MassDOT Innovation Webinar Series

Artificial Intelligence Framework for Crosswalk Detection Across Massachusetts

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OUTLINE

• Background and Objectives
• Data Sources and Preparation
• Model Development and Results
• Data Post-Processing
• Summary and Conclusions
Knowing the locations of crosswalks is important for understanding and enhancing pedestrian safety and accessibility.

This research aims to

- Develop an artificial intelligence (AI) framework to detect crosswalk locations across Massachusetts.

- Categorize crosswalks by type and location to better inform safety interventions.
DATA SOURCES AND PREPARATION

MassGIS Aerial Imagery

- 2021 (188 GB, 10,211 tiles)
- 2019 (125 GB, 10,218 tiles)
DATA SOURCES AND PREPARATION (CONT.)
DATA SOURCES AND PREPARATION (CONT.)
MODEL DEVELOPMENT

• Tools
  – ArcGIS Pro
  – Python
  – Anaconda
  – JupyterLab
  – PyCharm

• Models
  – Detection (Mask RCNN, Faster RCNN)
  – Segmentation (DeepLab V3 +, U-Net, YOLOv8)

DETECTION VS. SEGMENTATION

Detection

Segmentation

Instance Segmentation
SAMPLE SEGMENTATION RESULTS
LIMITATIONS

• A limited number of model options
• Not always the latest models
• Speed
  – ~ 2 minutes per image. Each image is 10,000 pixels * 10,000 pixels (100 MP). Each year has over 10,000 images.
  – Exporting training samples is time consuming.
  – Training a model also takes a lot of time.
YOLOV8

• Pros
  – Works great for detection as well as segmentation
  – Much faster (~ 10 seconds per image)
  – Generates accurate bounding boxes

• Cons
  – Needs customizations
  – Needs integration
YOLOv8 is a family of deep-learning model which supports a wide range of tasks, including OBB detection.

Architecture of YOLOv8 is modular and highly extensible.

Excellent balance between efficiency and speed.

Loss for OBB task:

- Distribution Focal Loss (DFL): An improved version of the Focal Loss, which adjusts loss based on the distribution of classes.
- IoU loss: Probabilistic Intersection-over-Union.

Image adapted from a diagram by @RangeKing on GitHub, originally posted in the issue thread at https://github.com/ultralytics/ultralytics/issues/189.
SEGMENTATION VS DETECTION
SEGMENTATION VS DETECTION (CONT.)
SEGMENTATION VS DETECTION (CONT.)
SEGMENTATION VS DETECTION (CONT.)
PERFORMANCE METRICS
POST PROCESSING

All Crosswalks (Polygons) Generated by the AI Model

Polygon Area > 20 square meters

Within 30 meters of an intersection

Midblock Test (SSL > 8 meters)

Within a road buffer of 8 or 10 meters?

False Positives

Driveway Crosswalks & Count

Midblock Crosswalks & Count

Intersection Crosswalks & Count
POST PROCESSING
MODEL GENERALIZATION

Garrisonville, VA
MODEL GENERALIZATION (CONT.)

Nashua, NH
MODEL GENERALIZATION (CONT.)

Bar Harbor, ME
REMAINING ISSUES

• Should we include faded crosswalks?
• What about speed humps?
• Raised intersections?
• Color painted crosswalks?
FUTURE WORK & APPLICATIONS

- Other road assets
- Other models
- Comparing data from multiple years
- Complete street applications
SUMMARY AND RECOMMENDATIONS

• The YOLOv8 OBB model works well, particularly for zebra and parallel line crosswalks.

• Quality check is still needed. However, the AI approach can save a substantial amount of time compared to manual detection.

• Crosswalk pavement marking patterns should be standardized.

• Assessing the conditions of crosswalk pavement markings is also important and will be our next step.
THANK YOU!

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