ISSN: 1857-9000, EISSN: 1857-9019

JENGO, A PROTOTYPE MOBILE APPLICATION BASED ON CROUWDSOURCING FOR LIS

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UDC: 004.382.76:004.455]:528.44

SUMMARY

The possibility of collecting data with one's own mobile tools is very inviting and at the same time attractive, and useful. There are strong initiatives to adopt crowd-sourcing, citizens in Land Administration. In that way citizens can be provided with useful and easy-handling mobile tools for mapping, so they can give land related information with their own mobile phone (McLaren, 2011; Brabham, 2013). On the one hand in many less developed countries the people lack land rights documents and citizens without documentation often lack secure tenure over land. On the other hand the inadequate quality of cadastral maps affects the life of citizens who need means to quickly and cost-effectively settle their cadastre related issues. The first goal of paper is to identify the success factors relevant to cadastre related crowdsourcing projects. Another goal of paper is to present an adequate mobile application, according to the established factors, Jengo, for mapping 2D/3D buildings/constructions and to record attributes, including photos, and also for uploading captured data to the system of those who are asked to participate in the crowdsourcing campaign. The methodology of collection includes primary objectives which were the on-site scanning of a construction, identification and recording of their violations and graphical presentation of their expansion on the OS map.

Key words: OSM, mobile application, crowdsourcing, cadastre

1. INTRODUCTION

The crowdsourcing is an on-line, distributed problem-solving and production model which was generated by the inherent needs, and ambitions of the human society enabled by info communication revolution in the end of the twentieth century.

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Because crowdsourcing draws input and insight from individuals in on-line communities, it has the potential to be a useful digital tool to complement traditional public participation programs for governance (Brabham, 2009).
As it was described by Sharma (2010) the adequate definition of the vision and the strategy are necessary for citizen, who distribute information through crowdsourcing. There are strong initiatives to adopt crowdsourcing in Land Administration. On the one hand in many less developed countries there is a lack of documents on land rights and without documentation citizens often lack secure land tenure. On the other hand the inadequate quality of cadastral maps affects the life of citizens who need means to quickly and cost-effectively settle their cadastre related issues. The stability of the land administration affects not just some governmental sectors but the economy as a whole that is why a strong, stable land administration is an aim for each society. Likewise in some European countries/regions a significant proportion of the inhabitants live in buildings/houses, which do not have proper permits. It is of national interest to legalize the status of these constructions. The related public administration procedures heavily involve the citizens. In order to legalize illicit constructions the public authorities must have important spatial information such as positions, dimensions, information about type and characteristics of a building or construction etc.
The main aim of this paper is to present a possible solution, a tool for solving the above outlined problems. In addition it will present the mobile application, whose development was started by Compet-Terra Ltd., and development path of application, by which citizens can collect, and give land related or other information with their own mobile phone, using a simple, cost-effectively mobile application such as Jengo (http://competterra.com/index.php?jengo_en). As a possible crowdsourcing data collecting mobile tool for the editing objects, in this paper the main concepts of Jengo will be presented taking into account the critical successful factors of crowdsourcing. Within the presentation of new applications it is necessary to look back on the existing android application for supporting OSM (OpenStreetMap).

2. CONCEPTS OF JENGO

According to the study of Sharma (2010), which analyzed the critical success factors of an outsourcing initiative in the available academic and professional literature, the motive alignment of the crowd occupies a central place in the Crowdsourcing Critical Success Factor Mode. The peripheral factors are neither exclusive nor exhaustive, but the mentioned ones are the

following; vision & strategy of the crowdsourcing initiative, linkages & trust, external environment, infrastructure and human capital.
Based on the acquired experience in LIS projects and studying broad range of crowdsourcing literatures our analysis resulted that these success factors are highly relevant to cadastre related crowdsourcing projects as well. Jengo is conceptualized on this basis. The following analysis identifies principles of the Jengo mobile application.

