WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE

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7th symposium on pavement surface characteristics

SURF 2012

DETERMINATION OF PAVEMENT SURFACE CRACKS FROM VIDEO-IMAGES USING AN IMAGE SCALE-SPACE APPROACH

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with contributions from
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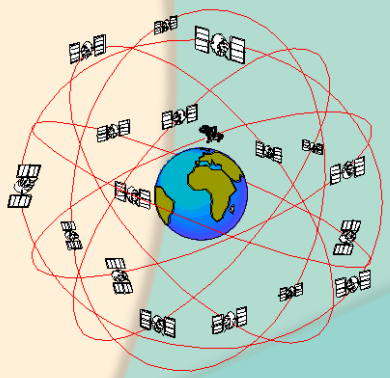


GEOICT

YORK UNIVERSITÉ UNIVERSITY

redefine THE POSSIBLE.

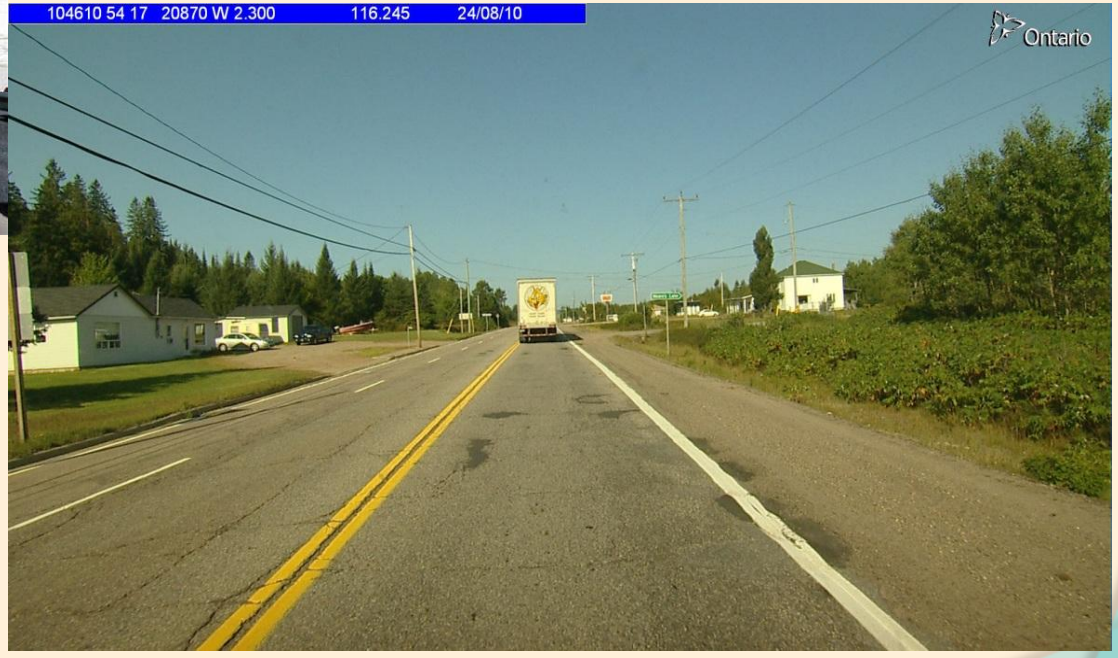
Outline

- Motivation
- Data acquisition
- Image scale-space
- Methodology
- Implementation

Research question

- **MTO has collected a large number of highway images using a video system**
- **Detection and assessment of pavement surface distress from oblique video images**

Image capture



Overview of the methodology

- ** Camera calibration **
- Image scale-space the image
- Image rectification
- Mask road markings
- Detection of pavement distress features
- Classification of the detected distress features
- Determine a severance index per image
- Software development and implemenation

Image scale-space

- **Spatial scale (resolution) of an image depends on the levels of details we can distinguish**
- **Key features in an image can be detected / located based on the scale of the image**
- **An image *I(x,y)* is represented at a different resolution (scale) by applying a Gaussian spatial filter:**

$$I_\sigma(x,y) = I(x,y) * g(x,y,\sigma)$$

Image scale-space

Source: http://en.wikipedia.org/wiki/Scale_space

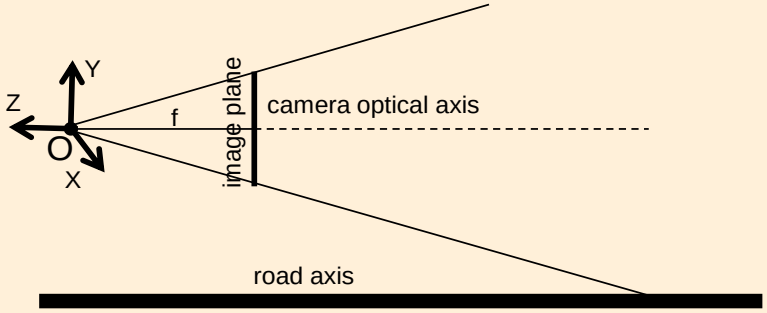
Image Rectification

- **Utilizes the property of parallelism of lane markings to change the view angle of the roads.**

