Determining the Projection of Small Scale Maps Based on the Shape of Graticule Lines

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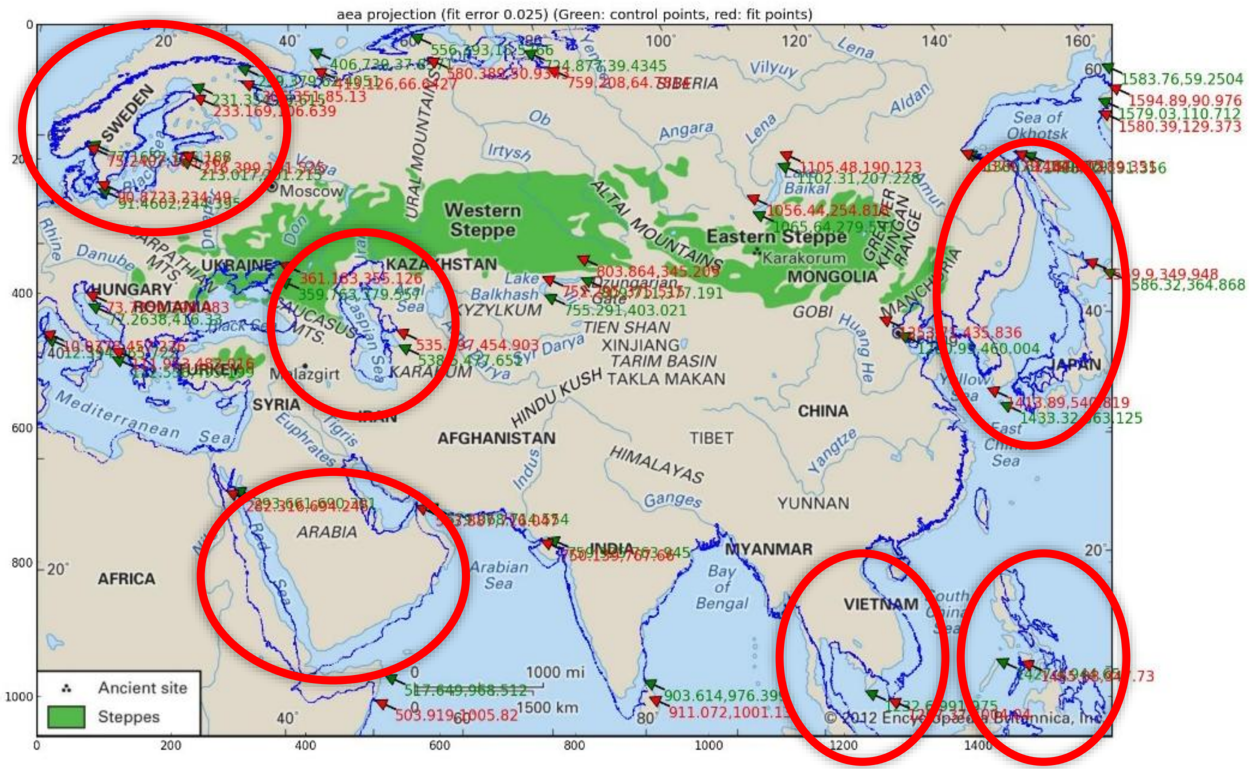
Motivation

Georeferencing a small-scale map with an unknown projection

Without projection info (GCPs only)



Motivation

Georeferencing a small-scale map with an unknown projection

Take the projection into account *(if it is present)*

Ask the producer.

If you know common CRS for your geographic region, you can try some of them. But asking is better.