2.1. Vision and strategy of the Jengo Supported Crowdsourcing Projects

The first of the peripheral factor of the motive alignment of crowd is the "Vision and Strategy". Clarity in 'Vision' is vital and imperative to the success of crowdsourcing initiatives (Brabham, 2009). The successful crowdsourcing initiatives enter the market with clear and well-defined objective and ideas (Sharma 2010). To convince the crowd to participate in the data collection can be done with the previous definite aspects, and it is important that the specified visions are flexible. The flexibility of vision is necessary for successful crowdsourcing not only in the term of organic changed environment in which these initiatives are realizing, but if the crowd feel it his own the vision, the enthusiasm and ambition of crowd take the initiative to the defined purpose.
The cadastre domain embraces several problems, which are relevant for adoption of the crowdsourcing model. Legalization of Illicit Building. Significant proportions of the society or important groups have build constructions out of the legal regulations. Their inevitable interest to legalize and register their land. They are highly motivated to accomplish this vision of having legally/technically checked and recorded building. Managing Informal Settlement results more secured land use rights in a dynamically changing organic system of society. The special residential areas, like Kibera in Kenya, near to city Nairobi, are dense, buildings have frequently been reconstructed and the fluctuation of inhabitants is significant. However, residents are deeply interested in their property being recorded, which provides them some sort of legal security. Crowdsourcing is a cost effective approach to map and record rights of informal settlements. Environmental problems can have impact on health and motivates crowd by morality.

2.2. Jengo's Approach to the Human capital Aspect of Crowdsourcing

To satisfy the next peripheral factor, the human capitals, in the first hand the crowd need to be convinced of the goal, to feel the vision as his own. Based on as Carmel (2003) describes, the collective characteristics, skills and abilities of the crowd is human capital, which is not limited to, language

skills, managerial skills, national orientation, traditions and level of education. Mapping parcels and building expects some understanding of geometry and topology. The crowdsourcing business model call the crowd to carry out tasks, which usually done by professionals (Reference to the definition: Howe, 2008), however the motivated crowd is not interested in mapping and can frustrated to use a GUI focused on mapping.
Bridging this gap we need to find a non-GIS approach to GUI, which is more desirable for users. The GUI should be simple, user-friendly, equipped with easy to understand symbols, and to be supported in on-line and off-line mode too. Data collection crowdsourcing projects are controlled via inputs (Podolcsák, 2014). The participant should provide input according to predefined standards.

2.3. Infrastructure

The crowdsourcing initiatives are mostly either mobile or web based. According to Donner (2009) the Crowdsourcing requires abundant, reliable and cheap telephone or mobile access for its communication needs. The critical aspect is the availability of the much needed capital sources for development of the initiative (Kleemann et al. 2008). For the crowdsourcing that-why mostly were used an open source software, which are ease accessible, reliable. Another important thing is that the developed application should be simple, user-friendly, equipped with easy understand symbols, and to be supported in on-line and off-line mode too.
In the cadastre domain the crowdsourcer calls stakeholder to provide graphical data and makes them possible to access public data and status of business processes. The infrastructure serves a client server based architecture, which can be a web based application or cloud computing infrastructure. As it was highlighted in the previous point the external business can be considerably different thus the IT requirements are various. The crowdsourcing approach can be adopted in a formal business process then the collected data need to be transferred via a more secured channel, e.g. ftps. access to Internet. The crowdsourcing initiatives are usually financed by public budget, and the sustainability is better when the software application is open source. As simpler the code is as many people can be involved in the software development society.

2.4. Serving Linkages and trust

A good relationship is essential to human-centered operating model of crowdsourcing respect. Providing that the right connections - among others - the knowledge transfer becomes easier, and also enables to ease the

implementation of feasible crowdsourcing initiatives. Carmel (2003) defines the concept of linkages as "something, which emerges between individuals, between work groups, between firms or between nations due to geographic, cultural, linguistic, or ethnic connections". In some certain problems of average weight give better knowledge of approaches under certain conditions, such as Experts estimate. Here we can think to product evaluations, to estimate effects of climate etc. In all of that, people are linked, the uploaded information is viewable for the crowd, and linkages can add a substantial trust aspect to the crowdsourcing initiative (Brabham, 2009).

