RowanUniversity

CENTER FOR RESEARCH & EDUCATION IN
ADVANCED TRANSPORTATION ENGINEERING SYSTEMS

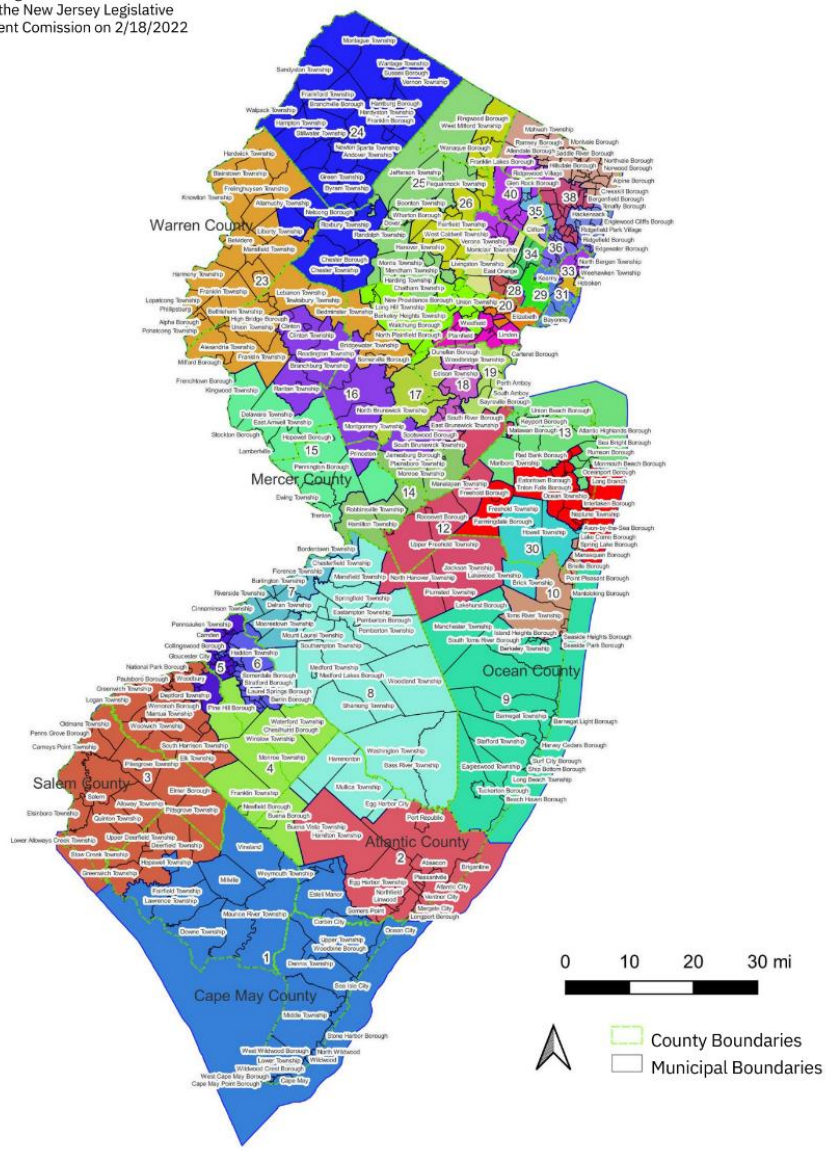
Cost-Effective Pavement Management System for Municipalities in New Jersey

Yusuf A. Mehta, Ph.D., P.E.
Professor, Department of Civil and Environmental Engineering
Director, Center for Research and Education in Advanced Transportation Engineering Systems (CREATES)
mehta@rowan.edu/ 856-256-5327

Dr. Surya Teja Swarna
Research Scientist, CREATES
Rowan University
swarna@rowan.edu / 551-332-8935

RowanUniversity
CENTER FOR RESEARCH & EDUCATION IN
ADVANCED TRANSPORTATION ENGINEERING SYSTEMS

New Jersey Legislative Districts 2022-2030
Adopted by the New Jersey Legislative
Apportionment Comission on 2/18/2022



New Jersey

564 Municipalities – 21 Counties

Road network

Out of 39,000 miles, about 26,000 miles of roadway is managed by municipalities

Each municipality and/or County competes for

- $140 million Municipal Aid or $160 million County Aid

Award criteria

Scoring system based on existing road conditions, traffic volume, proposed safety improvements, project service to the public, and special designation.

