Intro to Computer Systems_CSCI 6011

Department of Computer Science

Final Project Report

Title：Enhancing Urban Accessibility: Tactile Pavement Obstacle Detection Device Utilizing YOLOv8

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Part.1

Introduction

Motivation and Background

Background

According to the report of World Health Organization, at least 2.2 billion people in the world suffers from vision impairment. The utilization of tactile pavement intends bring convenience to people with vision impairment and enhance their independence in life.

Motivation

Our project proposes a new system to detect the region where obstacles occupy tactile pavement which can help the government to improve their management of tactile pavement and assist people with vision impairment to avoid obstacles when walking on street.

Using technology to improve the situation of people with visual impairment.

Resolution

1 Length of tactile pavement

TABLE I. LENGTH OF TACTILE PAVEMENT SURFACES IN MAJOR CITIES OF CHINA [3]

City	Length of Tactile Pavements Surfaces
Bejing	Over 1600 km
Shanghai	Over 1700 km
Shenzhen	Over 232 km
Guangzhou	Over 1100 km
Xiamen	Over 460 km

2 Resolution

- To determine whether any obstacle is on the tactile pavement, the primary concern is to acquire the position of both obstacles and tactile pavement. Therefore, YOLOv8, a state-of-the-art in segmentation tasks, is adopted by us.

PART.2

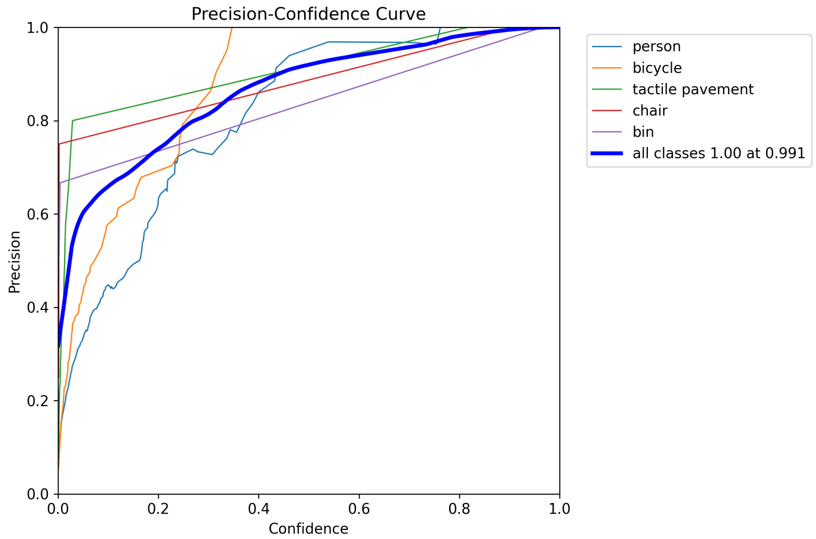
Methods

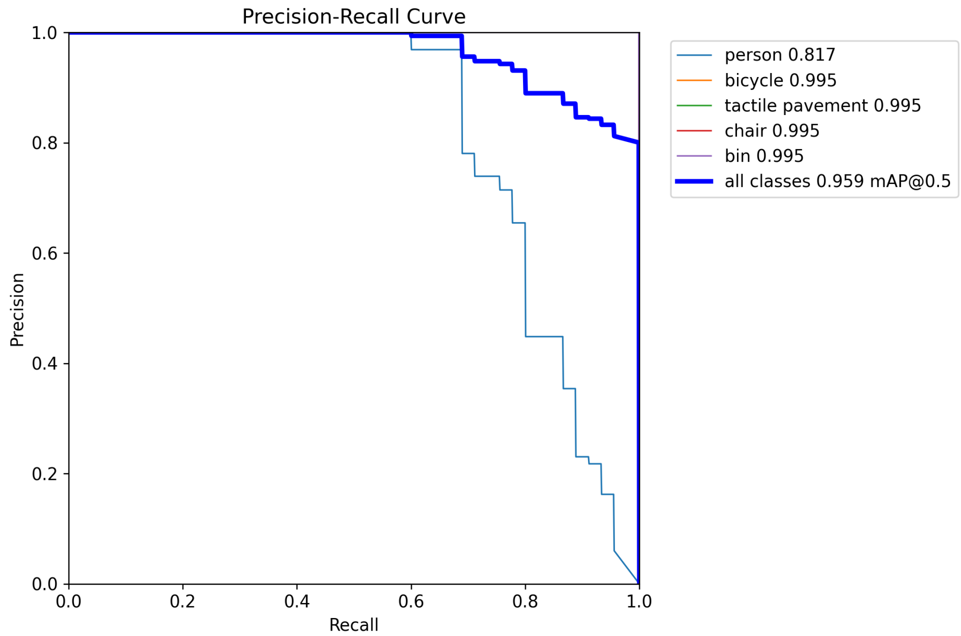
YOLOv8-seg for Segmentation of tactile pavement and obstacles

