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TRAIL-TRACKER: ANTI-POACHING INTELLIGENCE USING AI AND IOT

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Abstract: Poaching in today's world is one of the most significant threats to wildlife. Poachers use different methods to capture animals. Many commercial poachers use military-grade weapons along with arrows and spears to hunt wildlife. Sometimes, objects called snares (a set of wires tied to trees configured to capture any animal by their leg or neck that gets into it) are also implemented. Poachers also trap the animal into large nets, known as trap nets, pitfall traps (a vast pit dug in the ground that is layered with leaves and plants) or baits. In this paper, we suggest a new solution that operates in real-time to pursue the cause of wildlife conservation by preventing the poaching of any species of animals - endangered or non-endangered by profit-hungry poachers with the help of Artificial Intelligence(AI) and Internet of Things(IoT). In comparison to previous methods in the same domain, it presents an alternate approach, in the form of a monitoring system that can track poaching activity and predict poachers' behaviour and alert forest authorities for any suspicious crime.

Keywords: Artificial Intelligence, Internet of Things, Anti-Poaching, Wildlife Conservation, Applied Machine Learning

1. INTRODUCTION

Poaching is the plunder of wildlife organs. Trade of ivory, animal skin and bones are a few well-known resources acquired by hunting the animals in exchange for money[1]. For example, the illegal ivory trade in Africa causes the continent to lose 100 elephants every day. Since the 1990s the problem has escalated rapidly in particular for elephants. Like in 2011 the total world population of elephants was dropped from 1.3million in 1979 to 423,000. As per the Tanzania Wildlife Research Institute, daily loss of 30 elephants has been estimated in Tanzania to poaching. A population of 355,000 was tallied in 1994 in Tanzania but since then in 1999 it dropped promptly to 180,000 and below that in 2011.[2][7]. The global tiger population has dropped over 95% from the start of the 1900s and has resulted in three out of nine species to be brought on the brink of extinction. At this rate, these creatures will be endangered and will eventually face extinction. These activities are continuously increasing in the world due to the decrease in the population of the animals and the increase in the number of the rarity of some species of animals. In order to protect wildlife and their habitats from poaching and illegal trade various wildlife conservation agencies are established across the globe. Many rangers are stationed to patrol throughout the conservation areas. Many local communities, wildlife populations, and the environment is negatively affected by wildlife poaching. The animal parts are sold as novelty items and are sold for their "medicinal" properties in various black markets. For example, Ivory is used by the Chinese for arts and utility purposes, the Americans to make gun and knife handle as well as decorative details on these weapons.[3]

International efforts to put an end to wildlife poaching are lead by various International and National bodies such as The United States Fish and Wildlife Service (USFWS), The World Wildlife Fund for Nature (WWF), and The International Anti-Poaching Foundation (IAPF), environmental groups, animal right groups, government agencies. A powerful message against elephant poaching and the illegal ivory trade was delivered by Kenyan Government on 30 April by burning 105 tonnes of ivory, worth up to US $220 million.[4]

In order to discourage poaching activities that threaten the natural fauna, sophisticated technology needs to be applied as a better solution over the current anti-poaching efforts.

This paper presents a new system for anti-poaching involving image sensor (i.e. RGB cameras) and a remote computing unit (i.e. Raspberry Pi) along with Vision Processing Unit(VPU) like Intel Movidius Neural Compute Stick 2 to process complex machine learning computation on the unit itself and a central computer system for data transmission. With this system, a properly selected machine learning algorithm is implemented on the device, if any suspicious activity is observed three actions will take place. The first action is the computing unit will send a notification to the central computer system, the second action is through internet medium a text notification will be sent to wildlife conservation officers alerting them about illegal events in the area and the third action is the frames will also be sent to the central computer system to be transmitted to the wildlife conservation officers and hence providing them with the live stream of the events.

