TRIMM is supported by funding from the 7th Framework Programme Call: SST.2011.5.2-2. Theme: Advanced and cost effective road infrastructure construction, management and maintenance

TRIMM Task 4.1 – Identifying Water Ponding

Malal Kane (IFSTTAR) and Dean Wright (TRL)

TOMORROW'S ROAD INFRASTRUCTURE MONITORING AND MANAGEMENT

TRIMM Task 4.1

Identifying Water Ponding:

- Road Surface Data
- Water Ponding Algorithms
- Testing
- Conclusions

Introduction

TRIMM

Safety issues

- Skid resistance
  - ✓ **Hydroplaning**
  - ✓ …
- Splash/Spray
  - ✓ **Visibility issue**
  - • …

Objective

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Offering the possibility to predict and detect where water might accumulate on a given road network (or local road) after heavy rains :

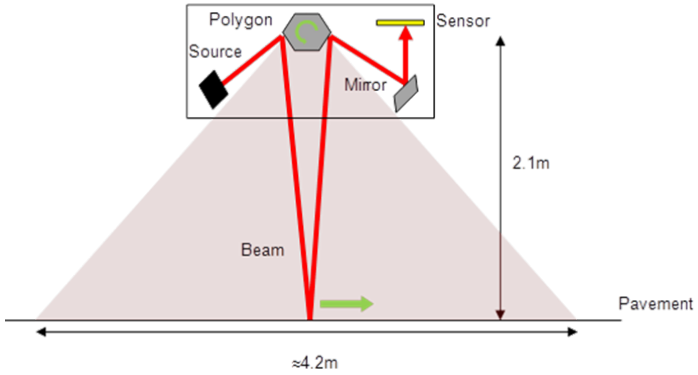
- from the **3D height data** of these road surfaces
- to build an **algorithm** capable to evaluate the quantity and distribution of water present on road surfaces after heavy rains

