

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 perform 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

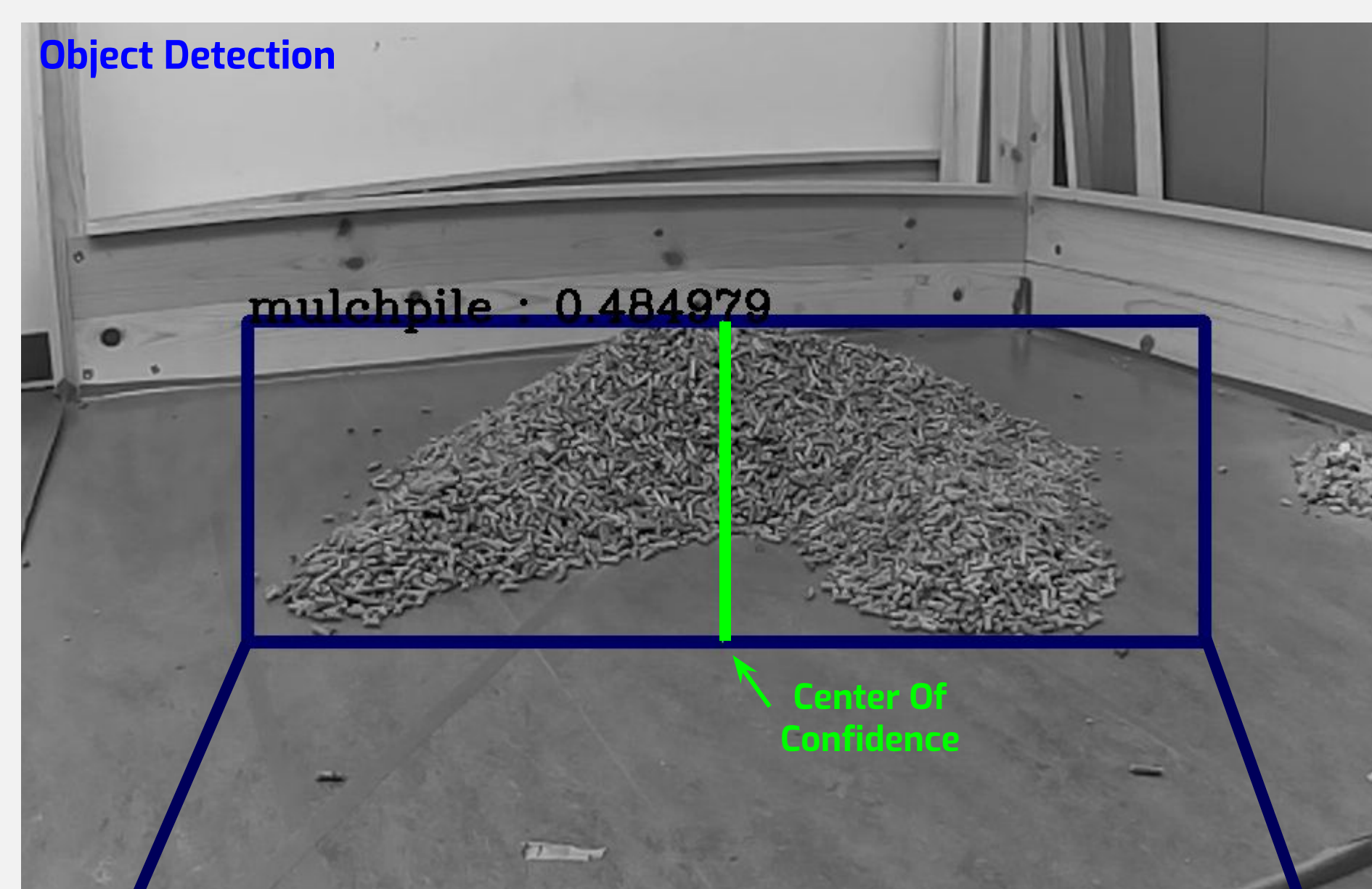
- Built on the Tensorflow framework
- Trained with specifically constructed images
- Segment bounded image and run through texture network
- Outputs target texture accuracy for each segment

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



Texture Analysis

0.01	0.06	0.96	0.54	0.16
0.16	0.83	0.98	0.93	0.16
0.17	0.96	0.98	0.93	0.35
0.49	0.98	0.60	0.96	0.58
0.84	0.06	0.02	0.73	0.37