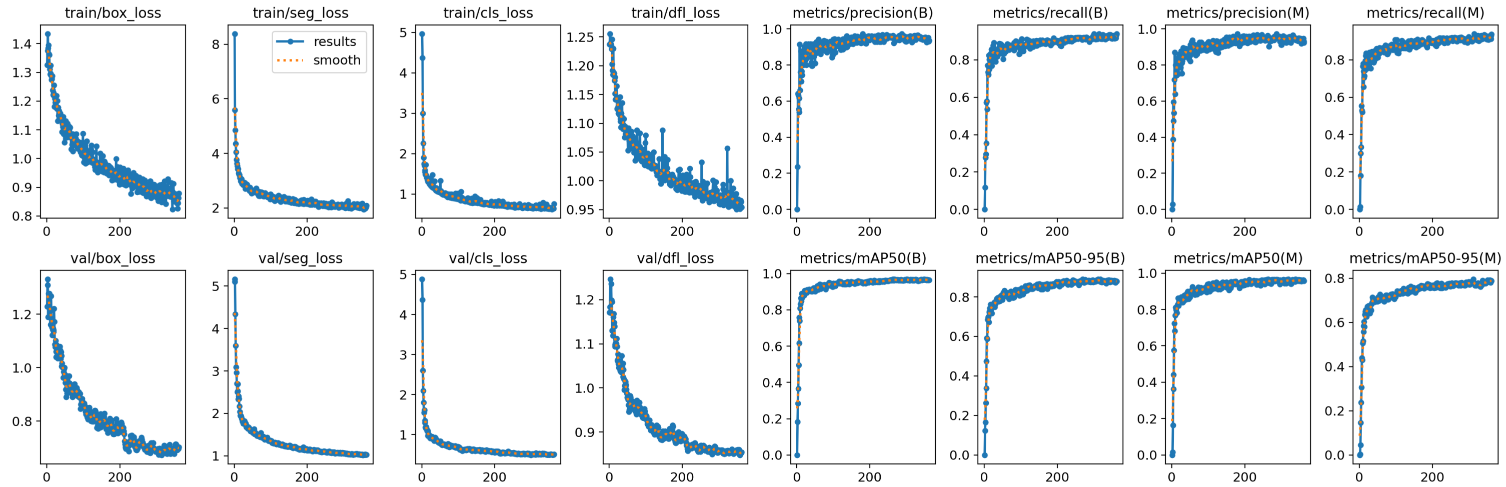
1 **Original**

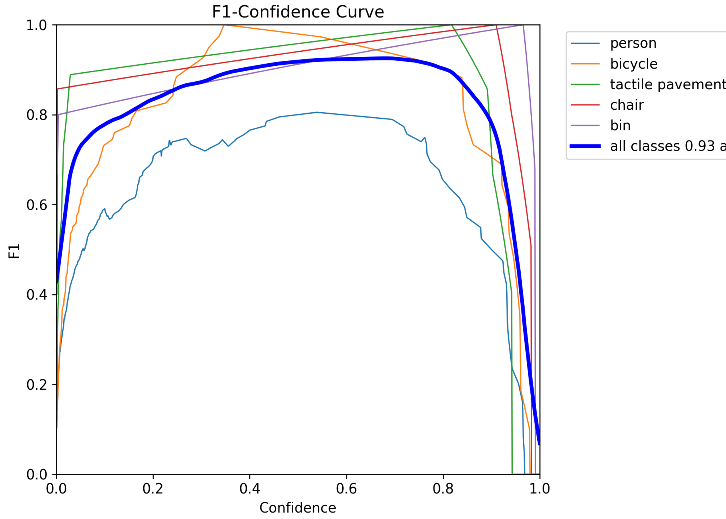
2 **Prediction**

Prediction Result









Prediction Result

Analysis of the Prediction Result

ultralytics.engine.results.Results Attributes

Name	Type	Description
`orig_img`	`ndarray`	The original image as a numpy array.
`orig_shape`	`tuple`	The original image shape in (height, width) format.
`boxes`	`Boxes`	A Boxes object containing the detection bounding boxes.
`masks`	`Masks`	A Masks object containing the detection masks.
`probs`	`Probs`	A Probs object containing probabilities of each class for classification task.
`keypoints`	`Keypoints`	A Keypoints object containing detected keypoints for each object.
`speed`	`dict`	A dictionary of preprocess, inference, and postprocess speeds in milliseconds per image.
`names`	`dict`	A dictionary of class names.
`path`	`str`	The path to the image file.
`_keys`	`tuple`	A tuple of attribute names for non-empty attributes.

Analysis of the Prediction Result

ultralytics.engine.results.Boxes
Attributes

Name	Type	Description
