Real-Time "Frame Twist" Measurement Device

PACCAR

Introduction

- PACCAR Technical Center (PTC) is looking for a simple method to measure tractor/trailer frame twist which is needed for the calibration of vehicle dynamic simulation models.
- An unexplored camera-based approach for measuring frame twist has been proposed by PTC.

Figure 1: Truck twisting

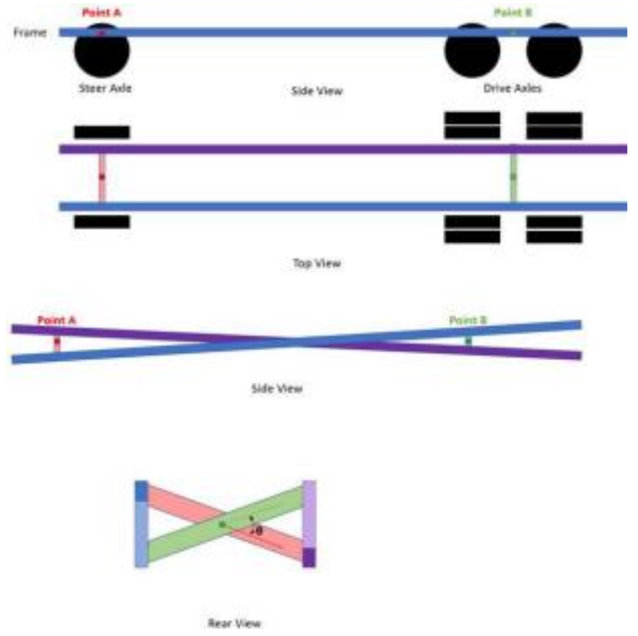

Figure 2: Frame twist diagram

Objective

- Develop a device capable of measuring ±20° in angular deflection with a resolution of ±0.2°.
- The device should broadcast the data over the CAN bus interface in "Real Time", or 60Hz.
- Our data should include the angular measurements along with diagnostics showing the level of confidence in the accuracy of the measurements
- Our device should be able to calibrate to different wheelbase lengths.

Implementation

- A camera-based approach where a camera records markers, then uses computer vision to identify the illuminated markers and calculate the angle with respect to a calibrated zero.

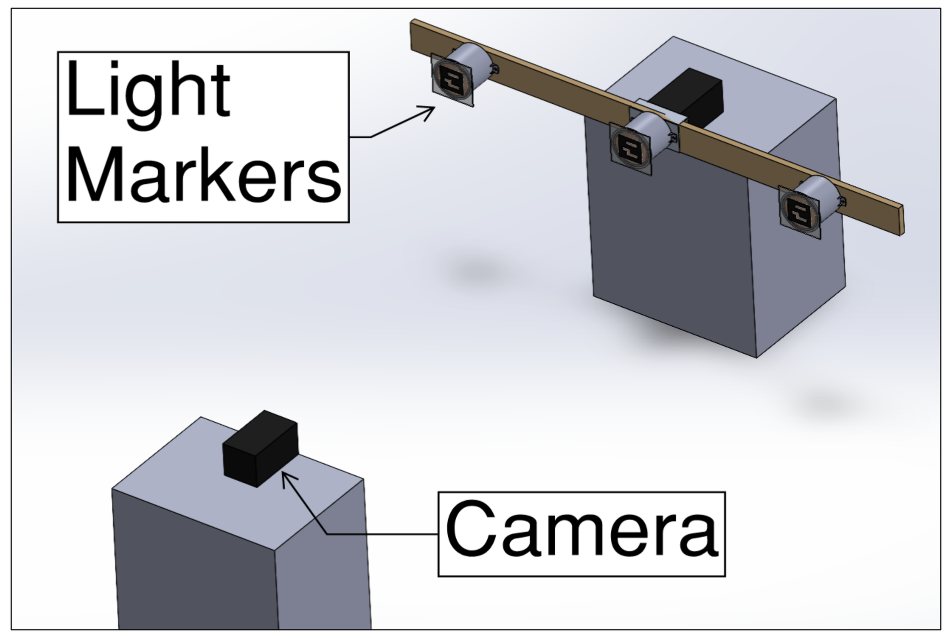

Figure 3: CAD model of prototype test setup

Light Markers

- A light source is used to illuminate the markers patterns to allow easy detection independent of environment.
- Red film is used to turn the light red which paired with a red-light filter, filters out all but red light.
- ArUco codes are used for the marker patterns for they are simper to detect at a distance.

