UC SHNTH CRUZ Baskin Engineering

Capstone Project

Automated Stockpile Moving: Experimental Validation of a Vision Based Front Loader

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Objective

Research and develop technology to enable a Bulldozer's autonomous approach and dig operation.

Computer vision & robotic software designed for:

- Pile identification and alignment
- Optimal approach calculation
- Dig verification

Target Identification & Alignment

Neural Networks performe object detection & texture analysis.

Object Detection

- Uses YOLO (You Only Look Once) algorithm
- Trained with public domain construction stockpile images
- Outputs a bounding box and confidence of identified object

Texture Analysis

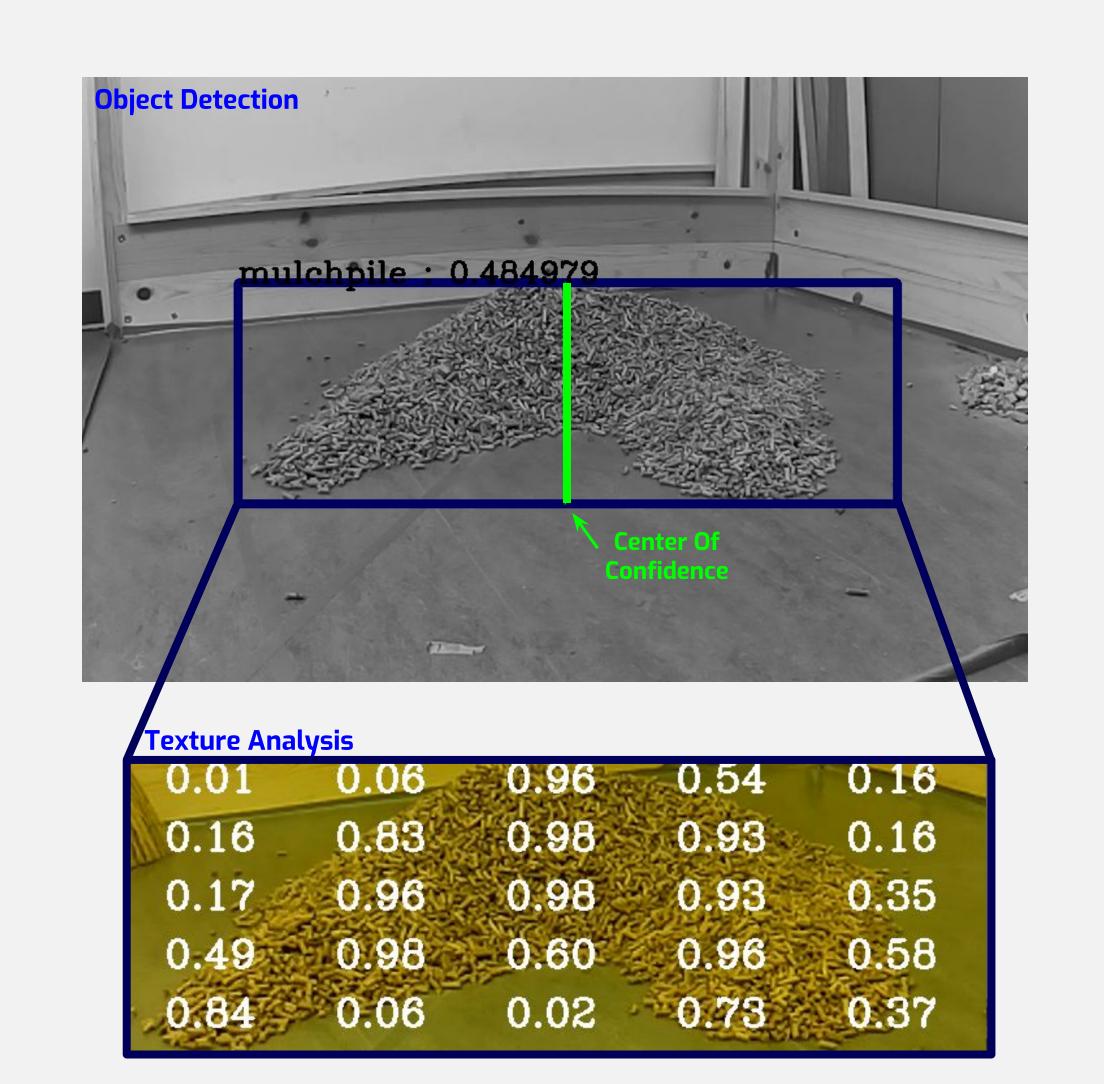
- Built on the Tensorflow framework
- Trained with specifically constructed images
- Segment bounded image and run through texture network
- Outputs target texture accuracy for each segment

Alignment

- Compute center of confidence based on texture segments
- Center of confidence demarcated by green line

Verification

- Discard "false-positive" object detections with invalid texture
- Retry dig operation if bucket has low texture score