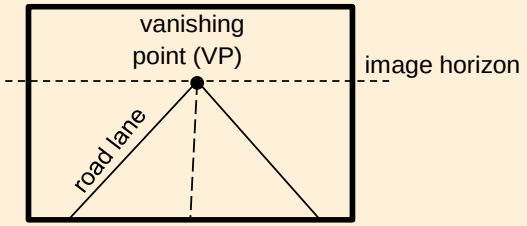
- **The parallel lane markings converge at vanishing point.**

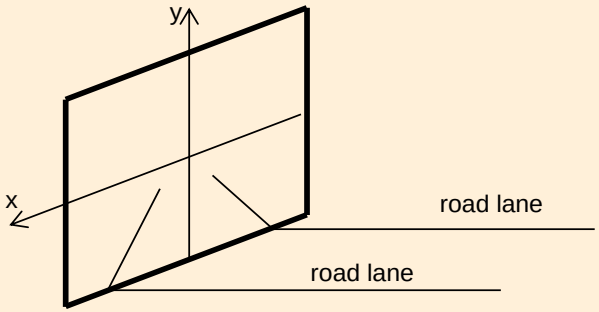
Image geometry and rectification

Image capture geometry

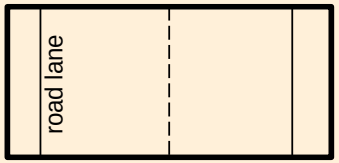


Original Video Image





Perspective geometry

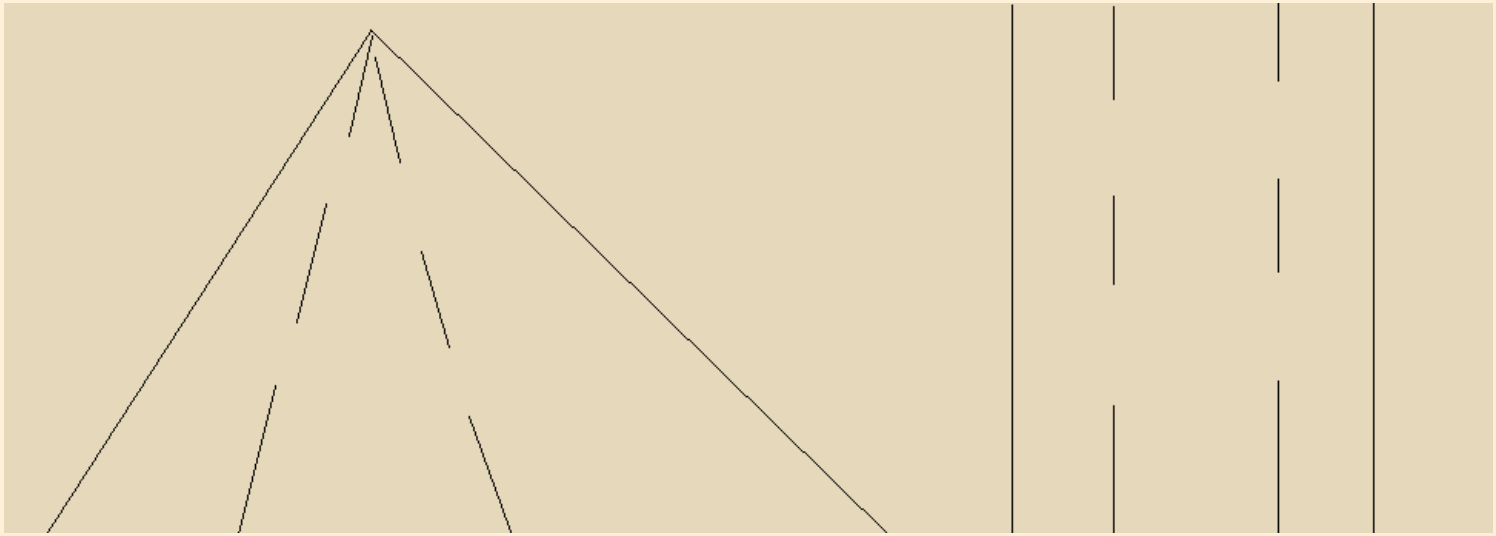


