OpenBuildingModels - Towards a Platform for Crowdsourcing Virtual 3D Cities

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Abstract Within the last years, Volunteered Geographic Information (VGI) has developed rapidly and influenced the world of GIScience significantly. Most prominently, the OpenStreetMap (OSM) project maps our world in a detail never seen before in user-generated maps. Particularly within urban areas, the focus recently shifts from only streets towards buildings and other objects of the environment such as parks or street furniture. However, this innovation is mostly restricted to 2D so far. In order to come closer to the Digital Earth, it needs to be discussed, how the 3D aspect can be integrated into such VGI-projects. This article has two objectives that are closely related: firstly, the current situation of 3D-VGI is reviewed and crucial issues for future development are pointed out. This leads to the concept of defining a free and open web repository for architectural 3D building models. Therefore secondly, the concept of such a new web platform called OpenBuildingModels is presented. This is an important effort towards 3D-VGI. The models can be linked to OSM objects and displayed by a dedicated 3D viewer. This can extend the possibilities to crowdsource 3D city models in the future.

Keywords: Volunteered Geographic Information, OpenStreetMap, 3D city models, 3D spatial data infrastructures, 3D building modelling

1 Introduction

It's now been over four years that Goodchild (2007) has introduced the term "Volunteered Geographic Information" (VGI) describing the recent revolution of collaboratively created spatial information on the Web 2.0. The increasing availability of smartphones as devices for creating, using and sharing geoinformation spatially enables our society more and more (cf. Williamson et al. 2011). This leads to an ever growing amount of various VGI-related activities which also have

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an impact on research in geographic information science (e.g. WikiMapia 2012; Cloudmade 2012; Panoramio 2012).

The most popular and successful VGI project is probably OpenStreetMap[2] (OSM). Recent investigations on its completeness and quality have shown, that in particular urban areas in Central Europe have already been mapped with an impressive level of detail (cf. Haklay 2010; Neis et al. 2012). In those areas, OSM is meanwhile well ahead of only mapping the street network. For a continuous improvement of OSM it is crucial to enable the mapping of even more detailed, three-dimensional spatial information.

Another phenomenon which is rapidly gaining relevance over the last decade not only in the geo-domain but also in the general public is 3D city models. This has been an important research field in GIScience since a couple of years now (cf. Förstner 1999; Früh and Zakhor 2004; Kolbe 2009). Furthermore, numerous efforts exist from both companies (e.g. Google 2012) as well as public administrations (e.g. Stadtmessungsamt 2012). The era of mapping the Digital Earth (Gore 1998) in three dimensions has long begun. Based on the recent developments in VGI it now becomes possible to investigate the potential of applying crowdsourcing also to 3D geodata.

The dominant parts of 3D city models are buildings. In early 2012, the total number of mapped building footprints in OSM exceeded 50 million[3]. It even surpassed the number of mapped streets. This shows the gradual shift in the purpose of this project, which is no longer limited to only the streets but also includes buildings and other components of urban environments. However, the footprint is only a very rough representation of a building and much more information lies in its detailed 3D structure. The idea of letting the crowd assemble comprehensive 3D city models is very promising.

This paper firstly examines the current state and future directions of user-generated 3D spatial information. Secondly, the concept of OpenBuildingModels, one possible way of how to advance 3D-VGI, is introduced thereafter. We investigate the following questions: How can the potential of VGI be exploited for generating 3D city models beyond what has been reached so far? What are the main scientific and practical questions and problems in this leap forward from 2D to 3D with respect to crowdsourcing? What are the means to enable voluntary users to contribute rich 3D information?

The remainder of this paper is structured as follows: the review part starts in chapter 2 with related work on user-generated spatial 3D content. Subsequently, the current situation of 3D-VGI is critically reflected and crucial issues for the future development are pointed out. In chapter 3, the concept and a first prototype of OpenBuildingModels (OBM) is described. Furthermore, a discussion of advantages and drawbacks of the OBM approach as well as the implemented prototype is given. The last chapter summarises important aspects of this article, pointing out the main insights and limitations as well as potential future work.

[2] http://www.openstreetmap.org

[3] extracted from our internal, regularly updated OSM database

2 The 3D aspect in VGI

2.1 Related Work

Letting the crowd generate spatial 3D information is still in its early stages, however, the idea is not entirely new. This section contains related work which deals with this topic, approaching it from different directions.