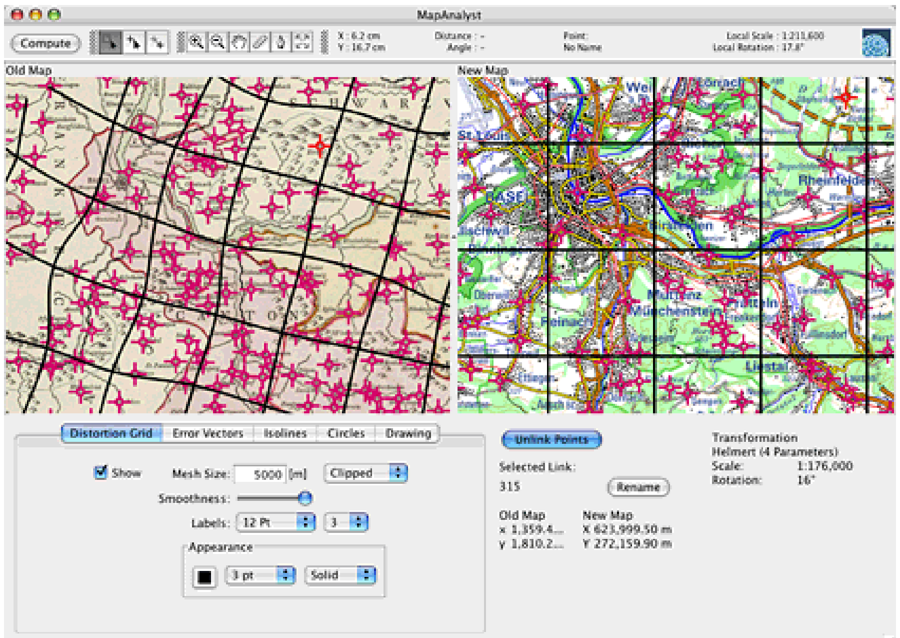
Research what possible coordinate systems are used in this area. One place to check is the

2. Now make some educated guesses on what projection the unknown layer could be. (UTM, Plate Carree, etc). Project your known coordinate system layer into each projection until you find one that matches the unknown layer as much as possible.

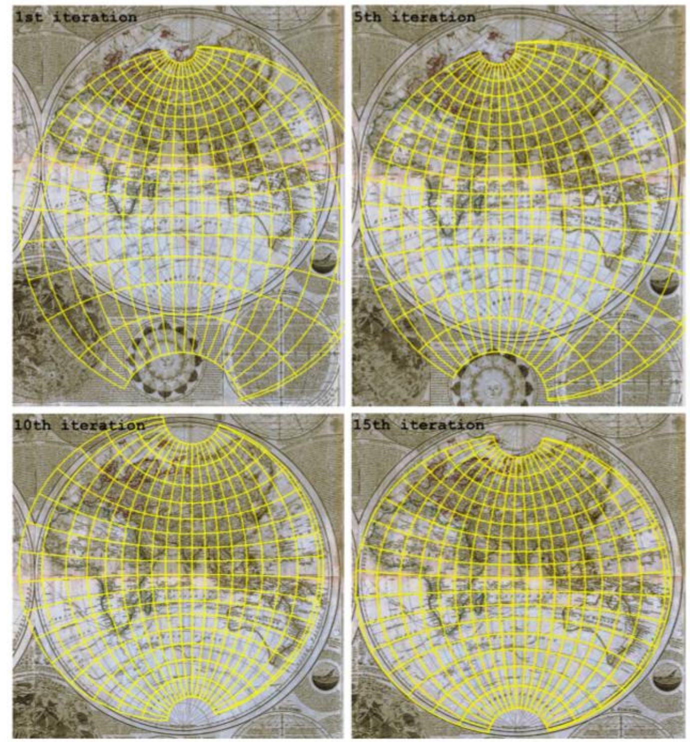
I was beside myself!! The acronym in the naming convention stood for "surface Geology of the Former Soviet Union", and the Google search led me "directly" to the source (USGS). Everything, and I mean "**EVERYTHING**" I could ever need to know about this shapefile was at the top link I hit. I'm not saying that Google can find **anything & everything**, but let me tell you, I was fresh out of university, and just taking a "shot in the dark", and look at the feedback I got!! My boss was so impressed, yet I just **got lucky**!!

As far as I know, there's no tool that can directly figure out the projection of a given map, although one would be very useful. What I have done in the past is a bit like the brute-force method, but perhaps a bit more refined.

