PATROLBOT

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Abstract

The PatrolBot project is about learning how to automate security by creating a patrol robot. The PatrolBot project is important because our system can be a fantastic tool to help small security operations properly monitor their campus. The project utilizes a robot with a camera, a website, and machine learning models, all connected through the internet. Our team has created a web server, controlled a robot through our website, and deployed custom machine learning models to help the UNR Police Department (UNRPD) detect a common problem for the UNR campus, bike theft. Our object detection model can predict occurrences of different tools used for bike theft, and our action detection model can predict abnormal behavior.

Goals

- Create robot that can alleviate personnel needs for a small security force
- Deploy state-of-the-art machine learning models in novel ways
- Solve the UNRPD problems of bike theft and lack of security cameras in older areas on campus

Architecture

The architecture is divided into three parts: Front-end, Back-end, and Robot. Figure 1 below displays a detailed setup of our architecture, showing the full path that each command takes from origin to destination. To connect the client interface to all other parts, we utilized AWS.

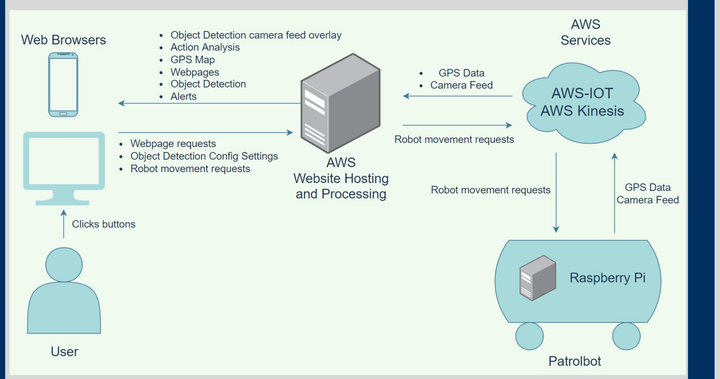

Figure 1. Project architecture

Web Server

Built with bootstrap, the front-end of the dashboard website permits a simple, intuitive, and beautiful look as seen in Figure 2, Figure 3, and Figure 4.

The front-end website communicates with all parts of the project through our back-end Django web server, hosted on AWS Elastic Beanstalk. This design features:

- Integrated processing and communication between the user and all system aspects
- Camera feed overlay provided by the on-premises robot through AWS Kinesis
- Movement requests and robot world position in GPS coordinates through AWS-IoT
- Centralized hub for all project pieces

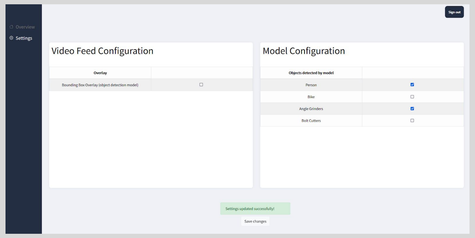

Figure 2. Dashboard settings page

Figure 3. Dashboard home page

Models

Object Detection Model

Using publicly available computing resources, we trained a custom object detection model utilizing the YOLOv5 architecture to detect and label People, Bikes, Angle Grinders, and Bolt Cutters. These are objects of interest in a bike-theft scenario. A detection instance can be seen to the right in Figure 4. The PatrolBot system can then label and log these instances of objects being detected and make them available for download in a .csv file using the website.

Threat Determination Algorithm

Using the determinations of the object detection model, an algorithm is used to check for Intersection Over Union (IOU) for bounding boxes of malicious items such as bolt cutters and angle grinders when near bicycles. If this IOU is above a certain threshold, an alert is generated to notify a user that a bike theft is likely in progress.

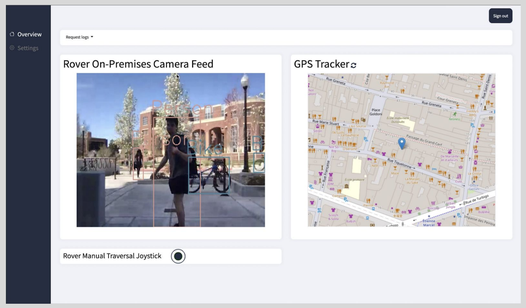

Figure 4. Camera detection example

Action Detection Model

An inflated 3D convolutional neural network was trained on a dataset containing normal crowd behavior and aggressive individual behavior. The created model is successfully able to determine whether specific input videos or camera feeds contain aggressive or normal behavior. This determination helps detect behavior that needs to be addressed by an on-duty officer or other security official.

Robot

Software

The robot is the information gathering nexus of the project. By using a medley of software including Ubuntu 18.04, ROS Melodic, and the AWS Python SDK, our robot can:

- receive movement commands from the website
- execute these commands
- send data back to the website

Hardware

The robot uses a plethora of tools to perform required functions. The assembled robot platform is seen to the right in Figure 5. The robot features:

Figure 5. Robot platform

- Raspberry Pi 4 to control robot communication with the web server and perform local processing
- Rover Zero Robot containing motor drivers, wheel encoders, and a rechargeable battery
- GPS module that continuously updates robot location for the web server
- Raspberry Pi 3B+ with a camera module to perform camera-related tasks
- Portable battery to power both Raspberry Pis

Future Work

There are many directions this project could go in the future. The four major ones would be:

- Incorporating drones to provide the user with an aerial perspective of their campus
- Implement multiple robots in the same system to increase the coverage of an area and allow for scalability
- Develop a fully autonomous robot system to further decrease attention required to operate the system
- Improve the machine learning models to detect a greater number of threats and objects associated with specific crimes, allowing the user to cater the system to their specific organizational needs

Conclusions

The PatrolBot is meant to reduce the strain caused by lack of cameras or personnel on UNRPD or other security forces. By utilizing the system's traversal, camera, and associated models, security forces, such as UNRPD, will be able to respond quicker to aggressive incidents and bike theft on their campuses. Students will be able to focus more on their studies by being in a safer environment, rather than worrying about different aggressive incidents or their bicycle being stolen.

This project was developed in Spring 2022 as part of the course CS 426 Senior Projects in Computer Science