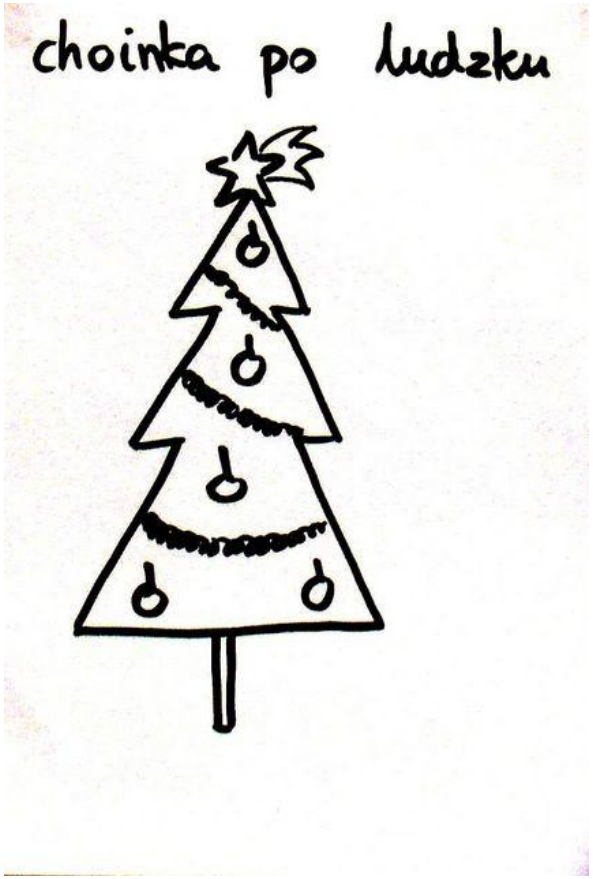
# Once upon a time...

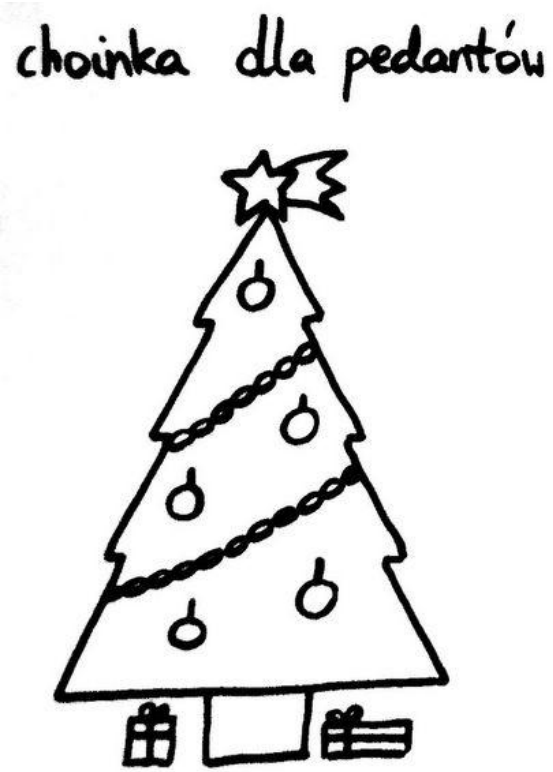



A normal christmas tree
https://www.mimuw.edu.pl/galerie/matematyczne-choinki

# ...there has been a tree...


An orthodox christmas tree
https://www.mimuw.edu.pl/galerie/matematyczne-choinki

# ...a very special tree...

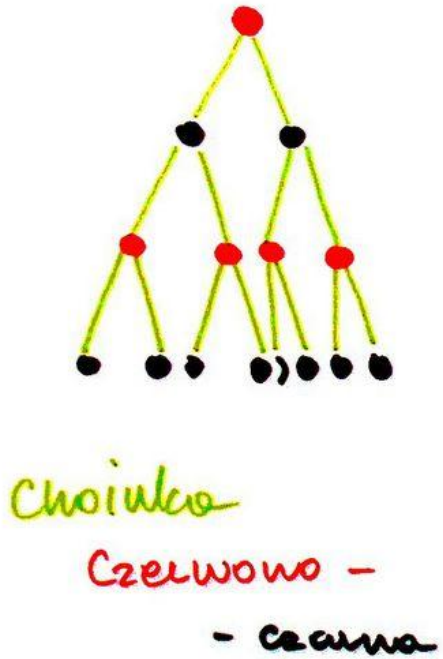



A perfectionist's christmas tree
https://www.mimuw.edu.pl/galerie/matematyczne-choinki