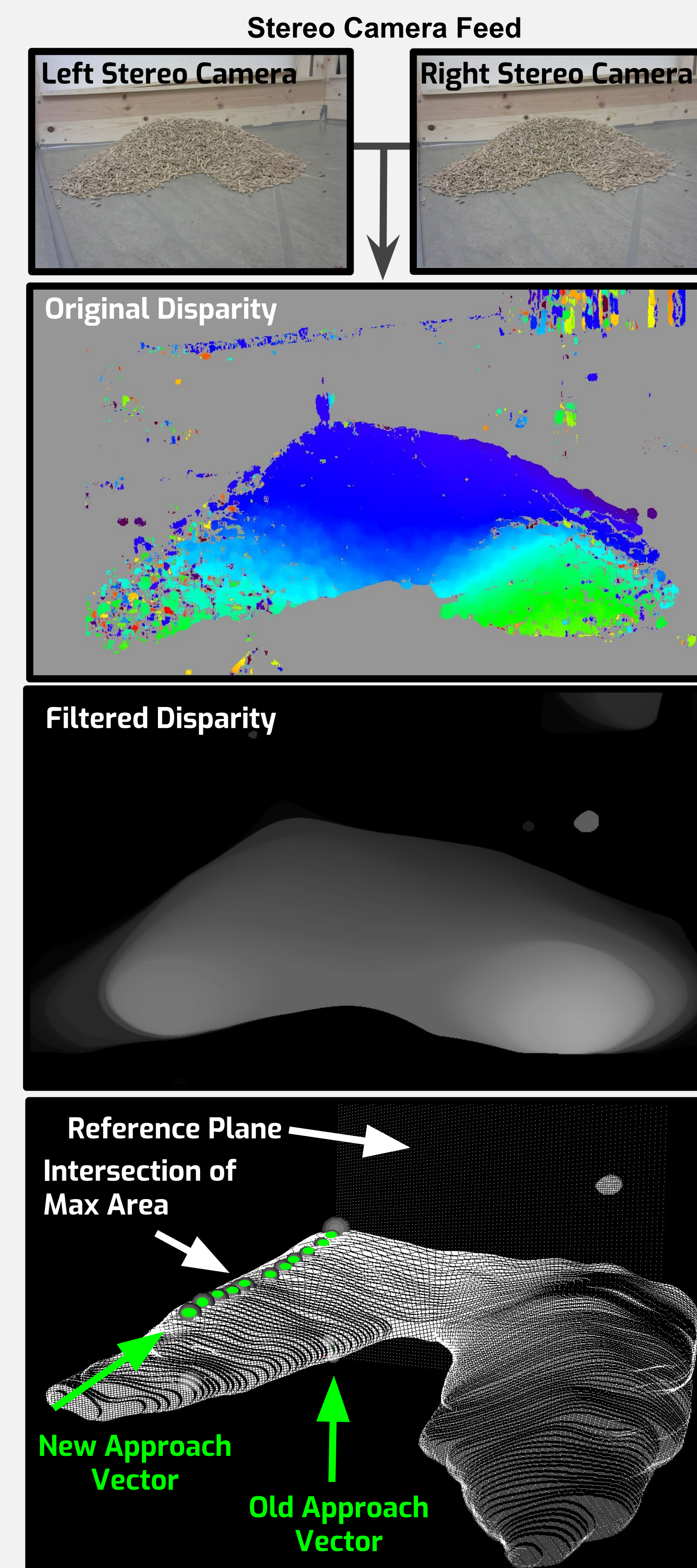