One of the most prominent examples is *Google*'s *3D Warehouse*[4]. This shared repository contains user-generated 3D models of both geo-referenced real-world objects such as churches or stadiums and non-geo-referenced prototypical objects like trees, light posts or interior objects like furniture. The former also appear in *Google Earth*. In order to voluntarily contribute, users have to have a certain level of 3D modelling skill. The main focus of this repository does not lie on assembling 3D city models as the non-geo-referenced objects seem to be more important in related work. They are for example used to improve methods of automatic object recognition in the field of laser scan classification (Lai and Fox 2009) or robotic vision (Klank et al. 2009). Also, the 3D warehouse models are being integrated in several commercial systems like design tools (RenderLights 2012) or simulation software (Simio 2012).

Google also developed the *Building Maker*[5], which provides a model kit to create buildings, deriving the 3D geometry from a set of oblique (and proprietary) birds-eye images of the same object from different perspectives. In contrast to the *3D Warehouse*, this tool specifically aims at geo-referenced 3D building models only. It is intended for people who do not have knowledge in 3D modelling, but still want to contribute. Willmes et al. (2010) and Yiakoumettis et al. (2010) have demonstrated, how this tool can be used to create 3D buildings rather quickly, even of an entire university campus. Drawbacks are the potentially inaccurate modelling due to image errors or obstructions, the current little availability of the required oblique aerial imagery as well as limited usage of the result due to restrictions of *Google*'s proprietary data.

Even though both introduced methods are based on collaboratively collected data, it is *Google* who stands behind it and claims usage and distribution rights for the contributed contents. Hence, this is far away from being open source or open data. However, there are also numerous free-to-use 3D object repositories on the internet, for example *OpenSceneryX*[6], *Archive3D*[7] or *Shapeways*[8]. These projects emerged from entirely different communities with interest in e.g. flight simulators

[4] http://sketchup.google.com/3dwh

[5] http://sketchup.google.com/3dwh/buildingmaker.html

[6] http://www.opensceneryx.com

[7] http://www.archive3d.net

[8] http://www.shapeways.com

or 3D printing. The contents usually lack the connection to the real-world but can nonetheless also be useful to enrich real 3D city model visualisations.

More and more ideas for collaboratively mapping the third dimension are also being discussed recently in the OpenStreetMap community. Several approaches exist which basically all try to utilise the crowdsourced data for deriving 3D city models from it.

The OSM2World[9] software takes into account various 3D-related information that is available, such as the building height or the basic roof shape. It offers different export possibilities like .obj-files, direct output via an OpenGL binding for Java (JOGL) or a .pov-file for the *persistence of vision*[10] raytracer. It also experiments with the integration of terrain data from a Digital Elevation Model (DEM), however, this is currently still under development. Also, an easy-accessible web or desktop interface or standardisation of output formats is missing.

Another example which is intended to support the user in generating 3D data for OSM is the Kendzi3D plug-in (Kendzi 2011) for the widely used Java OpenStreetMap-Editor (JOSM)[11]. It directly converts several 3D-related information into a 3D model during an edit session on the screen, allowing the user to immediately see the result of their annotation. This makes model creation in the OSM context much easier. It is, however, still under development and many improvements in usability and the supported 3D-related OSM annotations have to be carried out in the future.

The most advanced work in the context of creating 3D city models from VGI data is the OSM-3D project (cf. Over et al. 2010; OSM-3D 2012). It combines the extrusion of the building footprints into the third dimension with a detailed integrated terrain model derived from SRTM[12] height data. It provides the 3D data in a standardised manner through a Web 3D Service[13] (W3DS), which is currently a discussion paper at the Open Geospatial Consortium (OGC). At present, the OSM-3D W3DS supports different terrain generalisation levels and provides tiled 3D scenes, based on the requested point of view, in VRML, X3D, COLLADA or KML format. There has also been developed a tailored client software called XNavigator[14], which automatically requests the data from the W3DS server and assembles complex 3D landscapes worldwide. This client also allows the integration of other OGC Web Services such as a Web Feature Service (WFS), the OpenGIS Location Services (OpenLS, Schilling et al. 2009) or the Sensor Observation Service (SOS, Mayer and Zipf 2009). Thus, for example POIs or 3D routes can be included. The interoperability with different data sources (e.g. also CityGML), web services and targets has recently been examined within the OGC