# ...quite extraordinary...

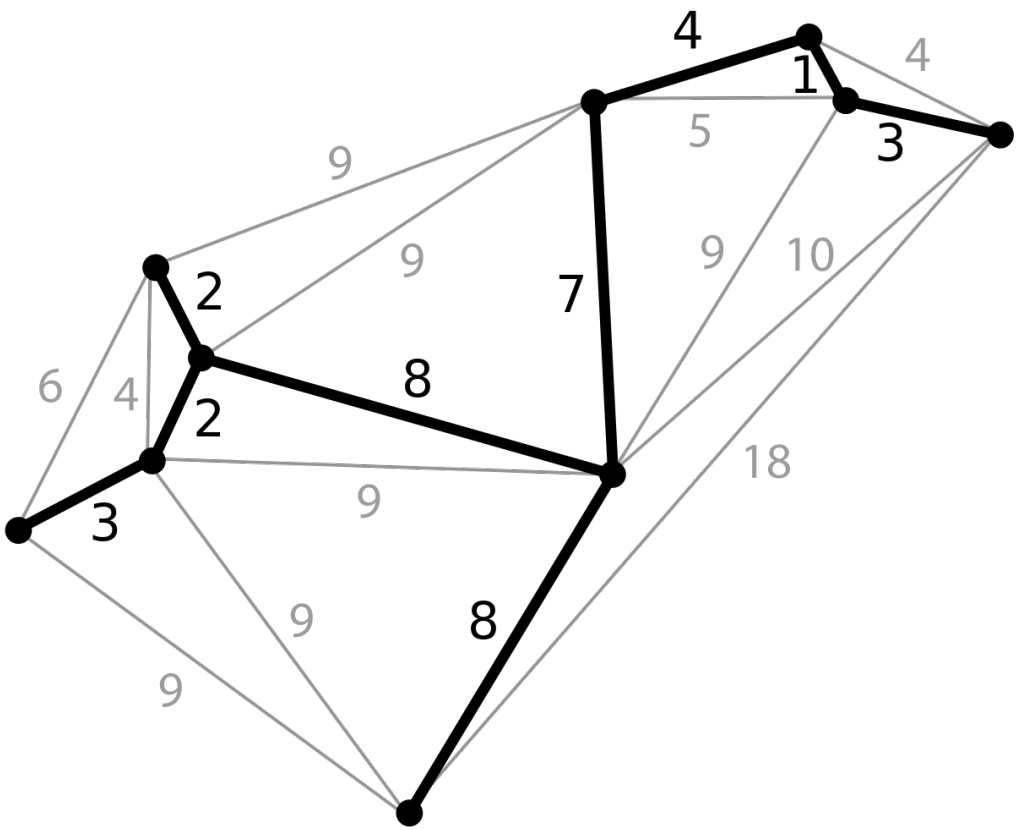

Dijkstra's christmas tree
https://www.mimuw.edu.pl/galerie/matematyczne-choinki

# ...and useful...




A red-black christmas tree
https://www.mimuw.edu.pl/galerie/matematyczne-choinki

# ...and awesome!




https://en.wikipedia.org/wiki/Euclidean_minimum_spanning_tree

# From HTML to PostGIS presents: (Euclidean) Minimum Spanning Tree

Michał Okulewicz, Anna Okulewicz

Wydział Matematyki i Nauk Informacyjnych
Politechnika Warszawska

# Minimum spanning tree applications

# Navigating through Virtual Trips I

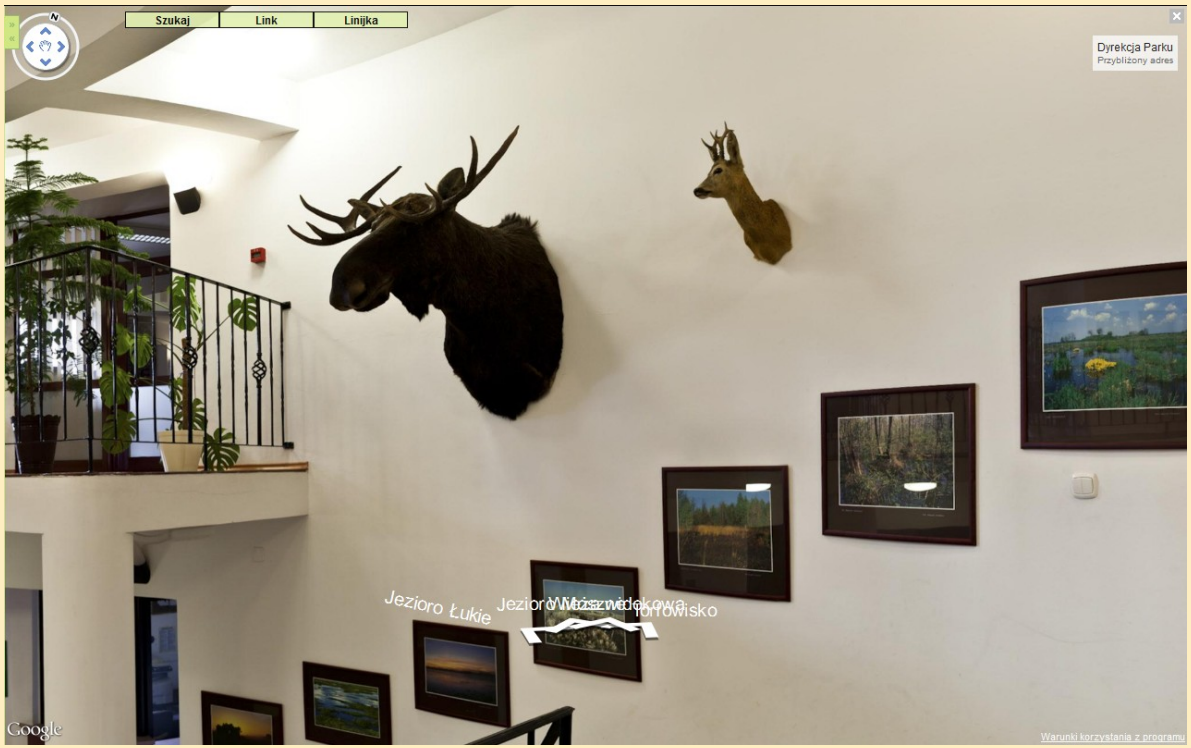
# Navigating through Virtual Trips II

## Task

Automatically create navigational links for 360° photos

# Navigating through Virtual Trips III

## What if we just connect everything...?



# Navigating through Virtual Trips IV

## Local node requirements

L1. One SHOULD be able to navigate to the closest photos.

L2. Navigational links MUST be readable, no matter how the photo is rotated.

L3. One MUST be able to go back to the photo from which one came.

## Global requirements

G1. There MUST be a possibility to walk through all of the photos in a given group.

G2. There SHOULD be as many possible walk-throughs as possible.

# Mathematical model

## Local node requirements

L1. Possible moves graphs should be minimized with respect to the edge weight

L2. Graph edges (links) should have an angle of at least 52 degrees (observation and experiment).

L3. Graph must be undirected (simple).

## Global requirements

G1. Possible moves graph must be a connected graph.

G2. Possible moves graph should be maximized with respect to the number of edges.

# Solution I

## Minimum Spanning Tree

L1. Sum of all edges is minimal (with respect to G1.).

L2. In a euclidean minimum spanning tree angles between edges are greater or equal to 60 degrees.

L3. Tree can be an undirected (simple) graph.

G1. Spanning tree is connected.

G2. Tree can be extended with additional edges.

## L1. Fact (from optimality of the Kruskal algorithm)

The shortest edge of each of the nodes belongs to the minimal spanning tree.