Majority of the Cadastre problems relates to security and involves private information too. Users should be convinced their private data is transferred safely while their public data is mutually accessible and the whole process is transparent.

2.5. Compliance with the External Business Environment

The tasks associated with crowdsourcing must be compatible with the prevailing business practices and cultural norms. The crowd must also be able to relate the goal of the crowdsourcing initiative to their living environment. It's important that the crowd do not need to change their behavior in order to make the maximum use of the system, because it is the environment in which being the crowdsourcing realized, is not necessarily permanent, it could be ever-changing, organic. The business environment of the crowdsourcing cadastre projects is various.

Informal settlements are organic systems. Land users move in and out while the walls of the flats and the building are changing as well. An informal settlement registration can be kept informal focusing on a consensus of the users, their neighbours and the local rules in the informal settlement. These type of projects need to share information among stakeholders and support their forums to reach a mutual agreement. The users are focusing on their space of living, agreed alteration of boundaries, and entrance while geometry overlaps and gaps are less important. In these types of informal settlement projects Jengo is a mean to edit the layout of the flat, upload data to a server then visualize actual use together with background layers, e.g. orthophoto for stakeholders. The photo of the entrance is part of the record, which serves both the positioning of layout and protecting the right of the user. The exact matching of floor-plans is not a mandatory prerequisite since mismatching is in line with organic organization of informal settlements however some careful post-adjustment can be done by privileged participants of the crowd using desktop applications.

There are other problems which have more formal business environment. E.g. in some countries or regions a significant proportion of the inhabitants live in buildings which do not have proper permits. The related public administration procedures heavily involve the citizens in. In order to legalize illicit constructions the public authorities must have spatial information such as positions, dimensions, information about type and characteristics of a building or construction. In these types of cadastre related projects the crowd-sourced information relates to a formal application, which is settled according to a legally defined public administration process.
In spite of the above mentioned samples some urban cleanliness and public health focused cadastre related projects have no territorial limits and have higher frequency of data collection/process/distribution. The type of data can also be various apart from geometry and location information scanned docs and pictures could also be collected.

3. OVERVIEW OF JENGO

3.1. Use case

The Crowdsourcer and the Participants use the Jengo application (Figure 1). In order to manage the campaign the Crowdsourcers customize Jengo by setting-up some technical features of the crowdsourcing project. The participant uses Jengo to capture data of the construction; the details are indicated by the next diagram

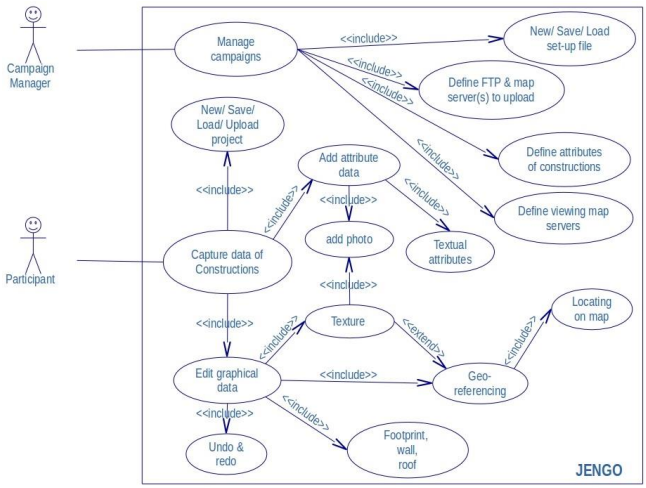


Figure 1. The participants, their leading role and available function

There is a recent request to slightly extend the above use case structure by extending the texturing to make possible to map parcels using Jengo. The planned texturing GUI allows the user to move the vertices of the polygon to their image on the picture then adjust the image to the polygon. This extension uses the same GUI but do not modify the image but alter the polygon. In this way parcels can be drafted by Jengo's edit functions then map to orthophoto using the altered texturing function.