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[9] http://osm2world.org

[10] http://www.povray.org

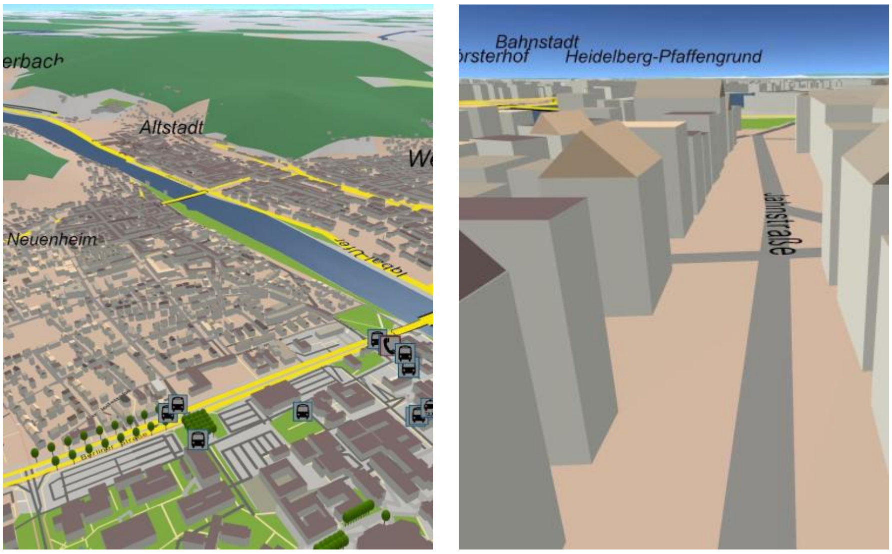
[11] http://josm.openstreetmap.de

[12] http://srtm.csi.cgiar.org

[13] http://www.w3ds.org

[14] http://xnavigator.sourceforge.net

3D Portrayal Interoperability Experiment (3DPIE, OGC 2011). The wide applicability of the W3DS and XNavigator with heterogeneous data could be demonstrated. Fig. 1 exemplarily shows two scenes of Central Heidelberg rendered in XNavigator.



(a) (b)

Fig. 1 (a) OSM-3D overview of Central Heidelberg in XNavigator. (b) Detailed view of a street with its buildings

All these approaches are mainly different available tools in this highly innovative field of 3D volunteered geographic information and only little research on it exists. Some related work shows, however, that the preconditions for voluntary 3D data capturing are already mostly fulfilled. With low-cost sensors and cameras which are often available in today's smartphones, the acquisition of 3D data becomes possible for a wider audience. This allows for example the reconstruction of 3D objects based on 2D images taken by low-cost sensors (Rocchini et al. 2001; Pomaska 2009; Wang 2011). According to the typical processing workflow of any geographic data, the capturing is followed by data editing and visualisation. Research about suitable data structures, modelling techniques and visualisation strategies in the context of crowdsourced 3D data is strongly needed. While a lot of research about accurate 3D reconstruction of buildings is available (e.g. Brenner 2005; Sampath and Shan 2010), all this has to be examined in an altogether different light for the crowdsourced approach. Apart from some work on 3D-VGI within indoor environments (Goetz and Zipf 2012), there is, to the author's knowledge, no related scientific work in this area.

2.2 Current issues and future directions

The previous section shows, that crowdsourced spatial 3D modelling is still a very young and innovative field of research with only little existing research and many open questions. This section will take a closer look at the field of 3D-VGI, investigating current issues and possible future directions more thoroughly. This will be done with a focus on OpenStreetMap, since it is currently the most elaborated platform for crowdsourced geoinformation. Apart from the above mentioned approaches, there are also various other ideas and concepts in the OSM community. Numerous people are working on this topic and lively discussions on how to advance it are taking place (cf. OSM Wiki 2011a).