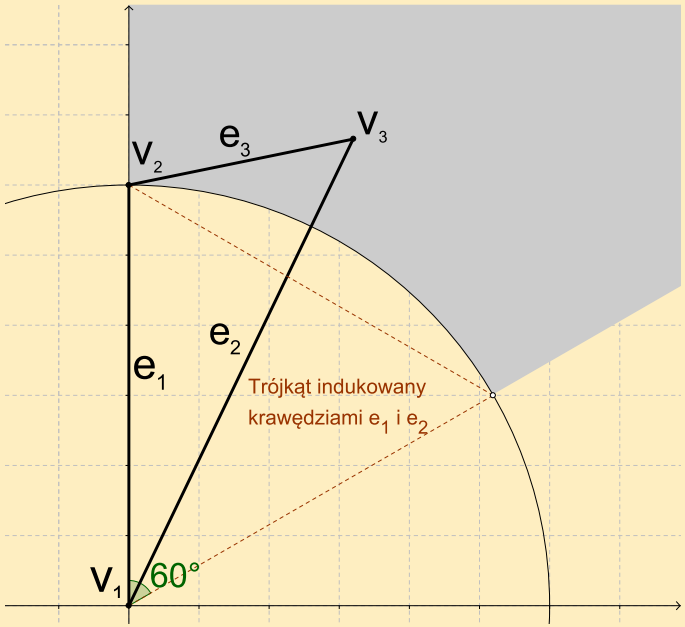
# Solution II

**L2. Theorem (edges of Delauney traingulation belonging to MST)**

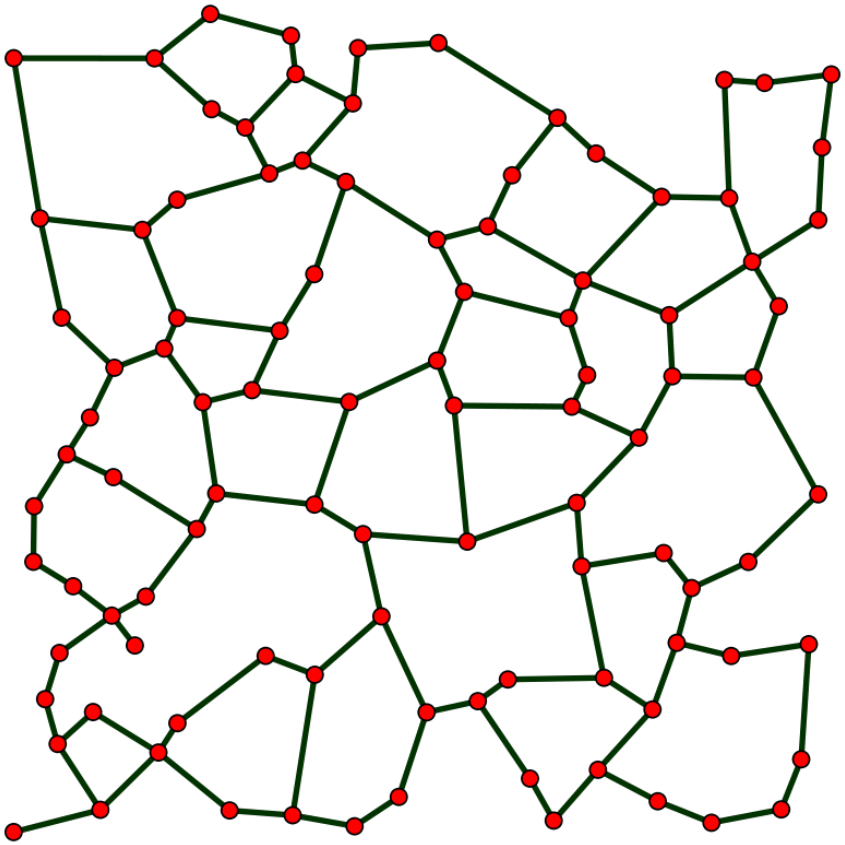
In a minimum spanning tree of a fully connected Euclidean graph, a lower bound for an angle between adjacent edges is equal to 60°.

# Solution III

## Possible locations of the adjacent edges $e_2 \geq e_1$



# Relative neighbourhood graph (Godfried Toussaint 1980)



https://en.wikipedia.org/wiki/Relative_neighborhood_graph



THE INTERNET

# Geostatistics

## PTIP

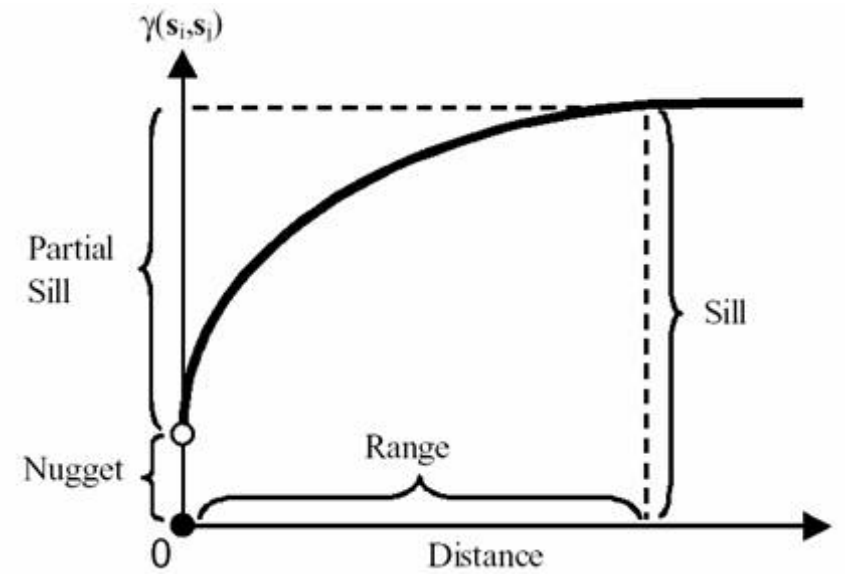
**Geostatistics**: statistics methods adjusted to handling geospatial data.

## en.wikipedia.org

**Geostatistics** is a branch of statistics focusing on spatial or spatiotemporal datasets.

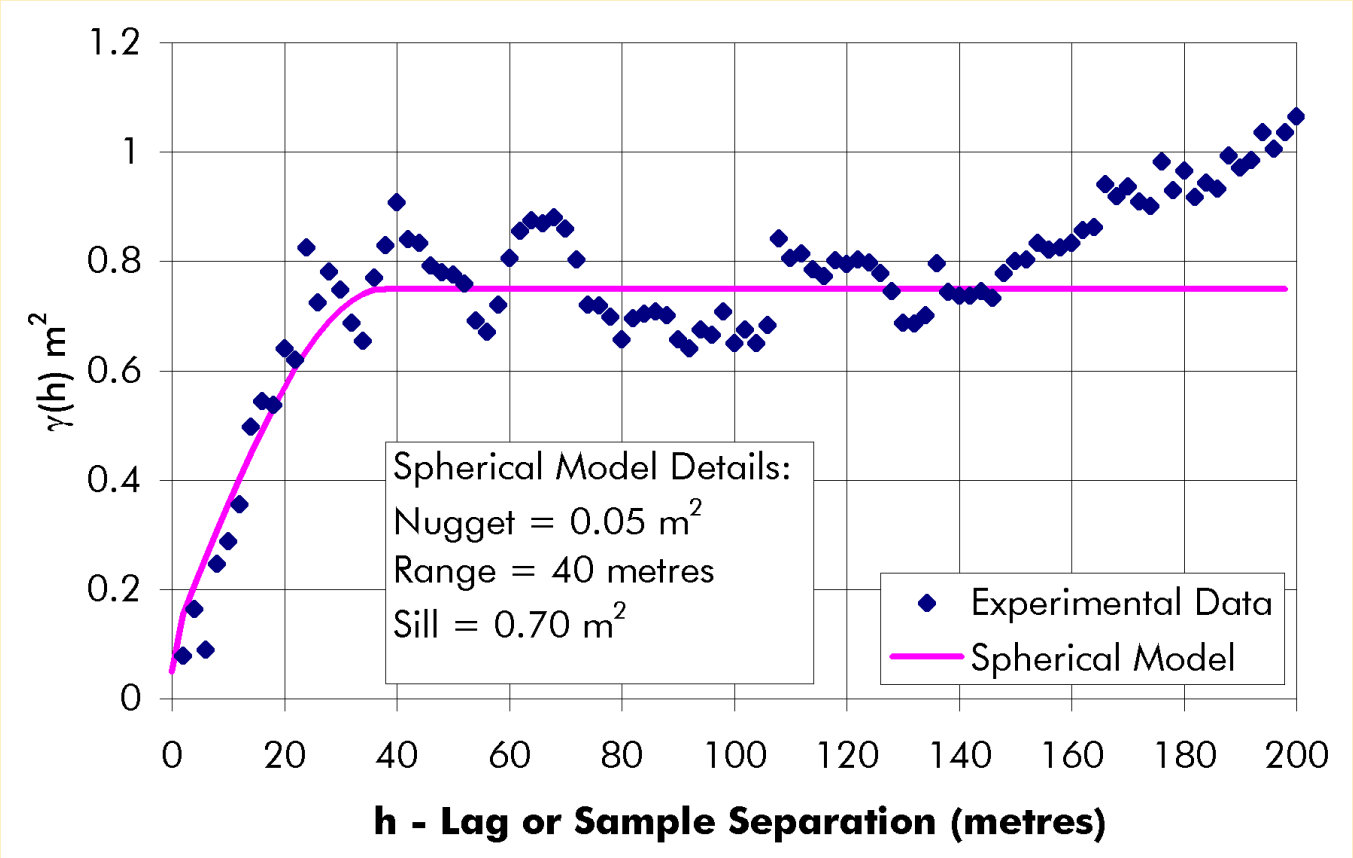
# Variogram I

- Presents relation between measured variable differences and distance between measurements
- Difference distribution is described by the range, sill and nugget
- It has been previously used to measure features of gold or oil deposits