Already existing tools



MapAnalyst[1]



detectproj[2]

[1] Jenny Bernhard, Hurni Lorenz (2011). “Studying cartographic heritage: Analysis and visualization of geometric distortions”. In: Computers & Graphics 35.2, pp. 402–411.
http://mapanalyst.org

[2] Tomáš Bayer (2014). “Estimation of an unknown cartographic projection and its parameters from the map”. In: Geoinformatica 18.3, pp. 621–669.
https://web.natur.cuni.cz/~bayertom/detectproj/

Already existing tools
(MapAnalyst & Detectproj)

- **Input**
  - **list of GCPs** on both…
    - The **unknown** map
    - A **reference** map
  - built-in **list of possible projections**

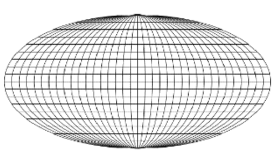
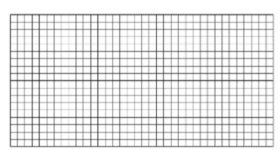
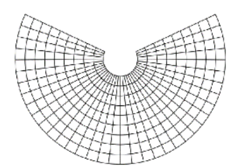
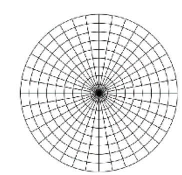
- **Algorithm (outline)**
  - **Transform reference map GCPs** into all of the possible projections
  - **Compare resulting point set** with GCPs on the unknown map
  - **Quantify goodness of fit** (calculate transformation parameters between the two point sets)
  - Minimize errors and **choose the best fit as the result**

Our Approach

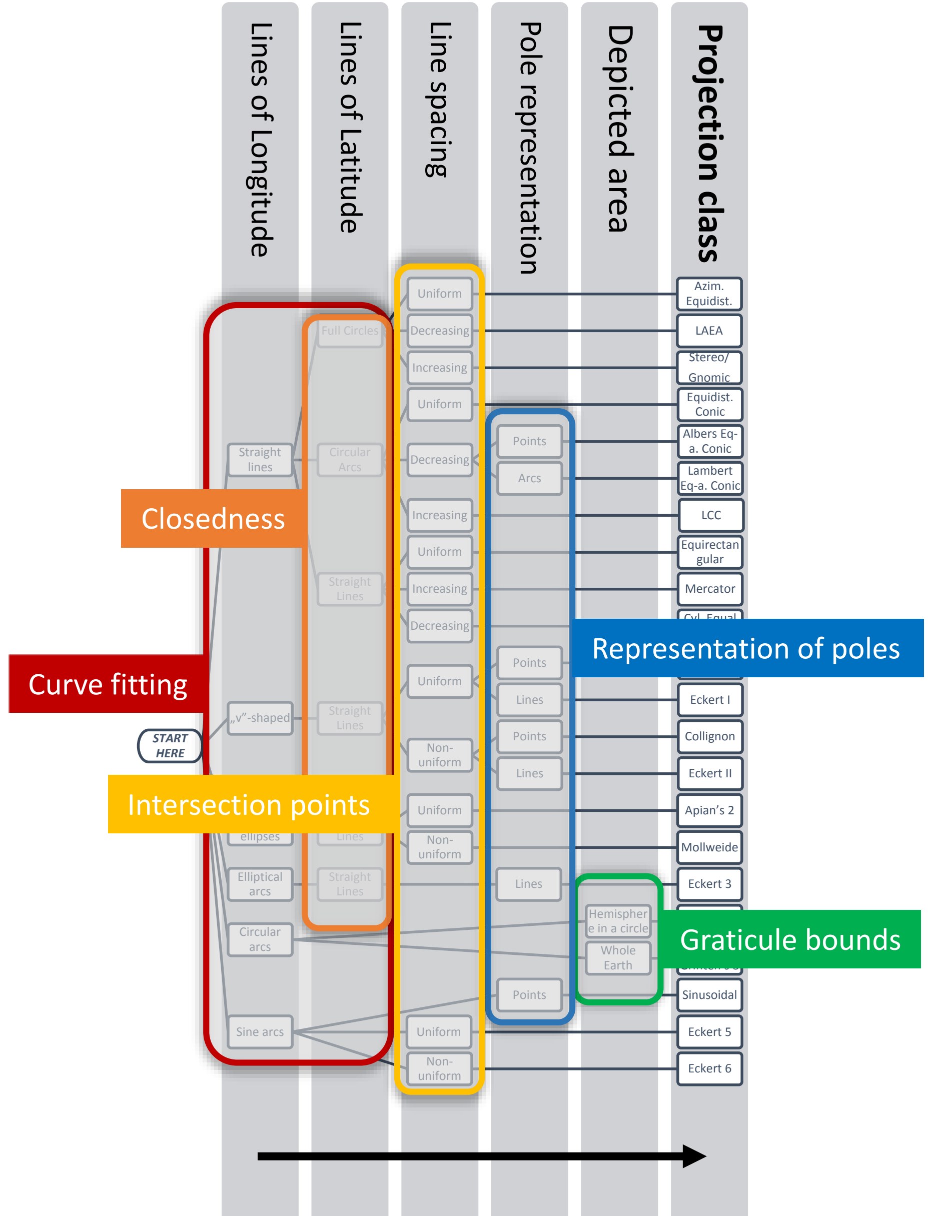
- *Analysis of Cartographic Projections* by *György Érdi-Krausz*[1]

