ISSN No:-2456-2165

AI System to Protect Endangered Animal Population and Prevent Poaching Threats using Weapon Detection

Sachini Kuruppu
Sri Lanka Institute of Information Technology

Abstract:- International Wildlife Trade (IWT) poses a grave threat to global biodiversity conservation efforts, exacerbating the ongoing sixth mass extinction crisis. With IWT ranking fourth among the world's largest criminal industries [1], worth an estimated $7-$23 billion annually [2], urgent measures are required to prevent the illegal exploitation of endangered species. This research paper proposes the implementation of an automated weapon detection system in forest areas, where the population density of endangered animal species are high, aiming to detect concealed weapons used by poachers, even in dense forest environments with limited internet connectivity. The paper provides an overview of IWT, its detrimental effects, strategies for prevention, the importance of biodiversity protection, and outlines an advanced artificial intelligence-based approach combining camera traps, the YOLOv5 object detection algorithm, and Long Range (LoRa) technology with Raspberry Pi 4 to identify poachers carrying concealed weapons. The proposed system has the potential to significantly enhance wildlife protection and safeguard the lives of park rangers by monitoring unexplorable geographical areas, detecting weapons and alerting the presence of poachers to park rangers and pinpointing the location in real time.

Keywords:- *Illegal Wildlife Trade, Yolov5, Camera Traps, Long Range (LoRa) technology, Raspberry, detecting weapons.*

I. INTRODUCTION

A. Literature Review

Poaching is the illegitimate act of hunting, killing or holding wild animals in captivity and it's done for several reasons such as, the trade of rare animal products (ivory, fur, teeth, medicinal oil, skin) for its financial value and to re-use the land etc [5]. It is an unfortunate fact that, nearly 30,000 species are driven to extinction annually according to the Center for Biological Diversity [6]. Alongside these devastating numbers, endangered species are killed in thousands per day worldwide. As experts report, up to 2000 endangered species go extinct annually [7]. Human activities such as climate change, deforestation, pollution and over exploitation have caused an overwhelming decline of species population to flora and fauna, from whales to rhinos and elephants according to the World Animal Foundation [7]. Within the time range from 2012-2019 alone, 160 million animals were reported to be illegally trafficked from Brazil. The IUCN red list [8] [9] has over 40,000 species categorized as threatened and it has been observed that, the percentage of threatened mammals has only increased by 21% during the period of 2007 to 2020. The African Savannah elephant population has decreased by over 60% over the past two generations alone [7]. The loss of one keystone species in an ecosystem will change migration patterns, breeding habitats, food webs, behavior and community. As a result, biodiversity itself faces a threat. It is no secret that biodiversity is walking into its sixth mass extinction [10].

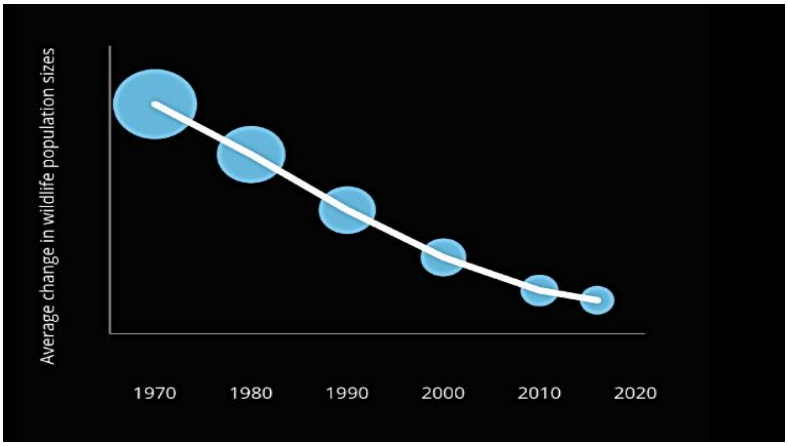

Fig. 1: Sixth mass extinction

The lives of wildlife rangers may also be at risk since the number of poachers often outnumber those of rangers and accidental brushes with traps meant for animals. According to the Global Conservation, almost two rangers are killed per week due to poaching incidents [3].