2. Current Scenario

Each protected wildlife reserve forest has its own wildlife conservation authorities wherein managers and officers of authority recruit field ranger staff for patrolling within the forest region. The recruitment and training are done on the basis of:

1. Analyze current poaching activity and future trends, both locally and regionally
2. Analyze the protected area's specific issues, i.e. size, topography, entry, portability, points of approach, group centers, specific species, etc.
3. Evaluate current protection plans and capabilities
4. Determine the number of additional staff required (if necessary) and necessary skill sets.[5]

The task of these field rangers is to patrol the forest areas to identify and remove any traps within the forest terrain and to register any poaching case that occurred within the forest. Rangers note their analysis, including signs of animals and poaching activity, e.g., traps set by poachers during the patrol, and therefore get insights by these records into the poaching patterns.

3. Related Work

This research suggests the use of computer vision to make an intelligent monitoring system which will send a report back to the rangers when any criminal activity takes place within the forest region. Various efforts had been undertaken by the scientific community to develop systems which will only report back to the rangers after the incidence of poaching had happened or when it absolutely was occurring.

In one of those efforts, a new solution was proposed by utilizing both very limited data about the forest and human knowledge to predict and analyze poaching patterns. It proposed an approach to assemble quantitative information through a questionnaire built upon a clustering-based division of the conservation area from domain experts. Additionally, it also proposed algorithms that exploit qualitative and quantitative information provided by the domain experts to reinforce the dataset and improve learning.[1]

In other efforts, a sensor-based Anti-Poaching System was implemented by Tanzania National Parks where sensors were collared to elephants and rhinos with built-in measures to use animal panic behaviours and horns synchronizations to detect and report poaching incidents and show the location through GPS. Furthermore, this system provided assistance in monitoring normal animal's death and understanding animal's group behaviours. However, it faced the drawback of dangers involved in collaring animals like an elephant with sensors and hence needing trained personnel. Also, the use of battery brought about many problems such as pollution and extra radiation.[2]

Few Research works were subjected to the utilization of drones in order to put a stop on poaching activities. In a research conducted by collaborative efforts of the University of Southern California, Carnegie Mellon

University, Microsoft, AirShepherd proposed the use of SPOT(Systematic POacher deTector) with the capability to automatically detect poachers and animals in near real-time.

SPOT illustrated the feasibility of building upon state-of-the-art AI techniques, like Faster RCNN, to deal with the challenges of automatically detecting animals and poachers in infrared images. This paper reported the planning and architecture of SPOT, a series of efforts towards more robust and faster processing to form SPOT usable within the field and supply detections in near real-time, and evaluation of SPOT supported both historical videos and a real-world test pass by the end-users within the field. This system works in varying situations and does not require the users to regulate any parameters while using it. Thus, it is easily accessible to non-expert users. Furthermore, the system can detect poachers in near real-time without any inconvenience in connectivity.[8]

4. Motivation

With the introduction of AI and IoT, today real-time prediction and real-time inter-communications, as well as intra-communications, can be achieved. Traditional approaches to stop animal poaching included patrolling forest rangers along a specific path at particular intervals to confiscate snares, arrest poachers, and make other observations. In due time AI algorithms were developed to predict the poacher activity within spatial and temporal dimensions using historical information. Another method used involved collaring animals with wireless sensors so as to track them and report poaching activity around them. However, in order to predict poaching activity, it is important to provide precise historical information that should follow a particular pattern to draw a proper correlation to poacher's behaviour. Also collaring may affect animal behaviour and cause injury to animals or devices alongside the cost involved in designing such an expensive device. An alternative approach can be taken to prevent poaching activity which involves placing an infrared and surveillance camera at a specific strategic location within the forest so that it may provide a proper vantage point to cover maximum area and detect activities within its range attached to a smart computing device which will perform the task of detecting the activity and report the authorities if the activity falls under the suspicious category in real-time.