- Primary method: **observing different properties of the graticule** (the geographical grid)
  - ➢ Formulated as a decision tree

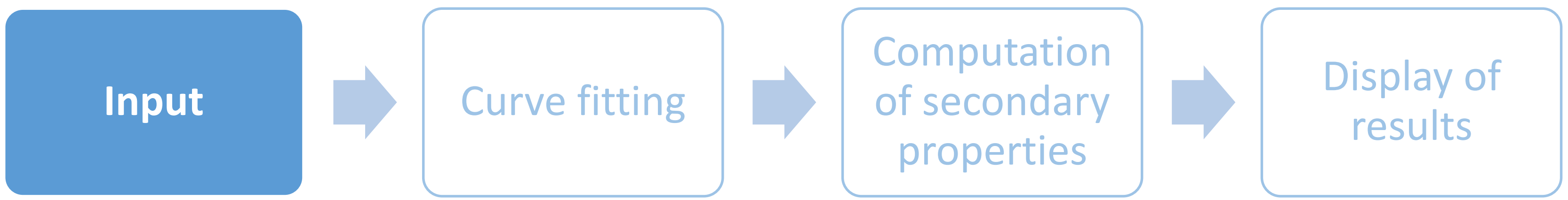
- Reserch goal: develop an **application for a non-professional audience** based on this system

[1] Érdi-Krausz Gy. (1958). „Vetületanalízis. (Analysis of Cartographic Projections)" Térképtudományi tanulmányok (Studia Cartologica). 1:194-270.

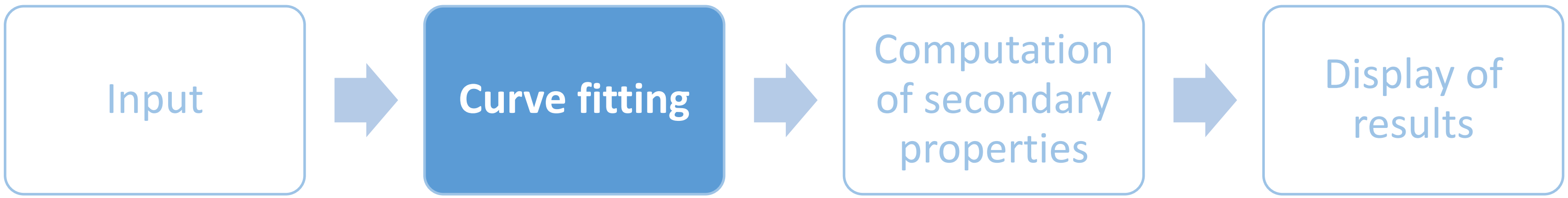

Lines of Longitude
Lines of Latitude
Line spacing
Pole representation
Depicted area
Projection class
Closedness
Curve fitting
Intersection points
Representation of poles
Graticule bounds
START HERE
Straight lines
„v"-shaped
ellipses
Elliptical arcs
Circular arcs
Sine arcs
Full Circles
Circular Arcs
Straight Lines
Uniform
Decreasing
Increasing
Non-uniform
Points
Arcs
Lines
Hemisphere in a circle
Whole Earth
Azim. Equidist.
LAEA
Stereo/ Gnomic
Equidist. Conic
Albers Eq-a. Conic
Lambert Eq-a. Conic
LCC
Equirectangular
Mercator
Eckert I
Collignon
Eckert II
Apian's 2
Mollweide
Eckert 3
Sinusoidal
Eckert 5
Eckert 6

