Nature Photography Robot

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Use Case

- Problem:

  Animal photography is time consuming and mundane. Remote controlled photography robots do little to fix this problem. Photo editing is necessary, but similarly human-capital intensive.

- Goal:

  Produce a stationary nature photography robot, which can locate, track and photograph animals. The system should also perform automated image editing.

- Electrical and Computer Engineering Areas:
  - Signals and Systems - Image Processing and Control Systems
  - Software Systems - Embedded System Programming

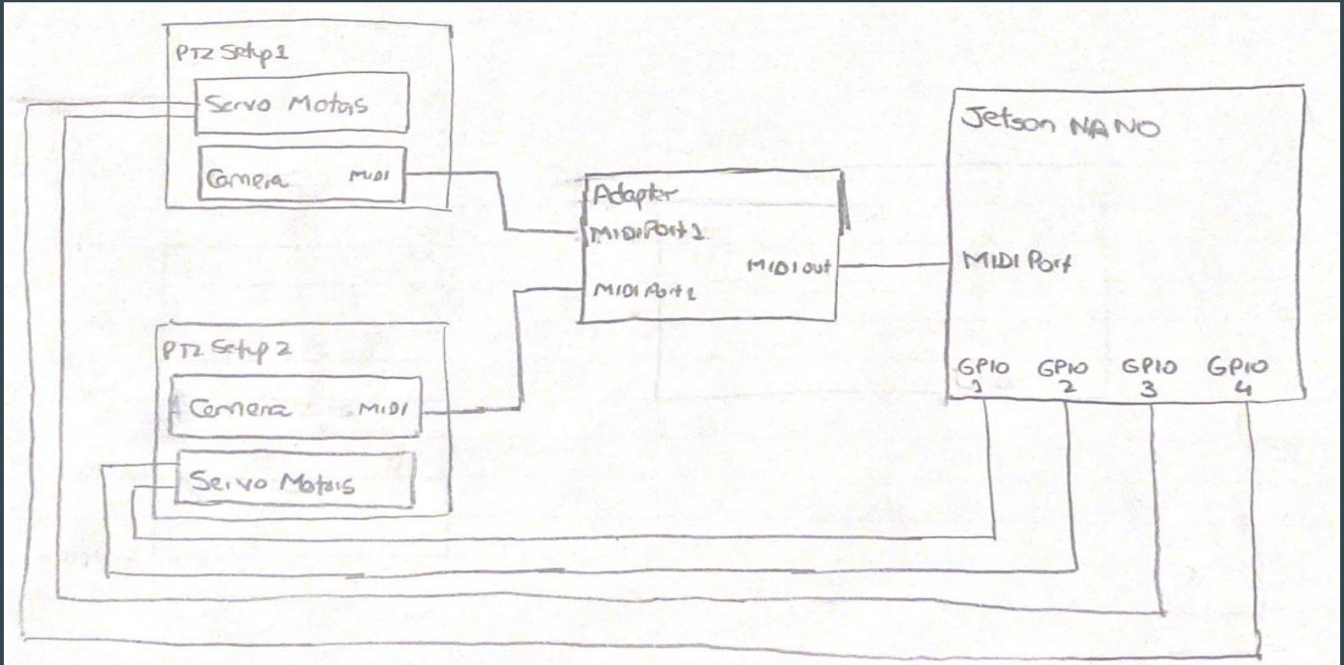
Quantitative Requirements

- Detection Ability:
  - The system must detect animals within 25 meters with a recall of 75%
- Detection Speed:
  - The system must detect animals within 15 seconds.
- Tracking Ability:
  - The system must be able to follow and photograph an animal moving 2 m/s.
- Photo Quality:
  - The photo should be 12MP and have quality indistinguishable from a human shot and edited photograph.