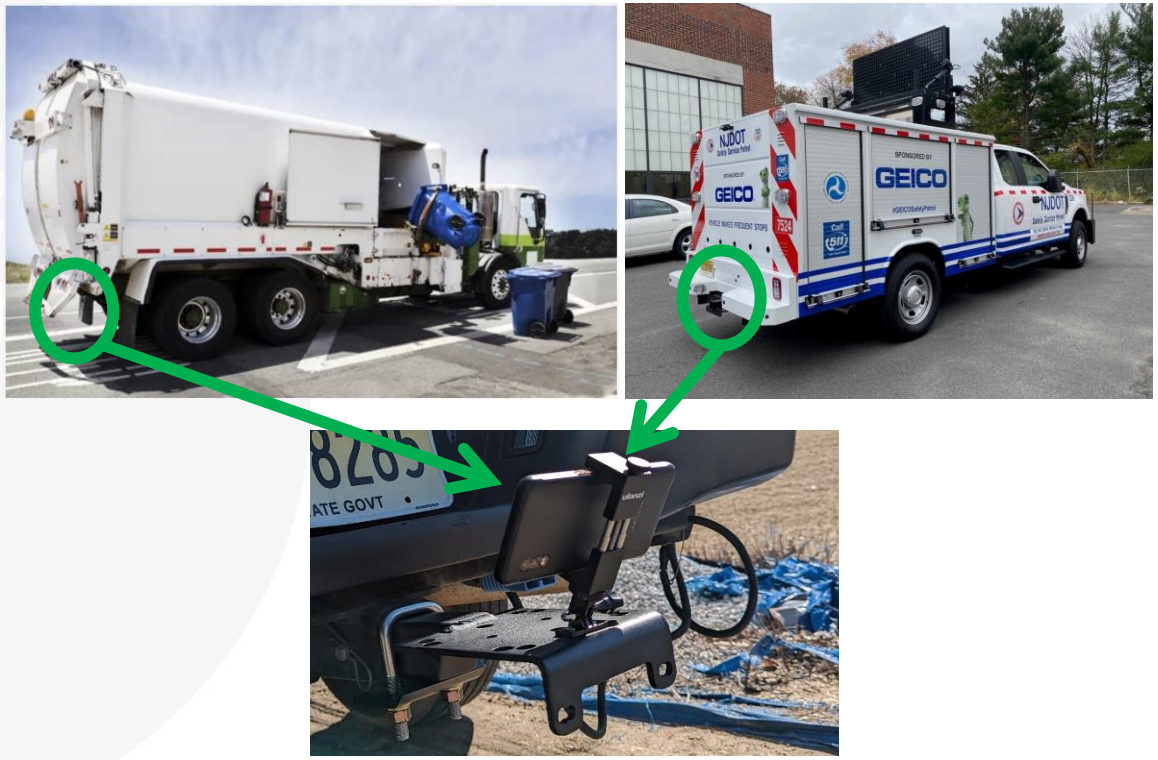
Each applicant (municipality or county) may need to invest significant portion of their budget for pavement distress data collection to *apply for municipal aid or county aid.*

Current Data Collection Method

- Data collection: $150-$400 per centerline mile
- Data collection + Analysis + Maintenance recommendation: $350-$800 per centerline mile.
- Several cases there is manual data analysis.
- Several times no map visualization is provided.

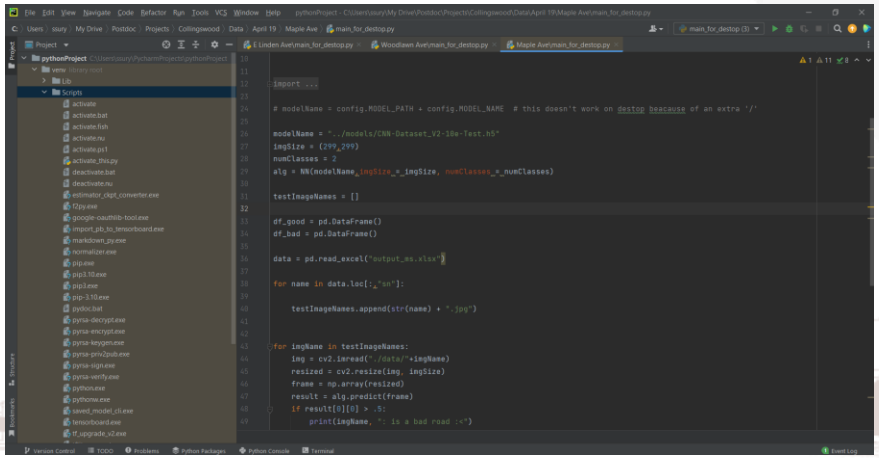
An intelligent, affordable, scalable pavement distress detection system

- No need for dedicated vehicles to collect data.
  - Use existing utility vehicles with swappable sensors.
- No need for manually locating potholes.
- User-friendly front-end to visualize roadway condition.
- Automated AI–based data analysis.
  - Feedback system to integrate expert opinion (if needed).



