3D Micro-Mapping

Crowdsourcing to Support Image and 3D Point Cloud Analysis

Prof. Dr. Bernhard Höfle
L. Winiwarter, K. Anders, B. Herfort
3D Micro-Mapping

Mapping of 3D geoinformation within a few seconds using a simple web browser feasible for non-experts
Micro-Mapping: My definition

- "Micro" refers to quick and easy single mapping task that can be solved in a few seconds

- Perception tasks that complex for computers but easy for human interpreters
  - e.g. complex objects (high inner-class variation)

- Context and local knowledge can be incorporated

- Makes use of visual interpretation strengths and high data redundancy

Refs: Herfort (2017), Herfort et al. (2018)
Dimensions of crowdsourcing

**TECHNICAL**
- Backend server
- Web 2.0 mapping tools
- Databases
- ...

**DATA**
- Data availability
- Data preparation
- Rights and privacy
- ...

**SOCIAL**
- Activate crowd
- Training material
- Education effects
- ...

**INTEGRATED VIEWS**
- Design of tasks
- Training material
- Quality assessment
- ...

3D Micro-Mapping: Principle concepts

2D → 3D

3D → 2D → 3D

3D → 3D

3D GEO-INFORMATION

Refs: Griesbaum et al. (2017), Herfort et al. (2018)
Structure and challenges of 3D Micro-Mapping

Refs: Barrington et al. (2011)
Structure and challenges of 3D Micro-Mapping

1. Split into micro-tasks
2. Merge contributions
3. Organize the crowd

Refs: Barrington et al. (2011)
Minimal technical system

INPUT DATA

Data Preparation

Logic & Task Management

Geo-Database

Frontend / GUI

Data Post-Processing

OUTPUT DATA
Research Studies
Selected research examples

Crown Base Estimation

3D $\rightarrow$ 3D

Tree Localization

2D $\rightarrow$ 3D

Refs: Herfort et al. (2018)
Conceptual approach

- **Input:** Segmented ALS point clouds of trees in Vienna
- **Several tasks** by simple answer or user interaction
- **Implementation:** Web browser (Pybossa + WebGL,...)

Refs: Höfle et al. (2012), Herfort et al. (2018)
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Refs: Höfle et al. (2012), Herfort et al. (2018)
Crown base height

3D Micro-Mapping ↔ Automatic method

Reference by experts

Refs: Koma et al. (2016)
## Users and contributions

<table>
<thead>
<tr>
<th></th>
<th>Tasks</th>
<th>Contributions</th>
<th>Users</th>
<th>Contributions/task</th>
<th>Tasks/user</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td>834</td>
<td>9,906</td>
<td>152</td>
<td>11.9</td>
<td>65.2</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>460</td>
<td>5,580</td>
<td>110</td>
<td>12.1</td>
<td>50.7</td>
</tr>
<tr>
<td>Experiment 3</td>
<td>363</td>
<td>7,110</td>
<td>96</td>
<td>19.6</td>
<td>74.1</td>
</tr>
</tbody>
</table>

Refs: Herfort et al. (2018)
Duration per task

![Distribution of runtime per task]

- **Experiment 1:**
  - $N=834$
  - Mean = 4.38
  - Median = 3.65
  - Variance = 6.62

- **Experiment 2:**
  - $N=460$
  - Mean = 6.72
  - Median = 6.02
  - Variance = 10.28

- **Experiment 3:**
  - $N=363$
  - Mean = 5.05
  - Median = 4.56
  - Variance = 3.62

Refs: Herfort et al. (2018)
Evaluation of crown base height

Difference to reference correlates ($R=0.46$) with user agreement (std.dev.)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Average difference [m]</th>
<th>RMSE [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>crowdsourcing</td>
<td>363</td>
<td>0.008</td>
<td>0.054</td>
</tr>
<tr>
<td>computer (automatic)</td>
<td>324</td>
<td>0.058</td>
<td>0.147</td>
</tr>
</tbody>
</table>

Refs: Herfort et al. (2018)
Learning moment

- **Data quality** dependent on **task design**
  - Single annotation and crown base height easier to solve
  - Multi-answer classification is difficult: no micro-task?

- **User agreement** as intrinsic quality indicator

- **Crown base height**: Higher accuracy and completeness than applied automatic method

- **Strong visual component** in task design leads to better results in 3D crowdsourcing

Refs: Herfort et al. (2018)
Selected research examples

Crown Base Estimation
3D $\rightarrow$ 3D

Tree Localization
2D $\rightarrow$ 3D

Release of new mapping project

Refs: Herfort et al. (2018)
Design of project and single tasks

- **Goal:** Retrieve positions (xyz) of tree stems from UAV-LiDAR point clouds

- **Reduce complexity for users**
  - My kids and beloved granny should be able to do the job

- **Full 3D task not possible** due to forest complexity
Motivation

Why crowdsourcing and not with automatic methods?

- Co-registration of diverse point clouds (TLS, ULS, ALS)
- Validation / Training of automatic approaches
- Development of hybrid approaches: Crowd + Algorithm

Refs: Liang et al. (2018)
Motivation

Why crowdsourcing and not with automatic methods?
- Co-registration of diverse point clouds (TLS, ULS, ALS)
- Validation / Training of automatic approaches
- Development of hybrid approaches: Crowd + Algorithm

Hypothesis
Anyone can do it easily by manual 3D mapping!

Refs: Liang et al. (2018)
Design of project and single tasks

• Development of 2D→3D tasks
  – Mapping trees in **point cloud cross-sections**
  – Complete area is covered with overlapping sections
Implementation of project

Web browser app
Live statistics

Your statistics
No. of mapped trees: 15
No. of solved tasks: 11
Avg. time per task: 3.58 seconds
By this, you visually processed 272279 points!
Your current rank in our database is 723

Your mapped trees
Click on tree to view profile

Project statistics
No. of mapped trees: 653
No. of users: 47
No. of solved tasks: 675
Number of contributions: 477
Avg. time per task: 1.03 seconds
Avg. no. of contributions per task: 1.61
Number of processed 3D points: 82988357

All mapped trees
Click on tree to view profile
You can come back anytime

• to continue and improve your statistics!
Results

Tree position candidates

All mapped trees

Statistics

Phowo 3D Micro-Mapathon results will be released on https://uni-heidelberg.de/3dgeo
Results and data

We expect to

• identify **challenging issues** for users
• evaluate different **methods to aggregate** user contributions in a robust way
• evaluate **data quality** (180 TLS trees)

• push forward the **combination of automatic methods, simulation and crowdsourcing** in an effective way
  – reduce crowdsourcing effort (cf. Herfort et al. 2019)

Refs: Herfort et al. (2019)
Value of crowdsourcing for algorithms

Current bottlenecks of computer-based methods

• **Long process** of algorithm development
• Missing understanding of **causality** of results
• **Lack of data:** Training / test / validation data etc.

Independent data & information

Refs: Griffiths & Böhm (2019)
The science is to keep it as simple and effective as possible.

Let's map: https://uni-heidelberg.de/3dgeo
References