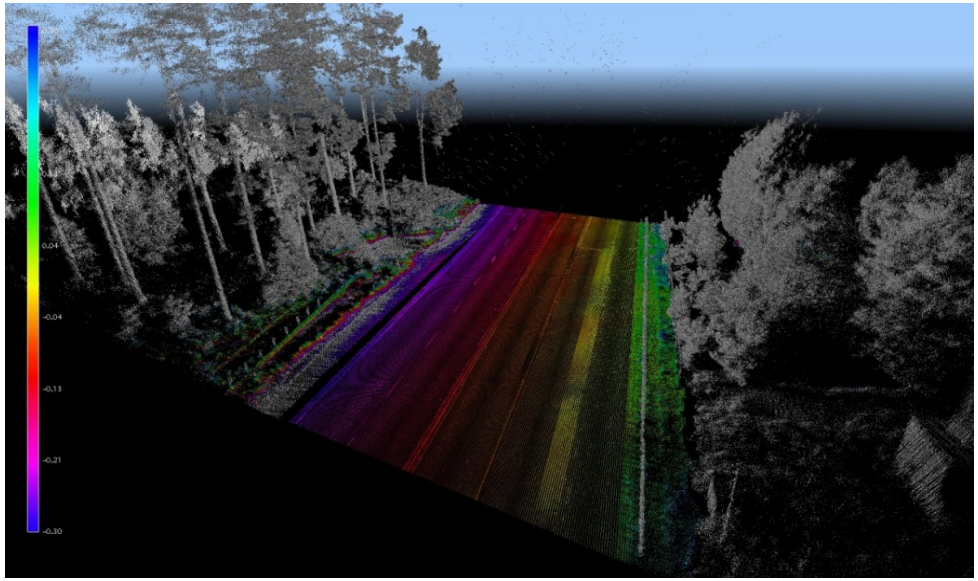
Road Surface Data

3D surface measurement system

TRIMM

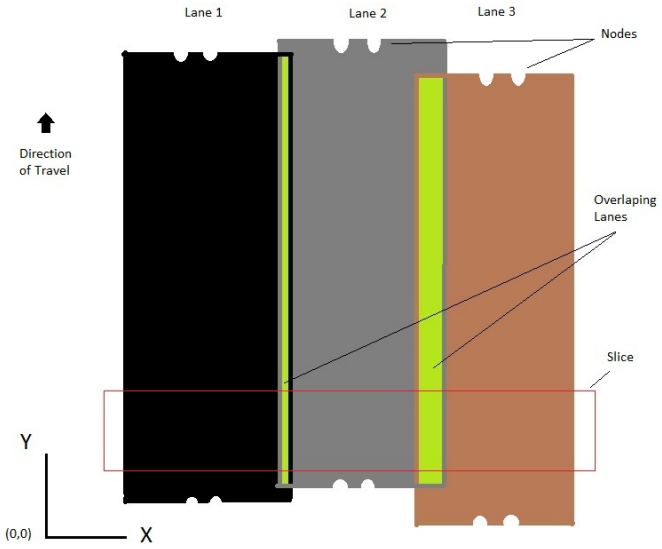
GPS, LIDAR and PPS (Pavement Profile System) mounted on the HARRIS2 vehicle

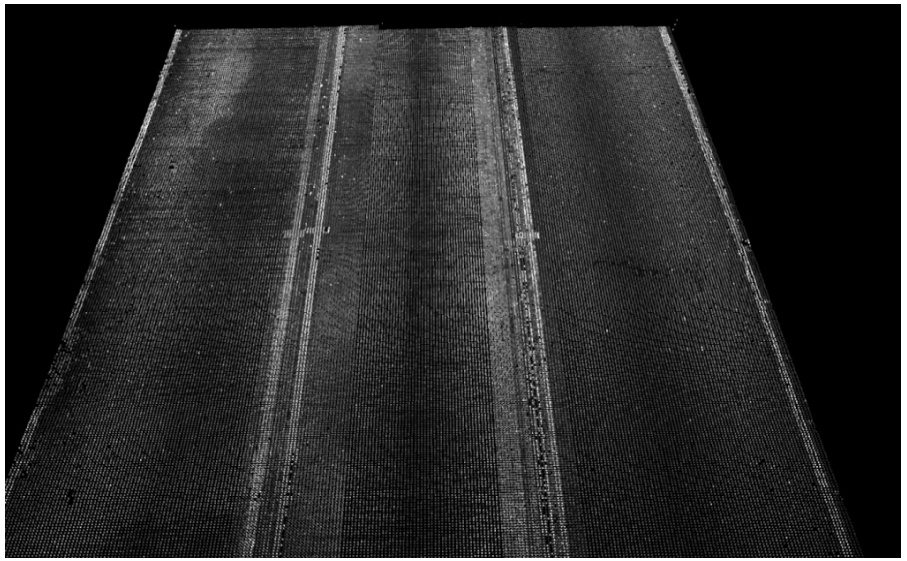




Road Surface Data

Data alining





- Road Surface data is captured in scans of multiple lanes.
- Data is offset due to GPS drift.
- Data must be re-aligned, since information is needed about the entire carriageway.

