Automatic detection of sealed cracks using images and 3D data

Pavemetrics

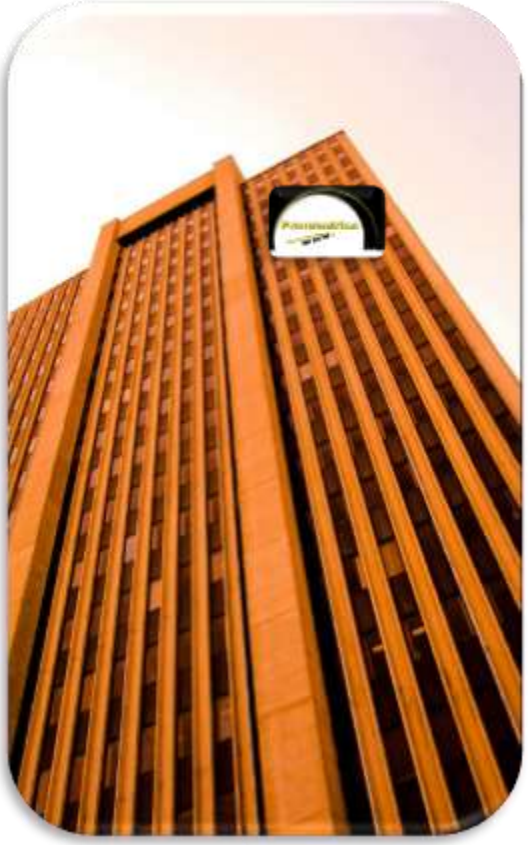
Vision Technology for Inspection of Transportation Infrastructures

PAVEMETRICS Systems Inc.

150 Boulevard René-Lévesque Est, Suite 1820
Québec, Québec, CANADA
G1R 5B1

www.pavemetrics.com

Pavemetrics; Infrastructure Vision Systems Specialists

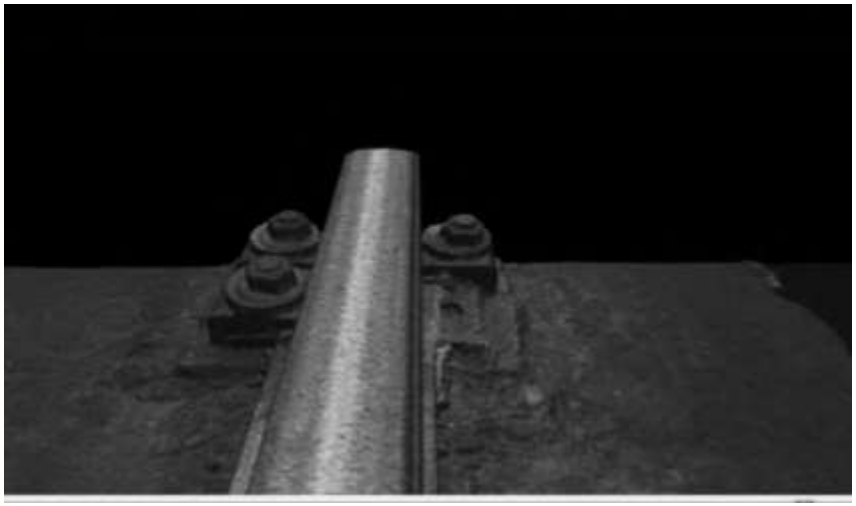


Pavemetrics Headquarters
(Banque Nationale Bldg., QC)

- **Founded 2009; a "Spin-off" of Canada's National Optics Institute (INO)**
- **Develop high-speed, mm-level scanning and pattern analysis systems**
- **20,000,000+ Miles of Data Collected Since 1997**
- **300 Systems in 35+ countries**

Pavemetrics

APPLICATION: Rails

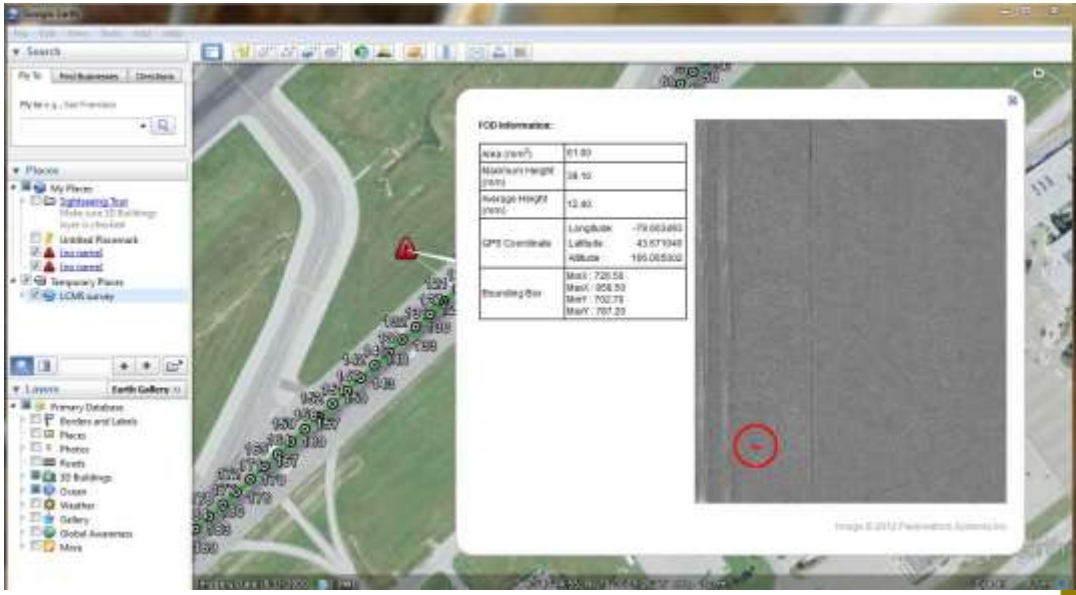


Pavemetrics

APPLICATION: Tunnels

Pavemetrics

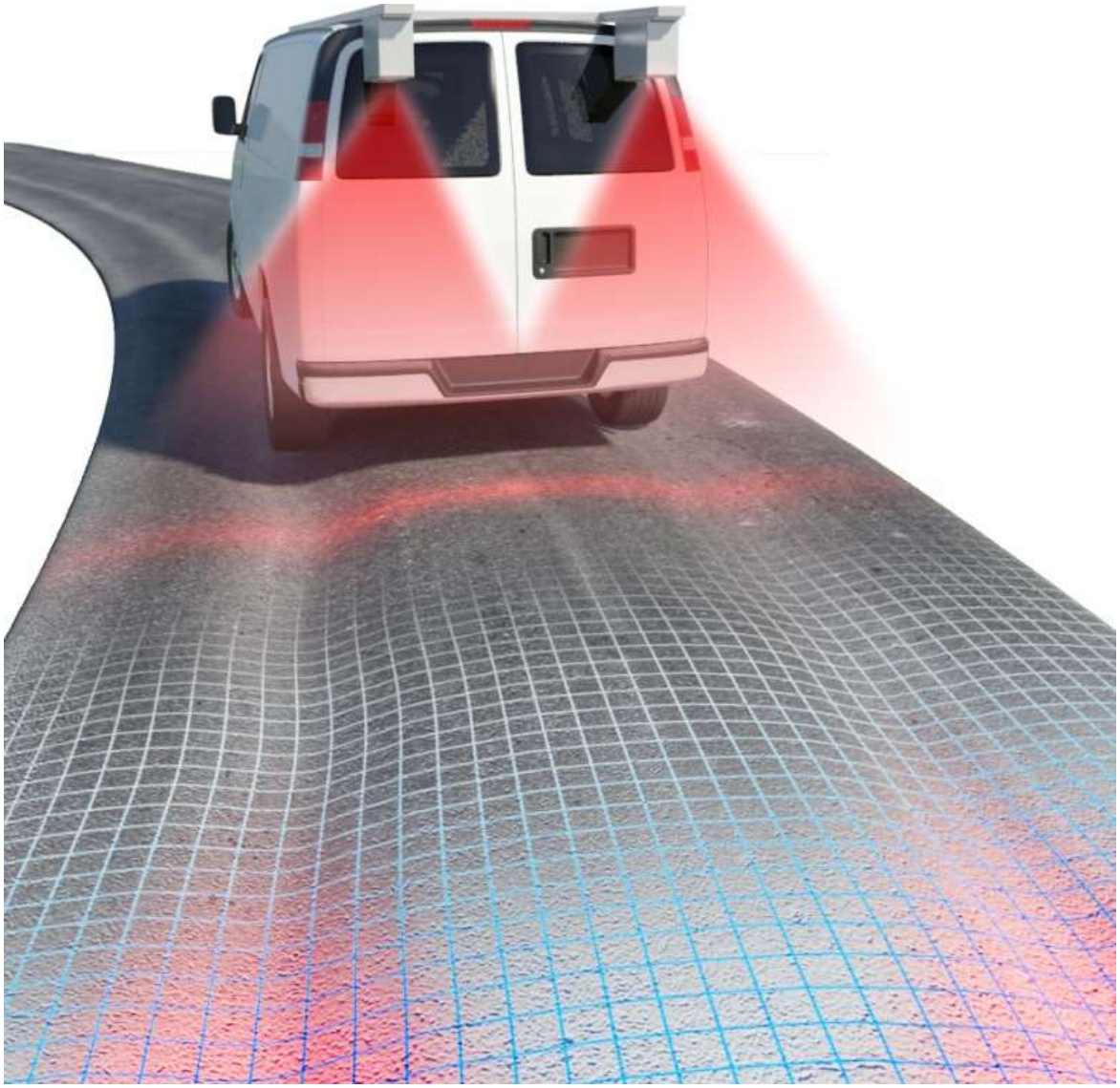
Application: Airports - FOD



Runways currently scanned with Pavemetrics Technology

Pavemetrics

Application: ROADS distress and DTM



Pavemetrics

The Sensor Technology Most Relied-on by DOTs worldwide

Pavemetrics

Collect Your Own, or Contract-out

arrb GROUP

Stantec

FUGRO

RAMBOLL

MANDLI COMMUNICATIONS INC

INTERNATIONAL CYBERNETICS
Where technology meets the road

romdas

VECTRA FRANCE

EUROCONSULT NUEVAS TECNOLOGÍAS

EnterInfo

Dynatest®
Pavement engineering specialists & equipment

LVM

SNC·LAVALIN

Pavemetrics

LCMS – Certified Technology

NOT a prototype

Certified AND proven around the world.

AASHTO THE VOICE OF TRANSPORTATION

ASTM INTERNATIONAL

INTERNATIONAL CERTIFICATIONS ISO 9001

CE

FC

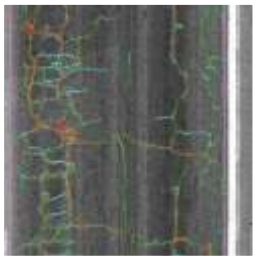
TÜV SÜD ISO 9001

DEPARTMENT OF HEALTH & HUMAN SERVICES • USA FDA

NEMA

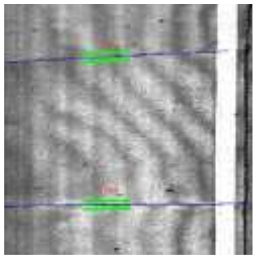
Pavemetrics

Any Paved Surface



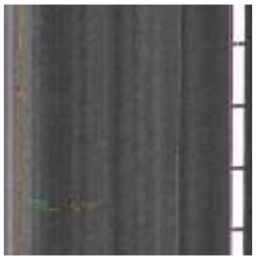
Hotmix

Chipseal

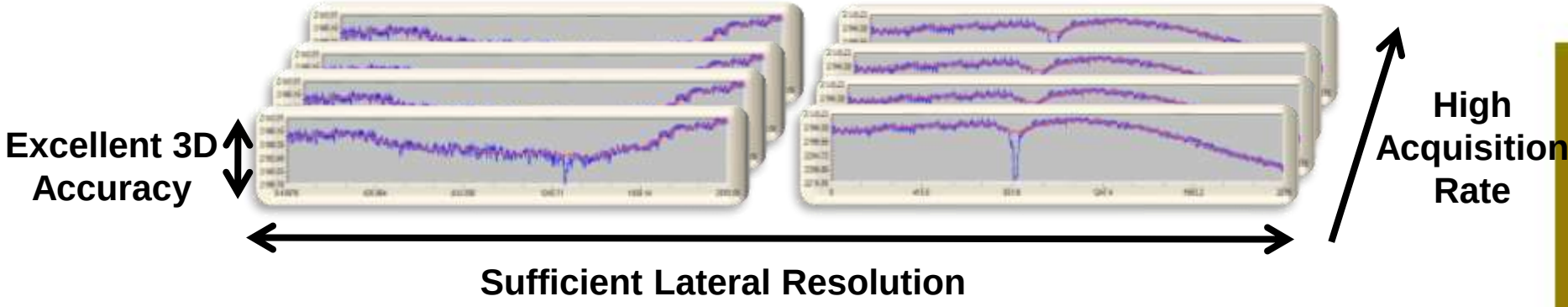


Concrete

Porous



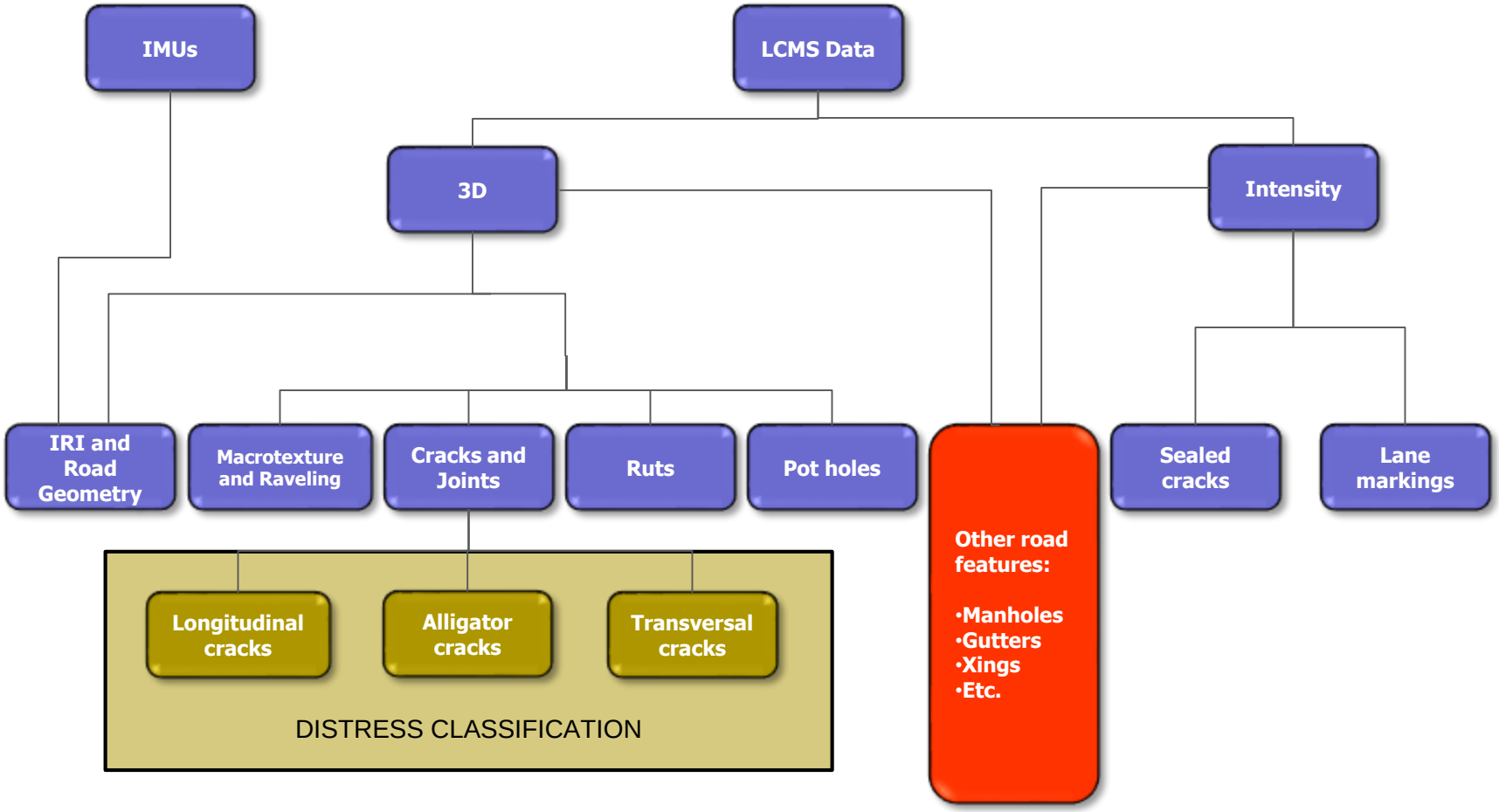
LCMS - Specifictions



LCMS Specifications	
Acquisition Rate	5,600-11,200 profiles/s
Range Accuracy/resolution	*0.5mm / 0.25mm*
Lateral Resolution	1mm (FOV = 4m)