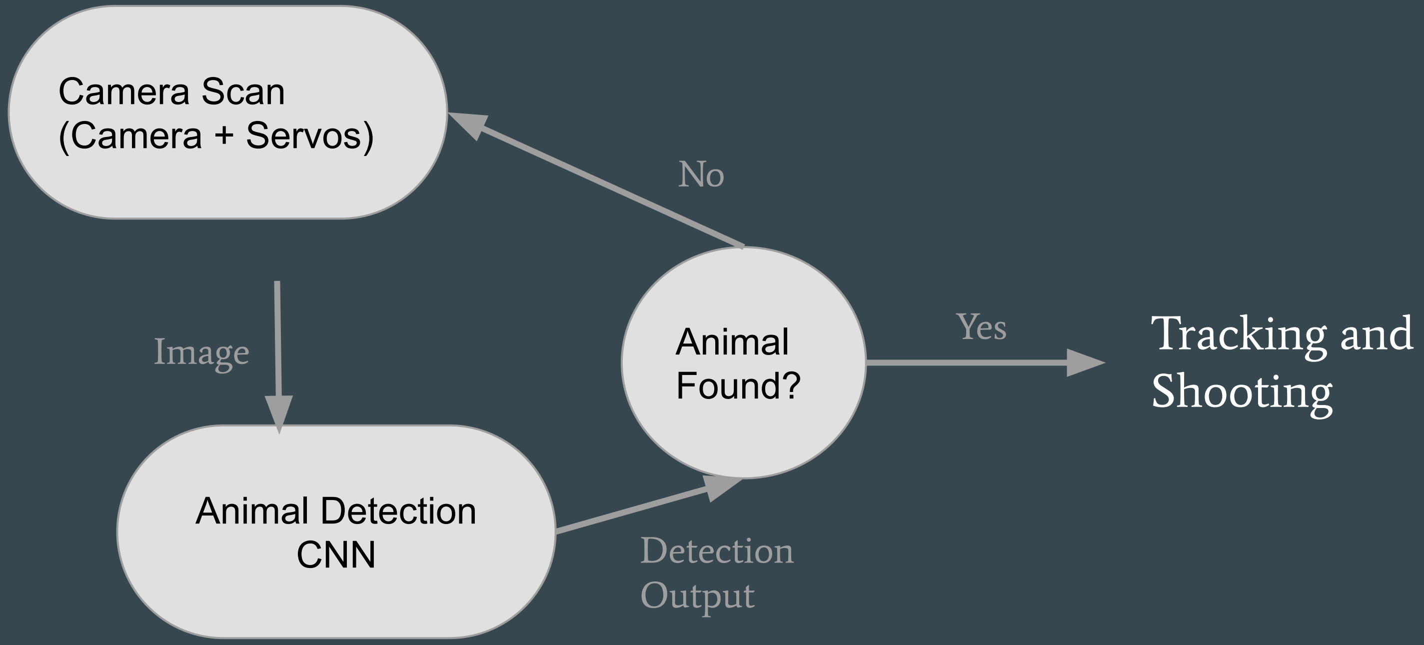
Solutions Approach

- Two Arducam 8MP Pan Tilt Zoom Camera with Metal Base and 2 Digital Servos
- Jetson Nano 2GB Developer Kit
- 3 Phase Software Approach
  - Animal Search and Detection
  - Tracking and Photography
  - Photo Editing

