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DEVELOPMENT OF ANIMAL TRACKING SYSTEM USING COMPUTER VISION

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Abstract: **The behavior of animals in the wild is studied animal migration tracking in wildlife biology, conservation biology, and ecology and wildlife management. Animal banding, which involved attaching passive ID tags to animal's legs to identify it in a sub sequent catch and release operation, was one of the earliest techniques used. A tiny radio transmitter is fastened to the animals during radio tracking, and a receiver tracks the signal. In genius temporary methods use GP tags that retain are cord of the animal's where abuts as well as satellites to follow tagged animals. Devices tailored to the species or item being monitored by the you look only once algorithm may now be developed thanks to the development of new technology. One of the numerous goals of animal migration research has been to determine the creature's final locations. The goal of object detection, a field of computer science related to computer vision and image processing, is to find instances of semantic objects belonging to a specific class in digital pictures and videos. Two well researched object detection fields are face and pedestrian detection. Object detection is used in several computer vision domains, including video surveillance and OPEN CV library.**

Keywords: **Animal tracking system using computer vision, CNN Method, Raspberrypi 2**

I. CHAPTER 1 INTRODUCTION

1.1 CT DETECTION

Every object class includes distinguishing qualities that make it easier to classify the objects; for example, all circles are spherical. Detecting the object class is done using these distinctive properties. When searching for circles, one can look for objects that are a specific distance from the center or a point. Finding objects with equal side lengths perpendicular corners is required, much like looking for squares. Similar techniques are used to recognize faces using characteristics including skin tone, the space between the eyes, the nose, and the lips. Object detection methods are often divided into two groups: approaches based on neural networks versus non-neuronal methods. For non- neural approaches, it becomes required to first define features using one of the techniques listed below, and then perform the classification using a method like support vector machine (SVM). On the other hand, neural approaches, which are often based on convolution neural networks, are capable of doing end to end object detection without expressly defining features (CNN).

1.2 OPEN-CV

Open CV is a set of programming tools with a focus on real-time computer vision (Open Source Computer Vision Library). Intel originally designed it, while Willow Garage and It sees later provided funding for it (which was later acquired by Intel). The library is freely available and cross plat form thanks to the Apache 2 License for Open-Source Software. As of 2011, Open CV now provides GPU acceleration for real-time operations. The Open CV project was initially an Intel Research initiative to create CPU intensive applications, and it was launched in 1999. It was only one of many projects that also featured ray tracking in real time and 3D display walls The Intel Performance Library Team and several optimization specialists from Intel Russia were major contributors to the project. The following were the project's objectives in the early stages of Open CV. Further vision research by providing not only open but also optimize decode for the fundamental vision infrastructure. Stop attempting to invent the wheel. A standard infrastructure was created that developers could use to spread vision information in order to make code more legible and transferrable, by making portable, performance optimized code for vision-based business applications freely available.

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Image-Processing:

- Picture processing is a technique for applying various operations to an image in order to improve it or to draw out some relevant information from it.
- According to the simplest definition, "Image processing is the study andalteration of a digital image, particularly to increase its quality".

Digital-Image:

- An image can be thought of as a two-dimensional function, f(x, y), with x and y being spatial (plane) coordinates. The intensity or grey level of the image at any given position is determined by the amplitude of the function at any given pair ofcoordinates, (x, y).
- To put it another way, a picture is nothing more than a two dimensional matrix (or a 3D matrix in the case of closured images) that is defined by the certain formula.