3.2. General Workflow

Conceptual, general workflow of using Jengo for mapping constructions is shown on the Figure 2. Dimension of the object must be determined by direct measurement or copying data from existing documents. These data will be edited on Jengo's work-screen, as wire-frame, on the edges of the white vertexes. After recording attributes (such as ID, use, status, etc) the taken photo can be selected as the texture of the wire-frame. The building is defined in 3D, but before that, the optional coordinates (high of the building) must be calculated. The default value of location is based on the mobile provided coordinates and the user move/rotate the footprint to the right position. It is planned, that Jengo stores data as project file, city GML, or KML, GIF, and upload them. As the processes are finished, it is possible to share or upload data to the crowdsourcer.

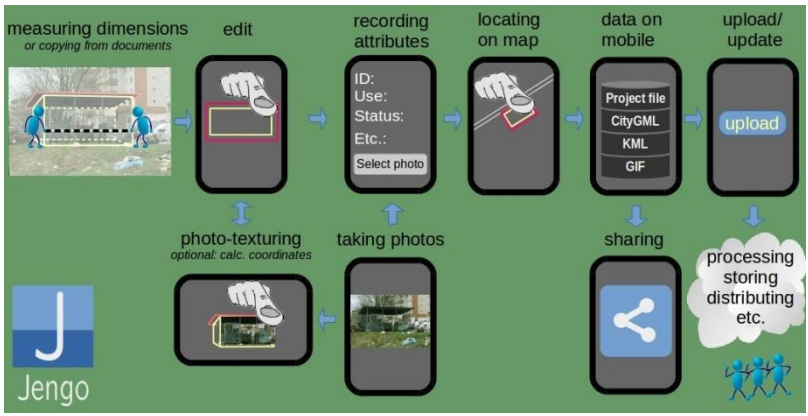


Figure 2. The work-flow of Jengo application

3.3. Infrastructure

Jengo can be used in standalone mode, editing the constructions geometry, texture, all this in offline mode. In this local mode, all the functions are available (Figure 3), and the complete file can be saved to the mobile device

memory unit. Via internet connection the above -mentioned, created data can be uploaded to the server. The other two solution/mode for using Jengo, is a direct creating/editing files, with all already presented functions, to the server-cloud or to the FTP server, which include permanent internet connection (Figure 3).

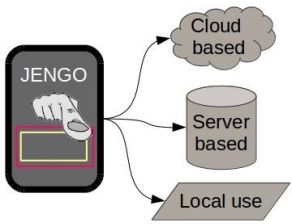


Figure 3. The schematic presentation of Jengo infrastructure

3.4. Application Architecture

Jengo uses proven open source technologies for mobile application development. The software framework is QtQuick, which is a cross-platform application development framework using the QML GUI description language, which allows the integration of JavaScript code and libraries (Figure 4). Data are stored in a SQLight database, 3D presentation adopts Three.js. The prototype uses the QtLocation library to access Open Street Maps.

Jengo uses SQLight for storing all the data of the features (constructions). SQLite is an in-process library that implements a self-contained, server-less, zero-configuration, transactional SQL database engine. SQLite is an embedded SQL database engine. Unlike most other SQL databases, SQLite does not have a separate server process. SQLite reads and writes directly to ordinary disk files. A complete SQL database with multiple tables induces, triggers, and views, is contained in a single disk file.

Jengo is based on Qt Quick, written in QML and JavaScript (Figure 4). Qt is a cross-platform application framework that is widely used for developing application software that can be run on various software and hardware platforms with little or no change in the underlying code-base, while having the power and speed of native applications. Qt provides Qt Quick that includes a declarative scripting language called QML that allows using JavaScript to provide the logic. With Qt Quick, rapid application development for mobile devices became possible, although logic can be written with native code as well to achieve the best possible performance.