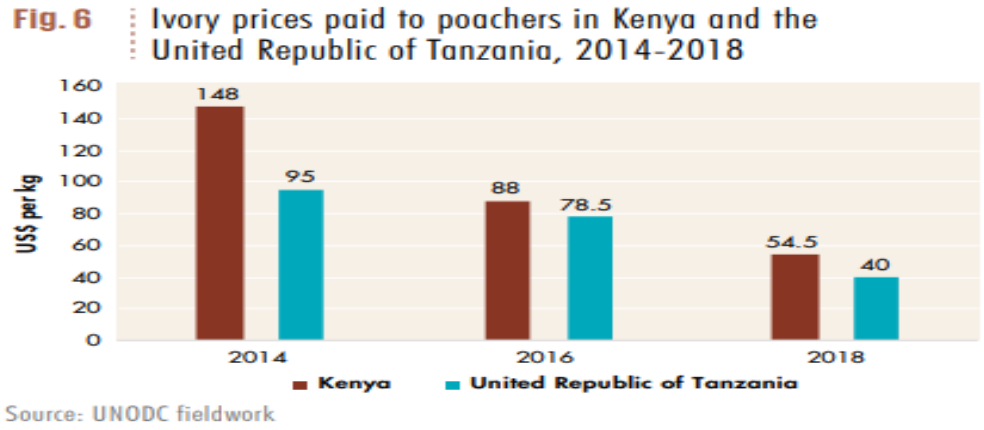

Fig. 2: Ivory Prices Paid in Kenya and United Republic Of Tanzania, 2014-2018

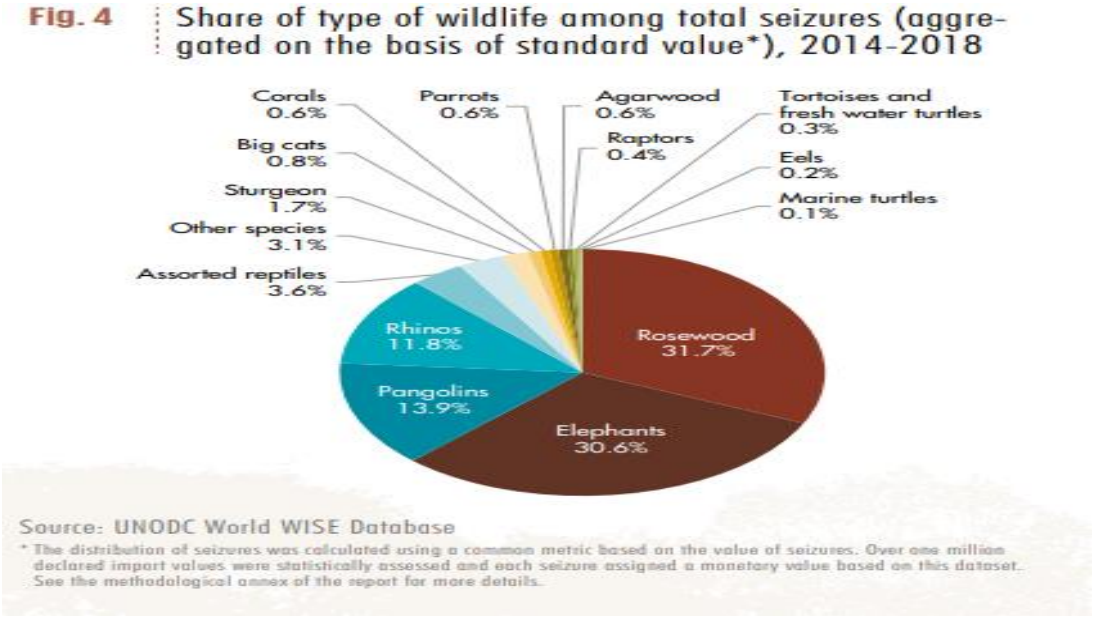

Fig. 3: Share of type of wildlife among total seizures, 2014-2018

According to the World Wildlife Crime Report issued in 2020, the variation of ivory prices in Kenya and the United Republic of Tanzania (figure 2) and the share of type of wildlife among total seizures during the same period (2014-2018) (figure 3) [11] are illustrated. The general weapons used by poachers are deadly snares, poisoned arrows, jaw bombs, firearms etc [12]. According to the conflict awareness report issued by Kathi Lynn Austin in 2019, poachers can be followed by their firearms[13]. The National Geographic author, Rachael Blue, enunciates how the illegal wildlife trade and the arms trade complement each other in many levels [14].