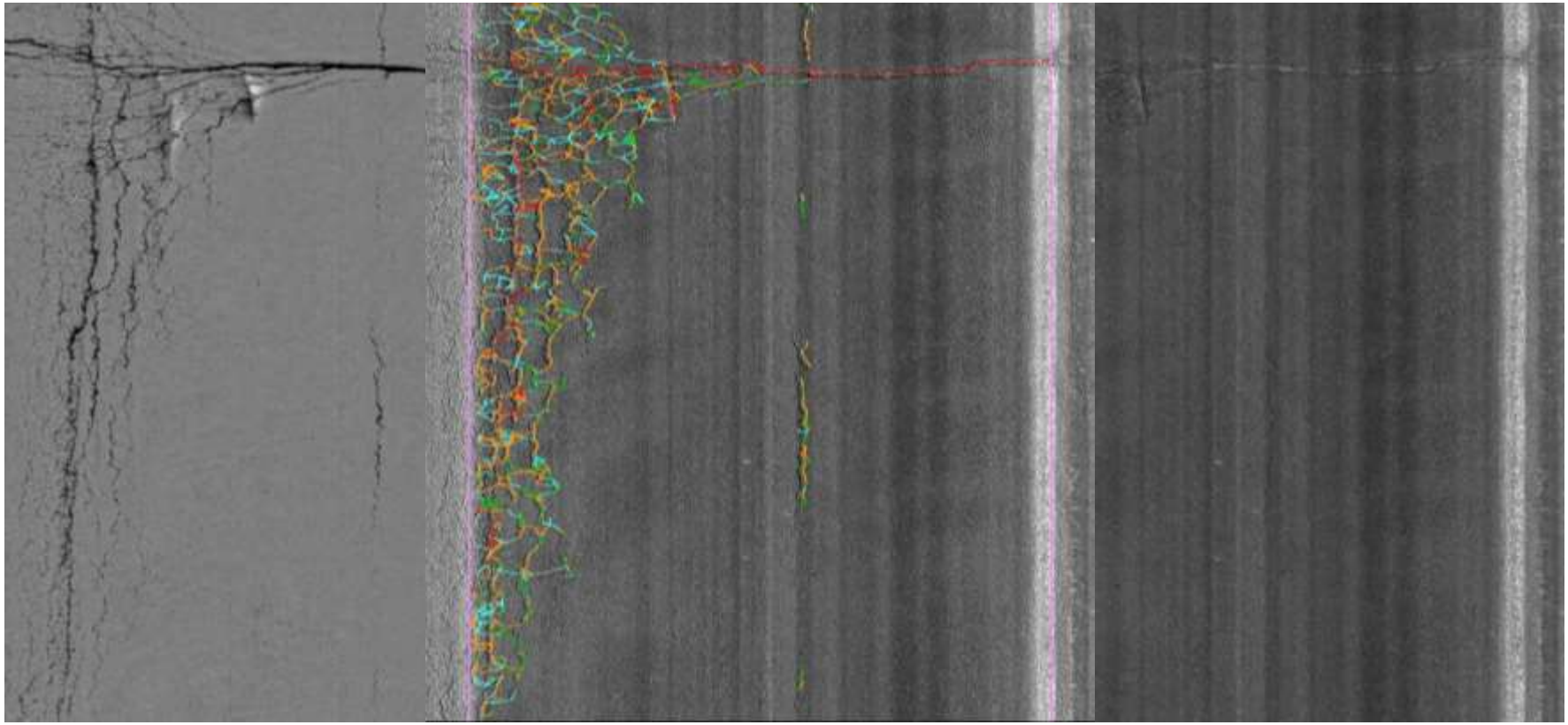
Pavemetrics

LCMS Data Processing Tree



Pavemetrics

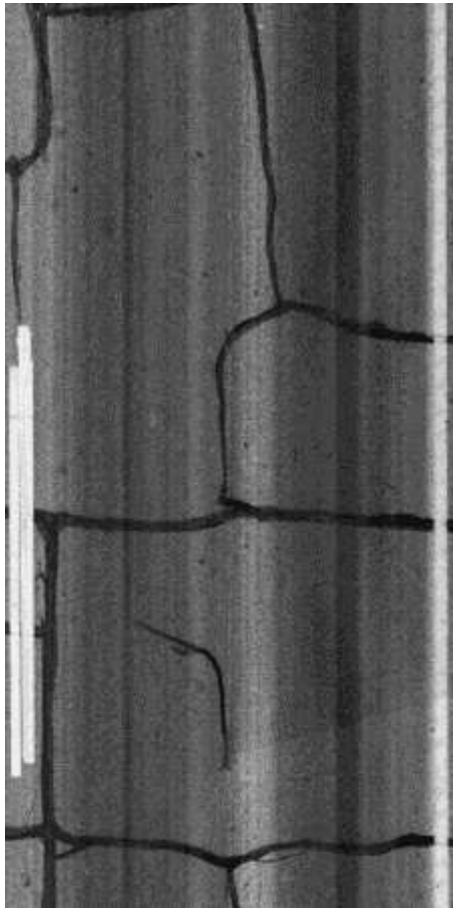
Understanding 3D Imaging



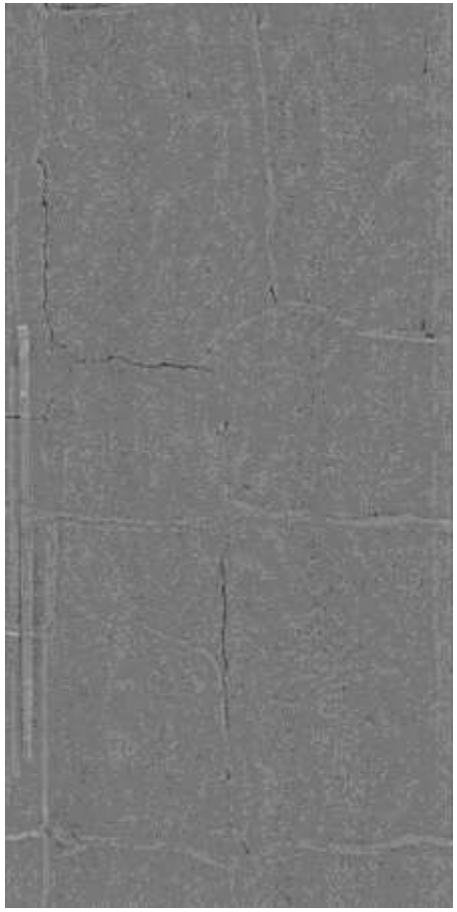
Range Merged Intensity

Pavemetrics

Hypothesis: Sealed cracks are perfectly visible in intensity images, not in 3D



Intensity

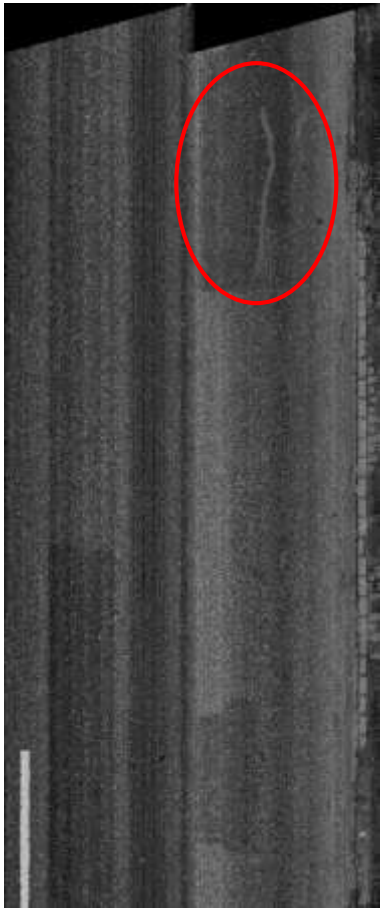


Range 3D

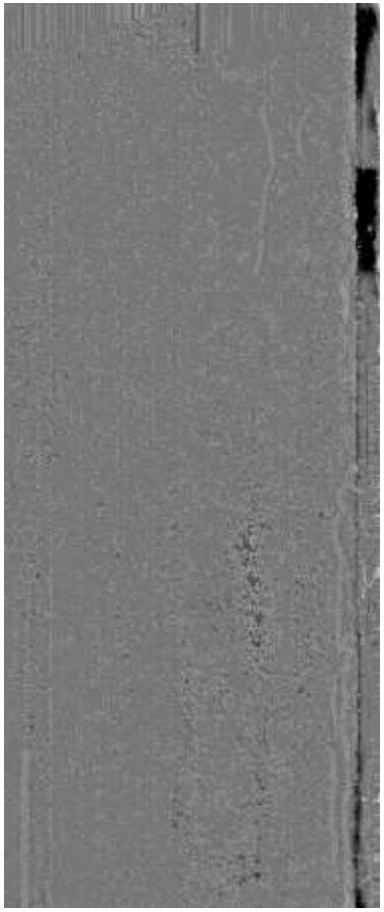
BUT…

Pavemetrics

Some sealing materials can make the sealed cracks to appear perfectly grey…



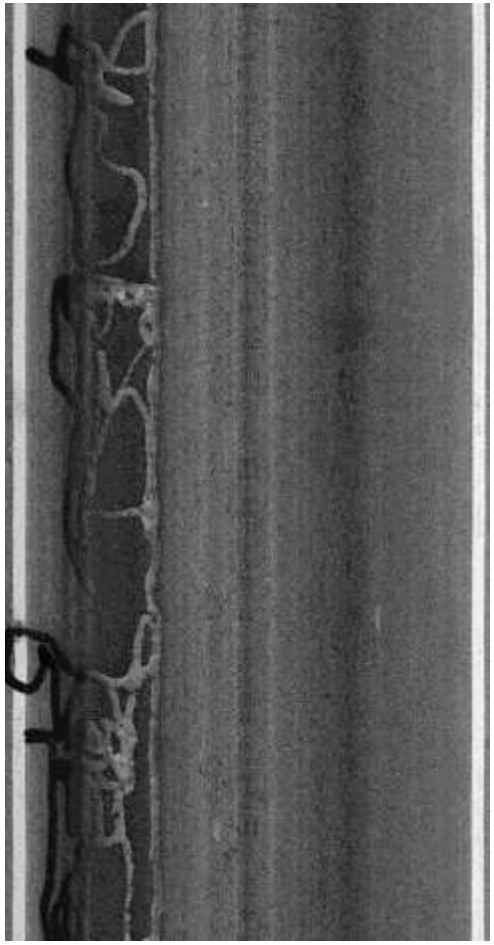
Intensity



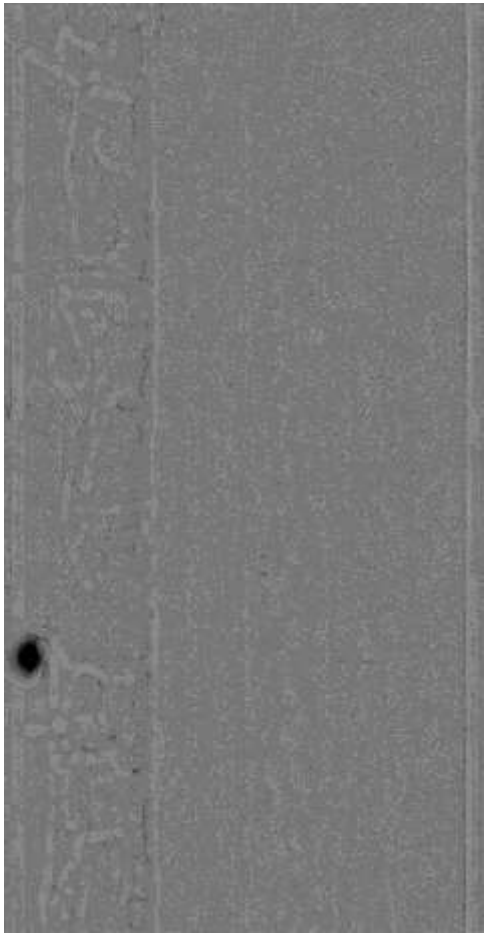
Range 3D

Pavemetrics

...or partially white...



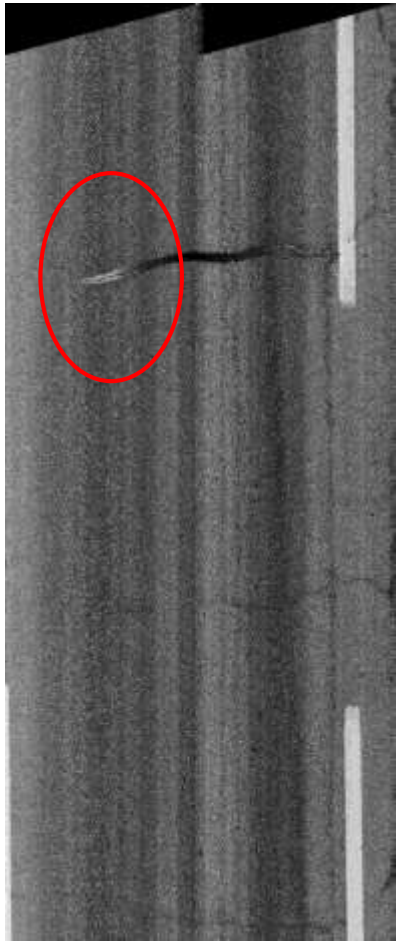
Intensity



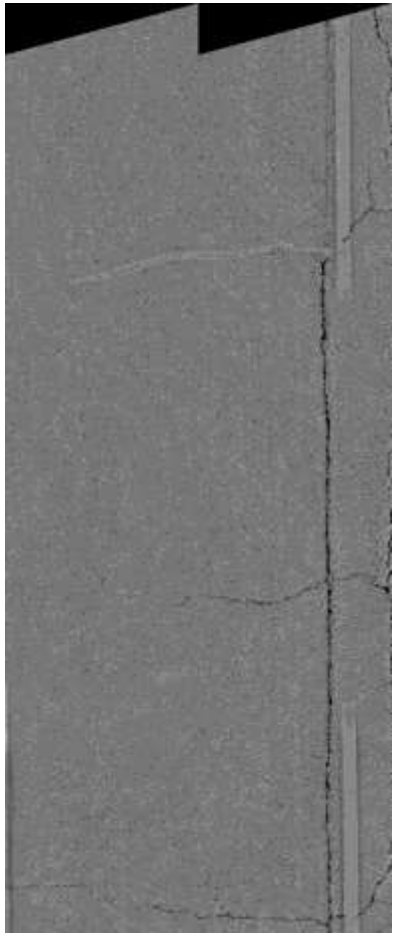
Range 3D

Pavemetrics

...or partially shiny...



Intensity



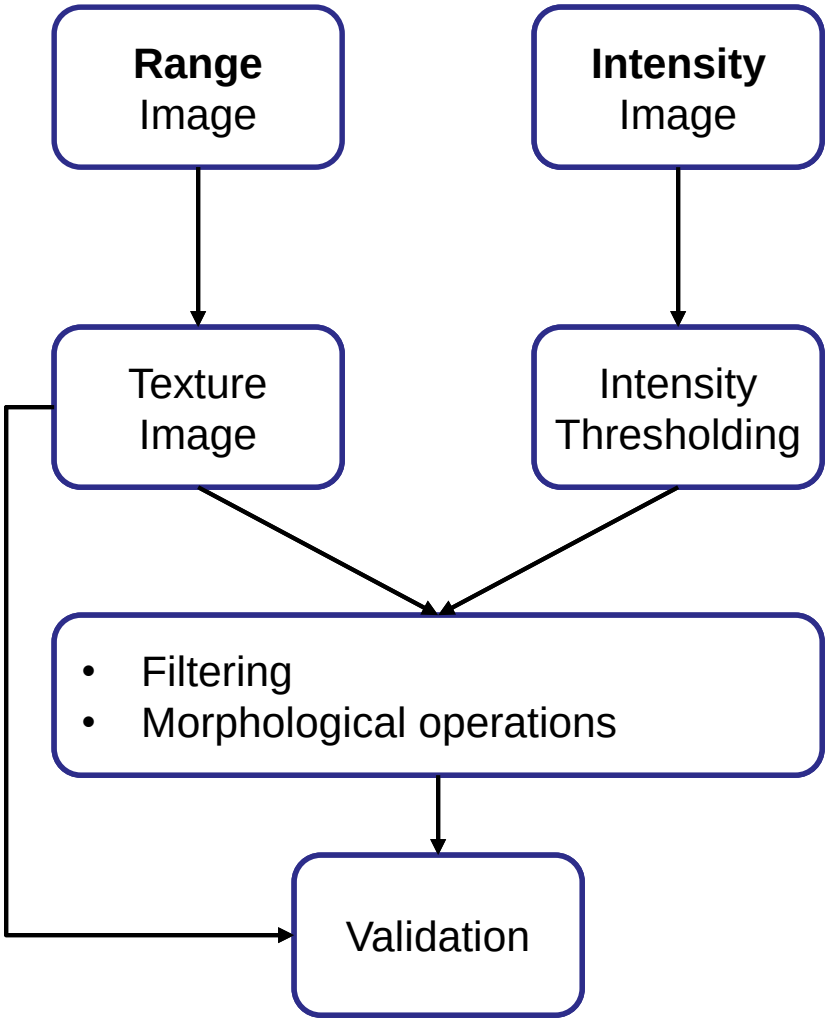
Range 3D

Pavemetrics

...and a lot of stuff may be confused with a sealed crack (oil patches, tire breaks, etc...)

Pavemetrics

Algorithm



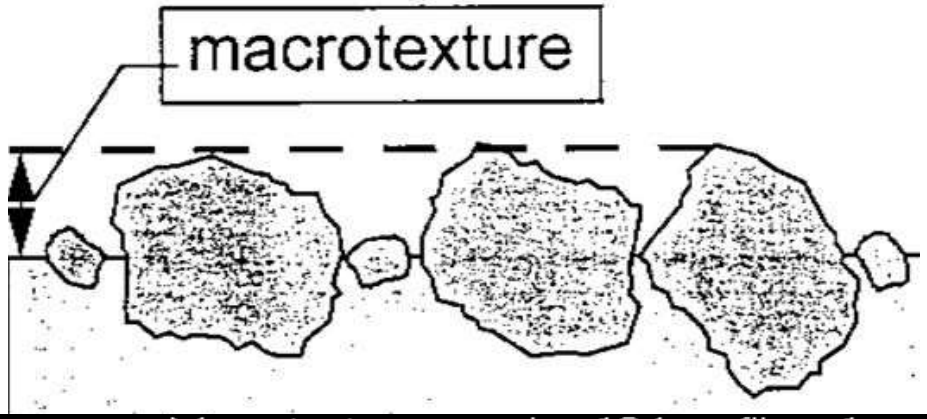
Macrotexture : Mean Profile Depth (ASTM E1845-01)

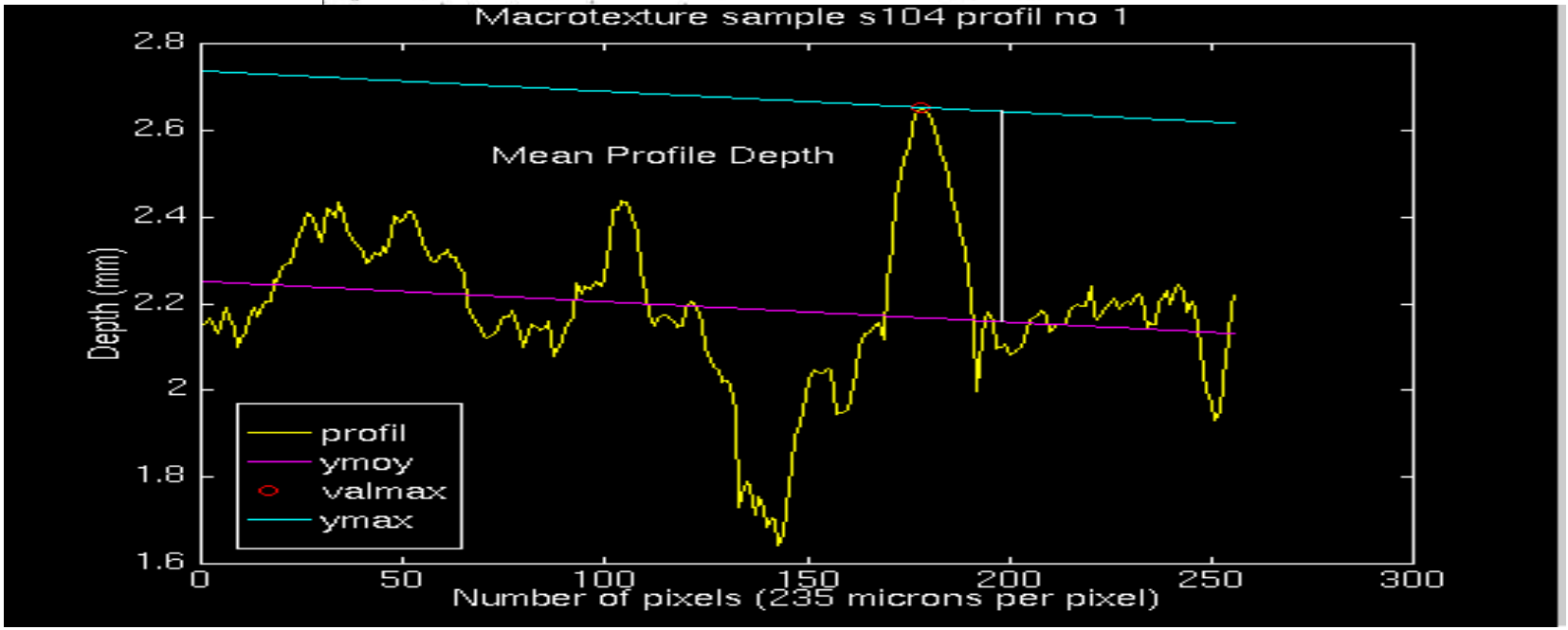
Specifications:

- 32kHz or 64kHz laser
- 1mm point spacing (minimum)
- 0.05 mm vertical resolution
- Low pass filtering 2.5mm features removed. 5mm+ features kept intact.

