Highlights

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Interactive interpretation of 3D surfaces in field-based geosciences using mobile devices - concepts, challenges and applications

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Abstract

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1. Introduction

- computing equipment continuously elevates the analytical capabilities for solving geoscientific problems
- large drawback on computing equipment: the more powerful it is, the more stationary it is
- geoscience disciplines such as hydrology, geology or glaciology are driven by outdoor experiments that prohibit bulky equipment
- the advent of mobile computing equipment, such as smartphones and tablets, provides a possible solution to the equipment problem

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- form factor of mobile devices is small enough to allow every field-related geoscientist to carry one in the field
- as seen is popular articles, the range of available devices increases, which allows to find a devices fit-for-purpose to each situation
- range of devices also comes with a range of capabilities that influence their usability for specific field tasks
- availability of small form factor devices is only on part contribution to making digital geosciences more "mobile"
- availability and easy access to geoscience data (e.g. domain-specific maps, digital elevation models (DEMs), surface models in 3D) is equally important to perform combined digital- and field analysis
- while basemap access on mobile devices is trivial, surface-scanned data in form of point clouds and (textured) triangulated meshes is becoming increasingly available with novice-operable structure from motion (SfM) software and drones
- crowdsourced data and Volunteered Geographic Information (VGI) provides numerous data for domain-specific analysis, which is facilitated by easier data capture from amateur scientists using mobile devices
- In order to connect data and devices in the field, domain-specific mobile software is required
- the difficulties in mobile software development stem from the specific demands and challenges for mobile software, such as energy efficiency, multi-manufacturer support, smart sensor utilisation [add and expand]
- with the emergence of new application cases, which are demonstrated and discussed in this article, and an increasing interest from geoscience- and computer technology industry, a significant rise in the mobile software

availability for geoscience problem solving is expected for the near-term future

- Challenges

2. Target case studies

3. Representation basis – Geometry and Radiometry

4. Algorithms

4.1. Structure-from-Motion model generation

4.2. Image-to-geometry

4.3. Data representation and rendering

4.4. Interpretation and annotation

5. Technology

5.1. Sensors

5.1.1. Localization

5.1.2. Orientation

- stability IMU (see 3D-NO)
- precision IMU

5.1.3. Parameter sensitivity

5.2. Graphics

- software- vs hardware renderer
- web-rendering
- rendering-on-device
- hardware differences: speed, capability, CUDA

5.3. Power consumption

6. Applications and Requirements

Due to the increasing usability of mobile devices for in the field annotations, several use cases concerning geosciences has become apparent. In the following, two essential

6.1. Derivation of hydrological parameters: Water level gauging

The last decade is characterized by a continued increase of globally devastating flash floods after heavy rainfalls. Even smallest creeks turned into hazardous streams causing flooding and landslides. Conventional gauging stations provide precise information about water levels measured over a short time period. For official gauges in Germany, standard derivation of one centimetre is required [1] [need more references]. But they are rather cost expensive in purchase and maintenance and thus just sparsely installed. Exemplary, the overall distribution of gauging stations in Saxony, Germany amounts to 154 compared to 259 creeks and rivers with small, medium and large catchments [2]. Thus, around a third can not be monitored neither during flood events when the most protection is required. Recently, commercial smartphone applications arose to enable crowd-sourcing based water level data acquisition [3, 4]. But all of them have one thing in common: the water level is entered manually by engaged citizen scientists finding and photographing tide gauges close to rivers which makes them not only a potential danger to themselves (f.e. by sudden landslides) but also it is still limited to open and visible gauges.

Improvements in this sense can be achieved through image-2-geometry intersection and 3D annotation for automatic water level determination without reference gauges for almost every situation regarding running waters. for this, the smartphone application *Open Water Level* that bases on the freely available open source camera framework *Open Camera* [5]. Open Water Level allows for free stationing water line detection using short hand held time-lapse image sequences (for details please refer to [6]). To interpret these, image measurements must be transformed into object space. Thus, exterior information needs to be provided by smartphone sensors for orientation and positioning.