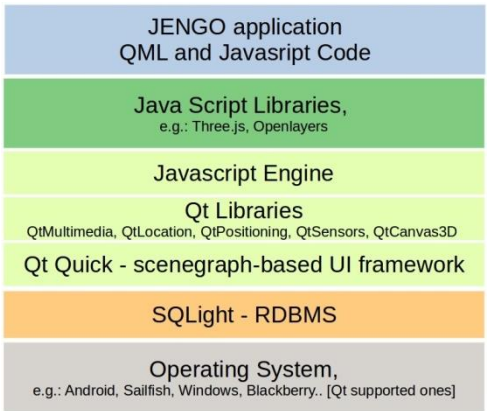


Figure 4. Jengo's architecture

For graphics, positioning and 3D Jengo uses QtMultimedia, QtLocation, QtPositioning, QtSensors and QtCanvas3D libraries. For 3 dimension display Jengo also uses three.js JavaScript library (Figure 4). The application also has a strong GIS component that is based on OpenLayers. OpenLayers are an open source JavaScript library for displaying map data in web browsers. It provides an API for building rich web-based geographic applications.

3.5. Software Development Framework Jengo and the Licenses

During the selection of software development framework, the following principles were taken into account;

1. It was necessary that the software can be easily transferred to various mobile platforms, to be a cross platform application.
2. Also, it was important to be supported on web technology, to be ease of use inspired by OGS standards.
3. And lest but not last the chosen program must have simplicity of software development

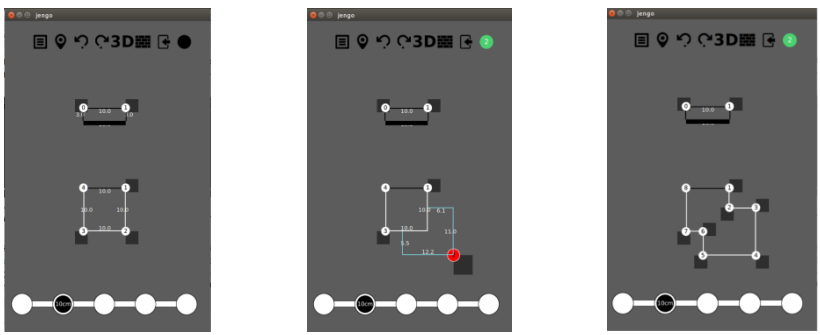
Qt was selected because it can be loaded with features and functionality for all application developments. It can run on various software and hardware platforms, having the power and speed of native applications. Qt Open Source is available under the GNU Lesser General Public License (LGPL).
Qt is frequently used for developing application software with graphical user interfaces (GUIs); however, programs without a GUI can be developed as well, such as command-line tools and consoles for servers. GUI programs created with Qt can have a native-looking interface, in which cases Qt is classified as a widget tool-kit.

Qt Quick includes a declarative scripting language called QML that allows using JavaScript to provide the logic. With Qt Quick, rapid application development for mobile devices became possible, although logic can be written with native code as well to achieve the best possible performance. Qt can be used in several other programming languages via language bindings. It runs on the major desktop platforms and some of the mobile platforms. It has extensive internationalization support.
QML is a user interface mark-up language. It is a JavaScript-based, declarative language for designing user interface–centric applications. QML is mainly used for mobile applications where touch input, fluid animations. QML elements shipped with Qt are a sophisticated set of building blocks, graphical (e.g., rectangle, image) and has tools (e.g., state, transition, animation). These elements can be combined to build components ranging in complexity from simple buttons and sliders, to complete internet-enabled programs. QML elements can be augmented by standard JavaScript both in-line and via included .js files. Elements can also be seamlessly integrated and extended by C++ components using the Qt framework.
As it mentioned, QML is using JavaScript to provide the logic. JavaScript is a high level, dynamic, untyped, and interpreted programming language it is prototype-based with first-class functions, making it a multi-paradigm language, supporting object-oriented and functional programming styles. It has an API for working with text, arrays, dates and regular expressions.
Jengo development is using Open Source software development tools. Taking into account their licenses it is possible to issue JENGO with Open Source license.