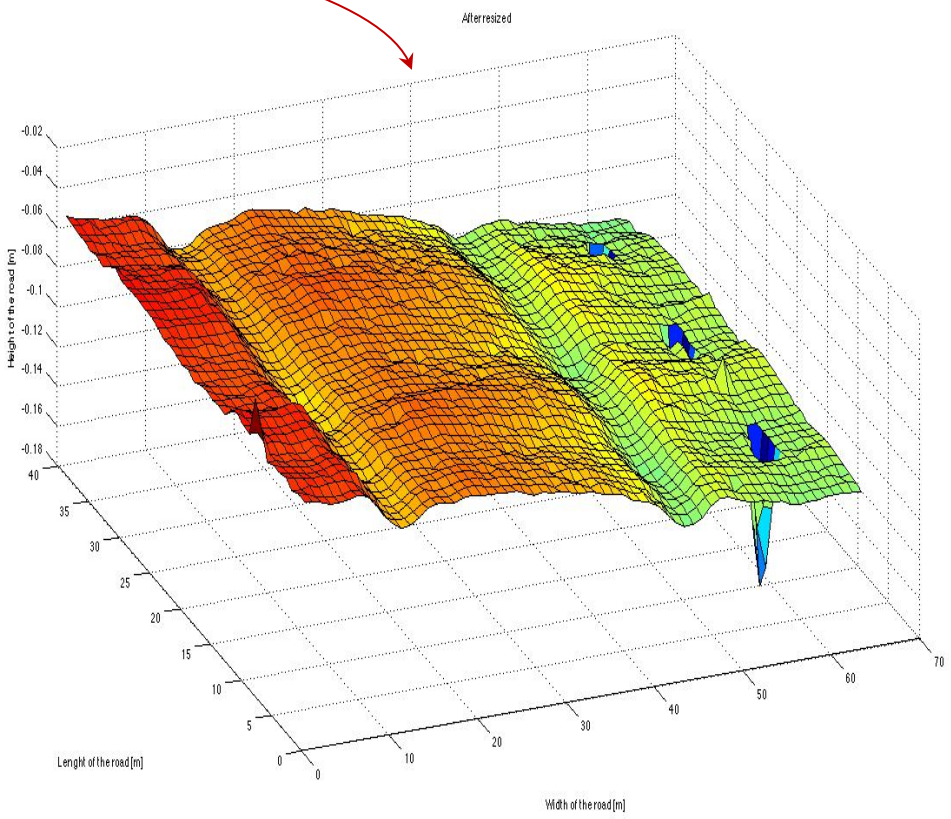
- Mulitple methods for aligning data, (correlation, LIDAR)
- Automated methods work well in the presence of broken white lines
- Automated methods work poorly in the absence of features appearing between the lines

Water Ponding Algorithms

Data formatting (pre-treatment)

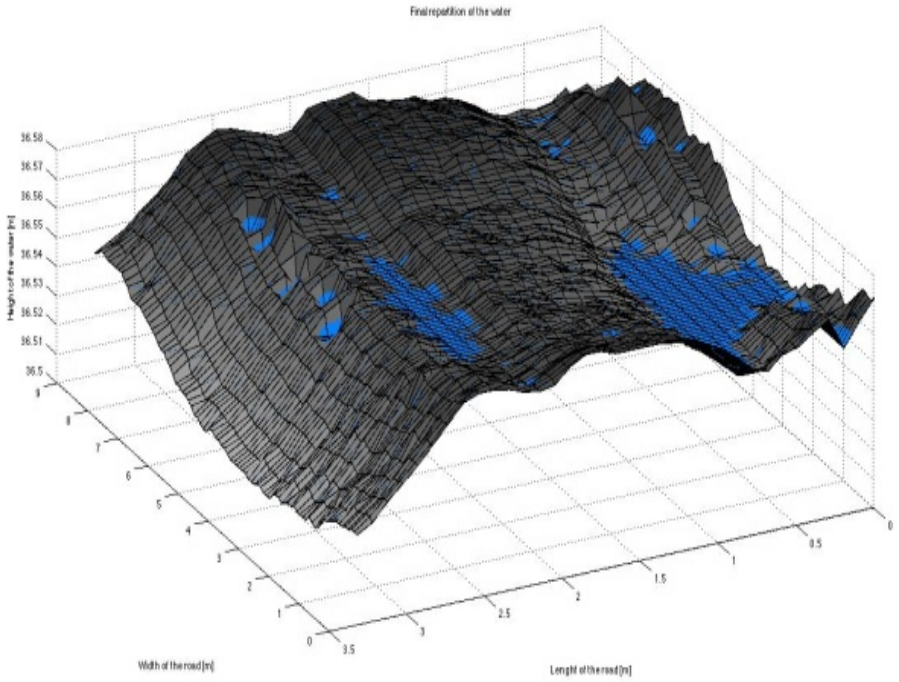
TRIMM

X	Y	Z	Red	Green	Blue
1319.30,	-2875.32,	208.40,	107,	107,	107
1337.29,	-2912.78,	243.56,	117,	117,	117
1310.47,	-2692.31,	255.17,	119,	119,	119
1272.00,	-3733.04,	272.49,	109,	109,	109