1.3 CONVOLUTIONAL NEURAL NETWORK

- Convolutional neural networks (CNNs) are a type of artificial neural network (ANN) that is commonly used in deep learning to interpret visual data. CNNs are also known as Shift Invariant or Space Invariant Artificial Neural Networks because they are based on the shared-weight architecture of convolution kernels or filters that's lineal input features and produce translation equivariant responses known as feature maps(SIANN). Contrary to popular belief, because of the down sampling operation they perform on the input, most convolution neural networks do not translate invariantly. They are used in image and video recognition, recommender systems, image classification, image segmentation, medical image analysis, natural language processing, brain- computer interfaces, financial time series, image and video analysis, and segmentation, among other things. CNN has a variety of Convolution Neural Network design applications.
- A convolution neural network is constructed by stacking numerous invisible layers in a specific order on topo fono another. It is a feed-forward neural network with multiple layers. Because of the sequential design, CNN can learn hierarchical properties.
- Convolutional layers are typically followed by activation layers, grouping layers,and hidden layers in CNN.
- The Visual Cortex's organization served as inspiration for the preprocessing required in a is similar to the analogous pattern of neurons in the human brain.
- A CNN's input is a Sensor with the dimensions (number of inputs) (input height) (input width) (input channels). The picture is Movement-Related Wildlife Camera traps are increasingly being used to follow animals remotely and aid in various ecological research all around the world. The system records animal behaviors so that there Levant country's forest agency may monitor severely endangered species, keep track of their where about, and study environmental changes to provide solutions. Millions of photographs and movies are routinely captured when this equipment is used in the forest region in significant numbers. To fully comb through the dataset and identify the collected animals, it typically takes days, if not months. In this article, we examine various classifiers for fauna images that analyze and classify the species photographed bythese camera traps using CNN.
- Animal Finder is a model created that is used to identify the presence of animals in wildlife camera trap photographs by comparing each image to every other image in the collection.65291 photographs total were gathered, and they were divided into 1557 images of deer,590 images of wild pigs, and 2108 images of raccoons.
- The total number of images flagged increased from 2174 images when the threshold value was set to 0.95 due to an increase in the number of threshold values used by Animal Finder. When the threshold is set to 0.005, it is divided into images of deer, wild pigs, and raccoons with percentages of 45, 23, and 18 respectively. As soon as the threshold. Using Deep Learning Algorithm focuses on identifying, counting, and describing animals. They have trained CNN to understand the behavior of 48 species in roughly 3.2 million images of the Serengeti dataset, and this CNN automatically identifies animals with nearly 93.8% accuracy. Their system automates animal detection for 99.3% of the images in the data set with accuracy 96.6%, which saves a lot of human labor. Five procedures are carried out by the algorithm to find the animal. This uses the ml unit algorithm perceptron. Using an image matrix and filter, the features of the image are recovered while maintaining the relationship between the pixels in the input, which contains raw pixel values for the three channels R, G, and B. When the size of the image changes, pooling layers reduces the parameter.

1.4 RASPBERRY PI

- The Raspberry Pi Foundation, in collaboration with Broadcom, developed a line of small single-board computers known as Raspberry Pi in the United Kingdom. The Raspberry Pi project's initial goal was to promote fundamental computer science education in class rooms and under developed countries. Because

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it was more widely used than anticipated, the first model sold outside of its intended market for applications such as robotics. As a result of inexpensive cost, versatility, and open design, it is frequently used in numerous fields, including weather monitoring.

- Following the introduction of the second board type, the Raspberry Pi Foundation appointed Upton as CEO of Raspberry Pi Trading, with the task of developing technologies. The Foundation reaffirmed its commitment to supporting education. The Raspberry Pi 4 Model B, which was released in June 2019, has a 1.5 GHz 64-bit quad core ARM Cortex-A72 processor, onboard 802.11ac Wi-Fi, Bluetooth 5, full gigabit Ethernet (through put not limited), two USB 2.0 ports, two USB 3.0 ports, 1-8GB of RAM, and Dual –monitor support via a pair of micro HDMI (HDMI Type D) ports for up to 4K resolution. The 1 GB RAM version has been discontinued, while the cost of the 2 GB RAM versions has been reduced. The circuit board has been replaced. Additionally, the Pi 4has a USB-C port that can be used to power it, providing extra power to peripherals when coupled with the right PSU. However, the PI can only run with 5 volts.
- It is possible to over clock most Raspberry Pi systems-on-chip to 800 MHz and some to1000 MHz There are rumors that the Raspberry Pi 2 can be over clocked in a similar way, going as high as 1500 MHz (discarding all safety features and over-voltage limitations). Without nullifying the warranty, a software command called " sudo- raspi- config " can be used to over clock the Raspberry Pi OS at boot time. In those circumstances, the Pi automatically stops over clocking when the chip temperature reaches, but it is possible to disable automate cover-voltage and over clocking settings.To prevent the chip from seriously overheating, a heat sink of the proper size is required.