The step from 2D maps to 3D models is not a small one and there exist a lot of issues that have to be tackled. In particular, three main aspects can be pointed out which currently prevent a faster development into the third dimension within OSM:

- The missing support of 3D geoinformation in the simple OSM data model
- The lack of a mature and disseminated 3D viewer for OSM
- The lack of appropriate mechanisms that allow users to contribute various kinds of 3D environmental information with different levels of detail

2.2.1 No suited 3D data model

The main issue regarding the first point is that the OSM data model is deliberately kept rather simple in order to attract as many users as possible. It tries to model the world with only nodes, ways and relations. Apart from this geometry, every kind of additional information for a certain feature has to be expressed by so-called *tags* in the form of key-value pairs (cf. Haklay and Weber 2008). Whilst these tags can in general be freely defined by any user, there exists an agreement on common tag names and values, whose usage is recommended (OSM Wiki 2011b). With this ontology it is possible to semantically annotate many features of our environment. For instance, building footprints can be modelled with closed way geometries which are annotated with the tag *building=yes*. That is, 3D geometry is not inherently supported in the data model, but can so far only be expressed with appropriate tags. Simple building properties like its height or number of floors can be modelled this way. However, for more complex geometrical features such as detailed roof structures, dormers or balconies, this approach is severely limited. Nevertheless, there are efforts trying to express 3D phenomena with this simple data model. Simple 3D-related tags are partly already being used in OSM (cf. Goetz and Zipf 2012 in press). Also, proposals for appropriate tagging schemas for more complex 3D buildings are currently being discussed in the community (cf. Strassenburg-Kleciak 2011). Most of the proposed tags are nonetheless only rarely used so far since no consensus on tag-based 3D modelling has been reached yet. One could argue that the basic OSM data model should be extended to better allow for 3D modelling. However, such a major change is currently not very likely to be accepted by the community, since there are also people disapproving of the idea to bring 3D into OSM. It is preferable to find out how far the approach to build 3D information on top of the simple OSM model brings us closer to the goal of supporting crowdsourcing 3D, and at which point a different approach with a dedicated data model is needed.

2.2.2 No widespread 3D viewer

Another reason for the little usage of 3D-related attributes is the absence of a widespread and established 3D viewer that visualises the 3D data. The appearance of one's specially created cartographic object on a worldwide available online map is one of the main motivations why people are committed to the OSM project in the first place (cf. Coleman et al. 2009). An essential point in order to push forward 3D mapping is therefore the development and dissemination of such a 3D viewer which displays the objects modelled by the users. If already existing approaches like OSM-3D or OSM2World are improved and promoted, there will probably be a boost in the interest of 3D mapping. Without it, it is currently not surprising that only few people are willing to contribute 3D information, even though it is already possible to a certain extent.

2.2.3 Not enough support for voluntarily contributing 3D information

Finally, there are currently too little possibilities for the crowd to contribute 3D information to OSM apart from the aforementioned tag-based modelling. This aspect of missing capturing and editing mechanisms will be reviewed more thoroughly in the following.

The range of possible 3D-related information in our environment that could be mapped by the users is very wide. It starts with simple building characteristics such as the number of floors, the facade material or a rough roof structure. This information is easy to obtain by any mapper, neither 3D modelling skills nor specialised equipment are required, and it is already supported in OSM. However, it should also be possible to map more details about a 3D object, up to entire architectural models, and link them to the OSM world. The above mentioned example of the *Google 3D Warehouse* has shown that there are people who have the skills and interest to do this. Accordingly, there should be a wide range of tools and concepts which support the motivated mapper in contributing various 3D information in different levels of detail.

