SICK BIRDZ

Group 10

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Chapter 0: Introduction

Wildlife monitoring plays an essential role in the maintenance and conservation of natural ecosystems around the globe. Due to rapid increases in technology in the last 100 years, humanity's impact on the planet is already irreversible, but it can be mitigated through the research and analysis of different ecosystems. One such issue is the impact of feral and domestic cats on local prey animal populations, specifically birds. Cats are incredibly resilient and invasive animals, and were brought all over the world as early as 9,000 years ago from Egypt on trade routes. Nowadays feral and domestic cats can be found all over the world, in urban and rural environments, hunting and killing small birds and rodents. According to the local sources, wild cats are playing a major part in disturbing the 'ecological balance' by killing some of the endangered species (meadow birds)[1]. Wistfully, the only solution that was proposed by local authorities is by sterilising these cats. However, since this solution is expensive and time consuming, a monitoring system to collect large amounts of data on cats would be ideal[2].

The "Bastet" RFID tracking system uses an interconnected web of beacons and smart collars to monitor the positions of tagged cats in a set area, although using a modular approach would allow almost exponential growth of the active network by adding in more detection beacons over a wider area of land. At a very basic level this would allow data to be cross referenced with data collected by avian conservation societies in the area of operation to monitor how the position of feral and domestic cats affects bird populations. However,

[1] Trouwborst, A. and Somsen, H. (2019) "Domestic cats (*felis catus*) and European Nature Conservation Law—applying the EU birds and habitats directives to a significant but neglected threat to wildlife," *Journal of Environmental Law*, 32(3), pp. 391–415. Available at: https://doi.org/10.1093/jel/eqz035.

[2] Nederland, V. (no date) *Standpunt Huisdieren en Wilde Vogels*, *Vogelbescherming*. Available at: https://www.vogelbescherming.nl/over-ons/standpunten/standpunt-huisdieren-en-wilde-vogels (Accessed: January 12, 2023).

changes can be made to the system to allow a more in depth analysis of feline behaviour, such as bird decoys to log cat hunting patterns, infrared homing cameras to monitor bird movements around the beacons, and sonic repellents to dissuade cats from hunting near beacons.
To have more accurate and meaningful data on the impact that cats make to bird colonies a collaboration with team Group 7 *Rangers* is going to be performed as the addition of relevant data about *Bird species and their specific amount* in a similar area of investigation as us. The complete data set that will be collected will make it easier to analyze and view any correlation with the birds population and the cats. Both the teams will be sharing their own data that was collected and also share some of our general knowledge and research.
This report contains a detailed analysis of wildlife issues around the globe, such as projects including systems which use audio, visual, and radio sensors to monitor species in different environments. Accompanying these issues is a breakdown of common problems addressed in by wildlife monitoring, and a narrowing of important issues to focus on as a group. From this breakdown a final issue is expanded on in chapter 4, including a brainstorm of potential solutions to the problem, taking inspiration from projects analysed in chapter 1. Finally, the report contains the system to be used in monitoring cat movements, as well as differences between the minimum viable product and a more advanced version of the system, a sort of "Bastet 2.0."

Index

Chapter 1:

Find 20 meaningful publications on the general subject of wildlife monitoring. Make a summary of each publication.

Christopher Sta. Maria Nase 2654369

[1] Sound Activated Wildlife Capturing

Conclusion - Non manned tracking cameras are a viable alternative to stationing people with cameras out in the wild

Having people out in the wilderness with cameras stalking creatures is rather costly and can often scare away the wildlife that aims to be captured. As an alternative to this, a simple cost effective combination of a raspberry pi, two microphones, an ultrasonic sensor, a camera, and a servo were used to make a tracking system to turn the camera in the direction of the incoming sounds. Should no sounds be made, the ultrasonic sensor allows for the camera to trigger when a creature passes by, functioning as a simple “camera trap”. Combining these techniques with the capability of RasPis to connect with wifi, the data could be sent forward to the emails of the researchers.

Problem Noticed : Due to the energy demands of the raspberry pi and the utilization of wifi for transmission, this technology has lots of room for optimization.

[2] Edge AI as low power low cost low maintenance solution of elephant monitoring

Conclusion - Edge AI platforms such as the Jetson nano allow for a flexible low power option for monitoring wildlife

One of the key issues when it comes to conservation efforts is the means of monitoring. One common technique is camera traps, in which cameras are set up along high traffic routes and pictures are taken whenever motion is detected. This uses not only alot of power but also requires someone to go out and both retrieve the data and replace the battery. Edge AI solutions along with the utilization of audio analysis allow for on site data processing and transmission using limited power, possibly even solar power!

Problem Noticed: The technology being used here is very expensive. Also, the utilization of triangulation requires very accurate time stamps to determine when the sound reached the microphones.

[3] Correlation between an increase in road traffic and road kill incidents

Conclusion - The more traffic there is, the less likely it is for an animal to get killed as they will avoid the road.

Wildlife barriers are often placed along roads with higher traffic volumes in an attempt to keep nearby animals safer from the perceived higher risk. Although well intentioned, there is not actually a higher risk as the animals will avoid these roads due to the constant noise and perceived increase threat of it. The issues mainly lie in roads with lower traffic volumes as animals will attempt to cross them and will be shocked when they do encounter a car or the like due to the infrequent nature of vehicles. This report argues that prevention methods should mainly be placed along roads with less than 5000 cars crossing per 24 hour time period.

[4] Hedgehog population density in urban environments

Conclusion - Lack of predation and more plentiful food supplies increased their population.

Urban areas tend to have a higher population density of Hedgehogs than rural/wild ones due to the combination of some key factors. Firstly, the lack of predation from badgers within urban environments allows hedgehogs to reproduce more freely. Secondly, the availability of human made foods from pets (i.e. cat and dog food) allows for a more nutritionally dense food source. Lastly, the presence of both agriculture and gardens means that even their natural food source (earthworms) is far more readily available. This phenomena is paralleled in the increase of birds of prey and even deer within urban/suburban areas.

[1]
S. Kumar, S. Sushmitha, M. Sirisha, P. Assistant, και S. J. Roopashree, 'Sound Activated Wildlife Capturing; Sound Activated Wildlife Capturing', *2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, 2018. Available: https://ieeexplore.ieee.org/document/9012357

[2]
st D. Schwartz, nd J. M. G. Selman, rd P. Wrege, και A. Paepcke, 'Deployment of Embedded Edge-AI for Wildlife Monitoring in Remote Regions 4 th'. . Available: http://ilpubs.stanford.edu:8090/1169/1/elephants_embeddedWithAuthors.pdf

[3]
C. Grilo, F. Z. Ferreira, και E. Revilla, 'No evidence of a threshold in traffic volume affecting road-kill mortality at a large spatio-temporal scale', *Environmental Impact Assessment Review*, τ. 55, σσ. 54–58, 11 2015. Available: https://www.sciencedirect.com/science/article/pii/S0195925515000621

[4]
P. Hubert, R. Julliard, S. Biagianti, και M.-L. Poulle, ‘Ecological factors driving the higher hedgehog (Erinaceus europeaus) density in an urban area compared to the adjacent rural area’, *Landscape and Urban Planning*, τ. 103, σσ. 34–43, 10 2011. Available: https://www.sciencedirect.com/science/article/pii/S0169204611002118

Fred

[5] RFID monitoring of european badger populations

This study focused on monitoring European badger populations in densely wooded areas to effectively analyse social patterns. The system contains two major components, RFID equipped collars which had to be manually placed on badgers, and detection beacon to monitor badger movements. Beacons were placed at known badger latrines[3] and dens, and would log badger movements when a RFID tagged badger would pass through. Detection beacons were set up in a network, working in tandem with environmental monitoring sensors (for temperature and humidity) and connected to a solar powered gateway, placed within 3G cell range to allow data to constantly be sent to researchers. This flow of data allowed researchers to monitor the melding or splitting of badger societies, by monitoring movements through badger dens and latrines. This also provided valuable social, genetic, and disease information in badger cultures.

Problems: The beacons and sensors were difficult and expensive to reach and maintain, as they were placed in heavily wooded areas with no real paths to them. Also, the software used in the tagging beacons was hard to update, and with each new hardware iteration required a new round of bug fixes and updates to accommodate new power limitations and data intake. The environmental sensors also were prone to water damage due to the humidity inside of the sensors, although this was remedied by sealing the sensors with hot glue, making them airtight and waterproof. Finally, the need for constant interaction with scientists in the field to take and analyse the data prompting unexpected and usually costly upgrades.

Issue: Lack of data on badger co-existence and populations

[6] Wildlife population surveillance among free living avian species

The detection of avian influenza virus (AIV) led to the discovery of so called “natural reservoirs” for these types of viruses, where viruses would breed and distribute in isolated areas and piggy back on birds to more populated areas, leading to outbreaks of AIV and other similar viruses in livestock and humans. Through the monitoring of multiple varying species, it was found that AIV was most common in birds using aquatic habitats (ducks, geese, etc.), which allowed the study of virus reservoirs to focus on specific target groups in

[3] Badger latrines are small areas consisting of one or more pits, dug next to markers like fences, trees, etc. They are used to distinguish boundaries of badger colonies

these areas. The study of these reservoirs has been on-going for 50 odd years, and with future changes in land use, human intervention, and bird migrations the monitoring of these species migrations and reservoirs remains critical.

Problems: Natural reservoirs are still difficult to isolate, as migratory birds are hard to tag and track. At the time of discovery, the available technology was not advanced enough to maintain an overview of reservoir locations and hotspots, however it should be less difficult nowadays.

Issue: Viruses being transmitted by birds and impacting bird habitats

[7] Wildlife Monitoring using Wireless Image Sensor Networks

Systems using networks of wirelessly connected cameras and other imaging technology has become a promising area of wildlife monitoring.One such example is a network using a rotating infrared image sensor beacons, a base station, and a monitoring centre working together to tag and keep track of Red Deer cubs in the centre of Mongolia. A wide area is covered with IR beacons, which remain dormant until an animal triggers the sensor, which then takes pictures of any animal in its range. These images, along with gps data, is then processed in the node and sent to a sink node, which relays the processed information to the base station through 3g cell service. Finally, this base station sends the information via the internet to the monitoring centre, which comes equipped with a 3D GIS system[4] and a wild animal image database for researchers to properly analyse and categorise location, species, and individual data. This system, implemented in Mongolia and designed to help combat cub hunting and habitat erasure, allows researchers to track groups, populations, and birth rates of Red Deer.

Problems: A large issue with these systems is being able to compress the images taken by the sensor beacons well enough to be transmitted with relatively little bandwidth, while still keeping the image quality good enough. Along with this is the ever present issue of powering the beacons , as well as placing them strategically to cover as much ground as possible, reducing costs and maintenance issues.

Issue: Large amounts of cubs being hunted

[5] V. Dyo , S. A. Ellwood† , D. W. Macdonald† , A. Markham‡ C. Mascolo§ , B. Pasztor ´ § , S. Scellato§ , N. Trigoni‡ , R. Wohlers‡ , K. Yousef§ (2010, November, 3). *Evolution and Sustainability of a Wildlife Monitoring Sensor Network*
Available: https://dl.acm.org/doi/pdf/10.1145/1869983.1869997

[6] D. E. Stallknecht, (2003, January). *Wildlife Population Surveillance*
Available: https://www.jstor.org/stable/pdf/3298674.pdf

[7] J. Zhang, X. Luo, C. Chen, Z. Liu, S. Cao. (2014, October, 31). A Wildlife Monitoring System Based on Wireless Image Sensor Networks.