1.1 RASPBERRY PI

1.5 PIR SENSOR

- A passive infrared sensor is an electronic sensor that measures the infrared (IR) light emitted by objects in its field of vision (PIR sensor). They are most commonly used in PIR- based motion detectors. PIR sensors are commonly used in self-contained lighting and security alarm systems.
- PIR sensors can detect movement in general but cannot identify who or what moved. An imaging infrared sensor is required for this purpose.
- PIR sensors are also known as "PIR" or, less commonly, "PID," which stands for "passive infrared detector." PIR devices are classified as passive because they do not emit energy to detect objects. They rely entirely on the detection of infrared radiation emitted or reflected by objects. A passive infrared sensor (PIR sensor) can detect variations in the amount of infrared radiation impinging on it based on the temperature and surface properties of the objects in front of it. When an item, such as a person, passes in front of a background, such as a wall, the temperature at that location in the sensor's field of vision rises from room temperature to body temperature and then returns. In order to activate the detection, the sensor translates the ensuing variation in the incoming infrared radiation into a variation in the output voltage. Moving objects may have a different infrared emission pattern from objects that are comparable in temperature but have different surface properties. PIRs are available in a number of configurations for numerous purposes. There are models with broader viewing angles, including 360° that are normally made to install on a ceiling. Some larger PIRs can detect changes in infrared energy up to 30 meters away and are constructed using single segment mirrors.
- PIRs are available in a variety of configurations to suit a wide range of applications. The most common types have several Fresnel lenses or mirror segments, an effective rangeof around 10 meters (30 feet), and a field of view less than 180 degrees. Models with 360° fields of vision are available, as are models with broader fields of view, which are frequently designed for installation on a ceiling. Some larger PIRs use single segment mirrors to detect changes in infrared energy up to 30 meters (100 feet) away. PIRs with reversible orientation mirrors that provide either extensive coverage (110°wide) or extremely limited "curtain" overage, or with individually selectable port "shape" the coverage, are also available.

1.1PIR SENSOR

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1.6 GPS MODULE

- The Global Positioning System (GPS) is a satellite based navigation system that provides location and time information. The system is freely accessible to anyone with a GPSreceiver and unobstructed line of sight to at least four of GPS satellites. A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites. GPS is nowadays widely used and also has become an integral part of smart phones.
- The GTPA010 module is easy to use, having RS232 as well as USB interface. It operates over 3.2 to 5V supply range thus enabling interfacing with microcontrollers with 3.3V as well as 5V. The module outputs GPS data in NMEA0183 format. Each of message string starts with '$' and then the message identifier. Each parameter is separated using a comma so that the message can be parse with the help of the commas.

1.3 GPS MODULE

1.7 CLOUDE STORAGE

- Cloud storage is a type of computer data storage that stores digital data in logical poolsthat are said to be "on the cloud." A hosting company frequently owns and maintains the physical environment, and the physical storage spans multiple servers, possibly in different regions. These clouds to range provider responsible for keeping the physical environment safe, secure, and operational, as well as making data accessible and available. People and businesses buy or lease storage capacity from provider stature user, organizational, or application data.
- To access cloud storage services, you can use a co-located cloud computing service, a web service application programming interface (API), or software that uses the API, suchas cloud desktop storage, a cloud storage gateway, or web-based content. Because both are built on highly virtualized infrastructure, cloud computing and cloud storage have similar interfaces, near-instant elasticity and scalability, multi-tenancy, and metered resources. To gain access to cloud storage, services such as Amazon S3 or on-premises deployments can be used (Vi ON Capacity Services).

1. 8 YOLO (You Only Look Once)

YOLO is an algorithm for real-time object detection that makes use of neural networks. Because of its precision and speed, this method is widely used. To identify traffic signals, pedestrians, parking meters, and animals, it has been employed in a variety of applications. The YOLO algorithm for object detection is described in this article along with its workings. It also high light safe wafts practical uses.

1.8.1 YOLO ALGORITHM AND YOLO OBJECT DETECTION

Image classification is one of the many fascinating applications of convolution neural networks. A side from simple image classification, there are many exciting issues in computer vision, one of which is object identification. YOLO, or You Only Look Once, is a powerful real-time object recognition method. The concept of object detection, the YOLO method, and Dark net one of the algorithm's open-source implementations.