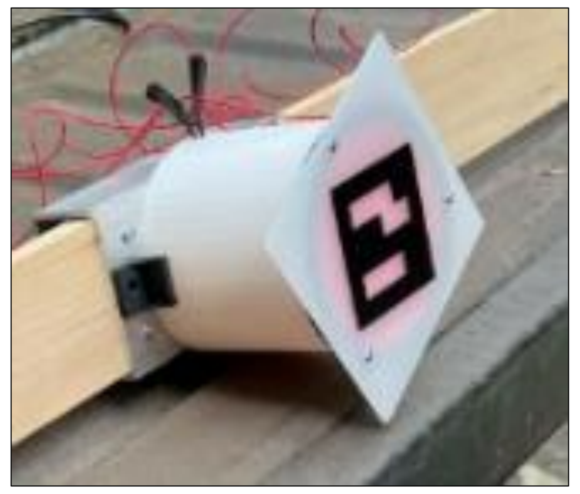

Figure 4: Assembled light marker

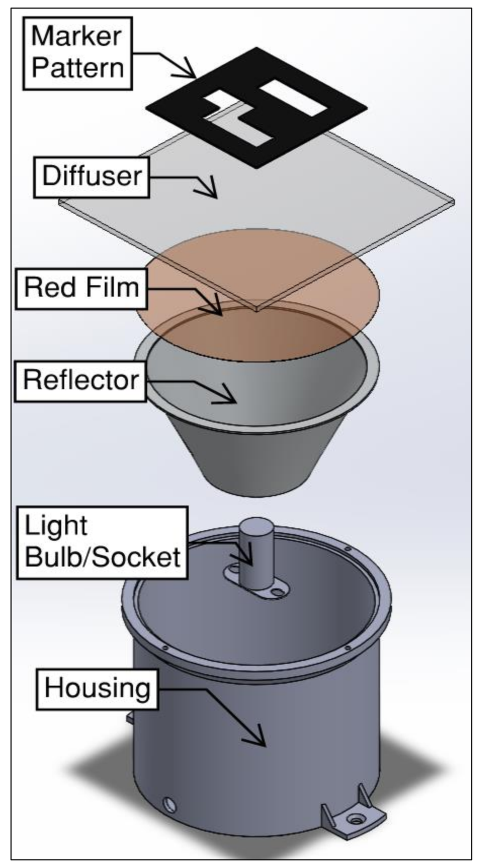

Figure 5: CAD model of light marker

Algorithm Overview

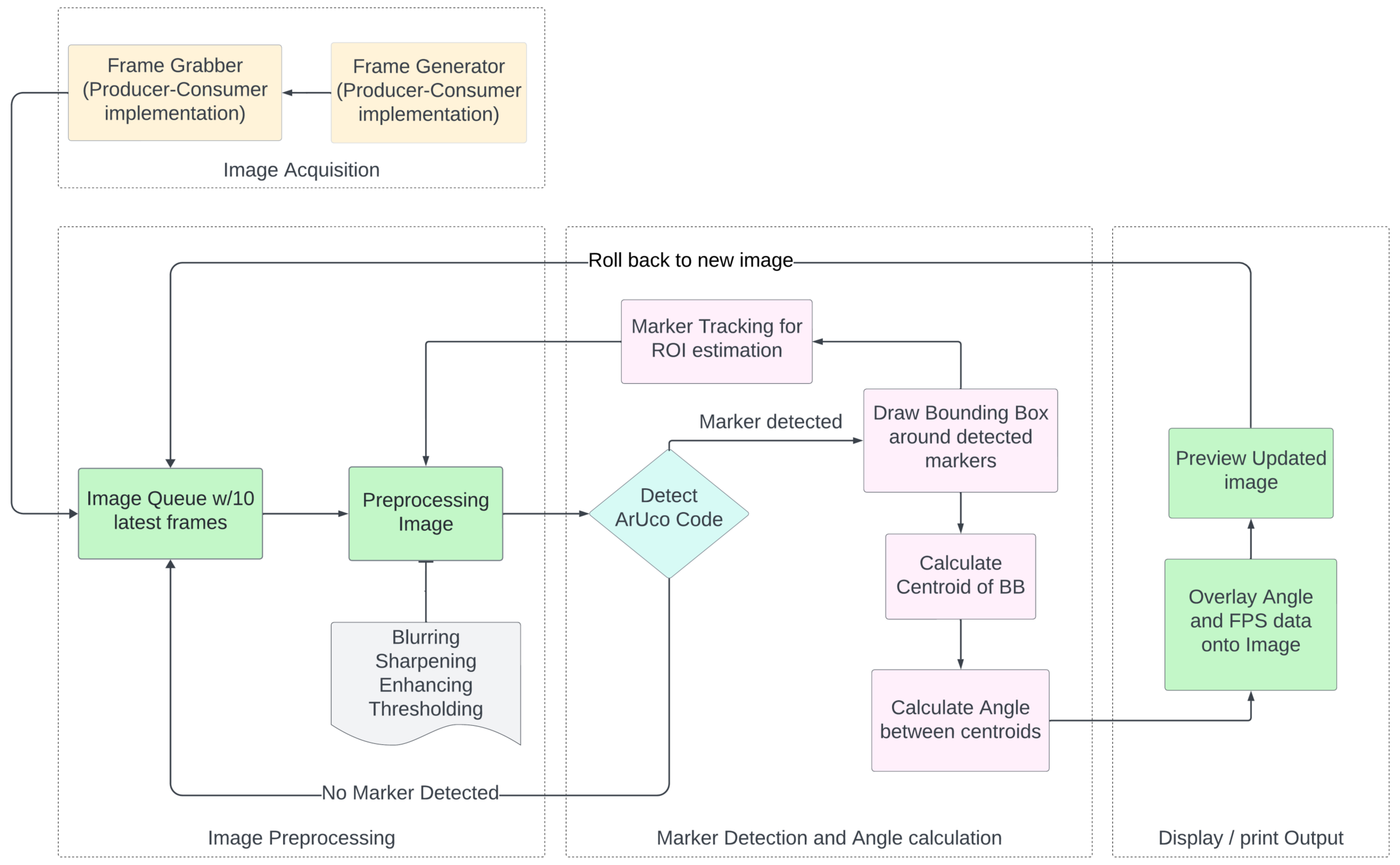

Figure 6: Block diagram of camera detection

- Image Acquisition:
  - Utilizes a Frame Grabber to capture images.
- Image Queue and Preprocessing:
  - Processes an input queue of 10 frames.
- Marker Detection & Angle Calculation:
  - Estimates the Region of Interest (ROI) and performs warping for ROI tracking
  - Detects markers, draws bounding boxes (BB), calculates the center of the BB, and computes the angle between centroids.
- Display/Print Output:
  - Updates and previews the image with information such as angle and frames per second (FPS) data.

Testing

- We lab tested our using a stepper motor to create prescribed angular displacements as a reference to compare with our camera system performance.

Figure 7: Lab test setup

- Our system was field tested by mounting onto a truck and trailer. By driving the truck, we could simulate vehicle frame twist.