[4] A 3D Mapping software

Available: https://www.sensorsportal.com/HTML/DIGEST/october_2014/Vol_180/P_2446.pdf

Roel

[8] Using Egg-Mass Counts to Monitor Wood Frog Populations

Most of the time calling surveys are used to monitor the frog population in North-America. In this article they use Egg-Mass counts, because the calling surveys don't work for every frog species. Especially the wood frog they were noticed in less than 50% of the surveys. Egg-Mass counting is cheaper than the other options, is more accurate and is not a lot of work, but there are some problems that can come along with this method: You can't always get permission from the landowner to access the breeding points, if the breeding point is very big you have to look at every inch of the pond and if the water level rose considerably then some places of the pond would be impossible to reach. Conclusion is that Egg-mass counts are more accurate and cheaper and work for every frog species but the method brings some problems along with it.

Problem: You can't always get permission from the landowner to access the breeding ponds, if the breeding point is very big you have to look at every inch of the pond and if the water level rose considerably then some places of the pond would be impossible to reach.

[9] Animal Recognition and Identification with Deep Convolutional Neural Networks for Automated Wildlife Monitoring

Automatic trap cameras gather millions of pictures that all have to be categorised. This takes many hours and costs a lot of money because this is very hard to let a computer do. In this article they were trying to automate this process. Their program was very successful with recognising if there was an animal in the picture (which already saves a lot of time, because 32% percent of the pictures that the humans identifying the pictures get to see are empty), their program was also quite good in identifying the top 3 most common animals but with more animals the accuracy decreases significantly.. They made their program by analysing millions of pictures by hand, so their program could learn. Conclusion is that it is a work in progress for now the computer is not good enough, but maybe it can partly help in the process.

Problem: Takes way too long and costly to analyse all the pictures.

[10] Using long-term monitoring of red fox populations to assess changes in rodent control practices

The use of rodenticides has drastically reduced the fox population. Some decisions on how to control rodent outbreaks are poorly informed which results in irrational treatment over large areas. This article shows that the use of rodenticides has an influence on the fox population, if switched to preventive treatment with reduced anticoagulant rodenticide the treatment is less harmful for the fox population. But the article also mentions that to get to a zero impact approach, treatments should be reduced further and we should use alternative methods to chemical control. One of the most important things this article shows is that "long-term monitoring of wildlife populations using index methods can provide valuable information about the adverse effect of pesticides."

Problem: Pest control is a global issue for health, biodiversity conservation and economy.

Sources:
[8] W. B. Crouch and P. W. C. Paton. (2000, Winter). "Using Egg-Mass Counts to Monitor Wood Frog Populations". Wiley [Online]. Vol. 28, issue 4, 7 pages. Available: https://www.jstor.org/stable/3783845?seq=7#metadata_info_tab_contents

[9] H. Nguyen et al. (2017, October, 21). "Animal Recognition and Identification with Deep Convolutional Neural Networks for Automated Wildlife Monitoring," Available: https://ieeexplore.ieee.org/document/8259762

[10] M. Jacquot. (2013, July) "Using long-term monitoring of red fox populations to assess changes in rodent control practices." Journal of Applied Ecology [Online]. Vol. 50, issue 6, p 1406-1414. Available: https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.12151

Slava

[11] Identifying individual gray wolves by their howls

Conclusion: Acoustic monitoring could potentially track all the wolves in multiple packs whereas radio-collaring is typically used to track a single member in select packs.

Summary: Keeping track of wolf pack movements is important for reducing human-wolf conflicts. The traditional way to track wolves involves setting traps and sedating them. However, this approach entails risks for the animals. The author questions whether wolf howls could be used to help identifying non-radio-collared pack members. In the experiment, it was possible to isolate 21 howls from two adult wolves over two evenings. For each howl, six types of frequency measurements and two types of duration measurements were made. Frequency is how high or low the pitch of the howl sounds and duration is the length of time the howl lasted. For wild gray wolves, the maximum frequency and the frequency at the end of the howl were the most individualistic. For captive wolves, the lowest frequency is the fundamental one, but the loudness is what differentiates them. Therefore, to monitor wolf populations, researchers would need to record known individuals in a particular area. Once they've built up a database of known individuals' howls, they can conduct nightly surveys. Comparing new recordings to those in the audio library would let them determine which individuals are in an area.

[12] Integrating remote sensing into wildlife monitoring for conservation

Conclusion: Remote sensing offers many opportunities for wildlife data collection if integrated into well-structured monitoring plans with clear goals.

Summary: In recent years, conservation project managers have increasingly turned to technological innovations to enhance wildlife monitoring. Satellite-based remote sensing of wildlife habitats and wildlife populations has been complemented by the newest generation of Earth-based sensors, including camera traps, acoustic recording devices, and unmanned aerial vehicles or drones. These sensors, as well as emerging methods such as environmental DNA monitoring for tracking community composition and genetic monitoring for identifying individuals within populations, provide new opportunities for enhancing the quality and volume of wildlife monitoring data. If used in systematic ways, remote sensing can also help fill the data gaps that exist in high-biodiversity tropical countries and help build time-series data of higher temporal and spatial resolution. However, there are several risks: excitement over the technologies, blockages to the biodiversity data for management, weak monitoring plans, and tools that are poorly adapted to local conditions. To be effective and to learn from recent research, wildlife monitoring schemes (especially those using remote sensing) should be developed and implemented while taking into account key issues around monitoring design, indicator selection, monitoring methods and tools, data collection, and data sharing.

[13] An automatic wildlife tracking system using GPS and WSN

Conclusion: Automatic tracking and alert system is flexible, efficient and easy for an implementation process and can be more beneficial for monitoring wildlife related complexities.

Summary: It is not a secret that wildlife creatures require careful monitoring by humans to procure early treatment for the sick animals. The global positioning system (GPS) is used to locate them, while the wireless network system (WSN) is used to check their health status. The most efficient tracking system would consider not only gathering the live location of wild animals but also the lowest power consumption possible. Therefore, the article discusses the block diagram of the device that consists of: GPS, flame sensor, humidity sensor, light dependent resistor, LCD screen and bluetooth. The author believes that this system is more useful than the previous ones due to the combination of keeping track of the animal's health and location.

[11] A. Dassow. (2018). *Scientist at work: Identifying individual gray wolves by their howls* [Online]. Available: https://theconversation.com/scientist-at-work-identifying-individual-gray-wolves-by-their-howls-96086

[12] P. J. Stephenson. (2019, June). “Integrating Remote Sensing into Wildlife Monitoring for Conservation”. *Environmental Conservation* [Online]. vol. 1, issue 46. Available at: https://www-cambridge-org.ezproxy2.utwente.nl/core/services/aop-cambridge-core/content/view/CA5A6CFB1C56E4E789EEB8343EAD6018/S0376892919000092a.pdf/integrating-remote-sensing-into-wildlife-monitoring-for-conservation.pdf

[13] R. Nalawade. (2021, June). “An Automatic Wild Life Tracking System Using GPS and WSN". *International Journal of Recent Advances in Multidisciplinary Topics* [Online]. vol. 2, issue 6. Available at: https://journals.resaim.com/ijramt/article/view/862/831

Sanne

- Negative effects of Offshore Wind Farms on Birds and how to monitor them.

  https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1653806&dswid=-7230

The upcoming windmills and the massive placement of windmills is one of the reasons for the extinction of birdlife. In this research, a system is designed to detect birds. A possible methode is the CCN (convolutional neural networks). It is a vision based detection with background subtraction that contour detection and confusion matrix classification. These methods help detect birds in raw images and with help of a classifier make it possible to see the bird fully in the desired pixels with the full resolution. The classification method has two staps, first the background needs to be removed, then a classification needs to classify the object. This can be done with the use of YOLO v3 version for object classification.

Problem: The windmills are killing a lot of birds.

P. Notla, S. R. Ganta & S. K. Jyothula (2021, June). "Bird Detection System: Based on Vision." https://www.diva-portal.org/smash/record.jsf?dswid=-7230&pid=diva2%3A1653806

- The reintroduction of the Eurasian otter (Lutra lutra) into the Netherlands: hidden life revealed by noninvasive genetic monitoring

  https://link.springer.com/article/10.1007/s10592-010-0051-6

The last otter in the Netherlands was spotted in 1989 and went extinct due to the upcoming industrial revolution. A reintroduction program started between June 2002 and April 2008 where 30 individuals (10 males and 20 females) were released into a lowland peat marsh in the north of the Netherlands. Noninvasive genetic monitoring based on the genetic profiles obtained from DNA extracted from otter faeces (spraints), was chosen to keep track after the otters were released. In June 2002 till April 2008 there were 1.265 spraints analyzed, which 582 successfully. With this method they discovered that there 54 offspring(23 females and 31 males). During the winter of 2007/2008 there were 47 individuals identified, of which 41 originated from mating within the released area.

Conclusion: “This study demonstrates that noninvasive molecular methods can be used efficiently in post-release monitoring studies of elusive species to reveal a comprehensive picture of the state of the population.”

Problem: The otter in The Netherlands is a species that need protection.

H. P. Koelewijn, M. Pérez-Haro, H. A. H. Jansman, M. C. Boerwinkel, J. Bovenschen,D. R. Lammertsma, F. J. J. Niewold & A. T. Kuiters, (2010). “The reintroduction of the Eurasian otter (Lutra lutra) into the Netherlands: hidden life revealed by noninvasive genetic monitoring.” Conservation Genetics, 11(2), 601-614, https://link.springer.com/article/10.1007/s10592-010-0051-6.

- ## Longterm monitoring of underwater environment

  https://www.pure.ed.ac.uk/ws/files/11410182/Boom_Huang_et_al_2012_Long_term_underwater_camera_surveillance_for_monitoring_and_analysis_of_fish_populations.pdf

Long-term underwater monitoring of the environment is labor-intensive work. Therefore is the use of cameras to monitor this environment ideal to make the task less labor-intensive. In this research, a system that can analyze long-term underwater footage(more than 3 years of 12 hours a day underwater camera footage from 10 cameras) is described. This system can recognize different species and is divided into four software components and 2 databases for the storing of the footage. The software components are fish detection, fish recognition, user interface, and workflow. This experiment is one of the largest and used 320 fish images to verify the performance of their data.

Problem: The underwater ecosysteem is hard to monitor.

B. Boom, P. X. Huang, C. Beyan, C. Spampinato, S. Palazzo, J. He, E. Beauxis-Aussalet, S-I. Lin, H.M. Chou, G. Nadarajan, J. Chen-Burger, J. van Ossenbruggen, D. Giordano, L. Hardman, F-P. Lin & B. Fisher (2012) ‘Long-term underwater camera surveillance for monitoring and analysis of fish populations” in 2012 21st international conference on pattern recognition
https://www.pure.ed.ac.uk/ws/files/11410182/Boom_Huang_et_al_2012_Long_term_underwater_camera_surveillance_for_monitoring_and_analysis_of_fish_populations.pdf

Massimo

[17]Passerine Birds Breeding under Chronic Noise Experience Reduced Fitness

The study researches how noise pullition affects the reproduction in passerine birds.
An island population of sparrows was their source of data. Their data shows that noise from generators caused the sparrows to produce less chicks, the chicks also have a lower BMI and even when the parents were specifically selected for their genetics it did not improve the chicks conditions. The noise did not affect the mating choice neither the reduction of territory quality. Their conclusion was that were missing an important hypothesis which is that environmental noise could cause the parent-offspring communication to be problematic. Their final point is that even when cross-fostering was utilised, the chicks stil had fitness problems which means that noise pollution can cause great damage to bird populations.

Problem: noise pollution

[17] Schroeder, J. (2012) Passerine Birds Breeding under Chronic Noise Experience Reduced Fitness. Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0039200.

[18] Noise Pollution Changes Avian Communities and Species Interactions

Noise pollution caused by humans, this problem seems to affect mostly birds.
In the research they have proven that noise alone reduce the number of species nesting is altered and that different species populate these new avain communities.
It has been discovered that nesting actually increases in the noisy areas because predators are less present and there is a lower number of prey-predator interaction. They also mention that previous research indicates that noise is a big cause in brid declines the evidence brought up from their research suggest that the methods used in previous attempts were not sufficient and lacked the control over certain variables.
With these variables under control they were able to give very strong evidence that birds are affected by noise and that it reduces the likelihood of birds reproducing

Problem: Noise pollution in avian communities

[18] Francis, C.D., Ortega, C.P. and Cruz, A. (2009) “Noise Pollution Changes Avian Communities and Species Interactions,” Current Biology, 19(16), pp. 1415–1419. Available at: https://doi.org/10.1016/j.cub.2009.06.052.

