

Group Name: Group 4

Group Members: Nguyen Hong Lam – 470538184, Tamara Rogers – 480566494

Smart Collar for Pets an IoT Application

Summary

This report encloses an enhanced product available to help enrich the quality of lives of cats and dogs and establish an additional communication between pets and the owners. The Smart Collar device running is an IOT application which will process existing information about pets, process and alert the pet owners in the time of pet protection needed. The device is expected to provide quality product while promoting the importance of pet living standard in modern era.

Introduction

The Internet of Things continues to expand its reach. Every day, there is a new product using the cloud, big data, or internet connectivity to deliver capabilities once thought they were impossible. It was only a matter of time before the pet industry found their niche as well with pet specialized technologies.

Needs for love does not come only from people pets also can be a source of unconditional love. Pets are not considered as wild life animals any longer they are as close as a family member. They certainly have an effect on emotional and mental wellbeing of the pet owners. Therefore, their health and wellbeing are as important as the human beings. Furthermore, the global pet industry is nearly a \$70 billion industry in2017, with \$30 billion spent on pet food alone. Pet care market size is expected to worth \$202.6 billion by 2025. [1]

The increasing in demand for pets determines the need for supply and development in said industries. Many people can see the use of keeping cattle: they serve as food for people. But the concept of keeping pet is only established in modern time when people are well-off and starting to further improving their live quality, thus improving their surrounding environment quality. The most common reasons for keeping pets are:

- Companionship.
- Socialization.
- Entertainment.
- Protection.
- Service.

Pet play an important role in many people's lives no matter what the purposes are. In addition to seeing-eye dogs like Australian Guide dog and dogs that can be trained to detect seizures, dogs can also be used in occupational therapy, speech therapy, or physical rehabilitation to help patients recover. Aside from these designated therapeutic roles, dogs are also valued as companions, which can certainly affect the quality of human lives. Is that companionship beneficial to our health?

Many people have pets to substitute relationships with partners, children or family members. Many elderly people for instance, like having a dog instead of being all alone at home. This could be a lap dog, very affectionate and caring. The animal serves people's need to cherish, love and fight boredom. The pet keeps them from pining and they have been bred especially for their needs. Pets make socializing with others easier. People are more inclined to start a conversation when they can focus their attention on the animal in a moment of silence. Just like with any other hobby, it's nice to talk to people that have the same hobby. People in developed country generally treat their pet as another family member, thus making the pet market flourished in recent years.

Problem

In absents of the pet owners monitoring the health routines of the pet has become crucial. The absence is not always the attendance at work or studies, it sometimes comes from human negligence at the time when they have locked the pet inside their vehicle. In situations arise, people just require a bridge between them and their pet to effectively minimize such risks happening or reduce the consequences.



Figure 1 Common problems

Global Impact of pets

Global impact of having a household pet is a vast subject however this report is addressing the most significant aspects for the current and future impacts of its global effects. It would be hard to quantify the precise social and economic impact of pets but it is clear that our animals have a positive effect on many aspects of our lives. The better we understand the human-animal bond, the more we can use it to improve people's lives. To summarize what is known and not known about how pets help improve the health and well-being of people, and what the implications might be for helping people who don't have pets of their own. Most people think of their pets as members of the family. Some research studies have found that people who have a pet have healthier hearts, stay home sick less often, make fewer visits to the doctor, get more exercise, and are less depressed. Pets may also have a significant impact on allergies, asthma, social support, and social interactions with other people.

- Pets and Human Society

The authors of the report stress that this is only an estimate and that further research is required. But it seems likely that pets are saving the National Health Service a huge amount of money. The report also emphasizes the many ways in which pets enhance their owner's lives and contribute to society. Guide dogs, hearing dogs and the many animals who help people with physical and mental challenges such as autism, all make a significant contribution to human society.

- The guide dog are alike human eyes

Every hour of every day, an Australian family learns that their loved one will have severe or permanent sight-loss. Nine of these Australians will eventually go blind. It is estimated that there are over 450,000 Australians who are blind or have low vision and this number is expected to raise to significantly increase with an ageing population. [2]

Guide Dogs Australia in collaboration with its state-based organizations, deliver essential services to children, teenagers, and the elderly who are blind or have low vision in every State and Territory across Australia. The mission is to assist people who are blind or have low vision gain the freedom and independence to move safely and confidently around their communities, and to fulfil their potential.