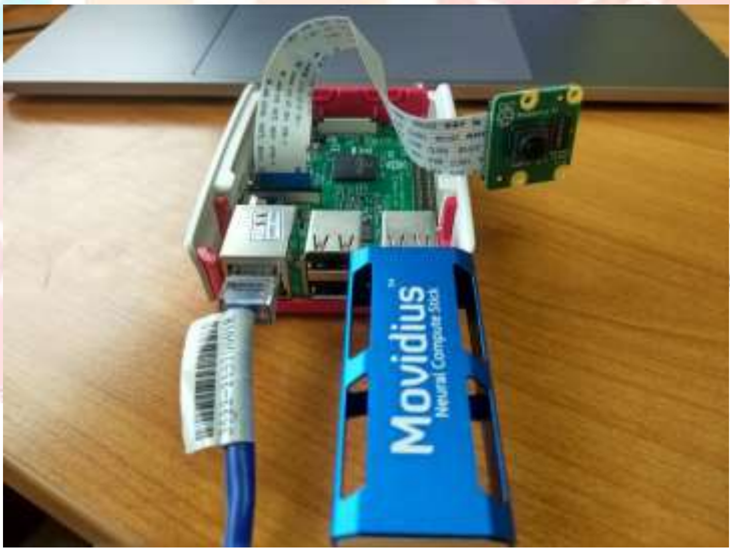

Figure 1: Sample device that can be used in the system

5. Proposed Infrastructure of The System

The proposed infrastructure of the system can be adapted from existing surveillance systems or install the new one. The constituents of the system can vary but the compulsory devices essential to the system include the following:

Camera Module: The best method proposed in this paper is the use of access points as this method is cost-effective. Access points are used to collect data from sensors attached to trees and compute them on the spot. This method doesn't have any involvement of animals which makes it much simpler than other methods taken. As the camera is attached directly to the computing device the transfer of data becomes much easier and reduces the need for communication modules. Multiple camera modules are used to cover the entire forest area, and each of the modules is distinguished by the camera id given to each of the camera modules to specify in which area the poaching activity is taking place.

Computing Module: The Computing Module receives the data(video frames) from the camera module and estimates the position of the human to detect whether the person is in a poaching state or not. It comprises a Raspberry Pi Version 3 Toolkit and an Intel Movidius Neural Compute Stick 2 which is a Vision Processing Unit that helps in accelerating the rate at which the model performs computations on real-time data. After the processing is complete the system raises an alert if any activity classified as suspicious is detected and alerts the forest rangers, else the system continues to monitor the area.