[19] Detection of Bats by Mist-Nets and Ultrasonic Sensors

This study was taken to monitor the number of bats in the mountains of Nevada. They utilized two recognition methods, using ultrasonic sensors and mist-nets, and compared the numbers of bats detected with the two methods.
There was a minor difference between these two methods but both were not able to identify all the species present on the site. They suggest that for future test to utilize the same techniques and improve ultrasonic detection.

[19] Kuenzi, Amy J., and Michael L. Morrison. (1998) *Detection of Bats by Mist-Nets and Ultrasonic Sensors - Available at: JSTOR*. www.jstor.org/stable/3784055

[20] A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates

This paper talks about how the presence of microplastics in water may influence the growth reproduction and feeding of freshwater creatures.
They found that the most frequent effect on sea life exposed to microplastic is reduced consumption of natural prey. For some other study pools, there were negative effects shown on growth, reproduction, and survival. For future tests, they recommend improving microplastic density detection as it is an important factor to be observed.
Overall it is determined by the research that microplastics are a danger to aquatic ecosystems.

Problem: microplastics

[20] Foley, C.J. et al. (2018) “A meta-analysis of the effects of exposure to microplastics on fish and aquatic invertebrates,” Science of the Total Environment, 631–632, pp. 550–559. Available at: https://doi.org/10.1016/j.scitotenv.2018.03.046.

Chapter 2:

Identify 8-10 general problems & challenges from the list of publications in Chapter 1

1. Audio monitoring, though less energy intensive than cameras, has a few other issues. The technology being used here (NVIDIA Jetson Nano) is very expensive, so a more optimised version of the edge AI software needs to be used to operate on cheaper hardware. Also, the utilisation of triangulation requires very accurate time stamps to determine when the sound reached the microphones.
2. The beacons and sensors were difficult and expensive to reach and maintain, as they were placed in heavily wooded areas with no real paths to them. Also, the software used in the tagging beacons was hard to update, and with each new hardware iteration required a new round of bug fixes and updates to accommodate new power limitations and data intake. The environmental sensors also were prone to water damage due to the humidity inside of the sensors, although this was remedied by sealing the sensors with hot glue, making them airtight and waterproof. Finally, the need for constant interaction with scientists in the field to take and analyse the data prompting unexpected and usually costly upgrades.
3. Natural reservoirs are still difficult to isolate, as migratory birds are hard to tag and track. At the time of discovery, the available technology was not advanced enough to maintain an overview of reservoir locations and hotspots, however it should be less difficult nowadays.
4. A large issue with these systems (wireless cameras) is being able to compress the images taken by the sensor beacons well enough to be transmitted with relatively little bandwidth, while still keeping the image quality good enough. Along with this is the ever present issue of powering the beacons , as well as placing them strategically to cover as much ground as possible, reducing costs and maintenance issues.
5. You can’t always get permission from the landowner to access the breeding ponds, if the breeding point is very big you have to look at every inch of the pond and if the water level rose considerably then some places of the pond would be impossible to reach.
6. Takes way too long to use camera traps and is very costly to analyse all the pictures.
7. The windmills are killing a lot of birds.
8. The otter in The Netherlands is a species that needs protection.
9. The underwater ecosystem is hard to monitor.
10. noise pollution
11. Problem: microplastics
12. bats

Chapter 3:

Identify 5 new problems you find relevant, urgent and interesting, not yet been addressed effectively

1. Birds

https://www.jstor.org/stable/3677276#metadata_info_tab_contents
https://onlinelibrary.wiley.com/doi/full/10.1111/j.1474-919X.2008.00828.x

Problem: difficulty to study the foraging routine of birds

In the winter there is a lot less food for the birds and we found out that there is not that much research on the foraging routines of birds in the winter. So we think we should improve the available food for birds in the winter. This way we know where they are and it would be easier to monitor them. We could go a lot of ways with this, putting a camera near a bird feeder (so we know when they like to eat), we could make an automatic feeder and see how this affects the birds routines or implement a weight sensor so we know how big of birds come to our little contraption etc.

2. Camera networks

Camera networks used for wildlife monitoring are a convenient way to allow for tracking creatures in remote areas, but they do come with a number of inconveniences that could be optimized with modern technologies. Camera networks rely on the wireless transmission of images using battery powered motion activated camera traps. A step up from their predecessors, which lacked transmission capabilities and relied on build in storage that had to be collected, camera networks send their images automatically to the researchers. This removed the need to manually collect the data, but poses a second issue. The transmission of data is rather power intensive. This means that the batteries need to be replaced more frequently than dumber camera traps.

Optimization for camera networks would involve finding ways to either cut down on the power draw needs of a network, or improving the means of supplying said power. An optimized network could be used to monitor for wild boars with little to no maintenance.

3. Monitoring soil health

Soil acts as the “bedrock” for any healthy ecosystem, as plants serve as the starting point for any food chain. In order for sufficient vegetation to grow in an area there must be the presence of the required food sources for the native fauna. It is for this reason that the monitoring of soil health is vital for the benefit of wildlife populations.

Although it might seem like it is not directly monitoring the wildlife in the area, we could also monitor the biodiversity in the solid. Besides that the monitoring of soil health acts as another point of data that can aid in the mapping and understanding of the complex systems that influence the biospheres around us. A majority of the regularly available data on the state of soil health is primarily concentrated in the late 90s and or focused on agricultural systems. This means that nowadays there is a distinct lack of data points to check for correlations between soil health and the declining health of ecosystems worldwide. From abandoned mines to up river farming, there are lots of vectors for pollution to make it into the soil, build up concentration within the plants, and work its way into the digestive systems of larger fauna. Often increased levels of heavy metals are found in animals after they start showing signs of degraded health, but here we only discover there was an issue after it has taken its toll. Rather than focusing on monitoring the wildlife for symptoms of environmental poisoning or contamination, perhaps it's better to monitor the soil instead?

Remote networks of low maintenance sensing stations could be placed near water sources, railways, road networks, or farms and factories. Transmitting data only when there is a noticeable change in soil health, they would save labor by operating for long periods of time without needing maintenance. If properly optimized, they could potentially be solar powered, thus requiring no maintenance for charging.

4. Ants

https://www.sciencedirect.com/science/article/pii/S0006320706001467?casa_token=4oXo0Xckt7oAAAAA:9RBPdj3NchXFRuZyuPzMefCAaah6qTJdRk5Sjsl0IGuu-hc6ZEES79IEJSxF9CbdtJLLeTVM76k
https://www.icup.org.uk/media/glclx2xa/icup004.pdf

Problem:
Ants are significant indicators to know how an ecosystem is doing. Ants provide valuable information for management-based monitoring. If monitor them you can for example detect the presence of invasive species, detect trends among threatened or endangered species, detect trends among keystone species, evaluate land management actions, and assess long-term ecosystem changes.
Through the implementation of a smart environment, it could be possible to keep tabs on these areas without the need of a constant human pressence. Possible monitoring methodes for this

possible monitoring methods:

- Sampling methods do not collect all species equally, so not the best way of monitoring.
- “The understanding of nest site locations and habitat preference help determine the probability of capturing a species with a given type of sampling method.”
- Monitoring the activities of the species helps collect data on species richness, abundance, and complementarity.

5. Feral cats

Problem:
In the Netherlands, there are about two to three million house cats and tens of thousands of stray cats. According to European legislation, house cats should be kept indoors. Every year, cats in the Netherlands are estimated to kill about 140 million animals. According to the lawyers' research, cats are a risk to 367 endangered species. And the issue is just the fact that cats hunt birds and other small animals, they also spread diseases.

Some 1000 feral cats have been shot in just 3.5 years in the provinces of Friesland and Utrecht, where culling(reduction of a wild animal population by selective slaughter) is allowed. Friesland and Utrecht are currently the only two provinces in the Netherlands to allow the cull of cats that have become wild.

Their reasons are:

- *to prevent the animals from disturbing the 'ecological balance'*
- *to prevent cats from eating the meadow birds*

According to the bird protection organization, feral cats are a threat to birds but shooting them is not a structural solution as it doesn't prevent more cats from becoming feral.

Solution:
Cat trap: a box that closes when a cat comes inside and makes an annoying sound for a person that passes it by to notice it and call an organization that deals with stray cats (or maybe automatically notifies it).

6. How does noise pollution affect bats?

Noise pollution (or anthropogenic noise) is an important factor that has to be analyzed and studied more in-depth as many studies only cover its effects on avian species.Bats have not been looked into and we do not know how noise levels affect their lifestyle and fitness. There have been studies about how highways may disrupt their auditory/movement abilities (as bats use echolocation to navigate their way in the air) but there has not been much about urban areas and the amount of bats in these areas compared to forest areas.
Possible solution could be setting up smart bat houses with a motion sensor that detects when a bat enters the house a camera will take a picture of the animal inside.

Chapter 4:

Problem: Feral cats impacting the environment

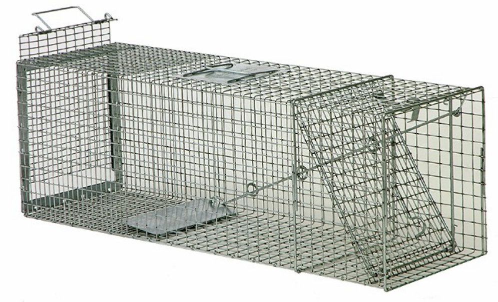
Cats all hold a place in our hearts, but though we view them fondly, the environment has a different view. Cats often prey on local fauna leading to an imbalance in the ecosystem. It isn't uncommon to hear about species being driven to near extinction due to cat attacks. It has gone so far that some authorities feel that the only solution is in culling them. Through the implementation of smart monitoring environments it could be possible to assure that cats either are no longer able to affect their environments negatively and or link them empirically to the decline of local species.

Potential smart environments could include smart traps to capture rogue cats before they can strike, monitoring cat locations through tracking means, cat based sensing devices that make noise to alert animals of cat presence, etc.

Chapter 5:

Solutions:

1. Cat trap: (Slava)
    a. A box that closes when a cat comes inside and automatically notifies the organization that deals with stray cats. To attract them into the trap, the box will make a sound which only cats can hear (frequency up to 64kHz). Because there will be a camera inside, it will be possible for the organization to see which animal exactly is inside the box. If it is any other animal it will be possible to open the box remotely. For testing purposes, because cats are not that big compared to some other animals, it will be possible to build it by keeping in mind a cat's average size, hardware and camera. The size of the trap does not matter, i.e., it will be possible to put something else inside so the box might not be based on average cat size.



2. Cat microphone to detect kittens (Roel)
    a. https://cattitudedaily.com/why-dont-feral-cats-meow/
    One of our solutions is to equip the cat with a microphone and a device that can send the current location of the cat. We would tweak the microphone in such a way that it knows when it hears a (kitten) miauw at that time the tracker sends the location to us. This way we know where the nests of the feral cats are, because feral cats don't miauw, it is only the pet cats that do miauw because they want to interact with humans. But feral **kittens** do miauw because they want to communicate with their parents, so when we hear a miauw in the wild, we could assume it is a kitten or a cat who is screaming for its human. If we receive the location we could create a heat map of where the most miauws take place, we could search for nests, we could also replace the microphone with a camera. This way we get a visual of where the miauw happens, so know we could see if it was a different cat or a nest that triggered the camera and we could send a message to animal control or something like that.

With finding the feral nests we are starting to solve the problem, because if we can prevent the wild nests which inevitably will become feral cats eventually the feral cat population will start to decay.