- Detector dogs help protect Australia's border

Detector dogs are trained to find prohibited and restricted goods. They can check people, products and large areas quickly, without discrimination or intrusion. Other government law enforcement agencies also use detector dogs. [3]

- **Pets Impact on Physical Health**

Companion animals may improve heart health by lowering blood pressure and regulating the heart rate during stressful situations. In a 2002 study, researchers measured changes in heart rate and blood pressure among people who had a dog or cat, compared to those who did not, when participants were under stress (performing a timed math task). People with a dog or cat had lower resting heart rates and blood pressure measures at the beginning of the experiment than non-pet owners. People with a dog or cat were also less likely to have spikes in heart rates and blood pressure while performing the math task, and their heart rates and blood pressure returned to normal more quickly. They also made fewer errors in their math when their pet was present in the room. All these findings indicated that having a dog or cat lowered the risk of heart disease, as well as lowering stress so that performance improved.

- **Reducing the Burden on the National Health Service**

The scientific studies from the last twenty years to assess how pets effect human health. They found that dog owners walk far more than non-dog owners and that they suffer from significantly less minor health problems. Older dog owners are twice as likely to maintain good mobility as non-dog owners. Pet owners in general have lower blood pressure and lower cholesterol and boast a better survival rate following heart attacks.

If pet owners are healthier then they place less burden on the health service as they make fewer visits to their doctors and to hospitals. There have been several studies around the world which have attempted to quantify the savings.

- **Animal (pets) assisted therapy**

Researchers have also used animals to temporarily provide companionship to children with health or mental health problems, or elderly people who may not have the energy or resources for a live-in pet. While these studies do not always have consistent results, some positive findings of interacting with a therapy dog include reduced levels of pain and anxiety among hospitalized children and adults, as well as increased focus and interaction among children with autism and other developmental disorders. In nursing home settings, interaction with visiting dogs has led to more social behaviours, more interaction among residents, and less loneliness. While research on animal-assisted interaction and therapy is not always consistent and is often done with small groups of participants, there is some evidence that interaction with a companion animal even for a short time might have a range of benefits. The fact that animal assisted therapy has been used for many years, According to Alzheimer's disease International, the worldwide costs of dementia in USA alone amounted to more than 1% of the global gross domestic product in 2010. The worldwide cost have \$1 trillion in 2018. Currently, over 46 million people are living with dementia. By 2050, this number will have risen to 131.5 million. Furthermore, dementia patients have increased healthcare utilization rates compared with patients with other major diseases. Research shows that informal costs make up a substantial part of the total annual costs of dementia. [4]

- **Mental Health**

Pets also impact our mental health. Pet owners feel less lonely and report feeling happier than those without animals. A strong bond with a pet has been shown to ease depression associated with bereavement. Studies have found that childhood exposure to pets reduces the incidence of allergies and asthma.

- **The Bottom Line of Global Impact of Pet ownerships and healthcare**

The research findings are encouraging, so it makes sense to conduct more studies on how human-animal interaction influences our health. We don't yet know precisely what types of animals influence what types of health issues (physical, mental, and social well-being) and what characteristics about human-animal interaction are most important. People who have pets know that there are many benefits to having a companion animal, but we do not yet know under what circumstances those benefits are most likely. If research shows specific health benefits under specific circumstances, that information can be used to change policies in ways that benefit even more adults and children, by influencing rules and regulations for schools, health or assisted living facilities, residential treatment centres, and other places where people's

exposure to animals is sometimes discouraged but could potentially be encouraged. Therefore all above mentioned advantages of pet ownerships wins the lion's share over the disadvantages of the pet meat consumptions globally. [5]

Global Impact of negligence of pets

The first and foremost subject to consider for the main impact is the cost. As Australia in 2016, 62% of Australian people have one pet at least. The number of pets left alone in Australia is estimated to be around \$6 million and 623,979 pets whom left alone each day. Further research confirms that to hire a pet sitter each day costs minimum \$40 each day therefore it will cost an average of \$265 million Australian dollars a day and 9×10^{10} a year to hire a pet sitter for the left alone pets. Our product aim is to significantly minimize the cost of pet health and caring bill. [6]

The second aspect is the emotional attachment, it is true that money can buy a lot of things but there are things that we can't simply trade for it. The bonds between the owners and the pets are undeniable thus raising such job as veterinarian which did not existed until modern era, the reason people spend money for their pet is the same reason why most people wear protective equipment or planning healthcare services: they treasure their pet as well as their well-being. Smart Collar's purpose is to avoid or reduce these unfortunate event by adding an extra layer of protection.

