CETE Normandie Centre
centre d'Études techniques de l'Équipement

Optical Recognition of Road De-icers

XIII INTERNATIONAL WINTER ROAD CONGRESS

Quebec, February 8 – 11, 2010

Ressources, territoires, habitats et logement
Énergie et climat
Développement durable
Prévention des risques
Infrastructures, transports et mer

Présent pour l'avenir

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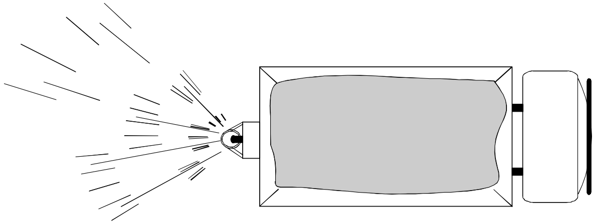
Research goals

Road de-icers (salts):

- Are expensive
- Damage the environment
- Are sometimes hard to come by (this winter in Europe!!)

Deciding to apply a road de-icer is difficult:
- It should be used wisely; that is, at the proper time,
- in the proper shape (solid, liquid or a mix), at the right place and in the proper amount.

Spreading road de-icers is a tricky operation because just a few grams of product must be evenly sprinkled per square meter from a vehicle traveling at 50 km/hr (French regulations)!



Research goals

All countries and all equipement manufacturers are currently working on control of dosage; work on European standardization is being done by Committee 337 (TC 337).

In the context of this work, on-site tests were carried out during a meeting of the technical committee in Bingen, Germany, to visualize different methods.

CEN / TC337 / WG1

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On this occasion, photos were taken; because of the bright sunshine, the contrast between the black rubber ground covers and the white salt was particularly strong. The distribution of salt was easy to evaluate under these conditions.

Could a system or method using image analysis do the same thing?

If we take our reasoning to its logical conclusion, is it possible to determine the mass of salt spread over a given area using a photo?

This is what our research tried to do.

An analogy between certain representations from geographical information systems and a photo of salt grains

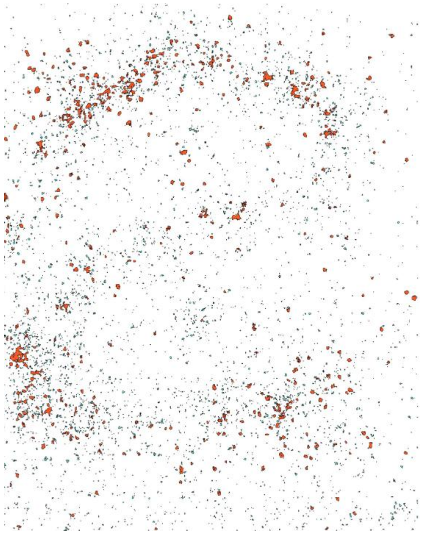
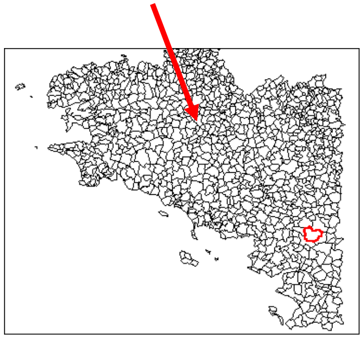
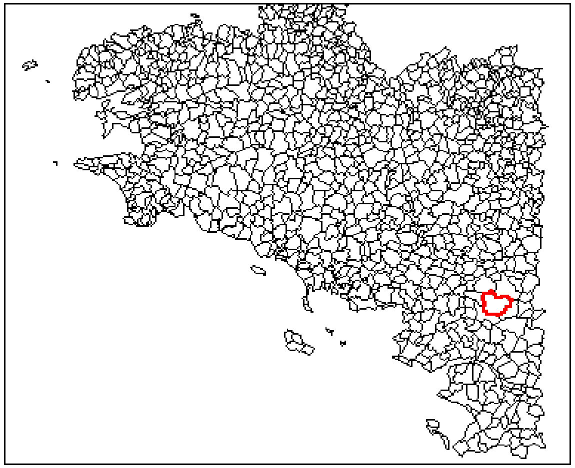