3. RFID Cat tracking: (Chris)
    a. RFID can detect out to a few meters, this would allow for the tracking of a sample set of cats to determine their travel patterns
       RFID, or radio frequency identification, is a wireless form of identifying things using a combination of antenni, transverse, and transponders. Some RFID technologies can function without the need to power transceiver. This would have the advantage of minimal maintenance but would also require sub yard distances from any transponder. Ultra high frequency RFID would circumvent the distance issue by having an up to 8 yard detection distance. Although batteries would be required, these would only need to be replaced every 3 years.
       The usage of RFID transceivers would allow for the unique identification of cats as they travel past strategically located beacon locations. These could be located near areas of interest such as parks, nature sanctuaries, garbage cans, and so on. By asking families to attach a simple tag to their pets collar, it would be possible to see how far cats travel and potentially correlate decreases in bird/rodent/etc populations to increased levels of cat activity in an area.
       Populations should have little issue cooperating with the program as a majority of the cost is not in the trackers, but rather the beacon system. Most families already tag their pets with information incase they get lost so a second tag for the added piece of mind of knowing where they might be when they get lost should be encouragement enough to add a tag to their pets collar.

4. Cat band/collar catch release (Massimo)

Cats are territorial mammals, this means that they stay around the same area and when needed they move outside that area to go hunting for prey. Knowing that information we came up with the idea of a retro-reflective collar which is detected by a sensor placed in strategic location that the cat would have to go to hunt. This solution would monitor the time and place were the cat is going to hunt for food.
This retro reflective sensor could also be connected to a camera so that when the cat is passing through we could see if the cat has a prey in his mouth.

5. Cat body cam? (for kill cam or make a noise to scare bird) (Sanne)

a. Activates camera based off orientation, speed, acceleration, and other factors, to monitor cat movements and hunting patterns. If a cat is ready to attack they move to the ground and stop moving. After that they will sprint and if they are lucky they catch something. We want the camera to activate when this happens. Because with the camera it is possible to take a picture and see what they have killed. If you frequently check the camera you can monitor the birds that are killed by the cats.
There are a lot of factors to keep in mind when you make this camera because not every attack is the same and sometimes you register an attack when there isn't one.
b. Possible heart rate monitor to determine when the cat is hunting or in heat and then take a picture. As said above, when cats are in a hunting stage they go to the ground and are waiting for the perfect moment to attack. A second thing that happens is that the heartbeat goes up. This can also mean that the cat is just excited or something else is happening so the accuracy of this method is lower than the other methods.

6. Smart scratch trees (Fred)

Cat trees offer a place for cats to scratch itches, and are very popular with most feline species. By creating trees which register when an animal is on its base, and taking a photo of it, a database of animals can be created and filtered to tag cats specifically. The functionality of the tree is roughly the same as a camera trap, although the design of it would entice cats to come to it, rather than hoping for an animal to walk by. This can also create ways to incite cats away from areas with high prey animal densities, garbage, and other areas which would place the cats or other animals out of harm's

way. These trees would log location and species data, creating a database of cat movements and behaviour from which a heat map could be created.

Although these traps would be designed for use by cats, since they would be placed in the wild it is almost guaranteed that other animals would trigger the pressure sensors in the base. Through the use of image recognition software, these images could be filtered out either to be deleted or to log other wildlife activity in the region.
[5]

[5] https://www.chewy.com/lovely-caves-coconut-palm-tree-cat/dp/525710

Chapter 6:

Cat tracking (solution 3) is the most feasible problem to tackle in the limited time frame of the project, and is easy to implement in the real world. Although it is not clear if it is the most effective way to fight the cat problem, its ability to efficiently acquire data on cat movement is invaluable. By creating a map of cat movements from the collected data, researchers could for example compare it with population data of prey animals like mice and birds to see if the cats affect those species. If areas where cats congregate the most become apparent, the issue of cats harming prey species can be tackled in areas which are high population first.

This solution is also the easiest to test out, as RFID tracking is heavily researched and there is a lot of work to base our system on. One of the only holdups in our research could be not getting permission from the owner of the cat to tag and track their pet.

Chapter 7:

Brainstorming

The system works autonomously, collecting and sending data without user interaction. Through interaction with the environment, our beacons collect, interpret and transmit relevant data to be used in analysing cat movement patterns. For a more advanced version of the system, a speaker can be used to interact with the environment, allowing our beacons to not only receive data from the environment but also manipulate it.
For this project some equipment like RFID equipment, microprocessors with wifi capabilities (ESP 32, Arduino, etc), weather proofing (resin, hot glue, tarpaulin), Cat collar is needed. For the more ambitious version solar recharging, LoRa communication tech, speakers, a hydraulic mounting system, and resin cast collar boxes could be integrated.

- Beacon Equipment
  - ESP 32 Wroom Board
  - Radio Frequency receiver (nRF24)
  - Possible Additions
    - Solar Panel
    - Solar li-po charger
    - LoRa antenna
- Collar Equipment
  - Radio Frequency Transmitter (nRF24)
  - Arduino Nano
  - Battery Solution (CR2032)
  - Collar

The beacon, equipped with a microcontroller for handling the processing of signals, in this case an ESP32 is proposed for its inherent wifi capabilities, would scan for signals emanating from the cat collars using an nRF radio receiver. Should time and budget permit, it would also be possible to include solar power and storage capabilities. A final possible addition would be the integration of LoRa for long range networking without the need for a wifi connection. LoRa would be advantageous over normal RF due to its vast network of publicly available relay stations, but that being said, the ESP32's ability to link to available wifi makes this an optional feature.

The collar should be composed of a small microcontroller, a radio transmitter, and a power supply that would allow it to operate for long durations with minimal upkeep while also costing as little as possible.

A system of this size brings some problems with it like battery usage and costs. To optimise battery usage in the system, it is necessary to find a good balance between scanner range and power draw. For this there would be a need to calibrate the system to increase range at the cost of battery life and vice versa.

All equipment used in the full scale system other than the hub/base terminal will be placed in an uncontrolled environment. The collars would need to be weather resistant and decently sturdy so as not to fall off or break when a cat interacts with its environment. Also, each collar should be light and small enough that a cat can move unobstructed while wearing it.

The collar will be made by a 3D printer and a small case too that will be able to be attached to the collar, the filament is waterproof so the electronics that will be used in the collar should all be secured from weather. The beacons would be slightly different, as they would need to be robust, weather resistant, and ideally hermetically sealed to prevent humidity and condensation from building up on the inside and interfering with the electronics. Each node also needs to be rigid enough to handle blunt force trauma from collisions with falling branches, other animals, etc..The casing for the node will be made out of wood containing a layer of tarp in it which will render the components safe and weather proofed. Finally, to mount the beacons there is a need for multiple screws/mounting points for a single node to properly secure it to a point. The beacons however do not need to be very light, so a weight limit is not needed. As long as the beacons are not too heavy as to break its mounting, no other weight factors would need to be taken into account.

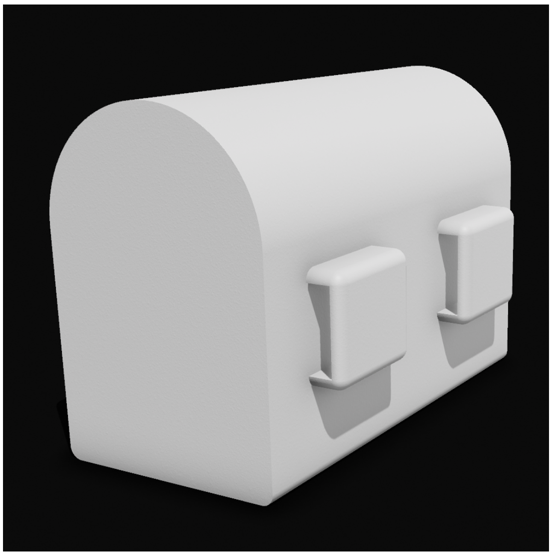


Image 7.1a

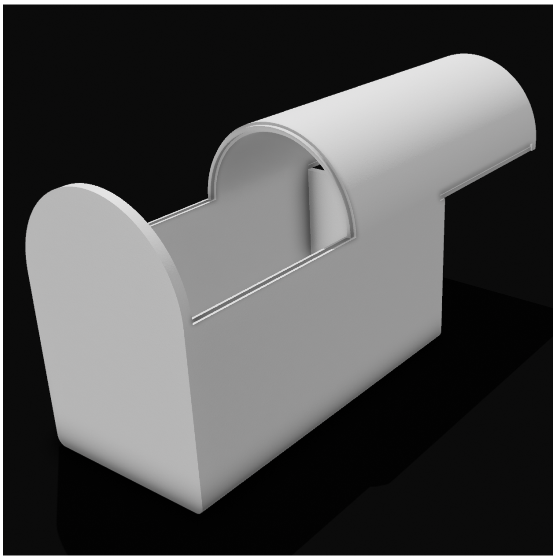


Image 7.1b

Implementation/Execution

Two stages of validation will be conducted. The first stage will involve testing the transmitter-receiver combination (beacon and collar) using a full-sized beacon and a full-sized collar. This will involve evaluating the range of detection, the ability to distinguish individual signals, and the power draw requirements in order to determine the suitability of the beacon and collar for the project.

In order to demonstrate our achievements, it was proposed to build a replica model of a city with multiple LDR’s that emulates the actual beacons. This will allow for the generation of a sample data set to determine the ability of the hub to properly map the data it receives.

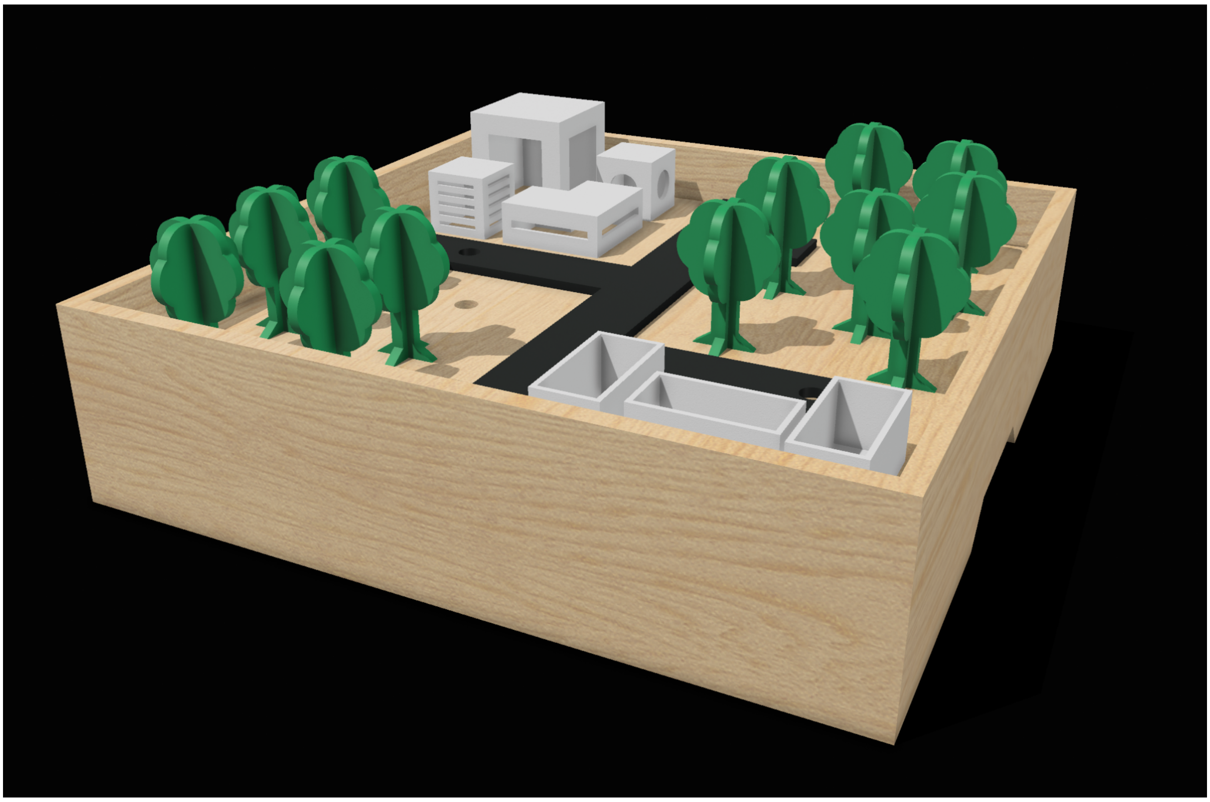


Image 7.2

Collar

The collar is made up of three key parts, an Arduino Nano, nRF24 transmitter, and lastly a battery pack. The arduino nano is set up to send a transmission at a fixed interval. This transmission is a "blind fire" with no direct target. The key concept here is that should this blind fire happen often enough, eventually it will be detected by a beacon when the cat is in range thus detecting its location. Through a technique where a series of multiple transmissions are sent rapidly one after another, it is possible to deduce how far away the collar is from a beacon by calculating the success rate of transmissions. This puts all the burden of calculations upon the beacon rather than the collar ensuring the battery life is optimized as much as possible. The power is amped up to the required voltage for the Arduino nano using a boost converter.

