SPATIAL ANALYSIS OF TRANSPORT INFRASTRUCTURE

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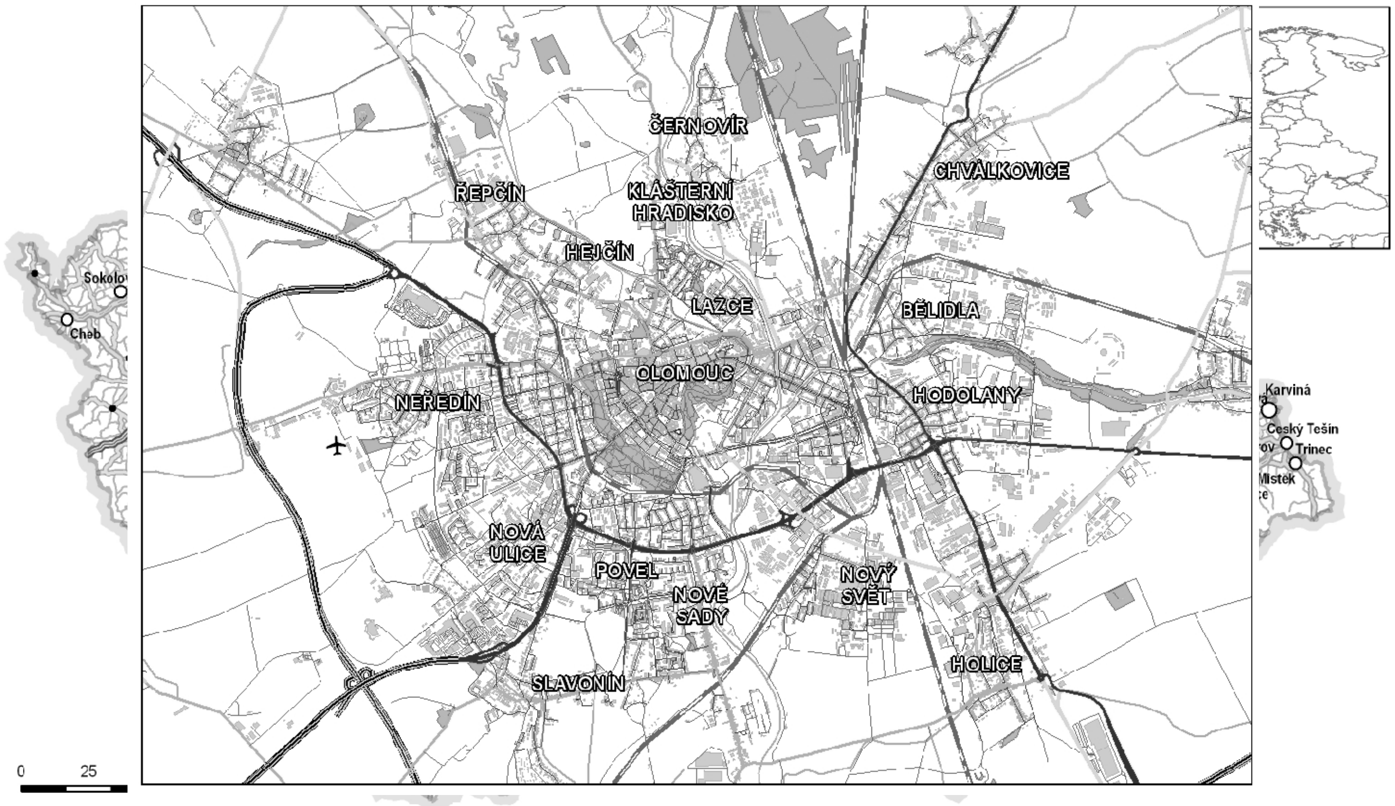
MOTIVATION