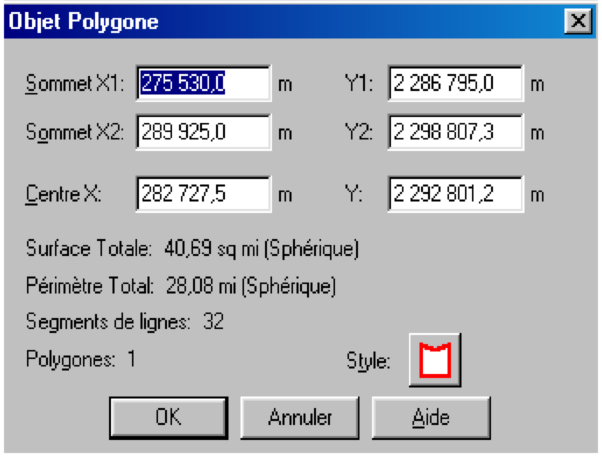
Photo of salt grains



Geo-referenced communes in Brittany…

An analogy between certain representations from geographical information systems and a photo of salt grains





Code_	Nom	Statut	Pop_M	Sup_Ha	X	Y	Z
35009	BAGUER-MORVAN	06	1,3	2 440	2 964	23 974	51
35010	BAGUER-PICAN	06	1	1 613	3 026	24 021	34
35012	BAIN-DE-BRETAGNE	05	5,3	6 604	2 996	23 222	72
35013	BAINS-SUR-OUST	06	2,8	4 516	2 690	23 106	24
35016	BAULON	06	1,1	2 522	2 818	23 414	91
35017	LA BAUSSAINE	06	0,4	978	2 860	23 766	73
35022	BECHEREL	05	0,6	55	2 825	23 750	165
35026	BLERUAIS	06	0,1	336	2 686	23 556	75
35029	BONNEMAIN	06	1,2	2 411	2 970	23 937	70
35033	BOURG-DES-COMPTES	06	1,7	2 344	2 968	23 325	30
35035	BOVEL	06	0,3	1 465	2 792	23 373	74
35037	BREAL-SOUS-MONTFORT	06	3,4	3 394	2 867	23 467	61
35045	BRUC-SUR-AFF	06	0,8	2 116	2 749	23 217	53
35046	LES BRULAIS	06	0,4	1 209	2 716	23 304	58
35047	BRUZ	06	8,1	2 981	2 954	23 442	36

Explanation of the method

A digital photo
Camera format (jpg, raw, etc.)
with pixels

IT Tool
File
Transformation

X,Y, L text file
X and Y are pixel
coordinates and L
is pixel luminosity

Detect and identify salt
using L luminosity

Software to calculate the
spread area and
delimitation of salt grains

Transform
pixel groups
into polygons

Salt Cartography

Determination of the grain surfaces

Determination of the mass

Detect and identify salt using L luminosity

Salt is visible on the photo, where it is lighter. It stands out from the dark road background. Surfacing is recent and has been previously swept. Photographic conditions should be controlled to avoid shadows and tangential sunlight.