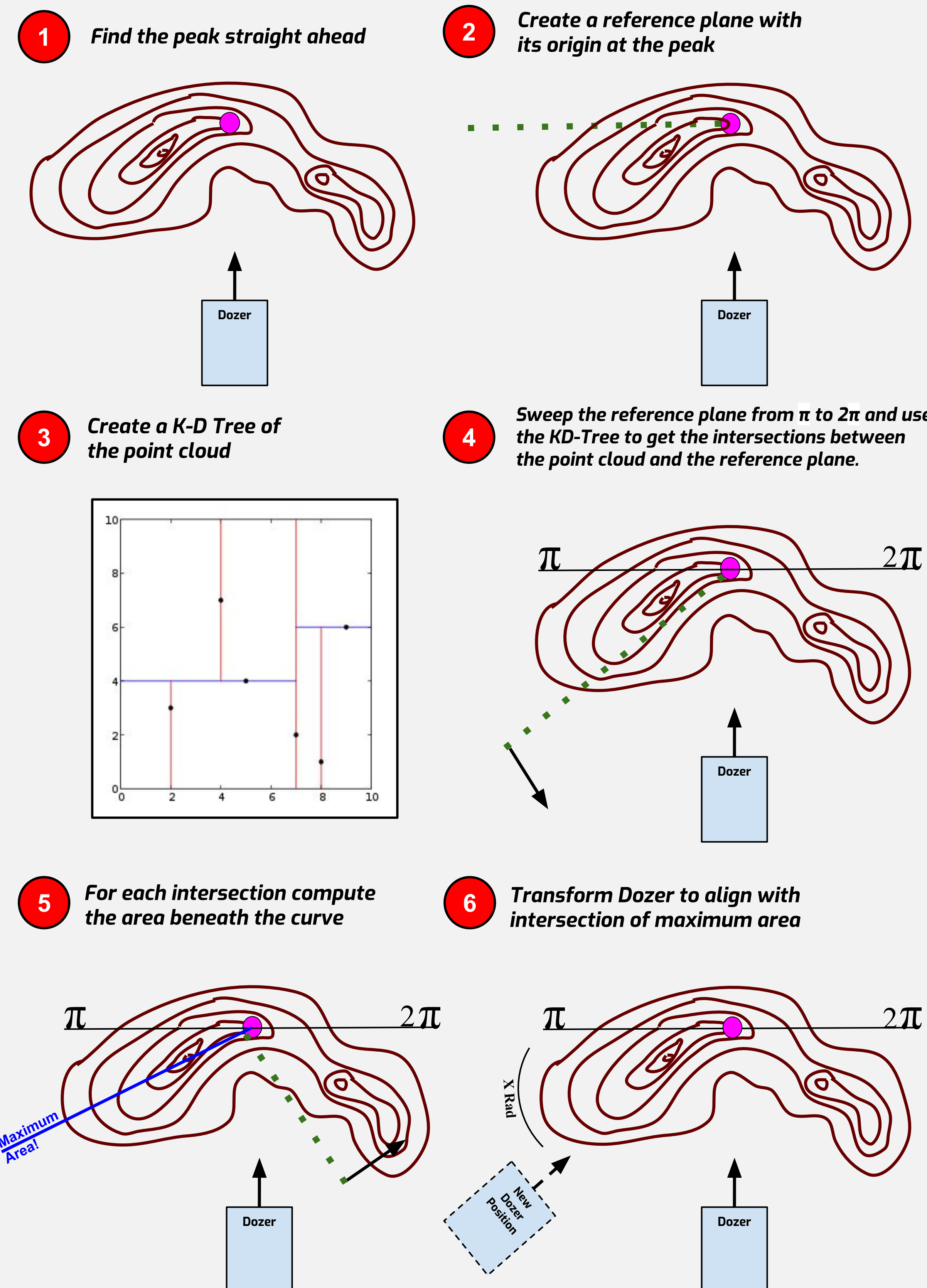
*Networks trained on:

Hummingbird Computational Cluster
UC Santa Cruz Research Computing

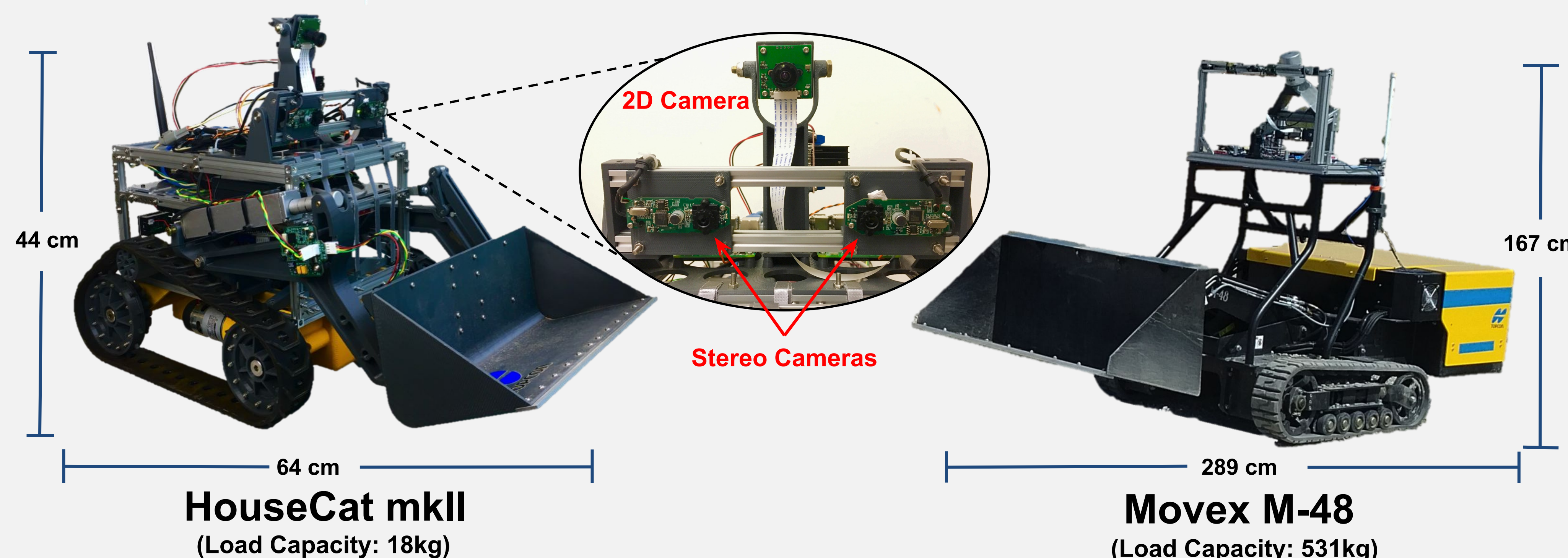


Optimal Approach Calculation

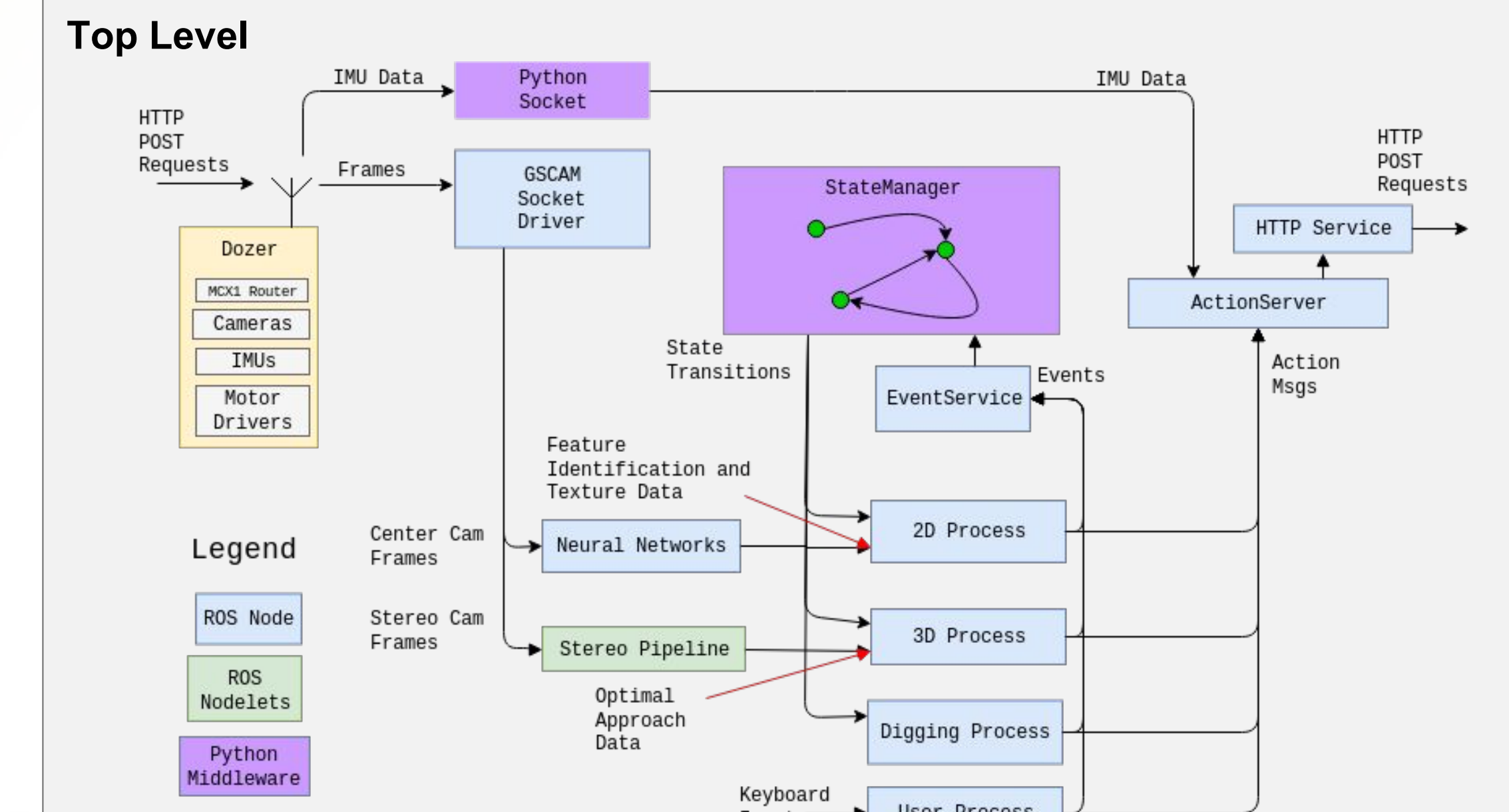
How do we determine the best entry point when filling a bulldozer's bucket?