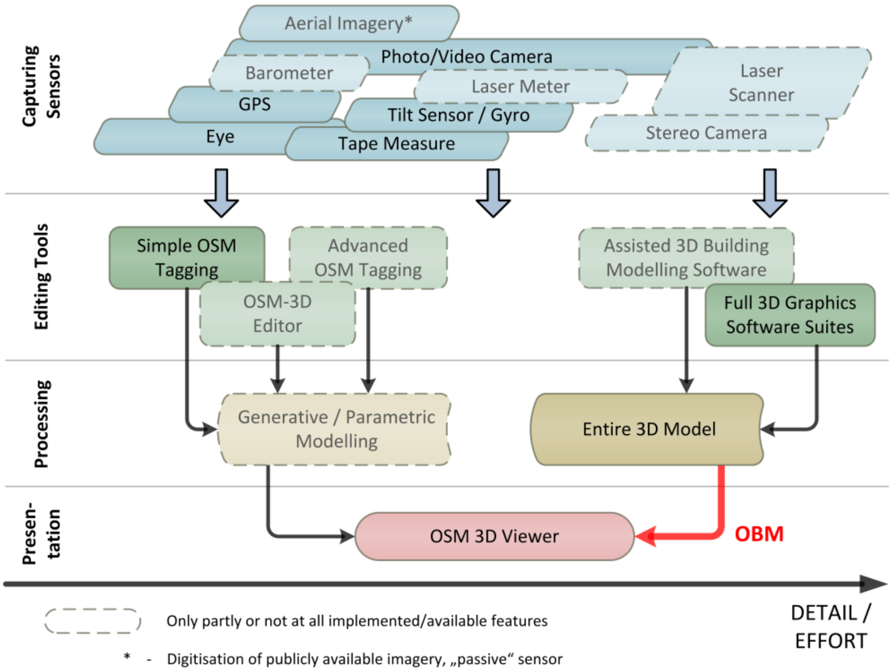


Fig. 2 Methods for capturing and processing 3D volunteered geographic information for OpenStreetMap on different levels of detail

On the top of the diagram in Fig. 2, different sensors are shown with which spatial 3D information can be obtained by voluntary mappers. Whilst simple building properties do not require sensors with high accuracy but are simply measureable with the eye, more complex models can only be created by means of various sensors such as laser meters, terrestrial and/or aerial imagery, GPS or even terrestrial laser scanning. Many of these sensors are nowadays included in modern smartphones, making them a multi-sensor-system which is pretty well-suited for crowdsourced 3D data capturing. In the future, further sensors like barometers, stereo cameras (e.g. Microsoft Kinect, cf. Elgan 2011) and maybe also laser meters and little laser scanners will possibly be included into smartphones, making them even more all-round tools for 3D-VGI.

Once the data is captured, it needs to be edited. Between simple OSM-tagging and the creation of entire 3D models with 3D graphics modelling software, there are further (planned or existing) tools in-between, which support mappers with different skills and ambitions in terms of the level of detail. For instance, an editor like the aforementioned Kendzi3D JOSM-plugin (Kendzi 2011), which is specialised for advanced OSM 3D-building modelling, makes it easier for the users to assemble parametric 3D models without caring about the rather complicated and cumbersome tagging itself. Such an editor could also avoid incorrect modelling and ensure topological consistency in complex 3D objects. Besides the manual creation of entire 3D models with 3D modelling software, there is also the possibility of reconstructing 3D buildings from terrestrial photographs. In research, many photogrammetric and digital image processing approaches exist (e.g. Debevec 1996; Müller et al. 2007). This reconstruction could traditionally only be accomplished with complex and expensive photogrammetrical software systems such as *ERDAS LPS*[15]. However, as already mentioned in chapter 2.1, there recently also emerged free-to-use "assisted" 3D modelling software like *Autodesk 123D Catch*[16] or *My3DScanner*[17] which offer a low-cost alternative for creating 3D models from photographs. This could evolve to an important feature for crowdsourced 3D modelling.

There are basically two types of models which emerge from the editing layer: On the one hand, we get parametric building models, which are based on a geo-referenced footprint plus various tags and can be generated dynamically by the 3D viewer. On the other hand, there are finished models, created by dedicated (or assisted) modelling software, which have to be placed properly in the 3D viewer. Attributes describing their geo-reference and scale are then required.

The currently available 3D viewers do only partly include the desired functionality and flexibility shown in the diagram. Generative modelling based on OSM tags is currently limited to some simple 3D-related attributes. The possibility to integrate *entire* 3D models is in general already available in the OSM-3D viewer XNavigator (cf. Fig. 3). However, this process includes many difficult steps which have to be carried out manually. Also, no real link to the OSM database is being established, nor is the model stored in a publicly available online repository. Hence, other viewers cannot display this model.