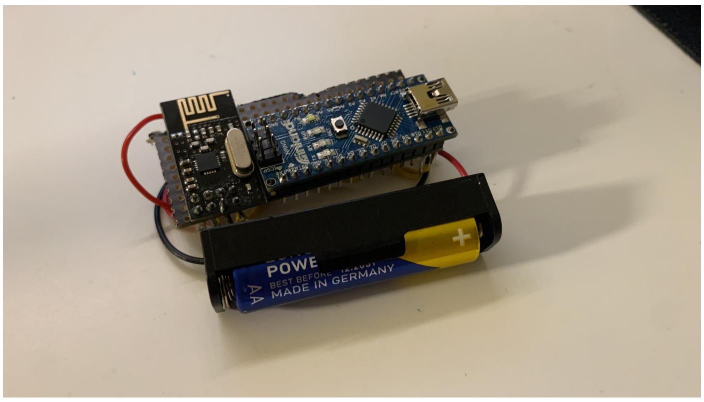


Image 7.3

Beacon

Within the beacon is a simple combination of an ESP32, an nRF24 transmitter, and a battery bank. Due to this part not being weight constricted, there were no demands placed on size or power consumption when it came to the beacon, rather emphasis was placed on connectivity. The beacon acts as a sort of radio portal, allowing for incoming radio transmissions to be relayed onto the internet. This is achieved through the implementation of a “radio -> mqtt” translation process where when a cat collar is detected, its identification number is attached to an mqtt message that contains the collars identification number, the beacons identification number, the time it was detected, and lastly the overall signal strength of the cat collar detection event. This is then sent to the “Zeroth” server as a single comma separated string.

The sensor housing (or beacon) measures roughly 25x25x40cm, and weighs less than 2kg (without the added electronics inside) and comprises 3 main components. The tray, skeleton, and covering. The covering comprises the largest and heaviest portion of the beacon, covering both the tray and skeleton with 10mm thick plywood, and offers a water resistant outer casing for the interior of the beacon. The skeleton is made from a group of 4mm thick pieces of plywood, which combine to create a structure on the inside of the box to add rigidity and stability to the tray and covering. The tray, however, is the most integral portion of the beacon. Its main purpose is to allow a removable interior section to house electronics and batteries, while also being light and structurally sound. It is created from 4mm thick plywood, with a locking mechanism attached to the underside. The lock uses a dual bolt gear driven rotary locking mechanism, attached to the bottom of the electronics tray housed inside, also made from 4mm plywood. This mechanism is not only strong enough to keep the structural integrity of the beacon intact, but is easy to unlock and lock when removing the tray from the beacon.

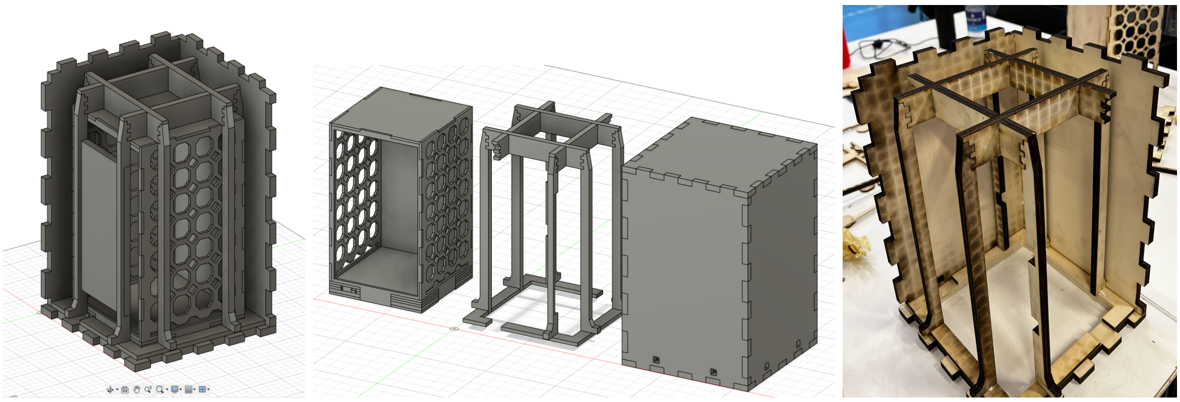


image 7.4a, b, c

The skeleton also has a 5mm gap between its outside wall and the interior of the covering. Although this sacrifices some structural integrity of the box, this space allows extra waterproofing to be added in the form of a tarpan “sock” of sorts, or even just a plastic bag can be wrapped around the skeleton and glued to the base. This is slightly unnecessary, as the covering of the beacon provides adequate waterproofing to the top and sides of the beacon. However, in environments which are extremely wet where rainfall, hail, or snow is extreme, the extra waterproofing can be added easily when creating beacons.

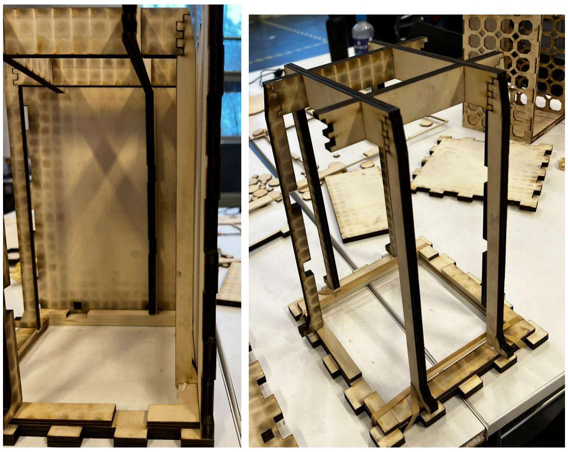


image7.5 a, b

The “Zeroth Network”

In the same line of thinking as the “Integration” idea, it could also be beneficial to create a unified “heat map” application that could take the data produced by all the different groups and map them out in a singular place. Potentially through using simple mqtt protocols it would be simple for other research teams to submit their data to this theoretical network.
The implementation of this idea was accomplished as follows. An ESP32 was used for the internal electronics of the beacon, as it has the ability to transmit strings through the MQTT protocol to a central repository. The central repository is the aforementioned “Zeroth” server. Using a raspberry pi as its hub, data is sent to and from it using a combination of mqtt and node-red. Onboard the raspberry pi was an SQL database that either deposited or retrieved information as it was requested. Through this it was possible to retrieve or deposits live and or past data from anywhere with in internet connection.
Below is a picture of the “flow” or program used by node-red to process the incoming and outgoing data points. Although a bit hectic, the overall functionality of the code goes as follows. Any purple block is an MQTT block, either with a flow leaving the right indicating that it is an input or with it on the left indicating an output. Orange blocks are functions, used for parsing incoming data so that it is understandable to the SQL database and then restructure it again before transmitting the data to an output. The rest of the colours either serve to manipulate the flow lightly or were just for debugging purposes.

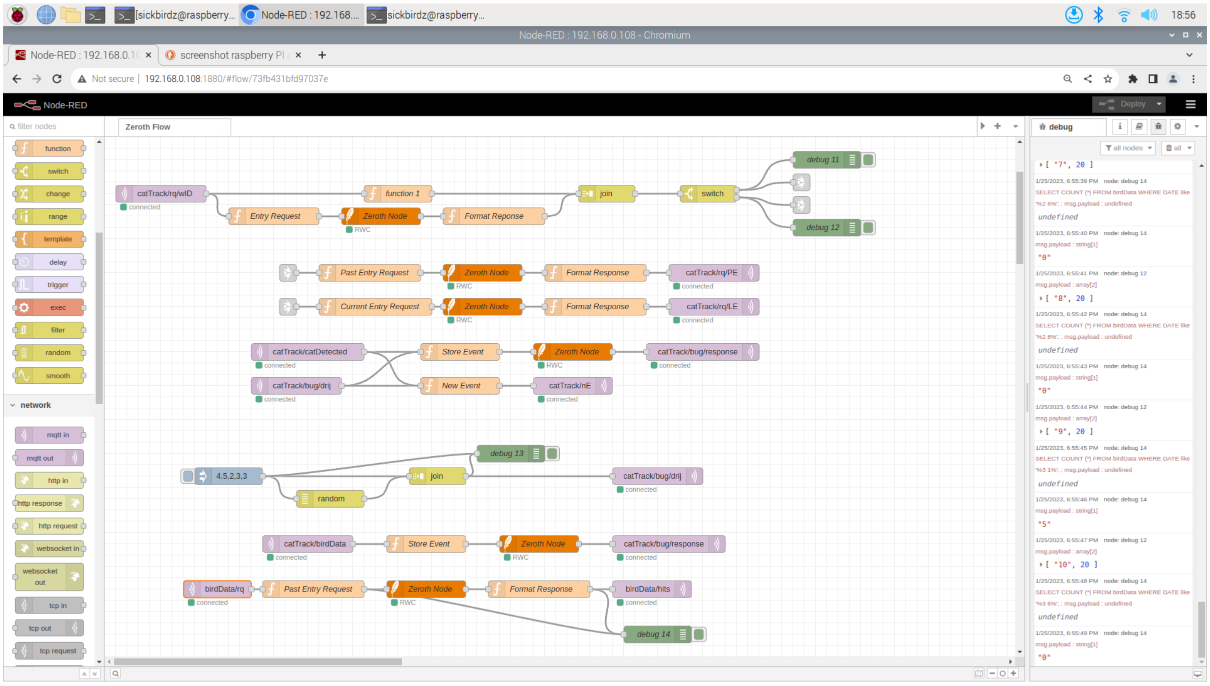
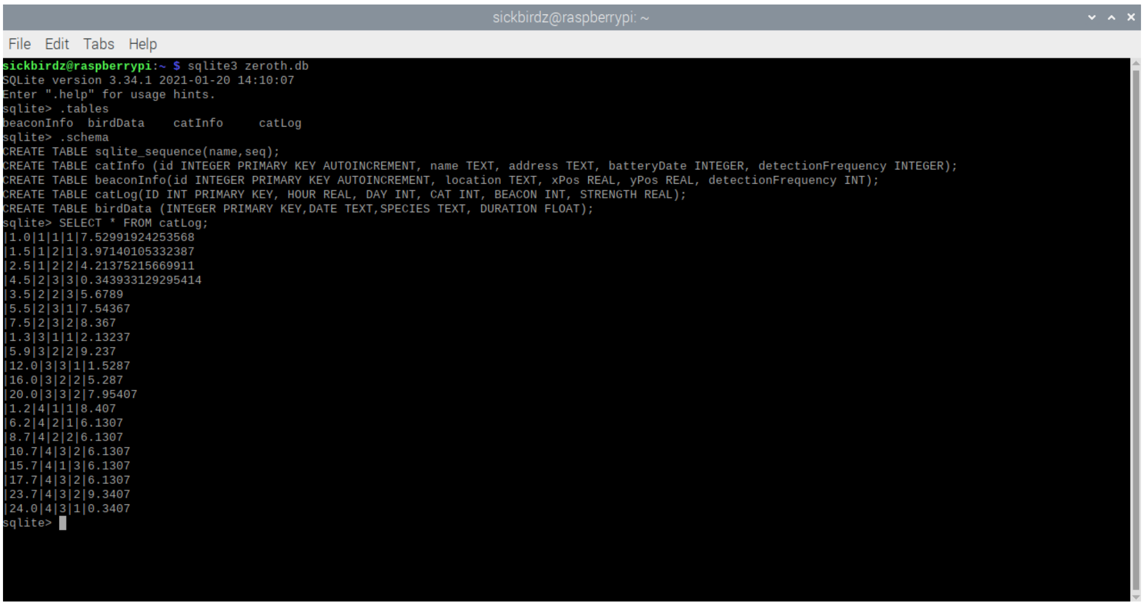


Image 7.6

Going one level deeper it is possible to look directly into the SQL database itself. Running on sqlite3, the database is composed of 4 different tables: beaconInfo, birdData, catInfo, catLog. Each table had different information stored within it, but for the sake of validation, the catLog and birdLog were the most important. Below can be seen the dataset used for testing and validation of the Zeroth server.