1.8.2 Object Detection Overview

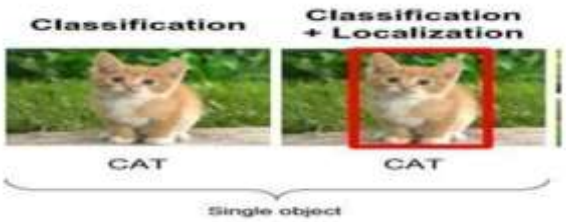
Object detection is frequently associated with self-driving cars, in which systems use computer vision, LIDAR, and other technologies to create a multidimensional picture of the road for all of its users. It is also commonly used for video surveillance, especially in crowd control to prevent terrorist attacks, counting people for general statistics, or studying how customers interact with pedestrian paths in retail malls. Object detection is based on four factors: "Image classification, Object localization, Object detection, and Instance segmentation."

1.8.3 Image classification

By studying a digital image, we may classify and label groupings of pixels or vectors as part of the pattern recognition subfield of computer vision. The fundamental aim is to classify an image's contents by assigning a label or a class to all of its characteristics in terms of the object.

1.8.4 Object Localization

Object localization is a key practical challenge in computer vision for locating the target within a picture or video. It has been used in a variety of applications, including autonomous monitoring systems, automated driving, retail check out recognition, and human facial recognition.



Object Localization

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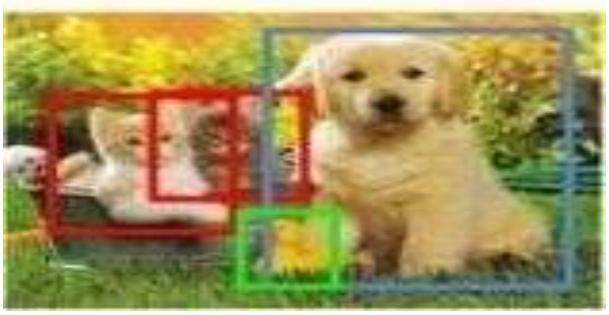

Object Detection

1.8.6 Instance Segmentation

Even if they are all from the same class, it makes an effort to give each item in the scene a unique ID. A typical instance segmentation pipeline consists of two stages. An item is first identified, and then semantic segmentation within the discovered box area. Which necessitates costly up sampling is performed.

Instance Segmentation

1.8.7 Algorithms based on classification

The reimplementation is divided into two stages, they high light the area so interest in an image. Convolutional neural networks are used to categories these areas. Because predictions must be made for each chosen location, this method may take some time. Well-known examples of this type of algorithm include there going based convolutional neural network (RCNN) and its relatives Fast-RCNN, Faster-RCNN, and the newest member of the family, Mask-RCNN. Retina Net is another example.

II. CHAPTER 2 LITERATURE SURVEY

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III. CHAPTER 3: WORKING OPEARTION

The ideology behind the working of our project is that we place the device in such an area that animals frequently pass the limits of their habitats often leading to exploitation between humans and animals. The major reason is that the camera is kept so that the PIR sensor is switched on only when there is movement detection in that following area. The camera is attached to a GPS module that when there is motion detected coordinates of the following is sent to the control room. Also a night vision camera is attached to the following so that we can even see in low night. The weekly datasets are sent to the conference room so that analysis can be done frequently. Major advantage of using the given set of equipment is that the camera turns on only during movement detection; else it remains off stage leading to saving of energy in the battery. Thermal sensing applications, such as security and motion detection, use PIR sensors. They are frequently used in applications for security alarms, motion detection alarms, and automatic lighting. By using the Global Positioning System (GPS), optional environmental sensors, automated.

Data retrieval technologies like Argos satellite uplink, mobile data telephony or GPRS, and a variety of analytical software tools, biologists, scientific researchers, or conservation organization scan remotely observe relatively fine scale movement or migratory patterns in a free-ranging wild animal.

In order to prevent tampering with the animals, Internet-

enabled tracking collars for animals must be made with a multi-year lifespan. In extremely remote locations, satellite tracking systems are installed. The device only turns on when it is needed, protecting the battery life. Where connectivity is available, GSM or cellular technology is extensively used. However, GSM uses a lot of battery power. Devices are either powered on just when necessary or have a huge battery. New technologies supporting connectivity forthe Internet of Things include Sig fox and Lo Ra. Due to their ease of use and extraordinarily great range; these technologies are starting to be used in remote locations.