No salt

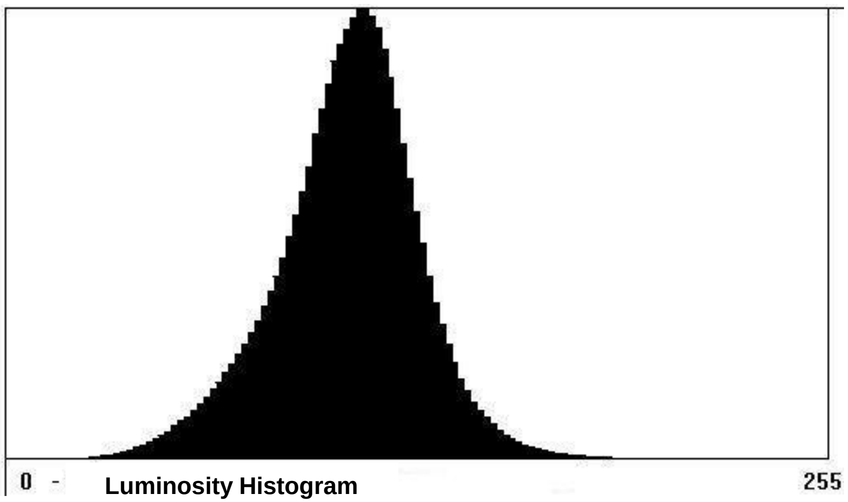
Salt spread by hand

Transformation of JPG file into text file

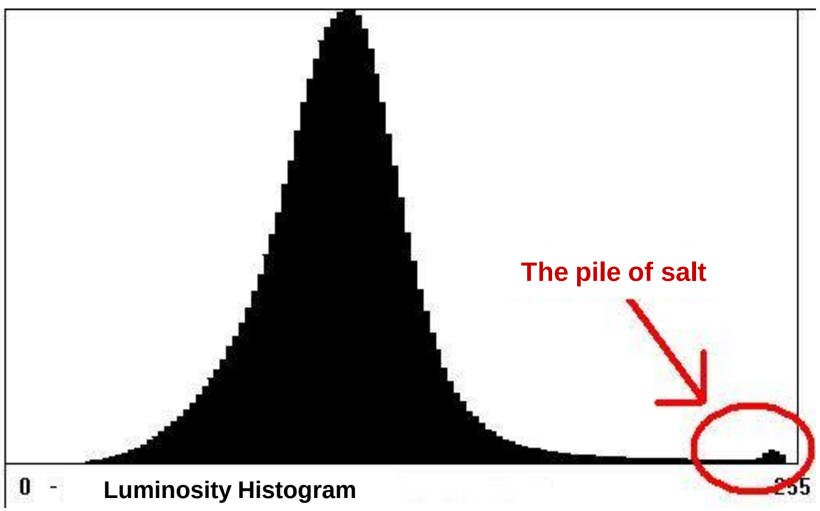
Pixel 1: X1,Y1, L1
Pixel 2: X2,Y2, L2
Pixel 3: X3,Y3, L3
etc.

Construction of a histogram

Detect and identify salt using L luminosity



Histogram of salt-free road



Histogram after salt was added

To detect salt, we used a luminosity histogram. This enables visualizing the number of pixels for each level of luminosity. Luminosity is a value that goes from 0 for black to 255 for white. The luminosity histogram is a bimodal curve: it shows two maxima and two modes.

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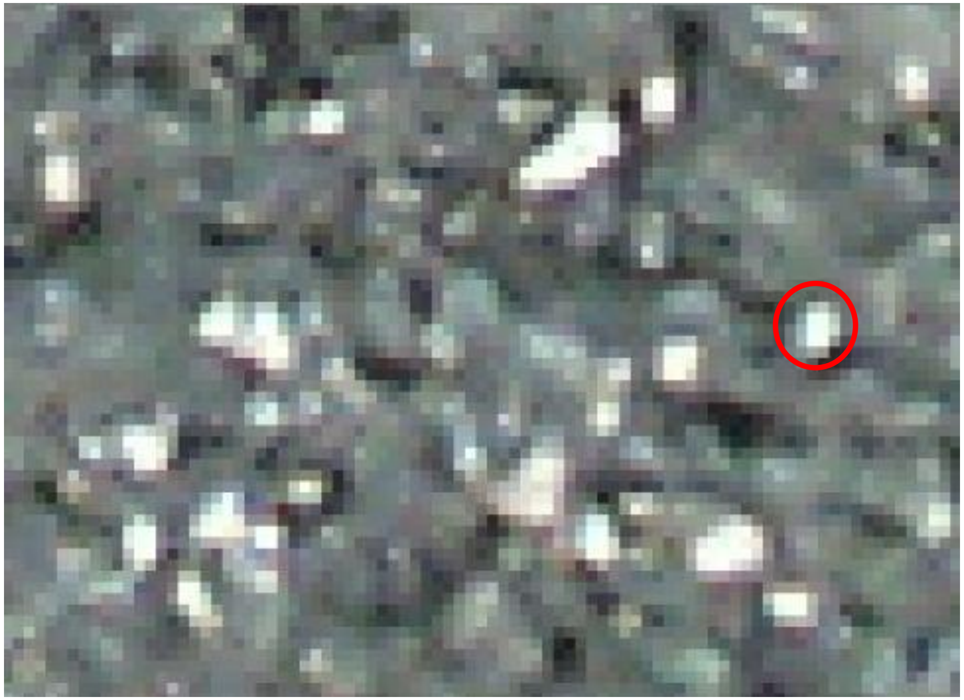
Establish salt cartography by analyzing pixels and their links



