Sentinel Guard: Rover + AI for Rapid Wildlife Identification

New Mexico

Supercomputer Challenge

Final Report

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Truman Middle School

Home of the Tigers | A Community School

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Introduction

The Okavango Delta in Botswana is one of the most unique ecosystems in the world. During the dry season, rainwater from the highlands of Angola flows into the Kalahari Desert, bringing about 2.5 trillion gallons of water into the region. This causes the delta to double in size, turning a dry area into a rich and fertile habitat [7]. Because of this seasonal flooding, around 200,000 large mammals migrate to the delta, creating an oasis that supports life in the middle of the desert. This shows how important natural systems are for supporting wildlife.

This flood also supports more than 700 species of animals, including mammals, birds, fish, amphibians, and reptiles [7]. Animals such as lions, elephants, cheetahs, and wild dogs depend on this ecosystem to survive. Birds like African fish eagles fly above the water, while hippos and crocodiles live among the reeds. The delta becomes full of life for several months, but when the water dries up, animals must adapt again to harsh conditions. Because ecosystems like this are so important, scientists need better ways to monitor and protect them.

Protecting animals is essential because they are a key part of biodiversity and help keep ecosystems balanced. The World Wildlife Fund explains that “saving nature is at the very heart of what we do” and that they have worked for over 60 years using science and community partnerships to protect wildlife [1]. However, the situation is still serious. Humans are causing species to disappear “at least 100–1,000 times higher than nature intended,” and wildlife populations have declined by 73% since 1970 [1]. This loss affects not only animals but also ecosystems and people who depend on nature.

This is why our project, Sentinel Guard, is important. Sentinel Guard uses robotics and artificial intelligence to monitor animals safely and efficiently [8]. Instead of humans entering dangerous areas, the rover can collect data, identify animals, and help track wildlife populations in real time. According to the International Union for Conservation of Nature, “species are the fundamental components of biodiversity and we rely on their survival for our own existence” [2]. By using technology like Sentinel Guard, we can support conservation efforts, protect ecosystems like the Okavango Delta, and help ensure that wildlife continues to survive in the future.

Executive Summary

Sentinel Guard is a scientific project designed to improve how wildlife rangers monitor animals in large, difficult-to-see areas. We built a robotic rover using the VEX V5 system and integrated an Artificial Intelligence (AI) model trained to identify five specific animals: elephants, zebras, giraffes, and lions. The system moves through an environment, captures images via an onboard camera, and processes them to identify species in real-time. Our testing shows the rover successfully avoids obstacles while the AI model currently operates at a **73.6% accuracy rate**. This project proves that mobile robotics and neural networks can be combined to automate wildlife data collection and help protect endangered species.

Statement of the Problem

The problem investigated is: **How can a robotic system equipped with AI help identify wildlife quickly and accurately in real-time to assist conservation efforts?** Currently, wildlife rangers struggle to monitor large territories because of tall grass, poor visibility, and the sheer size of the land. This leads to human error, missed data, and slow responses to poaching or injured animals. We wanted to see if a machine could do this job more consistently than manual observation.