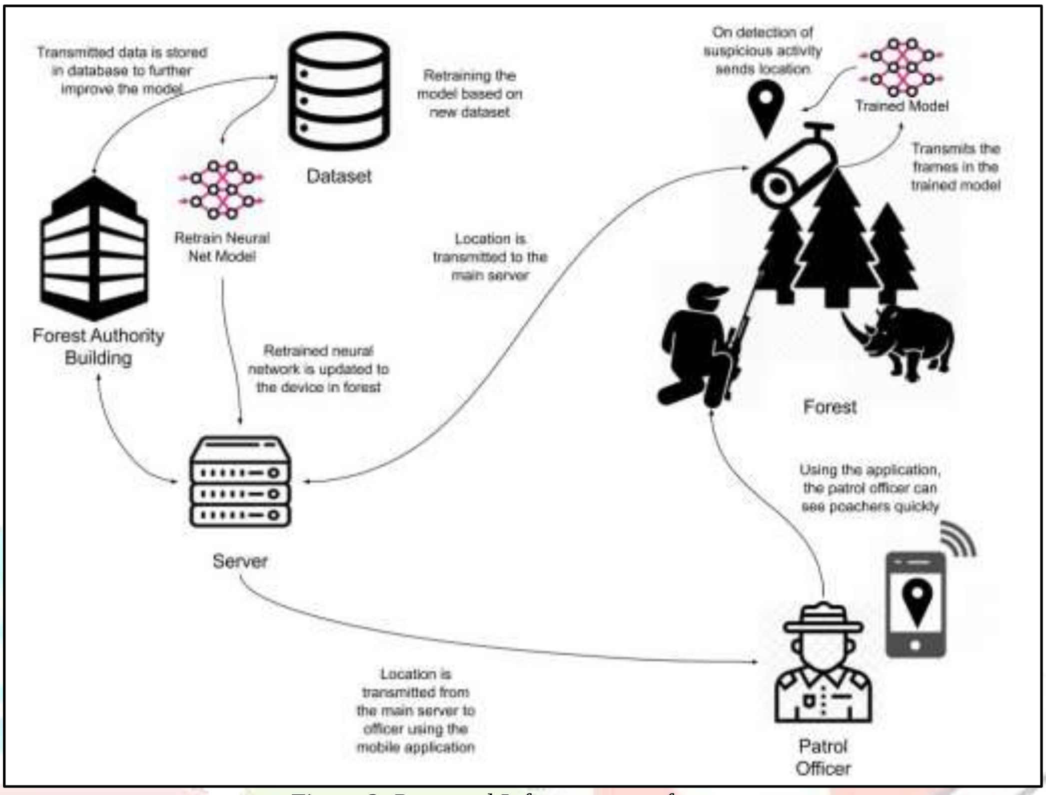

Figure 2: Proposed Infrastructure of system

Server: The Server gathers all the information from the different camera modules to understand the current situation in the forest and alert the rangers.

Handheld Device: The handheld device will receive notifications from the server as well as the data of activity from the computing module.

6. Proposed Methodology

The system functions in a stepwise manner as follows; The camera module sends the input video frames to the computing module (Raspberry Pi and Vision Processing Unit). The motion sequences that are converted to images are then passed through an image classifier to train(from scratch and retraining) and predict. A variety of Image classifiers used are SqueezeNet, AlexNet, Inception, PoseNet, ResNet, VGG and found that PoseNet yields the highest efficiency by retraining on their dataset. They used the OpenPose library to preprocess and extract the skeletal points from the video. Several variations in the representations of the two-dimensional images have been experimented upon. Points highlighting joints in the skeleton are extracted from the RGB video and then converted to a single two-dimensional image which is classified using image classifier. where the video gets divided into the frames so that the system can detect the actions performed by the humans in the sequence of frames. Time-Series analysis is performed on these frames since action to be predicted is a feature of the pose with respect to time. The action can be classified among various types of pre-classified sets of actions performed by the poachers like aiming a gun, crawling on the ground, making a and much more. The system is trained using the machine learning concept and can detect the poachers in live video feed which allows a live-action recognition of the poachers. This method provides a better solution than rangers personally patrolling the forest area. The camera modules are attached to the trees which makes it easy to set up the system. The software uses Python, Deep learning libraries like Tensorflow and Keras, Server technologies like Laravel, Firebase and Socket.io, Raspberry OS(Raspbian), OpenCV and Intel's OpenVino Toolkit for model optimization.