The goal is to significantly reduce the cost of data collection

System Overview



Pictures of distress

Only Potholes

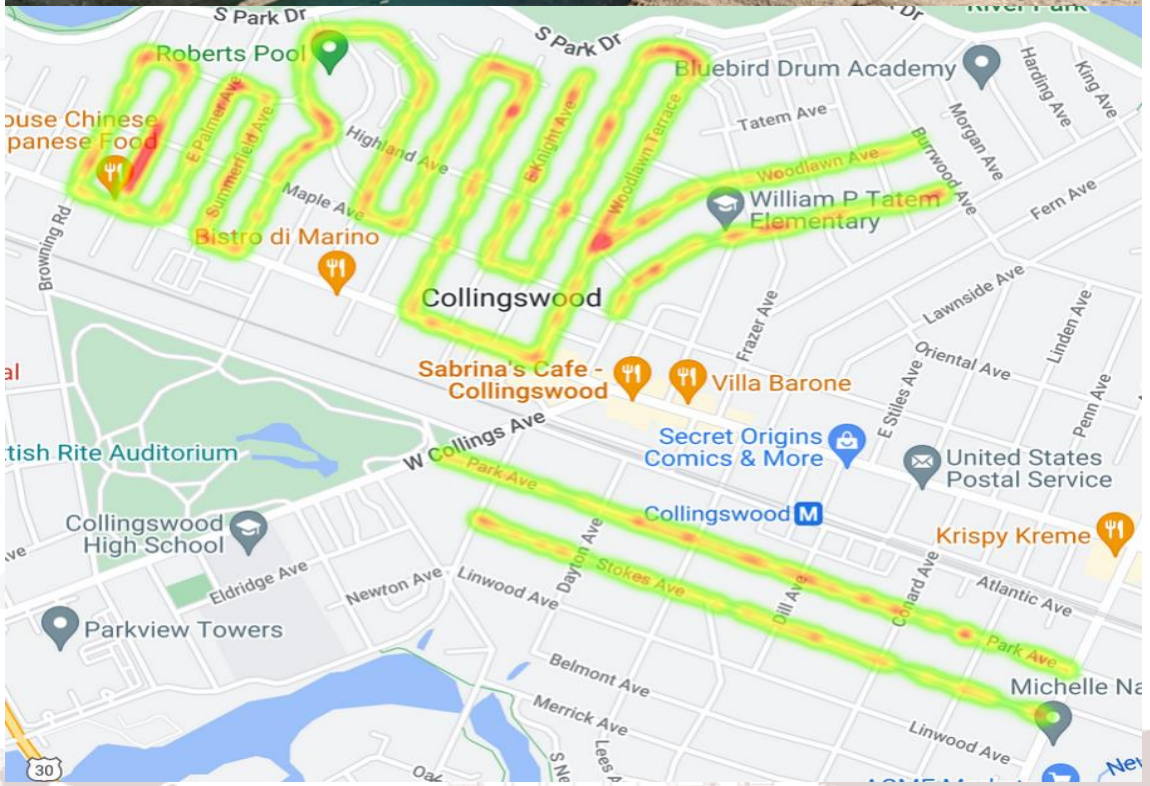
Only Cracks

Both Potholes and Cracks

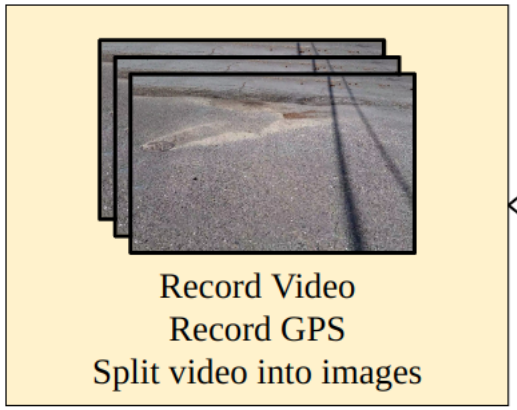
System Overview

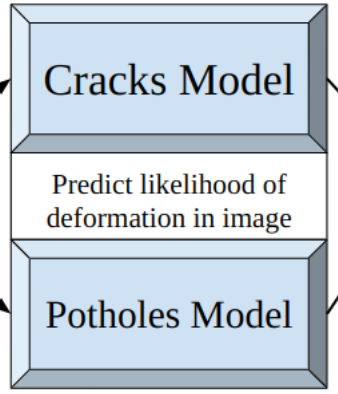
Ability to collect data multiple times in a year