Finally, by improving the pet's life quality, the pet owner's life quality is also increasing which is the purpose of many existing technology or research in our modern life.

New Product Idea

In our introduced product, constant health record is monitored and in the case of an emergency resulted from an unusual increase in the distance from home or undesired temperature raises or drops, an alert would be send to the owner. In the case of the need for protection the pet owner can assist the pet immediately. The design considerations of Smart Collar aims to meet customer need. The product is designed not only for the end users the pets, but also for the pet keepers.

- GPS location

In Smart Collar, a GPS module will be installed in the collar for tracking and recording the activity of the pets. It satisfies the needs of pet owners whom could not stay with their pets at all times because of work, study, or holiday, but still want to know the status of their pets. Moreover, the pet keeper could receive alert as a message if the range of pet activities exceeds the predetermined safe areas. To some extent, the loss of pets could be avoided or minimized.



Figure 2 Product main concepts.

- Ambient temperature alert

The safety of pets may be threatened for careless actions by their keepers. For example, some dog keepers may lock their dogs in the car and leave for shopping. Prolonged stay in confined spaces and extreme temperatures may result in the death of a pet. The temperature sensor inside the collar can detect and record the ambient temperature, and send alert to the owner if the detected temperature is over the set threshold that may cause the pet to feel uncomfortable.

- Additional features

In addition, a LED light will be on the Smart Collar for visibility at night. And the fabric of the smart collar will be made from leather waterproof materials, considering some usage scenarios may involve water-related activities. The GPS can be recorded as requested to

- Market sample

According to the survey, the willingness of the respondent in our survey to purchase Smart Collar was around 70 percent out of 46 people, therefore, it indicates a promising market for Smart Collar.

Competitive Advantages of The New Product Idea

The mission statement of the new product idea inculcates vision to the future new product development is to make effective and smart products and services that improve the quality of life of pets and help to take care of pets' health conditions; through extensive research, development and efficient production procedures.

Throughout Australian market research the most competitive existing product in pet's GPS are Link AKC and Findster Duo+ with these features can be summarized in the following table:

Table 1 Comparison between products

Features	Smart Pet Collar	Link AKC	Findster Duo+
GPS	✓	✓	✓
Safety Range	✓		✓
Tracking History	✓		✓
Activity Level	✓	✓	✓
Temperature Sensor	✓	✓	
LED	✓	✓	
Waterproof	✓		
Alert System	✓		
Retail Price	\$149	\$179	\$209

The main competitive advantages Smart Collar provided are a more affordable price with combined technology and an alert system. The main concept that our product provide is an IoT application which means user can interact and control their devices dynamically rather than passively using them. In addition, as an IoT device, our product can acknowledge existing information about the pets and process the information then decide to provide the buyers with useful information. Our product is expected to be a pioneer in IoT application in smart technology for pet collar.

We also believe that at the current state of the market which is rather newfound, these company monopolize the market and pushing the price to their favours which will incent new competitors to provide quality products in said market. The most prominent example is Apple in smart phone market.

Development Process

In development aspect, within our skills and devices limitation, we have built a prototype version of our introduced product. There are still some desired improvement but the main concept was finished.

Preparation

In addition to our provided Raspberry Pi 3B, the project requires an additional GPS module to provide the GPS coordinate as known as latitude and longitude. We have bought the item and connected the device through an USB cable to our rpi.

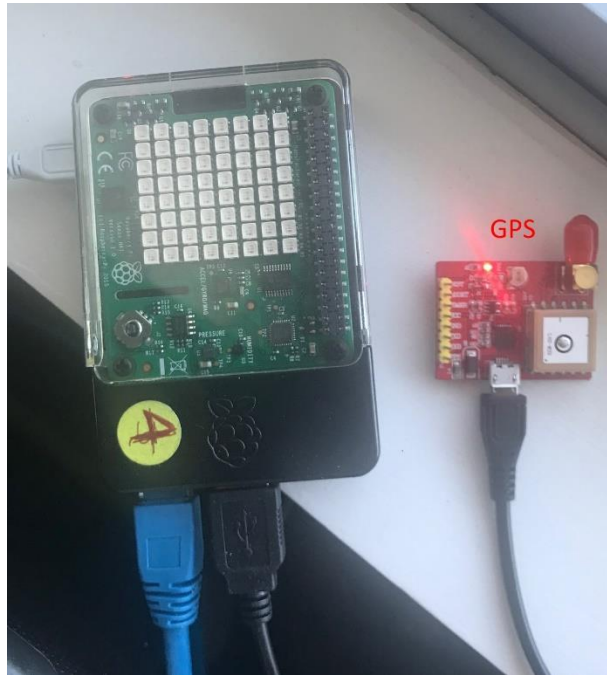


Figure 3 Equipment setup

Furthermore, we also need to setup an alert service through IFTTT's Applets application linking to Thingspeak's HTTP to automatically sending a message to our mobile in case a certain threshold is reached. In our project, it's the ambient temperature and the distance calculated from home to the provided GPS.