The principle is to delimit the contour of a grain using the analysis of pixel luminosity and aggregation rules.

Pixels measure 0.5 mm by 0.5 mm, for a surface of 0.25 mm^2 , which is coherent with the size of salt grains.

Each grain affects the luminosity of several pixels.

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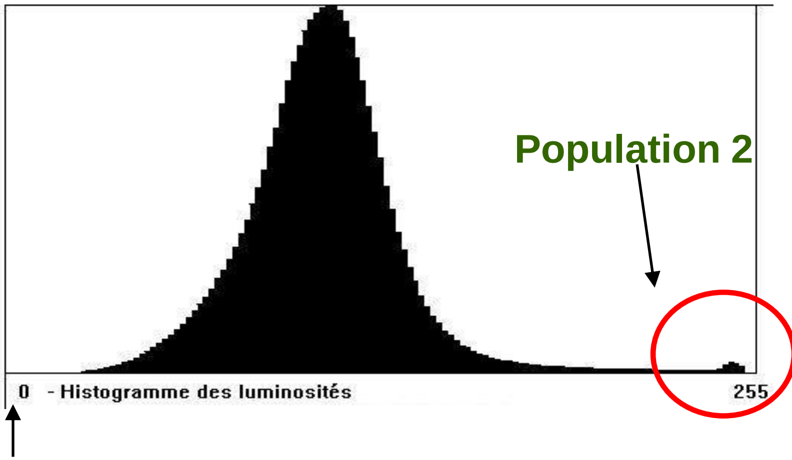
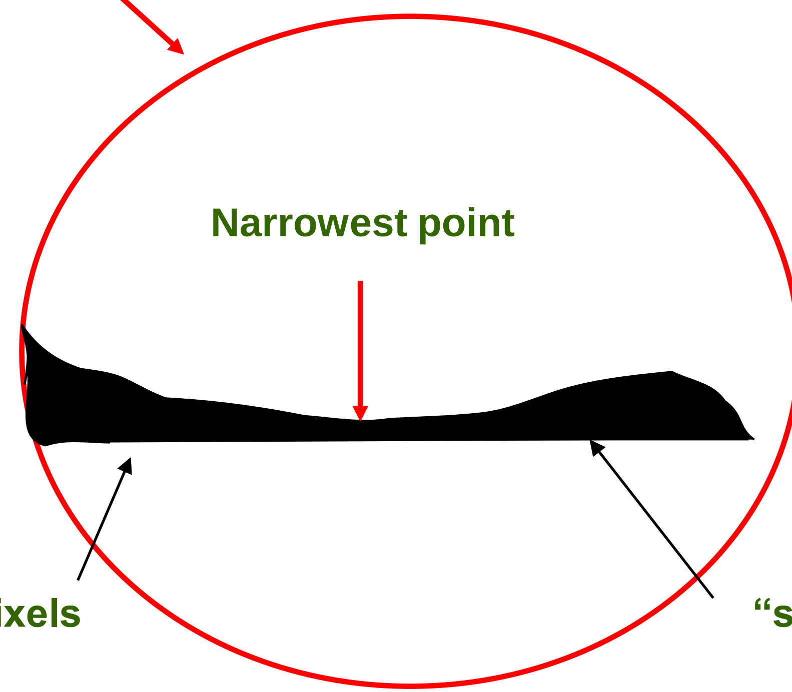
Establish salt cartography by analyzing pixels and their links



We consider that a pixel is "salted" when its luminosity is beyond the limit defined for the most narrow point on the isthmus, between the two pixel populations.