Pavemetrics

Macrotexture : Mean Profile Depth (ASTM E1845-01)





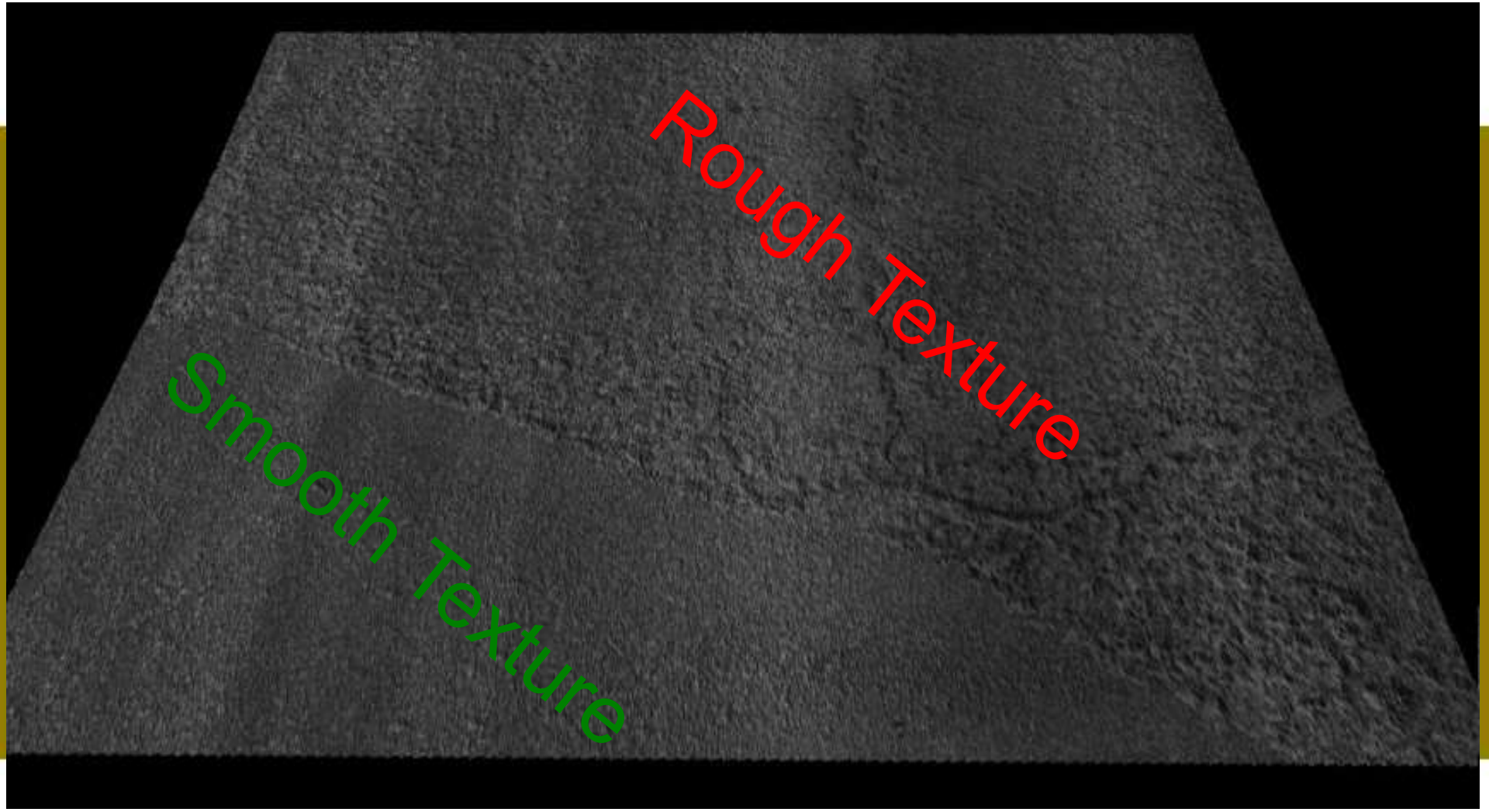
Macrotexture – LCMS Digital Sand Patch Method

Pros:

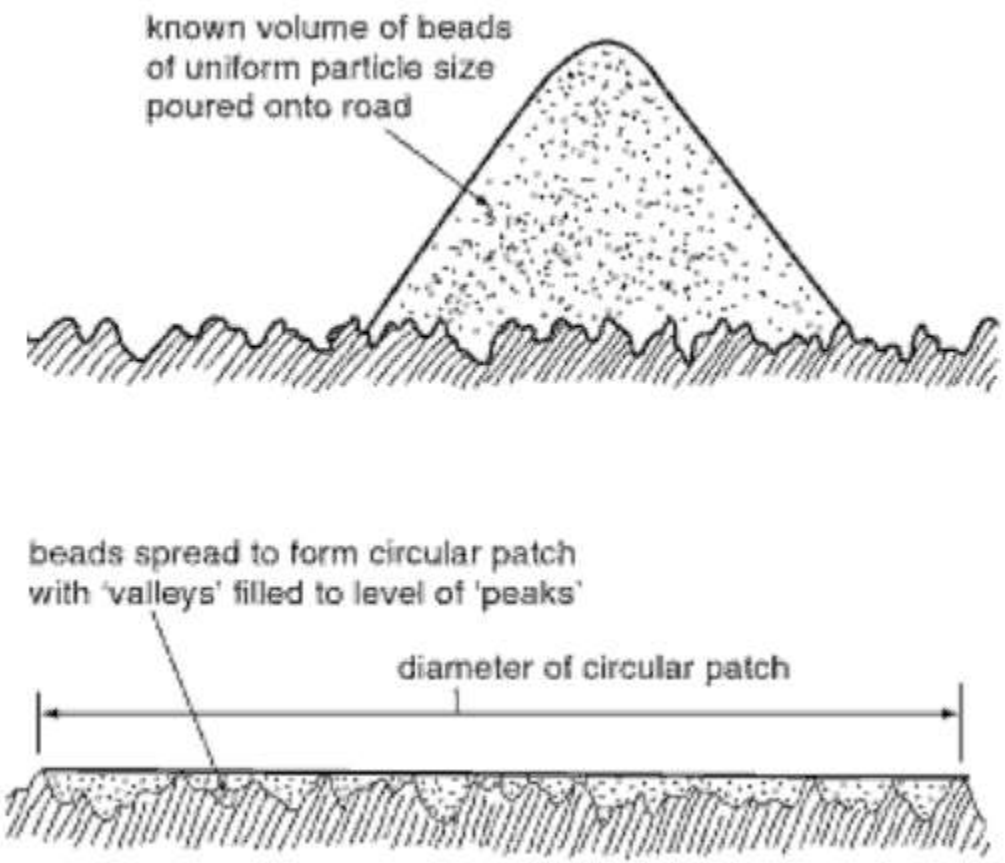
- Network survey is possible at 100kmh
- Full lane width is measured
  - 5 AASHTO bands
- Great repeatability
  - Automatic lane marking detection

Pavemetrics

Macrotexture

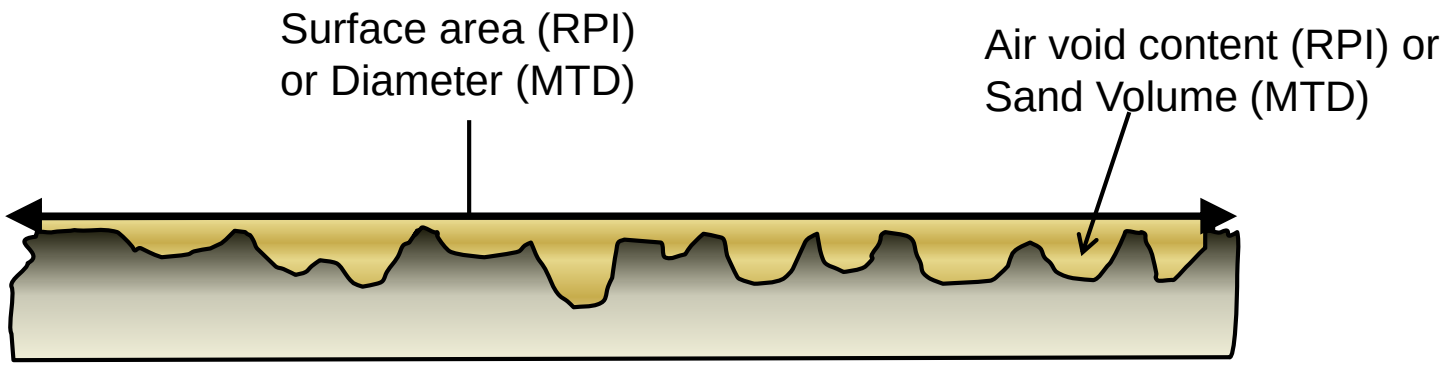


Macrotexture : Sand patch method (MTD) (ASTM E965)



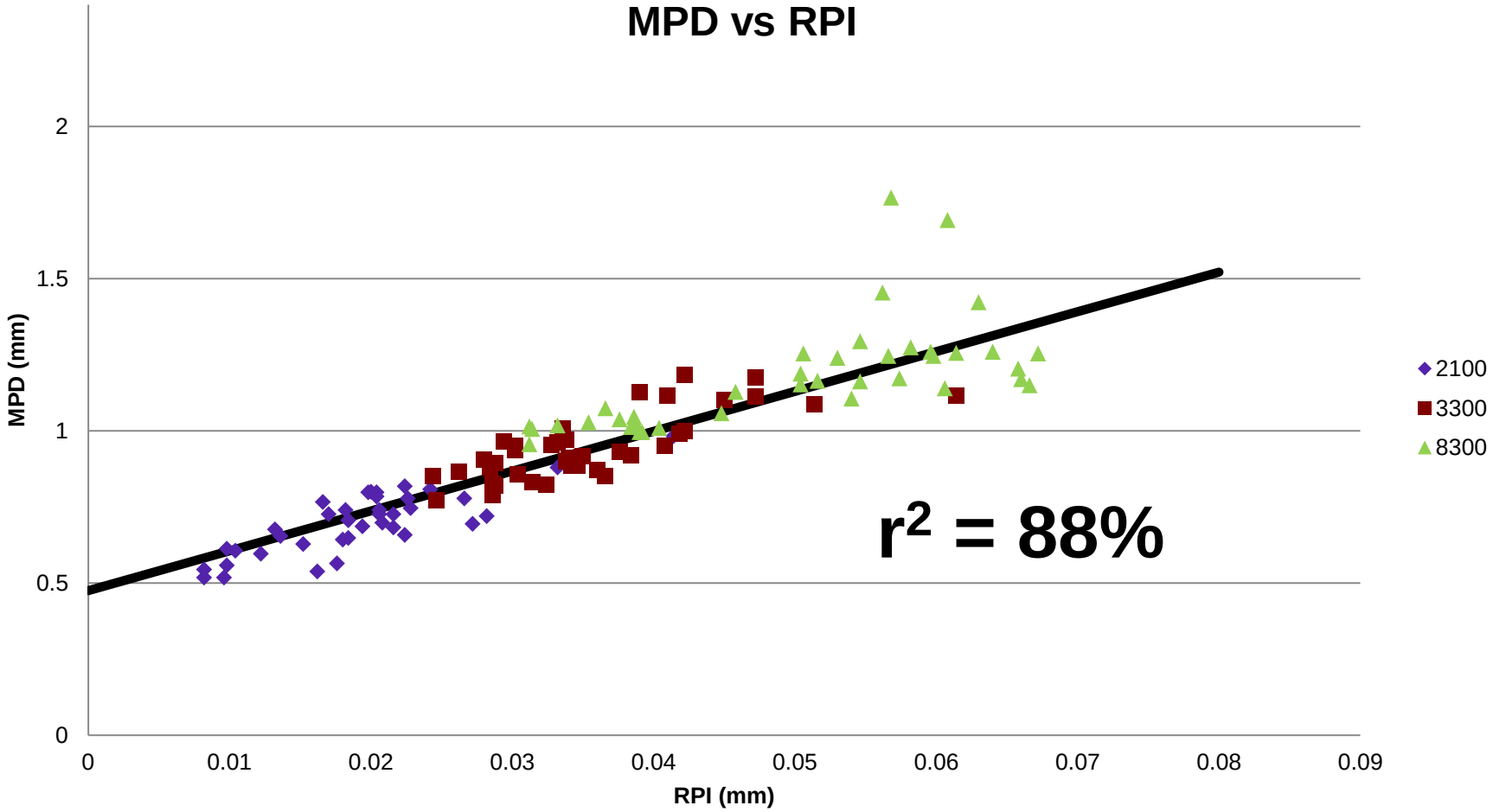
Macrotexture – RPI
Digital Sand Patch Method

RPI - Road Porosity Index = (Volume under the surface – Ravelling - Cracks) divided by a surface area



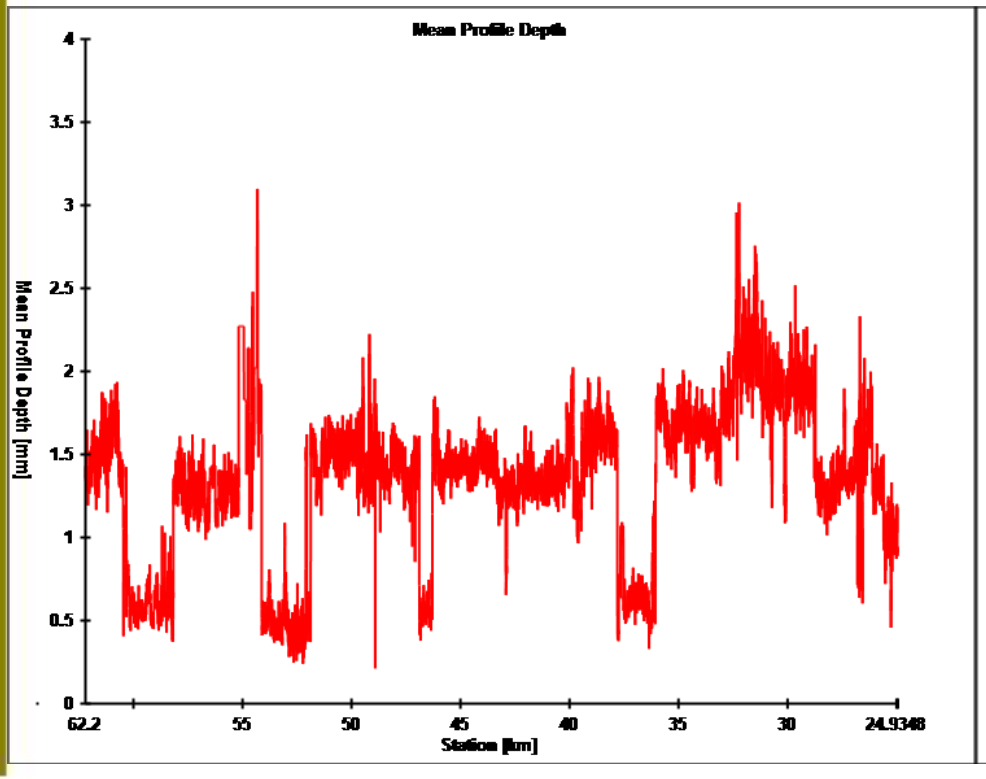
$$RPI = \frac{(Vol_{air\ void} - Vol_{pothole} - Vol_{cracks})}{Area_{Total}}$$

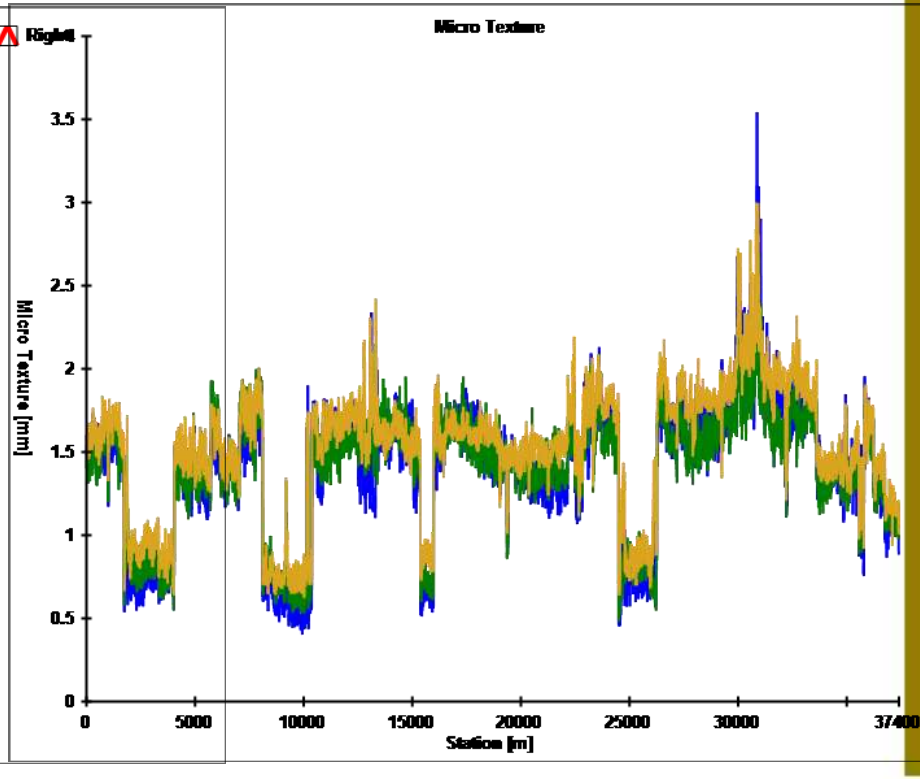
Macrotexture – Correlation between MPD and RPI