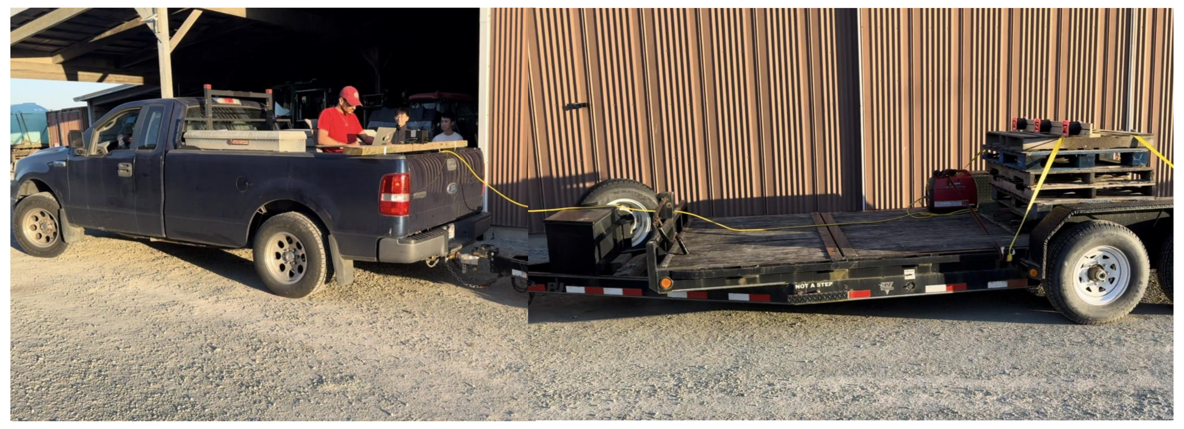

Figure 8: Field test setup

- An important thing to note is that our tests aimed at measuring relative angular displacement, rather than actual frame twist.

Results

- In testing we achieved the requested accuracy and range of motion.
- Additionally, we achieved in being able to calibrate different wheelbase lengths.
- The maximum FPS we were able to achieve is 45FPS.
- CAN bus integration has yet to be implemented.
- Error analysis and confidence diagnostics have also not been implemented.

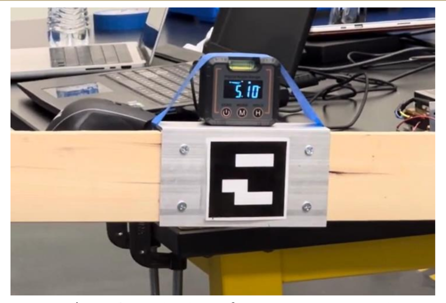

Figure 9: Test setup reference measurement

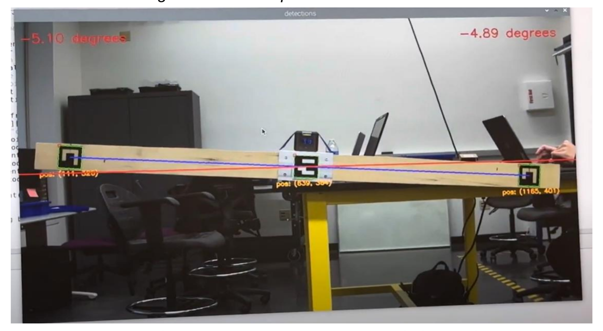

Figure 10: Camera measurement during testing

Future Work

- Explore different wheelbase lengths using different lenses.
- Increase FPS of data collection.
- Implement CAN bus Integration.
- Implement Error analysis for data processing.

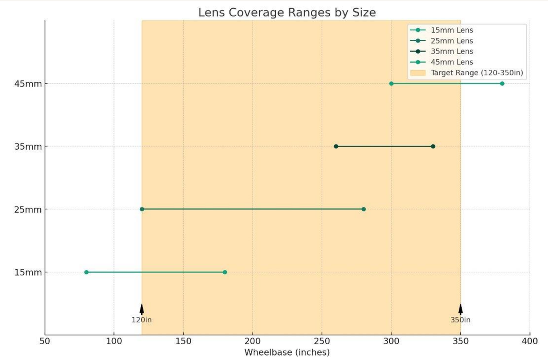

Figure 11: Graph showing ideal lens for wheelbase ranges

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