In Sri Lanka, laws such as the Fauna and Flora Protection Ordinance (FFPO) [15] are enforced to prevent the illegal trade of wildlife. However, the rate of poaching has only increased with the inflict of inflation and the pandemic, and the loss of income from tourism and jobs [1]. Poaching is problematic to control mainly because, the number of rangers in a large conserved national park is considerably low and their daily patrol routes will not cover the entire area within a given time and not every path in the national park is accessible on foot/ by vehicle due to geographical limitations. Using AI and deep learning, we will develop an anti-poaching system that is able to monitor endangered animals and predict and prevent poaching threats. We will base our efforts in the Yala National Park, Sri Lanka because of its high density of endangered species [16].

For this purpose, we use deep learning methods, using AI to identify poachers by detecting their weapons. In our system, we will use a one stage object detection algorithm, YOLO-V5 [4]. Deep learning methods such as Faster R-CNN were previously used in object detection systems [17]. However, those techniques use two stage detection and because of the many inference steps per image, their performance is low and are found to be not ideal for real time video surveillance. These techniques have a high computational overhead and fail to detect guns due to low quality and visibility issues in surveillance videos. In comparison, one stage detectors like YOLO-V5, generally has a faster detection speed and greater structural simplicity and efficiency [18]. However, large datasets with annotated images are needed for model training in any case, as we are using a deep learning method.

ISSN No:-2456-2165

Fig. 4: Fastest real time object detection algorithm comparison

For our system, we will use Raspberry Pi, a low-cost single-board computer that combines external hardware, sensor and controller interfaces, with user- friendly programming capabilities, high connectivity and desk-top functionality. Although other single board computers exist, such as NVIDIA Jetson Nano and Banana Pi, we propose to use Raspberry Pi because of its updated comprehensive documentation and its maintenance over the years. LoRa, which is a long-distance radio frequency technology, enables the transfer of small data packages even in remote forest areas with low internet connection [19].

B. Research Gap

PAWS and Capture are the two most prominently automated applications designed to detect and prevent poaching using AI. PAWS use prior data from SMART, to predict a number of the most efficient routes for rangers to patrol [20]. CAPTURE (Comprehensive Anti-Poaching tool with Temporal and observation Uncertainty REasoning) uses a temporal behavioral model to detect the poacher's behavior and computes the defender's optimal patrolling given the complex poacher model [21] . Both above applications have been tested and implemented in Queen Elizabeth National Park in Uganda (Africa) and has been reported to be a success. Both these applications use data collected overtime such as pre-defined routes, previous incidents and predicts routes with possible poaching activity based on the poacher's behavior. The accuracy of data is limited through these approaches. Both the above components do not process a real-time weapon detection system to detect poachers. Our research is different from the two applications, as we do not predict the routes and time the poachers might be present at. Here, we detect the presence of weapons from cameras, retrieve the date, time and location, and alert the park ranger through the application.

In Sri Lanka, according to the data collected on-site at the Department of Wildlife Conservation in July 2023, no active automated system was used to detect weapons and poachers inside the conserved forest areas. However, after inspecting the Uwa Reigon Incident Log for the year 2023 itself (January- July), which includes the Yala National Park, over 26 cases of illegal poaching and illegal procession of weapons were found. Among the reported cases, were those where park rangers were offended on-duty, which enunciates the risk that park rangers face every day to protect wildlife.