Pavemetrics

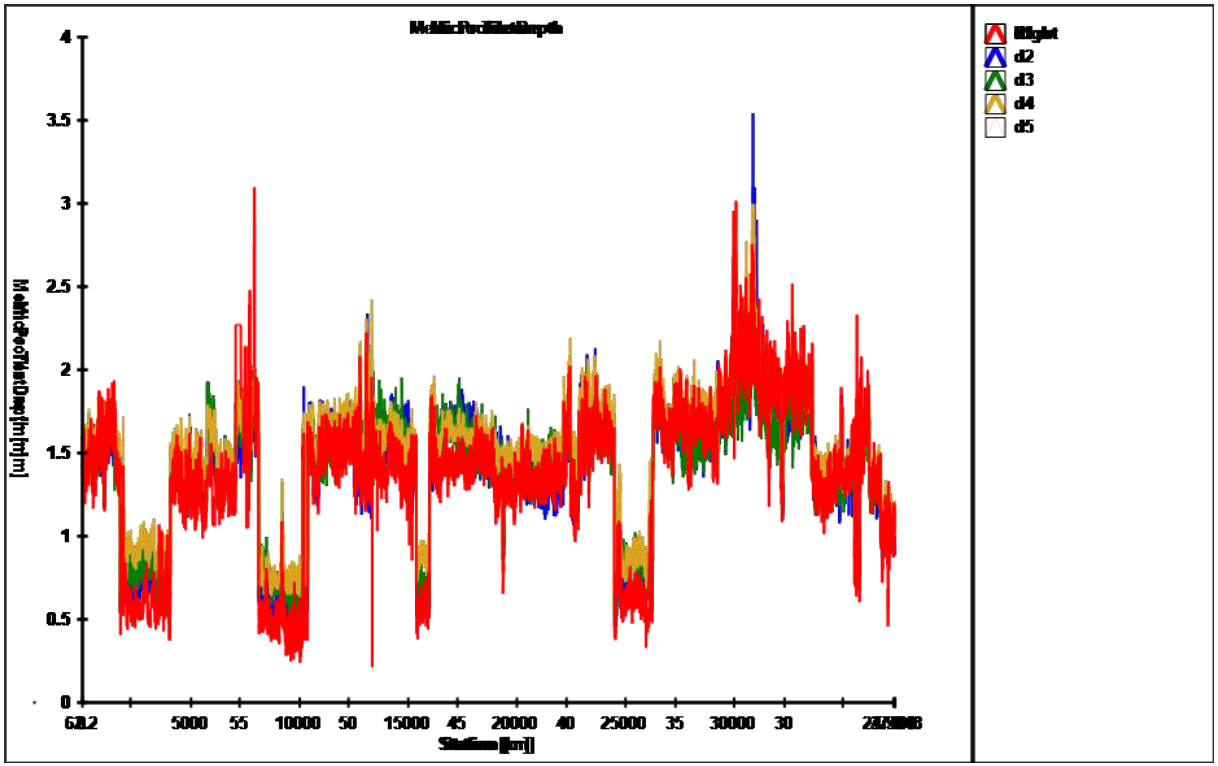
LCMS vs 64 KHz laser





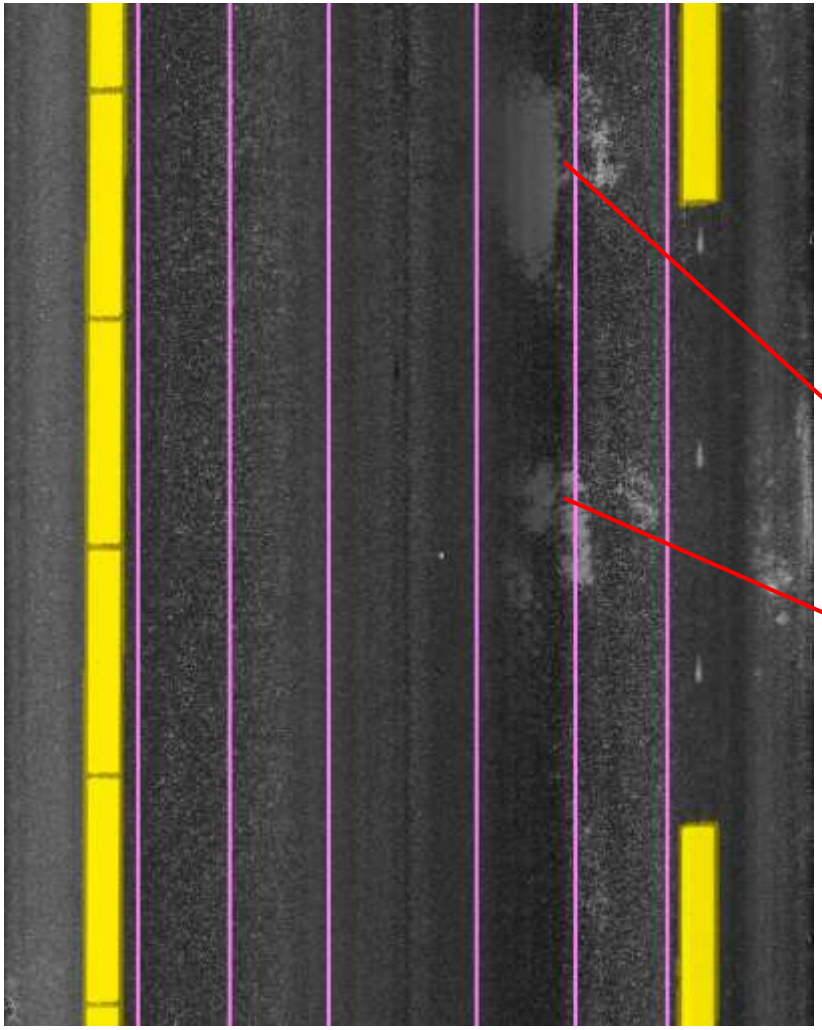
Pavemetrics

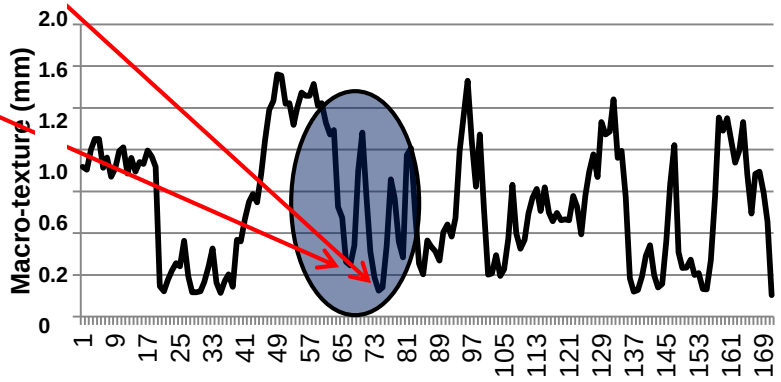
LCMS vs 64 KHz laser



Pavemetrics

Bleeding

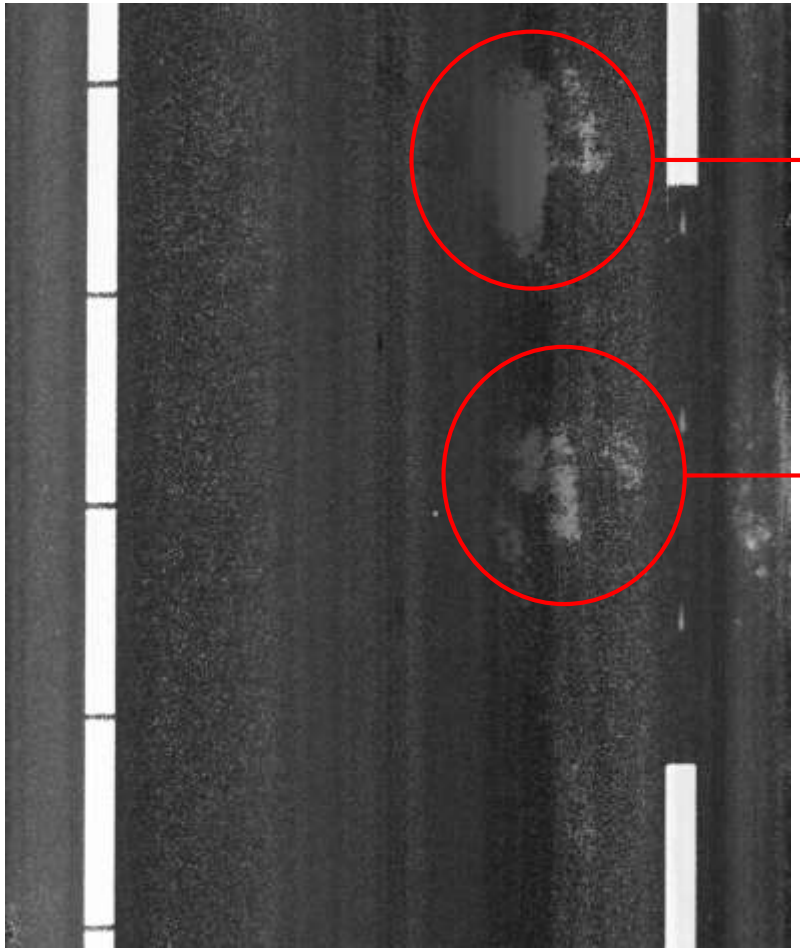




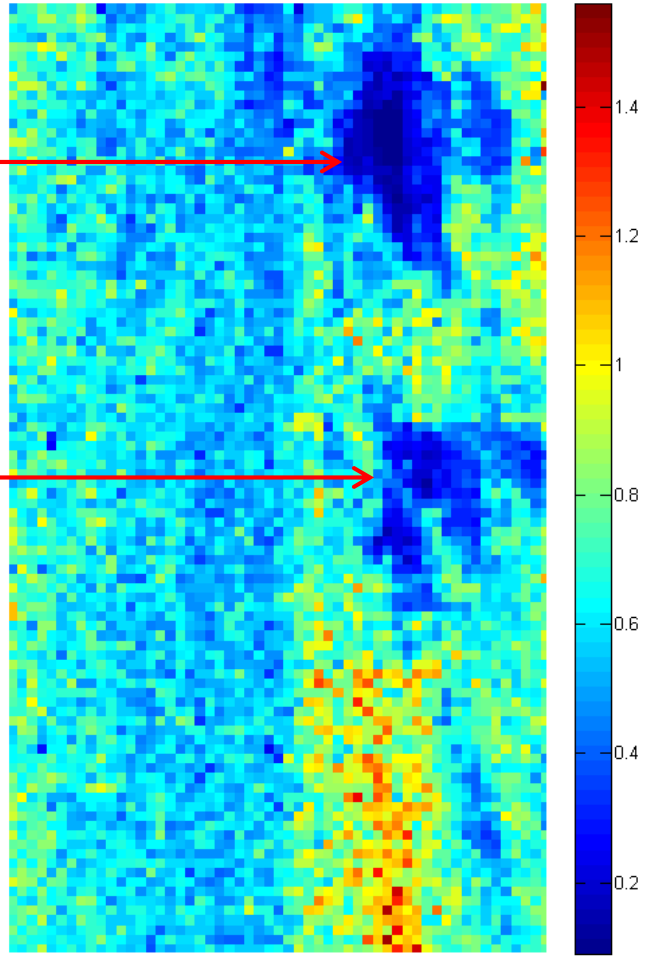
Pavemetrics

Macrotexture: bleeding

Intensity image

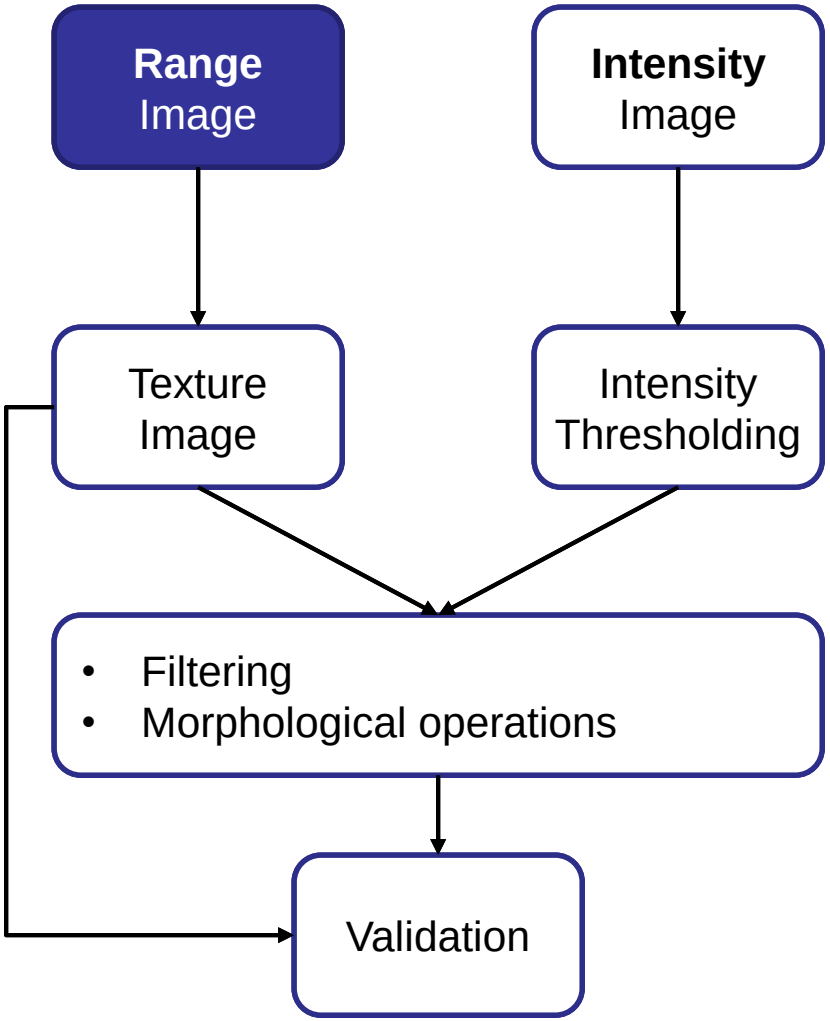


Texture image (MTD, mm)