# Variogram II

## Example



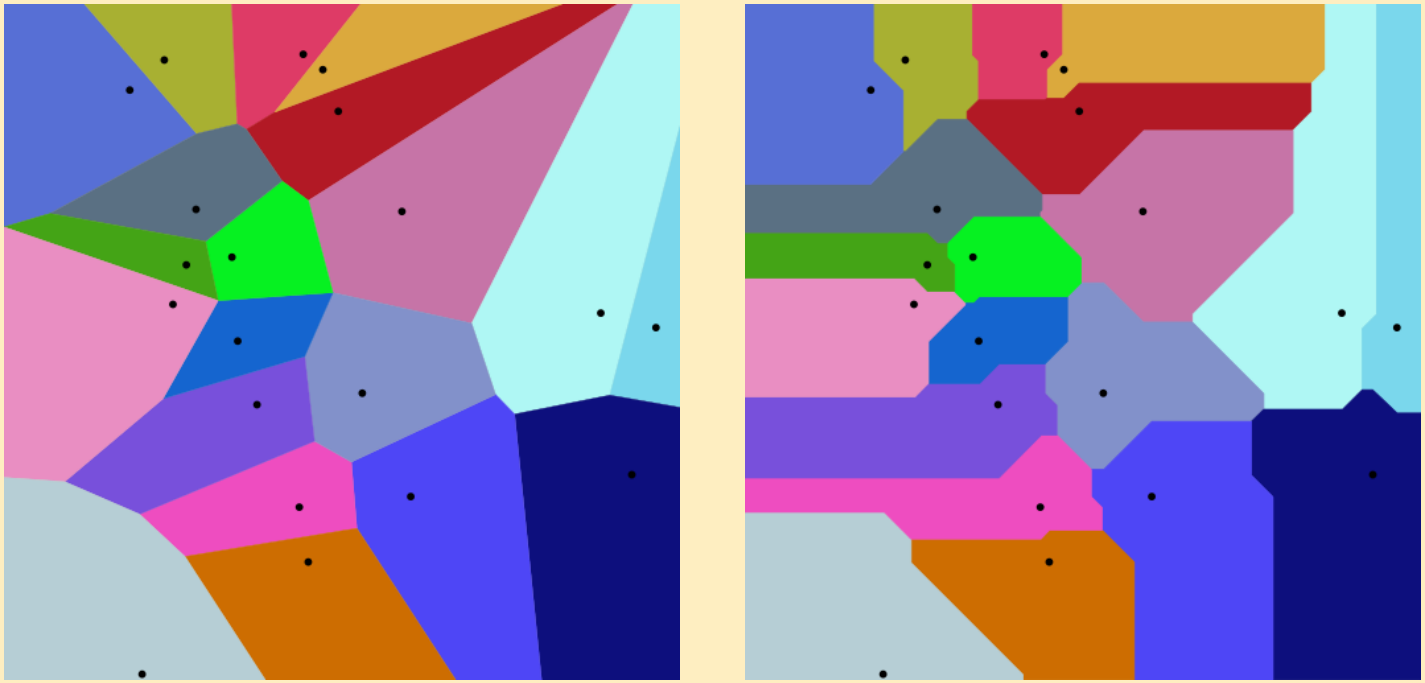

Source: http://www.minetechint.com/papers/droy-thesis/

# Voronoi (Dirichlet) Diagram I

- Presents space division on the bases of distance from a predefined set of points (called seeds)
- Points in space are associated with the closest seed - thus forming a set of Voronoi cells
- Used for identifying the source for London cholera outbreak „On the Mode of Communication of Cholera”, John Snow, M.D., Londyn 1855

