# Concept for an mobile assisting system for field engineers by the example of structural health monitoring

EXPOSE: Master Thesis Euteneuer

Technical University of Berlin
Institute for Geodesy and Geoinformation Science
Chair of Geoinformation Technology
superviesd by:
Prof. Frank Neitzel
Thomas Becker

by

**Frieder H. Euteneuer**

Berlin, August 7, 2013

Give it more structure! Why does we need field <=> office communication? Motivate this!
=> if we have a motivation we need the user requirements for that! In that case what do we have to integrate in a system BIM to support the field workers acc. to SHM.

# Contents

# 1 Introduction and Motivation

This master thesis will describe potential user needs in a graphical management and analysis tool for the constructional health monitoring. This system will help field engineers in:

- planning their field work,
- correspond with the office,
- and quickly evaluate measured values.

Classical work in survey engineering consist of the measuring tasks in the field, and its evaluation, analysis and correction in the office. This subdivision into to spatially different, but often very cooperating tasks leads to inefficiency of the work, time delay and avoidable mistakes in the procedures.

Nowadays a close interaction of different activities every time and everywhere is not any more a vision, it is common to our society and people get used to it. Field work today already contains usages of mobile devices which help organising the work flow.

There are three main advantages of using such a system following this approach:

- The Systems core functionality will be the assistance of the measurement engineer. This means it helps with understanding the measurements e.g. in comparison to former epochs.
- It is avoiding "mis-measurements" caused due to a incomplete knowledge of the measurement network by validation of measurement "on the fly" directly after the upload to the database.
- For a field exploration existing results of the former measures have not to be exported from the office infrastructure, the mobile system is linking real time data with existing results.

There is a need of such a system, the combination of used techniques like "Sensor Web Enablement", OGCs Web Services and mobile advanced IT platforms like tablet computers for a streaming of data from the field to the field is up to now an unanswered question. This master thesis will explore possible solutions and the real need of potential users.

It will not be an alternative for engineering management systems which are already running on mobile devices, the real benefit of this system being designed with this thesis will be a direct linkage of the sensors to the systems, from data streaming up to augmented reality.

# 2 Methods

Based on existing developments like IT-Architectures and Data-formats the system will be formed by the actual need of working field engineers. Use case models and research on already existing systems will help in finding a technically and financially optimal solution.
Main questions on the concept will be:

- Which Sensors will be linked, and what kind of data will be used (in case of e.g. interval)?
- How should an optimal database design look like (Handling problems like time-series, data-representation)?
- How will the data be transferred, and where will they be stored?
- How will the graphical user interface be structured and designed?
- What kind of it-architecture and which protocols will be used?

You are not responsible for that! Just focus on the field part and the communication to and from office!

To find a working and operationally usable solution following problems and concepts have to been reviewed, discussed and evaluated:

## 2.1 Feature Extraction

relation to the rest?

When talking about an structural health monitoring system, the data of different kind of sensors are part of the evaluation calculations. The System has to be able to access the Sensors and to translate the data in to machine readable and understandable information. The data of e.g. a terrestrial laser scanner is a point cloud which is unique in each epoch. Therewith the relevant absolute information have to be extracted, mostly in this case geometrical features. The RANdom SAmple Consensus (RANSAC) approach has been turned out as one feasible solution for the extraction of geometric Features [11]. And for the recognision of semantic features there are existing different approaches e.g. [10][4].

## 2.2 Complex Data

The used database then has to be able to store those different kind of data: Starting with point clouds from terrestrial laser scanners up to feature models of the observed structure. And also the raw material might be important for future scientific work, therewith maybe also pictures have

to be stored. Projects like the German Indonesian Tsunami Early Warning System have already developed examples for databases storing complex data [12].

## 2.3 Time Series

Second problem in case of the database will be the storage of time-series of the data. Monitoring means changes of values in comparison to former epochs. In our case most changing values are spatial information, and therewith the problem describes the storage of moving objects in a database. Several approaches exist dealing with this problem, first: For every change of one parameter a full snapshot of all data will be stored in the database but this would lead to a big amount of data. Second: Only the changed parameter will be stored, but then the relationship model of the database entities and therewith the managing system will become very complex. [2][7][14]

## 2.4 Data Streaming

The System then has to be able to stream and visualise the data on a certain platform. Webservices might be the actually best solution and they fit to the trend offering software as a service. The service oriented Architecture paradigm described in [? ] describes the method how to serve the relevant information without having a monolithic static system. With geometric data, as for example geometric primitives, the encoding of the data in CityGML [3][6] would be the best solution. With the help of Services defined by the Open Geospatial Consortium (OGC) like for example the Web Feature Service [8] [5][1][9][13] the related data could be visualised.