Rectified Video Image

Original and rectified view

Image capture geometry

Rectified image geometry



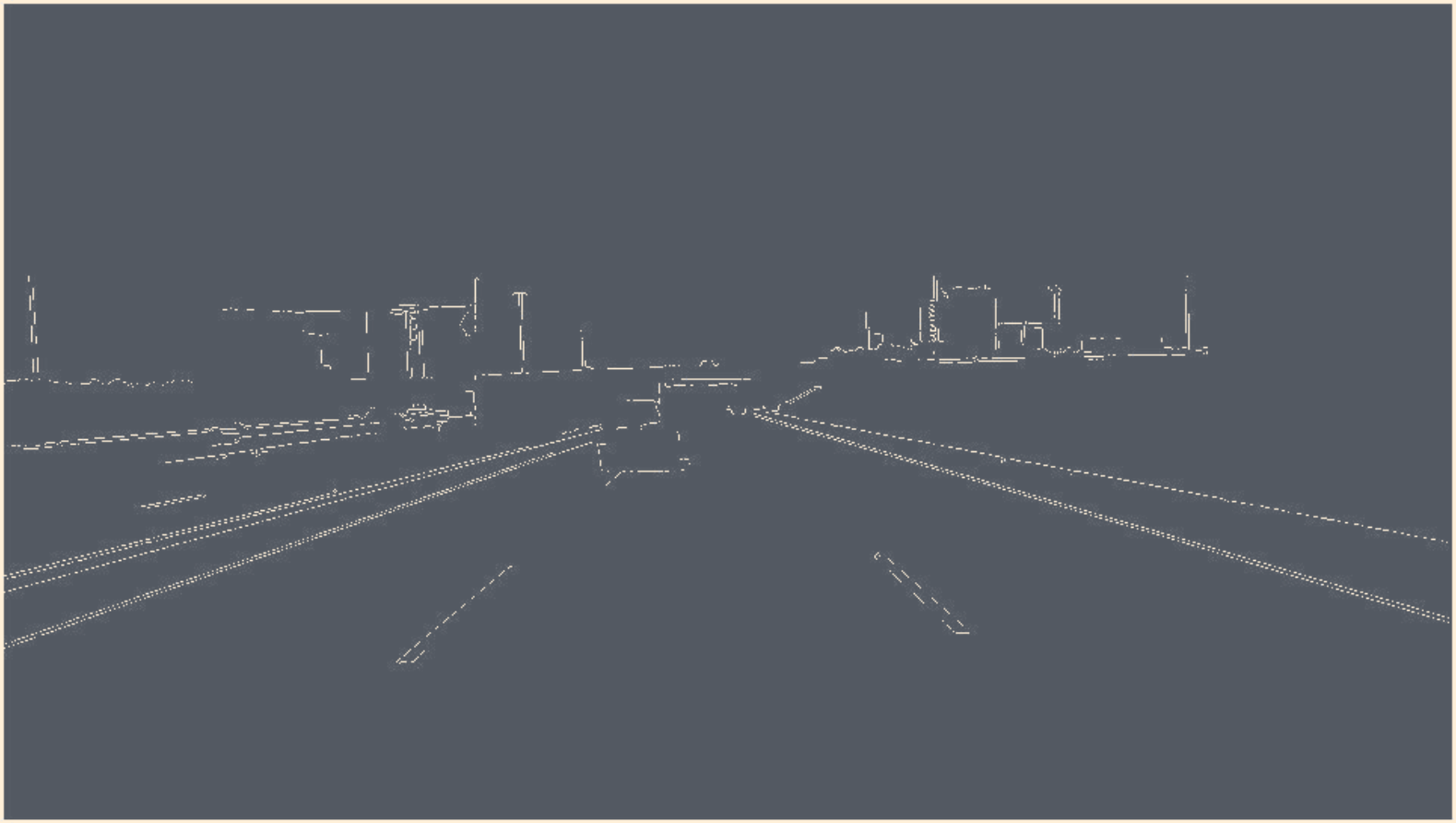
$$R = \begin{bmatrix} n(VP_x) & 0 & 0 \\ n(VP_y) & 1 & 0 \\ n(VP_z) & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = sR^T \begin{bmatrix} x \\ y \\ -f \end{bmatrix}$$