These technologies benefits for an animal tracking collar. Normally, a GPS tracking device will collect and save location data at predetermined intervals or if an environmental sensor interrupts it. This information can be broad cast to a central data repository or Internet-connected computer using an embedded cellular (GPRS), radio, or satellite modem or it can be stored while the device is being recovered. When analyzing the track later, a GIS programmer or customized software can be used to plot the animal's location against a map or chart in close to real-time. A GPS tracking device typically only gathers and saves location data when instructed to do so by a schedule or when triggered by an environmental sensor. A cellular (GPRS), radio, or satellite modem built into the device can be used to broadcast this data to a central data archive or an internet-connected computer, or it can be used to store it while the device is being retrieved. When analyzing the track with a GIS application or customsoftware, the animal's location can be plotted on to amour chart in almost real-time. This section goes over the proposed model in detail.

First, the loss function-based enhancement is described. The second section describesthe improvement based on the inception structure model. The enhancement based on the spatial pyramid pooling layer is then shown. This section outlines the system's overall design, which incorporates item recognition, tracking, and notifications. A variety of peripheral devices can be interfaced with by the Raspberry PI2 embedded system using a variety of protocols. Additionally, it has a powerful quad-core processor and other features for its small size.1GB RAM. It supports a camera module that can capture video at 30frames per second with a 5 MP resolution3. Both seamlessly integrate and serve a send point devices. Uses two Raspberry Pi devices to illustrate how the system functions.

The only method for devices to communicate with one another is during the hand-off process, in which a device alerts its neighbor’s when it can no longer see an animal that it was previously monitoring. Tracking is implemented on the device, but due to the processor's limited size, object detection is sluggish. Instead, a less accurate, but still capable of up to 1 frames per second, version of the object detection model is used.

The other Raspberry Pi devices receive a notification that the tracked individual has moved out of the camera's field of view. The transmitted message identifies the sender and provides information about the type of object that was identified, and a monitoring programmer uses this information to determine an alert notification is issued with information on the species of animal seen and its last known location, along with the camera's location.

3.1 YOLO and Working

The model's prediction for nearby items is insufficient because the loss function of the original YOLOv5 network takes the same error for large and small objects. Two items can only be identified if they appear in the same grid, making small items difficult to identify. The new loss function is more effective and adaptable than the previous one. In the new loss function, proportionality replaces the initial difference. Equation (1) depicts the initial loss function of YOLOv5, which uses a single loss function for both object categorization and bounding box calculation. The following are the five components of the loss function: Parts1 and 2 deal with the loss of bounding box coordinates. Parts 3 and 4 are concerned with the difference in the confidence that an object is present in the grid; and part 5 is concerned with the difference in class probability.

In the deep learning era there are two main technological paths for object detection: anchor-based and anchor-free methods, with the anchor-based method including One-stage and two-stage detection algorithms. Anchor-based algorithms were employed.

In one-stage detection, the item's class probability and position coordinate value are immediately generated from the predetermined anchor box; in two-stage detection, the picture is used to generate are g ion proposal, which is then used to generate the final target in the anchor-free technique, the Key point-based detection type used by FCOS primarily finds target key points to build the bounding box. Although one-stage object detection methods may be faster, two-stage object detection algorithms are typically more accurate.

In this study, we used three cutting-edge models to locate, identify, and cat ego rise animals. We settled on the YOLOv5s, YOLOv5m, and YOLOv5l architectures. The Cross Stage Partial Network (CSP Net) is adopted by Backbone. The YOLOv5 algorithm slices the image, adds the Focus module, and down samples it before it enters the back bone network. A Feature Pyramid Network(FPN) and a Path Aggregation makeup the neck.

Network (PAN) and aggregates information on features at three different scales. To get rid of extraneous prediction bounding boxes, it employs the Non- Maximum Suppression (NMS) technique.

