Datasets:

- Pothole-600 - Limited sample size. Already has segmentation masks which are helpful. Photos are taken from top down with no indication of a consistent frame of reference
- Cracks-and-Potholes - Large sample size (>2000) Has segmentation masks for the road, potholes, and cracks. Photos are taken in a consistent way which streamlines pre-processing. Road also has its own mask which means more accurate estimates can be made as to pothole dimensions. This dataset looks the best currently for models.
- RDD2022 - Very large sample size from multiple countries. No segmentation masks, only YOLO style boxes around potholes. If I need more data samples or want to improve accuracy, I can look into generating masks for this set and merging them with Cracks-and-Potholes. Photos are also taken in a consistent manner (smartphone mounted to car).

Goals:

Develop a model that can be applied to cameras in vehicles which can detect a pothole and flag potholes that have a high hazard risk if driven over. Ideally this data would be crowdsourced in the cloud such that other cars on the road would be alerted of a dangerous pothole at a specific GPS location.

Approaches:

Several ways of detecting potholes via image segmentation:

- YOLO algorithm (Faster than RCNN but outputs bounding boxes vs. segmentation masks. Can be combined with FCN to output seg masks)
- RCNN (Slower but directly outputs seg masks and can be combined with GrabCut for increased accuracy)
- Depth analysis
    - Convert potholes to top down view
- Pothole positioning
    -
- Otsu thresholding
    - May be able to generate image segmentation masks on RDD2022 using this algorithm

Plan:

- Train dataset to detect pothole + boundaries
    - Looking at using area/depth estimation method detailed here to obtain dimensions of pothole
- Model is fed pictures that may/may not have pothole
- Model outputs image mask of pothole
- Take output mask and get the percentage of the photo the pothole occupies

- Generate statistics on training data set to create different classification groups. Ex: Medium size group would be median percentage ± 1 std deviation, etc.
    - Size would have small, medium, large groups
    - Depth would have small, medium, and high risk group as depth correlates to more danger for the vehicle and its passengers

References:

- https://www.researchgate.net/publication/354248434_Potholes_Detection_Using_Deep_Learning_and_Area_Estimation_Using_Image_Processing
- https://pyimagesearch.com/2020/09/28/image-segmentation-with-mask-r-cnn-grabcut-and-opencv/
- https://www.diva-portal.org/smash/get/diva2:1421305/FULLTEXT01.pdf
- https://blog.roboflow.com/guide-to-yolo-models/
- https://www.researchgate.net/publication/363668453_RDD2022_A_multi-national_image_dataset_for_automatic_Road_Damage_Detection
- https://biankatpas.github.io/Cracks-and-Potholes-in-Road-Images-Dataset/
- https://sites.google.com/view/pothole-600/dataset
- https://academic.oup.com/tse/article/4/4/tdac026/6835624#382221514
- https://file.techscience.com/ueditor/files/cmc/TSP_CMC-73-2/TSP_CMC_27840/TSP_CMC_27840.pdf
- https://towardsdatascience.com/inverse-projection-transformation-c866ccedef1c
- https://pyimagesearch.com/2020/07/27/opencv-grabcut-foreground-segmentation-and-extraction/
- https://www.researchgate.net/publication/228529426_A_novel_approach_to_the_calculation_of_pothole-induced_contact_forces_in_MDOF_vehicle_models
- https://www.section.io/engineering-education/introduction-to-yolo-algorithm-for-object-detection/#:~:text=YOLO%20is%20an%20algorithm%20that,%2C%20parking%20meters%2C%20and%20animals.
- https://www.irjet.net/archives/V9/i4/IRJET-V9I4338.pdf
- https://www.mdpi.com/2079-9292/11/12/1882
- https://learnopencv.com/otsu-thresholding-with-opencv/