Original Image

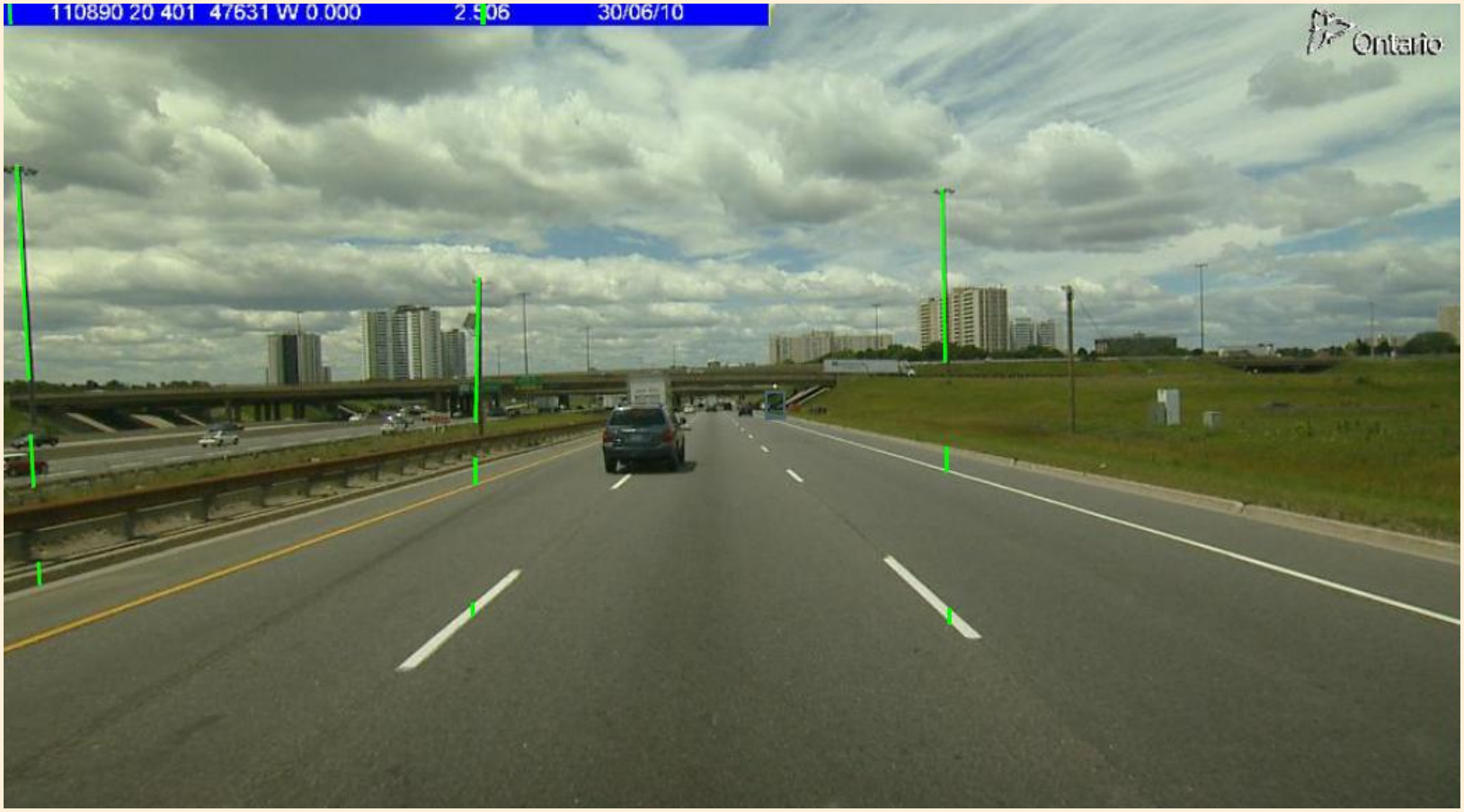
Source: MTO

Lane detection

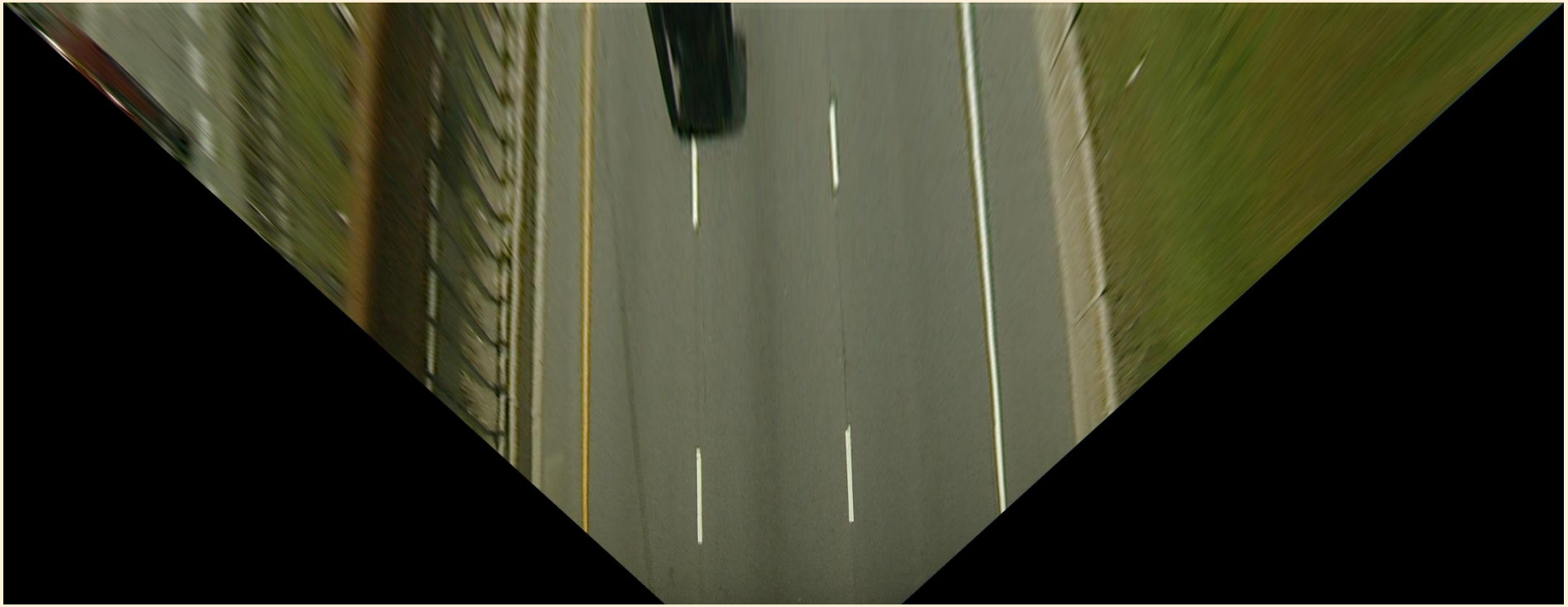


Vanishing Point Calculation

Vanishing Point Calculation



Rectified Image



Crack detection steps

1st Step

Segmentation of Road Markings (Lanes, Centerlines)

- K-Means colour segmentation