# Voronoi (Dirichlet) Diagram II

## Example

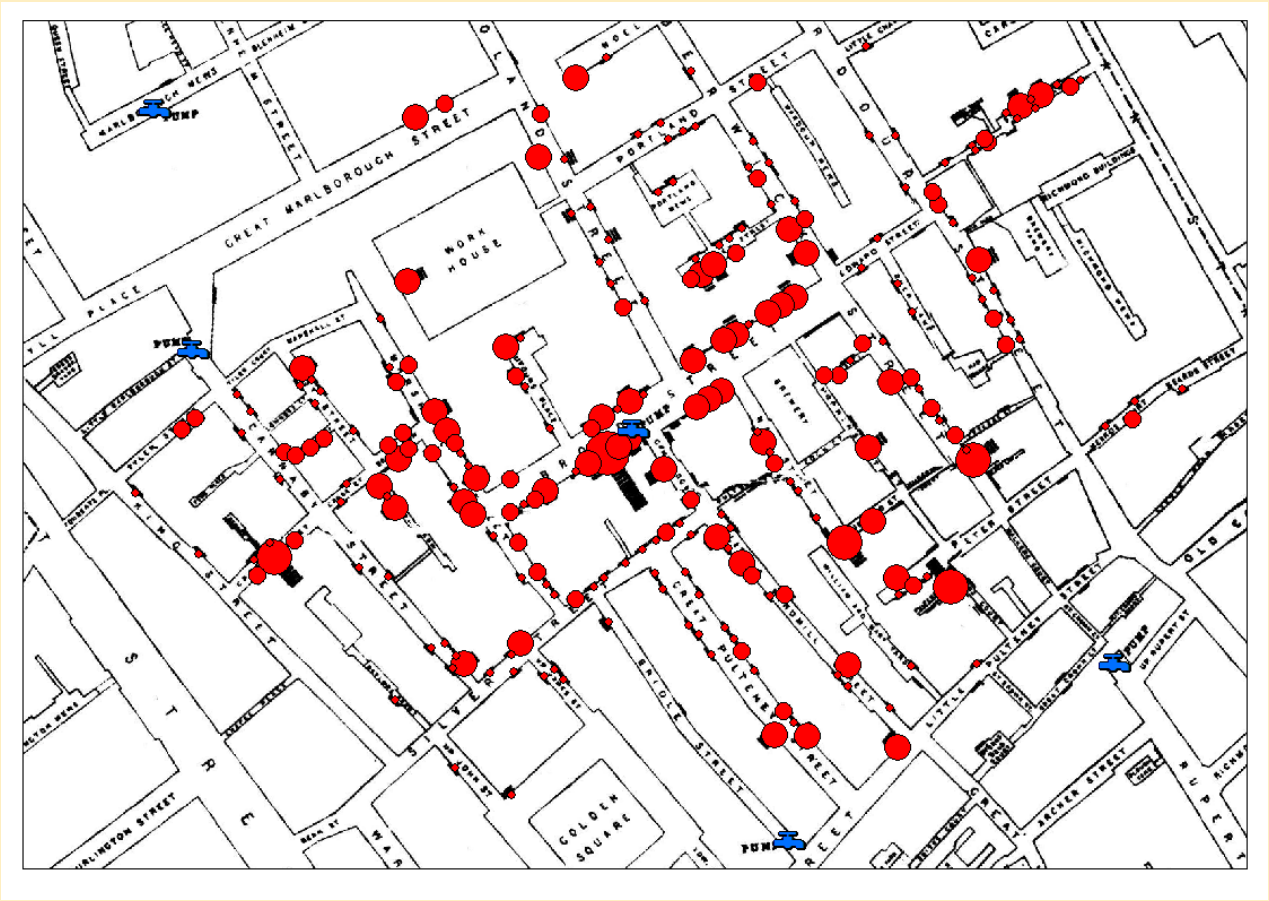


Euclidean distance Manhattan distance

Źródło: http://en.wikipedia.org/

# Voronoi (Dirichlet) Diagram III

## Cholera outbreaks map




http://blog.rtwilson.com/john-snows-cholera-data-in-more-formats/

# Labour market analysis I

Based on:

**An evolutionary approach to the delimitation of labour market areas: an empirical application for Chile**
**JM Casado-Díaz, L Martínez-Bernabéu, F Rowe**

## Input data

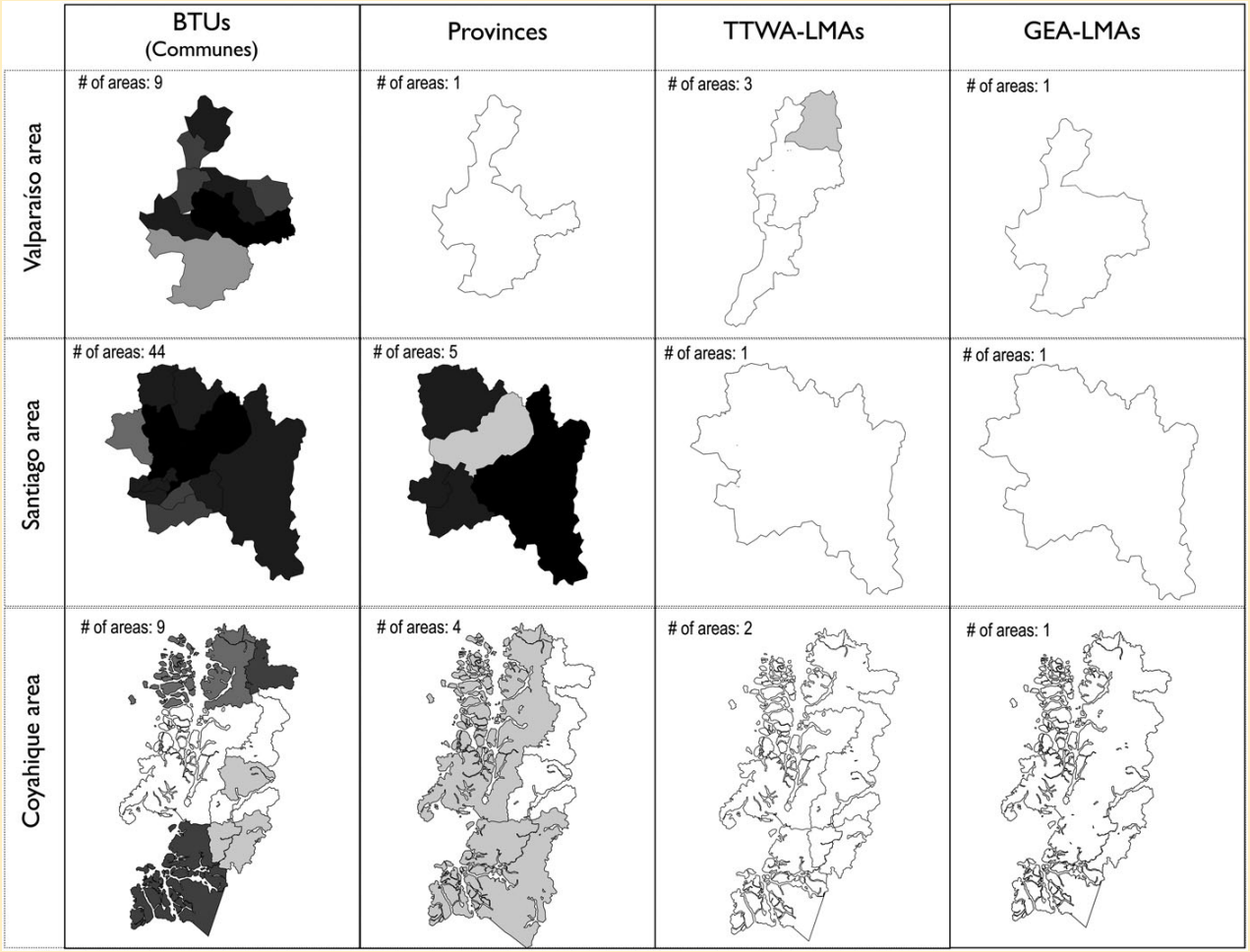
- Travel routes between points
- Basic administrative units (districts, municipals)

## Data processing

- Identification of a daily commute
- Clustering of the areas on the bases of number of inner- and inter- area daily commutes

# Labour market analysis II

## Sample results: identified areas



# Twitter event detection I

Based on:

**Efficient online extraction of keywords for localized events in twitter**

**H Abdelhaq, M Gertz, A Armiti**

## Input data

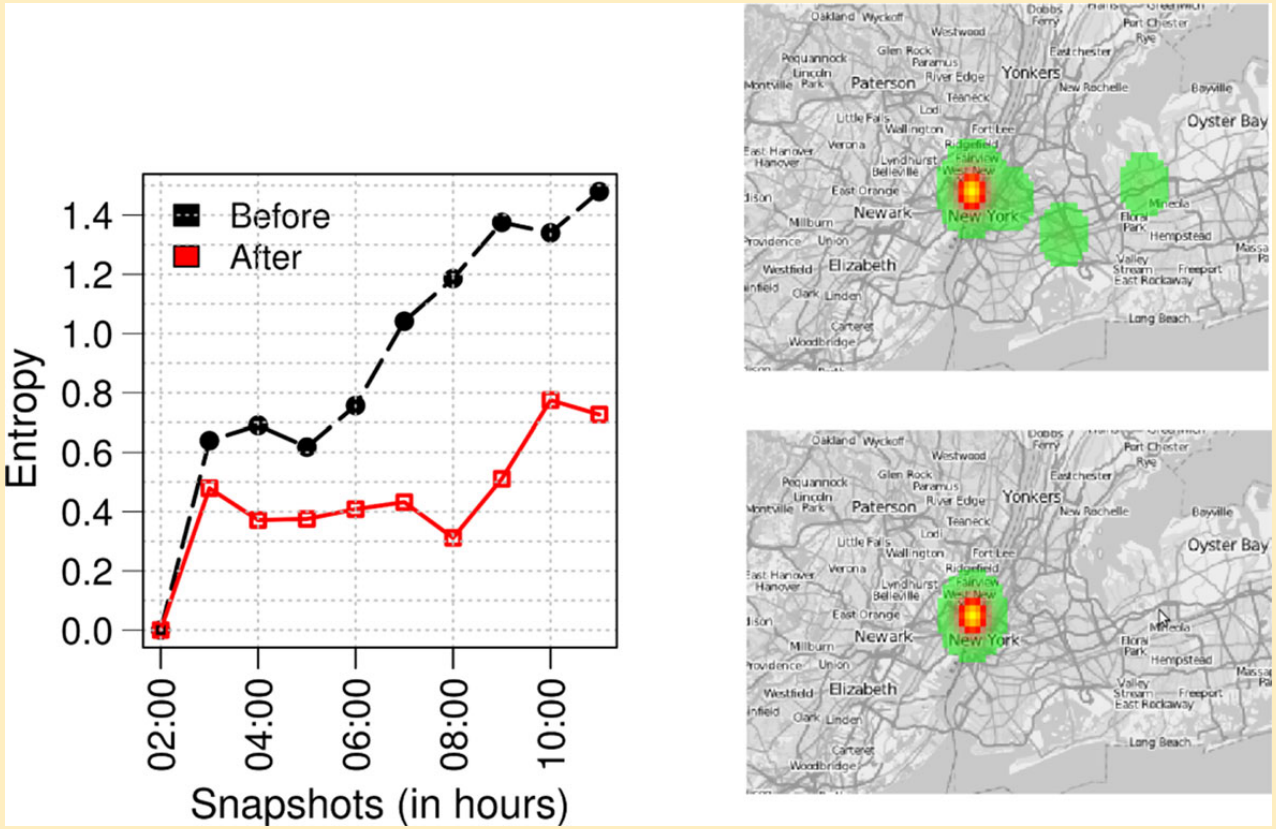
- Stream of geotagged twits

## Data processing

- Dividing twits stream into overlapping time boxes
- Analysis of local keywords
- Eliminating outliers

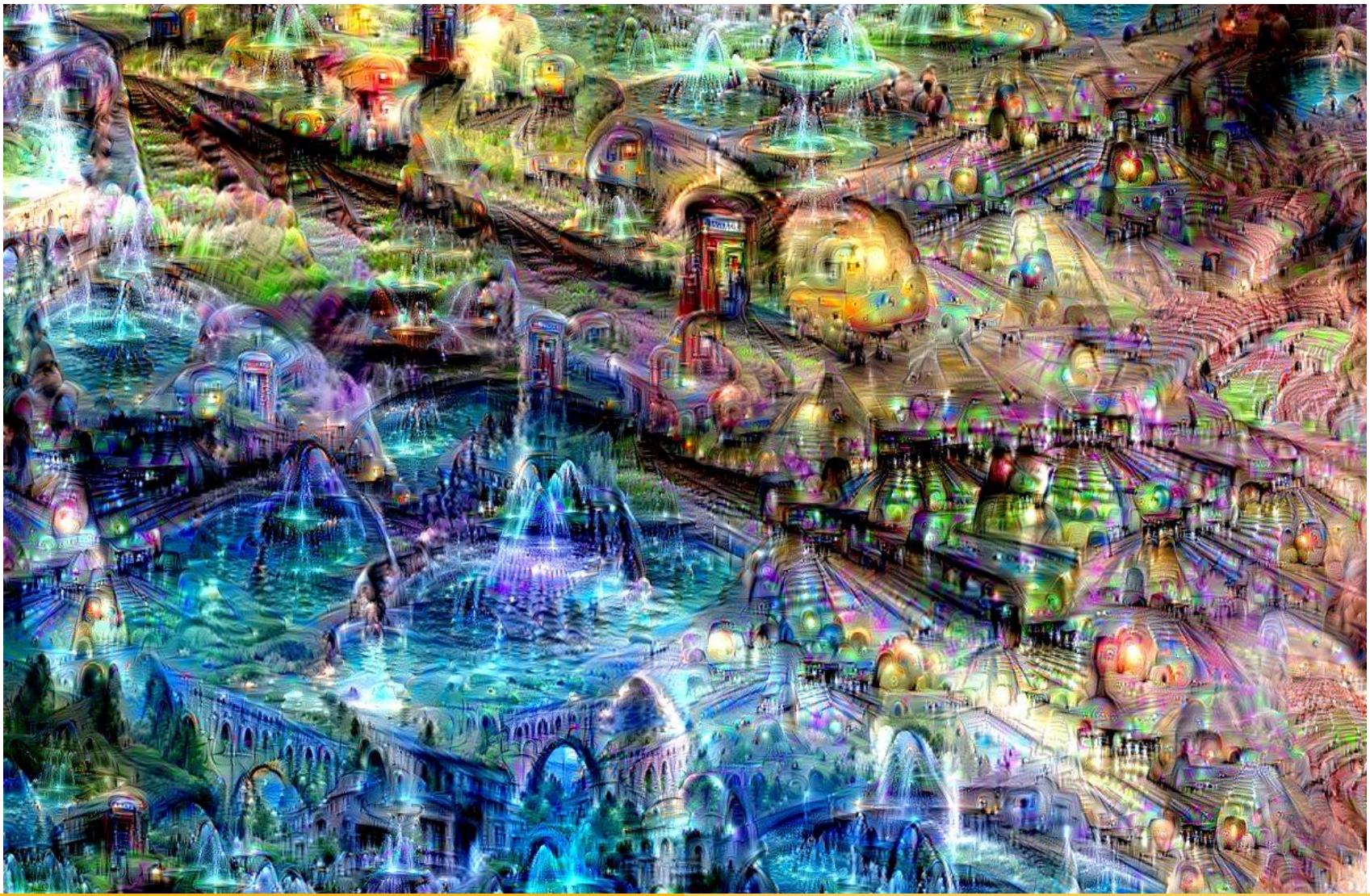
# Twitter event detection II

## Sample results: localizing a music band performance



# Wait! There is more!

# image recognition: this is where fun begins!



# Photogrammetry and Remote Sensing (Fotogrametria i teledetekcja)

## International Society for Photogrammetry and Remote Sensing (ISPRS)

**Photogrammetry and Remote Sensing** is the art, science, and technology of obtaining reliable information from noncontact imaging and other sensor systems about the Earth and its environment, and other physical objects and processes through recording, measuring, analyzing and representation.