Raw data: Typical Point Cloud excerpt data. Each line represents 1 point (the X, Y, Z co-ordinates of the point and the Red, Green & Blue levels)

Water Ponding Algorithms

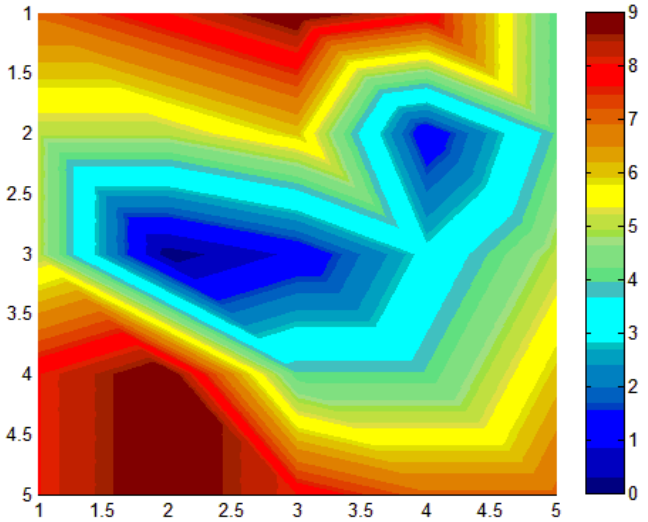


Water Ponding Algorithms

An overview of the iteration process

To illustrate, consider an arbitrary total volume of 16 (arbitrary units) that has fallen on the surface.

$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 0 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$



H is the height matrix

Water Ponding Algorithms

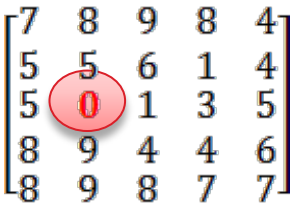
An overview

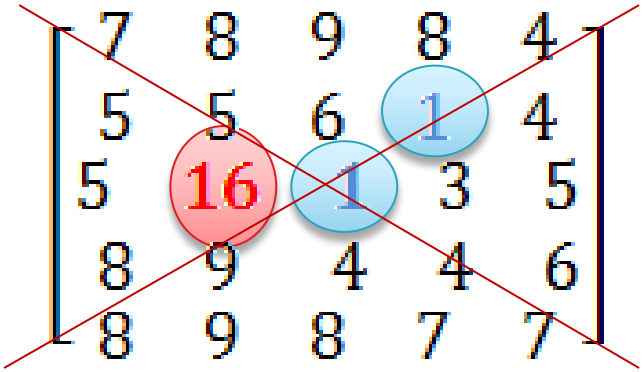
$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 0 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 16 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