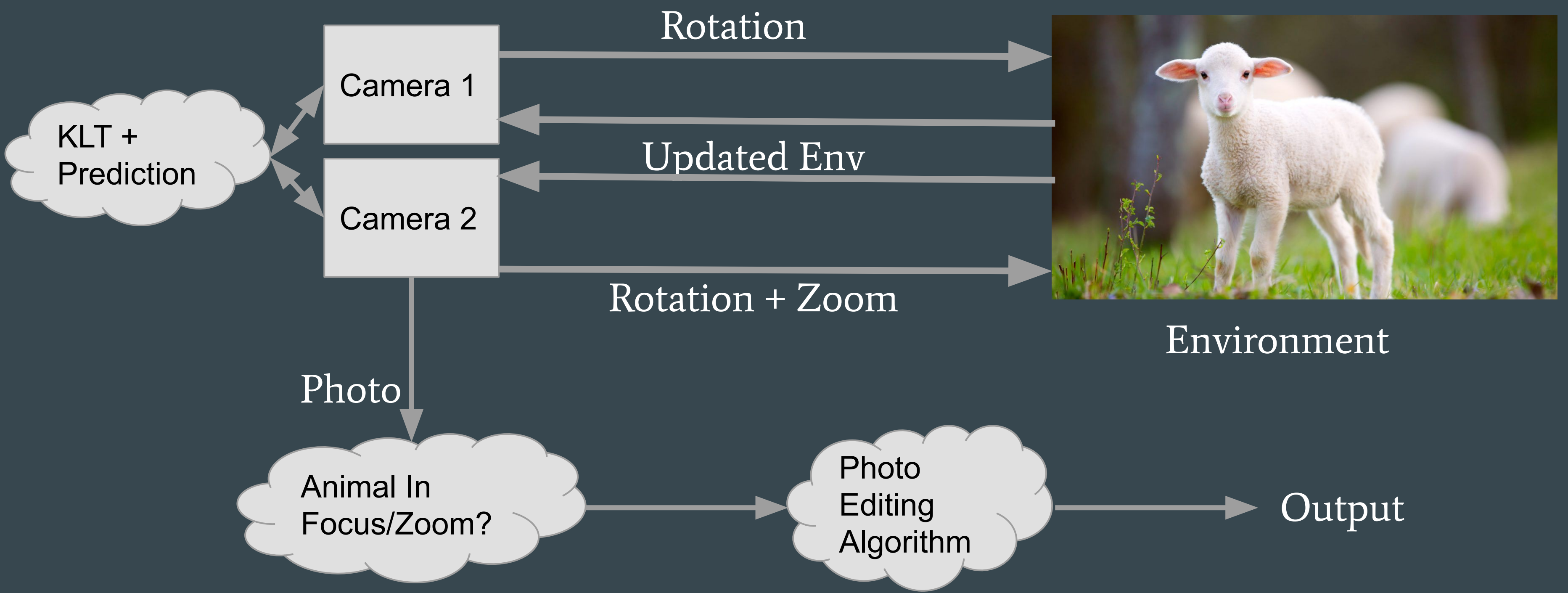
Hardware Specifications



Search and Detection in a Nutshell



Software Specifications - Tracking, Shooting, and Editing



Implementation Plan

- Hardware Implementation
  - The purchased cameras connect to a Arducam Multi Camera Adapter Module
  - The Adapter connects to the MIDI Port on the Jetson NANO
  - The purchased servo motor connect to the GPIO pins
- Search and Detection:
  - Training an animal detection CNN
    - Experimenting with EfficientNet/ Yolov5/ M-Resnet-50
    - WCS Camera Traps Dataset
      - 300,000 Photos with Bounding Boxes
      - 200+ Species
  - Constant Speed Scan w/ Zoom Layers

Implementation Plan Contd.

- Tracking and Photography
  - Feature matching algorithm to align the two cameras
    - Using OpenCV Library
  - Lucas-Kanade Optical Flow for Tracking
    - Reverse transforms and periodic updates to prevent accumulating errors
    - Using OpenCV Library
- Editing
  - Implement a library of image processing algorithms
    - Exposure, Contrast, Temperature, Tint, Vibrance, Saturation, Sharpness
  - Create a set of editing rules inspired by editing tutorials
    - Ex. Exposure histogram adjustment

Testing, Verification, and Metrics

- To test the robot's recognition capabilities, a set of animal pictures may be placed in its environment under different lighting conditions and levels of occlusion
  - Locate new animals in 15 secs
  - Targets 5m, 15m, and 25m away
- Human testers will be shown pairs of photos and asked to distinguish robot photos from professional photos
- Animal tracking to be tested at 3 different speeds and 3 different distances
  - Slow(0-1 m/s), medium (1-3 m/s), and fast (3+ m/s)
  - Consistent tracking for up to 5s

