Bachelor Thesis

Metro-Map Styled River Maps

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Chair for Algorithms and Data Structures
University of Freiburg
Introduction 1/7

- A piece of original OpenStreetMap
Introduction 2/7

- Rendered map, expressed by LOOM
Introduction 3/7

- Colors of the tributaries
Metro maps and river maps, similarities and differences?
Similarities

- Tributaries gather at the stem
- Geographical width can be ignored

way 4: waterway=river, “thalweg”
way 1, 2 & 3: waterway=riverbank
Differences

- Our river maps are geographical accurate
  - nodes are not equally spaced
  - without “underlying grid”
Output: GeoJSON file, as LOOM expected

```json
{
  "features": [
    {
      "geometry": {
        "coordinates": [945322.1435861, 6358143.7429898],
        "type": "Point"
      },
      "properties": {
        "color": "000000",
        "id": "1656844591"
      },
      "type": "Feature"
    },
    {
      "geometry": {
        "coordinates": [936620.2210671, 6376420.5050057],
        "type": "Point"
      },
      "properties": {
        "color": "000000",
        "id": "507930239"
      },
      "type": "Feature"
    },
    {
      "coordinates": [
        [945322.1435861, 6358143.7429898],
        [936620.2210671, 6376420.5050057]
      ],
      "type": "LineString"
    },
    "properties": {
      "color": "a4b020",
      "id": "514832816",
      "name": "Neckar",
      "length": "1.0633858",
      "from": "1656844591",
      "to": "507930239",
      "lines": [
        {
          "label": "Neckar",
          "color": "a4b020",
          "id": "514832816"
        }
      ],
      "type": "river"
    },
    "type": "Feature"
  ],
  "type": "FeatureCollection"
}
```

Output file with two nodes and one edge
OSM Data Structure

- Nodes
  - latitude, longitude, and node id
- Ways
  - nodes, referenced by their ids
- Relations
  - relationship between nodes, ways, and/or other relations
- Tags of nodes, ways, and relations
  - key + value, for example: waterway=canal
Extracting Procedure

1. Filter out the related ways and save
   - name of the waterway
   - type of the waterway (river, stream, canal, etc.)
   - node ids as ordered list

2. Find out the needed nodes and save
   - latitude, longitude
Storage structure 1/3

- **unordered_maps**
  - Node map, key: node id
    - set: edges referencing the current node (eInN)
  - Edge map, key: edge id
    - river id
    - set: upstream river ids (rInE)
  - River name map (temporary), key: river name
  - River map, key: river id
    - set: edges in the current river (eInR)
Storage structure 2/3

- Splitting rivers with the same name, why?

“Schwarzenbach” in the black forest
Storage structure 3/3

River Graph

Node Map
- Ion & lat
- set: edge in node (eINN)
- in & out

Edge Map
- name & type
- list: node in edge (nINnE)
- river id
- set: river in edge (rINnE)

River Name Map (temporary)
- name

River Map
- length
- ignored
- set: edge in river (eINrR)
- color
Data processing 1/10

Basic procedure of our program
Organising nodes, step 1/6

- Three kinds of special nodes in directed graph point of view
  - starting points (source of a river)
  - intersection points
  - destination points (mouth of a river)
- in and out for these special nodes
  - starting points: in = 0 and out ≥ 1
  - intersection points: in + out ≥ 2
  - destination points: in ≥ 1 and out = 0
Data processing 3/10

- Rearranging edges, step 2/6
  - Splitting edges
Data processing 4/10

- Rearranging edges, step 2/6
  - Concatenating edges
Data processing 5/10

- Sorting rivers, step 3/6
  - Add river map (key: river id)
    - river id is the id of the first explored edge in this river group
  - Delete river name map (key: river name)
  - Run “organising nodes” again
Adding river names, step 4/6

- Find all the global river source nodes
  - \( \text{in} = 0 \) and \( \text{out} \geq 1 \)
  - this is our initial explore set

- Add upstream rivers’ names to downstream rivers
  - for the upstream node: \( \text{out} - 1 \)
  - for the downstream node: \( \text{in} - 1 \)
  - if \( \text{out} = 0 \), wipe out from the explore set
  - if \( \text{in} = 0 \), add to the explore set
  - variant of breadth-first search (BFS) algorithm
Data processing 7/10

Step 1, Explore set (initial): 1 & 2

Step 2, Explore set: 2

Step 3, Explore set: 3

Step 4, Explore set: empty
Applying length filter, step 5/6

- In name adding procedure:
  - `ignored` was set to `true` if river length under the threshold
- Clean nodes, edges, and rivers respectively
  - downstream river of an unignored river will not be removed
Adding river colors, step 6/6

- HSV (hue, saturation, lightness) model, other than RGB
  - more intuitive in terms of choosing colors
- For each river, generate a unique color
- Make sure the intersected ones have different colors
Data processing 10/10

- Processing procedure from the code point of view

**directed graph**

- build node
- build edge
- add river names
- clean node/edge/river maps
- add river colors
- sort edges
- create edge
- sort rivers
- concatenate
- find neighbors
- build source map
Evaluation

- Test results

Laptop with Intel Core i7 2.7 GHz (4 Cores) with 16 GB Memory

<table>
<thead>
<tr>
<th></th>
<th>Map Size</th>
<th>Amount of points</th>
<th>Amount of lines</th>
<th>Running time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamburg</td>
<td>588 MB</td>
<td>1148</td>
<td>953</td>
<td>19</td>
</tr>
<tr>
<td>Freiburg</td>
<td>2.16 GB</td>
<td>7142</td>
<td>6377</td>
<td>72</td>
</tr>
<tr>
<td>Bavaria</td>
<td>10.52 GB</td>
<td>26832</td>
<td>23549</td>
<td>362</td>
</tr>
<tr>
<td>Germany</td>
<td>56.96 GB</td>
<td>124610</td>
<td>106394</td>
<td>2019</td>
</tr>
</tbody>
</table>

- Quasi-linear growth of running time by the size of the data
Possible problems 1/5

- Interruption Caused by Lakes

Rivers around Ammersee, Bayern
Possible problems 2/5

River loops
Possible problems 3/5

- Breaking points

Diagram with points labeled Neuer Graben and Affengraben.
Possible problems 4/5

- Repeated Edges
Possible problems 5/5

- Wrong Direction of Rivers
Future work

- Identifying and correcting the above data inconsistencies
- Other creative ideas, e.g. apply the results on octilinear grid graphs?
References

Wikipedia

OpenStreetMap Wiki

Literatures
https://doi.org/10.1145/3337790
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Thank you for your attention!
Questions?