# Deep learning I

Based on:

**Learning to Detect Roads in High-Resolution Aerial Images**
**Volodymyr Mnih and Geoffrey E. Hinton**

## Input data

- Manually labeled all pixels of selected images
- Labeled images and their random rotations

# Deep learning II

## Data processing

- Auto-associative learning of subsequent deep neural network (possible techniques: Restricted Boltzmann Machine, autoencoder)
- Standard supervised neural network training

## Sample results

# Image segmentation I

Based on:

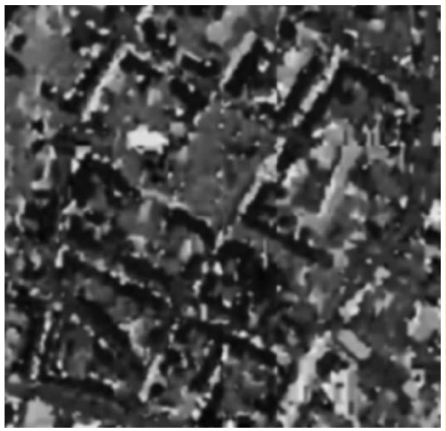
**IMMI: Interactive Segmentation Toolkit**

**Jan Masek, Radim Burget, and Vaclav Uher**

## Input data

- Manually selected image processing algorithms
- Manually labeled selected image pixels





# Image segmentation II

## Data processing

- We are looking for a best segmentation algorithm, which gives the best classification, with respect to selected image transformation algorithms
- Algorithm is available within IMage MIning plug-in to RapidMiner application

# Image segmentation III

## Sample results

| Type | Average precision* | Std. dev. |
|---|---|---|
| Segmentation, image transformation i machine learning | 78% | 2% |

*) Measured by number of points belonging to correctly classified segments

# Deep learning I

Based on:

**Detecting building on the aerial photography**

**Tomasz Półgrabia, Karol Bocian**

# Deep learning II

## Input data

- Vector OpenStreetMap data (turned into binary raster data)
- Satellite Google Maps data

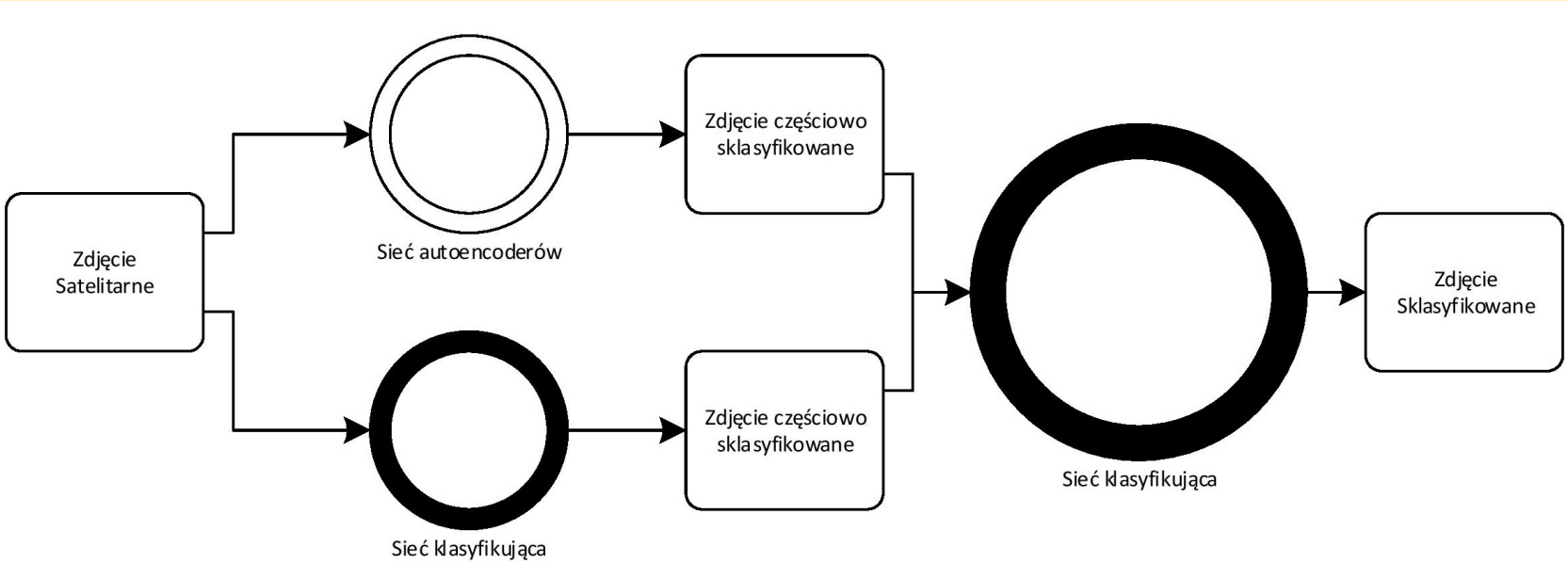
# Deep learning III

## Data processing

- Training feed forward neural networks
- Training deep neural networks with autoencoder
- Merging results

# Deep learning IV

## Prediction model structure




| Cell type | Average accuracy | Std. dev. |
|---|---|---|
| 4x4 | 53% | 7% |
| 8x8 | 55% | 7% |

# Getting the data

## QGIS 2.2

- Install OpenLayers plug-in
- Plug-ins $\rightarrow$ OpenLayers plugin
- Vector data $\rightarrow$ OpenStreetMap
- Selecting area
- Styling the data (e.g. black fill-in without border)
- Exporting maps and satellite images as pictures

# Building numerical terrain model I

Based on:

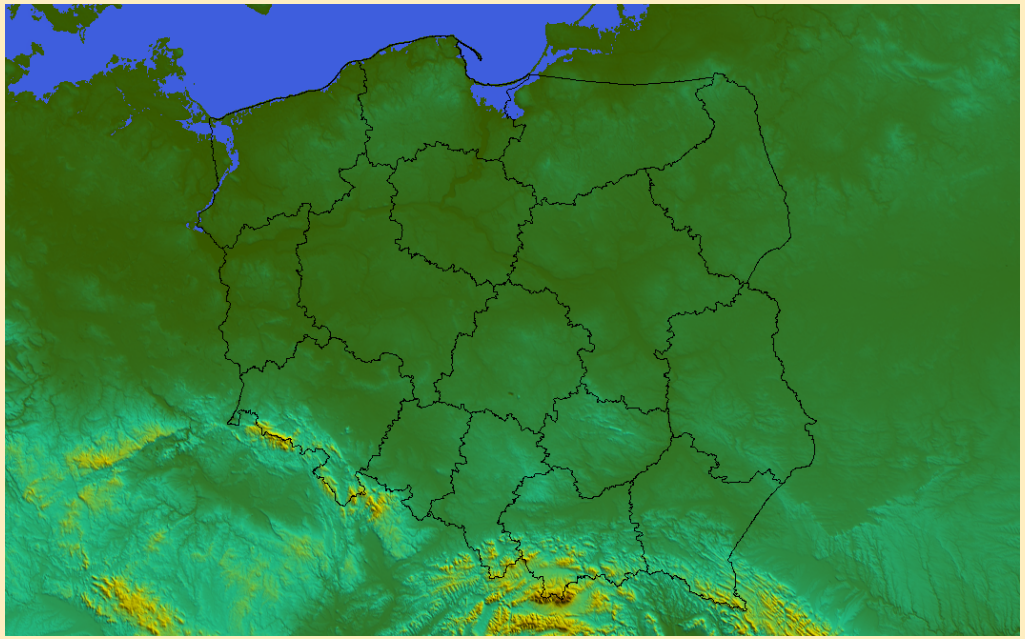
**Automatic generation of digital terrain models from CARTOSAT-1 stereo images**