C. Research Problem

Poaching of endangered animals deeply impact the biodiversity. They are unique and cannot be replaced. Comprehensive poaching statistics are limited and maintained only in six countries (South Africa, Kenya, Mozambique, Namibia, Botswana and India)[6]. Not only flora and fauna, but humans are also affected by illegal wildlife trade. Innocent wildlife rangers are often in the line of danger because of traps and confrontations with the poachers [6]. Another problem identified is that, with the low number of rangers in a very large conservation park, the area inspected over daily patrols will be low and a large area will not be covered. Rangers are often outnumbered in comparison to the number of poachers. Rangers also have limited accessible patrol routes that they can cover within a set time (slopes, rivers etc are hard to approach easily). Additionally, the uncertainty of the accuracy of alerts faced in both PAWS and CAPTURE, is improved, since once a suspicious object is detected by Yolo-v5 algorithm, the alert is 55.6% accurate [22].

According to the regional distribution of elephant deaths in Sri Lanka from 2018-2023.07.31, 330 elephants were found to be dead due to gun shots, 262 due to electrocution, 335 due to jaw bombs and 33 due to poison. It is a fact of shame that such rare, endangered, beautiful creatures that bring tourism and beauty are subject to poaching threats throughout their lifetime.

II. WORKDONE

Poaching, and IWT at whole, is one of the biggest profitable green crimes in the world [23]. 'Anthropocene' is a word used by ecologists and conservation biologists worldwide, to address the direct impact of human activities on the sixth mass extinction [24]. According to a survey by the Wildlife and Nature Protection Society of Sri Lanka in 2019, it was found that only 52% of people in Sri Lanka were aware of the term "illegal wildlife trade." A 2020 survey by the Sri Lanka Customs Department found that only 43% of

ISSN No:-2456-2165

people in Sri Lanka were aware of the laws and regulations that are in place to protect wildlife. A 2021 survey by the Environmental Foundation Limited found that only 38% of people in Sri Lanka were aware of the negative impacts of illegal wildlife trade on the environment. Internationally, a 2018 survey by TRAFFIC found that only 33% of people in the United States were aware of the term "illegal wildlife trade." A 2019 survey by the World Wildlife Fund found that only 46% of people in China were aware of the negative impacts of illegal wildlife trade on the environment. A 2020 survey by the International Union for Conservation of Nature found that only 53% of people in India were aware of the laws and regulations that are in place to protect wildlife. Based on these statistics, it could be concluded that, despite the recognition of the sixth biomass extinction and accompanying conservation efforts conducted, the general public lack awareness of the problem. This could be a root cause for poaching to continue within the general society, and for the consumption of goods resulted from IWT, and the use of them in fashion, traditional medicine, wild food etc [25]. Awareness sessions and research centering illegal trade of endangered animal species could likely have a more lasting effect on the public, as an effort to combat poaching and illegal wildlife trade. For our research, we have selected critically endangered animals globally recognized by the IUCN red list, namely, *Panthera pardus* , Sri Lankan leopard, *Elephas maximus,* Asian Elephant and *Melursus ursinus*, Sloth bear. In a research that collected publicly available reports on IWT from 89 countries, species reported as poached included, elephants (n = 107, 12.5%) and leopards (n = 54, 6.3%) [26].

The proposed anti-poaching system will alert the presence of poachers by detecting weapons using camera traps. The camera units must be installed at regular intervals, covering a 360□ angle, to get maximum coverage. The weapons selected for detection are guns because they are found to kill efficiently with less effort than other weapons. Also, they are portable and easier to conceal. Other weapons generally used by poachers are deadly snares, poisoned arrows, jaw bombs, firearms etc . According to the conflict awareness report issued by Kathi Lynn Austin in 2019, poachers can be followed by their firearms. The National Geographic author, Rachael Blue, enunciates how the illegal wildlife trade and the arms trade complement each other in many levels. In 2016, a study by the International Union for Conservation of Nature (IUCN), found that guns were the most commonly used weapon for poaching in Africa, accounting for 70% of all poaching incidents.In 2017, another study by the TRAFFIC wildlife trade monitoring network found that guns were the most commonly used weapon for poaching in Asia, accounting for 60% of all poaching incidents. In 2018,a study by the World Wildlife Fund (WWF) found that guns were the most commonly used weapon for poaching in Latin America, accounting for 50% of all poaching incidents.