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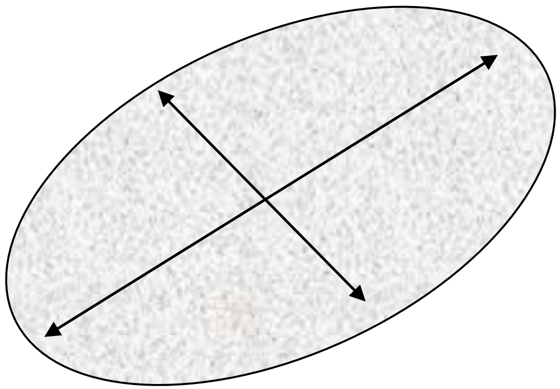
Establish salt cartography by analyzing pixels and their links

To divide large salted surfaces into grains, we used software to calculate the spread area by assimilating the darkest areas to peaks and the brightest areas to low points.

We analyzed first one pixel and then its neighbor.

For each grain outlined, we looked for the large and small axes by considering the grain as an ellipsoid in revolution: we calculated the volume and mass by considering an absolute density of 2.17 g/cm^3.

It is a hypothesis of simplification; we could Imagine using a shape coefficient.



Implementation of the method

First, we take a photo.

A software application analyzes image input and supplies sell mass in output.

Calculation is instantaneous. The application has two parts:

- A DLL (dynamic link library) of functions that can be integrated within a standalone application.

- An application with an evolved Human-Machine Interface (HMI) that calculates the salt mass and provides special functions.

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From a practical point of view