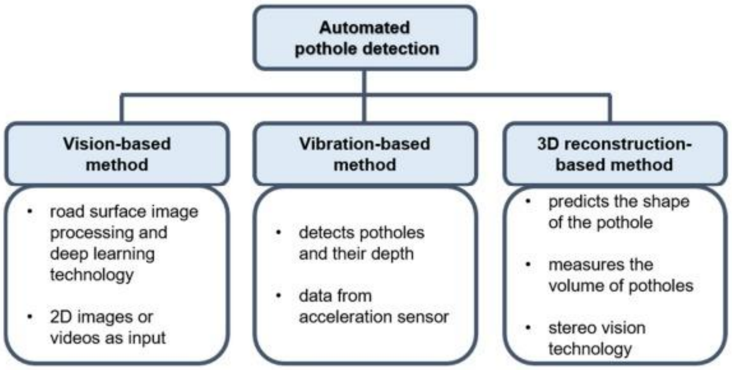

Automated pothole detection
Vision-based method
Vibration-based method
3D reconstruction-based method
road surface image processing and deep learning technology
2D images or videos as input
detects potholes and their depth
data from acceleration sensor
predicts the shape of the pothole
measures the volume of potholes
stereo vision technology

Figure 2. The characteristics of automated pothole-detection methods.

Table 1. The strengths and weaknesses of automated pothole-detection methods.

Methods	Strengths	Weaknesses
Vision-based method	• It is more cost-effective than the 3D reconstruction-based method • It is suitable for determining the number and approximate shape of potholes	• It has limitations in measuring information such as volume and depth of potholes • It is affected by lighting and shadow condition
Vibration-based method	• It is the most cost-effective among the three methods • It requires small storage • Real-time data processing can be applied	• It has limitations in providing the exact shape of potholes • It is affected by the sensor and vehicle applied in the data-acquisition process
3D reconstruction-based method	• It measures the shape of potholes most accurately among the three methods	• It is the most expensive among the three methods

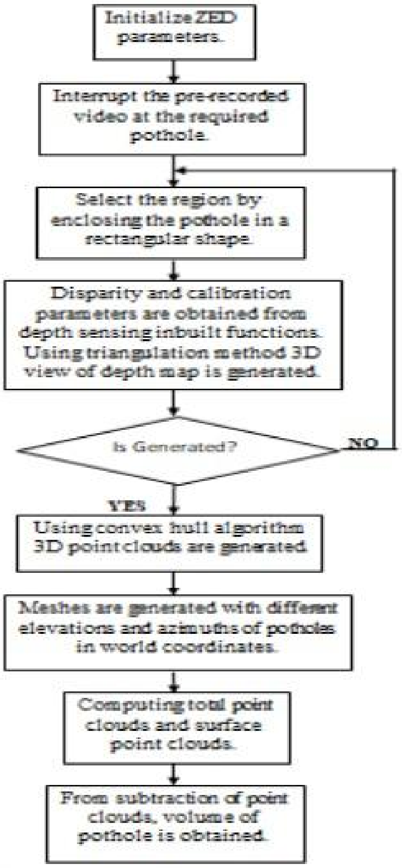
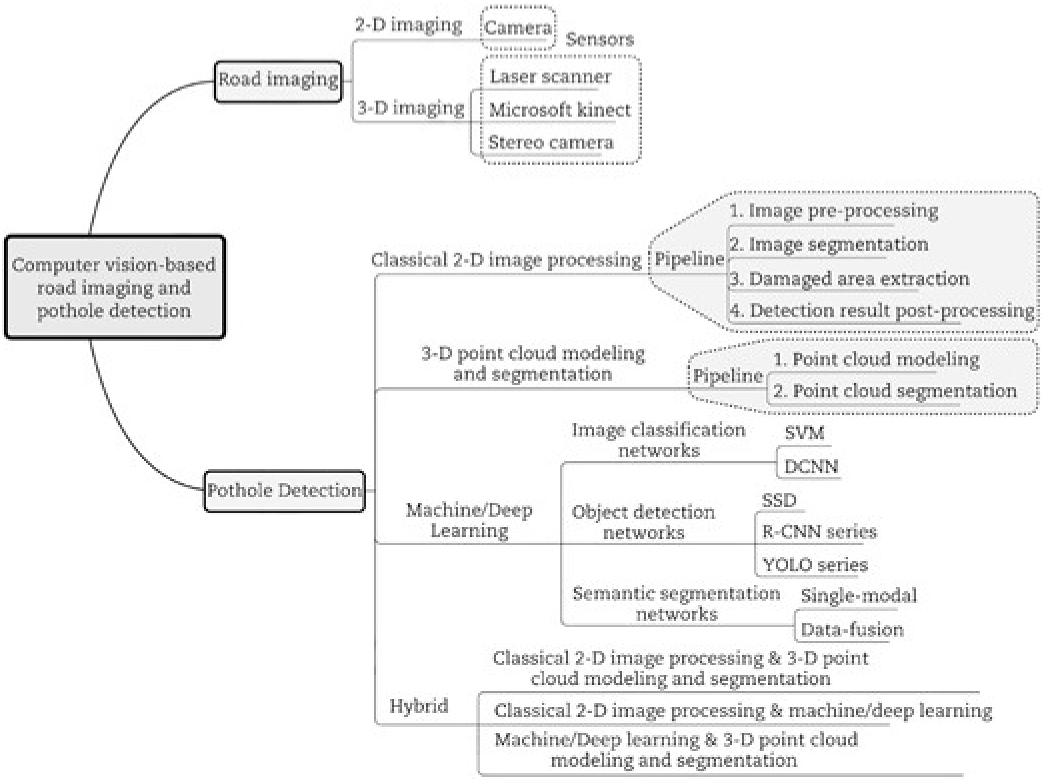