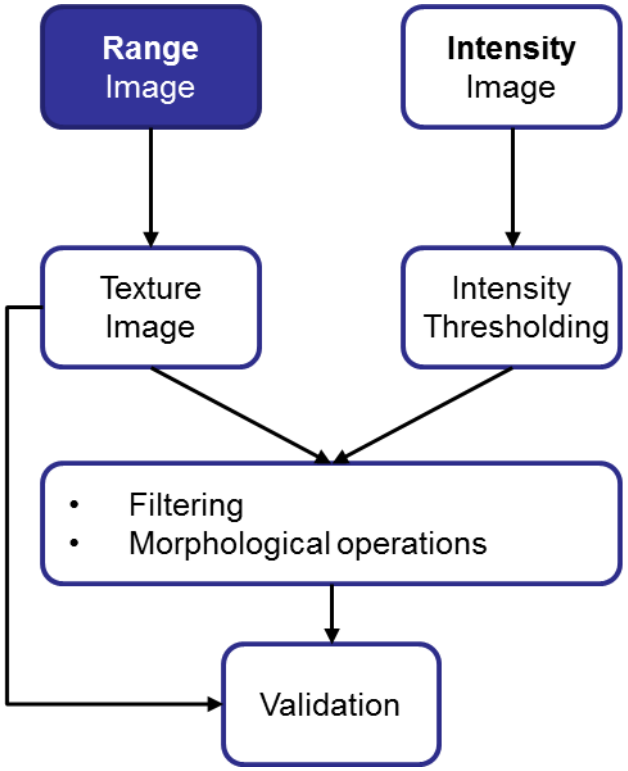
Pavemetrics

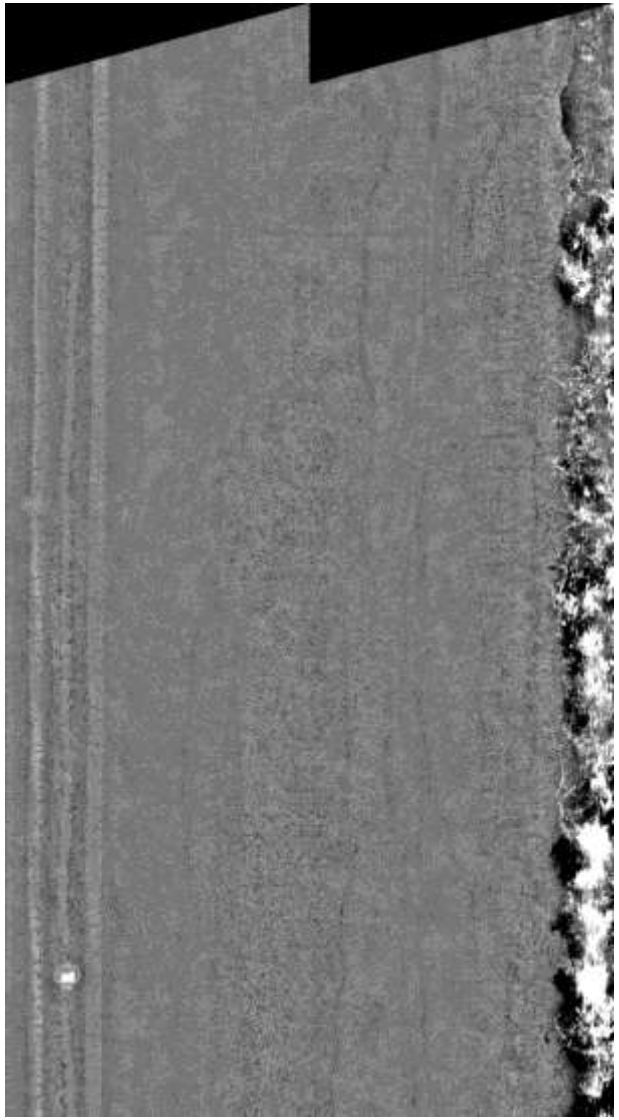
Algorithm



Pavemetrics

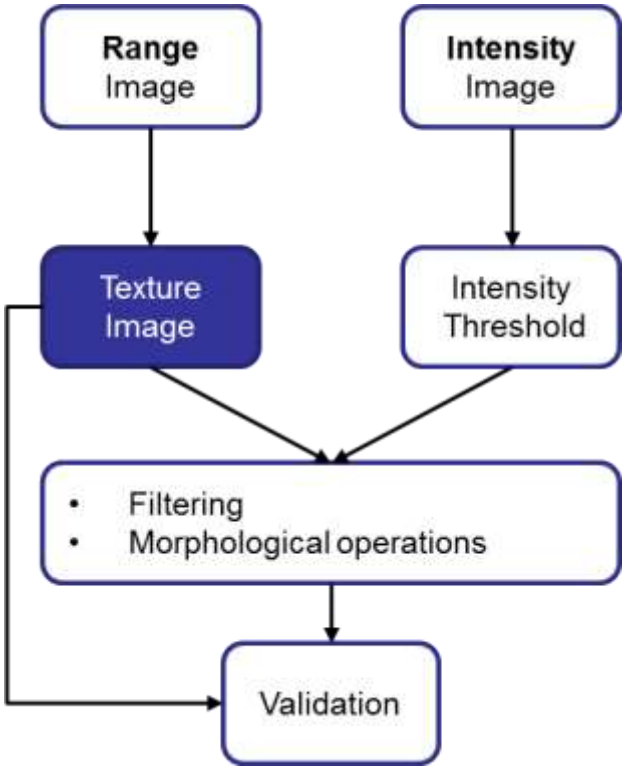
Range Image

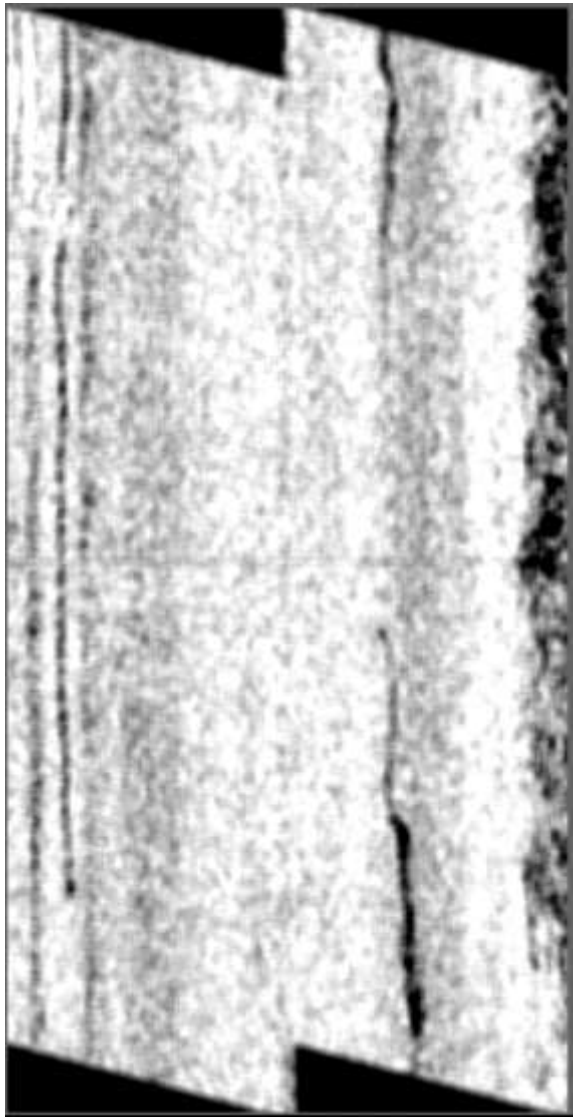




Pavemetrics

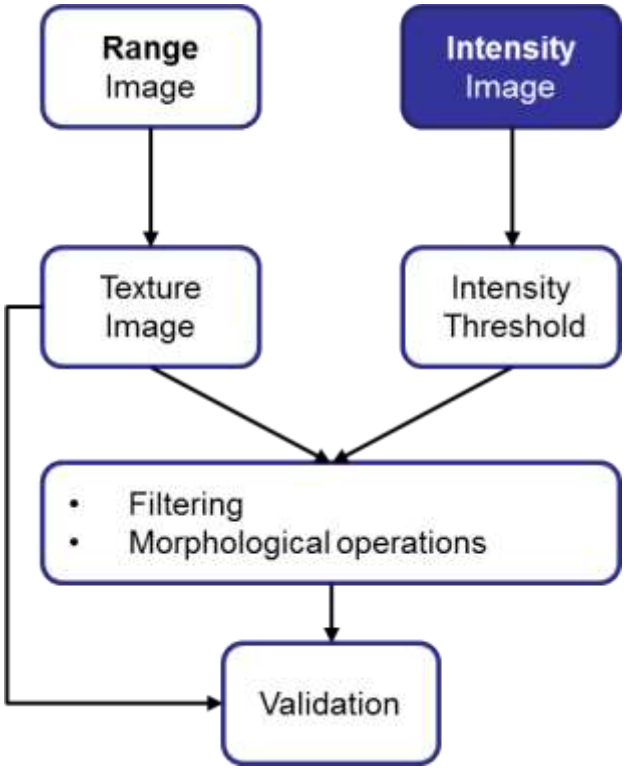
Texture Image

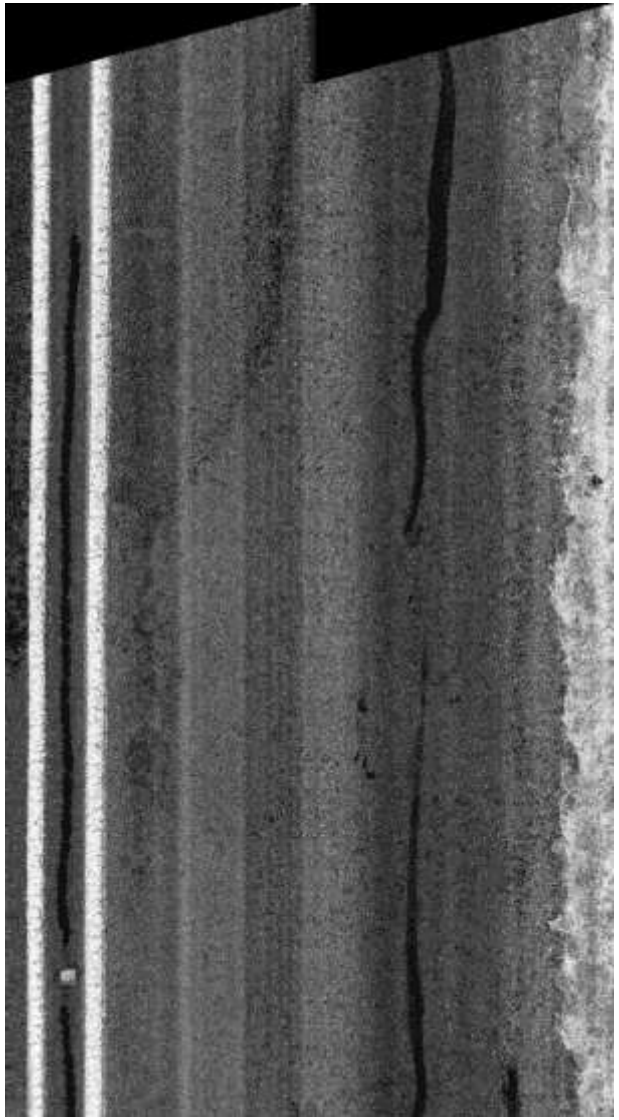




Pavemetrics

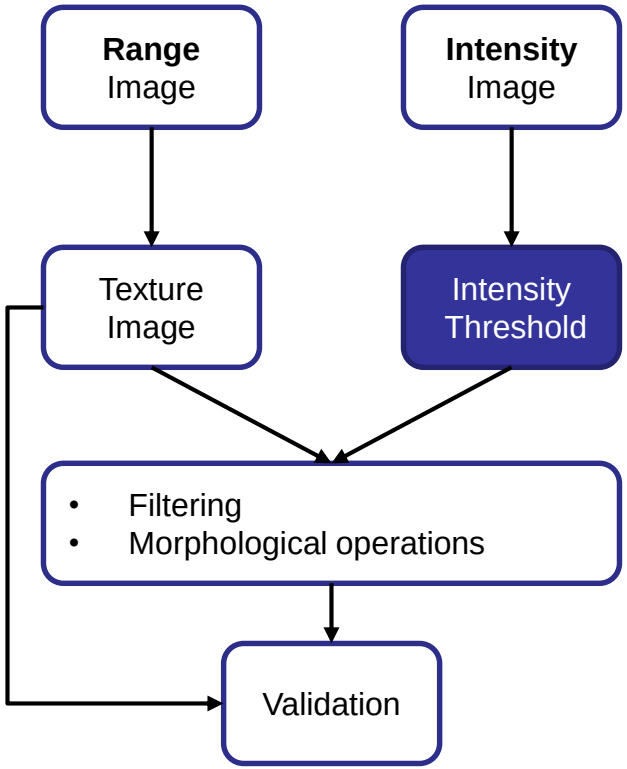
Intensity Image





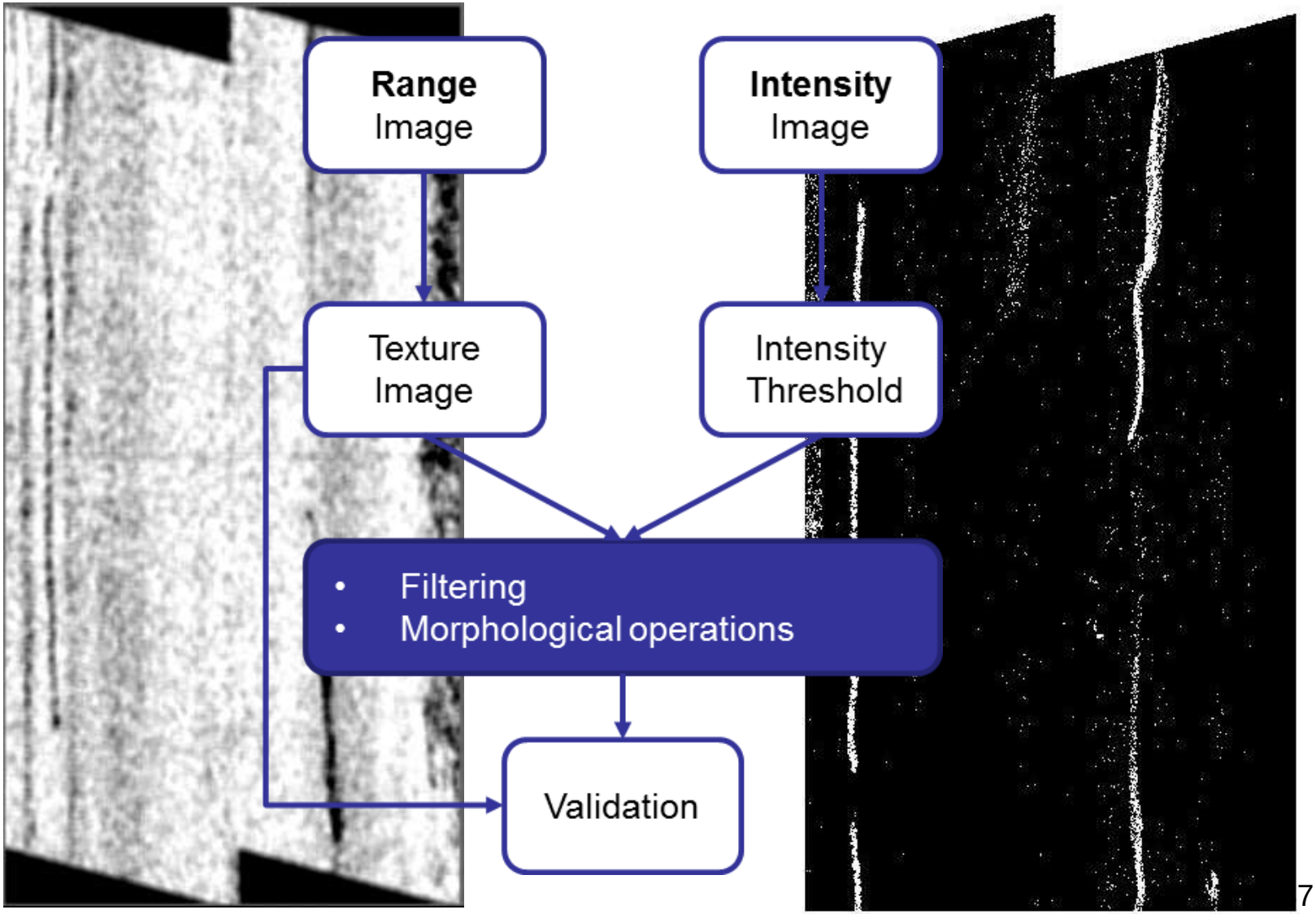
Pavemetrics

Intensity Thresholding Image



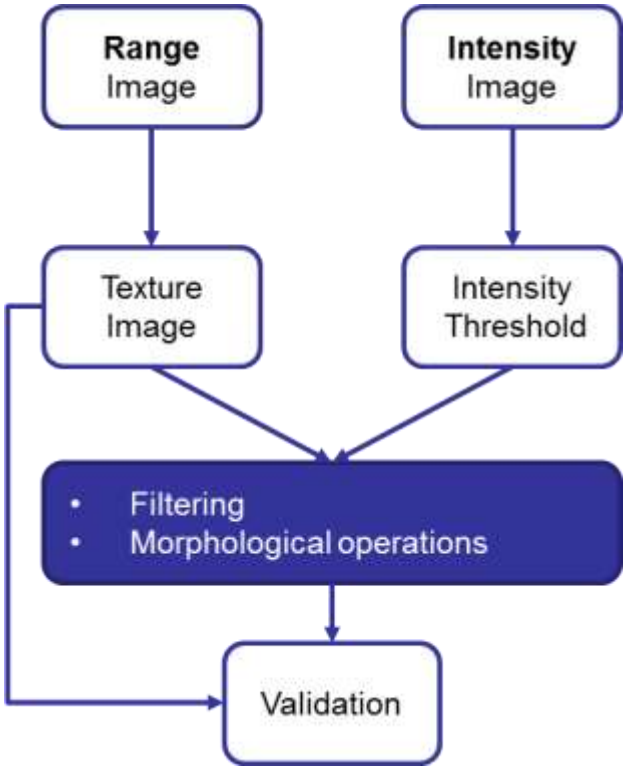
Pavemetrics

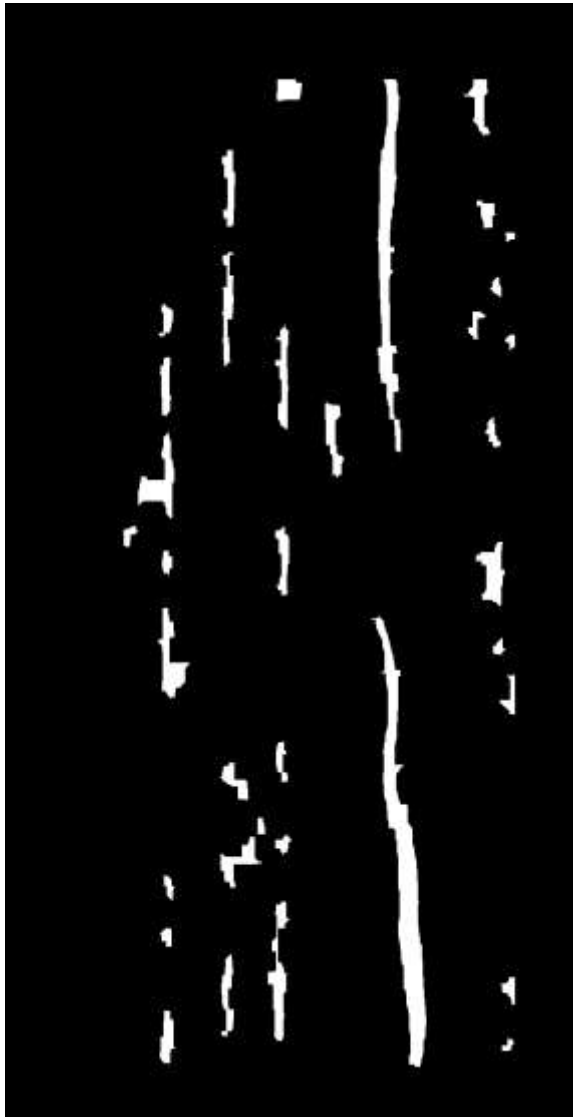
Texture + Intensity Thresholding Images



Pavemetrics

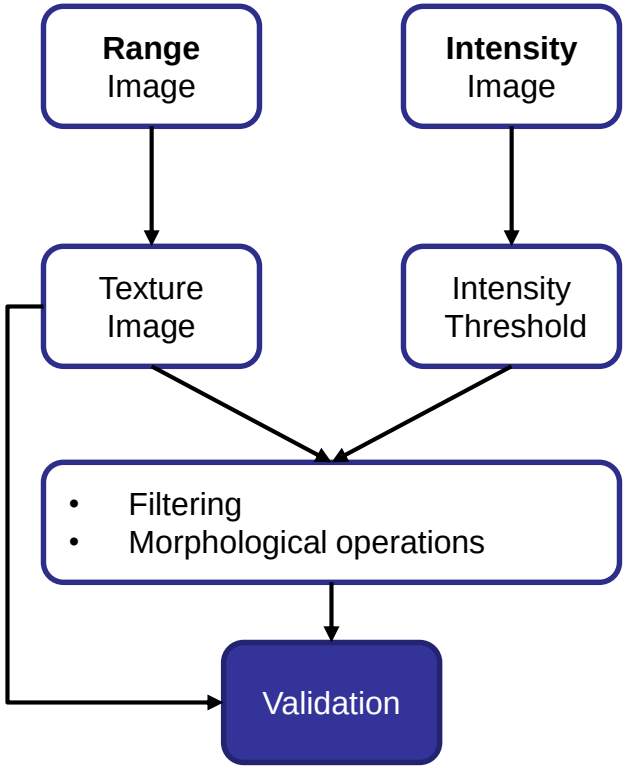
Morphological Operations

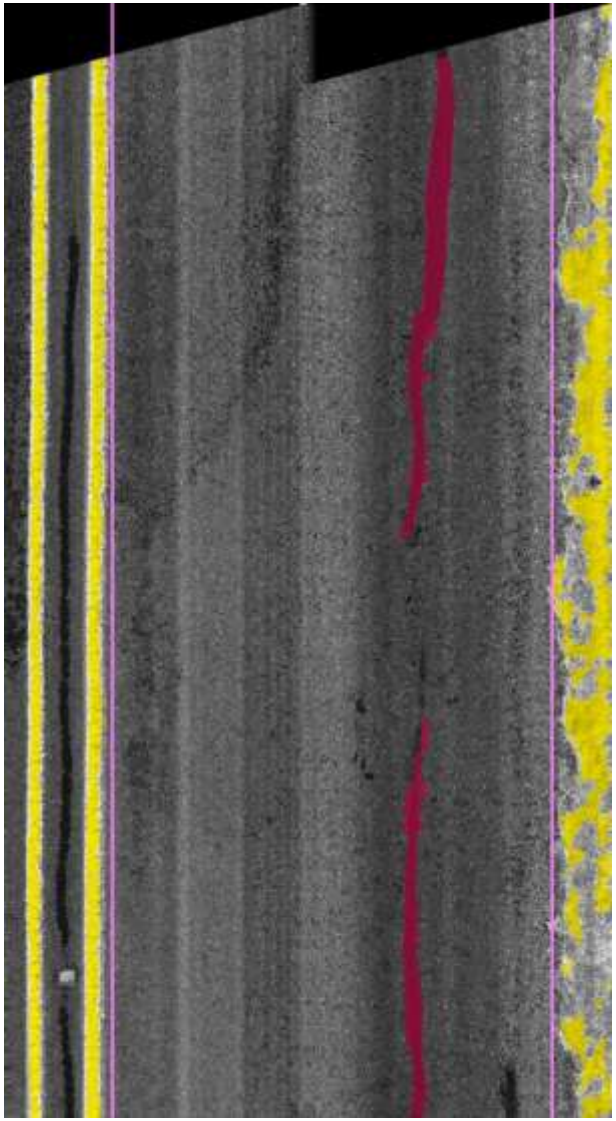




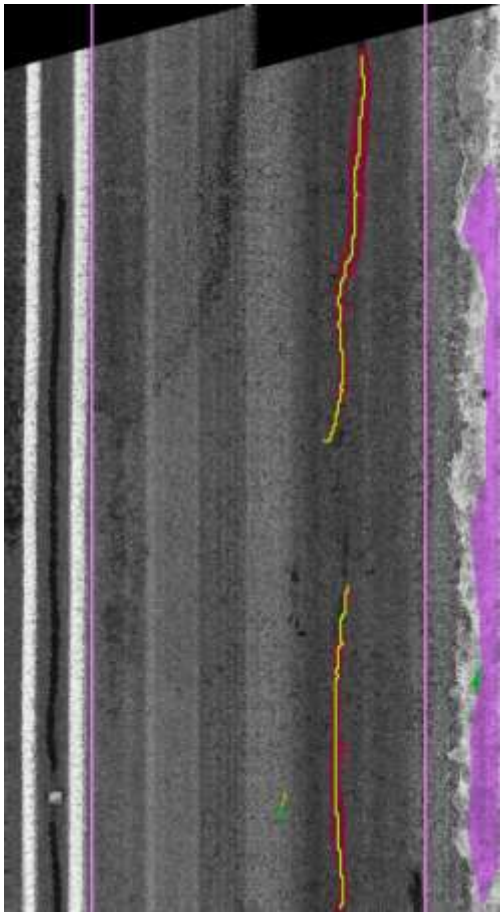
Pavemetrics

Validation





Reporting and display: sealed crack perimeter and skeleton



Red blobs = Perimeter

