Unveiling Insights: A Journey into Pothole Detection

Exploring Machine Learning for Safer Roads

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U.S. | NEW YORK

New York To Spend $100 Million To Fix Potholes

Gov. Andrew Cuomo announced that the state would add to funds already allocated to repair roads across New York

By Paul Berger

April 30, 2018 7:39 pm ET

Potholes Impact Road Safety

-The uneven road surfaces created by potholes can lead to vehicle damage and accidents, causing financial burdens.

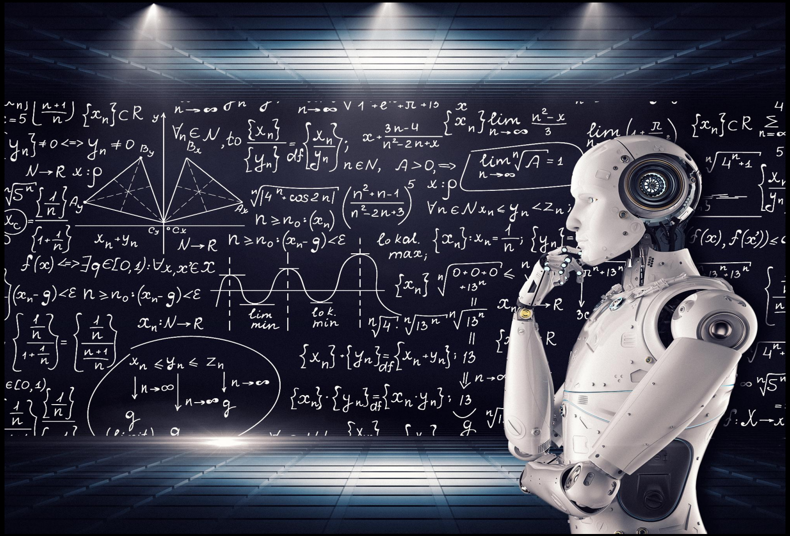
- Pedestrians face tripping hazards, particularly in poorly lit areas or adverse weather conditions.

Potholes Impact Finances

- Fixing roads is being heavily funded by the government and creates a great opportunity for business.

Why machine learning?

By using machine learning, we can automatically find and fix potholes faster, helping to keep roads safe and reduce risks.



OUR DATA

Found at https://www.kaggle.com/datasets/srajanchourasia/pothole-dataset

- Data Characteristics:
    - The dataset comprises a total of 30,000 images,.
    - The "Number of Potholes" column indicates the count of potholes in each image.

- Types of Roads Covered:
    - The images represent diverse road types, including urban streets, highways, and suburban roads.

Balancing our dataset
Using Image Data Generator

Due to imbalances in our dataset, specifically in the ‘Number of Potholes’ category, it was necessary to oversample some photos using the following metrics

```
rotation_range=30,
width_shift_range=0.2,
height_shift_range=0.2,
shear_range=0.2,
zoom_range=0.2,
horizontal_flip=True,
fill_mode='nearest'
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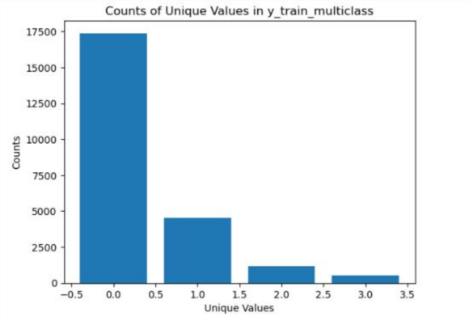
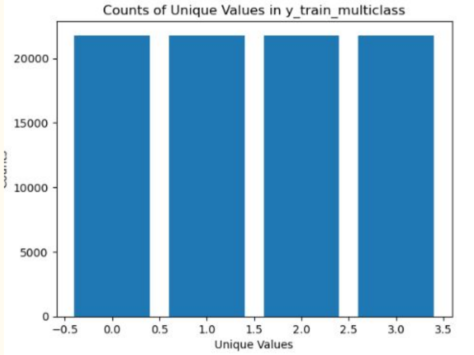




Goals

-We aimed to first work based on presence of potholes. A binary classification problem

-We then moved to the next step of classifying number of potholes

Our chosen Model

Convolutional Neural Network

CNN models are ideal for image classification tasks like this