4. JENGO – EXISTING VERSION

Based on the concepts a prototype version have been developed, which has some basic functions of the planned Jengo application. The emphasis was on the user-friendliness. The functionality of Jengo allows users to map 2D/3D buildings/constructions, upload KML, it can be downloaded from: http://competterra.com/index.php?jengo_en.
The existing version, which will be presented, has passed several iterations so graphical editing based on users' experience has been significantly improved. The Jengo assumes that each building is composed of rectangular polygons which sides are parallel either with X or Y axis. The default value of each angles are exactly 90 or 270 degrees, however the user can modify it. In accordance to that, running the Jengo application user can see a pre-made geometry and topology, a square and its cross-section on the centre of screen (Figure 5/a). The existing version is available only in English, with which

users rarely encounter. On the top of the screen is a menu with eight icons, namely menu, displaying on the map, undo and redo, 3D view, editing wall, exporting KML file, and the last icon is the "selecting – activating indicator", which shows the possibility of editing an element. On the lower part of the screen the grid is located, which used to determine the resolution of editing.
The graphical user interface of Jengo is designed to take the user, and he/she can start editing, without reading the instructions, because editing is straightforward and does not require any knowledge, neither GIS basics. The undo/redo option is encouraging too. A grid selector is situated at the bottom of the GUI that controls the size of grids from 5 cm to 1 meter. Jengo provides a default footprint shape, which is a 10x10 meter rectangle that the user can immediately tap and alter. While user is editing shape Jengo indicates dimensions, however tapping on grid selector does it as well. Above the footprint the selected or active wall is shown and can be edited as well. (Having set-up function completed indication of the wall can be switched on/off)
Shaping the topology of desired object follows logic of simple gestures having the same results in any context. Edit the object, although the pre-made geometry suggests, it is possible with displacement of the vertexes or edges (dots of square). To move the vertex, touch it until the activity indicator becomes green, in the same time the vertex becomes red, and it is ready to move along the X and Y axes (Figure 5/b). Meanwhile on the neighbouring edges of active vertex can be seen the length, in order to precisely editing. The topological correctness is checked by the application thus it is impossible to create an incorrect shape (Figure 5/c).

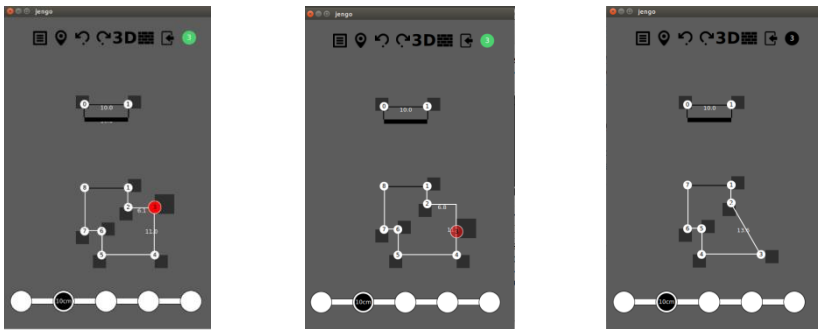


a. b. c.

Figure 5. Running Jengo mobile application: a) the start screen of Jengo application, b) displacement of the vertex, with displayed length of edges, c) the excepted wire frame shape, after checked topological correctness.

Displacement is a different operation then the modification of shapes but both need to select a vertex or edge. There is a need for a simple gesture,

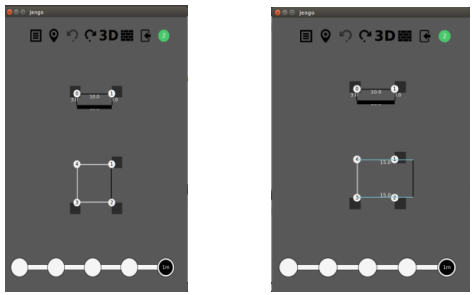
which differentiates these two functions. So after having select a geometry element the user lifts up his/her finger then taps the already selected element and moves it (Figure 6/a). Jengo allows displacing a vertex along one of the two connected edges. An edge is displaced parallel at a right angle to its direction (Figure 6/b). These rules make possible the way user can fully control the geometry characteristics of the resulted polygon.
The system automatically deletes edges which have zero length. In this way vertexes can be deleted pulling them on the neighbourly vertex (Figure 6/b, 6/c), as well as with this gesture can be managed the corner truncate too (Figure 6/c).



a. b. c.