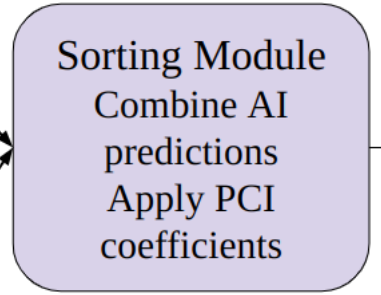
Visualization

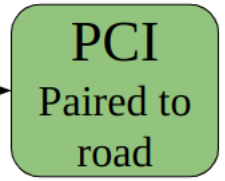


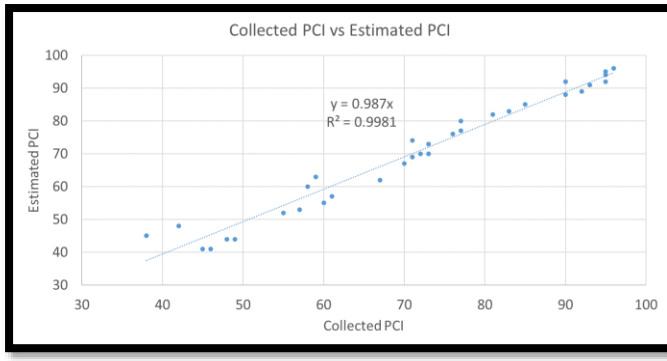
Approach









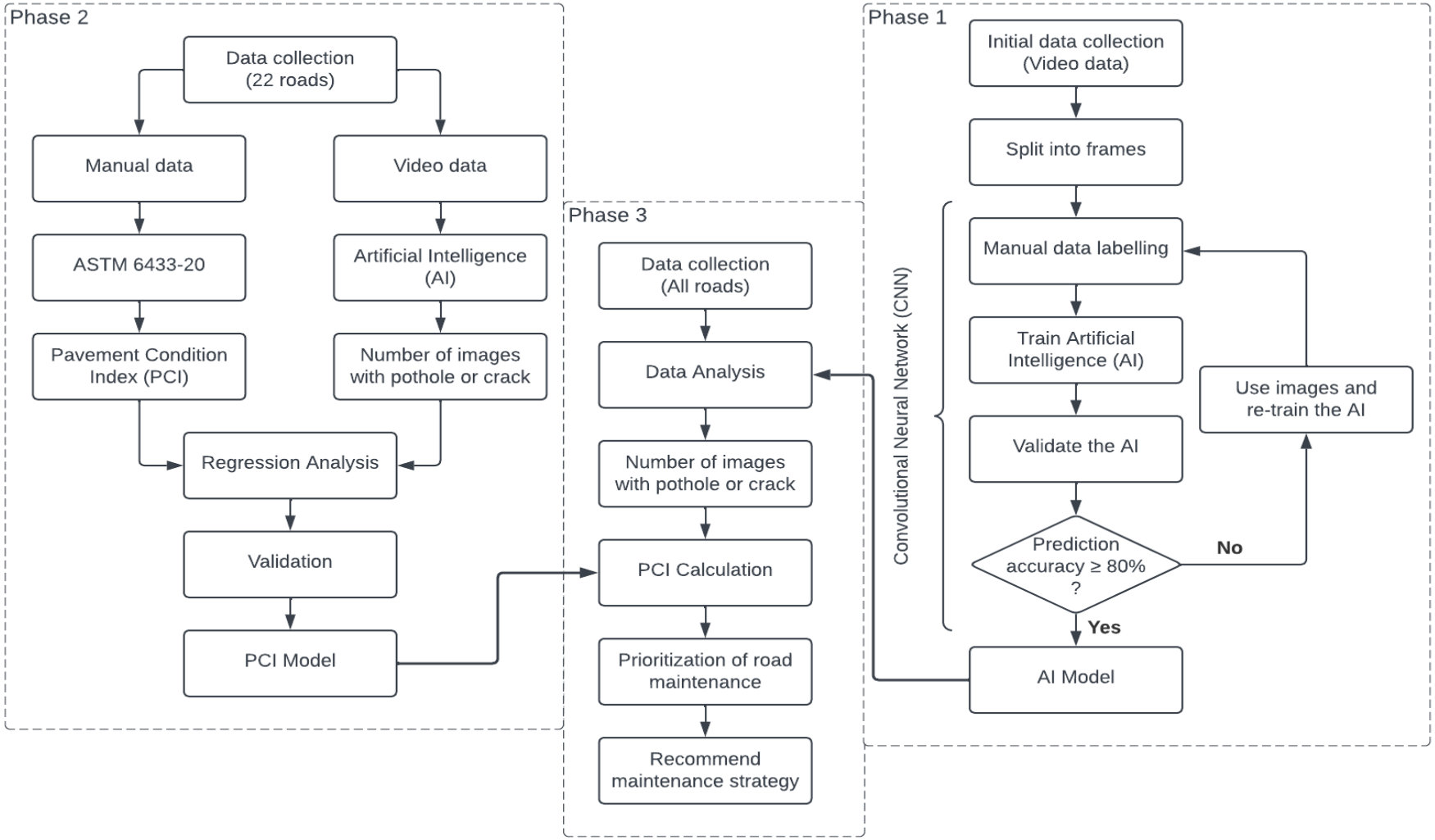


Develop the AI model;

Develop a PCI tailored to AI

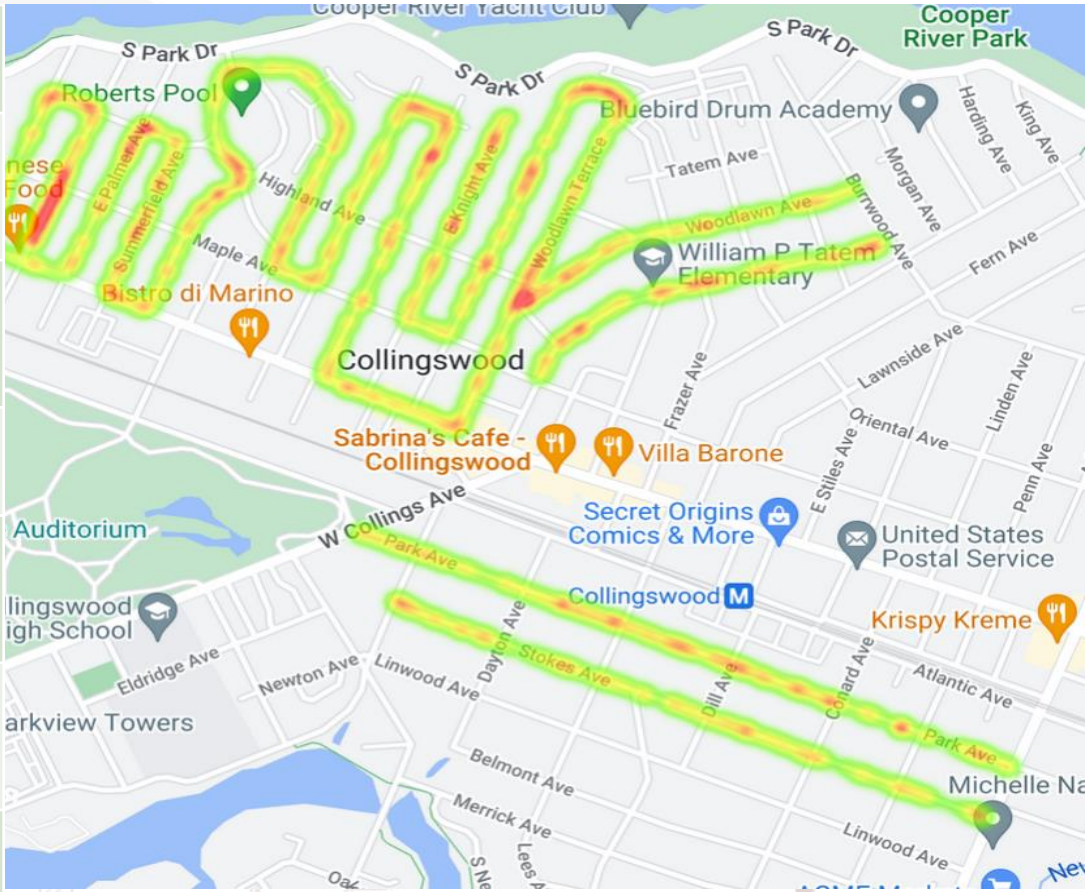
Validate with ASTM standards

Outline


Phase 2
Data collection (22 roads)
Manual data
Video data
ASTM 6433-20
Artificial Intelligence (AI)
Pavement Condition Index (PCI)
Number of images with pothole or crack
Regression Analysis
Validation
PCI Model
Phase 3
Data collection (All roads)
Data Analysis
Number of images with pothole or crack
PCI Calculation
Prioritization of road maintenance
Recommend maintenance strategy
Phase 1
Initial data collection (Video data)
Split into frames
Manual data labelling
Train Artificial Intelligence (AI)
Validate the AI
Prediction accuracy ≥ 80% ?
No
Yes
Use images and re-train the AI
AI Model
Convolutional Neural Network (CNN)

Data Collection

Total number of images	54,035
Images taken specifically of roadway deformations	17,568
Images collected from municipalities in New Jersey	36,467
Phone camera resolution	1920x1080
Frame rate	60 frames per second
Video taken via hitch mount was taken at	60-degree angle
GPS coordinates	every 200 milliseconds