Our Approach
Algorithm



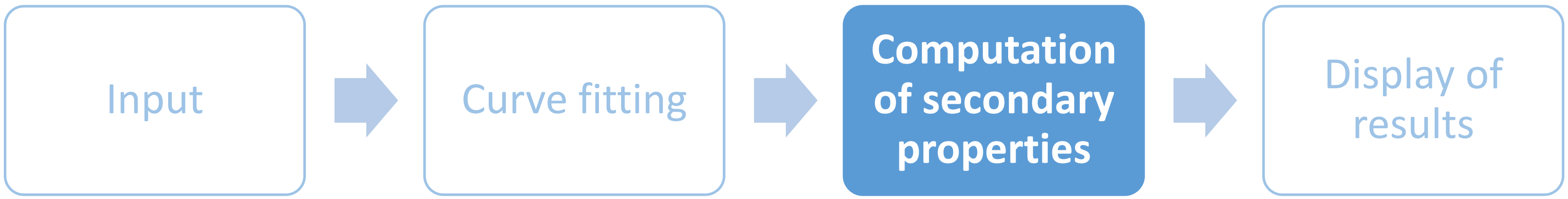
- **Manual digitizing of graticule lines** by the user
  - Result: a set of points
  - Drawing tools are provided on a web-based UI
  - Also pole points (N/S)

Our Approach
Algorithm



- Based on **iterative optimization**
  - **For conic sections (ellipses, parabolas, hyperbolas):**
    - **Levenberg-Marquardt** method
  - **For straight lines**
    - A form of least-squares fitting (QR-decomposition)
- **Choose the best fit as the solution**
- **Fast convergence -> short processing time** (5 to 10s)

Our Approach
Algorithm

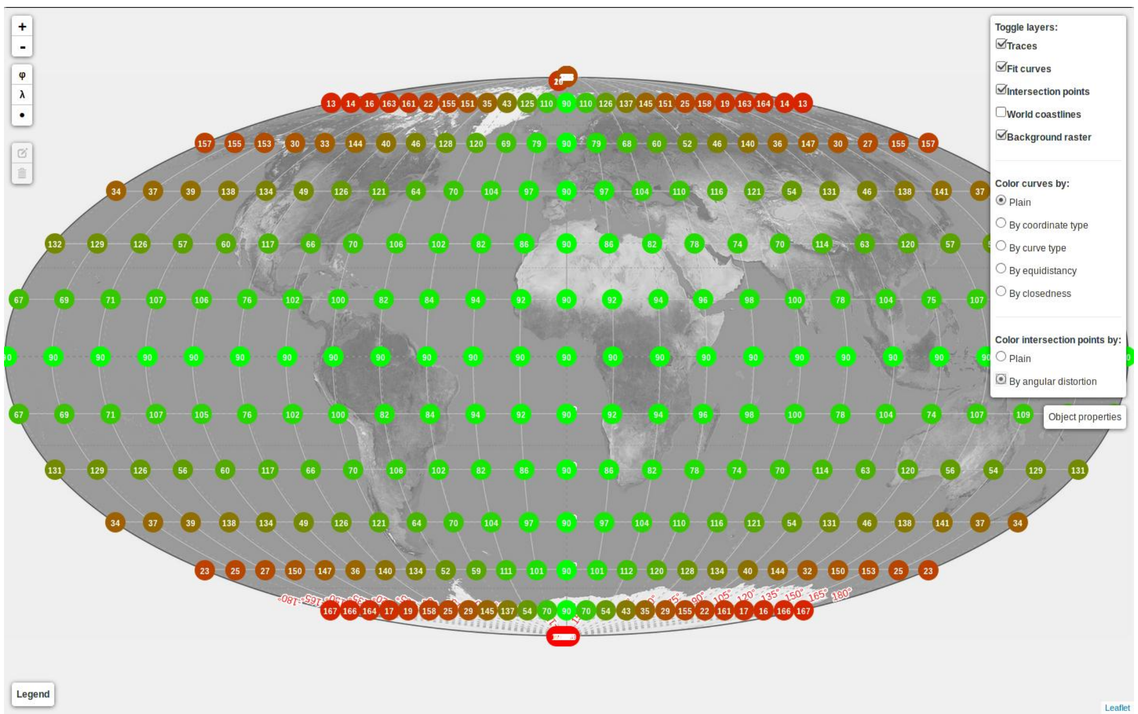


- **Closedness of curves**
- **Intersection points**
  - Also the spacing of intersection points along lines
- **Graticule bounds**