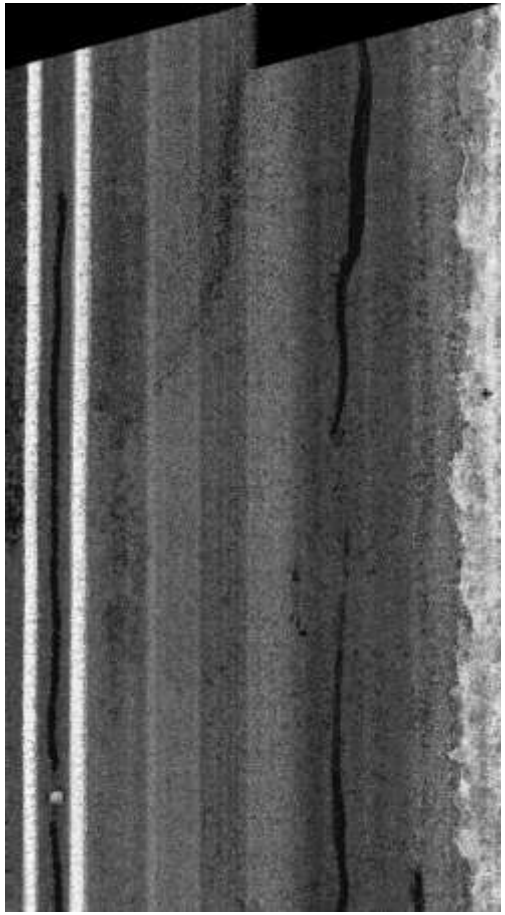
```
<SealedCrackPerimeters>
<SealedCrack><SealedCrackID>0</SealedCrackID>
<BoundingBox>
<MinX>2730.0</MinX>
<MaxX>2900.0</MaxX>
<MinY>5.0</MinY>
<MaxY>2745.0</MaxY>
</BoundingBox>
<TextureInside>1.547</TextureInside>
<TextureOutside>2.091</TextureOutside>
<AvgIntensity>41</AvgIntensity>
<Area>0.222</Area>
<Perimeter>
<Node>
<X>2775.0</X>
<Y>5.0</Y>
</Node>
<Node>
<X>2785.0</X>
<Y>5.0</Y>
</Node>
<Node>
<X>2795.0</X>
<Y>5.0</Y>
</Node>
<Node>
<X>2805.0</X>
<Y>5.0</Y>
</Node>
<Node>
<X>2815.0</X>
<Y>5.0</Y>
</Node>
<Node>
<X>2825.0</X>
<Y>5.0</Y>
```

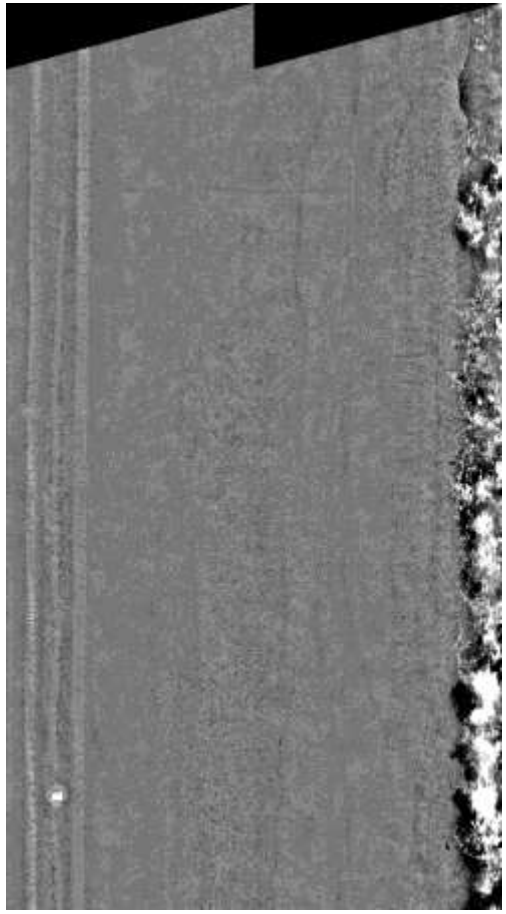
Yellow line - Skeleton

```
<SealedCrackList>
<SealedCrackSkeleton>
<SealedCrackID>0</SealedCrackID>
<Node>
<X>2840.0</X>
<Y>4374.0</Y>
</Node>
<Node>
<X>2820.0</X>
<Y>4394.1</Y>
</Node>
<Node>
<X>2820.0</X>
<Y>4414.1</Y>
</Node>
<Node>
<X>2840.0</X>
<Y>4434.2</Y>
</Node>
<Node>
<X>2840.0</X>
```