```
----------------------------------------------------------------
Layer (type)            Output Shape          Param #
================================================================
rescaling_9 (Rescaling)    (None, 32, 32, 3)      0

conv2d_27 (Conv2D)        (None, 32, 32, 128)    3584

batch_normalization_9 (Bat  (None, 32, 32, 128)     512
chNormalization)

activation_9 (Activation)  (None, 32, 32, 128)     0

max_pooling2d_27 (MaxPooli  (None, 16, 16, 128)     0
ng2D)

conv2d_28 (Conv2D)        (None, 14, 14, 256)    295168

max_pooling2d_28 (MaxPooli  (None, 7, 7, 256)      0
ng2D)

conv2d_29 (Conv2D)        (None, 5, 5, 512)      1180160

max_pooling2d_29 (MaxPooli  (None, 2, 2, 512)      0
ng2D)

flatten_9 (Flatten)       (None, 2048)          0

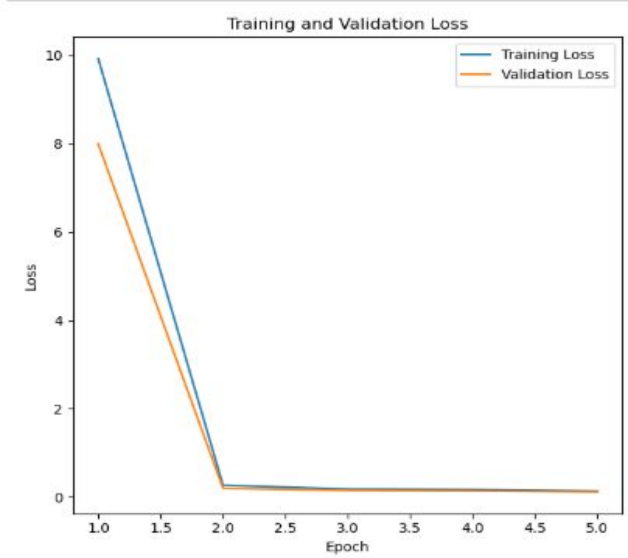
dense_18 (Dense)          (None, 512)           1049088

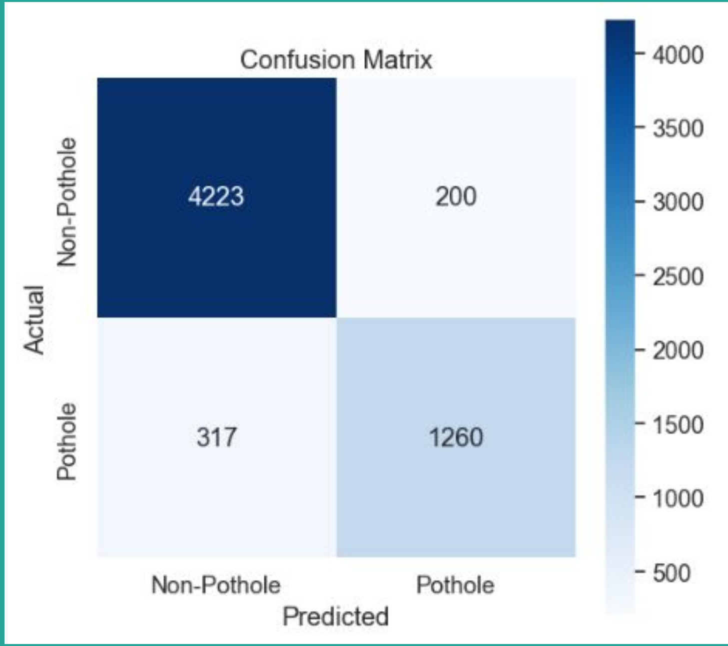
dropout_9 (Dropout)       (None, 512)           0