ČERNOVÍR
CHVÁLKOVICE
ŘEPČÍN
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HEJČÍN
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OLOMOUC
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NEŘEDÍN
NOVÁ ULICE
POVEL
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SLAVONÍN
Cheb
Karviná
Český Těšín
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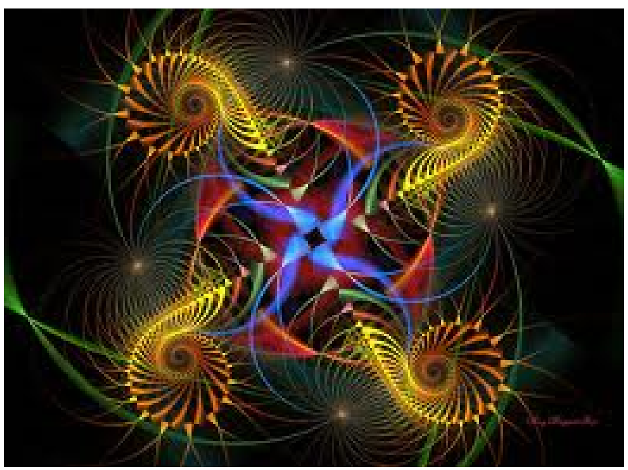
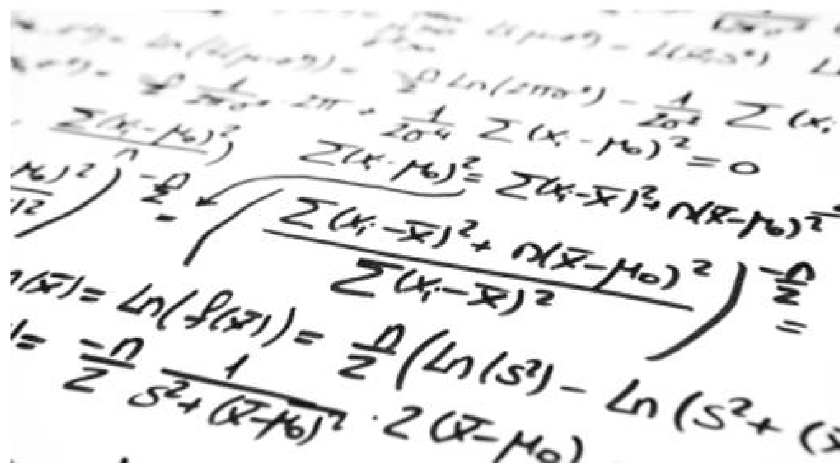
MOTIVATION

Main goals

1. Selection of various cities
2. Spatial analysis of transport infrastructure
3. Statistical comparison





Methodology

Fractal dimension describes the complexity of objects. Its applications range from evaluation of roughness of coasts or surfaces to complexity of networks. In pure mathematics, the fractal dimension is known as the Hausdorf dimension. However, it may be calculated only for self-similar objects (Sierpinski triangle, Cantor set, square) or objects derived from self-similar ones (their unions or bi-Lipschitz transformations). When dealing with natural objects we estimate the Hausdorf dimension in several different ways. These approaches have usually form of the power law. The best known and most used ones are the box-counting dimension and correlation dimension.

Methodology

$$D_B(A) = \lim_{n \to \infty} \frac{\log(N(\varepsilon))}{\log \varepsilon}$$

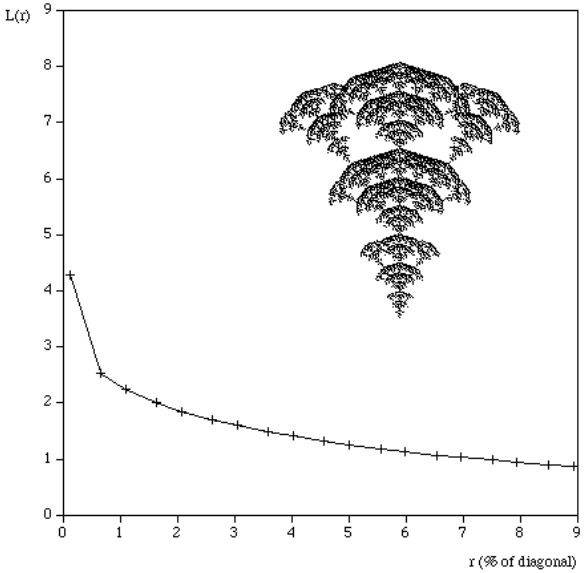
$$C(\varepsilon) = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} \Theta\left(\varepsilon - d\left(x_i - x_j\right)\right)}{N^2},$$

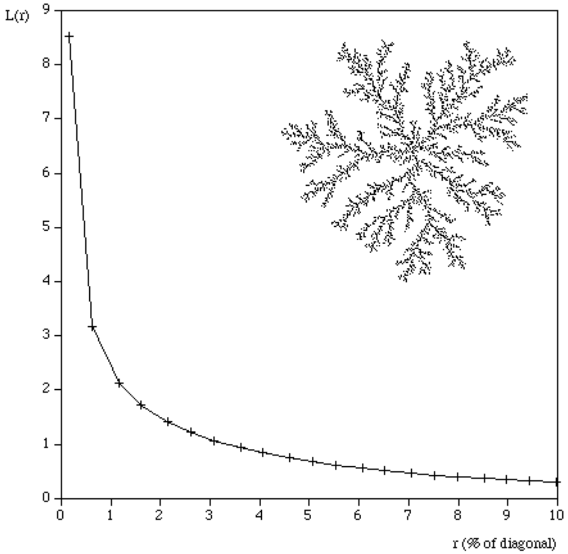
The box-counting dimension is based on covering an object with boxes. Grids of different sizes $\varepsilon > 0$ are used to cover the object A. The number $N(\varepsilon)$ of boxes needed to cover the object is found.