Pavemetrics

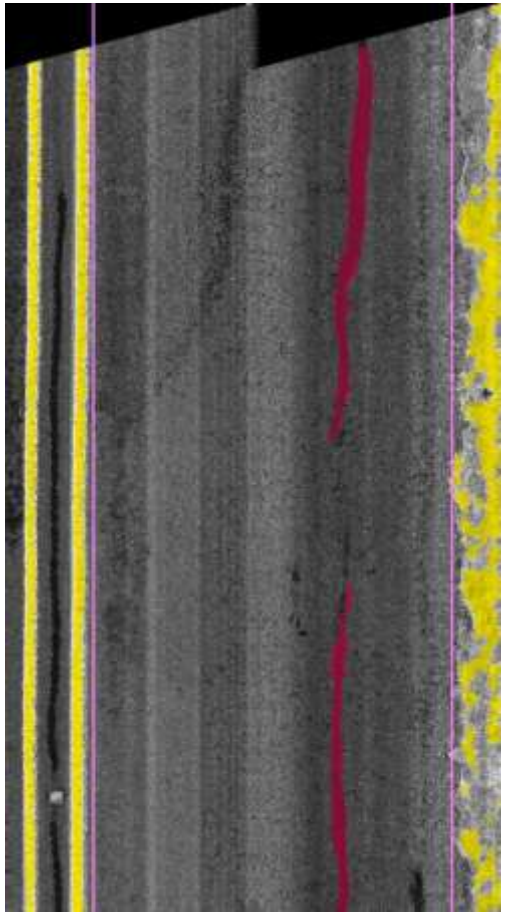
Example 1

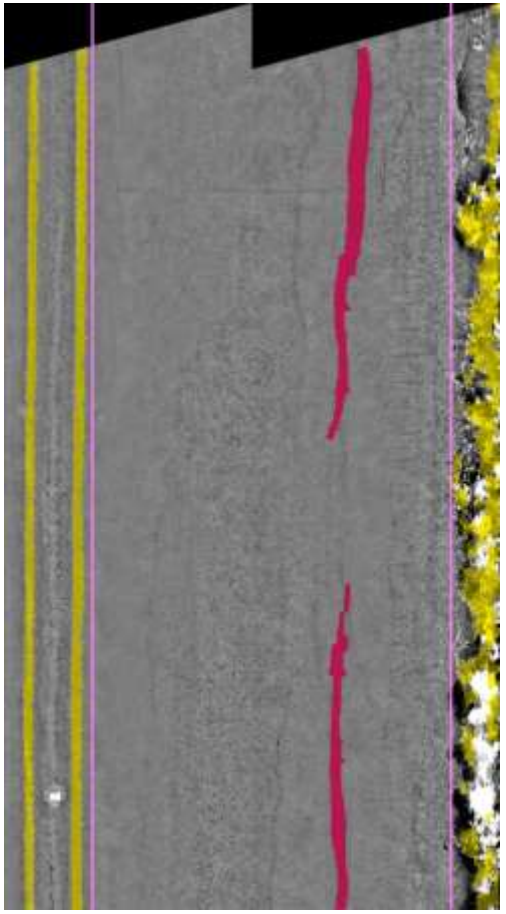




Pavemetrics

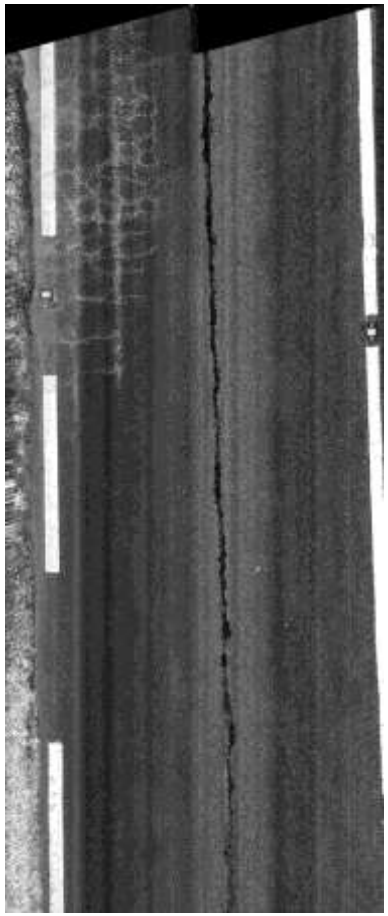
Example 1

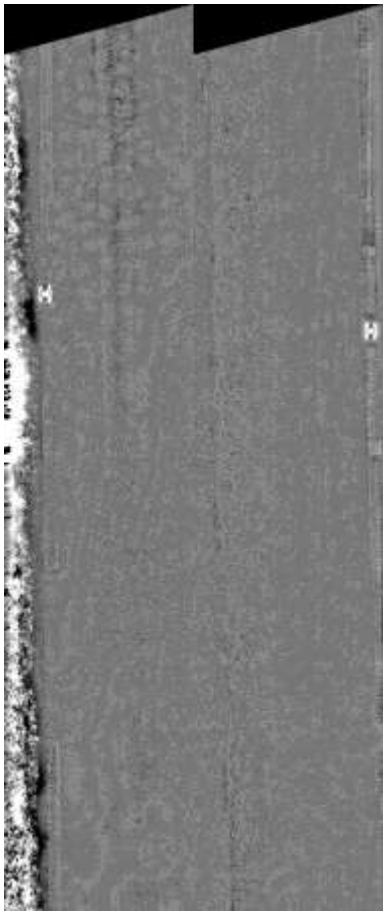




Pavemetrics

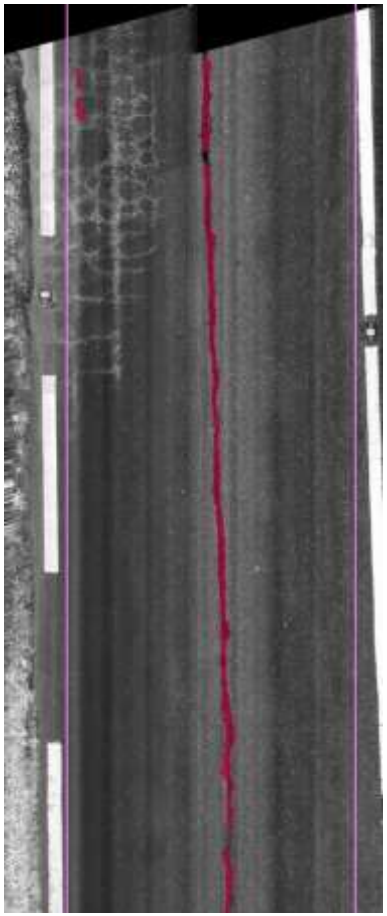
Example 2

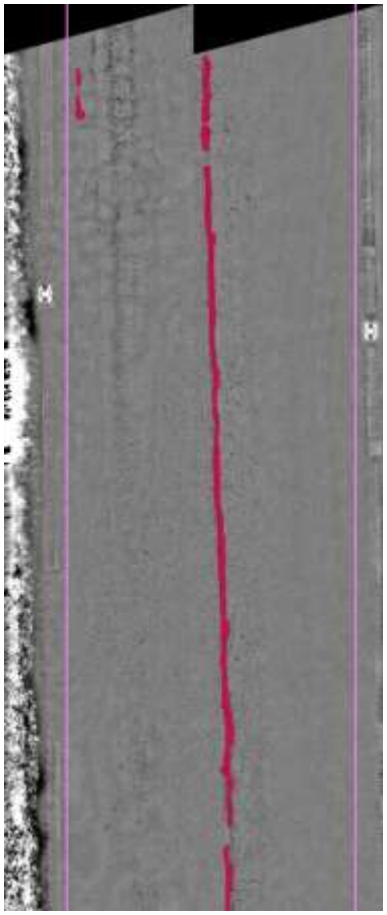




Pavemetrics

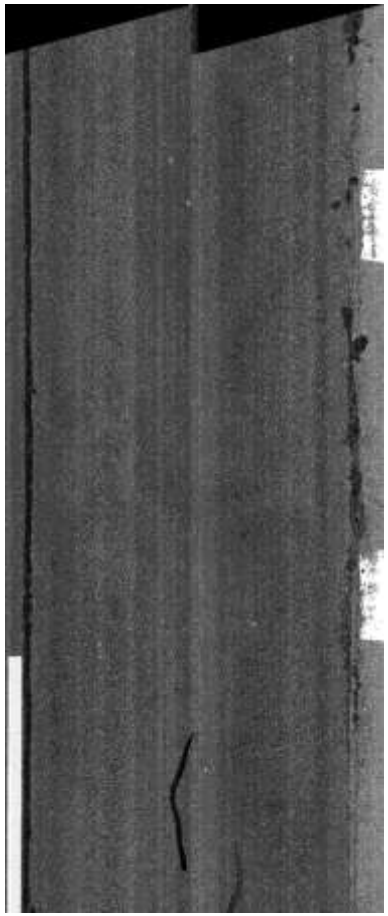
Example 2

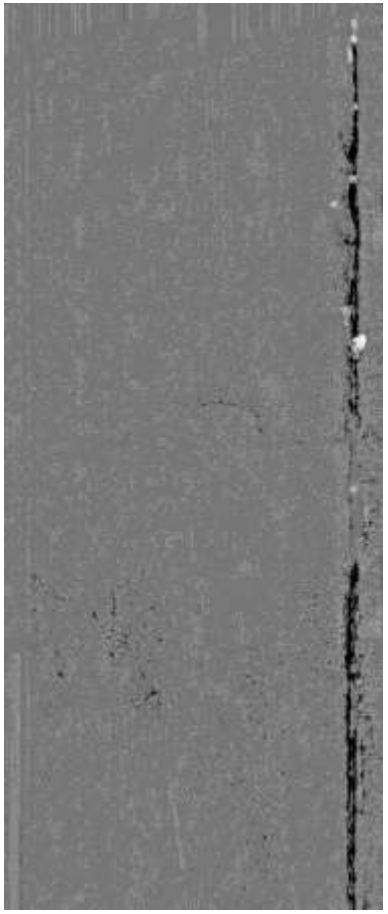




Pavemetrics

Example 3



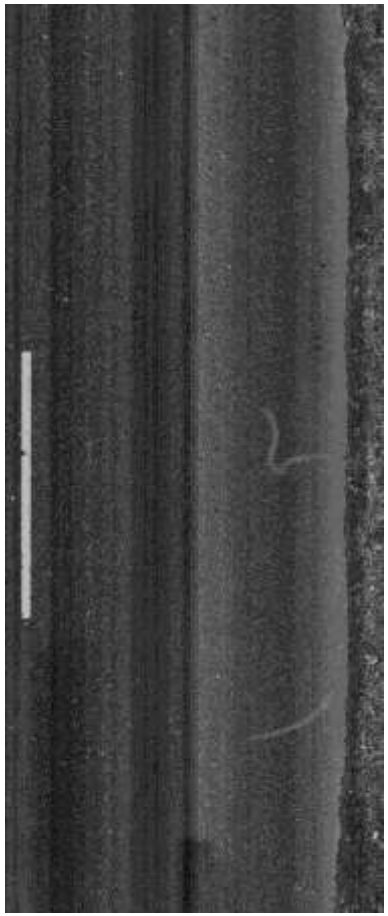


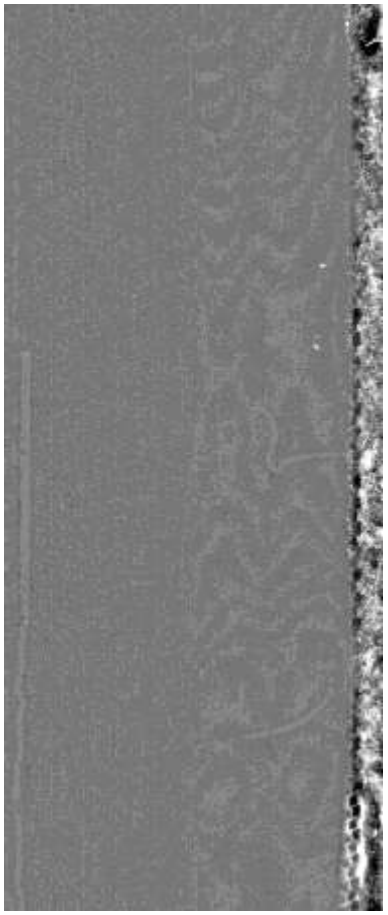
Pavemetrics

Example 3

Pavemetrics

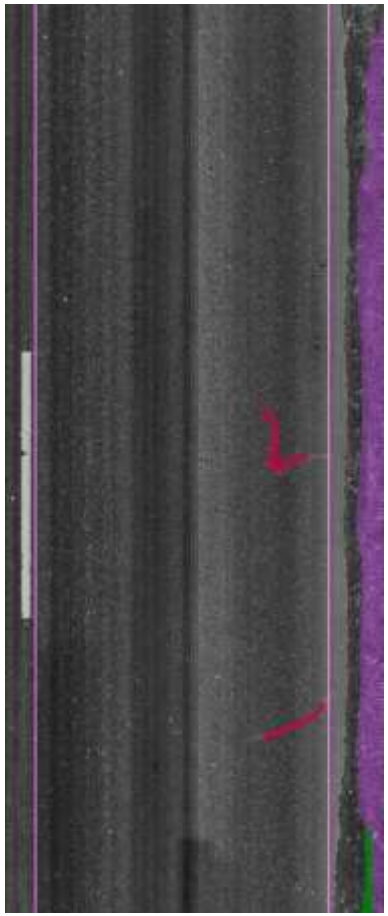
Example 4

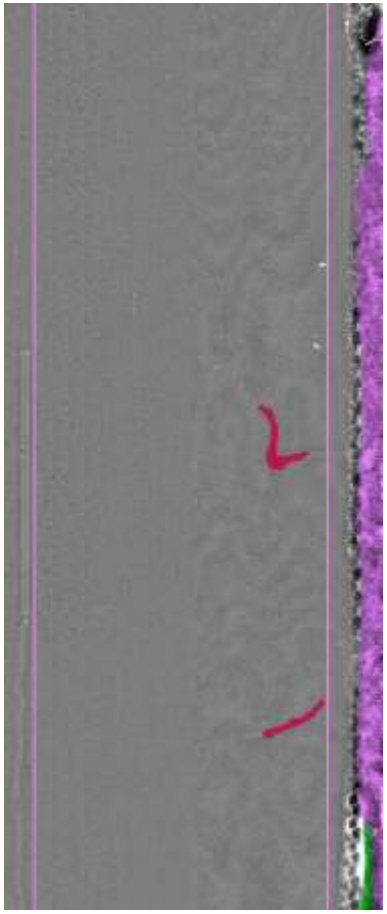




Pavemetrics

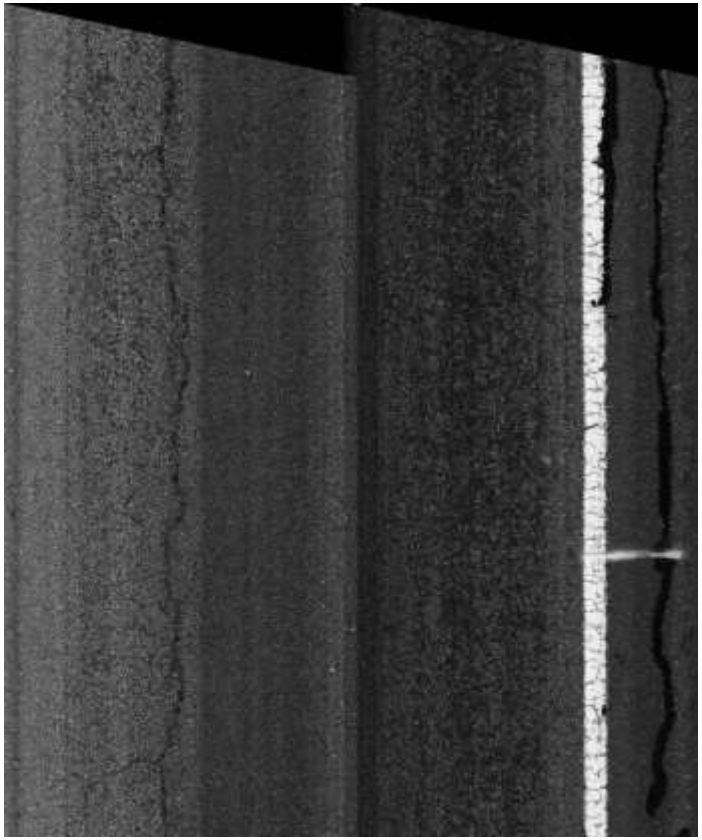
Example 4

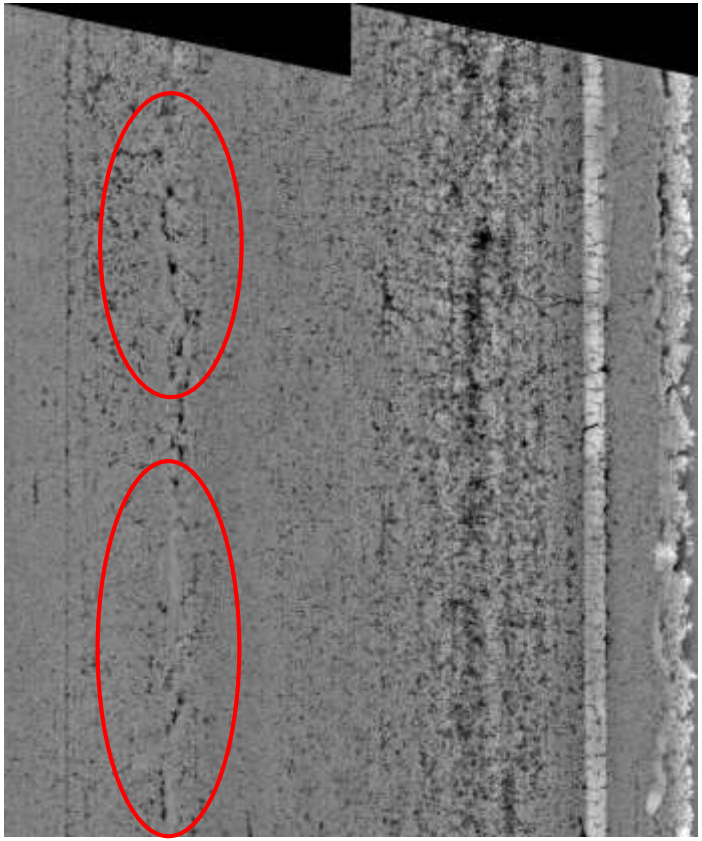




Pavemetrics

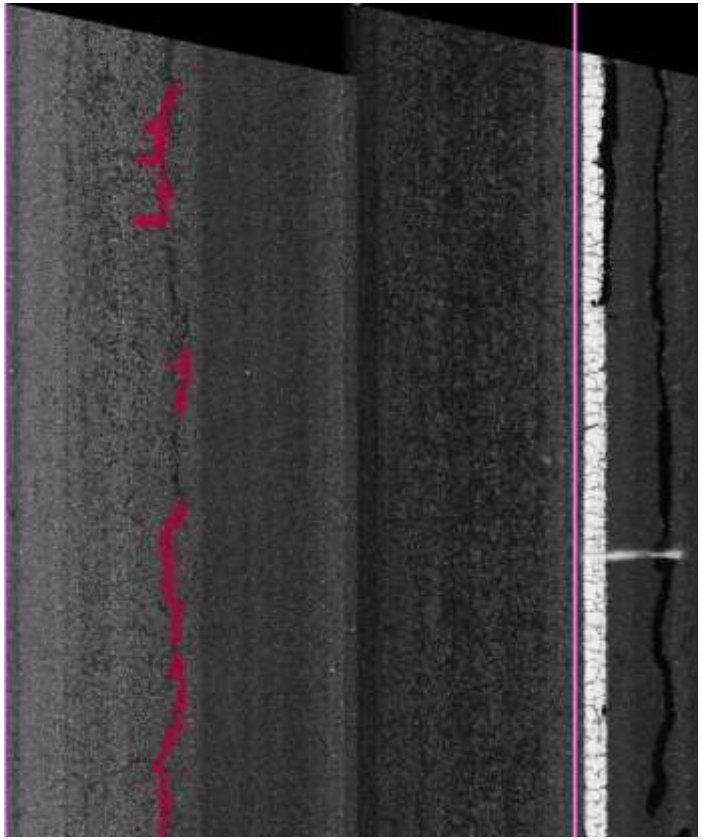
Example 5 (raveled section partially repaired)

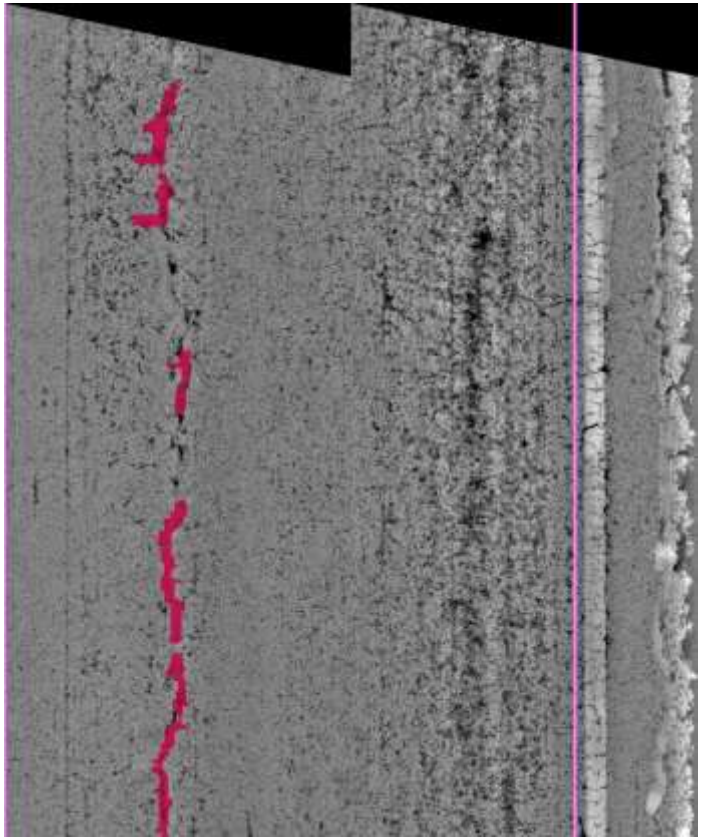




Pavemetrics

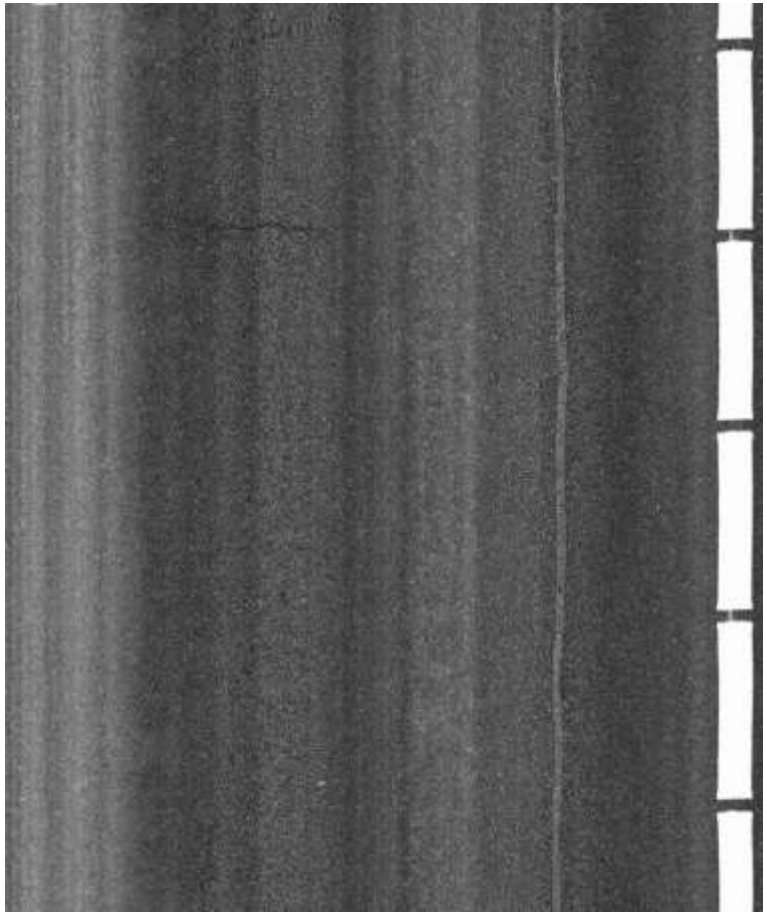
Example 5 (raveled section partially repaired)

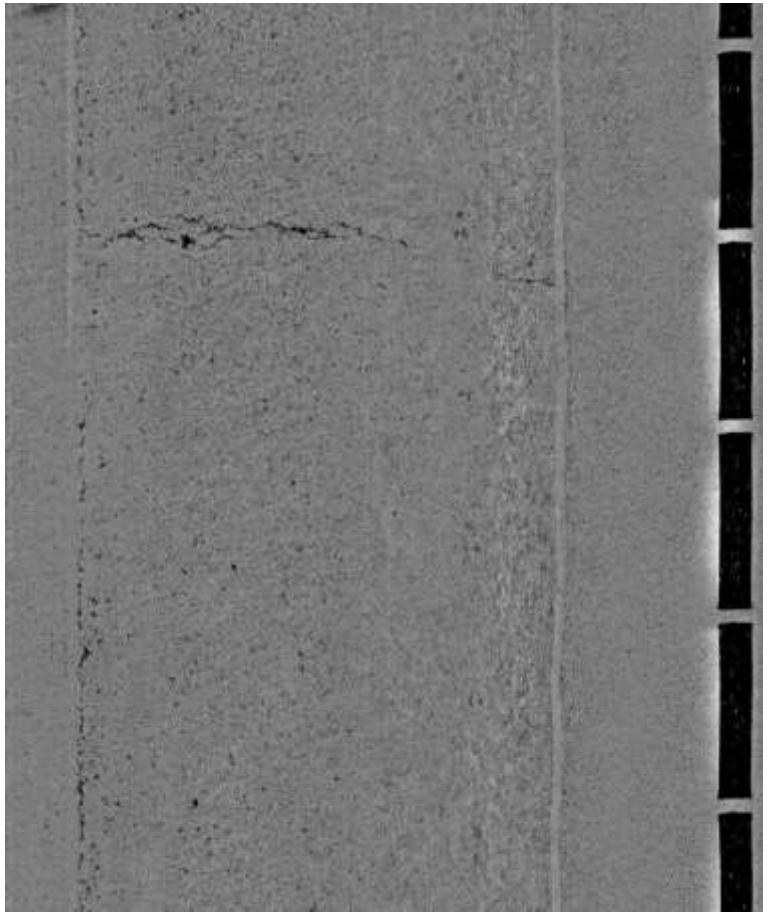




Pavemetrics

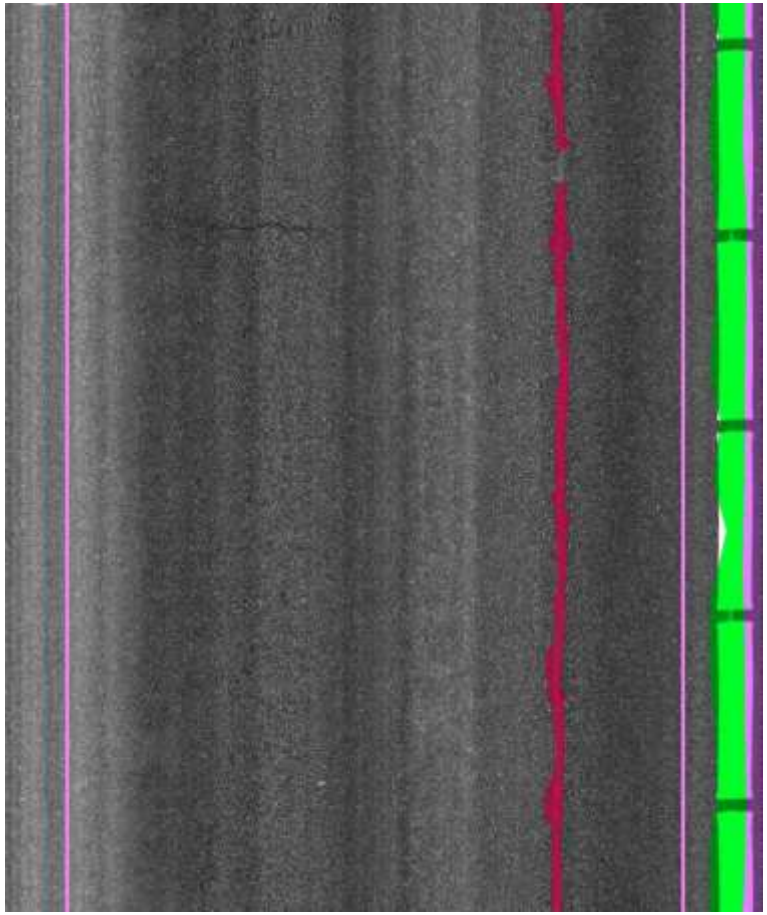
Example 6 (porous road)