Spread the salt

Install the camera support

Position the camera

Photo obtained after spreading

The two developers of the method

Change the photo and launch processing

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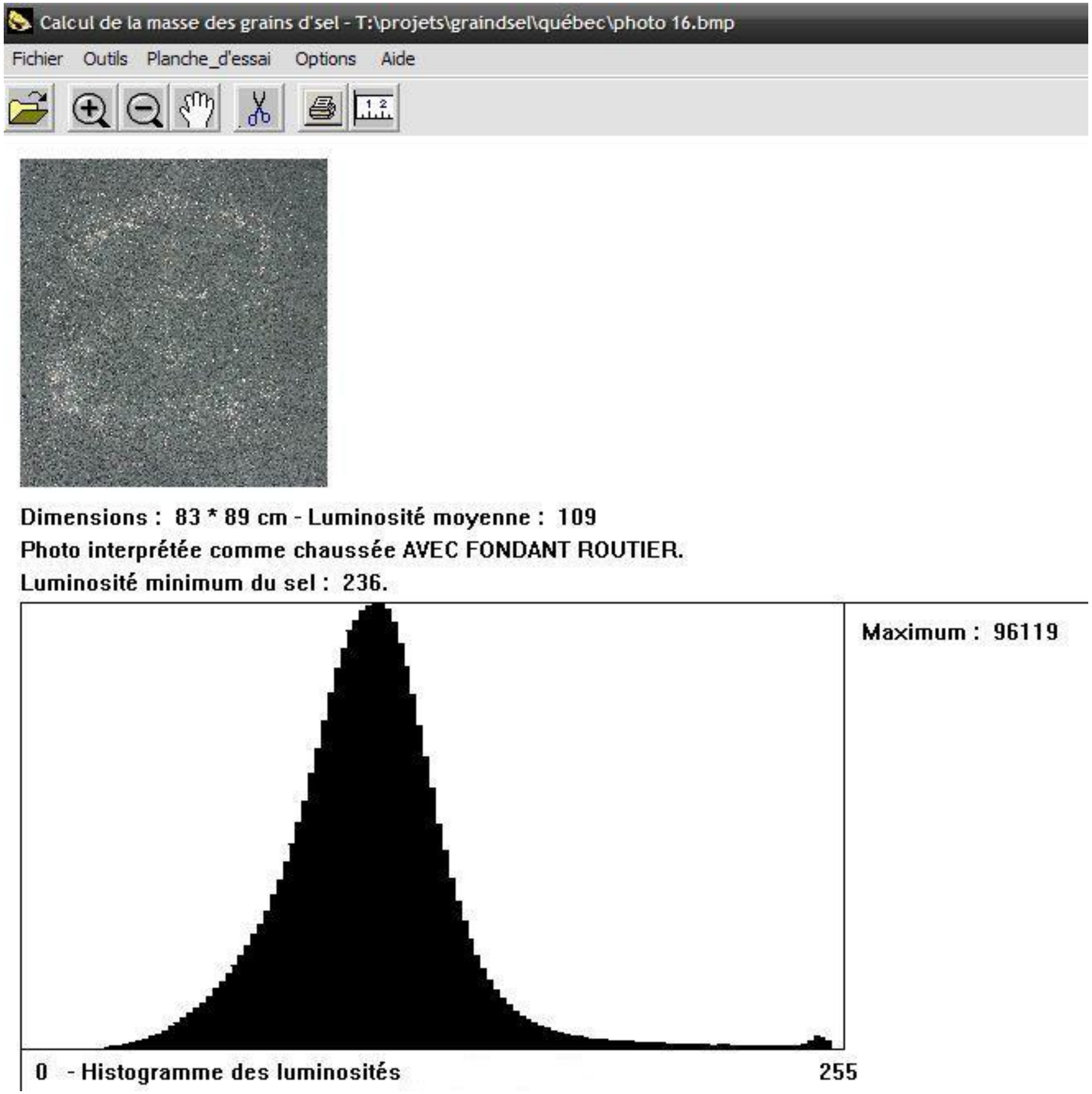
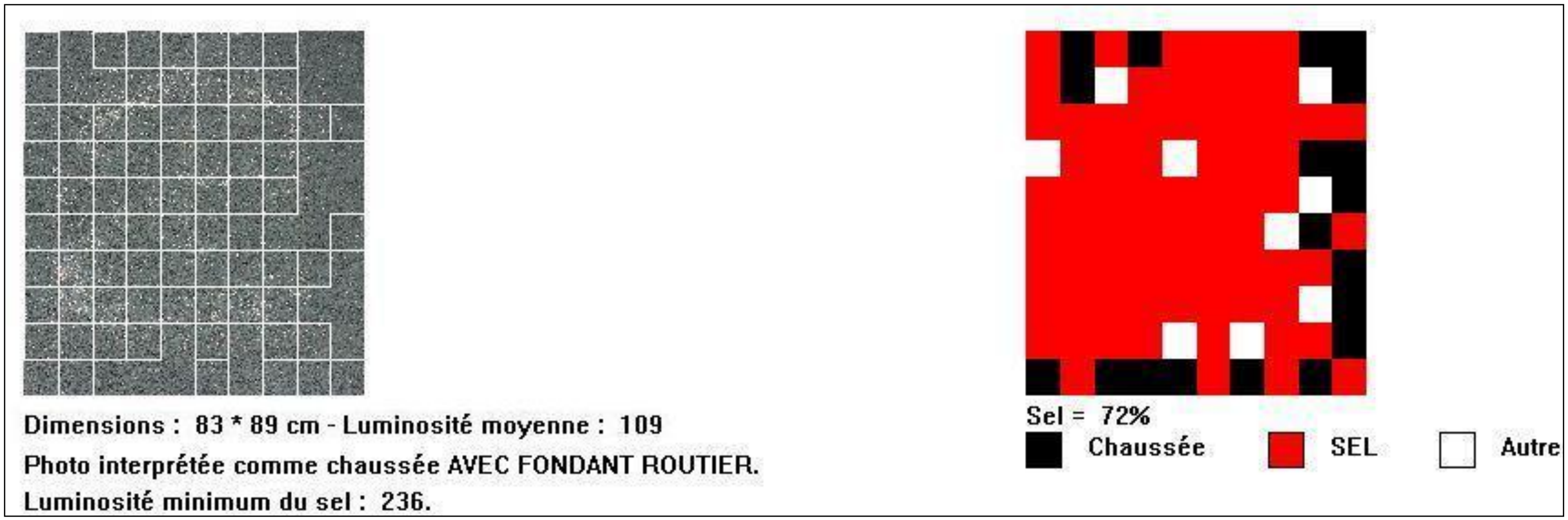
Interface: display of the luminosity histogram



Interface: distribution of salt on the image, separation into squares with or without salt



The application divides the image into squares with and without salt; here, they show the very good distribution of salt over the roadway.