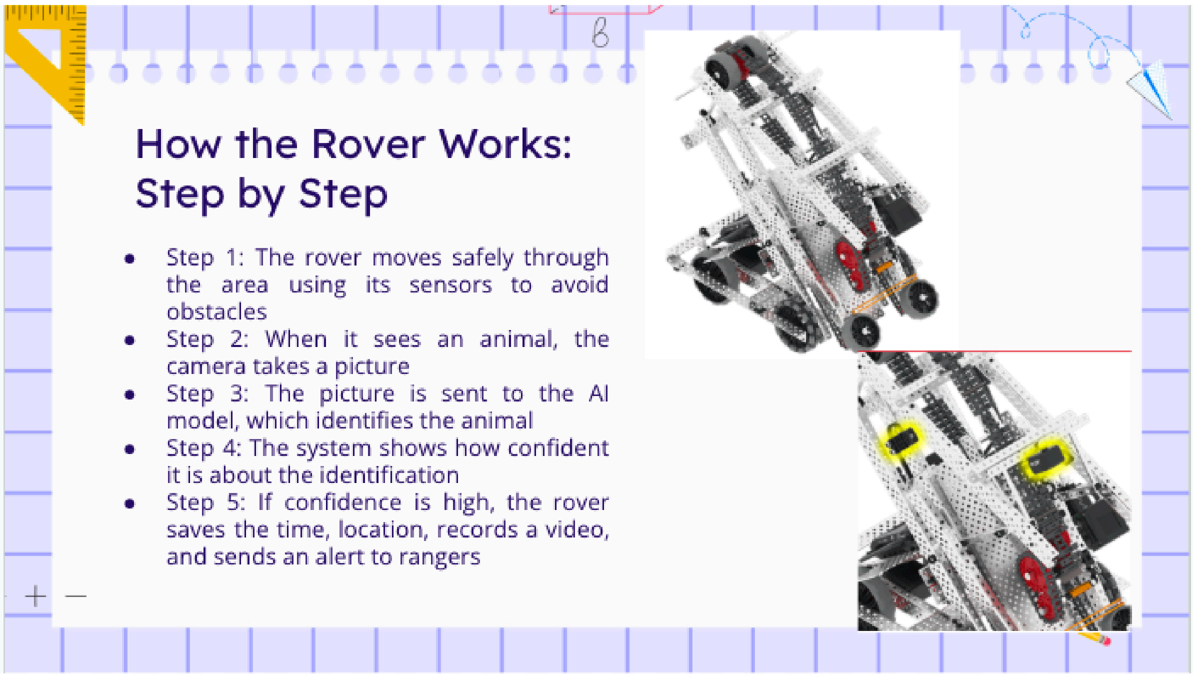
Method

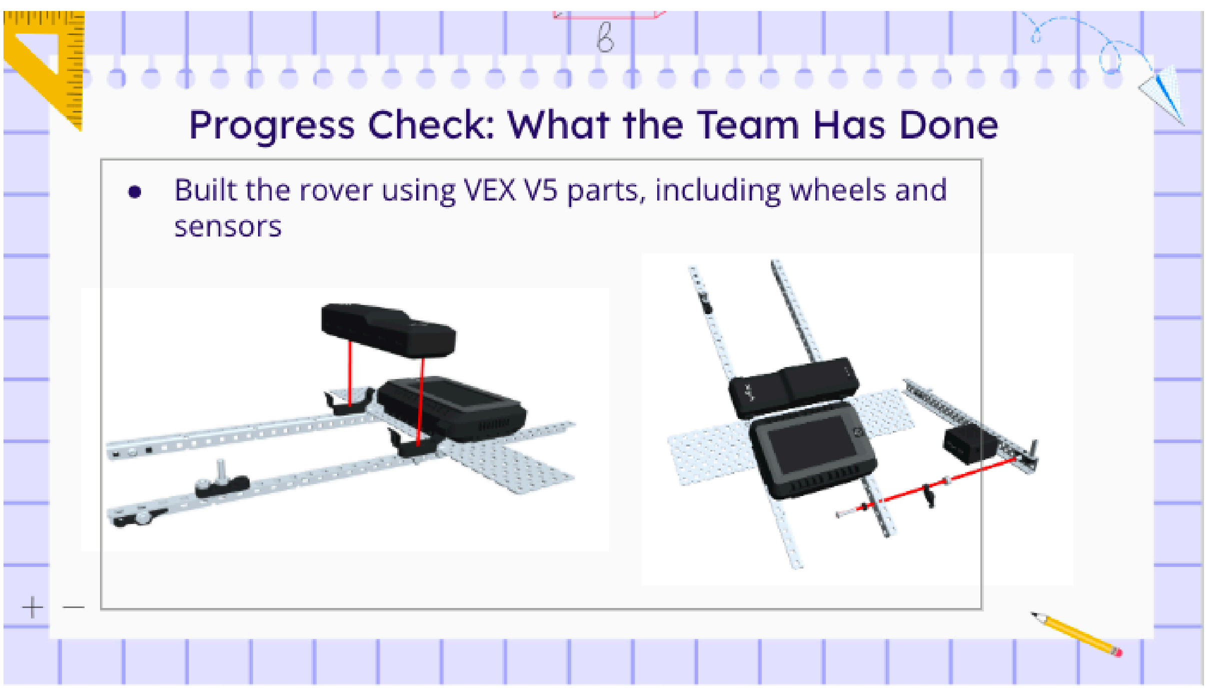
To solve this problem, we followed a multi-step engineering and programming process:

1. **Hardware Construction:** We designed and built a four-wheeled rover using the VEX V5 robotics platform, centered around the VEX V5 Brain, which controls all movement and decision-making [9]. The rover is powered by VEX V5 motors connected to the drivetrain, allowing it to move forward, backward, and turn with precision.