Mask Pixels of Segmented Markings

- Morphological filtering

(Erosion filter to completely remove lane marking pixels)

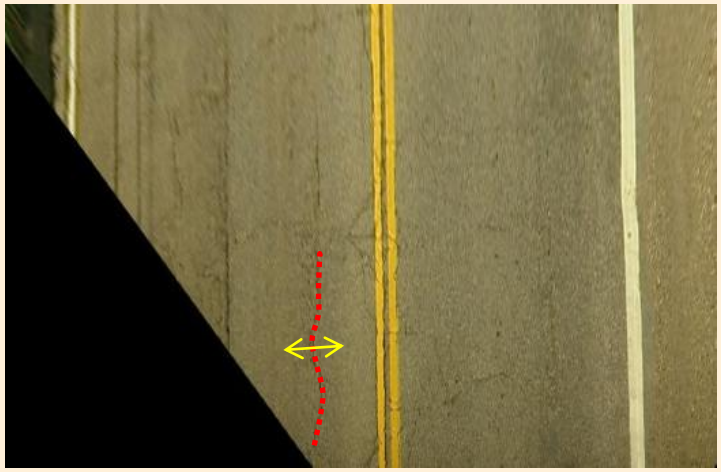
2nd Step

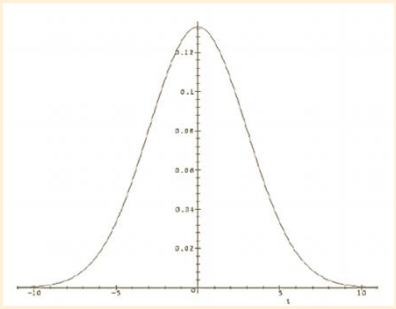
Detection of Curvilinear Features

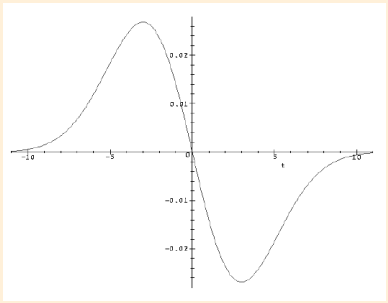
- Applied Steger's curvilinear feature detection algorithm

