# Developing a Sidewalk Navigation System for Telepresence Robots

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## Introduction

**Research Question:**

How can a robust sidewalk navigation system be developed to enhance the mobility of telepresence robots?

**Main Focus of the Research:**

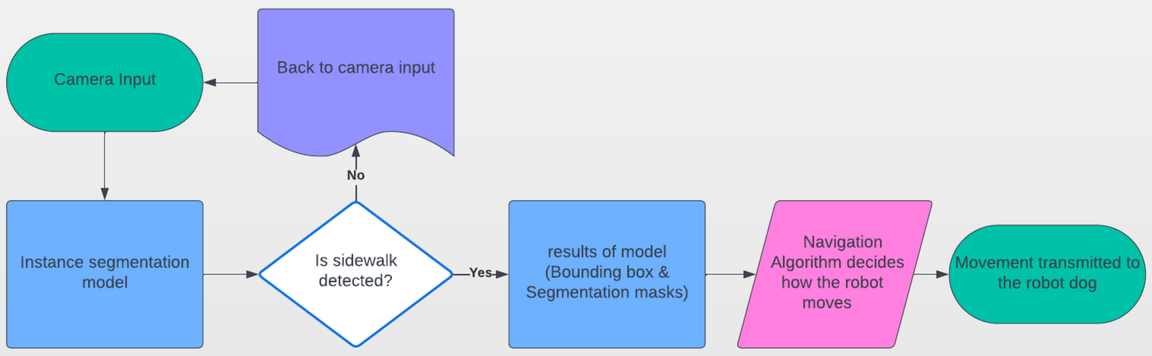
The main focus is on designing and implementing an efficient sidewalk navigation system tailored specifically for telepresence robots.

Emphasis on addressing challenges related to seamless navigation, obstacle avoidance, and user interaction in urban environments.

**Problem Addressed:**

Current sidewalk navigation systems for telepresence robots may lack robustness, hindering their effectiveness in real-world scenarios.

The project aims to overcome these limitations by developing a customized navigation system that ensures smooth and reliable movement in diverse urban environments.




## Methodology

**Custom Model Development:**

Developed a bespoke instance segmentation model specifically for the Unitree Go1 Edu robot dog.

**Utilization of Computer Vision Techniques:**

Leveraged advanced computer vision techniques to achieve precise sidewalk detection and segmentation.

**Dataset Creation:**

Curated a diverse dataset featuring Australian sidewalks.

Incorporated variations in color, texture, and patterns to enhance model training.

**Model Testing:**

Tested popular models, including YOLO, SAM, and FastSAM.

Evaluated their suitability for real-time sidewalk segmentation.

**External Camera Integration:**

Integrated an external IP webcam to address technical limitations with the robot's onboard cameras.

| Models | mAP (box) 50-95 | mAP (mask) 50-95 | TRT A100 Inference Speed (ms) | Parameters (M) |
|---|---|---|---|---|
| YOLOv5n-Seg | 27.6 | 23.4 | 1.2 | 2.0 |
| YOLOv5s-Seg | 37.0 | 31.7 | 1.4 | 7.6 |
| YOLOv5m-Seg | 45.0 | 37.1 | 2.2 | 22.0 |
| YOLOv5l-Seg | 49.0 | 39.9 | 2.9 | 47.9 |
| YOLOv5x-Seg | 50.7 | 41.4 | 4.5 | 88.8 |