Water Ponding Algorithms

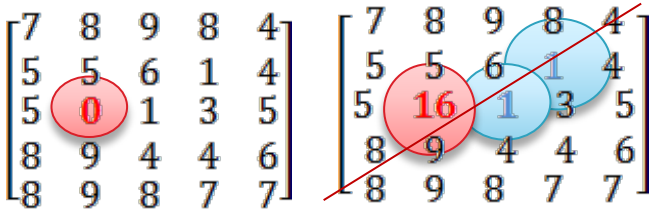
An overview





Water Ponding Algorithms

An overview

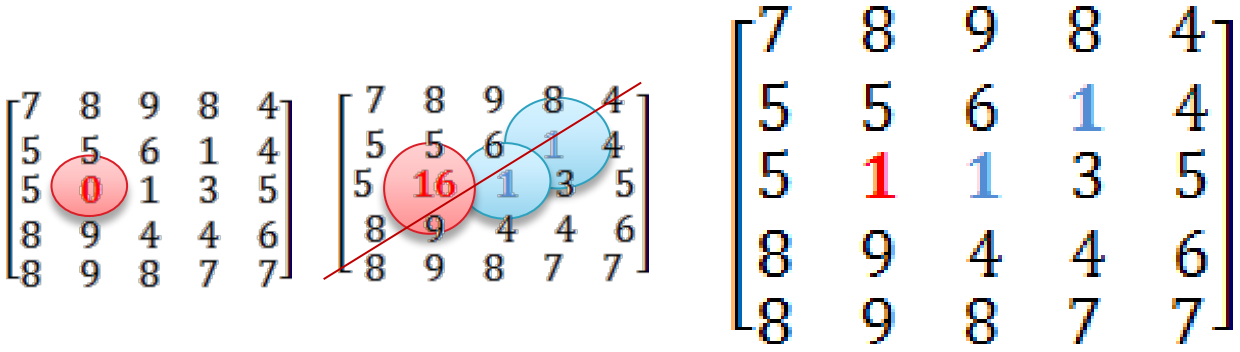


$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 1 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