dense_19 (Dense)          (None, 4)             2052

================================================================
Total params: 2530564 (9.65 MB)
Trainable params: 2530308 (9.65 MB)
Non-trainable params: 256 (1.00 KB)
----------------------------------------------------------------
```

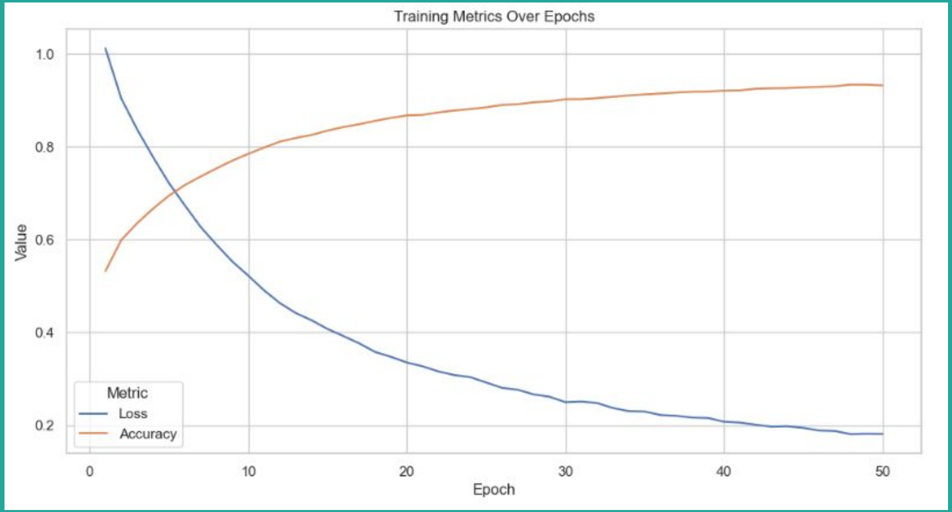
Our binary results:

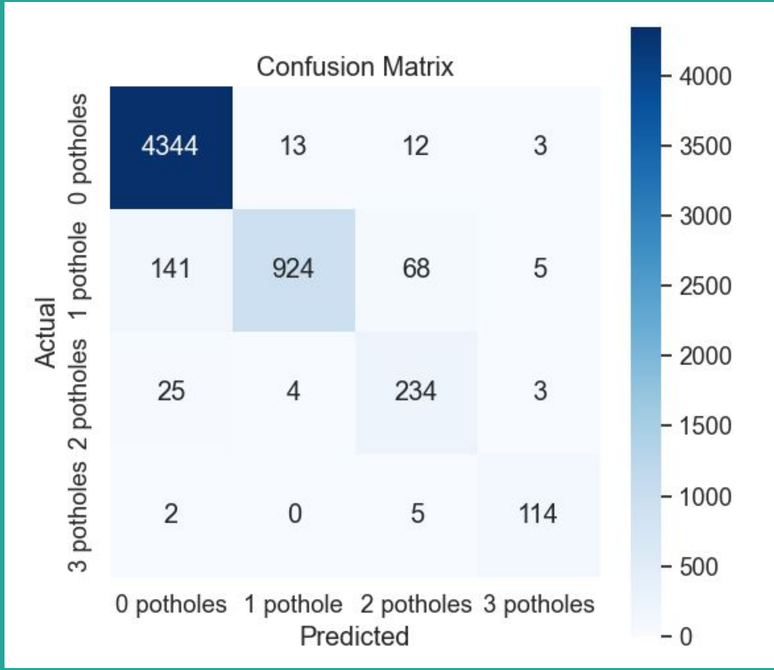




Roc_Auc:92%

Our multiclass results:





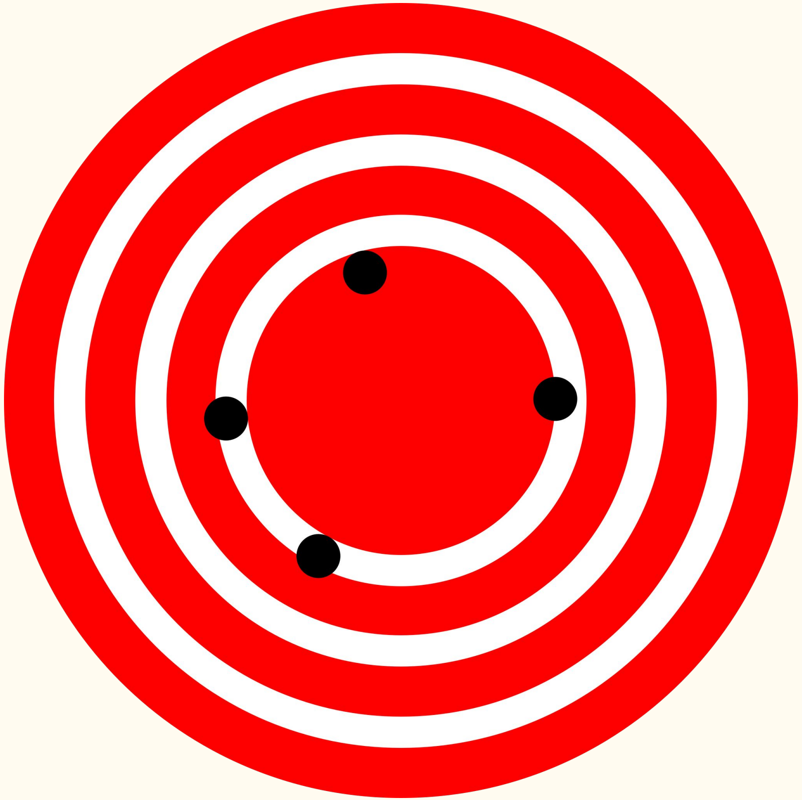
Roc_Auc: 0.9616

Why we chose our metrics

AUC-ROC (Area Under the Curve of the Receiver Operating Characteristic)

- It handles imbalanced classes better.

-AUC-ROC looks at both sensitivity and specificity, giving a better idea of how well our model can tell classes apart.



Conclusion

1. - Successfully developed a deep learning model for pothole detection, achieving a significant roc_auc score of 96% on the test dataset.

2. - Overcame challenges in data preprocessing, class imbalance, and model optimization through collaborative problem-solving.

3. - The model demonstrated robust performance in accurately identifying potholes, with a decreasing loss and increasing accuracy over 50 epochs.

Next Step

4. - Transfer learning models may have even better results due to their diversity in training

5. - Explore opportunities to collaborate with local authorities for real-world implementation of the pothole detection system.

   - Investigate the integration of additional features, such as road quality assessment and anomaly detection.