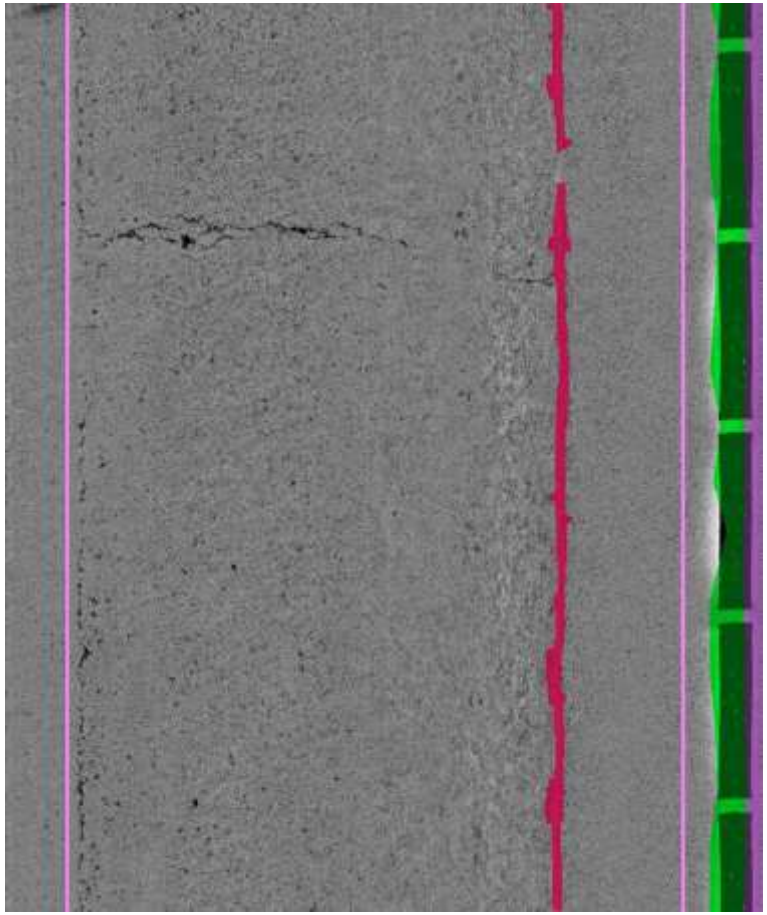




Pavemetrics

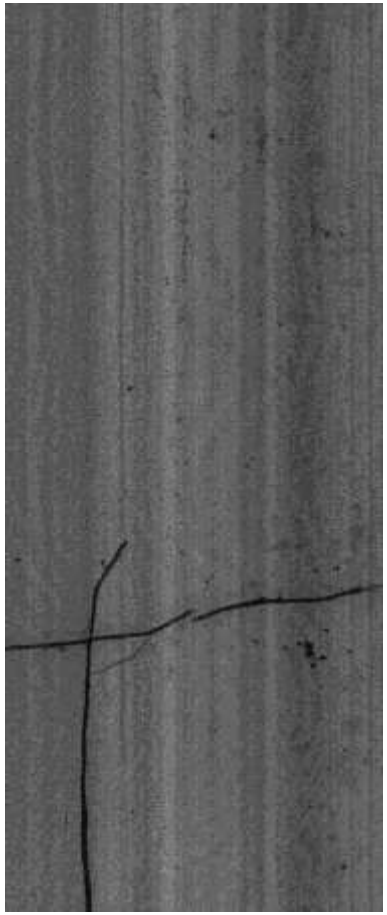
Example 6 (porous road)

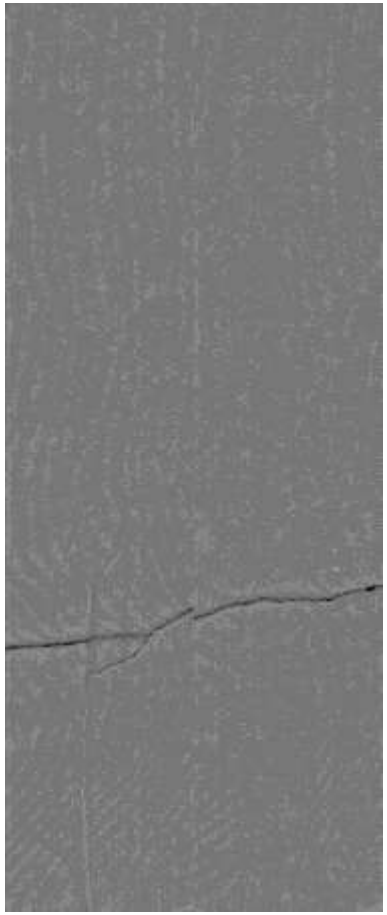




Pavemetrics

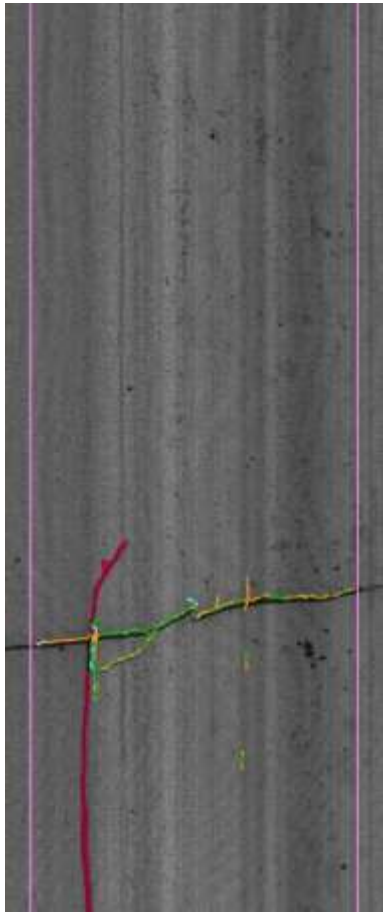
Example 7 (damaged sealing)

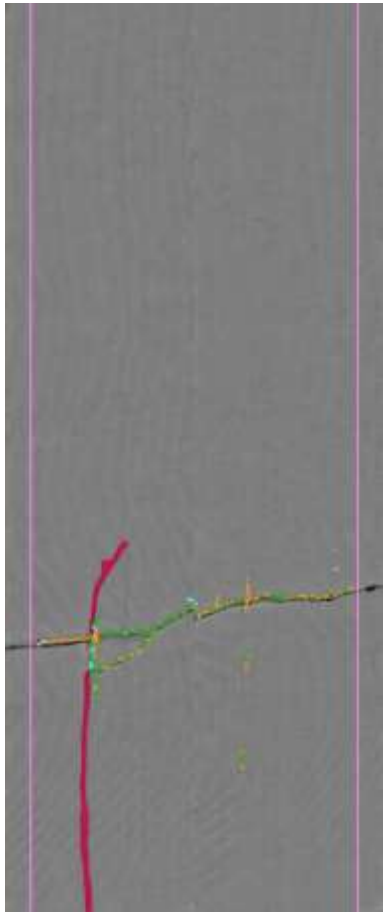




Pavemetrics

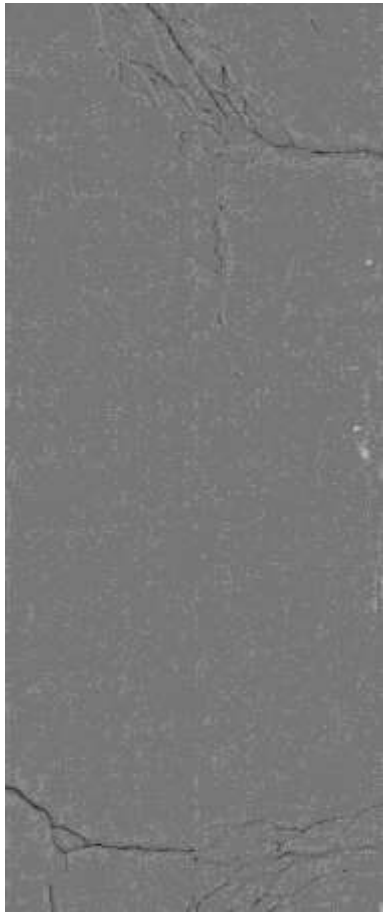
Example 7 (damaged sealing)





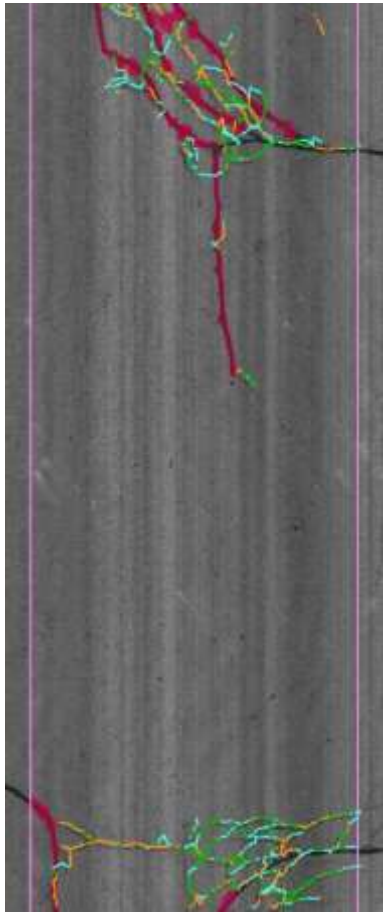
Pavemetrics

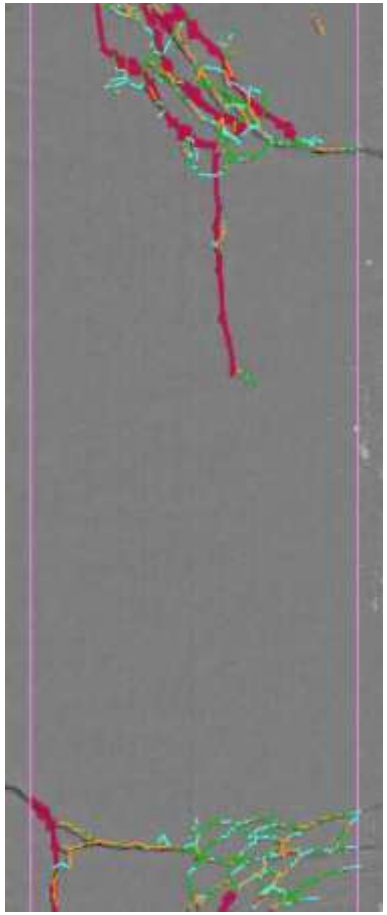
Example 8 (mix of sealed and 3D cracks)



Pavemetrics

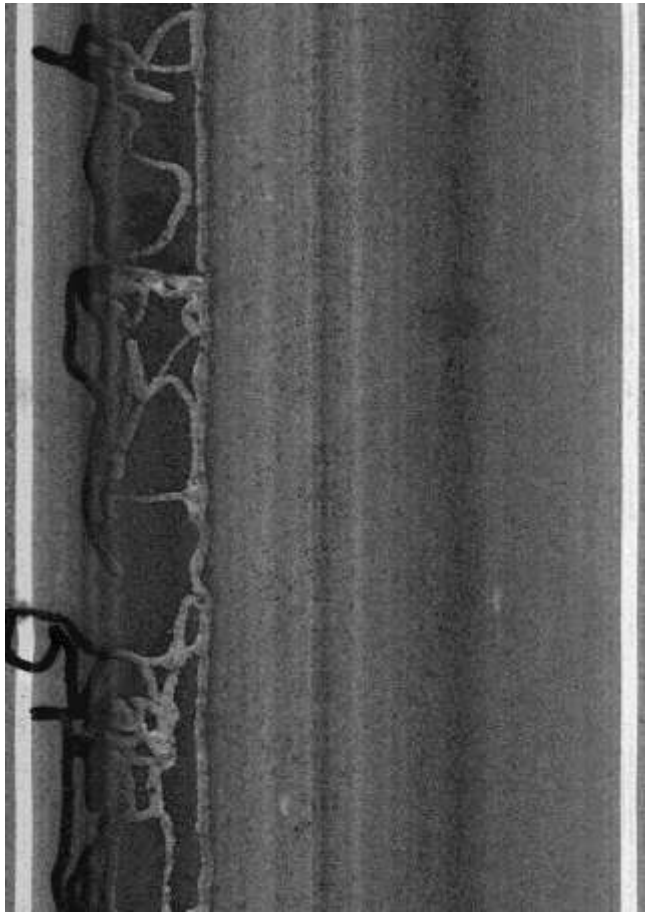
Example 8 (mix of sealed and 3D cracks)

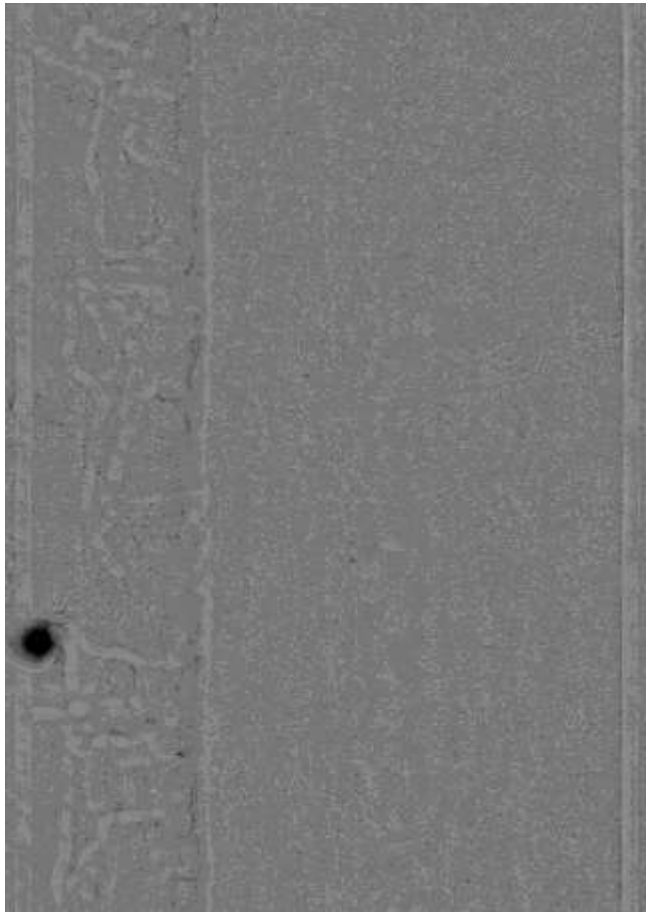




Pavemetrics

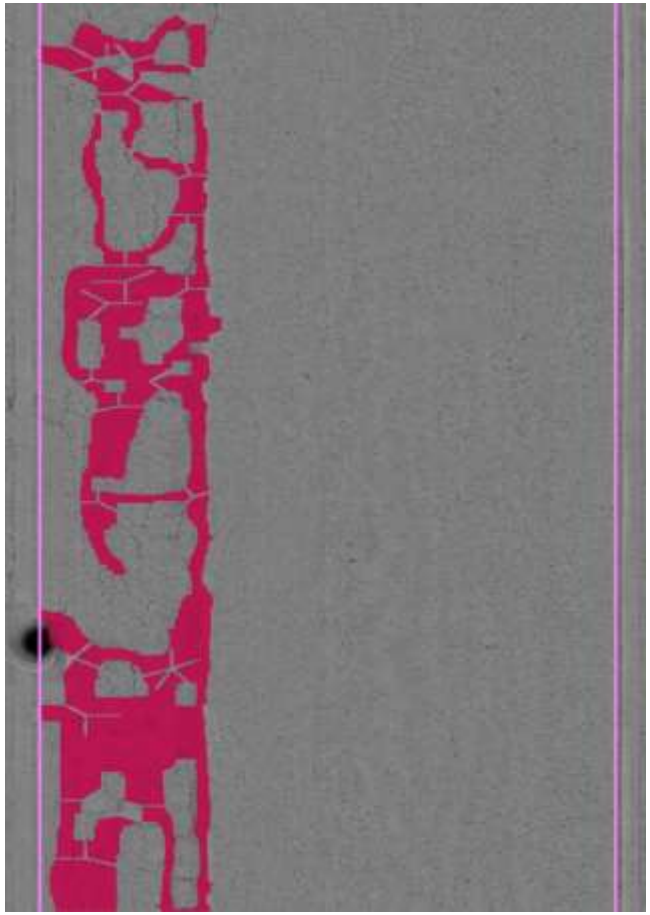
Example 9 (white and dark sealed cracks)





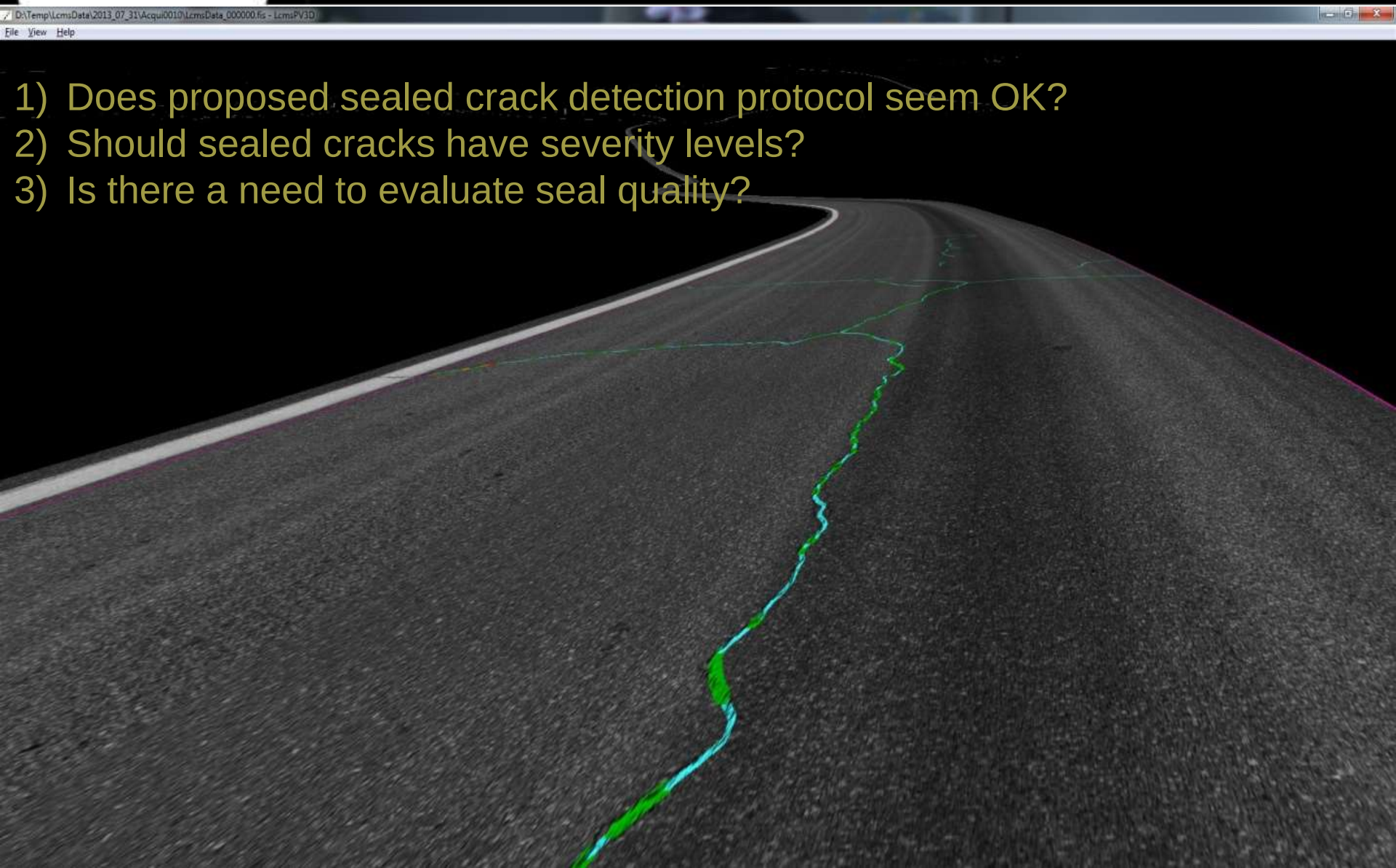
Pavemetrics

Example 9 (white and dark sealed cracks)



Pavemetrics

Any Answers?



1) Does proposed sealed crack detection protocol seem OK?
2) Should sealed cracks have severity levels?
3) Is there a need to evaluate seal quality?