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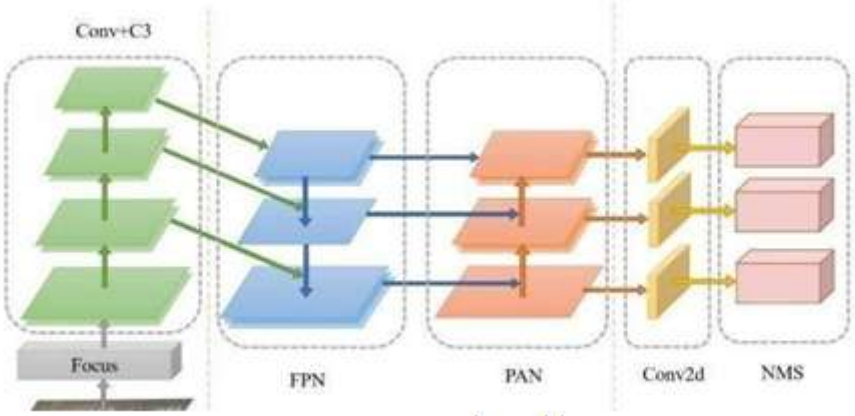
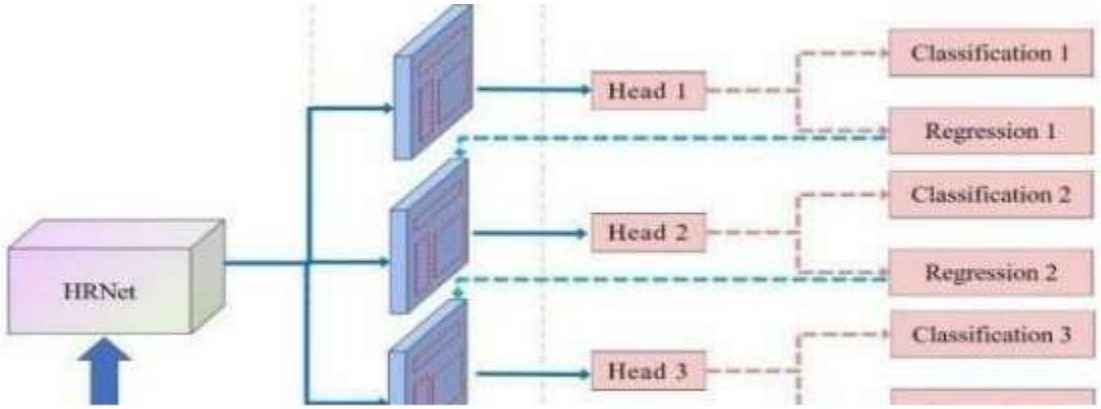


YOLO and Working



YOLO Framework

For model training base don Py Torch, we utilized the YOLO v5 frame work [42]. The momentum was set to 0.937, the optimizer was S to chiastic Gradient Descent (SGD).

At 0.0005, the weight decay was set. Was chosen as the starting learning rate, which In the detector, Cascade R-CNN layers several cascade modules and trains using various Intersections over Union (IoU) thresholds. It greatly increases accuracy.

3.1.1 Architecture Overview

HR Net32 was chosen as the backbone network for the Cascade R-CNN-style task of detecting wildlife objects. HR Net achieves the goal of strong semantic information and precise location information by using parallel branches of various resolutions and ongoing information interaction between distinct branches.

Cascade R-CNN has four stages in total, including one Region Proposal Network (RPN) and three detection stages with IOU values of 0.5, 0.6, and 0.75. 0.7. First detection stage sampling comes after Faster R-CNN. Resampling is accomplished in the subsequent stage by utilizing the regression method.

3.1.2 Application Specifics

- For the model training process, we employed the Py Torch-based MM detection frame work. The momentum was set to 0.9 and the weight decay to 0.0001 for the Stochastic Gradient Descent (SGD) optimizer. There were 30 epochs in total. The batch size was 2, and the learning rate was 1 102. The learning rate and batch size for combined training were 1 102 and 4, respectively. 500 steps were taken in total during the warm- up. According to the epoch, the learning rate would decline linearly, and in epochs 16 and 19, the drop ratio was10. On the RTX3090 GPU, tests were conducted.
- This paper used the precision, recall, and mean average precision (MAP) asevaluation metrics.

IV. CHAPTER 4 RESULTS AND DISCUSSION

Using some of the surveyed object detection models, compare the pre-trained model presented in this paper. This research presents a pre-trained model that detects humans with 99.8% accuracy and animals with 98.8% accuracy.