The new local volume available becomes 15

Water Ponding Algorithms

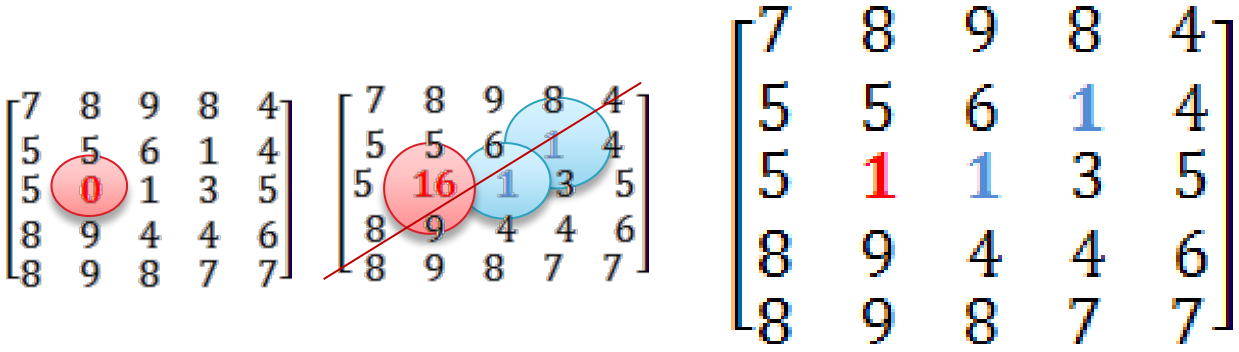
An overview



The 16 is reduced to 1… and now the new local volume available becomes 15

Water Ponding Algorithms

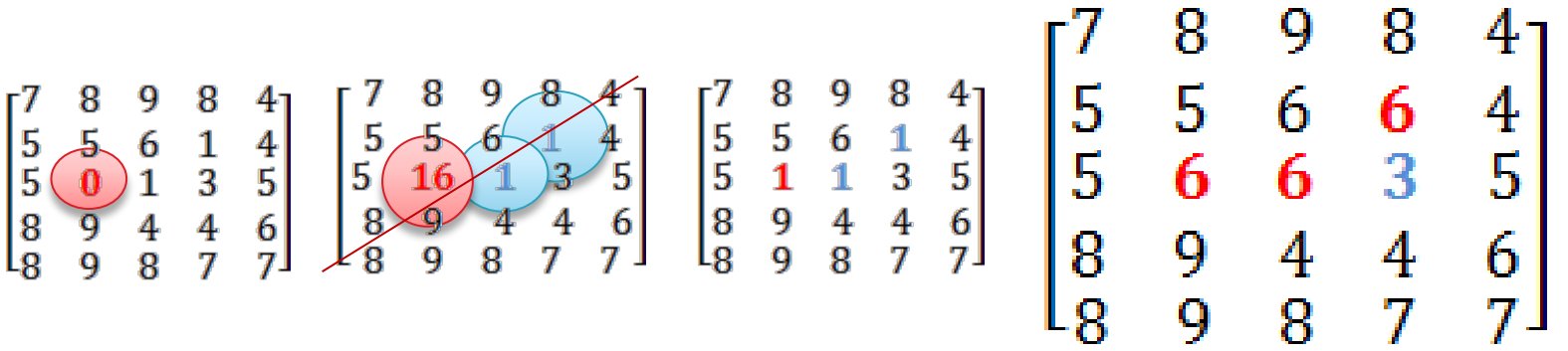
An overview



the new local volume available 15 has to distributed to the 3 new minimums

Water Ponding Algorithms

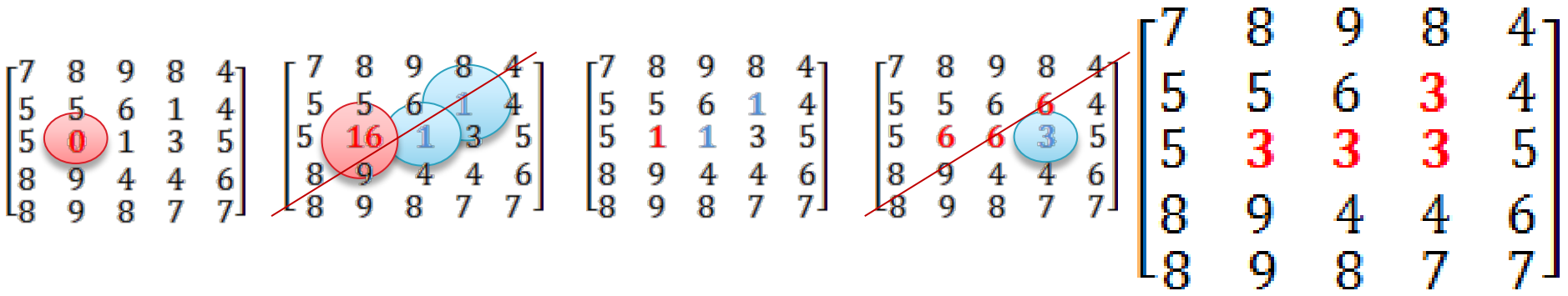
An overview



After distribution

Water Ponding Algorithms

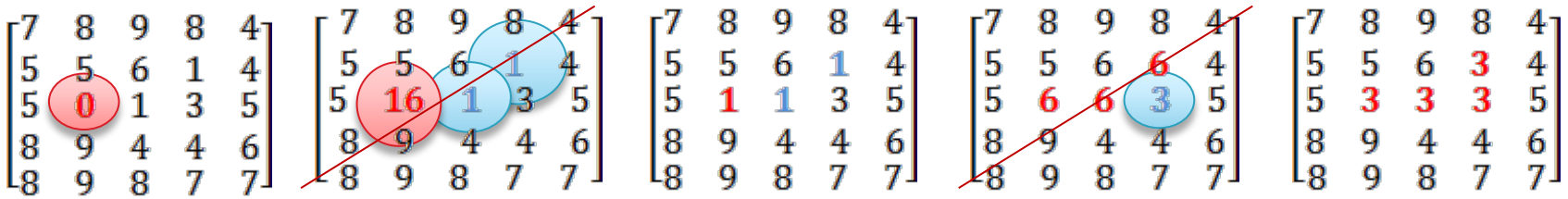
An overview



the new local volume available 9 has to distributed to the 4 new minimums

Water Ponding Algorithms

An overview

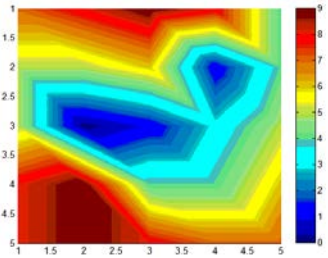


$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 5.25 & 4 \\ 5 & 5.25 & 5.25 & 5.25 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

After distribution

Water Ponding Algorithms

An overview

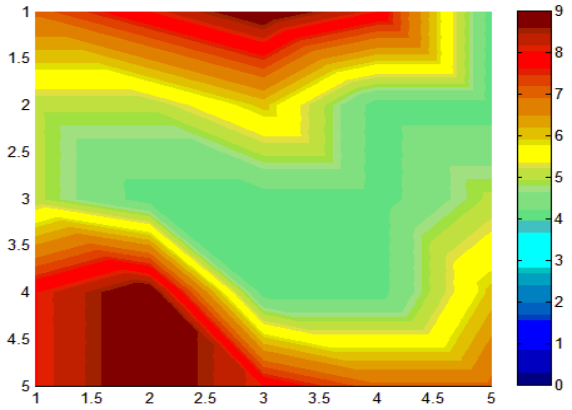


$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 16 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix} \quad \begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 1 & 4 \\ 5 & 1 & 1 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix} \quad \begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 6 & 4 \\ 5 & 6 & 6 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix} \quad \begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 3 & 4 \\ 5 & 3 & 3 & 3 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 5.25 & 4 \\ 5 & 5.25 & 5.25 & 5.25 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