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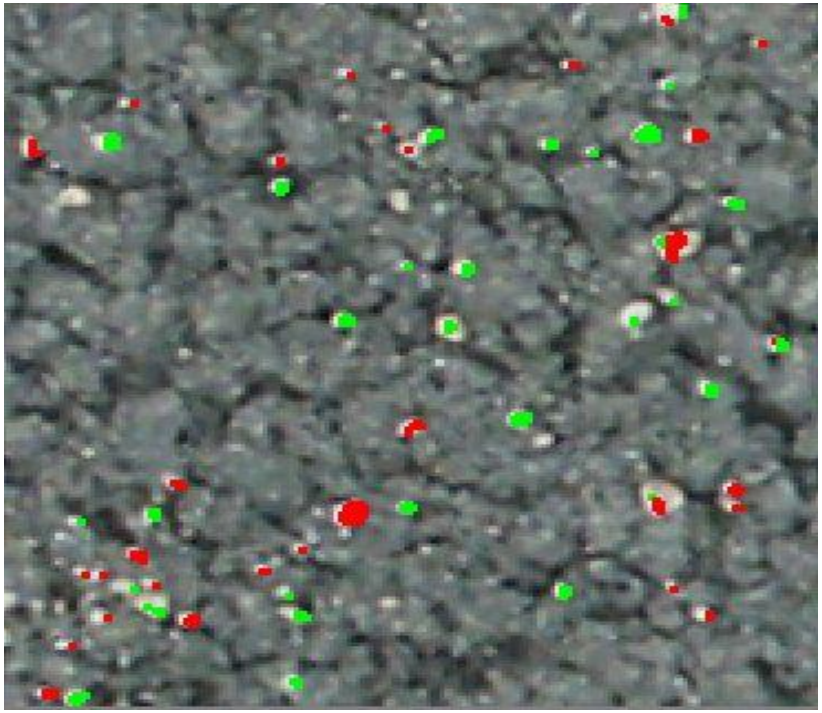
Interface : color visualization of grains on an image