Initialize ZED parameters.
Interrupt the pre-recorded video at the required pothole.
Select the region by enclosing the pothole in a rectangular shape.
Disparity and calibration parameters are obtained from depth sensing inbuilt functions. Using triangulation method 3D view of depth map is generated.
Is Generated?
NO
YES
Using convex hull algorithm 3D point clouds are generated.
Meshes are generated with different elevations and azimuths of potholes in world coordinates.
Computing total point clouds and surface point clouds.
From subtraction of point clouds, volume of pothole is obtained.

Fig. 3: Proposed methodology for reconstruction of a pothole.


Computer vision-based road imaging and pothole detection
Road imaging
2-D imaging
Camera
Sensors
3-D imaging
Laser scanner
Microsoft kinect
Stereo camera
Pothole Detection
Classical 2-D image processing
Pipeline
1. Image pre-processing
2. Image segmentation
3. Damaged area extraction
4. Detection result post-processing
3-D point cloud modeling and segmentation
Pipeline
1. Point cloud modeling
2. Point cloud segmentation
Machine/Deep Learning
Image classification networks
SVM
DCNN
Object detection networks
SSD
R-CNN series
YOLO series
Semantic segmentation networks
Single-modal
Data-fusion
Hybrid
Classical 2-D image processing & 3-D point cloud modeling and segmentation
Classical 2-D image processing & machine/deep learning
Machine/Deep learning & 3-D point cloud modeling and segmentation

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- https://arxiv.org/pdf/2012.10802.pdf
-

Json Label Format:
{"file_name":741369,"dataset":"Cracks-and-Potholes","pothole":1,"size":0,"depth":1,"pos-left":0,
"pos-cleft":0,"pos-mid":0,"pos-cright":0,"pos-right":0,}

File name: first 6 digits of file name
Dataset: name of dataset the image is from
Pothole: Whether there's a pothole or not (1=pothole, 0 = no pothole)
Size: Size of pothole (0=Small, 1=Medium, 2=Large)
Depth: Depth of pothole (0=Small, 1=Medium, 2=Large)
Pos-left: pothole in left (0= not there, 1 = present)
Pos-cleft: pothole in cleft (0= not there, 1 = present)
Pos-middle:pothole in middle (0= not there, 1 = present)
Pos-cright:pothole in cright (0= not there, 1 = present)
pos-right:pothole in right (0= not there, 1 = present)

If not sure leave entry as "null"

Convert Image masks to polygon for use in coco json format
https://github.com/cocodataset/cocoapi/issues/131