Development

In order for the rpi to function with the GPS module, we need to install the gpsd package from the main server using wireless connection to personal router/hotspot and set the default gateway to the router/hotspot's IP address. After that, we initiate the GPS module (Model: SKU:EZ-0048) through some command lines. The GPS in this case is rather insensitive and needed to put in roofless area and waiting for roughly 10 minutes before it can receive the signal from the satellite. This process costed us a large amount of time in our project due to the lack of knowledge in existing devices as well troubleshooting the connectivity's compatibility. We can see the data provided below:

```

pi@raspberrypi-QibH7OCPMx: ~
lqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqkllqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqk
x   Time:      2019-05-28T05:35:35.000Z   xxPRN:   Elev:   Azim:   SNR:   Used: x
x   Latitude:   33.890078 S               xx   3    70    353    15     Y   x
x   Longitude:  151.181381 E              xx  23    61    201    00     Y   x
x   Altitude:   60.2 m                    xx  16    51    073    23     Y   x
x   Speed:      1.9 kph                   xx  22    47    012    14     Y   x
x   Heading:    8.9 deg (true)             xx  26    41    116    32     Y   x
x   Climb:      0.0 m/min                  xx   9    29    237    12     Y   x
x   Status:     3D FIX (10 secs)           xx   7    22    297    18     N   x
x   Longitude Err: +/- 13 m                xx   6    11    235    14     N   x
x   Latitude Err: +/- 16 m                xx  31    09    129    40     N   x
x   Altitude Err: +/- 21 m                xx   1    08    337    00     N   x
x   Course Err:  n/a                      xx 193    00    000    00     N   x
x   Speed Err:   +/- 116 kph              xx                      x
x   Time offset: -28.618                   xx                      x
x   Grid Square: QF56oc                    xx                      x
mqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqjmqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqqj

```

Figure 4 Data from GPS module

Then we need to record this GPS value and feed the data into MATLAB in 60s interval loop to continuously calculate the distance from GPS to Home to input Thingspeak Channel.

In order to send the data, a short c code from user manual with some modification is compiled to send one latitude and longitude coordinate at a time. However, whenever recalling the code, the GPS took some time to start and the first three iteration will always fail to send signal, therefore, we setup to 4 iterations to catch the necessary information.

```

pi@raspberrypi-QibH7OCPMx:~ $ sudo ./gps
no GPS data available
no GPS data available
no GPS data available
latitude: -33.889567, longitude: 151.181022, speed: 0.391000, timestamp: 1559055
778.000000

```

Figure 5 Retrieved data

After that, we perform system call in MATLAB to receive the data as a string text and extract the necessary first seen latitude and longitude to perform the calculation.

```
gps = system(myрпи, 'sudo ./gps');
```

As an additional implementation, we can perform a history tracking and pinpoint them into a google map by increasing the recorded GPS data to desired number. As in this map, our home location is green dot and the GPS are red dots.

