**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 perform object detection & texture analysis.

**Objective 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
- 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

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**Optimal Approach Calculation**
How do we determine the best entry point when filling a bulldozer’s bucket?

1. Find the peak straight ahead
2. Create a reference plane with its origin at the peak
3. Create a KD-Tree of the point cloud
4. Sweep the reference plane from π to 2π and use the KD-Tree to get the intersections between the point cloud and the reference plane.
5. For each intersection compute the area beneath the curve
6. Transform Dozer to align with intersection of maximum area

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**Software Architecture**
Top Level

- 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

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**State Synchronized Processes**

**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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