**Hossein Arefi i in.**

# Building numerical terrain model II

## Input data

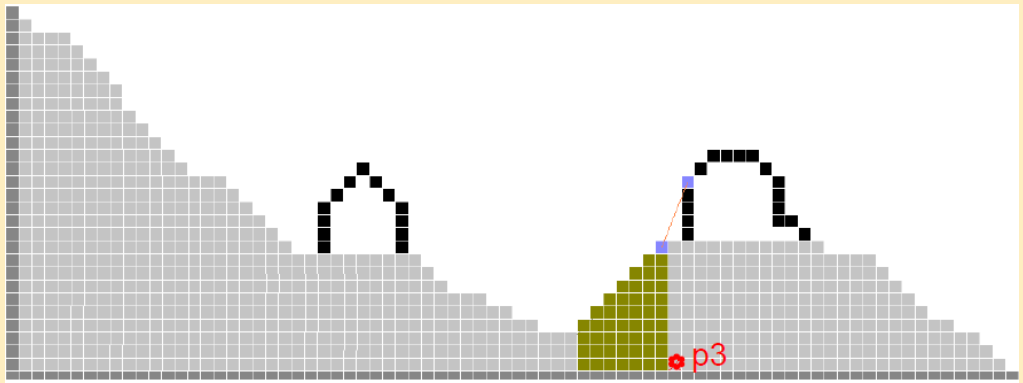
- Stereoscopic satellite imagery
- Rough terrain model from Shuttle Radar Topography Mission



# Building numerical terrain model III

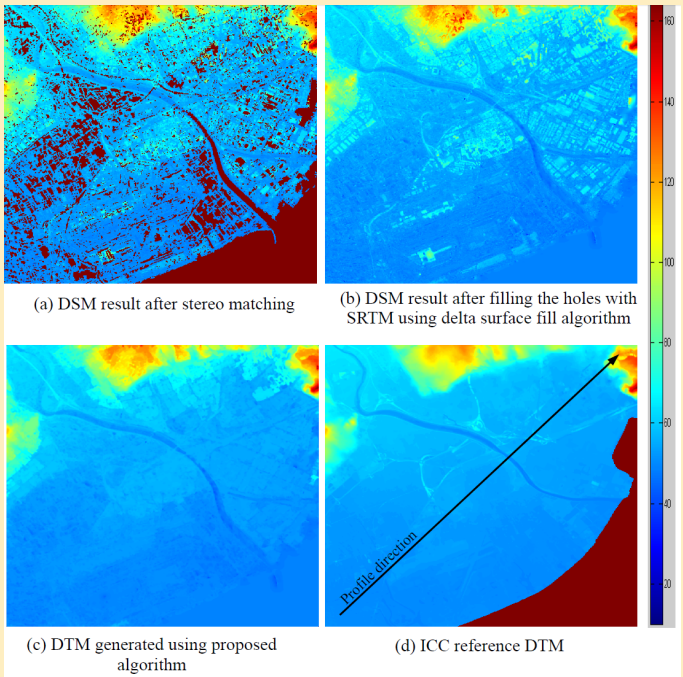
## Data processing

- Removing outliers
- Filling the gaps through interpolation
- Looking for discontinuities



# Building numerical terrain model IV

## Results




(a) DSM result after stereo matching

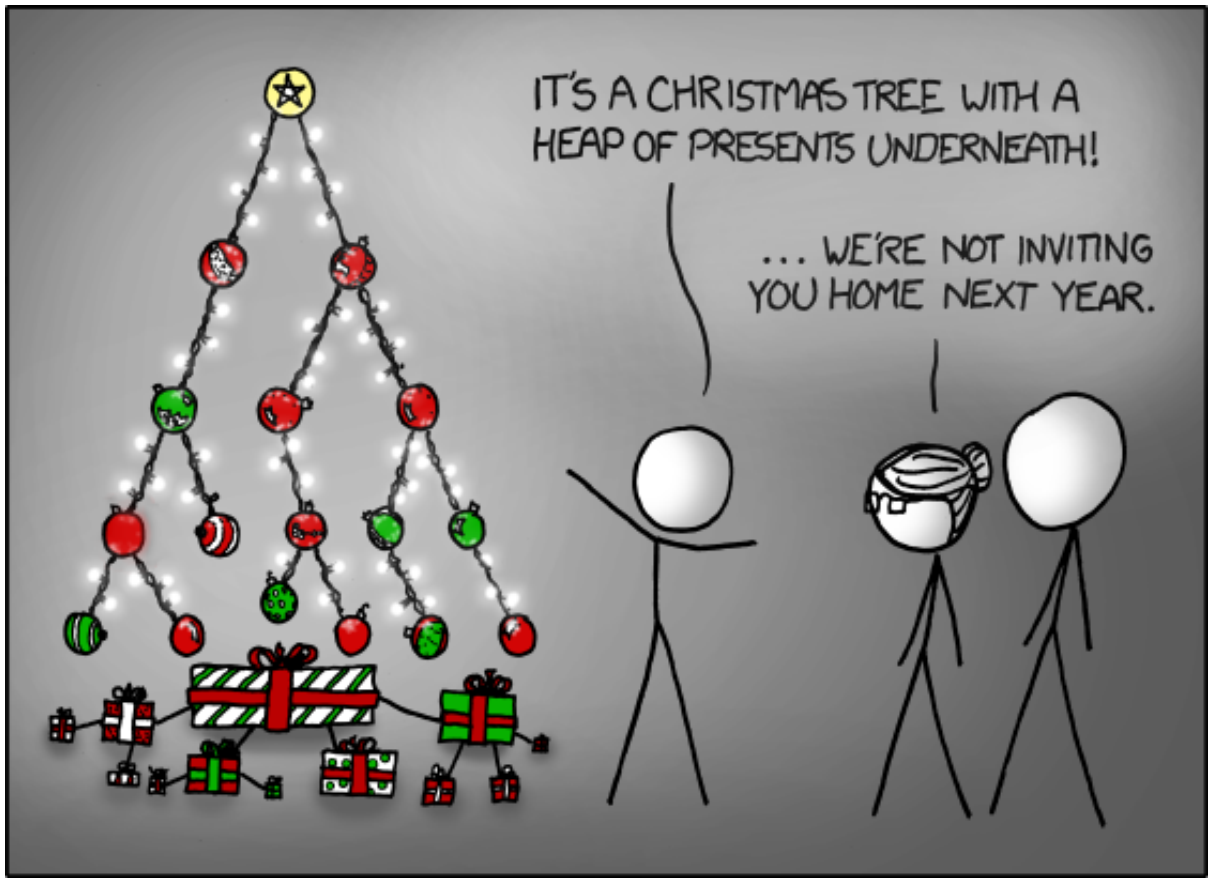
(b) DSM result after filling the holes with SRTM using delta surface fill algorithm

(c) DTM generated using proposed algorithm

(d) ICC reference DTM

| Type | Average height error |
|---|---|
| Original SRTM | 6.2m |
| Model based on CARTOSAT-1 | 1.8m |

# Merry Christmas!




Not only is that terrible in general, but you just KNOW Billy's going to open the root present first, and then everyone will have to wait while the heap is rebuilt.

https://xkcd.com/835/