[15] http://www.erdas.com/products/LPS/LPS/Details.aspx

[16] http://www.123dapp.com/catch

[17] http://www.my3dscanner.com

(a) (b)

Fig. 3 An OSM-3D scene shown in XNavigator without (a) and with (b) a manually integrated architectural 3D model of a church

Many parts of the diagram in Fig. 2 are visionary and only partly implemented, if at all. There are a lot of things to be done in order to assist the realisation of VGI in the third dimension. In this article, we start with a concept for linking entire 3D models to the OSM database. As Over et al. (2010) mentioned, the development of a free 3D repository with architectural building models would be a major step forward.

3 The concept of OpenBuildingModels (OBM)

In this chapter, a first prototype of OpenBuildingModels is introduced. Its objective is to create a web-based platform for uploading and sharing entire 3D building models. Many complex buildings like churches or other landmarks cannot be modelled in detail with a tag-based, parametric approach. Instead, 3D models from the OBM repository should be linked to OSM, so they can be rendered by OSM 3D viewers subsequently. Thus, crowdsourced 3D city models can be greatly improved.

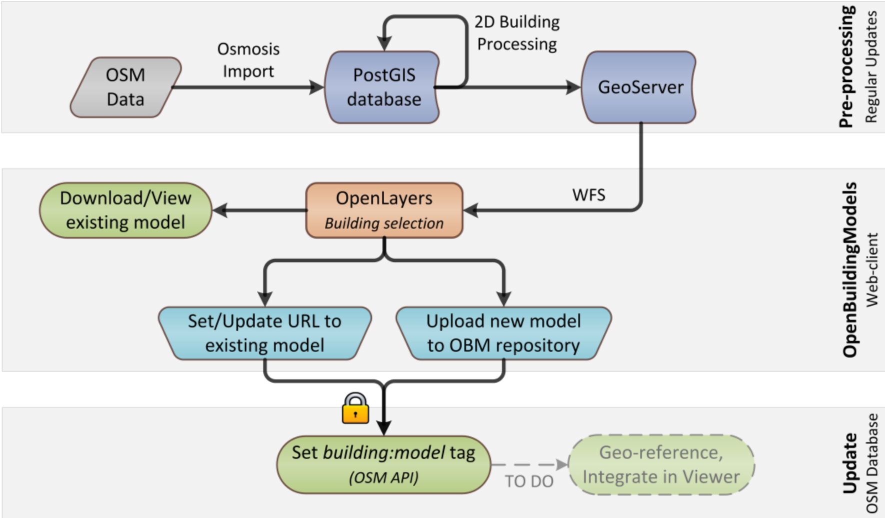


Fig. 4 Workflow of the OpenBuildingModels prototype

The processing of the OSM data and set up of a model repository in the first prototype comprises several steps, which are briefly described in the following. The user should be able to interactively choose the building of interest from a map. Therefore, the ground plans first have to be derived from the OSM data separately and overlaid as vector layer. This is achieved by first importing the OSM data into a PostgreSQL/PostGIS database with the *Osmosis* tool and converting the closed *ways* which are tagged as buildings to polygon geometries. Native SQL along with several PostGIS functions is used for this. More complex footprints that contain inner holes and therefore consist of more than one closed way, can also be converted (cf. Goetz and Zipf 2012; Goetz et al. 2012). This conversion step is part of the pre-processing illustrated at the top of Fig. 4. For the provision of the processed building polygons to the web-client, we set up a GeoServer[18]. The web-client requests the geometries via an OGC-compliant Web Feature Service.

