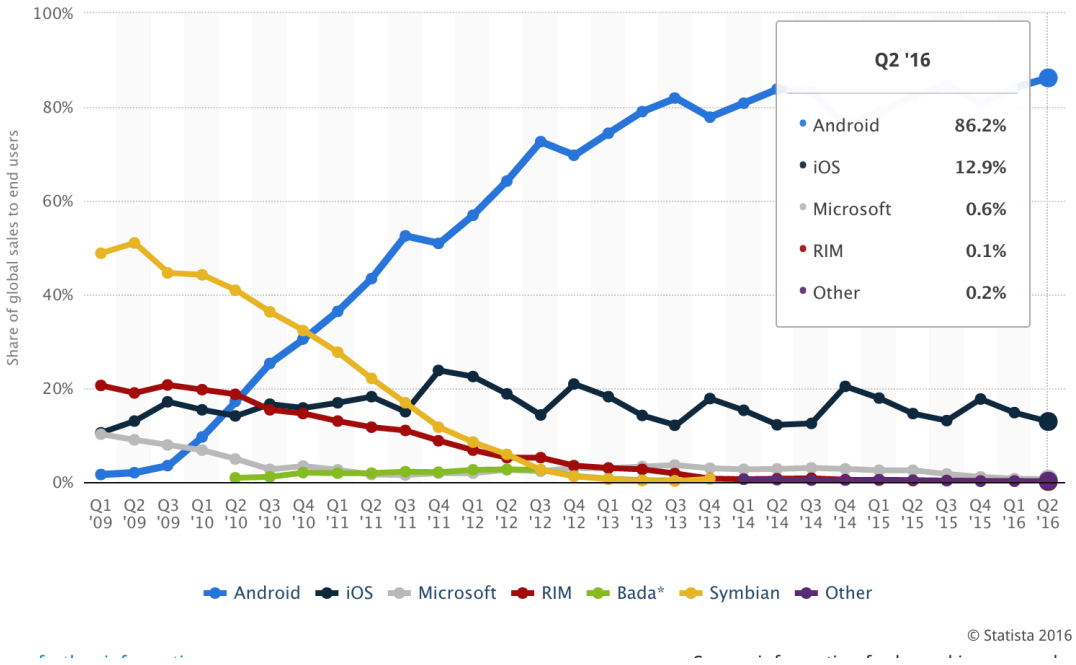
Depending on your region the device will support 2G, 3G or 4G technologies that can give GPS coordinates that are accurate up to two meters. Round Solutions also provide software development kits for the NanoTracker which is written in Python 2.7.2. (Round Solutions)

Application Platforms

From the research obtained in previous sections of this document it is evident that the majority of the available animal wearable's work across a variety of platforms from mobile to desktop. As this product is aimed at the agricultural sector which has seen smartphone usage surge in recent years, in principle this should at the very least run on mobile devices. (Potter) This then leads to the question of which mobile operating system to develop the application for? To determine the solution to this the advantages and disadvantages of each mobile operating system will follow.

Android

Android is an open sourced operating system based on the Linux kernel which was developed by the Open Handset Alliance. The first version of Android, version 1.1, was released in February 2009. Android applications are predominantly written in the java programming language accompanied by the android SDK. Android had an 82.6% market share in terms of sales at the end of the second quarter in 2016 as displayed in the following graph. (Statista)



iOS

iOS is the operating system that was developed by apple specifically for their iPhones that were first released in 2007. iOS applications are programmed in primarily in objective C along with HTML, JavaScript and CSS for the frontend. Apple also introduced the swift programming language that makes it easier to develop apps due to its more readable syntax. (Rundle)

Mobile Application Development Frameworks

Mobile application development frameworks offer a different approach to developing applications by enabling the programmer to create hybrid applications using web technologies like HTML, CSS and JavaScript for example. Not only do they remove the strain of having to learn android of swift programming languages and therefore having to develop the same application twice, but they also enable the programmer to port their application to any mobile operating system.