`xyxy`	`Tensor | ndarray`	The boxes in xyxy format.
`conf`	`Tensor | ndarray`	The confidence values of the boxes.
`cls`	`Tensor | ndarray`	The class values of the boxes.
`id`	`Tensor | ndarray`	The track IDs of the boxes (if available).
`xywh`	`Tensor | ndarray`	The boxes in xywh format.
`xyxyn`	`Tensor | ndarray`	The boxes in xyxy format normalized by original image size.
`xywhn`	`Tensor | ndarray`	The boxes in xywh format normalized by original image size.
`data`	`Tensor`	The raw bboxes tensor (alias for `boxes`).

Analysis of the Prediction Result

ultralytics.engine.results.Masks

Attributes

Name	Type	Description
`xy`	`list`	A list of segments in pixel coordinates.
`xyn`	`list`	A list of normalized segments.

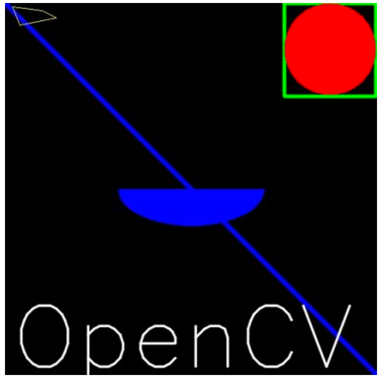
Fact: The mask and the box of a object have the same index.

-Iterate the boxes, when encountering the box with the tactile pavement class, record the corresponding mask.

-Iterate the masks of tactile pavement, find if any obstacle intersects with the mask of tactile pavement. If any obstacle found, return the obstacle class and the intersection polygon.