The correlation dimension was firstly applied in physics. It expresses how the amount of mass around points of an object varies with the distance. The object *A* is described with *N* sampled points *x*i. The correlation dimension is calculated with the help of the correlation function

Methodology

It is often needed at least one other measure that distinguishes fractal objects. Recently the lacunarity is the most popular concept. Lacunarity is a measure of the lack of rotational or translational invariance (or radial symmetry) in an image (see [9]). In general, lacunarity is a measure of the non-uniformity (heterogeneity) of structure.

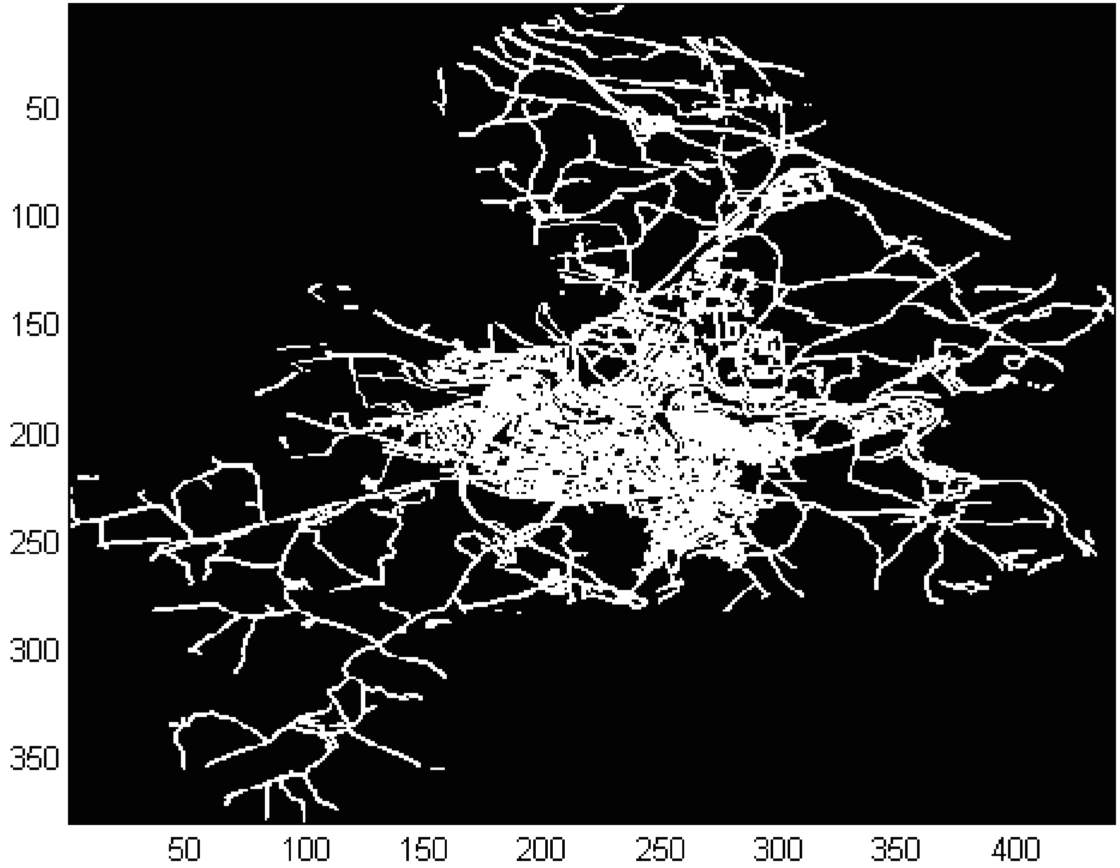




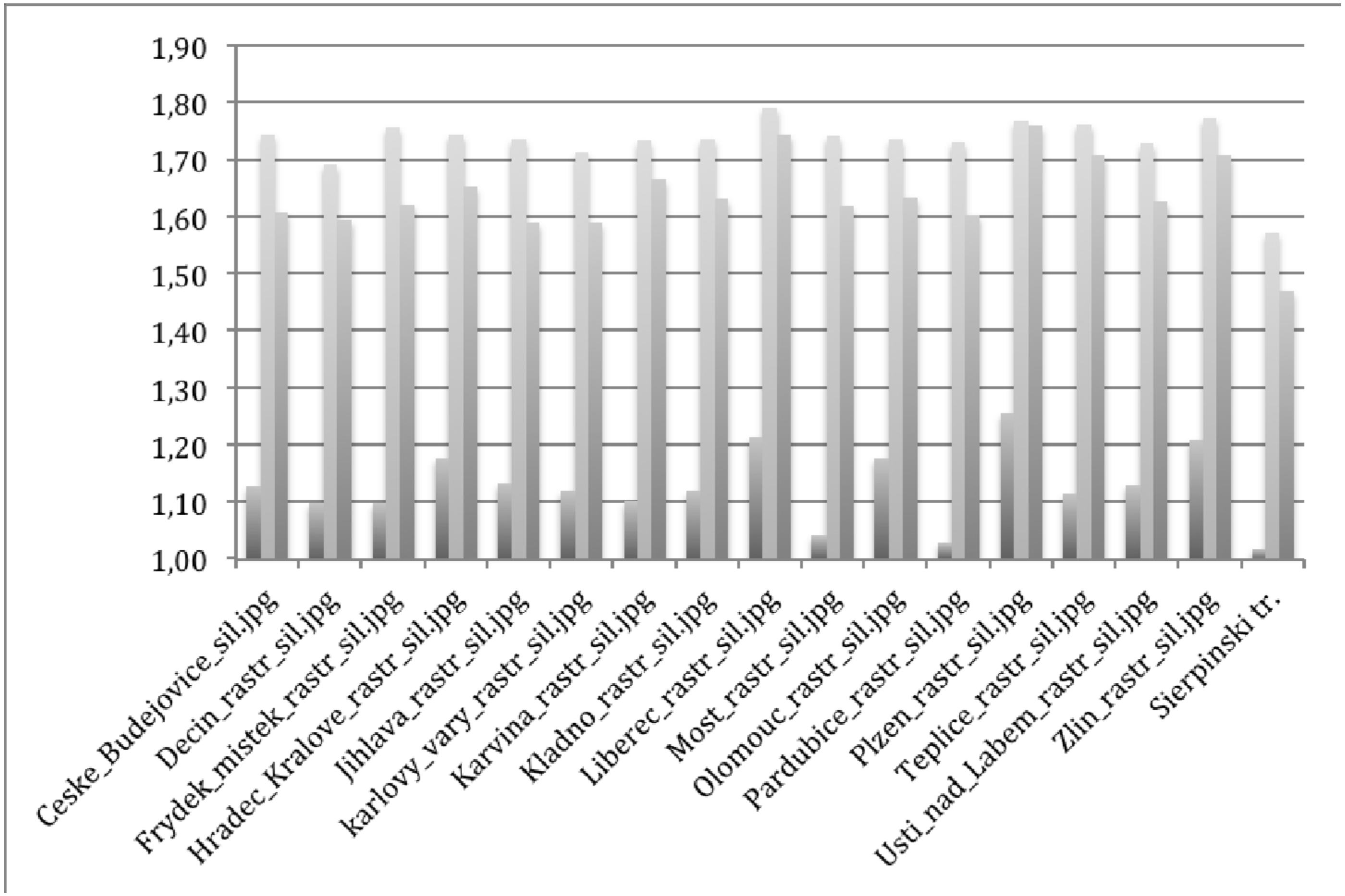
Results

In order to evaluate the complexity of the street and road networks in the Czech Republic (or across all suggested cities), we firstly produce the analysis of the street network for different citie. We have chosen quite similar mid-sized cities and the performed analysis is based on fractal dimension computation (lacunarity, box counting dimension and correlation dimension) and hypothesis testing. We have expected differences according to the landscape of cities (flat, hilly, historically bounded, etc.). In case of lacunarity, the bigger value represents also larger areas without street coverage. Box counting dimension represents in our case the uniformity of the landscape coverage by the street network. Correlation dimension represents the complexity