Roadway Classification Models

Rank	Architecture	Model Type	Sample Size	Classes	AUC	F1	Pothole MCC	Avg MCC	Avg Accuracy
1	GoogleNet	Classifier	400	8	0.928	0.809	0.696	0.594	0.8
2	Densenet201					.776	0.548	0.546	0.764
3	Xception						0.321	0.437	0.755
4	Resnet50						0.492	0.47	0.691
5	Squeezenet					71	0.717	0.502	0.655
6	Alexnet					0.626	0.390	0.487	0.636
8	NasnetLarge	Classifier	400	8	0.816	0.418	0.429	0.312	0.418

Identify the best AI model for pavement distress detection

Alex Apeagyei, Toyosi Elijah Ademolake & Mark Adom-Asamoah (2023) Evaluation of deep learning models for classification of asphalt pavement distresses, International Journal of Pavement Engineering, 24:1, DOI: 10.1080/10298436.2023.2180641

PCI Model Development

Collect Ground Truth Data

Collected **manual distress data** for 32 Roads in Collingswood to determine the coefficients for PCI Equation

Distresses Collected:

- Transverse Cracking
- Longitudinal Cracking
- Alligator Cracking
- Potholes

PCI Model Development

Determine PCI using **ASTM D6433 – 11**

1. Alligator Cracking	6. Depression	11. Patching & Util Cut Patching	16. Shoving
2. Bleeding	7. Edge Cracking	12. Polished Aggregate	17. Slippage Cracking
3. Block Cracking	8. Jt. Reflection Cracking	13. Potholes	18. Swell
4. Bumps and Sags	9. Lane/Shoulder Drop Off	14. Railroad Crossing	19. Weathering/Raveling
5. Corrugation	10. Long & Trans Cracking	15. Rutting	