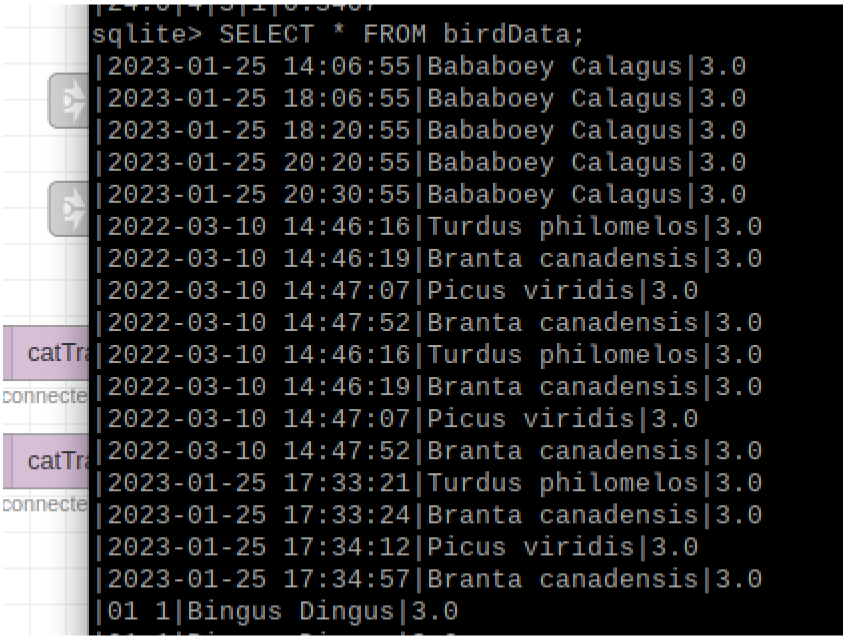


```
sickbirdz@raspberrypi:~ $ sqlite3 zeroth.db
SQLite version 3.34.1 2021-01-20 14:10:07
Enter ".help" for usage hints.
sqlite> .tables
beaconInfo  birdData    catInfo     catLog
sqlite> .schema
CREATE TABLE sqlite_sequence(name,seq);
CREATE TABLE catInfo (id INTEGER PRIMARY KEY AUTOINCREMENT, name TEXT, address TEXT, batteryDate INTEGER, detectionFrequency INTEGER);
CREATE TABLE beaconInfo(id INTEGER PRIMARY KEY AUTOINCREMENT, location TEXT, xPos REAL, yPos REAL, detectionFrequency INT);
CREATE TABLE catLog(ID INT PRIMARY KEY, HOUR REAL, DAY INT, CAT INT, BEACON INT, STRENGTH REAL);
CREATE TABLE birdData (INTEGER PRIMARY KEY,DATE TEXT,SPECIES TEXT, DURATION FLOAT);
sqlite> SELECT * FROM catLog;
|1.0|1|1|1|7.52991924253568
|1.5|1|2|1|3.97140105332387
|2.5|1|2|2|4.21375215669911
|4.5|2|3|3|0.343933129295414
|3.5|2|2|3|5.6789
|5.5|2|3|1|7.54367
|7.5|2|3|2|8.367
|1.3|3|1|1|2.13237
|5.9|3|2|2|9.237
|12.0|3|3|1|1.5287
|16.0|3|2|2|5.287
|20.0|3|3|2|7.95407
|1.2|4|1|1|8.407
|6.2|4|2|1|6.1307
|8.7|4|2|2|6.1307
|10.7|4|3|2|6.1307
|15.7|4|1|3|6.1307
|17.7|4|3|2|6.1307
|23.7|4|3|2|9.3407
|24.0|4|3|1|0.3407
sqlite>
```

Image 7.7

Through testing it was found that it was possible for multiple different devices to access the information of the Zeroth network with only the need for a stable internet connection and the correct mqtt address. Not only was it possible to request individual rows of data, but it was also possible to search through the available data to retrieve the number of entries falling under a certain time span or ones corresponding to a particular location. This functionality came in handy when processing the data coming from other teams. For example, with team

7, the rangers, the data being



transmitted was not using the same layout as the rest of the data on the database. Rather than having to restructure the whole database, it was possible to use advanced search functions within SQL to look for the identifiers that were desired. This is important in the long run because it means that collaboration between teams would be possible without implementing strong syntax/formatting rules. So long as the information is a comma separated string, it can be parsed by the database to be retrieved remotely later.

Image 7.8

Behind the processing

To visualise the database, processing is used. With the help of processing a heat map of all the data stored in the database explained above is created. Everytime a new line of data is added to the database that line gets a certain ID, the first line gets 1 and the second 2 and so on. The processing code is looking for an indication that a new line is added to the database and then asks for it.

Once the desired ID is retrieved. Once the data is received the comma separated string is split in an array of numbers, this way the numbers can be used separate from each other. The first number of the array is the cat ID (which cat), the second is the beacon ID (which beacon), the third one is the hour, the fourth one is the day and the fifth one is the signal strength. So everytime an array is made, the beacon ID is checked and the signal strength is added to the opacity and the radius of the circle of that beacon. This way the circle around the right beacon gets bigger, indicating more cat activity. The day and time are then displayed in the top left of the heat map and which beacon the latest information came from is then displayed on the left of the screen.

Now you can only see the present (the circles at their biggest), but for future research purposes a function to be able to scroll back and forwarth is added. You can press the arrow down to remove the last added signal strength from the heat map, all the way to the beginning of the research (day 0, hour 0). The day and time change with it so you know where you are during our research. This could come in handy when someone wants to know how many cats were somewhere at a certain time during our research, so in short this way you don't only see the live feed but can also go back in time. Ofcourse arrow up makes sure you can also go back to the present when you want to follow the live feed again.

Integration with the Bird Sensor groups

Adding on to the initial issue talked about in the “IR Bird Identification” section, it would also be possible to network with the other groups to combine data and create a better pool of data for researchers to use. Assuming the other groups are also sensing for birds with beacons, if the cat detection beacons were to be placed in the vicinity of the bird beacons the data could more easily be compared to each other.

We could kindly use the data from group 7 “Rangers” , because our database is very easy to connect and send data to, the same way of processing the data can be used. From group 7 we also get a comma separated string which is stored in the database (image 7.8). But for the heatmap we did not use the species of the birds (room for future improvement / research about which species of cats hunt more often), that's why we chose to not send the whole string to the processing code, but instead the processing codes send the day and hour of the latest cat sighting. The bird database then compares that timestamp with its content and sends back how many birds there were located during that time. Which is then displayed on the right side of the heat map. Right above that information the place of the device from group 7 that gathers the birds information (name device: Tweak) is displayed. This way you can compare the cat heat map with the bird sightings at a glance. If Tweak is deployed near beacon 1 you should see that if there is a cat sighten there, which you can check on the left side, there should not be many birds present, which you can check on the left side. And the same if Tweak is moved to beacon 2 or 3.
This feature works also if you scroll back and forward in time as mentioned before. This way you can check the relatedness between birds and cats at any time during our research.

Role Assignments Table 7.1

Role	Lead	Support	Contacts
Design	Sanne	Slava	Construction
Software	Roel	Massimo, Chris	Electronics, Design
Electronics	Chris	Fred	Software, Construction
Construction	Fred	Roel	Design, Electronics
Documentation	Massimo	Chris, Fred, Sanne, Slava	All
Modelling	Slava	Sanne	Design, Construction
Purchasing	Chris,Fred	Massimo	Construction, Electronics

Data Processing	Roel	Chris	Software

Plan - structure	Check
Electronics research	✔
Purchase of components	✔
• Design team with measurement given creates box • programming also begins working • electronics starts building	✔
• Testing for electronics • Software implementation • Design adjustments and completion	✔
• Documentation begins • Working prototype tested	✔
• Debugging (electronics and software) ☐ If prototype works data collection begins	✔
Data processing	✔
Final documentation	✔

Table 7.2

Requirement smart cat environment	must	should	could	won't	What did we implement
wifi for the beacon	x				✔
On board storage - beacon	x				✔
timer - collar	x				✔
nickel batteries 2032 - collar	x				✔
AT Tiny - collar		x			**X**
RF transmitter		x			✔

Solar Power			x		**X**
Some speaker with certain pitch to scare cats (or birds)			x		**X**
LORA			x		**X**
weather resistant self powered beacon	x				✔
Hermetic seal for the beacons		x			**X**
arduino or esp32 beacon	x				✔
processing for the heatmap	x				✔
app or website for the heatmap			x		**X**
Rfid scanner and receiver	x				✔
Live service model (updatable cats)			x		✔
Bluetooth				x	**X**

Table 7.3

Components and costs

Table 7.4

Components	Amount	Price
8 pin IC socket - double sided solderable	4	2.40
ATnano	3	12
433Mhz RF transmitter and receiver link kit	2	5
HT7533-1 3.3V Voltage regulator- TO92	3	1.05
3144 Hall Effect Sensor	6	2.70

Chapter 7.1 (Proposed modifications)

One of the issues identified with our proposed solution was the lack of actual impact/interaction with the environment. To solve this problem our team brainstormed a number of potential solutions, however waiting for feedback on the base solution before integrating one (or more) of the modifications to the system was more efficient than working on all of them..

The two main trains of thought focused on were the “Build More” camp and the “IOT” camp. Build More would focus on adding additional physical modifications to the system allowing it to either collect more data to provide more useful info to researchers or have a physical interaction with the environment that could lead to a positive change in the behaviour of the cats. In this camp the following ideas were proposed:

IR Bird identification

One issue that was identified was the lack of apparent ability to relate the data collected about cat migration to a decline in bird populations. One potential solution would be to monitor the amount of birds in the local vicinity. This could be achieved with an infrared camera pointed up at the sky. By “bitcrushing” the data to create a very low resolution image of the sky and could compare the average luminosity of each section vs the darkest point. If one area is especially dark in comparison to the rest it would be reasonable to assume that this indeed was a bird. To select against aeroplanes the minimum size of the pixel could be made larger as birds would appear to be bigger than planes from the distances this device would be observing them.

Bird Decoy Sensor

The main issue with the sensor system is that the system is not advanced enough to actively monitor a cat’s behaviour accurately. RFID tracking allows the system to check movements between beacons; however once a cat is inside the scanner range, it has no idea what the cat is doing at the moment. A solution to this would be including a sort of cat toy sensor near the base of the beacon. This sensor would look like a small bird, and move around a bit to mimic a living animal, however the inside of the decoy would be packed with pressure sensors to check if a cat has pounced on it. Once the decoy has been activated, the beacon would check which cat has triggered the RFID sensor in the last 10 minutes, and logs that cat as the attacker of the decoy. Then by quickly retracting the decoy and redeploying it later, it can be reused and would not need replacing every day. The main issue with this addition would be the increased power draw from the decoy deployment and withdrawal system, and the rigidity of the decoy. However, including this in the system would allow the system to also monitor hunting patterns of tagged cats, which can be correlated to previously recorded data of bird populations. This would create a much more solid correlation to the cat’s impact on local ecosystems and ecological balance.