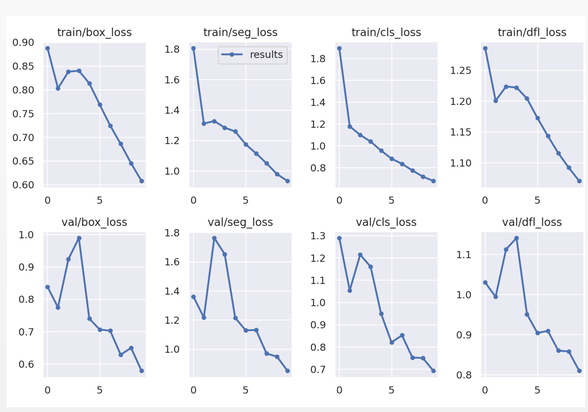
## Results

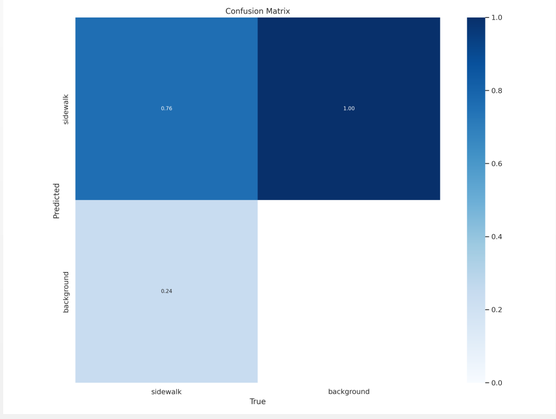
**Performance and Functionality:**

The implemented solution showcases satisfactory performance, effectively addressing the sidewalk segmentation challenge.

**Inference Times:**

The YOLOv8-based model, trained for sidewalk segmentation, demonstrates good inference times. Execution on a system with a dedicated GPU further improves inference times to an average of 10 ms.




**Segmentation Accuracy:**

The trained model exhibits robust segmentation accuracy, successfully distinguishing between sidewalk and background elements.

**Performance Metrics:**

Utilized confusion matrix and validation batch predictions to assess and validate the model's performance metrics.

These metrics offer insights into the model's efficacy, further confirming its accuracy in sidewalk segmentation.

## Conclusion


In conclusion, the research project not only achieved its objectives in developing a sophisticated sidewalk segmentation model but also opens up new possibilities for the practical implementation of computer vision techniques in the field of autonomous systems. The implications of this work extend beyond the immediate scope of the project, offering valuable insights and inspiration for future research endeavors in the intersection of robotics and computer vision.

```
image 1/1 e:\Code\code\segmentation-models\sidewalk\d2.jpg: 384x640 1 sidewalk, 168.2ms
Speed: 0.0ms preprocess, 168.2ms inference, 0.0ms postprocess per image at shape (1, 3, 384, 640)
Results saved to [1mruns\segment\predict23[0m

image 1/1 e:\Code\code\segmentation-models\sidewalk\d4.jpg: 640x384 1 sidewalk, 134.7ms
Speed: 4.6ms preprocess, 134.7ms inference, 0.0ms postprocess per image at shape (1, 3, 640, 384)
Results saved to [1mruns\segment\predict23[0m
```

General Sidewalk Dataset - https://universe.roboflow.com/projects5k1o6/sidewalk-dlu6l/dataset/1

Annotated Australian Sidewalk Dataset - https://universe.roboflow.com/projectnlr2u/sidewalk-segmentation-v4gpn/dataset/1

Robot Dog Navigation Demo - https://youtu.be/w4D5bM6zMF8

Robot Dog Navigation Demo (With model inference) - https://youtu.be/5iUNyrXyqjY

Source Code - https://github.com/cyber-panther/Unitree-go1-edu-sidewalk-navigation

## Acknowledgements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- Rath, S. (2024) YOLOv5 Instance Segmentation: A Comprehensive Beginner's Guide, LearnOpenCV. Available at: https://learnopencv.com/yolov5-instance-segmentation/
- *Legged SDK - Unitree Go1 Documentation*. Available at: https://docs.trossenrobotics.com/unitree_go1_docs/getting_started/legged_sdk.html
- *Give your software the power to see objects in images and video* (no date) *Roboflow*. Available at: https://roboflow.com/
- *IP Webcam - Apps on Google Play Google*. Available at: https://play.google.com/store/apps/details?id=com.pas.webcam&hl=en&gl=US