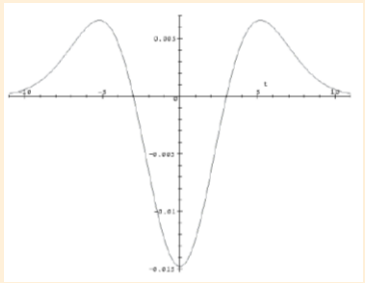
Segmentation of lane markings

Detection of crack lines in the image -concept









Detection of lines in the image-model

- The direction that of the profile perpendicular to the line corresponds to the maximum curvature of the *I(x,y)*

- The direction is determined by the eigenvectors of the Hessian matrix $H_\sigma(x,y)$ of the scale-space smoothed image $I_s(x,y)$:

$$H_\sigma(x,y) = \begin{bmatrix} I_{xx} & I_{xy} \\ I_{xy} & I_{yy} \end{bmatrix}$$

- The max eigenvalue is a line point .

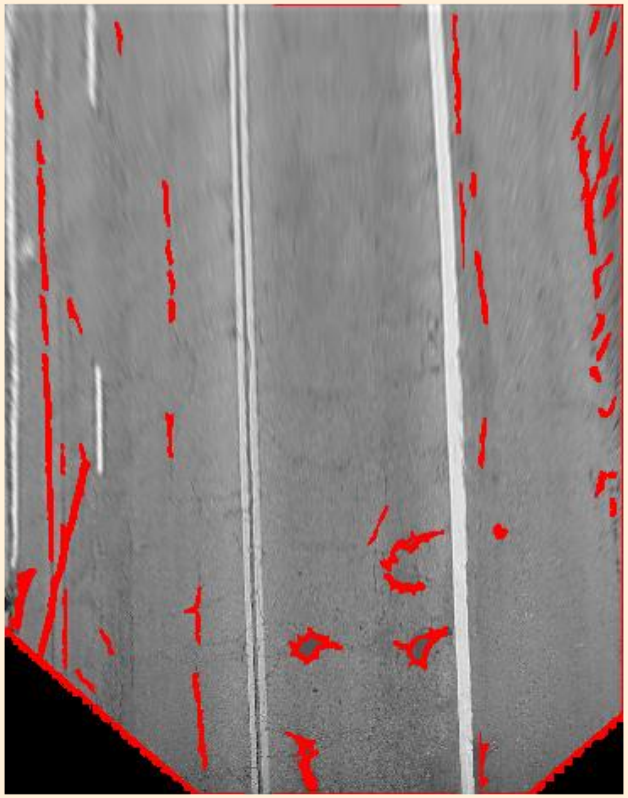
Eigenvalues images

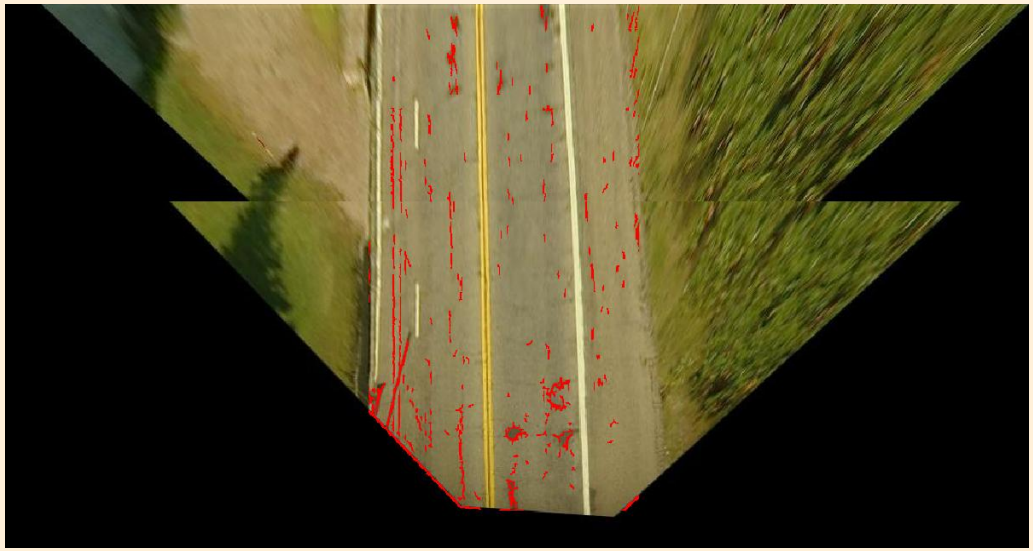
Line plausibility

Thresholding

Filtering

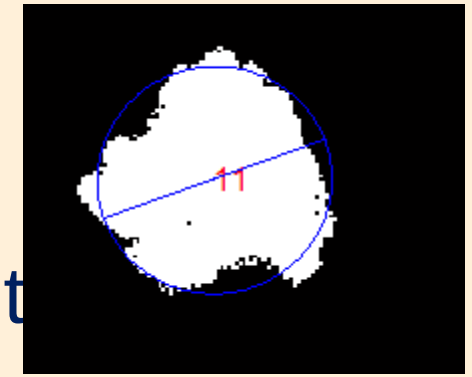
Detected pavement cracks

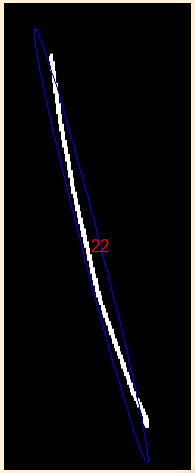




Classification of distress feature

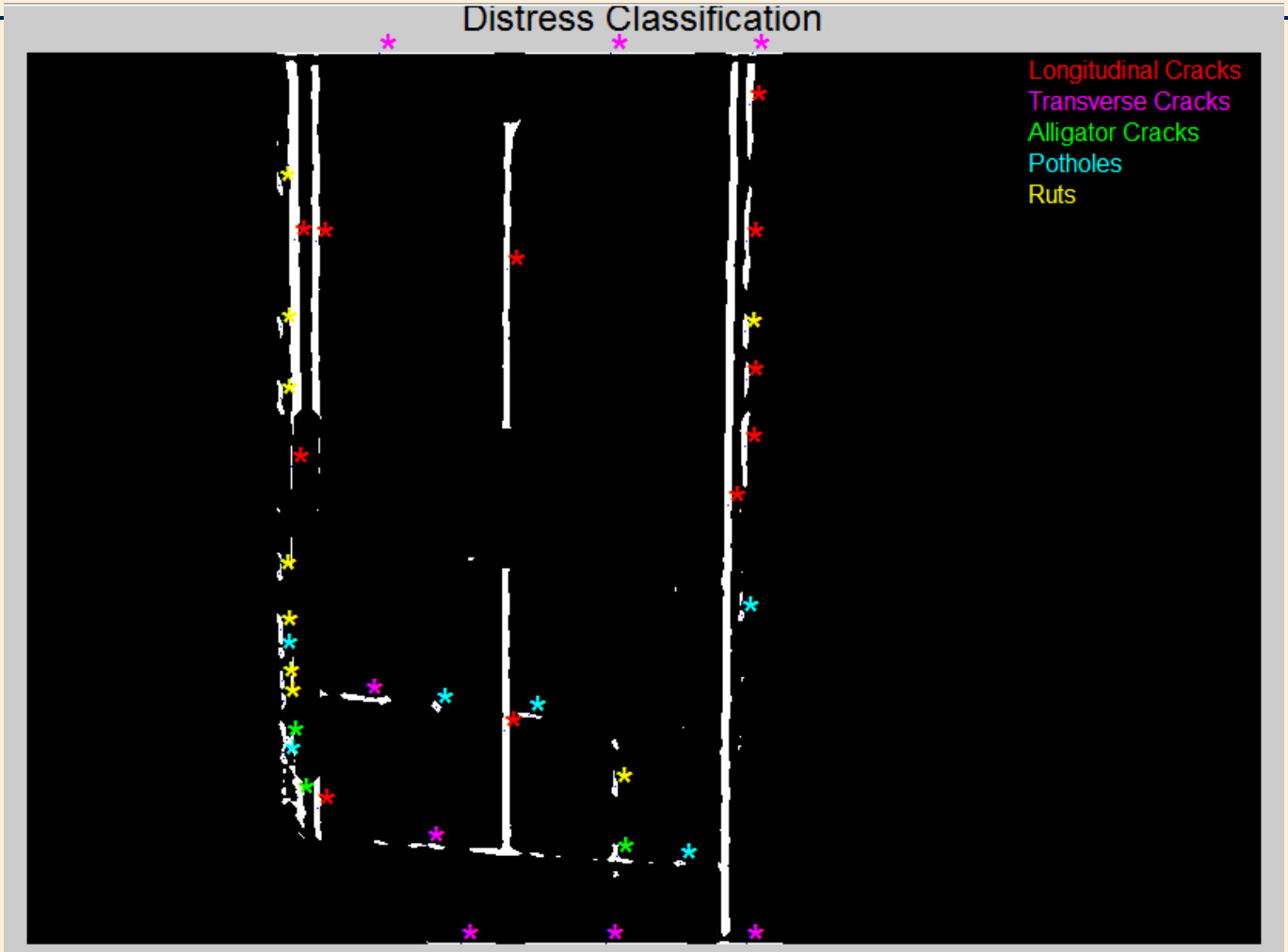
- ratio of width to length,
- area,
- orientation angle of the major axis wit respect to the road axis,
- ratio of actual area to convex hull (indicating area/ extent of feature)
- eccentricity.