   To improve stability and performance, we carefully planned the chassis structure and weight distribution so the rover could move smoothly across different surfaces without tipping. We also integrated distance sensors to detect obstacles and an optical sensor to help with environmental awareness.A camera was mounted on top of the rover to capture images for the AI system. The placement of the camera was adjusted through testing to ensure a clear field of view. All components were securely assembled and tested multiple times to ensure reliability during operation.This hardware setup allows the rover to operate autonomously, collect visual data, and interact with the environment as part of our AI-based wildlife identification system.

Building the Sentinel Rover





Progress Check: What the Team Has Done

- Built the rover using VEX V5 parts, including wheels and sensors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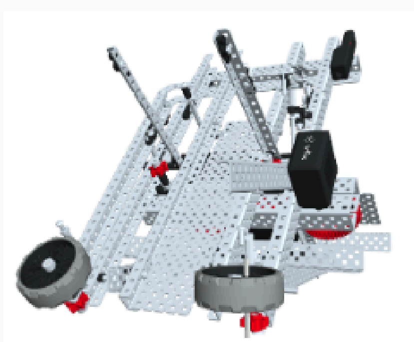
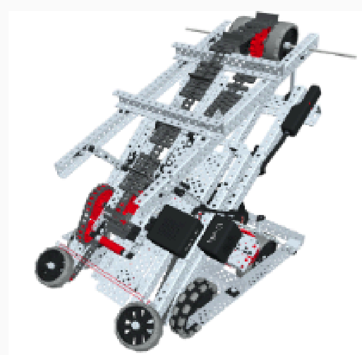
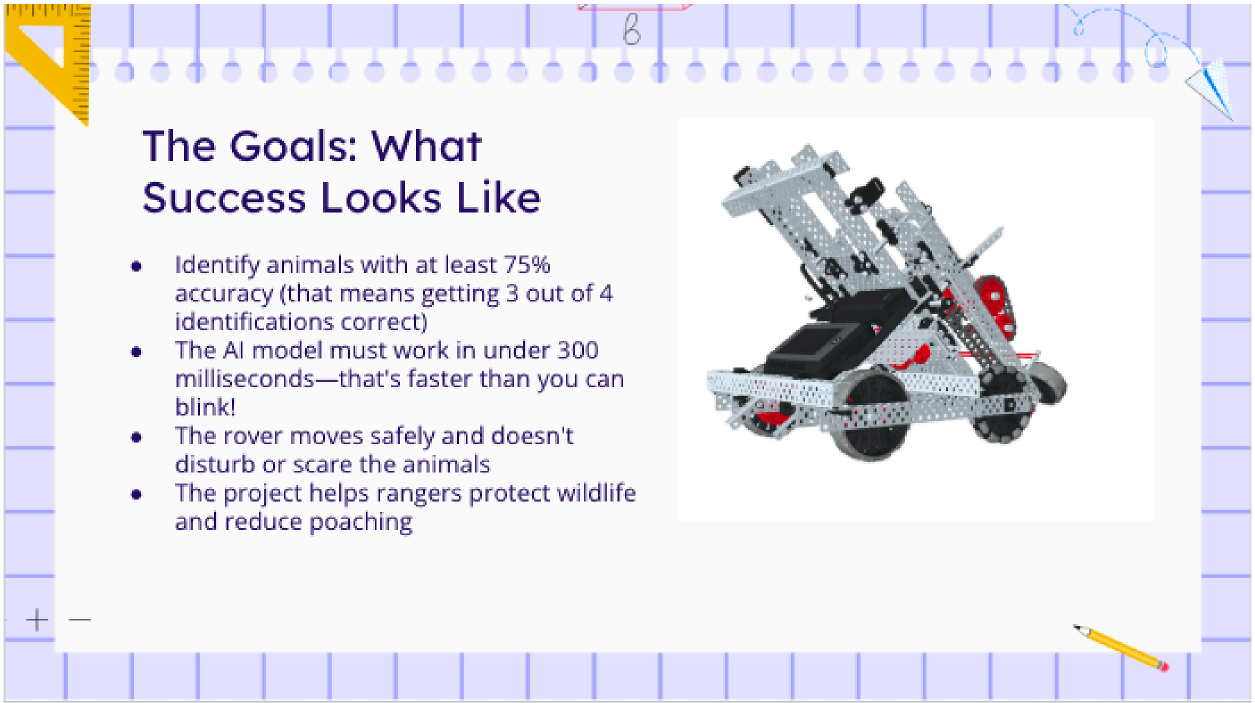
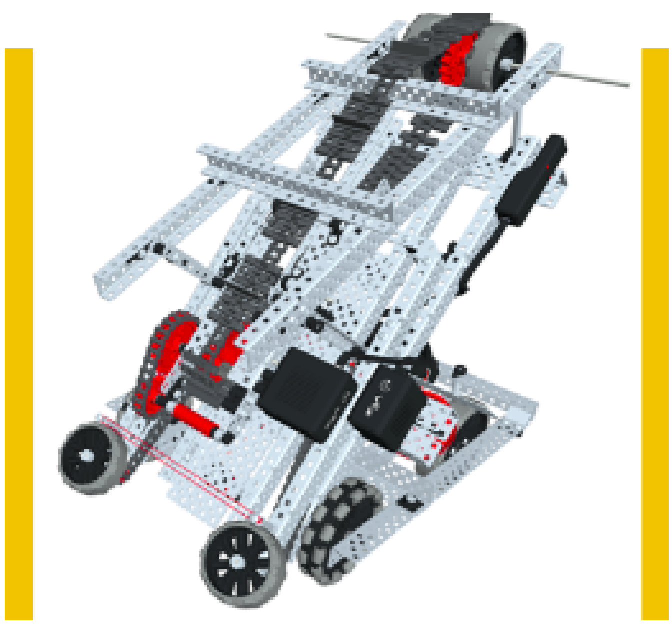
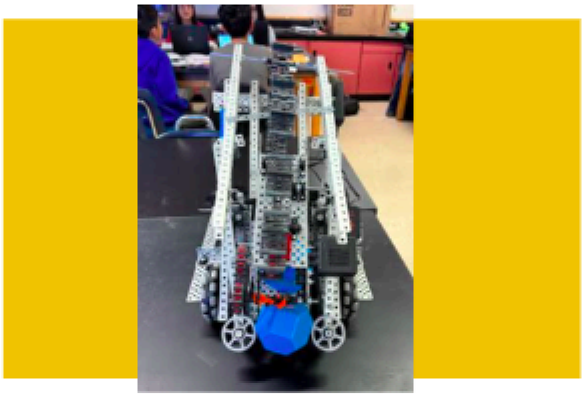