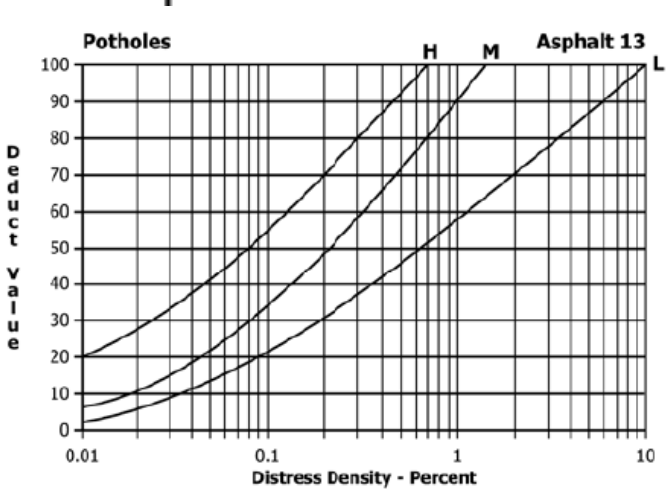


FIG. X3.18 Potholes

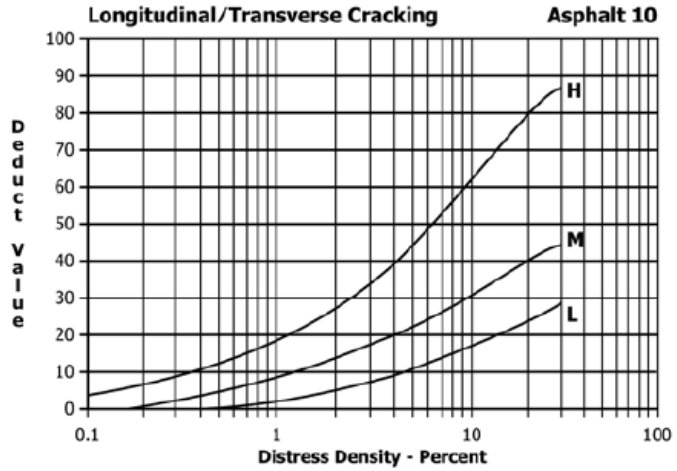


FIG. X3.14 Longitudinal/Transverse Cracking

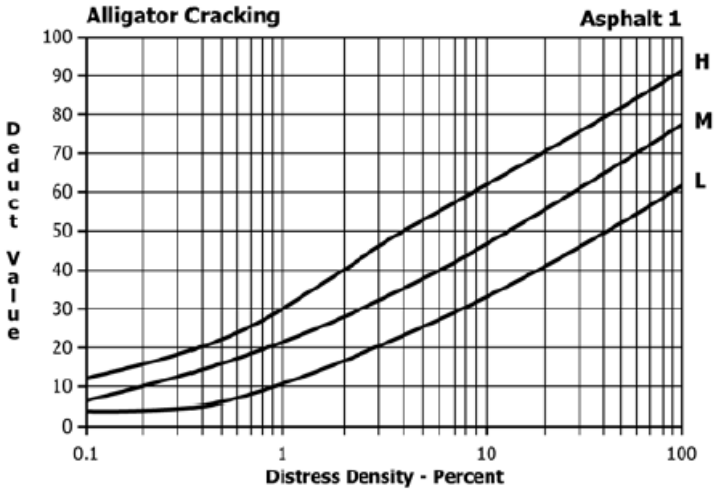
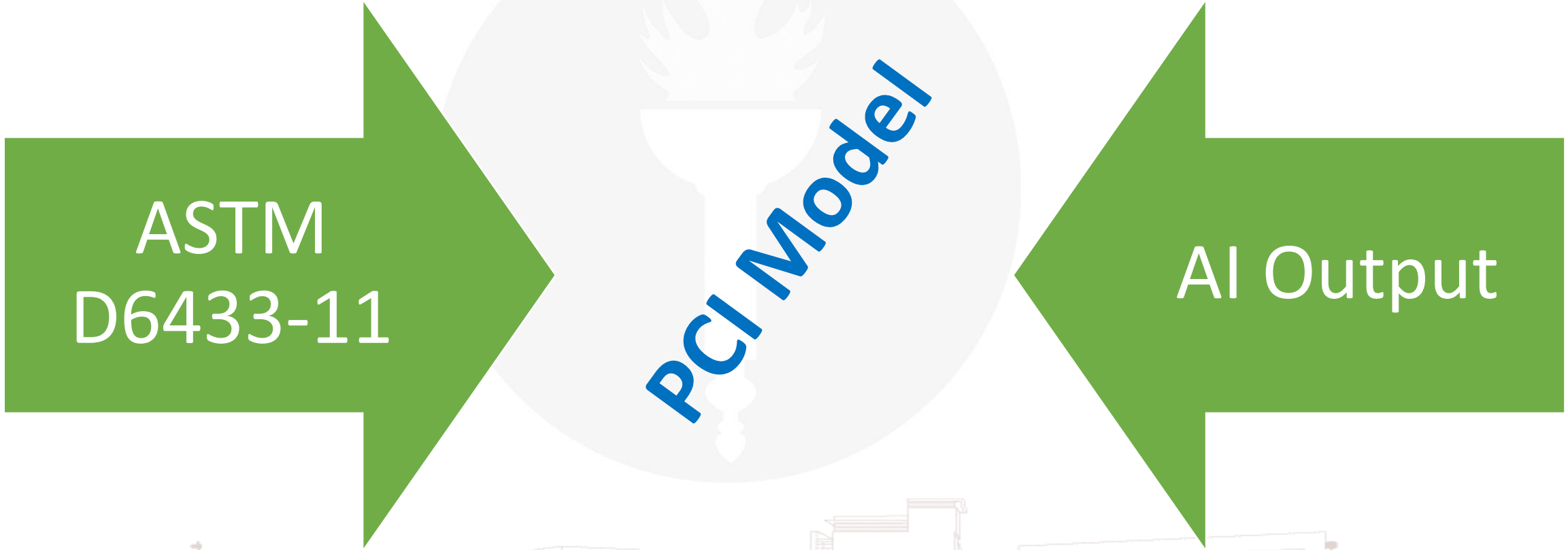