Image capture and output

Drawing Functions in OpenCV



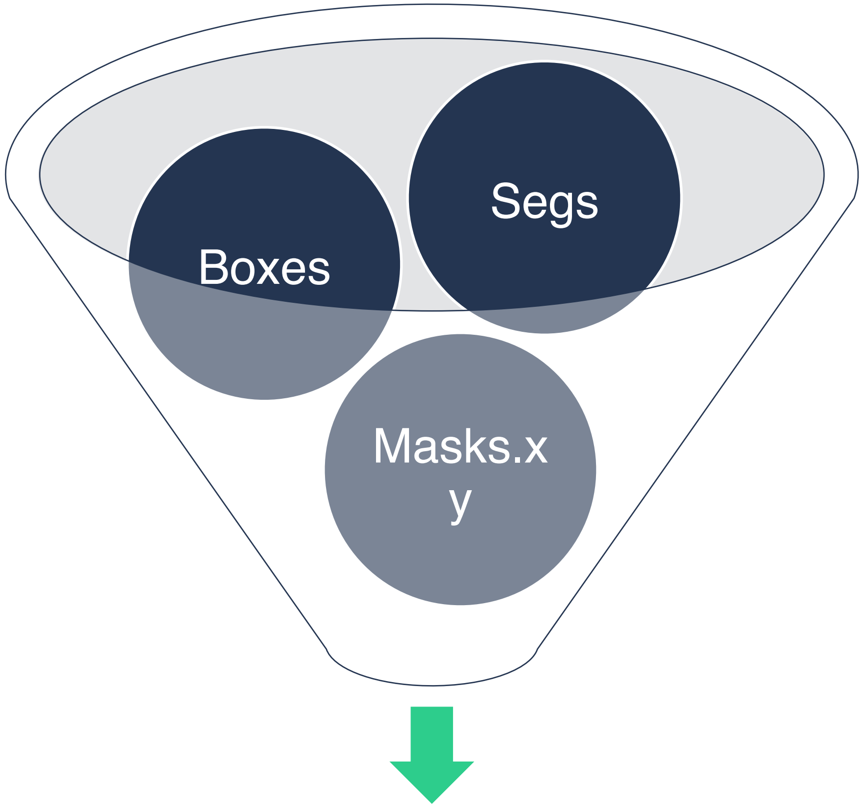
-To draw a polygon, first we need coordinates of vertices. Make those points into an array of shape ROWSx1x2 where ROWS are number of vertices and it should be of type int32. Here we draw a small polygon of with four vertices in different color.

-To put texts in images, we get the text data that we want to write and the position coordinates of where we want put it (i.e. bottom-left corner where data starts).

PART.3

Results

Prediction Result Classification



Prediction Results

Accuracy Assessment

1 Table

- 1

TABLE II. ACCURACY ASSESSMENT

Index	**Target**		
	Person	***Bicycle***	***Tactile Pavement***
Confidence[a]	86.72%	88.34%	96.45%

[a] The confidence level of the final model recognition result

2 Analysis

- The YOLOv8 model achieved a commendable accuracy of over 85% in the recognition of people and bicycles. This high level of accuracy is crucial for the device's effectiveness in identifying dynamic obstacles in real-time. The model's ability to distinguish between different classes of obstacles enhances its practicality, allowing users to receive specific information about potential challenges in their path.
- The recognition accuracy for tactile pavement on various surfaces reached an impressive 96%. This high accuracy rate is particularly significant given the diverse textures and materials encountered in urban environments. The device's ability to consistently identify tactile pavements ensures that users receive reliable information about the designated paths, contributing to safe and reliable navigation.

PART.4

Discussion

Limitations and Future Directions

1 Addressing Current Limitations

- The current limitation of relying solely on the device's own camera for image capture highlights an area for future improvement. Single-camera setups may struggle to provide depth information, leading to potential errors in obstacle detection. To address this, exploring the integration of additional sensors, such as depth sensors or LiDAR, could enhance the device's perception capabilities. These sensors can contribute crucial depth information, improving the accuracy of obstacle detection and ensuring a more comprehensive understanding of the environment.

2 Future Works

- A forward-looking strategy involves collaboration with government agencies and relevant units to access road surveillance images. Government partnerships can provide a wealth of data that complements the device's real-time image capture. Incorporating external image data into the device's model training process can contribute to a more robust and accurate obstacle recognition system. Such collaborations can also involve discussions on data-sharing agreements, ensuring privacy and compliance with regulatory standards.

User Impact and Market Uniqueness

1 User Impact

- The positive user feedback underscores the importance of maintaining a user-centric design approach. Ongoing collaboration with individuals with visual impairments will guide the customization options offered by the device. Ensuring that users have the flexibility to tailor auditory and visual cues according to their preferences will contribute to a more personalized and user-friendly experience.

2 Market Uniqueness

- The absence of similar devices in the market indicates a significant market gap that the Tactile Pavement Obstacle Detection Device aims to fill. Its potential for market success can be leveraged to advocate for greater attention to accessibility in the technology sector. Engaging with stakeholders, including accessibility advocates, policymakers, and technology developers, can amplify the device's impact and contribute to a broader movement towards inclusive design practices .

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Many thanks for listening!
Please feel free to give any suggestion.