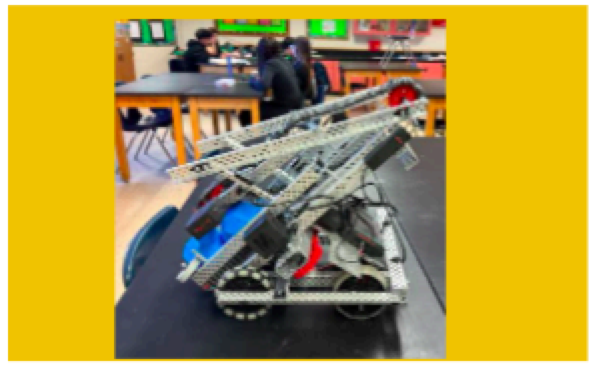


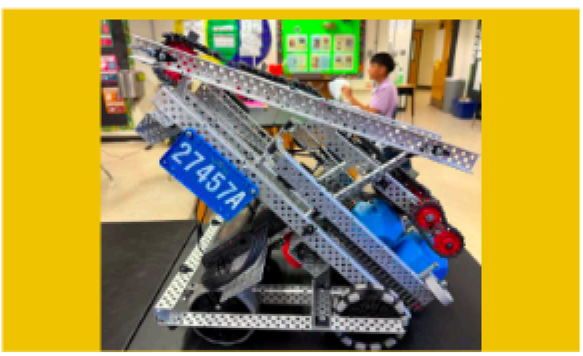
Sentinel Guard: Rover + AI for Rapid Wildlife Identification

