

Seeing Beyond Black: Automated Character Recognition of DOT Codes on Auto Tires

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1. Context of the Problem

The Department of Transportation (DOT) code molded on every tire sidewall provides essential traceability for manufacturing, recalls, and safety compliance. However, reading these codes remains a major challenge due to the tire's optical properties: high carbon black content results in extremely low reflectivity, the embossed geometry varies in depth (0.2–1.0 mm), and the black-on-black contrast makes text recognition unreliable. Currently, DOT codes are often transcribed manually during inspections or by handheld barcode-like scanners under strict lighting conditions. Manual reading takes roughly 2–4 minutes per tire and introduces up to 15% transcription errors, costing large fleets over \$50,000 annually in labor inefficiency. Missed or unreadable codes also lead to delayed recall compliance and safety risks, contributing to hundreds of fatalities linked to aged or defective tires.

This project proposes an automated vision-based DOT OCR system integrating optimized lighting configurations (raking, polarized, and structured light) and deep learning models (CNN/YOLOv8 + Tesseract OCR baseline). If successful, the system would enable 90–99% recognition accuracy within 20–30 seconds per vehicle, reducing cost, error, and liability while improving safety and traceability.

2. Objectives and Tasks

Objectives:

- Develop an automated solution for accurate DOT code recognition under uncontrolled conditions.
- Benchmark multiple lighting configurations to identify the most effective for embossed text visibility.
- Enhance road safety and regulatory compliance through reliable tire identification.

Tasks:

- Conduct literature review on tire materials, optical behavior, and OCR techniques.
- Design and build an imaging rig with raking, bidirectional, and polarized lighting setups (I already have a depth 3d camera from my lab).
- Develop and implement a computer vision pipeline for detection, enhancement, and recognition.
- Evaluate model accuracy against a ground-truth dataset of stationary and moving tires.

3. Proposed Approach

The solution will be developed in a stepss manner:

1. **System Development:** Construct the image acquisition system using high-resolution cameras and adjustable lighting modules. Capture datasets of stationary and slow-rotating tires under different lighting conditions.
2. **Algorithm Design:** Implement a baseline OCR pipeline combining Tesseract with traditional image processing methods (histogram equalization, gradient filtering). Train deep learning models (YOLOv8 + CNNs) to detect and read embossed DOT characters.
3. **Testing and Validation:** Quantitatively assess character-level accuracy, read success per tire, and average processing time. Compare automated results with manual transcription baselines. Conduct stress tests using dirty, wet, and aged tires to measure robustness. I found a dataset online, with 494 pictures of the sidewall text (not many are available) for later use (<https://universe.roboflow.com/tyj-euwyt/tyre-sidewall-text-detection-v2>) and I was going to use my own car tires as well as people who live in my apartment complex to collect information about different light conditions.

4. Time Plan

The project is scheduled for completion before the first week of December (prior to Dead Week). The timeline is as follows:

- **Weeks 1–2 (Oct 1–12):** Finalize literature review and procure camera, LED, and polarizer components (I got it done)
- **Weeks 3–4 (Oct 13–26):** Assemble imaging rig and capture initial dataset from stationary tires (I have started, run into some software issues)
- **Weeks 5–6 (Oct 27–Nov 9):** Develop baseline vision pipeline and integrate Tesseract OCR.
- **Weeks 7–8 (Nov 10–23):** Train and fine-tune CNN/YOLOv8 models; perform performance benchmarking.
- **Week 9 (Nov 24–30):** Conduct stress tests on degraded or moving tires.

- **Week 10 (Dec 1–7):** Final evaluation, results analysis, and preparation of final report and presentation.

Deadline: December 7, 2025 — one week before Dead Week.