**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
- 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 K-D 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**

**Stereo Camera Pipeline**
- **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
  - Outputs target texture accuracy for each segment

**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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