The Internet of Things camp had an initial idea that eventually snowballed into a more ambitious concept:

Chapter 8: Validation

The sensor testing was a success and it works as intended, the sensor detects at a range of about 50 metres and does not go above that limit. The tests have been conducted by moving the transmitter to various distances (ranges of : 20m, 25m, 30m, 35m, 40m, 50m) . Obstruction of large structures has an effect on the signal strength of the transmitter but the signal is still present and is detected by the receiver.

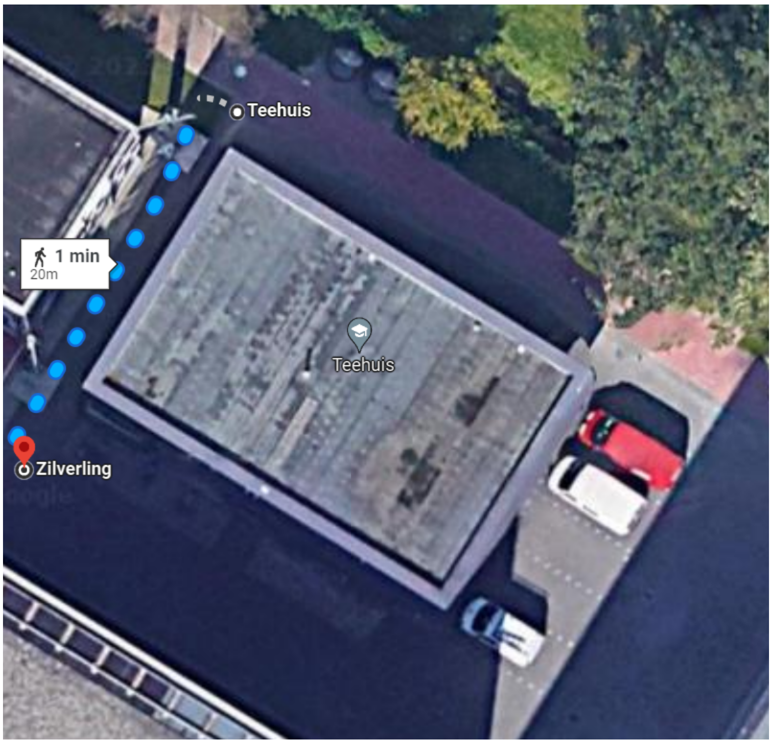


Image 1

Distance	Signal strength	Obstruction
20m	8.0	no

Table 1

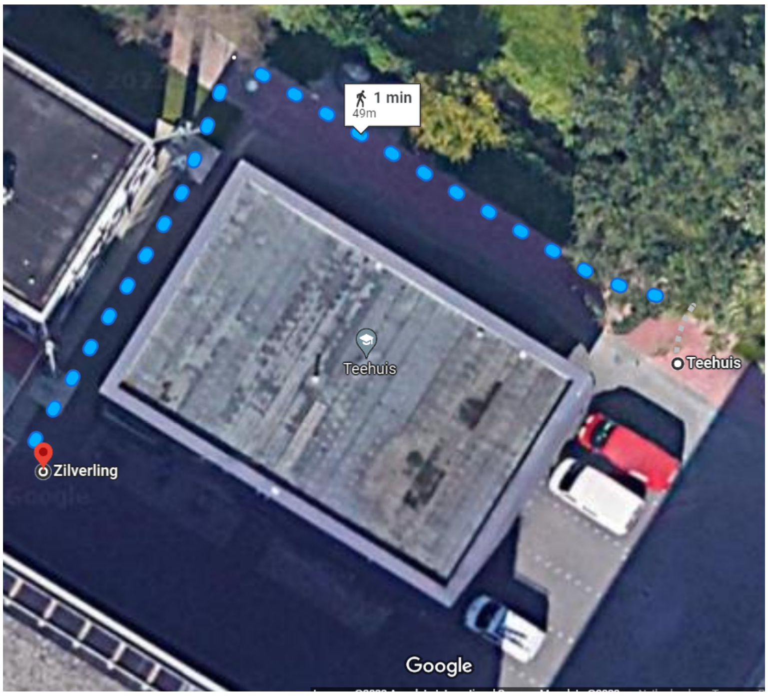


Image 2

Distance	Signal strength	Obstruction
35m	3.0	yes

Table 2

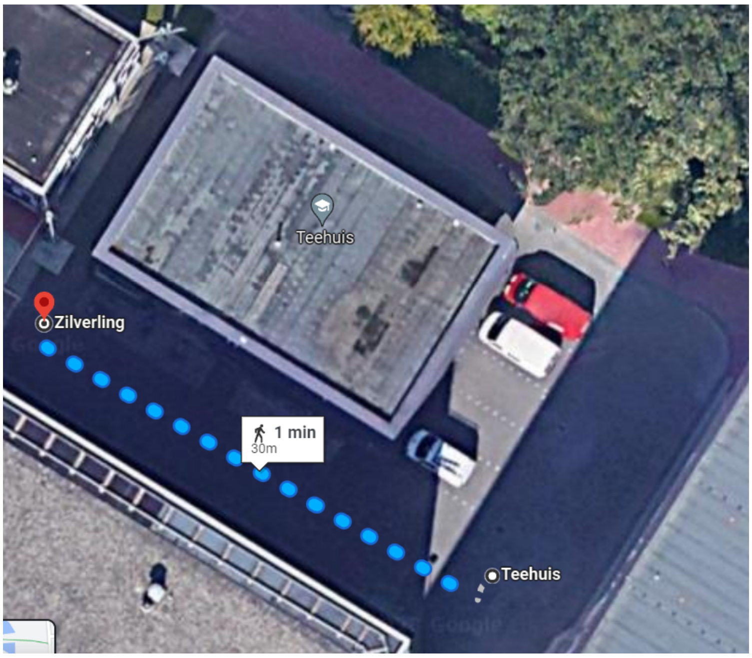


Image 3

Distance	Signal strength	Obstruction
30m	4.0	no

Table 3

Image 4

Distance	Signal strength	Obstruction
25m	6.0	yes

Table 4

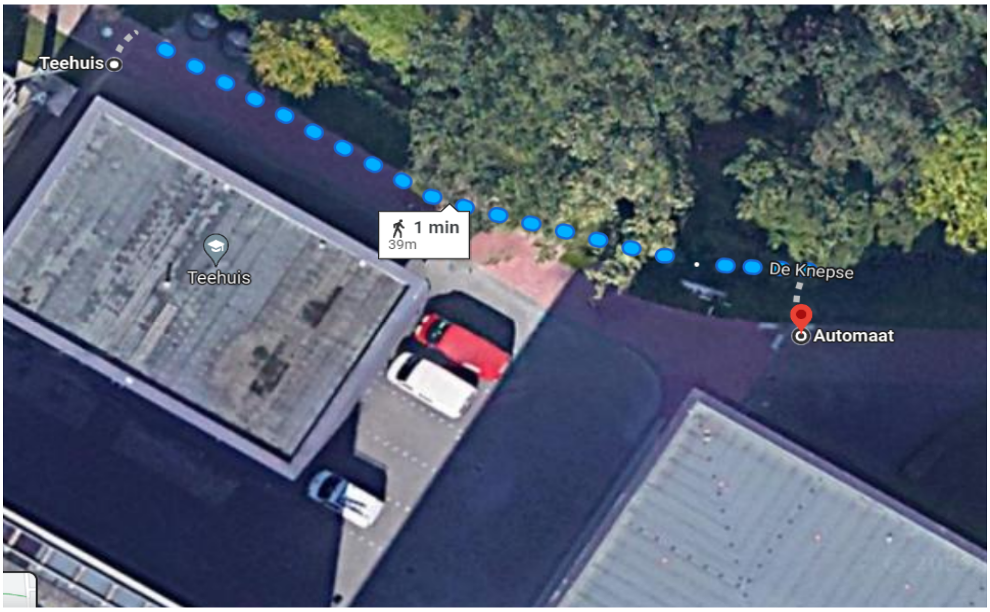


Image 5

Distance	Signal strength	Obstruction
40m	3.0	no

Table 5

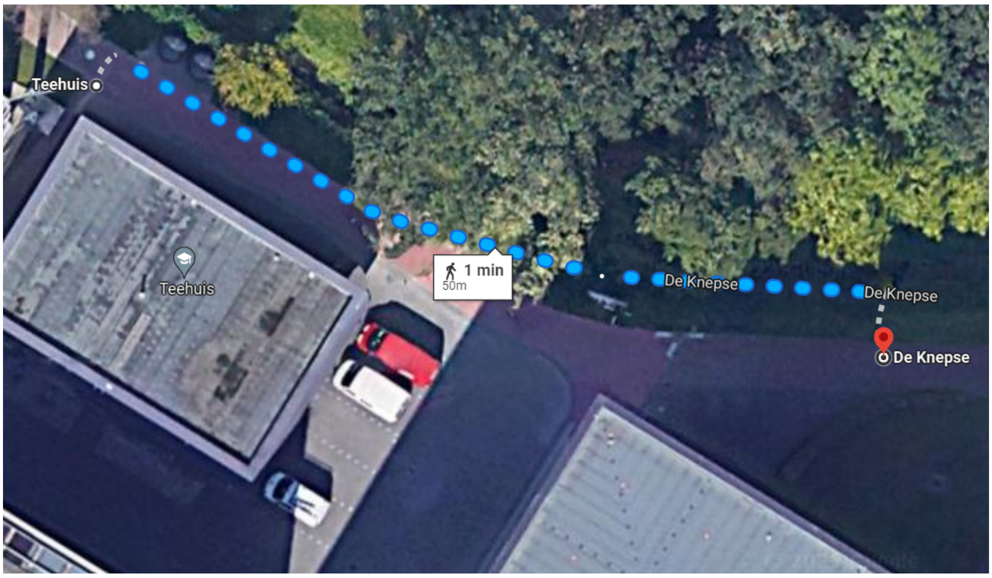


Image 6

Distance	Signal strength	Obstruction
50m	0.0	no

Table 6

The 50m range on the sensor is optimal for use in almost all environments, as well as the 8 second interval between signals to save battery life on the collar and in the beacon.

The casing that was made does not have any impact on the signal and is perfect for what needs to be achieved. Since the system does not require line of sight to function, the housing can be a solid case which is perfect for weather proofing. The material used and the colour applied to it are a perfect combination to utilise in a natural environment which makes it less visually detectable. Further interpretations of the beacon can be modified to include hermetic seals for dust and sand proofing, larger antennas for wider areas, and other such improvements.

Chapter 9: Results and Conclusion

The main 3 facets of this system included the hardware, software, and networking aspects. Throughout the course of the project, each member of the project contributed their own personal designs, ideas, and work to one or multiple of these aspects to create an efficient and functional prototype with multiple areas to expand the system.

The results collected by the beacon during the testing phase of the system showed that there was a functional range of up to 50m around the beacon. Although some interference was noticed due to buildings around the sensor, a signal was still received by the beacon with very little loss in signal strength. This is ideal for urban and rural environments, as obstructions like trash cans, buildings, trees, etc won't impact the validity of the data.

The combination of these data sets show how both data collected from cat movements and external collected data can be correlated to show how feral and domestic cats can impact the ecological balance in an environment.

Below you will be able to see a collection of some of the data we have collected throughout the duration of our project. These images contain multiple pieces of information that all together represent this data and it makes it fairly simple to analyse and visualise.
On the left hand side there is the day (since the beginning of the research), time and the feature to go back and forward between days and time so that data from previous days can also be accessed.
In the centre the heat map is present, with 3 beacons in 3 different sections. The red dots in the centre of the circles will become larger and the opacity of the colour will get higher as more data is collected. By how much and where is determined by the data that is retrieved from the database. Which circle to add to is determined by the beacon id and the opacity and radius is influenced by the signal strength.