FIG. X3.1 Alligator Cracking

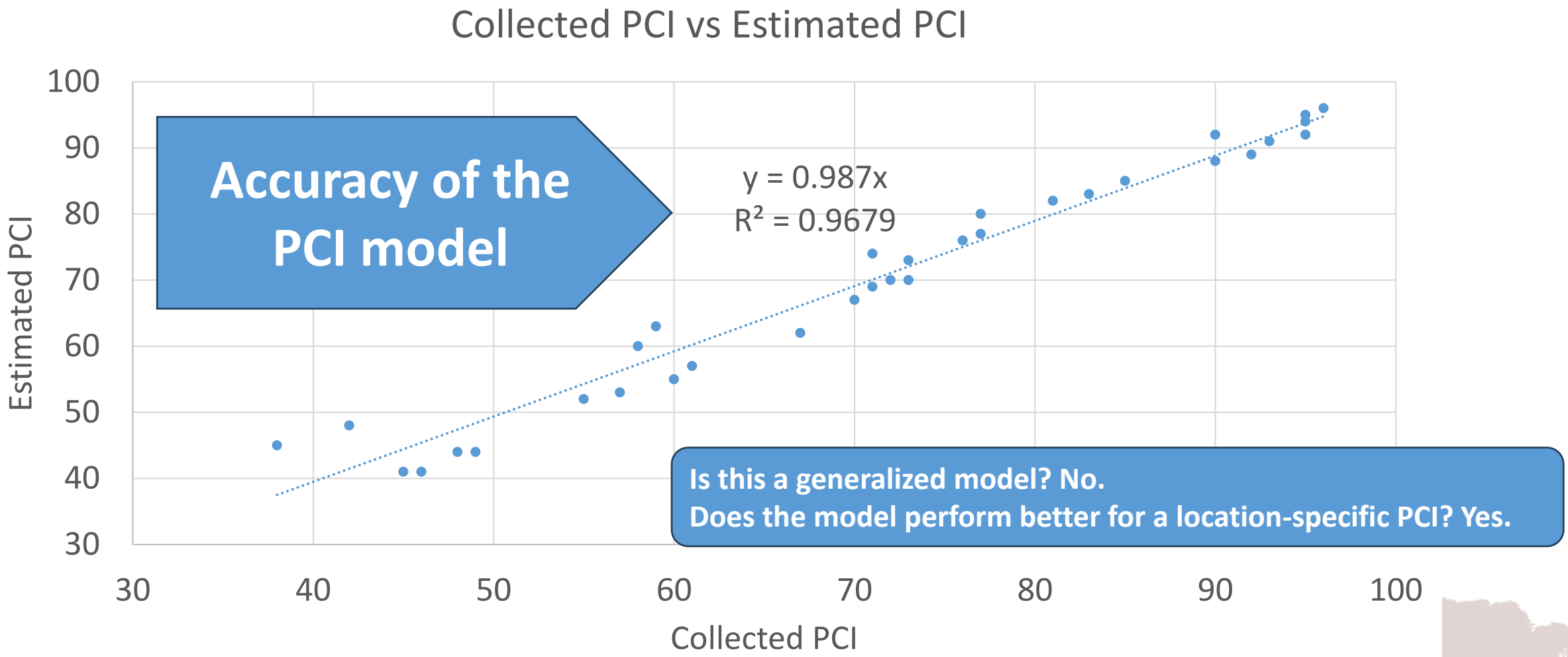
PCI Model Development



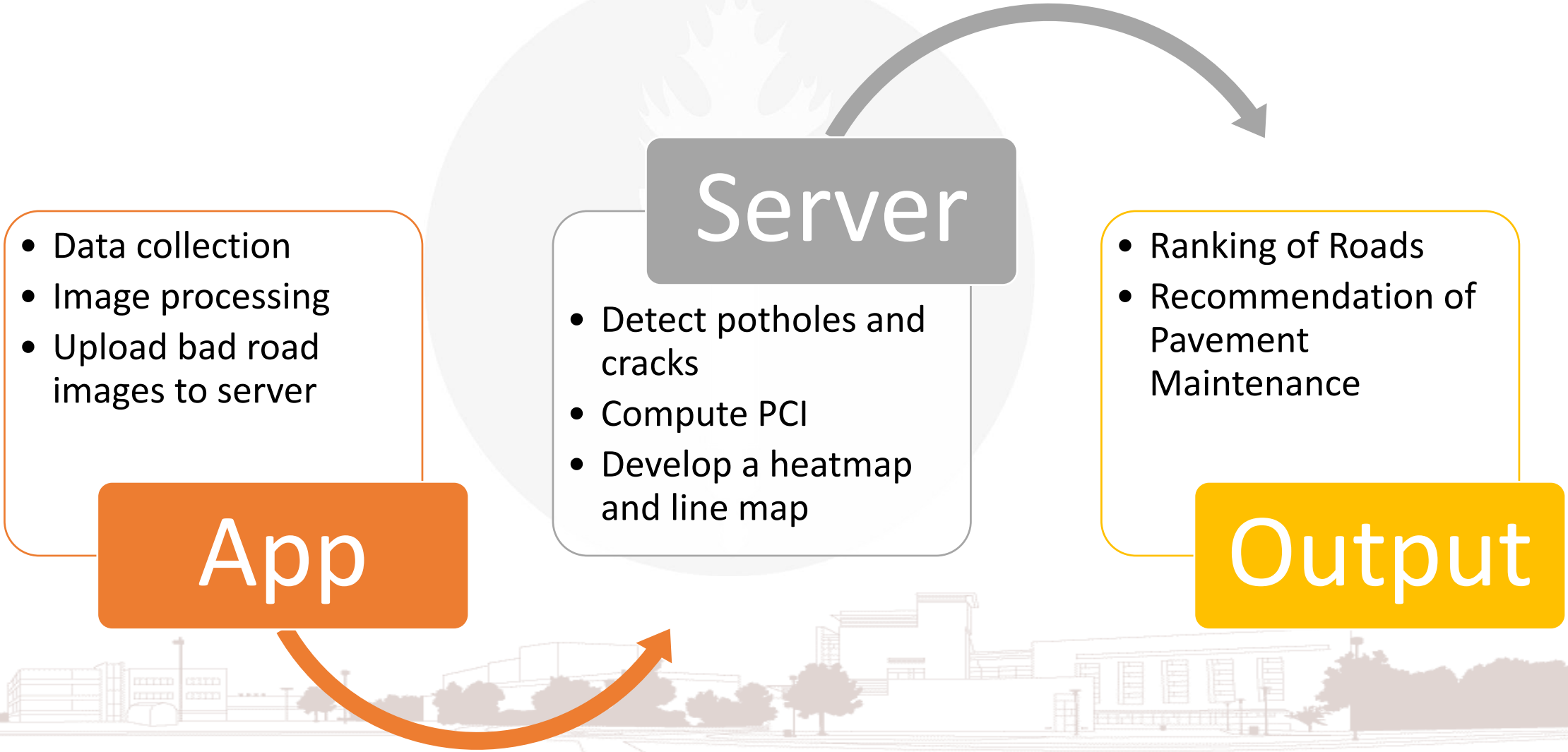
PCI Model for AI output

$$PCI = 100 - \left[35.147\left(\frac{Number\ of\ images\ with\ potholes\ only}{Total\ number\ of\ images}\right) + 12.448\left(\frac{Number\ of\ images\ with\ cracks\ only}{Total\ number\ of\ images}\right) + 52.405\left(\frac{Number\ of\ images\ with\ potholes\ and\ cracks}{Total\ number\ of\ images}\right)\right]$$