In the anti-poaching system, videos are collected real-time from camera units installed on higher grounds. For the unit to work best even at low internet connection or offline conditions without interruption, we use LoRa technology which uses radio frequencies to transfer small data packages. We will use Raspberry Pi 4, a low-cost single-board computer that combines external hardware, sensor and controller interfaces, with user-friendly programming capabilities, high connectivity and desk-top functionality. It will be used instead of other possibilities such as NVIDIA Jetson Nano and Banana Pi, because of its comprehensive, complete and updated documentation [27].

Raspberry Pi 4 is preferred over other Raspberry models because, it has a faster processor, larger RAM, more USB ports and is compatible with more operating systems (figure 4).

Feature	Raspberry Pi 4	Raspberry Pi 3B+	Raspberry Pi 3B
Processor	Broadcom BCM2711	Broadcom BCM2837B0	Broadcom BCM2835
Clock Speed	1.5 GHz	1.4 GHz	1.2 GHz
RAM	4 GB	1 GB	1 GB
USB Ports	4	2	2
Operating Systems	Raspbian, Ubuntu, Windows 10 IoT Core	Raspbian, Ubuntu	Raspbian, Ubuntu

Fig. 4 Comparison between Raspberry Pi 4 and other Raspberry models

The collected dataset will then be analyzed by YOLO-V5 framework, which can be suggested as the most suitable technology to process concealed images and videos, efficiently. It is also lightweight, easier to train, consumes less power and more accurate than other training models like R-CNN. This makes it a better choice for devices with limited resources, such as the Raspberry Pi . It is also much better than other YOLO models, since it uses new training techniques like mosaic data augmentation and auto learning bounding box anchors, to increases the accuracy. It also has a new neck architecture called PA-NET, which is more efficient and accurate at detecting small objects.

Once a weapon is detected in the received datasets, an alert will be sent to the mobile devices of park rangers, with the location of camera unit, date and time, in real-time (figure 5).