On the right hand side the data kindly provided by Team 7 “Rangers” is present and provides information of where their sensor is located compared to the beacons . Additionally the Rangers provide the amount of birds in the area of this sensor. This is used to determine if the presence of a cat has an effect on the bird population. You can compare where the latest detection took place and the position of the Tweak, if this is the same there should be less birds and if it is not the same there could be birds because at this time there were no cats detected in the area near the Tweak.

The below examples are of the data collected and shown by utilising the heat map

Starting position:

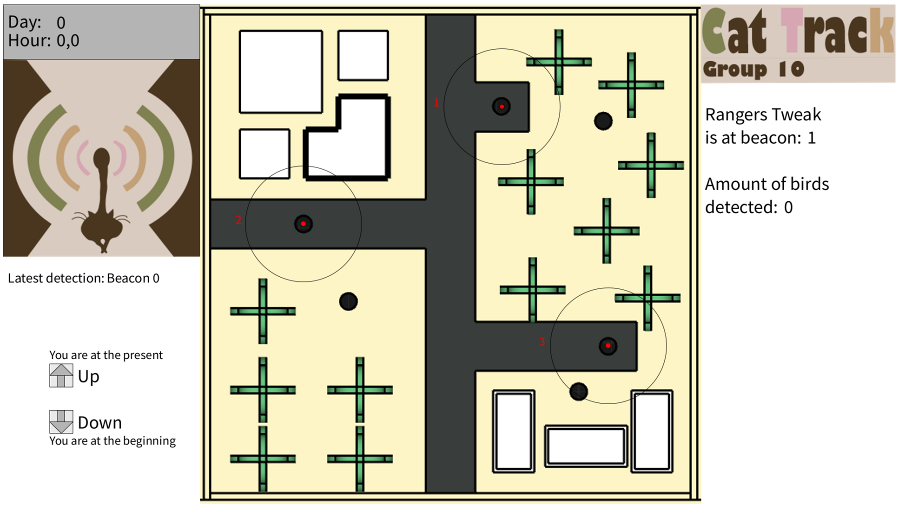


Image 9.1

After 5 cats detected:

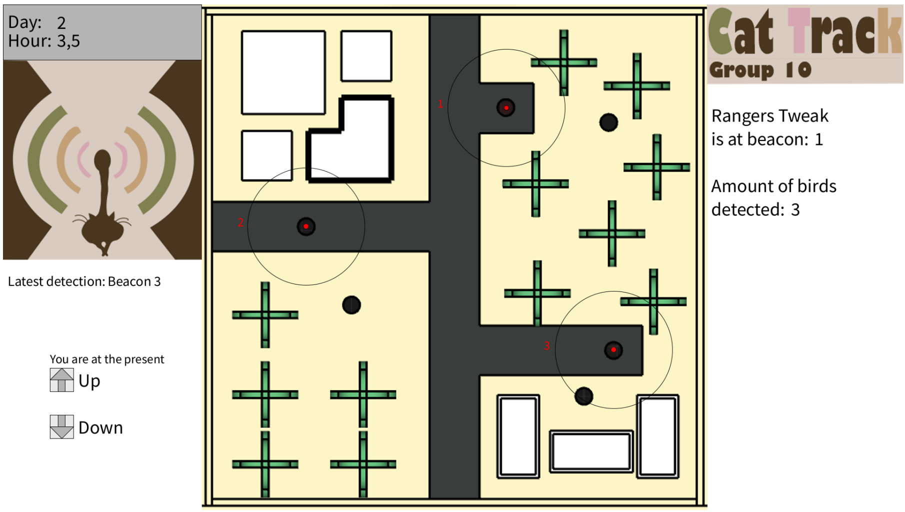


Image 9.2

After 10 cats detected

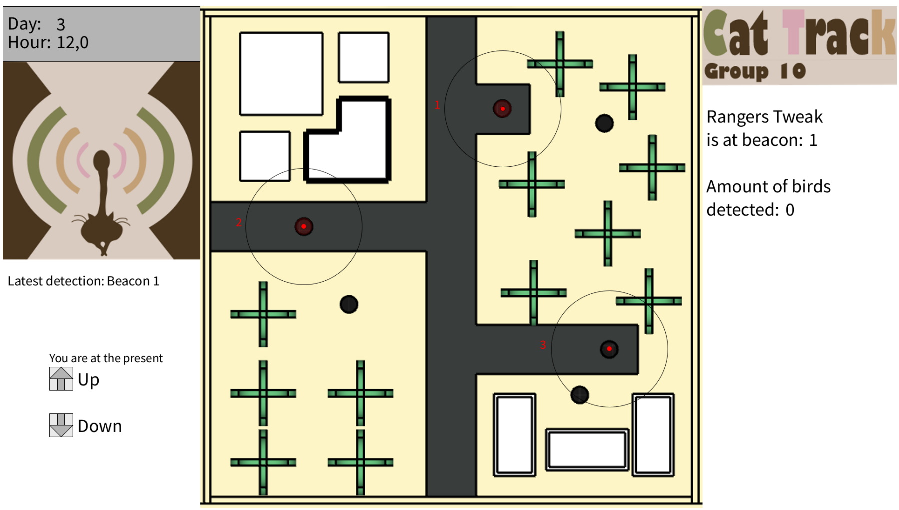


Image 9.3

After 20 cats detected

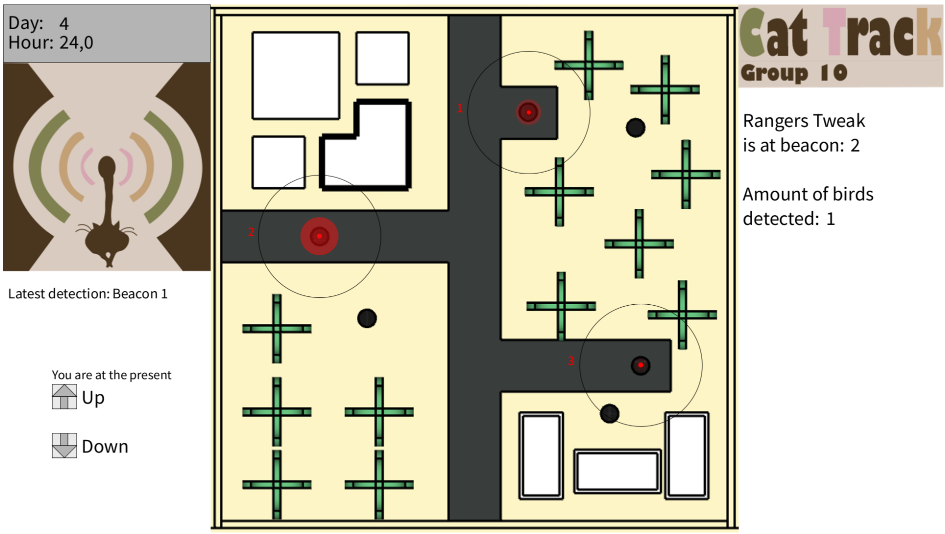


Image 9.4

As described above it is noticeable that the presence of cats in areas with a population of birds does have an effect as birds are less present in the area. This link can lead to two possible conclusions. Firstly, birds are learning to evade areas with a cat population, causing birds to become more and more scarce in heavily populated areas such as cities or suburbs. Secondly, birds are being hunted to a certain degree, visibly impacting their populations and their effect on the ecosystem. Both of these cases are incredibly worrying, as birds play multiple roles in keeping an ecosystem in check. Some birds, like sparrows and finches, keep the amount of insects present in an environment in check.

Overall, this study aims to contribute to research on the effects of cats on the environment by studying their behaviours and monitoring their positions. The resulting heat map can be used by other researchers to better understand the impact of cats on the fauna of the studied area.
This project provides crucial information in the study of the impact of feral cats in the environment and the ecosystems and it is a useful tool to start thinking of less expensive and more effective solutions that can help make a difference in the current situation of the large number of feral cats around the globe.

Resources

Bird protection agency (NL)

https://www.friesevogelwachten.nl/nl/over-bfvw/wie-is-de-bfvw

Feral cat colonies
https://sentientmedia.org/stop-killing-feral-cats-solution/

New European laws on domestic cats
https://nos.nl/artikel/2312219-wie-zijn-kat-niet-aanlijnt-overtreedt-europese-regels

Processing code, mqtt library reference: by Joël Gähwiler

https://github.com/256dpi/processing-mqtt

E-mails:

Hi Sanne,

Via the contact form I received your question about the effect of cats on wild birds. Ecologists, nature managers and conservation organizations generally agree that this effect is significant. I have put two articles below in which this effect has been investigated. As Ecoresult we do not conduct any research into the effect of cats ourselves, so I cannot really help you in that regard. In addition to Ecoresult, I also work for the province of South Holland on the conservation and protection of meadow birds. In this provincial role I am concerned with predation of meadow birds such as black-tailed godwit, redshank and lapwing. We see that cats also play a significant role in this. We have therefore recently set up various awareness campaigns to draw attention to this. Furthermore, as a province we are looking at what else we can do to prevent predation of meadow birds by cats. On Texel, for example, an action has been set up to catch and sterilize cats to protect ground-nesting birds. This could also be an option for South Holland in areas where many meadow birds breed. But we are still exploring these options.

Hopefully this information will help you. Let me know!

https://academic.oup.com/jel/article/32/3/391/5640440?login=false

https://www.nature.com/articles/ncomms2380

Sincerely,

Martijn van der Neut Adviseur ecologie | 078 75 184 12 | 06 868 61 930 | martijnvanderneut@ecoresult.nl
Waar gaan huismussen heen als de woningen worden gesloopt? Wij zoeken het uit!

Bye Sanne,

the best knowledge can be found at the Dutch bird protection. I found the link below. there you will find a first answer to your question. we have nothing to add to that.

good luck with your research.

Regards Louw den Best

https://www.vogelbescherming.nl/over-ons/standpunten/standpunt-huisdieren-en-wilde-vogels

Dear Sanne,

Thanks for your message and sounds like a good and important project!

Estimates of the number of victims vary, but if we assume the lowest estimates, it would still be about 18 million birds per year, which are killed by domestic cats and feral cats. (source. Steen and Dekker/ https://www.jasjadekker.nl/wp-content/uploads/2016/03/Steen-2016-Katten-in-de-NL-Natuur.pdf) That sounds worrying to many! Nevertheless, the populations of the various bird species do not seem to be under pressure on a national level. It is not for nothing that birds lay several eggs and many species often breed several times. It is a 'normal' phenomenon that a large proportion of the young do not grow up and die prematurely. Predation by predators is taken into account when laying the eggs. Most garden birds are doing well and cats are not a problem in the grand scheme of things.

But locally, predation by cats can indeed be a (pre)problem. Certainly for ground brooders and then in particular for birds for whom suitable steeds combined are less present. Those populations are of course extra susceptible to predation, including by cats. While cats are certainly not the greatest size for birds, they are the main culprit in some situations.

Predation as a whole is natural, but domestic cats and feral cats do not function as these natural hunters. Cats are not submerged in any native species, certainly not in the numbers we have in the Netherlands.

Here you can find more information about the effect of cat predation on the bird population:

Point of view pets and wild birds | Bird protection/https://www.vogelbescherming.nl/over-ons/standpunten/standpunt-huisdieren-en-wilde-vogels?gclid=CjwKCAiAy_CcBhBeEiwAcoMRHN-INFox8DFO1FeXoBDuyrg4i0OJI7vAGNBkFDe8yLEX1uLERS7LjxoCN2gQAvD_BwE

At the bottom of the article is a list of sources, where you can find more information.

I hope you can provide enough information, but you probably still have questions that we would like to answer.

Met vriendelijke groet,

Eva Fransen
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