Playing Catch with Boston Dynamics' Spot

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ABSTRACT

Human-robot cooperation can often be difficult due to robots' limited knowledge and mobility. In this research, we investigate the extent of a robot's ability to interact with humans like living dogs. To do so, we demonstrate an object detection model in tandem with a motorized payload to enable Spot to play "catch" with its owners.

INTRODUCTION AND RESEARCH GOAL

Boston Dynamics' Spot is a quadruped robot intended to inspect hazardous environments. However, this research aims to examine a more entertainment-focused application and test Spot's potential for commercial use.

Research Goals:

- Build a payload to launch balls atop Spot.
- Develop object detection models to detect racquetballs and humans.

Mission Sequence:

- A twist on the classic game of "fetch" played with dogs.
    - Detect, pickup, deliver (throw)

METHODS

Payload Design

- Dual flywheel propulsion mechanism
- ESP32 microcontroller

Figure 1. (Left) Spot Payload Prototype
(Right) General Expansion Payload/Power Supply

Object Detection

- TensorFlow Object Detection API
- 750+ annotated pictures in various scenarios
- Transfer learning from EfficientDet model

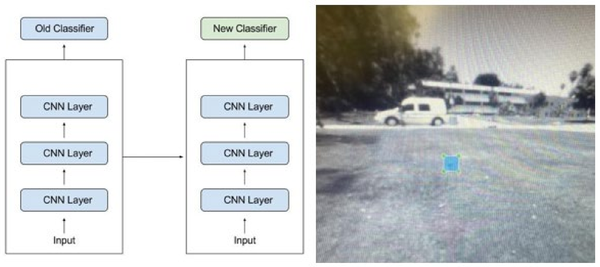


Figure 2. (Left) Breakdown of Transfer Learning Process
(Right) Example Image Annotation

Robot Manipulation and Catch

- Connect model to Network Compute Bridge
- Script's General Loop:
    1. Connect to model and search for ball
    2. Detect, navigate to, and pick up ball
    3. Find and navigate to nearest human
    4. Turn and release ball into payload

RESULTS

Machine Learning Model

- 40,000 Training Steps
    - Loss Value ~ 0.2, mAP ~ 0.35 -0.6
- Closer balls are more likely to be recognized

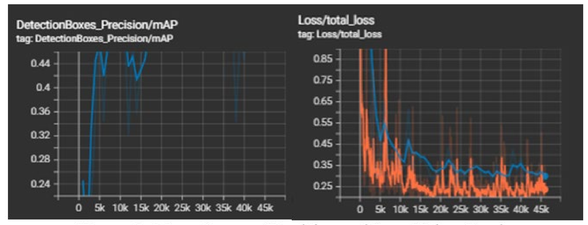


Figure 3. Mean Average Precision and Loss Value Graphs

In Practice

- 85 – 95% confidence in detections
- Successful ball pickup and delivery

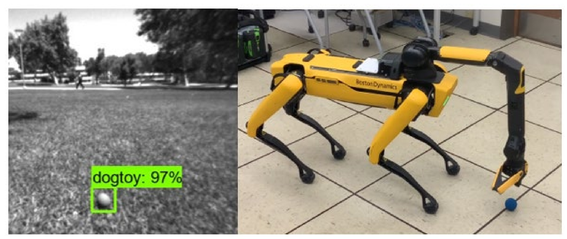
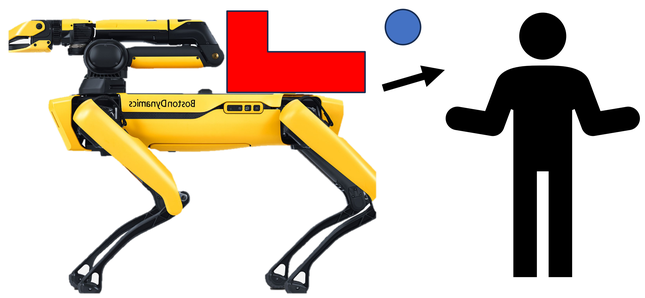


Figure 4. Successful Ball Detection and Pickup

Issues

- Initially experienced overfitting due to insufficient data from outdoors
    - More data and model retraining



CONCLUSIONS

Current Progress

- Working ball detection and pickup
- Can detect and navigate to human
- Can drop ball into propulsion payload
- Payload launches ball with manual control

Future Work

- ROS2 integration for payload autonomy
- Payload redesign for variable launch angle

VISIONS

Bridging the Gap

- Research done to advance human-robot interaction (HRI)

Applications Beyond Entertainment

- Can be diversified to other objects
- Orient towards assisting the disabled, etc.

Future of HRI

- Recent integration of Spot with ChatGPT
    - Human speech analysis and intelligent audio response
    - Elderly assistance applications

Ultimately, we foresee a future with citizens petting, playing, and speaking with robotic dogs in the same way as ones today.

ACKNOWLEDGEMENTS

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