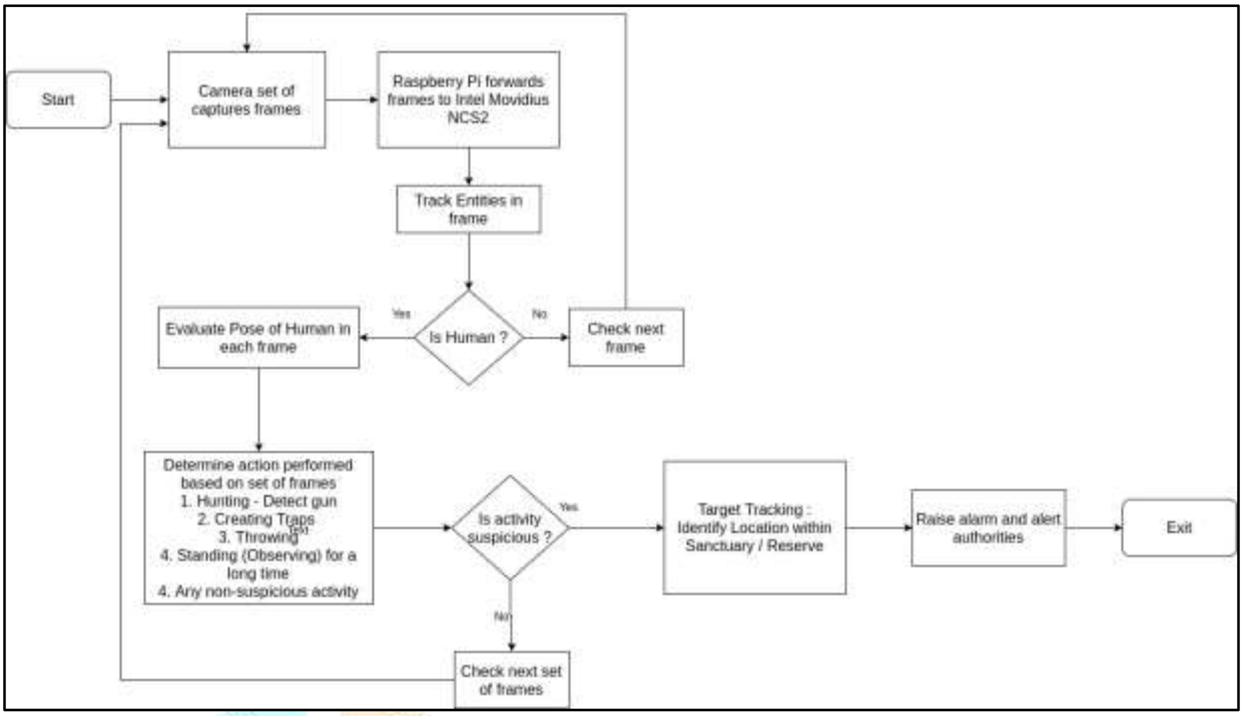

Figure 3: Proposed flowchart of the system

7. Model Analysis

In this section, we describe the models which we propose to conduct our experiments on. The model is a pipeline of two neural networks built around CNN and LSTM. The CNN aspect of the model is based on an approach to efficiently detect the 2D pose of multiple people in an image and fetch 14 joints of the project.[9] The LSTM aspect considers 80 sequences of these joints to specify the actions performed in the sequences with the help of attention mechanism.[10] The custom model based on Attention LSTM was trained on 5 classes where the dataset was constructed using NTU 120 dataset.[11] The results of the custom model for 100 epochs on 2905 training samples and 1940 validation samples were:

Table 1: Neural Network Model Results

Performance Measure	**Training Data**	**Validation Data**
Accuracy	96%	81.34%
Precision	97%	82.63%
Recall	95%	80.15%
F1 Score	96%	81.36%

8. Discussion

The proposed system takes the trees in the forest as a background for the deployment of the present modules. The system provides various advantages and can be easily adapted to the current system of poaching in progress. It also gives details about the presence of any human in the forest region. Along with this, the disadvantages are also provided in the system, the installation of the camera module on the trees is a challenge as the regions are not specific to the animals but rather the areas which are to be monitored only. To cover a large area many such modules would have to be installed in the forest and if any module falls down or gets tampered by the poachers or animals that region would lose the coverage.

9. Conclusion And Future Work

This research paper presents the trees as a static sensor which can be converted to mobile sensors by applying them to drones. The processing can be done on the backend servers for faster computing and the camera module can solely focus on gathering the input video frame data. It also effectively presents an alternate solution to fighting poaching in the forest regions through a method that is very cost-effective and does not harm any animals during the process of installation as well as while being under operation. The system can be used to detect thefts in shops and any kidnapping cases can be easily detected. It can also be extended to be applied in the military security domain. New sensors can also be added to the system to improve its processing power. This process can reduce the economic costs incurred by forest authorities by a considerable margin. The proposed system will help the policymakers to make informed and well-thought decisions, keeping in mind the demography of animals within a forest reserve, areas prone to greater poaching activities as well as areas with poor reachability within the forest.

The scope of this project can be further extended to :

- Predictive Analysis for determining vulnerable areas within a forest and analyzing poaching patterns.
- Surveillance over flocks of farm animals.
- Collaborate with Drones for efficient tracking of poachers.

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