Our Approach

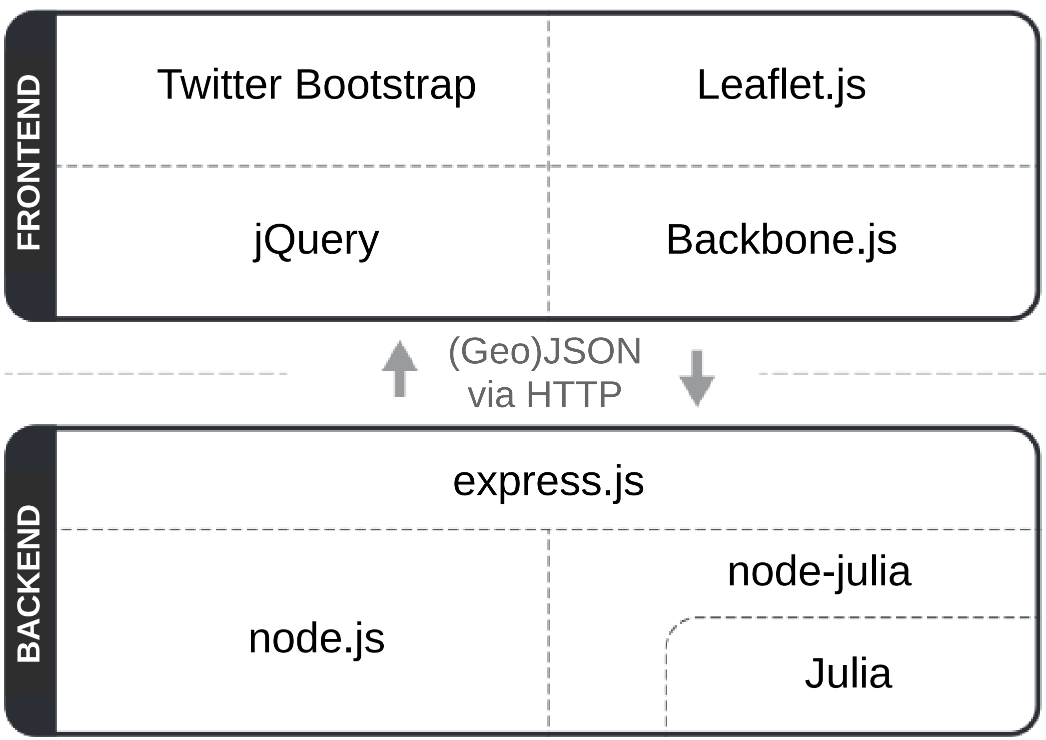
Algorithm

Input → Curve fitting → Computation of secondary properties → **Display of results**



Our Approach
Software stack

Software environment



Tasks

- Provide tools for tracing graticule lines and interacting with the backend
- Display the results of the fitting algorithms

- Curve fitting, computation of secondary properties
- Curve plotting
- Generation/loading/saving of test data

Results

Recognizable projections

- **Cylindrical**
  - Equirectangular
  - Mercator
  - Stereographic
  - Gnomic (polar/normal aspect)
  - Lambert Cylindrical Equal-area
- **Pseudocylindrical**
  - Apian's 1/2 (Ortelius)
  - Sinusoidal
  - Mollweide
  - van der Grinten's 3
  - Eckert 3-6
  - Kavrayskiy 1-2, 6-7
- **Conic**
  - Equidistant Conic
  - Lambert Equal-area Conic
  - Albers Equal-area Conic
  - Lambert Conformal Conic
- **Azimuthal**
  - Lambert Azimuthal Equal-area
  - Azimuthal Equidistant
  - Gnomic
- **Other**
  - Hammer (+ Equal-area)
  - Aitoff
  - Pseudoconic

Outlook

- **Computation of projection parameters**
  - Emitting ready-to-use georeferencing information

- **Automatic tracing of graticule lines** using computer vision techniques

Demonstration

http://omaps.elte.hu:8000/