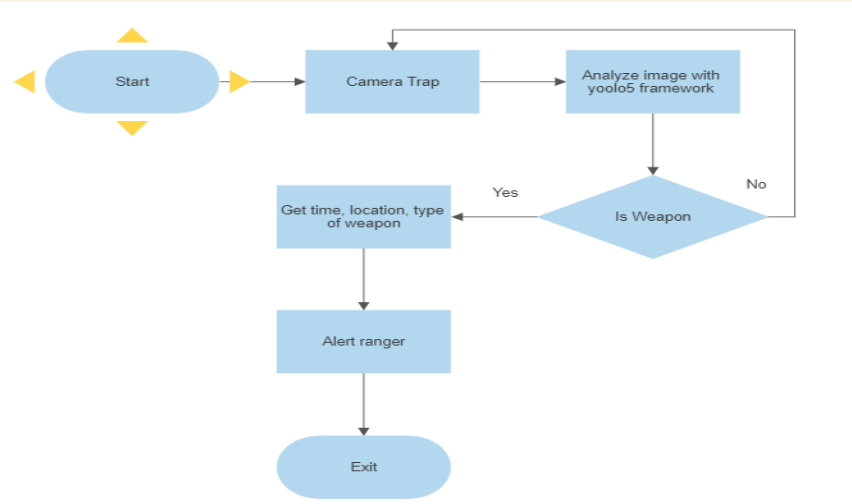

Fig. 5: Flowchart explaining methodolgy of anti-poaching system

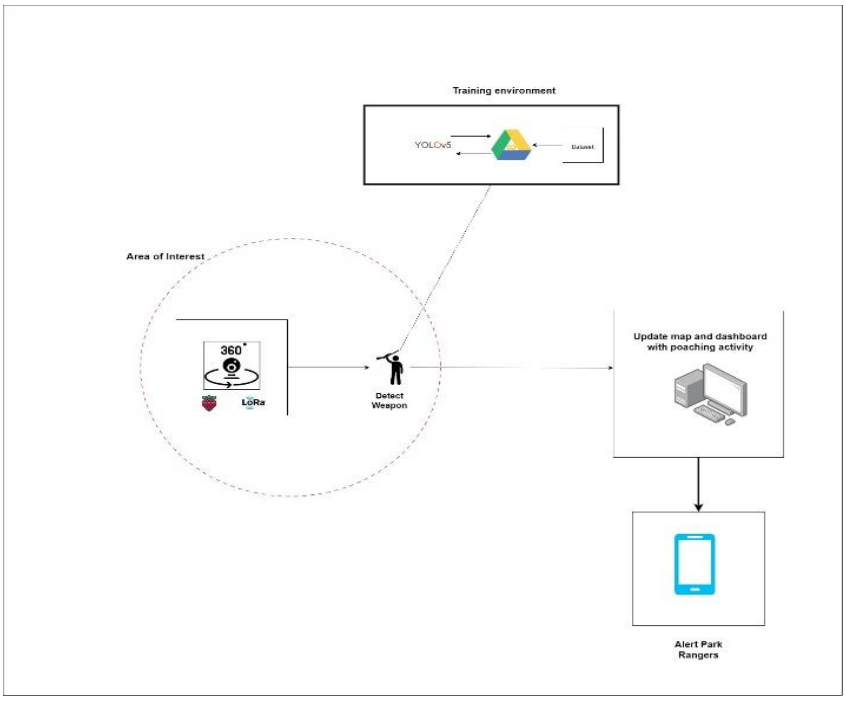

Fig. 6: Overall anti-poaching system diagram

III. CONCLUSION

Despite the low number of rangers and vast geographical area, our system can monitor the presence of endangered animals and give alerts to park rangers in case a suspicious event is detected (weapon, fire or gunshot). The overall goal of the research, which was to protect endangered animals from poaching threats, is then achieved, and poachers are detected through the presence of weapons, using AI and deep learning techniques. The wasted time and energy of wildlife rangers spent in inefficient patrols in unreachable areas are saved.

ACKNOWLEDGMENT

I am grateful for the support given by my supervisor, Dr. Sanath Jayawardena and my co-supervisor, Ms.Poorna Panduwawela, who gave guidance throughout the research.

REFERENCES

[1.] "(34) Why is the illegal wildlife trade a global threat? (It's more than COVID19) | LinkedIn." https://www.linkedin.com/pulse/why-illegal-wildlife-trade-global-threat-its-more-/ (accessed May 04, 2023).

[2.] "Poaching and Wildlife Trafficking in Sri Lanka during COVID-19 - Blog - Knowledge Hub." https://www.slycantrust.org/blog-posts-knowledge/poaching-and-wildlife-trafficking-in-sri-lankaduring-covid-19 (accessed May 04, 2023).

[3.] "Poaching Statistics – Illegal Hunting & Trade in Numbers!" https://worldanimalfoundation.org/advocate/poaching-statistics/ (accessed May 04, 2023).

[4.] "Object Detection in 2023: The Definitive Guide - viso.ai." https://viso.ai/deep-learning/objectdetection/ (accessed May 04, 2023).