There are several Mobile Application Development Frameworks available that will be analyzed below to determine the best option for the developing this application.

Adobe PhoneGap

Adobe PhoneGap is a mobile application development framework that enables programmers build hybrid applications using HTML, CSS and JavaScript that are compatible with multiple mobile platforms. Adobe PhoneGap also provides a Developer Mobile App that allows the programmer to test their application on a connected mobile device without having to reinstall their application to see the changes that have been made. (Adobe PhoneGap)

Adobe PhoneGap also provides a service called Adobe PhoneGap Build that is used for compiling and building your apps in the cloud. By submitting the code files in a zip folder Adobe PhoneGap Build compiles and builds your app using the latest SDK's for your target mobile operating systems after which it returns the URL's to the deployment bundle for the target mobile operating systems.

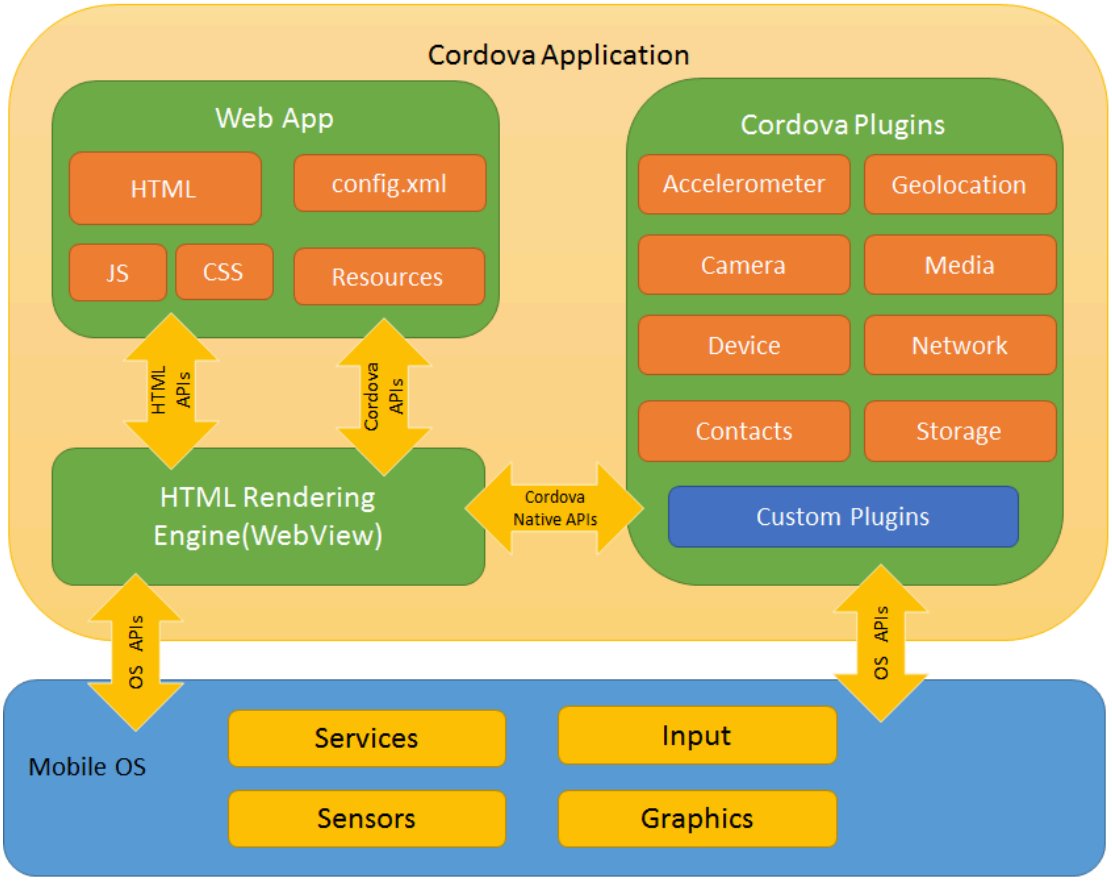
Ionic

Ionic is an open source mobile application development framework that enables programmers build hybrid applications using HTML, CSS and JavaScript that are compatible with multiple mobile platforms. Ionic also requires a working knowledge of AngularJS to develop applications. The ionic framework is intended for front end development which is then integrated with the intended backend technologies for the application. (Tutorialspoint)