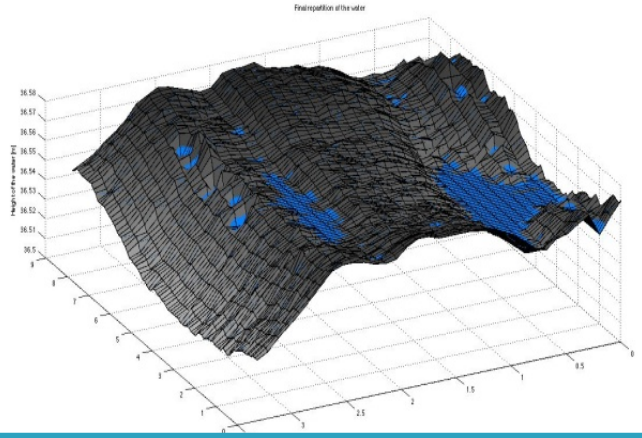
$$\begin{bmatrix} 7 & 8 & 9 & 8 & 4 \\ 5 & 5 & 6 & 4 & 4 \\ 5 & 4 & 4 & 4 & 5 \\ 8 & 9 & 4 & 4 & 6 \\ 8 & 9 & 8 & 7 & 7 \end{bmatrix}$$

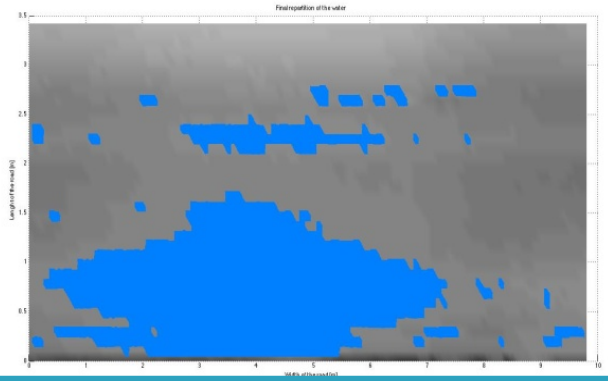
the available volume flows out of the road



Water Ponding Algorithms

TRIMM



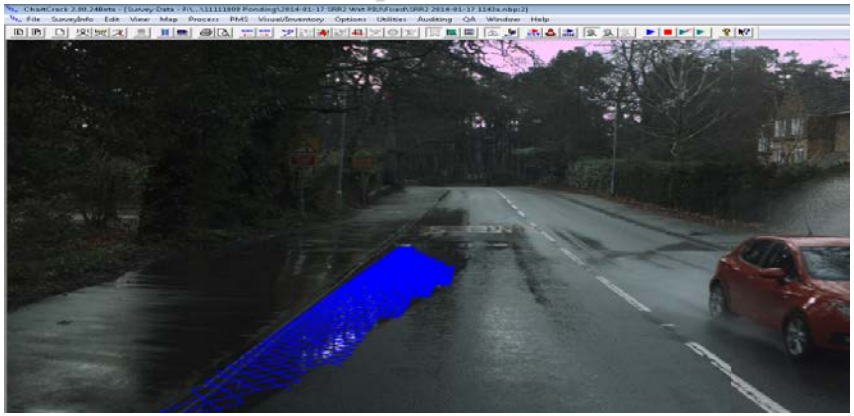


- A model of the road surface is provided by road survey data.
- Boundary options for the road are selected.
- A quantity of water to add to the surface is selected.

- Water runs into the minimums on the road.
- A matrix methodology determines the locations of the minimums and how the water behaves around them.
- Method produces an output describing the percentage of the surface covered in water, as well as the water volume.