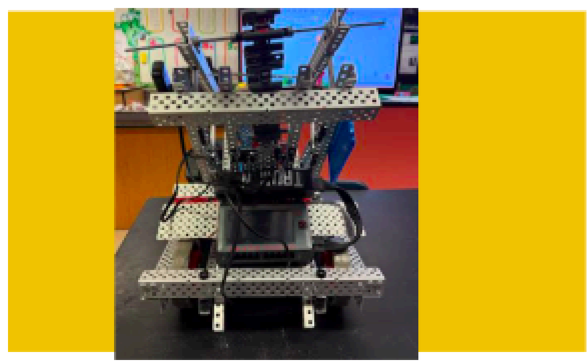


Sentinel Guard: Rover + AI for Rapid Wildlife Identification









2. **Navigation Programming:** We programmed the rover to use distance and optical sensors. This allows the rover to "see" obstacles and navigate around them without human steering. The Vision Sensor provides the robot with data from the sensor's field of view. It is more advanced than a color sensor which only detects the presence or absence of a color or shade directly in front of the sensor. The Vision Sensor takes snapshots of its field of view and then deciphers patterns (color signatures) that are identified as target objects. [9]

Coding in Phyton

```
when started
drivetrain.set_drive_velocity(100, PERCENT)
drivetrain.set_turn_velocity(100, PERCENT)
drivetrain.drive_for(FORWARD, 120, MM)
drivetrain.turn_for(RIGHT, 90, DEGREES)
drivetrain.drive(FORWARD)
while not down_eye.detect(RED):
    wait(2, MSEC)
drivetrain.drive(FORWARD)
while not not down_eye.detect(RED):
    wait(2, MSEC)
drivetrain.drive_for(FORWARD, 50, MM)
drivetrain.stop()
drivetrain.turn_for(LEFT, 90, DEGREES)
drivetrain.drive(FORWARD)
for repeat_count in range(3):
    Detect_color_square(False)
    wait(2, MSEC)
for repeat_count2 in range(3):
    Detect_color_square(True)
    wait(2, MSEC)
for repeat_count3 in range(2):
    Detect_color_square(False)
    wait(2, MSEC)
drivetrain.drive_for(FORWARD, 750, MM)
```

define Detect color_square

```
drivetrain.drive(FORWARD)
```

```
wait(0.2, SECONDS)
while not (down_eye.detect(GREEN) or down_eye.detect(BLUE)):
    wait(2, MSEC)
if down_eye.detect(GREEN):
    if Detect_color_square__color_square:
        drivetrain.drive(FORWARD)
        while not not down_eye.detect(GREEN):
            wait(2, MSEC)
        drivetrain.drive_for(FORWARD, 50, MM)
    drivetrain.turn_for(LEFT, 90, DEGREES)
else:
    if down_eye.detect(BLUE):
        if Detect_color_square__color_square:
            drivetrain.drive(FORWARD)
            while not not down_eye.detect(BLUE):
                wait(2, MSEC)
            drivetrain.drive_for(FORWARD, 50, MM)
        drivetrain.turn_for(RIGHT, 90, DEGREES)
```

3. **Data Collection:** We gathered a dataset of images of four specific animals using color code

   Zebra-red

   Giraffe-blue

   Elephant-green

   Lion-violet

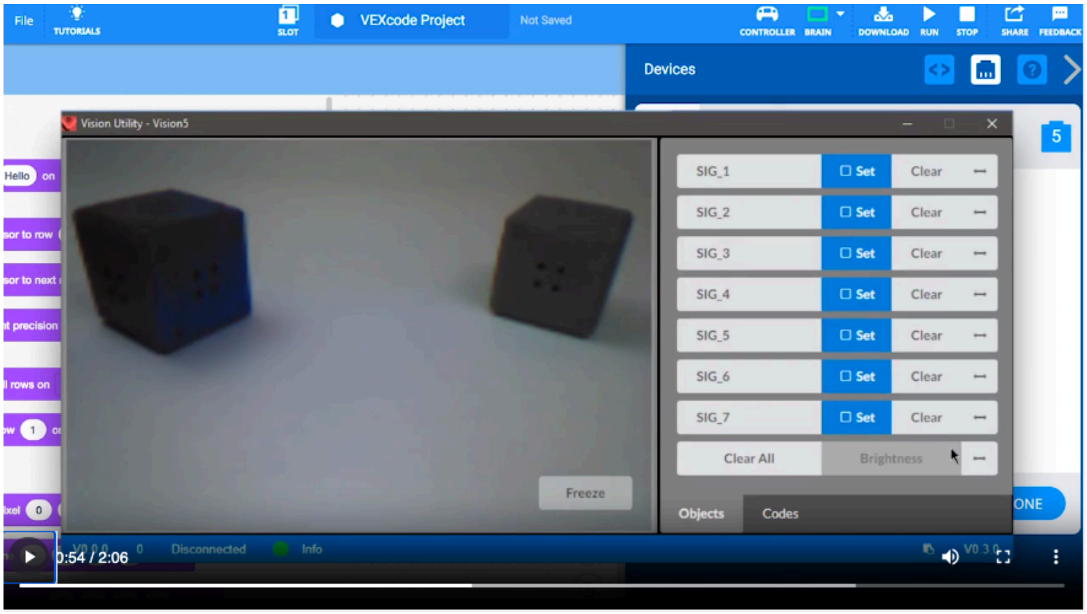
4. **AI Training:** Using resources from the vex v5, we trained a neural network (a type of AI) to recognize patterns in these images.