$$Feature\ Width / Feature\ Length \cong Minor\ axis\ length / Major\ axis\ length$$

Example of distress classification

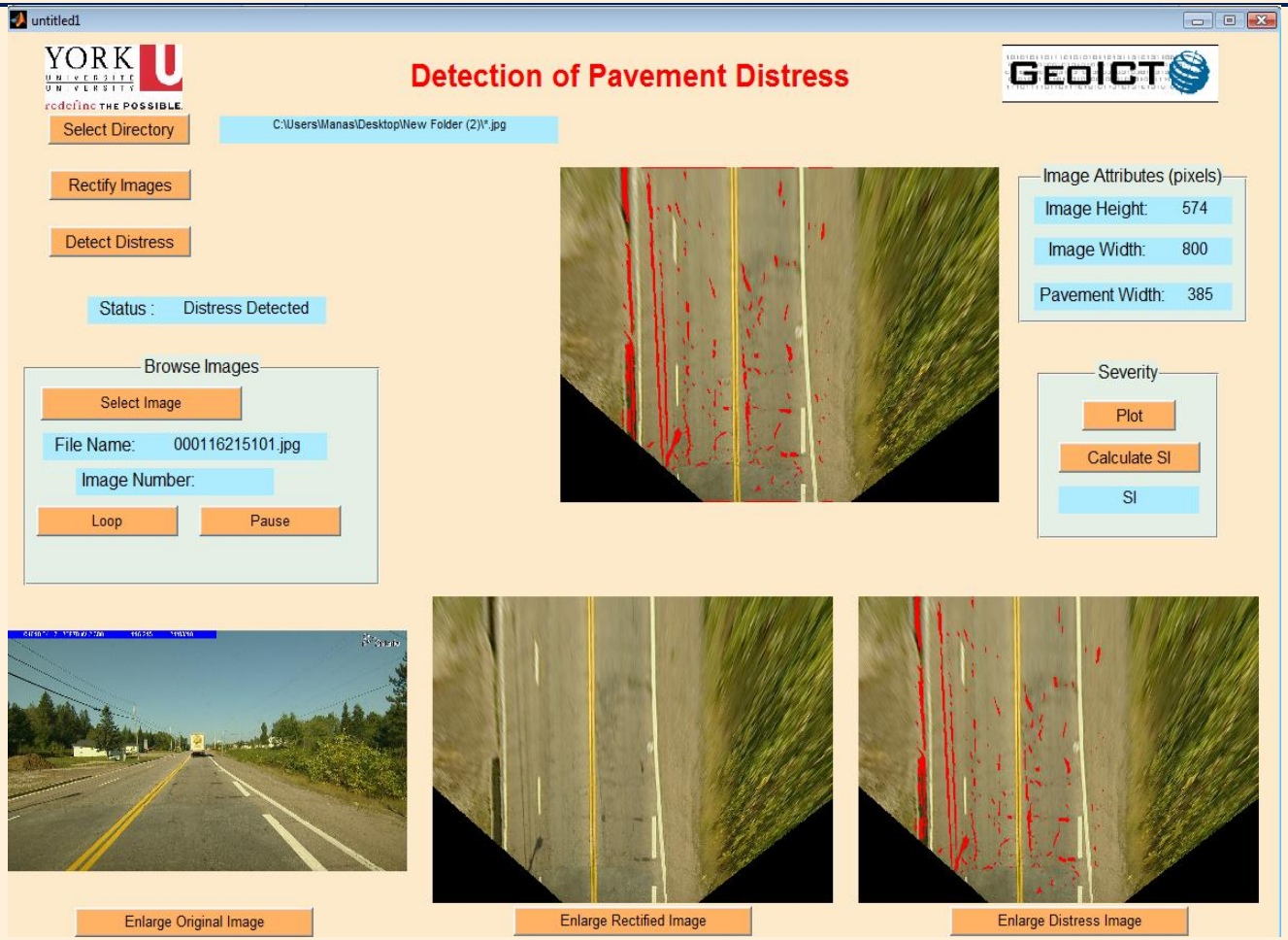


Severity index per image frame

$$SI_{image} = \sum w_i \left(l_i / DI + A_i / AI \right)$$

- i represents the distress feature under consideration, and w_i can be w_{long}, w_{trans}, w_{all}, w_{pot} or w_{rut}.
- l_i is the length of the feature
- A_i is the area of the feature.
- DI is the length of diagonal of the image and
- AI is the area of the image

Implementation



Acknowledgements

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Thank you!