One raster layer, one data layer

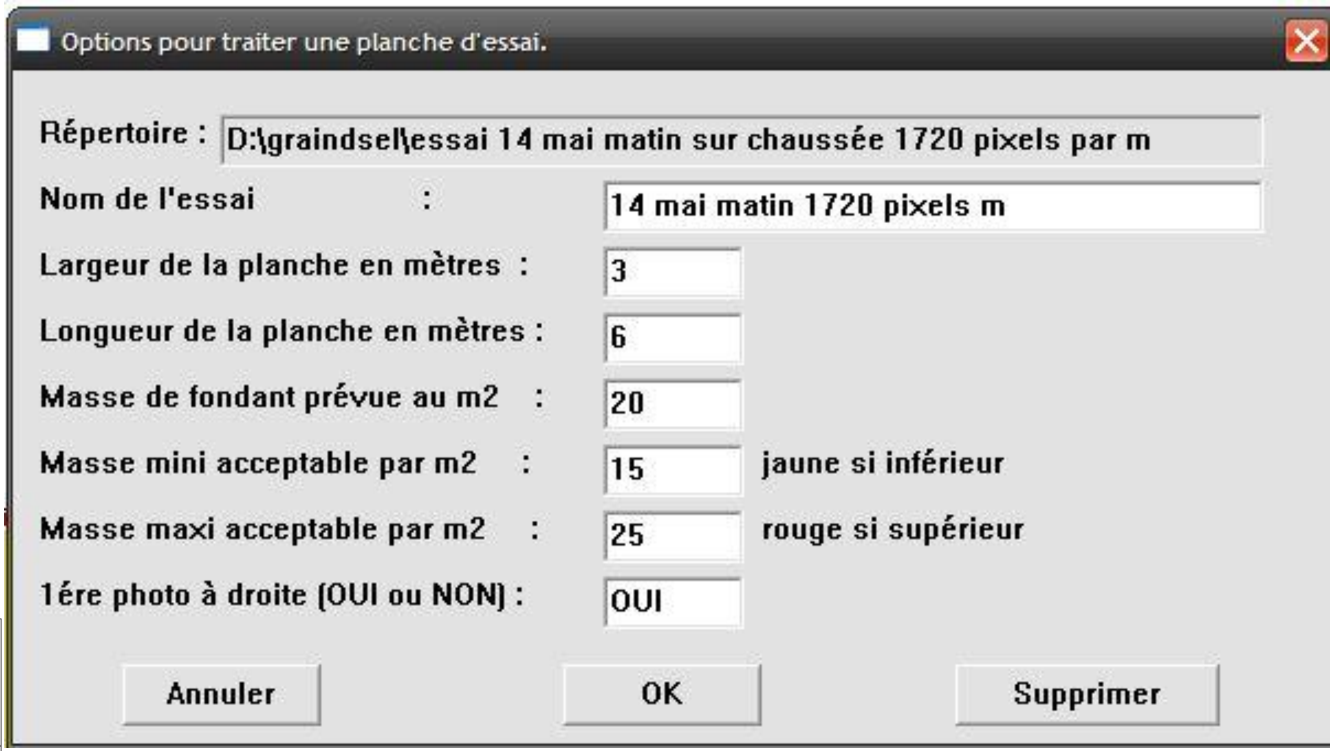
Interface: list of available information

Limit of salt in the precise histogram	**Number of grains per surface in pixels:**
Minimum grain luminosity limit is: 236	**1318 grains < 1 mm2: .45 grams.**
	1812 grains < 2 mm2: 3.59 grams.
There are 1850 pixels per meter	**442 grains < 3 mm2: 2.7 grams.**
Roadway surface is 7517.6 cm2 (89.8*83.7 cm)	**158 grains < 4 mm2: 1.68 grams.**
Salt surface is 44 cm2 or .59% of the roadway	**119 grains < 5 mm2: 1.96 grams.**
Number of salt grains: 3941	**39 grains < 6 mm2: .92 grams.**
Calculated volume is 6.33 in cm3	**18 grains < 7 mm2: .56 grams.**
Or a mass of 13.7 grams (density = 2.17 g/cm3)	**16 grains < 8 mm2: .64 grams.**
Or an average grain thickness of 1.4 mm	**10 grains < 9 mm2: .49 grams.**
	2 grains < 10 mm2: .12 grams.
Or a mass of 18.3 grams per M2	**1 grain < 11 mm2: .06 grams.**

The approach enables qualifying a square meter and the way in which it was salted, but it is also possible to produce test plates.

Making a test plate consists in systematically taking photographs of the surface of a roadway treated by a salt spreader (72 photos may be processed simultaneously).

The application allows configuring snapshot conditions for a test plate, then to carry out corresponding treatment without any other intervention.



Dialog box for configuring a test plate

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Example of the analysis of a 6 m x 3 m plate over 3 m; target dosage: 20 g/m^2

In green, the quantity of salt is correct, between 15 and 25 g/m^2

In red, excessive > 25

In yellow, insufficient < 15

In gray, the software did not recognize the photo as an analyzable road surface photo, which was due to lighting conditions when the picture was taken.

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Conclusion

The concept developed is interesting but has certain limits. It is difficult to obtain good coherency between the mass of salt actually spread over $1m^2$ and the mass calculated by the method proposed.

Many parameters affect the outcome. It would seem possible to control them in the laboratory and to adapt the type of analysis used according to these parameters (salt grain size, salt color, salt humidity, roadway roughness, lighting).

Operations on an actual road are not realistic.

However, the analysis of complete plates to understand spreading in relative terms seems very interesting. It is currently almost operational and is an axis that continues to be explored.

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For further information

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