[18] http://geoserver.org

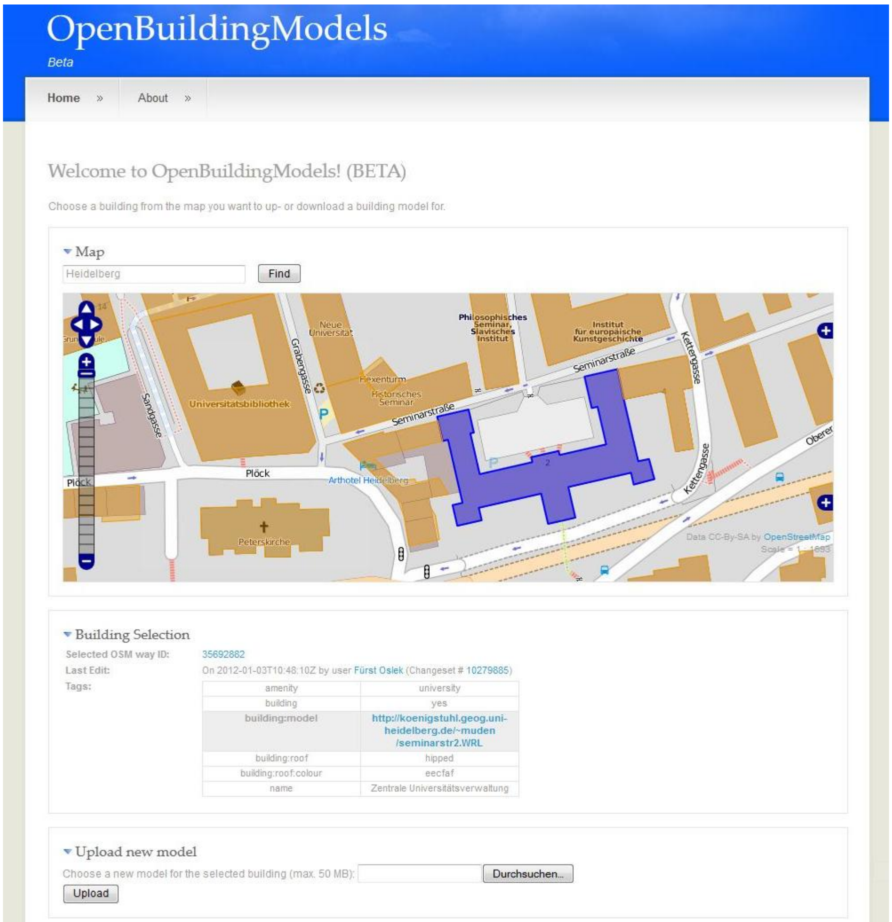


Fig. 5 Screenshot of the OBM web-client. The OSM properties of a building are shown on selection and a 3D model can be up- or downloaded to our repository

Fig. 5 shows a screenshot of the current OBM web client. The main component is an OpenLayers[19] map, which shows the building footprints as a vector overlay. When a building is selected, the client requests general information about the OSM way with the corresponding ID over the OSM API[20] via a HTTP GET request. The API delivers a small XML file which contains for example the user who created that geometry and all associated tags (key-value pairs). The XML is parsed by a PHP script and the information is displayed to the user. Since this operation only reads contents from the database, no OSM authentication is necessary.

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[19] http://openlayers.org

[20] http://api.openstreetmap.org

The connection of a separately created 3D model with the selected OSM building is being achieved in the current prototype by simply setting the tag *building:model=URL*. When a new building model is uploaded, this tag is set to the new URL automatically. Alternatively, the user can set or update the URL manually, if a model for the selected building already exists on some other publicly available server. For these operations, an OSM user account is required, since new information is written to the database. If the model-tag is already set for a given building, it is also possible to directly download the model, e.g. in order to edit it or convert it to a different format.

4 Discussion

After the technical components of the OBM prototype have been explained, the general approach as well as the client is reflected critically in the following.

Linking 3D building models with the OSM database was in general already possible before by manually setting the *building:model*-tag and storing the model on some publicly available server. However, the OBM prototype makes this process much easier and integrates building selection and uploading in an interactive easy-to-use client. Once the models appear in a viewer like OSM-3D, OBM can potentially attract valuable users from the 3D modelling domain with the necessary skills to build complex models. It is expected, that predominantly complex landmark buildings will be uploaded to the OBM repository first. This is beneficial, since these kinds of buildings are particularly important for possible applications like pedestrian navigation. The improved visualisation in the 3D viewer with enhanced landmark models will lead to better representations of the cities. This can be seen in Fig. 3b, where the integration of a recognisable, realistic 3D model of the church is a massive improvement.