6.1.1. Requirements applying to the sensors

To solve the task of autonomous water level determination on running rivers f.e. emergency cases using image-2-geometry intersection, citizen scientists position and orientation must be know. As figured out in 5, smartphone sensors accuracies for orientation and location are highly dependent on user's environment. Especially the strong correlation of heading and disturbing magnetic sources may be a issue must be solved specifically related to running rivers where metal railings usually exists. Similar effects can also be noted using high-end IMU systems for instance autonomous car navigation. But the magnetic influences inside cars are almost stable and can be calibrated during the drive (advanced navigation manual). For smartphone orientation, the magnetic strengths attaching the phone may change substantially in short time. A typical scenario would be: a citizen scientist walks along street, taking his phone inside the baggage close to metallic keys. While walking he passes several street lamps, signs, etc. Finally, he arrives at a bridge over a urban river, takes out the phone, looks down to the river and records the time lapse image sequence a few centimetres above a metallic railing. Meanwhile, several cars passing the same bridge. In this simple use case, the magnetic field around the smartphone changes countless times due to several unpredictable disturbances.

- (FIGURE WITH OBSERVED HEADING WHILE STANDING AT RIVER → check magnetic strengthens and there changes over short times)
- (FIGURE WITH HEADING TEST → CHANGED HEADING WHAT DOES IT MAKE FOR)
- recap: task to be solved
- main requirements for (location- and orientation) sensor accuracy and geometric accuracy

- specific requirements to this use case: data availability; illumination; device range to cover
- available approach to address the task

6.2. Field Geology

- recap: task to be solved
- main requirements for (location- and orientation) sensor accuracy and geometric accuracy
- specific requirements to this use case: data availability; illumination; network inavailability
- available approach to address the task

6.3. Virtual Field Trips

- recap: task to be solved
- main requirements for (location- and orientation) sensor accuracy and geometric accuracy
- specific requirements to this use case: data availability; illumination; network inavailability
- available approach to address the task

6.4. The digital fieldbook

- recap: task to be solved
- main requirements for (location- and orientation) sensor accuracy and geometric accuracy
- specific requirements to this use case: device range to cover; data integration; no network
- available approach to address the task

7. Conclusions

which problems are sufficiently solved ? which challenges remain that have already been discussed

8. Discussion

- porting existing desktop algorithms on mobile devices [quick and fast]
- vegetation in scans
- pre-processing of geodata for mobile use

References

[1] S. Siedschlag, Wasserstände und Durchflüsse - messen, speichern und übertragen im digitalen Zeitalter, in: Dresdner Wasserbauliche Mitteilungen, volume 53 of *Dresdner Wasserbauliche Mitteilungen*, Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik, 2015. URL: `https://henry.baw.de/handle/20.500.11970/103357`.

[2] Saxon Flood Centre, Water levels & flow rates, 2018. URL: `https://www.umwelt.sachsen.de/umwelt/infosysteme/hwims/portal/web/wasserstand-uebersicht`, accessed: 2018-03-05.

[3] S. Etter, B. Strobl, Crowdwater, 2018. URL: `http://www.crowdwater.ch/de/home/`, accessed: 2018-03-06.

[4] Kisters, Einfach smart: App für Pegelmessung auf Knopfdruck, 2014. URL: `https://www.kisters.de/fileadmin/user_upload/Wasser/Produkte/WISKI/Produktblaetter/MobileWaterTracker_de_mail.pdf`, accessed: 2018-03-06.

[5] M. Harman, Open Camera - Camera app for Android, 2017. URL: `https://sourceforge.net/projects/opencamera/`, version 1.38.

[6] M. Kröhnert, R. Meichsner, Segmentation of environmental time lapse image sequences for the determination of shore lines captured by hand-held smartphone cameras, ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences IV-2/W4 (2017) 1–8.