A comparison of the AI estimated PCI and the manually collected PCI



System Architecture



High Level Components

Recorder

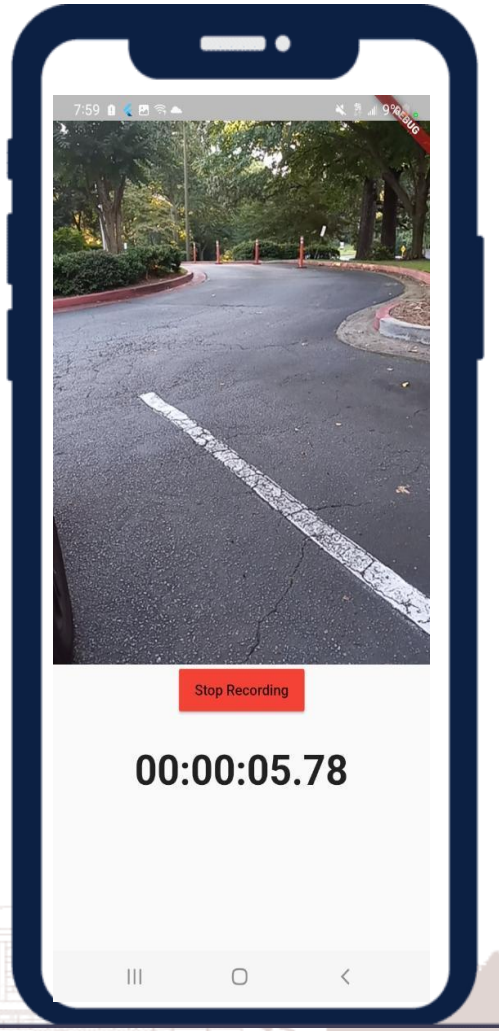
Extraction

Categorization

Components
Continuous Video Recorder, Start and Stop functionality

Components
Extraction of the frames to images

Components
Image Categorization into Bad and Good



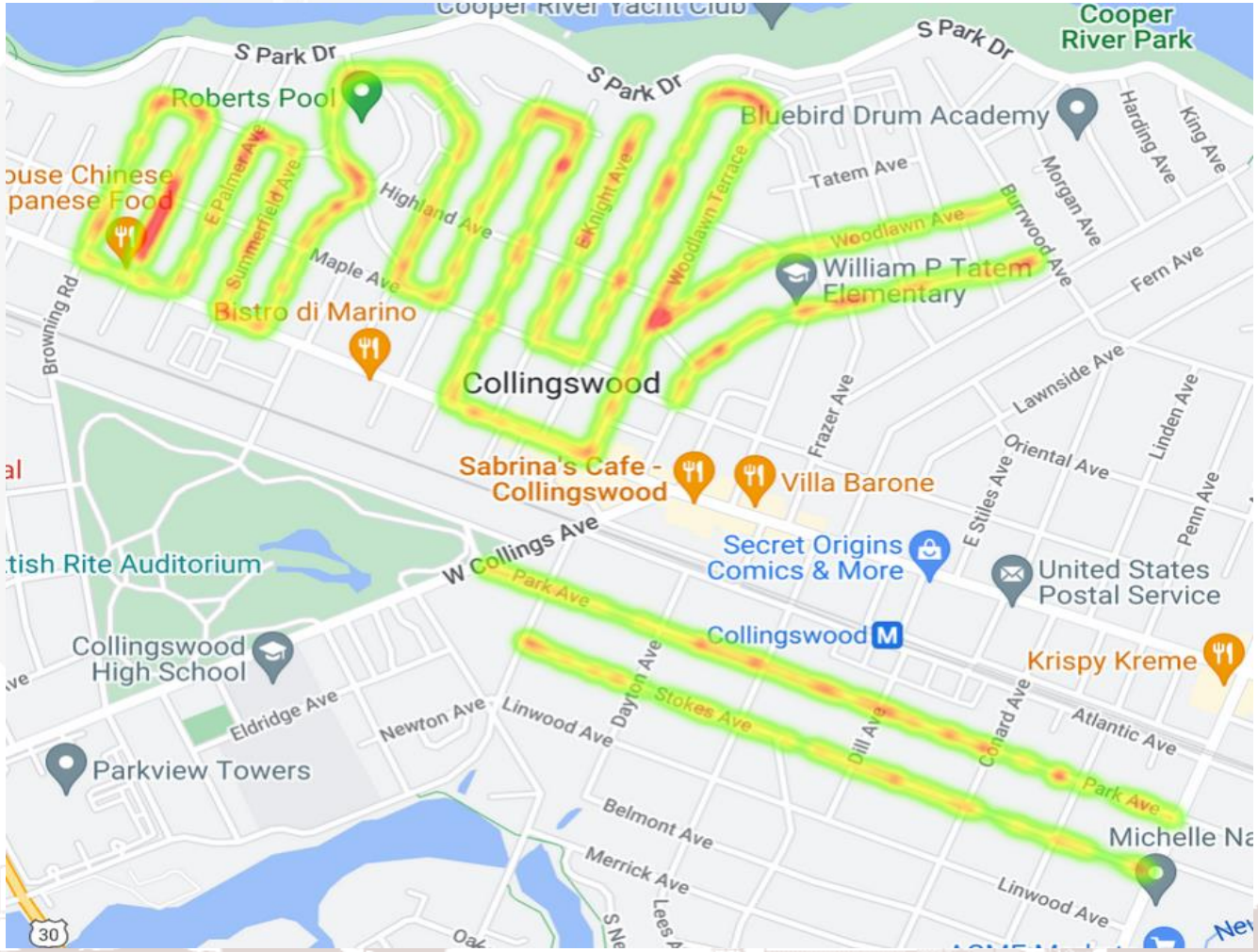
Google Maps Integration

Heatmap

- Shows in more detail where deformations are

Designated Lines

- Color changes with average PCI



Future Work

- Improve and maintain the accuracy of AI algorithms (introduce feedback tool).
- Include more pavement distress types into the system.
- Improve the AI model using You Only Look Once (YOLO) technique to detect the distress and the severity of distress.
- Automate the android application to run by itself.
- Work on different distress indices to make the PMS more accurate.

Acknowledgements

The authors would like to thank Rowan University undergraduate senior and junior clinic students ***Bekir Karbudak, Murteza Hasan, Nasir Brown, Richard Russo, Kinzey Paul, Jason Thomas Grandizio***, and ***Patrick Declan McCool*** for their dedicated efforts.


Dr. Yusuf Mehta (Director, CREATEs)


Dr. Parth Bhavsar (Assistant Professor, CEE, KSU)


Dr. Surya Teja Swarna (Postdoc, CREATEs)


Issouf Kindo (CS, MS)


Christian Hecht (ECE, BS)


Oluwaseyi (CS, MS)


Sai Sreeja Eegalapati (CS, MS)


Proma Dutta (Smart Infrastructure, PhD Student)

Thank you

Dr. Yusuf Mehta
Professor, Department of Civil & Environmental Engineering
Director, Center for Research and Education in Advanced Transportation Engineering Systems (CREATES)
Rowan University, Glassboro, New Jersey, 08028
Email: mehta@rowan.edu

Use this to contact us

Dr. Surya Teja Swarna
Research Scientist, Center for Research and Education in Advanced Transportation Engineering Systems (CREATES)
Rowan University, 201 Mullica Hill Rd, Glassboro, NJ 08028, USA.
Email: swarna@rowan.edu