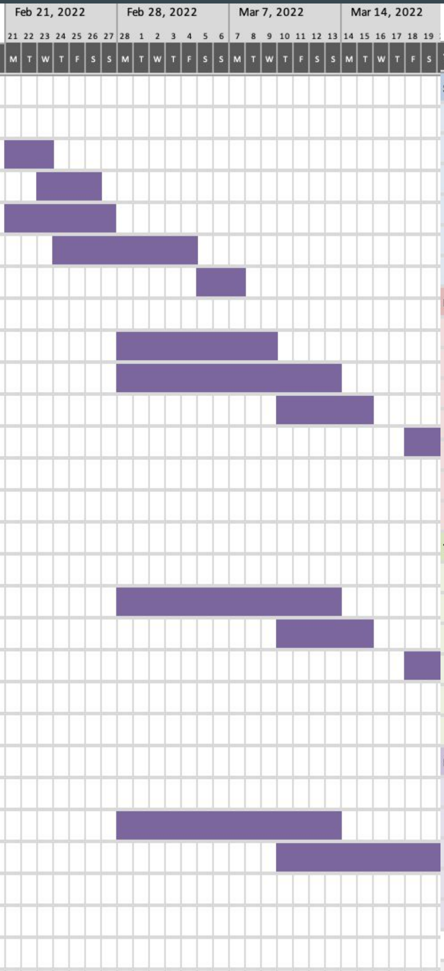
Testing, Verification, and Validation - Alternative Approaches

- Detection Failure
  - Try more representative datasets / combinations of datasets
  - Try slower and more accurate CNN model
  - Try bayesian optimization for search
- Tracking Failure
  - Inverse Compositional Alignment Algorithm
  - Run CNN During Tracking Phase
- Image Editing Failure
  - Neural Network approach for applying image editing algorithms

Project Management

Display Week: 1

TASK	PROGRESS	START	END
Setup			
Order Parts		2/20/22	2/20/22
Wiring		2/20/22	2/23/22
Getting Video to Jetson		2/23/22	2/26/22
Physical Setup		2/20/22	2/27/22
Controlling the Setup		2/24/22	3/4/22
Setup Slack		3/5/22	3/7/22
Detection			
Get CNN Operating		2/28/22	3/9/22
Initial Search Algorithm (Simple Scan)		2/28/22	3/13/22
Test Initial Search Algorithm		3/10/22	3/15/22
Planning Updates		3/18/22	3/25/22
Implementing Updates		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Detection Slack		4/17/22	4/24/22
Tracking			
Baseline Tracking Algorithm (HMM)		2/28/22	3/13/22
Test Baseline Tracking Algorithm		3/10/22	3/15/22
Planning Updates		3/18/22	3/25/22
Implementing Updates		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Tracking Slack		4/17/22	4/24/22
Editing			
Implementing Image Processing Algorithm		2/28/22	3/13/22
Implement & Research Hueristic Editing Rules		3/10/22	3/25/22
Explore Neural Network Approaches		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Editing Slack		4/17/22	4/24/22



Display Week: 4

TASK	PROGRESS	START	END
Setup			
Order Parts		2/20/22	2/20/22
Wiring		2/20/22	2/23/22
Getting Video to Jetson		2/23/22	2/26/22
Physical Setup		2/20/22	2/27/22
Controlling the Setup		2/24/22	3/4/22
Setup Slack		3/5/22	3/7/22
Detection			
Get CNN Operating		2/28/22	3/9/22
Initial Search Algorithm (Simple Scan)		2/28/22	3/13/22
Test Initial Search Algorithm		3/10/22	3/15/22
Planning Updates		3/18/22	3/25/22
Implementing Updates		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Detection Slack		4/17/22	4/24/22
Tracking			
Baseline Tracking Algorithm (HMM)		2/28/22	3/13/22
Test Baseline Tracking Algorithm		3/10/22	3/15/22
Planning Updates		3/18/22	3/25/22
Implementing Updates		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Tracking Slack		4/17/22	4/24/22
Editing			
Implementing Image Processing Algorithm		2/28/22	3/13/22
Implement & Research Hueristic Editing Rules		3/10/22	3/25/22
Explore Neural Network Approaches		3/26/22	4/16/22
Final Testing and Decision Making		4/7/22	4/17/22
Editing Slack		4/17/22	4/24/22