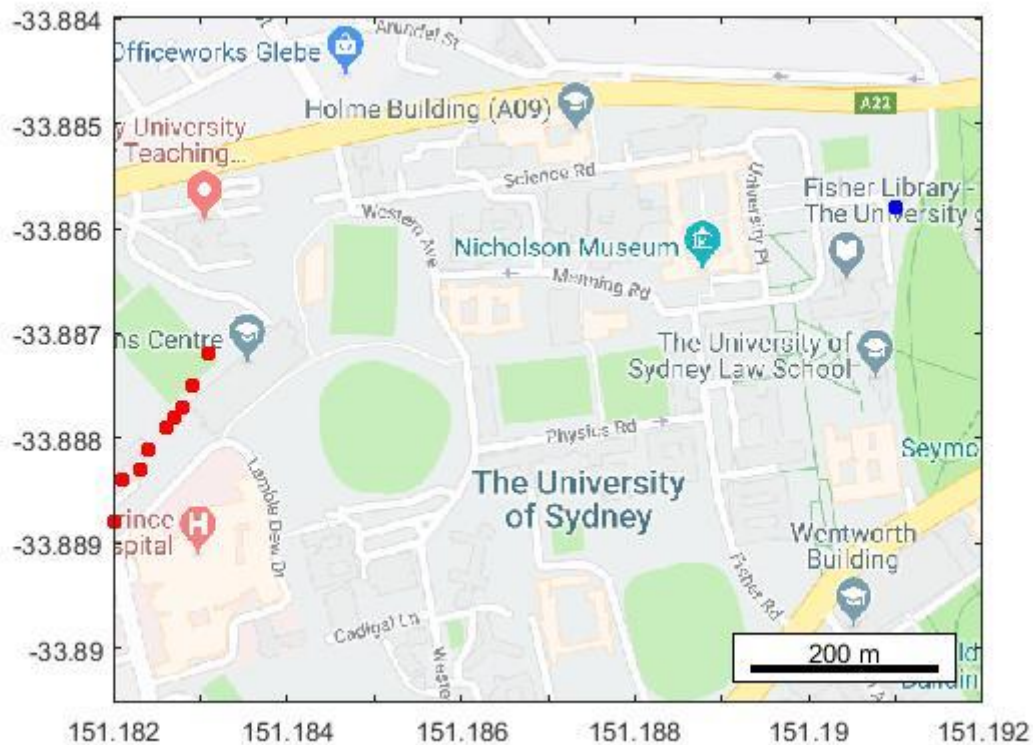


Figure 0 Google map of current location and GPS

The temperature sensor and alert system are functioning as lab exercises. The final tracking can be seen in Thingspeak channel as below:

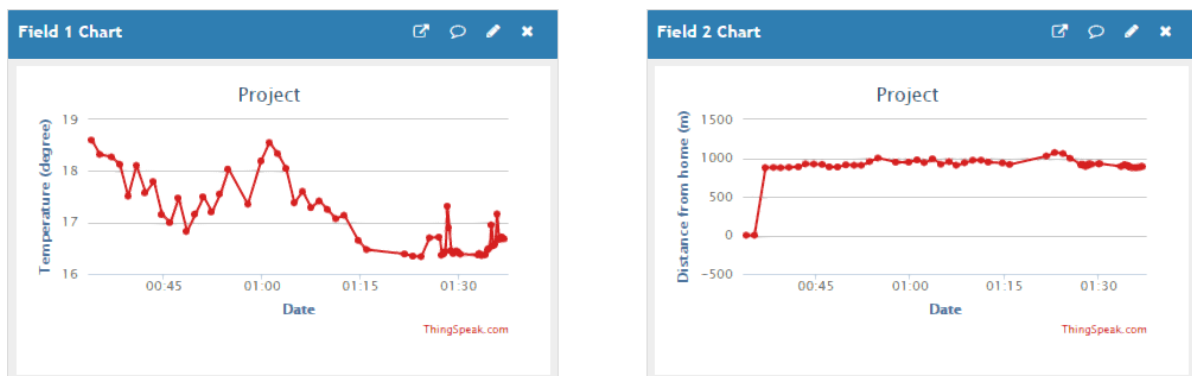


Figure 7 Thingspeak channels

When the threshold is exceeded, Thingspeak will generate a signal to IFTTT server to initiate the SMS service to send us a message as following:

Assumption & Further development

As a prototype, there are several assumptions that we need to include:

- The battery of this project is excluded due to existing wired power supply, however, to make this product functions we need decent battery quality as most of current competitors provided 3 days lasting with normal usage. This solution can be solved by providing a portable battery to our rpi.
- The connection in our case is Wi-Fi but in order to work with long range distance, a 3G communication is needed to implement the product.

- The used GPS module is rather weak under roof so a better GPS module might be needed if we want constant signals from GPS.
- The power issue also limit our ability to test as the GPS moving in realistic scenario, thus, we modified our home location to another spot and tested if the distance exceed the distance threshold to notify into our mobile. However, the device should work if it's under battery powered and within WiFi range or 3G range in ideal model.

Conclusions

As we are in the modern era, the well-being of people does not only include themselves but all the things surround them that including their pets. Their problem as well as global impact of the problems are also within our concern.

In this project, we introduced an IoT product that invade the current newfound pet caring market. The product is expected to perform well under current infrastructure as well as being a pioneer in the smart pet collar area. The prototype of this product performed as expected under a few assumption due to limitation of the current scope. However, possible improvements was proposed as future scope allows. In general, the current potential market and the solution to the problems of this market are introduced, analysed and solved successfully as a group project in an IoT application.