While the 3D visualisation can be greatly enhanced with this approach, it has also some drawbacks. As good as architectural 3D objects might look, they often lack topology and semantics, unless they are created in a dedicated format like CityGML. Apart from an improved visualisation, models without semantic annotation will have only little added value for applications that require semantic, standardised 3D city models. Similar to existing repositories, users will certainly create 3D models of varying complexity. Some might include in their model each and every detail of the outer structure or also model the interior. Others might create 3D models with a lower level of detail. On top of the entire 3D models, parametric models based on 3D-OSM-tagging will also exist with varying detail. Hence, one could generally argue that offering various tools and approaches for contributing 3D information could lead to a rag rug with a low level of standardisation and that an agreement on only one defined method to map 3D buildings is preferable. However, such heterogeneous modelling is a general phenomenon inherent in VGI. The current 2D OSM also consists of many differently mapped features and the consensus on common mapping techniques is rather low. And this is not necessarily a drawback, because only this keeps the barrier for beginners as low as possible. The introduction of mandatory mapping standards for quality assurance would repel most people from participating and contradict the general idea of the openness of VGI.

The described client is only a first prototype and there are lots of open issues that have to be addressed in the future. Fig. 4 indicates the most important next step: the models have to be geo-referenced in order to place them correctly in the real world. This could be accomplished by a semi-automatic approach which tries to reference the object by fitting it into the given OSM footprint first and asks the user for further manual refinement. In order to ensure a correct alignment between 3D objects and OSM footprints in the first place, it would be helpful to initially offer a download of the existing building outline as a basis for the modelling of a new building. OBM should support various 3D formats in the future in order to guarantee a high level of flexibility. At the same time, a 3D viewer has to support all these formats. This will lead to issues about format conversion and interoperability. Currently, textures are not supported by OBM. Since textures are an essential part of high-detail building models, this should be made possible in the future. Another important aspect is the usability of the web client. It is desirable to provide not only the upload of 3D models for buildings whose footprint is already part of OSM, but also for such that have not been mapped at all. The user could properly place the 3D model on the map and the corresponding 2D footprint could be derived and added to the OSM database automatically. Furthermore, an important improvement would certainly be to support models with different levels of detail for the same object. This is currently not possible due to the bijective approach that only uses the *building:model*-tag. Also, performance will play a crucial role once a couple of detailed models will have been added. Ensuring smooth visualisations and efficient storage of the models will be a challenging task due to the enormous data load.

5 Conclusion & Future Work

In this paper, the current situation of 3D volunteered geographical information was discussed and a new concept of how to push it forward was introduced with OpenBuildingModels.

In the first part, a review about related work in this context was given, showing that besides some available tools, only little research exists in this innovative field. Subsequently, the current situation was critically discussed and main issues regarding further progress in this area were pointed out. In the second part of this article, a basic prototype of OpenBuildingModels was introduced. This approach aims to build up a free repository of 3D building models which can be linked to the OSM database. Advantages and shortcomings of this approach were discussed thereafter. OBM has the potential to attract users with 3D modelling skills to the geo-domain and the OpenStreetMap project in the future. This is an important step for the progression of 3D-VGI, because it is impossible to model each and every building based on the rather low-level data schema of OSM. However, there are still many challenges to be tackled. Most importantly, these include a correct geo-referencing of the models. Also, there are many different 3D formats in which the models can be created and therefore questions regarding the conversion of formats and interoperability are to be answered as well. Furthermore, issues arise about how complex 3D models can be effectively edited by multiple users, since this is not as straightforward as it is for standard 2D map features. The possibility to upload multiple models for one object to the repository with different levels of detail must be considered. Finally, performance as well as effective storage and compression of complex models will be further issues.

A VGI-based approach to 3D city modelling is very promising and can potentially lead to an added-value in this field of application. User-generated approaches have already proven their potential to be capable of capturing high-quality spatial information. The interest in 3D mapping is rising in the OSM community. Since OSM is an established and successful platform, it is currently most qualified for 3D-VGI, although there are some shortcomings like the rather unsuitable data model. One key question will be how much 3D is capable and sensible in such a project and when new approaches and platforms are needed. OpenBuildingModels is one of several possible means to enable voluntary users to contribute rich 3D information. It is a first effort to push forward the 3D mapping and apart from it, many other possible issues could be tackled in the future. For instance, the tag-based modelling and therefore the parametric building model creation could be advanced. Dedicated OSM-3D editors have to be developed in order to make it as easy as possible for inexperienced mappers to contribute 3D information. There should be a wide range of mechanisms available to allow crowdsourced 3D mapping on different scales. Also, an extension of the OBM repository to not only buildings but also other objects of our environment like street furniture, prototypical landscape objects or the like is conceivable and would lead to more detailed and usable crowdsourced 3D city models.

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