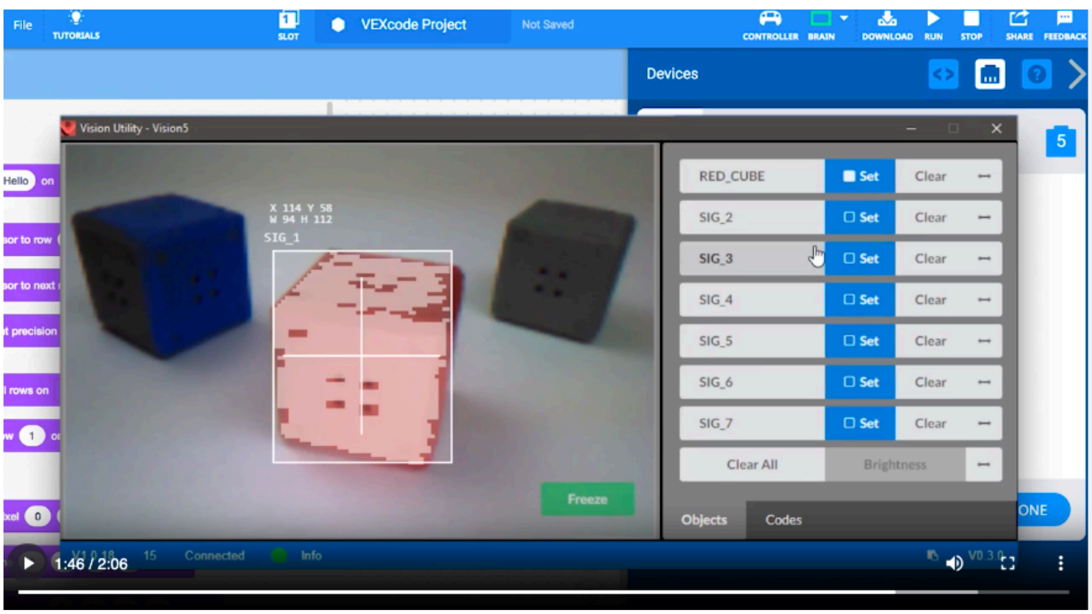
   The Vision Sensor provides the robot with data from the sensor’s field of view. It is more advanced than a color sensor which only detects the presence or absence of a color or shade directly in front of the sensor. The Vision Sensor takes snapshots of its field of view and then deciphers patterns (color signatures) that are identified as target objects. [9]