Testing

Local analysis

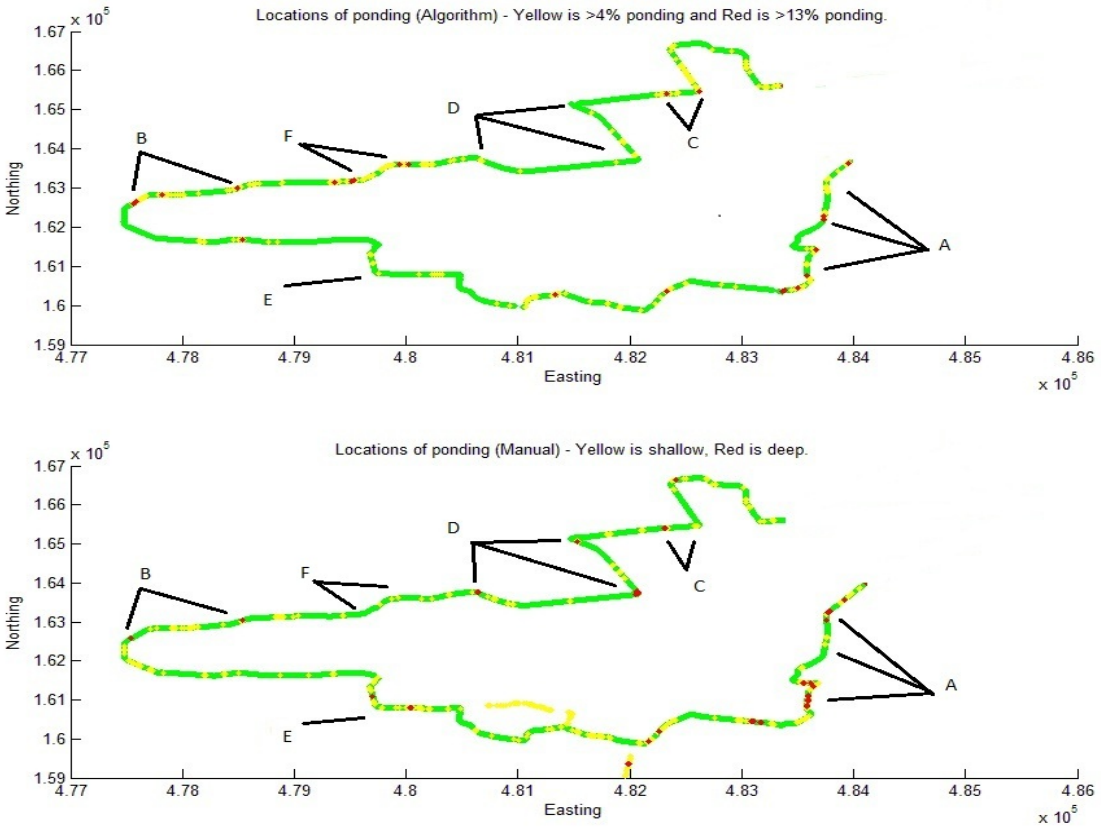


- TRL carried out a HARRIS2 survey of local roads on a dry day and a rainy day.
- Road scan data collected in the dry was sent to IFSTTAR for analysis.
- Image data collected in the wet was analysed by TRL by hand to find areas of water ponding.

- Comparison of water ponding algorithm against manual analysis showed qualitative agreement.
- Where there was disagreement, this usually arose from incorrect boudnary conditions (kerbs) or the presence of steep slopes on the roads that were not being accounted for in the analysis.

Testing

Global analysis



Comparison between automated (top) and manual (bottom) water ponding analyses for a 26km site close to TRL in the UK

TRIMM Task 4.1 – Conclusions

- Can treat a whole road defined by several sections.
- Can easily find hazardous areas on the entire road by sorting out important values from the analysis.
- Can precisely treat a small section of the road.
- Provides results that are easily understandable by the user.
- Can modify the road profile to keep only the important part of the road, by removing useless points or adding some boundaries conditions.