References

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- [6] RSPCA. [Online]. Available: <https://kb.rspca.org.au/knowledge-base/how-many-pets-are-there-in-australia/>. [Accessed 29 5 2019].

Appendix

Requires additional built-in function:

`plot_google_map.m`

https://www.mathworks.com/matlabcentral/fileexchange/27627-zoharby-plot_google_map

```

clear
clc
% Initial Setup
ChId = 740657;
writeKey = 'YM65F3J5U61LQPFJ'; %replacing it with your channel ID
ReadKey = 'AXTL8VGY370QHUT6'; %replacing 'key' with your Write API key
myrpi = raspi('169.254.0.2','pi','raspberrypi');
mysensehat = sensehat(myrpi);

% Home Configuration
home_latlon = [-33.8858 151.191]; %Uni avenue
% home_latlon = [-33.88703 151.18090]; %Home
safe_dist = 300;

for i=0:10
    % Acquire GPS data from rpi
    gps = system(myrpi, 'sudo ./gps');
    latLocations = strfind(gps, 'latitude');
    longLocations = strfind(gps, 'longitude');
    lat = str2double(gps(latLocations+10:latLocations+19));
    long = str2double(gps(longLocations+10:longLocations+20));

    % Calculate distance
    pet_latlon = [lat(1) long(1)];
    dist = lldistkm(home_latlon,pet_latlon);
    dist_m = dist*1000;

    %Acquire Temp data from rpi
    temp1=readTemperature(mysensehat,'usehumiditysensor');
    temp2=readTemperature(mysensehat,'usepressuresensor');
    temp = (temp1+temp2)/2 - 273;
    cpu_temp_str=system(myrpi,'vcgencmd measure_temp');
    cpu_temp = sscanf(cpu_temp_str,'temp=%fC');
    temp_calibrated = temp - ((cpu_temp - temp)/1.2);

    displayMessage(mysensehat,round(temp_calibrated,0),'ScrollingSpeed',0.2);

    %Write Thingspeak
    thingSpeakWrite(ChId,[temp_calibrated,dist_m],'Fields',[1,2],...
        'Writekey',writeKey);

    %Update every 60s
    pause(1);
end

% lat_map = [-33.8858 -33.8888 -33.8884 -33.8883 -33.8881 -33.8879 -
33.8878 -33.8877 -33.8875 -33.8872];

% lon_map = [151.191 151.1820 151.1821 151.1823 151.1824 151.1826
151.1827 151.1828 151.1829 151.1831];
% plot(lon_map(1), lat_map(1), '.b', 'MarkerSize', 20)
% hold on
% for i=2:10
%     plot(lon_map(i), lat_map(i), '.r', 'MarkerSize', 20)
% end
% plot_google_map('MapScale', 1)

```

```

#include <gps.h>
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <math.h>

int main() {
int rc;
struct timeval tv;

struct gps_data_t gps_data;
if ((rc = gps_open("localhost", "2947", &gps_data)) == -1) {
    printf("code: %d, reason: %s\n", rc, gps_errstr(rc));
    return EXIT_FAILURE;
}
gps_stream(&gps_data, WATCH_ENABLE | WATCH_JSON, NULL);

int i=0;
while (i<4) {
    /* wait for 2 seconds to receive data */
    if (gps_waiting (&gps_data, 2000000)) {
        /* read data */
        if ((rc = gps_read(&gps_data)) == -1) {
            printf("error occured reading gps data. code: %d,
reason: %s\n", rc, gps_errstr(rc));
        } else {
            /* Display data from the GPS receiver. */
            if ((gps_data.status == STATUS_FIX) &&
                (gps_data.fix.mode == MODE_2D || gps_data.fix.mode ==
MODE_3D) &&
                !isnan(gps_data.fix.latitude) &&
                !isnan(gps_data.fix.longitude)) {
                //gettimeofday(&tv, NULL); EDIT: tv.tv_sec isn't
actually the timestamp!
                printf("latitude: %f, longitude: %f, speed: %f,
timestamp: %lf\n", gps_data.fix.latitude, gps_data.fix.longitude,
gps_data.fix.speed, gps_data.fix.time); //EDIT: Replaced tv.tv_sec
with gps_data.fix.time

```

```
        } else {  
            printf("no GPS data available\n");  
        }  
    }  
}  
i++;  
sleep(3);  
}  
  
/* When you are done... */  
gps_stream(&gps_data, WATCH_DISABLE, NULL);  
gps_close (&gps_data);  
  
return EXIT_SUCCESS;  
}
```