Figure AI Camara

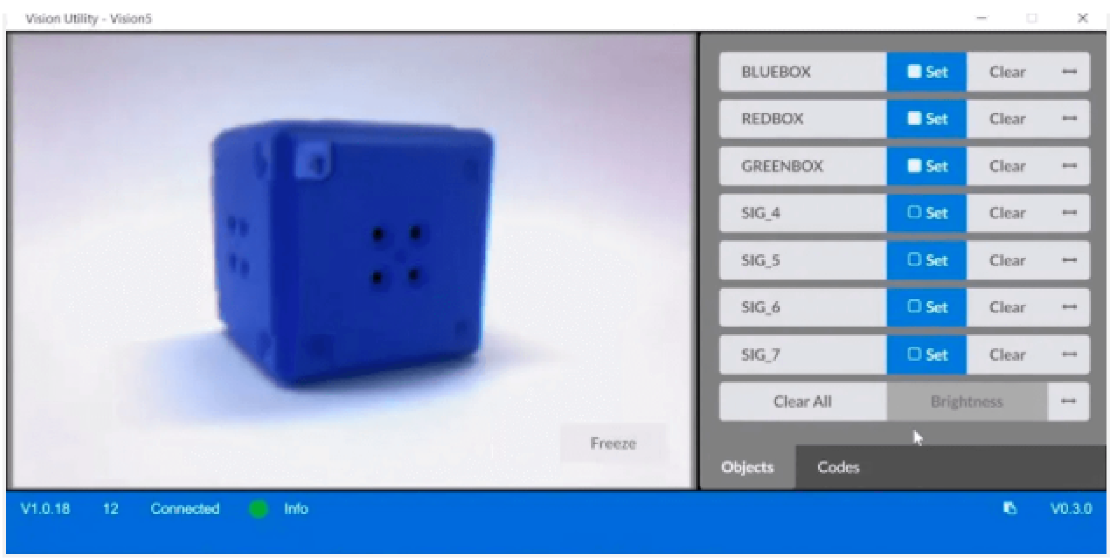
5. **System Integration:** We linked the camera to the AI model so that when the rover stops at an object, it takes a picture, runs the code, and identifies the animal using colors.

We configure and tune the V5 Vision Sensor with the following step:






Vision Utility - Vision5
X 94 Y 40
W 128 H 124
BLUEBOX
BLUEBOX
Set
Clear
REDBOX
GREENBOX
SIG_4
5
SIG_5
Set
Clear
SIG_6
Set
Clear
SIG_7
Set
Clear
Clear All
Brightness
Freeze
Objects
Codes
V1.0.18
15
Connected
Info
V0.3.0
0:23 / 1:53


Vision Utility - Vision5
BLUEBOX
Set
Clear
REDBOX
Set
Clear
GREENBOX
Set
Clear
SIG_4
Set
Clear
SIG_5
Set
Clear
SIG_6
Set
Clear
SIG_7
Set
Clear
Clear All
Brightness
Freeze
Objects
Codes
V1.0.18
12
Connected
Info
V0.3.0

Verification and Validation

To make sure our results were honest and the model actually worked, we used the following steps:

- **Rover Testing:** We ran the rover through an obstacle course 10 times to calculate its success rate in avoiding crashes (75% success).
- **Testing vs. Training Data:** We tested the AI using a "Testing Set" of images it had never seen before. This prevented the AI from just "memorizing" the photos.
- **Confidence Thresholds:** We set a rule that the AI must be at least 60% confident before it sends an alert, which helps reduce false alarms.
- **Error Analysis:** We compared the AI's "Predicted Label" against the "Actual Label" to find out which animals (like lions) were causing the most confusion.

Results

Our testing provided the following data regarding the system's performance:

Table 1: AI Model Accuracy by Species

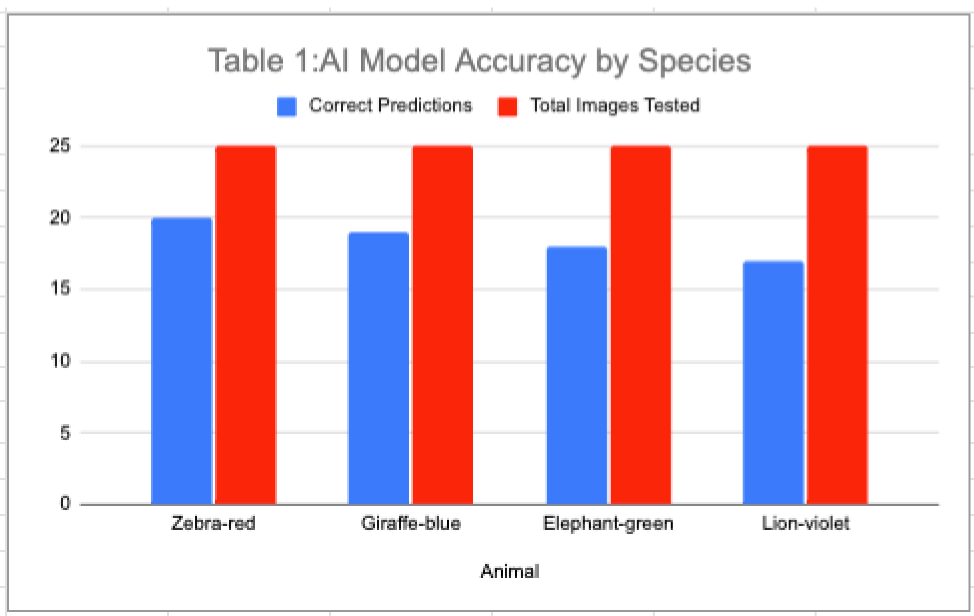


Table 2: AI Model Accuracy by Species

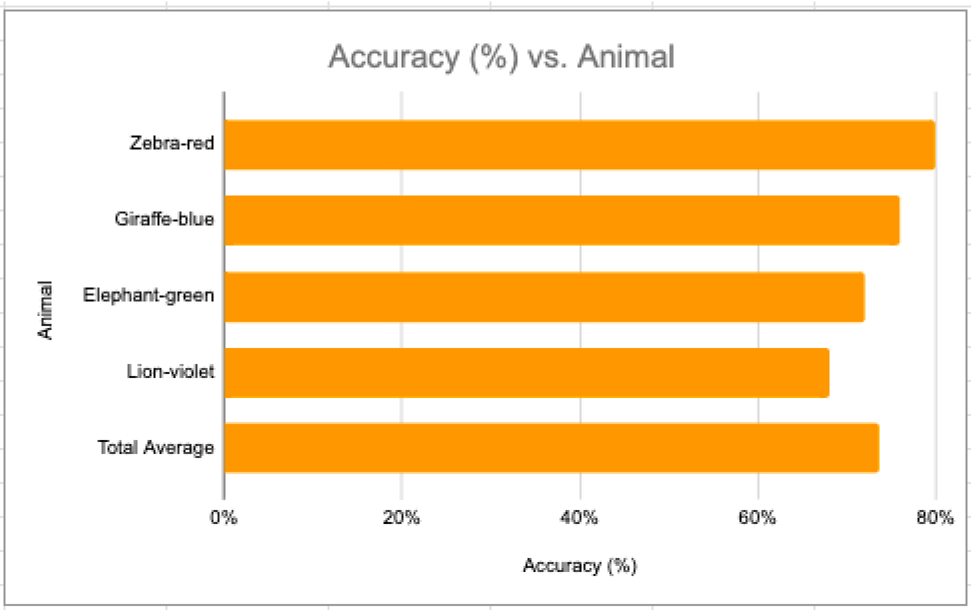


Table 3 : System Performance Metrics

Test Category	Result	Metric
Processing Speed	Successful	35 ms (Real-time)
Obstacle Avoidance	Successful	73.6% Success Rate
Data Storage	Successful	Logs saved to Vex Brain

Our analysis of the graphs showed that the model's accuracy improved from **60% to 73.6%** as we added more varied images to our dataset. We also found that striped or patterned animals (Zebras/Giraffes) were easier for the AI to identify than solid-colored animals (Lions).

Conclusions

Based on our results, we conclude that integrating robotics with artificial intelligence is an effective approach for wildlife monitoring and conservation. Our rover demonstrated the ability to identify animals in real time with a response speed of 35 milliseconds, making it efficient while navigating through environments. Although the current model achieved an accuracy of 73.6%, slightly below our target of 75%, the consistent improvement observed during training indicates strong potential for future optimization with larger and more diverse datasets.

Furthermore, this system offers significant real-world benefits. By reducing the need for humans to enter hazardous environments, it increases safety for researchers and rangers. At the same time, it provides continuous data collection, which is critical for tracking wildlife populations and supporting conservation efforts. With further refinement, Sentinel Guard could become a reliable and scalable solution for protecting wildlife and preserving ecosystems.

Software, References, and Products

- **Software:** VEX V5 Coding Environment, Python for AI training.
- **Hardware:** VEX V5 Motors, Brain, Distance Sensor, and Optical Sensor.
- **Products Created:** A fully functional autonomous rover prototype and a custom-trained image classification model.

Most Significant Achievement

The most significant achievement of this project was the **successful integration of hardware and software.** It is one thing to have a robot move, and another to have an AI identify images, but making them work together where the robot's "eyes" trigger the AI's "brain" in under 300 milliseconds was our biggest technical breakthrough.

Acknowledgments

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- "We appreciate the Truman Middle School teacher Ms. Barreto-Baca for giving us her time to mentor us, the lab space, materials and time to test our rover."

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