of the system. The correlation dimension expresses how the amount of mass (in our case streets) around points of an object varies with the distance. First, we computed all above discussed fractal characteristics and they are summarized in Tab. 1. For comparison with some known and described object, we have chosen Sierpinski triangle. Fig. 3 shows the example of comparison between Sierpinski triangle and digitalized street network of city Jihlava.

Results TI



Results TI


1,90
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1,60
1,50
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1,30
1,20
1,10
1,00
Ceske_Budejovice_sil.jpg
Decin_rastr_sil.jpg
Frydek_mistek_rastr_sil.jpg
Hradec_Kralove_rastr_sil.jpg
Jihlava_rastr_sil.jpg
karlovy_vary_rastr_sil.jpg
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Usti_nad_Labem_rastr_sil.jpg
Zlin_rastr_sil.jpg
Sierpinski tr.

Results TI vs. DEM

To compare the complexity of the transport infrastructure with the DEM profile, we calculated also the fractal dimensions of above mentioned cities, where both streets and DEM profile were taken into account.
The preliminary results show the statistical significant differences between cities. These results should be more exploited and more cities should be evaluated.

CITY	DIM_STR	DIM_DEM
katowice	1,39	2,17
kosice	1,62	2,12
leipzing	1,75	2,13
ostrava	1,52	2,10
szekeszfehervar	1,58	2,12

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Thank you for your attention: Pavel Tuček