Bulldozers



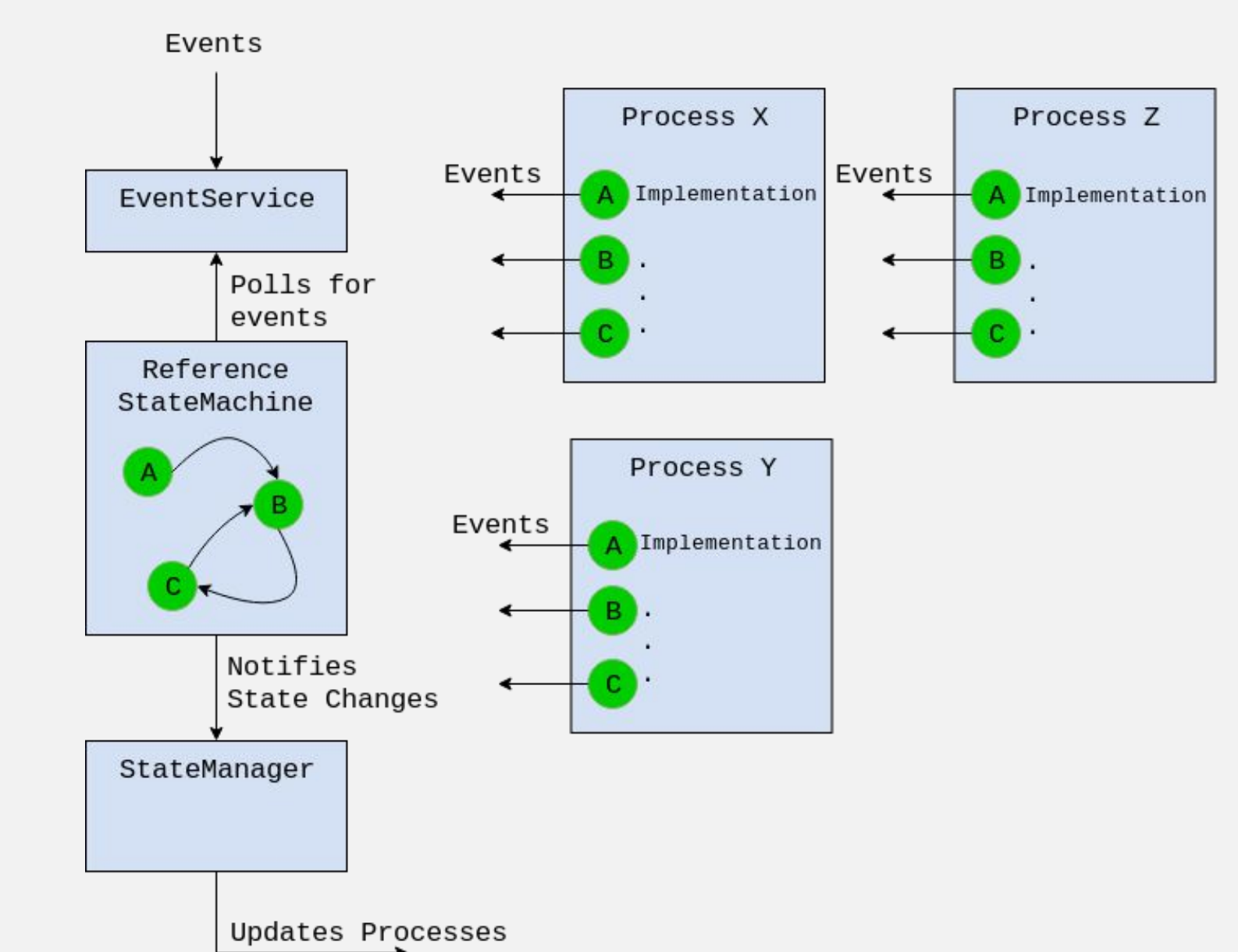
Software Architecture



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

Acknowledgments

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