[5.] "Animal Poaching | Poaching of Wildlife | Anti Poaching Organizations." https://seasave.org/poaching/ (accessed May 04, 2023).
[6.] "Poaching Statistics – Illegal Hunting & Trade in Numbers!" https://worldanimalfoundation.org/advocate/poaching-statistics/ (accessed May 04, 2023).
[7.] "40 Alarming Endangered Species Statistics [2023 Report]." https://worldanimalfoundation.org/wild-earth/ (accessed May 04, 2023).
[8.] "IUCN Red List of Threatened Species." https://www.iucnredlist.org/ (accessed May 04, 2023).
[9.] "Sus scrofa | The National Red List 2012 of Sri Lanka: Conservation Status of the Fauna and Flora | National Red List." https://nationalredlist.org/assessment/sus-scrofa-national-red-list-2012-srilanka-conservation-status-fauna-and-flora (accessed May 04, 2023).
[10.] "Biodiversity: Why the nature crisis matters, in five graphics - BBC News." https://www.bbc.com/news/science-environment-54357899 (accessed May 04, 2023).
[11.] UNODC, "World Wildlife Crime Report," 2020. Available: https://www.unodc.org/documents/data-and-analysis/wildlife/2020/World_Wildlife_Report_2020_9July.pdf
[12.] "Modern Poaching's Toll." https://campaign.awf.org/modern-poaching/ (accessed May 04, 2023).
[13.] "Follow The Guns Report on Rhino Poaching and Wildlife Crime." https://followtheguns.org/report.php (accessed May 04, 2023).
[14.] "How Illegal Weapons Fuel Poaching—and Poaching Fuels the Illegal Weapons Trade." https://www.nationalgeographic.com/animals/article/160112-Africa-gun-control-poachingelephants-rhinos (accessed May 04, 2023).
[15.] "National legislation and prevention of illegal trade of wildlife, including Ivory in Sri Lanka Background".
[16.] "Yala National Park | Plan Your Yala Safari with Eco Team Sri Lanka." https://www.ecoteam.lk/travel-destinations-sri-lanka/nature-an-national-parks-sri-lanka/yala.html (accessed May 04, 2023).
[17.] M. Mehdipour Ghazi, B. Yanikoglu, and E. Aptoula, "Plant identification using deep neural networks via optimization of transfer learning parameters," Neurocomputing, vol. 235, pp. 228– 235, Apr. 2017, doi: 10.1016/J.NEUCOM.2017.01.018.
[18.] "Object Detection in 2023: The Definitive Guide - viso.ai." https://viso.ai/deep-learning/objectdetection/ (accessed May 04, 2023).
[19.] J. W. Jolles, "Broad-scale applications of the Raspberry Pi: A review and guide for biologists," Methods in Ecology and Evolution, vol. 12, no. 9, pp. 1562–1579, Jun. 2021, doi: https://doi.org/10.1111/2041-210x.13652
[20.] "PAWS anti-poaching AI predicts where illegal hunters will show up next | Engadget." https://www.engadget.com/paws-anti-poaching-ai-predicts-where-illegal-hunters-will-show-upnext-203614412.html?guccounter=1 (accessed May 04, 2023).
[21.] T. H. Nguyen et al., "CAPTURE: A New Predictive Anti-Poaching Tool for Wildlife Protection", Accessed: May 04, 2023. [Online]. Available: www.ifaamas.org
[22.] "YOLOv5 : The Latest Model for Object Detection | by David Cochard | axinc-ai | Medium." https://medium.com/axinc-ai/yolov5-the-latest-model-for-object-detection-b13320ec516b (accessed May 04, 2023)
[23.] A. Mozer and S. Prost, "An Introduction to Illegal Wildlife Trade and its Effects on Biodiversity and Society," Forensic Science International: Animals and Environments, vol. 3, p. 100064, Feb. 2023, doi: https://doi.org/10.1016/j.fsiae.2023.100064.
[24.] C. Chen, "Mammal community responses to human disturbance : insights from global camera trap surveys," open.library.ubc.ca, 2023. https://open.library.ubc.ca/soa/cIRcle/collections/ubctheses/24/items/1.0431318
[25.] A. Mozer and S. Prost, "An Introduction to Illegal Wildlife Trade and its Effects on Biodiversity and Society," Forensic Science International: Animals and Environments, vol. 3, p. 100064, Feb. 2023, doi: https://doi.org/10.1016/j.fsiae.2023.100064.
[26.] A. L. Sonricker Hansen, A. Li, D. Joly, S. Mekaru, and J. S. Brownstein, "Digital Surveillance: A Novel Approach to Monitoring the Illegal Wildlife Trade," PLoS ONE, vol. 7, no. 12, p. e51156, Dec. 2012, doi: https://doi.org/10.1371/journal.pone.0051156.
[27.] J. W. Jolles, "Broad-scale applications of the Raspberry Pi: A review and guide for biologists," Methods in Ecology and Evolution, vol. 12, no. 9, pp. 1562–1579, Jun. 2021, doi: https://doi.org/10.1111/2041-210x.13652.