Apache Cordova

Another mobile application development framework available is Apache Cordova. Apache Cordova, which Adobe PhoneGap is based on, is an open source mobile application development framework that predominantly uses the same technologies as the previously mentioned frameworks, utilizing HTML5, CSS3 and JavaScript. Apache Cordova has a unique feature where there are API's readily available for implementing simple features such as displaying battery

status or adding notifications to the notifications bar at the top of the screen on a mobile device. The following image illustrates how an Apache Cordova application integrates with a mobile device: (Apache Cordova)



Databases SQL vs. NoSQL

A databases main function is to store vast quantities of data that can be retrieved and manipulated at any time. There are two main types of databases, SQL and NoSQL databases. The main difference between SQL and NoSQL is their method of data storage. In SQL the data is stored in tables that with each column having a specified data type. In a NoSQL database the data is stored in a document that can hold any type of data, there are no requirements to create a specific schema. (Buckler, 2015)

Advantages of SQL

- One of the major advantages of SQL is the availability of the JOIN operation. The join operation allows the user to add or retrieve information from more than one table using the JOIN operation.
- SQL databases are widely used meaning there is endless information available to anyone trying to work with them.
- SQL databases support transactions, which improve data integrity by ensuring that multiple updates that are being applied to tables either succeed or fail.
- Ability to create stored procedures for database calls that are made regularly.

Disadvantages of SQL

- Queries can become long and complex with the inclusion of JOIN statements in the query. Nested queries can also cause more complexity.
- More thought required for initial setup of an SQL database as you have to define the data types for each field in each table.

Advantages of NoSQL

- No schema required for the database.
- Starting to become more popular despite their existence since the 1960's.
- Faster at data retrieval as there's no need for complex queries with JOIN statements.

Disadvantages of NoSQL

- Not as commonly used as SQL databases so less support available.

SQL Database

MySQL

MySQL is a free relational SQL database provided by Oracle. As it is an SQL database the data is stored in a tabular format using tables with specified data types for each column in the table.

Advantages of MySQL

- One of the main advantages of incorporating MySQL into any project is the availability of support for such a database system due to its popularity.
- Requires little knowledge to setup a MySQL database partly because of the previous point.
- Supported by most platforms meaning it can be integrated into most projects.

Disadvantages of MySQL

- No longer open source meaning patches are not released as often.

NoSQL Database

MongoDB

MongoDB is an open source document based database system. As MongoDB is a NoSQL database system the data is stored in documents. (TutorialsPoint)

Advantages of NoSQL

- One of the main advantages of incorporating NoSQL into any project is the scalability it can provide.
- Documents have dynamic schemas meaning there is no requirement for any specific requirements in the collection of documents.

Disadvantages of NoSQL

- As NoSQL databases are only starting to come to prominence, there is less information available compared to MySQL.

Conclusion

Based on the research gathered it is suggested that the project will commence using the Adobe PhoneGap application development framework. This was the chosen application development framework because of the authors existing experience in HTML, CSS and JavaScript. The decision was also based on the vast quantity of information that is available regarding Adobe PhoneGap framework in general and the plugins available for it. When making the decision of which application framework to use, it was also noted that Ionic required AngularJS which would have added more complexity to an already steep learning curve.

It is also suggested that a MySQL database be used throughout the project. This decision was based on the tabular nature of the data and the authors prior experience with this database technology. Similarly to the choice of application framework, the vast quantity of information available was also a deciding factor in the choice of database technology.

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