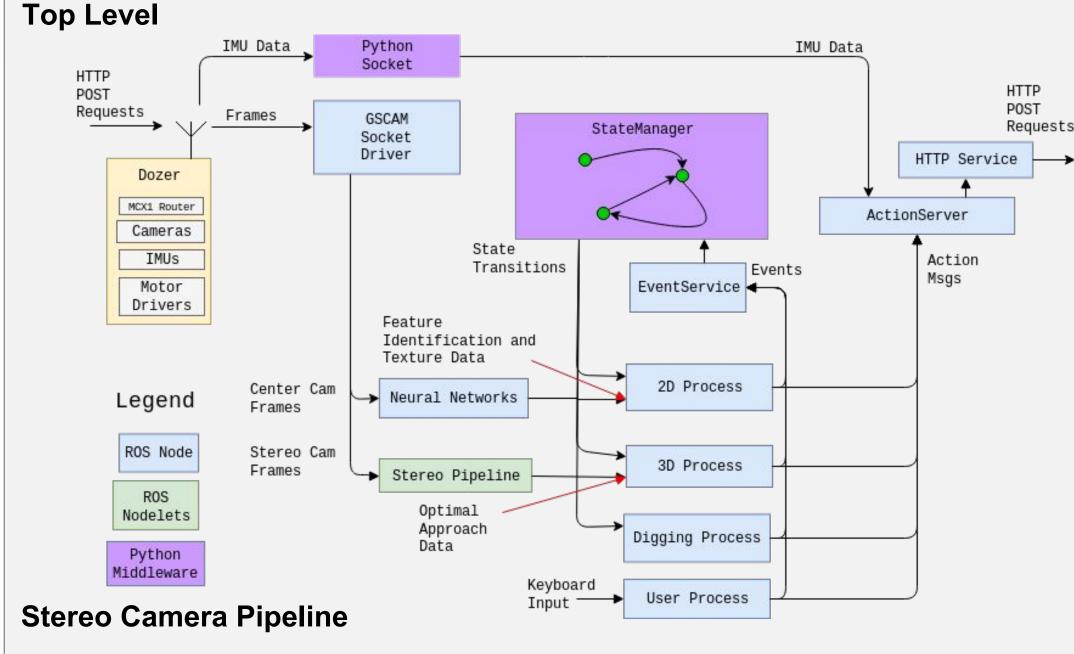
*Networks trained on:

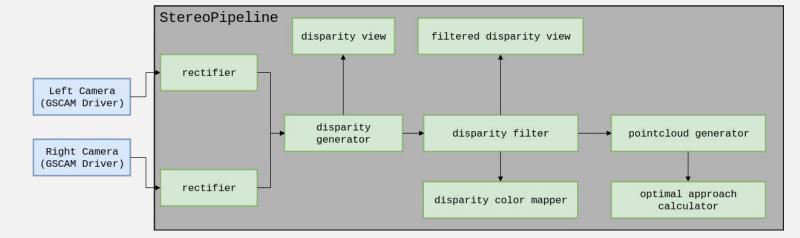
Hummingbird Computational Cluster
UC Santa Cruz Research Computing



Optimal Approach Calculation How do we determine the best entry point when filling a bulldozer's bucket? **Stereo Camera Feed** Right Stereo Camera **Left Stereo Camera** Create a reference plane with its origin at the peak Find the peak straight ahead Sweep the reference plane from π to 2π and use Create a K-D Tree of the point cloud the KD-Tree to get the intersections between the point cloud and the reference plane. Filtered Disparity For each intersection compute Transform Dozer to align with the area beneath the curve intersection of maximum area Reference Plane -Intersection of Max Area Bulldozers 167 cm **Stereo Cameras** HouseCat mkll Movex M-48 (Load Capacity: 18kg) (Load Capacity: 531kg)

Software Architecture

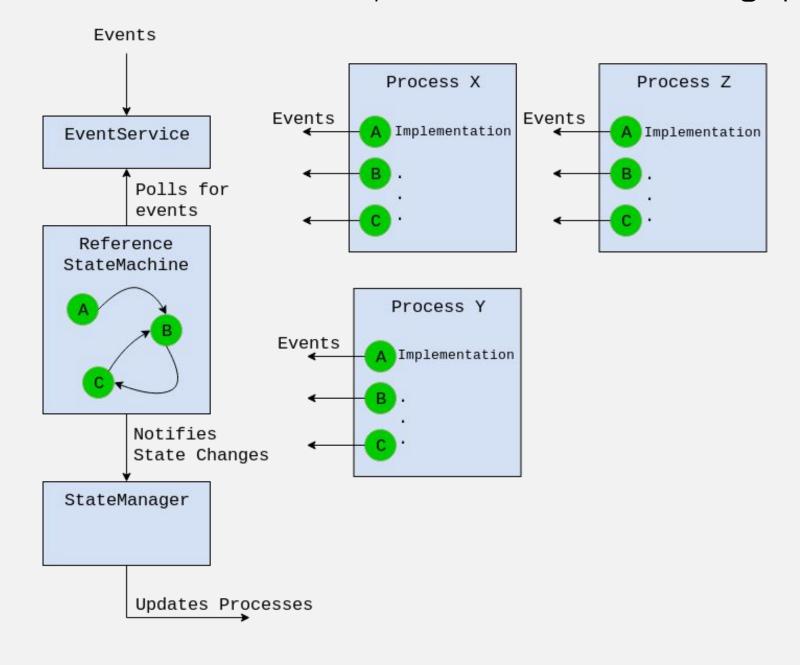




State Synchronized Processes

How to separate concerns for parallel development and modularity?

- Create N number of 'processes' to 'observe' a reference state machine
- This is based on the canonical Object-Oriented Observer design pattern



Conclusion and Results

Several key components for an autonomous bulldozer have been developed:

- Autonomous pile approach and alignment
- Optimal approach calculation
- Movement and bucket control command sequencing
- Successful dig validation

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