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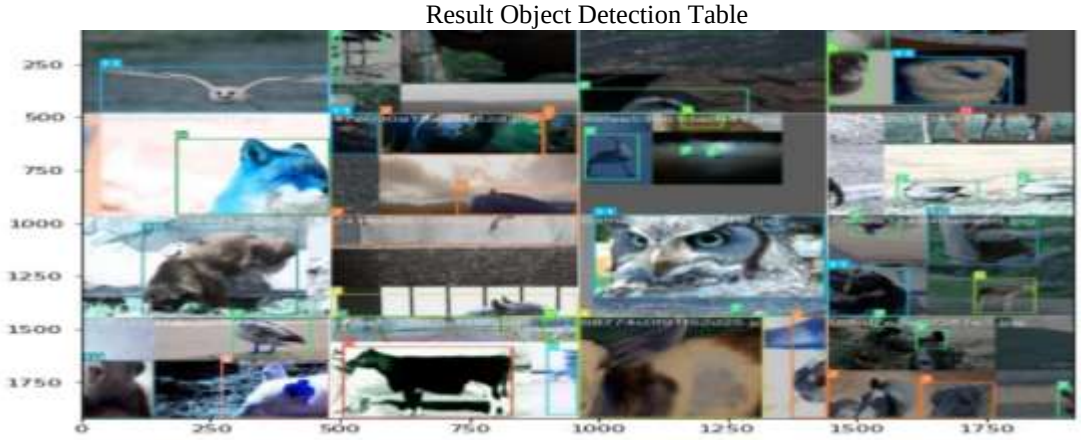
The sum of these two numbers is shown in the table. The processing times for a few cutting-edge object detectors while employing a GPU are shown in Table 2 for reference. The YOLO object detection technique was used to detect animals, and shows a few qualitative outcomes. Animals in the frame have bounding boxes that are marked with their anticipated types and a confidence score.

Species Category	No. of Total Images	No. of Daytime Images	No. of Nighttime Images	Image Resolution
17	25,657	15,313	10,344	1280 × 720/1600 × 1200

Species	Day and Night		Day		Night	
	Training Set	Test Set	Training Set	Test Set	Training Set	Test Set
Amur tiger	1123	246	676	145	447	101
Amur leopard	1260	314	872	219	388	95
Wild boar	1801	423	1159	291	642	132
Sika dear	1726	466	1216	328	510	138
Red fox	1504	358	802	188	702	170
Raccoon dog	1169	324	248	81	921	243
Asian badger	1052	257	735	176	317	81
Asian black bear	1084	285	772	188	312	97
Leopard cat	1589	385	841	196	748	189
Roe deer	1749	374	1317	293	432	81
Siberian weasel	985	284	554	175	431	109
Yellow-throated marten	779	205	681	178	98	27
Sable	483	129	152	40	331	89
Musk deer	1045	248	216	47	829	201
Manchurian hare	1010	270	17	3	993	267
Cow	1016	284	936	263	80	21
Dog	1150	280	1056	252	94	28
Total	20,525	5132	12,250	3063	8275	2069

Result Object Detection Table



Object Detection Image

The module for object detection is very precise. CNN models for object detection and image classification are widely used, and it is clear that with enough training data, the model scan generalize well to most domains. Similarly, the CSRT tracker eliminates the requirement for costly and resource-intensive continuous object detection. The usage of embedded devices like the Raspberry Pi makes this particularly advantageous. The notification system can be altered to send notifications via different protocols, such SMS or e-mail. Depending on the species of animal, various actions can be conducted in response to animal detection, including the use of deterrents such playing loud music or flashing lights.

The precision and usability of the YOLO object detection model are well recognized. But maintaining object detection on embedded devices is still difficult. For object detection, a quicker and more resource-efficient option might be investigated. Recent efforts to design networks especially

for mobile devices, such the Mobile Net architecture, show promise and could be an option for object detection. Utilizing a GPU device is an additional option, however doing so would make the solution less cost-effective.
The approach described here has the disadvantage that, if many cameras pick up the same animal, multiple notifications may be delivered and it may look that more than one animal is being identified while, in fact, only one is being picked up.

V. CHAPTER 5 CONCLUSION

- The proposed method aims to prevent confrontations between people and animals by constantly and automatically checking on vulnerable locations and using computer vision to detect animal invasions. The intrusion detection pipeline has three stages: warnings and notifications for users, animal detection, and animal tracking. The proposed method detects and identifies animals in photos with an average accuracy of 98.8% and is both cheap and effective. It is simple to expand the prototype presented in this work to detect and track more animal types with enough training data. The prototype has been trained to recognize five different animal species.
- Choosing species that are unique to a given region provides a distinct advantage over other existing solutions. If this happens the proper working of the system implementing the functioning of components is well equipped with amenities so that everyone is benefitted on both sides.

VI. REFERENCES

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