## 2.5 Data Analysis

Not as a central part of this master thesis but at least partially the analysis of the used data should be described. The development of appropriate algorithms might not be a task, but the way how to integrate them into the structure.
The Finite Element Method (FEM see e.g. [15]) should be mentioned here as an example relevant analysis tool.

# 3 relevant studies

# 4 Expected Results

As an overall output an demonstrating prototype of the system will be developed based on one concrete example. All open questions will in the end be answered and evaluated, based on the developed prototype.

The demonstrating example will contain data from different Sensors like Terrestrial Laser Scanners, Levelling Instruments, Total Stations and possibly also data from Accelerometers and other permanent observation sensors.

The data will be transferred to an central Database in such a quality and short interval that a direct an continuous observation of changes in the measurements on a mobile device is doable.

On the structural health monitoring test side for this prototype, experiments should be part of the evaluation of the developed system. Such like observation of loading test on the monitored construction (e.g. a bridge).

Changes in the measured data should be illustrated in a practicable way. An interpretation of numeric results by the user is not an option. Better would be a graphical symbolisation of changes and it pre-evaluation. What kind and which statistical interpretation of the measurements will be part of the algorithms will not be part of the development of this prototype and should be offered by the partnered scientists or parallel master thesis. This master thesis will simply develop the technological structure as a basis for any implementation of adjustment and statistical evaluation algorithms.

# 5 Expected Problems

## References

[1] Douglas Nebert, Arliss Whiteside, and Panagiotis (Peter) Vretanos. OpenGIS® catalogue services specification, February 2007.

[2] Martin Erwig, Ralf Hartmut Gu, Markus Schneider, and Michalis Vazirgiannis. Spatio-temporal data types: An approach to modeling and querying moving objects in databases. *GeoInformatica*, 3(3):269–296, 1999.

[3] Gerhard Gröger, Thomas H. Kolbe, Claus Nagel, and Karl-Heinz Häfele. OGC city geography markup language (CityGML) encoding standard. April 2012.

[4] Stefan Gumhold, Xinlong Wang, and Rob MacLeod. Feature extraction from point clouds. In *Proceedings of 10th international meshing roundtable*, volume 2001, 2001.

[5] Jeff de la Beaujardiere. OpenGIS® web map server implementation specification, March 2006.

[6] Thomas H. Kolbe, Gerhard König, Claus Nagel, and Alexandra Stadler. 3D-Geo-Database for CityGML. *Institute for Geodesy and Geoinformation Science Technische Universität Berlin, Documentation*, 2009.

[7] Manolis Koubarakis. *Spatio-temporal databases: The CHOROCHRONOS approach*, volume 2520. Springer, 2003.

[8] Panagiotis A. Vretanos. OpenGIS® filter encoding implementation specification, May 2005.

[9] Panagiotis (Peter) A. Vretanos. OpenGIS web feature service 2.0 interface standard, November 2010.

[10] Ruwen Schnabel. *Efficient point-cloud processing with primitive shapes.* PhD thesis, University of Bonn, 2010.

[11] Ruwen Schnabel, Roland Wahl, and Reinhard Klein. Efficient RANSAC for point-cloud shape detection. In *Computer Graphics Forum*, volume 26, page 214–226, 2007.

[12] C. Strobl, R. Kiefl, T. Riedlinger, and G. Strunz. Geodatenmanagement und-dienste am beispiel des tsunami-frühwarnsystems für den indischen ozean. 2007.

[13] Thomas H. Kolbe and Arne Schilling. Draft for OpenGIS® web 3D service implementation standard, November 2009. This document is not an OGC Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an OGC

Standard. Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

[14] May Yuan. Temporal GIS and spatio-temporal modeling. In *Proceedings of Third International Conference Workshop on Integrating GIS and Environment Modeling, Santa Fe, NM*, 1996.

[15] Olgierd Cecil Zienkiewicz and Robert Leroy Taylor. *The finite element method*, volume 3. McGraw-hill London, 1977.