Figure 6. Altering the wire-frame shape: a) activate the edge, b) displacement a vertex along the neighbourhood edges, c) delete a point – truncate the corner

Dimensioning the edges can be done in two steps; first activate the edge with touching it, and when it becomes black, it's ready to move, in a direction perpendicular to itself. Jengo supports data acquiring using on-site measured or collected data, therefore during a displacement of the wall, the user can monitor the sizes of the adjacent walls, in that way it is possible to dimension the object precisely (Figure 7/a, 7/b).

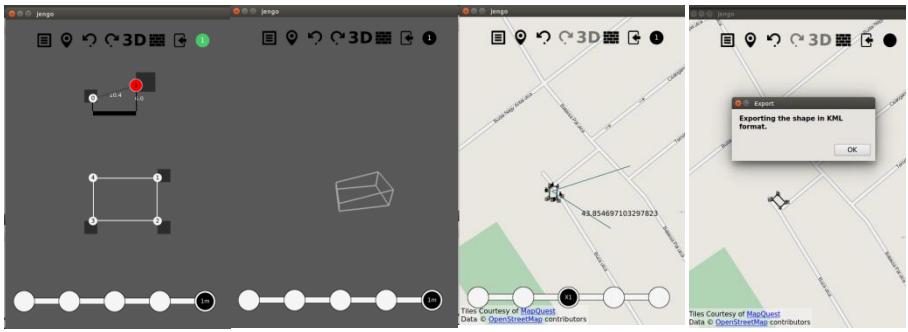


a. b.

Figure 7. Dimensioning the edges: a) activation of selected edge, b) displacement the wall/edge perpendicular to itself

The height of edges is given as default 3m, the user can give the height of each vertexes on the cross-section picture above the footprint (Figure 8/a), one by one, simply with selecting other edge. When the user finished editing a wire-frame object, editing a footprint and wall height, has a possibility to see the constructed object in 3D (Figure 8/b). During 3D display, the object rotates around its own centroid, thus ensuring that to can be viewed in its entirety.

The Jengo application gets the location from the built in positioning of the mobile phone. After having accessed Open Street Map via Internet the user can move and rotate the footprint to the right location (Figure 8/c, 8/d). There is a multi-position switch on the bottom of the GUI to adjust the sensitivity of the rotation. The export to KML function creates a simple and valid kml file named „out.kml" in the devices standard Documents folder (Figure 8/d). The file is created using the location data gathered and set during the editing and mapping of the shape. The KML file represents the nodes of the shapes with coordinate points of a Linear Ring, and allows the exported data to be imported to an Earth browser such as Google Earth, Google Maps, and Google Maps for mobile.



a. b. c. d.

Figure 8. 3D visualisation and displaying on the map: a) setting the edges height, b) 3D visualisation of wire frame object, c) rotation of the object, d) place on the right position and export KML data.

5. DEVELOPMENT PATH OF JENGO

Based on the development path, with the present version of Jengo software the footprint and the wall can be presented. For editing the wire-frame is simple, the user can use existing function as undo/redo. The location of the edited construction can be received from the GPS of the mobile device, and the exported KML file can be presented on the OpenStreet map.

In the next, improved version of Jengo the user have a possibility to construct not only the footprint and the wall of the building, but the roof too. The position and the data will be uploaded to the FTP server as layers, namely as raster and vector files, also there is an opportunity to upload 2D wfs file to the server without changing the server content. In this version it is already possible to use Jengo to support campaign, for e.g. in the framework of environmental campaign it's possible to map and edit a container and collect all information into the pre-designed and pre-defined database and map.

In the planned final version of Jengo software the users can give a textual characteristic of the walls and roof. Beside that the export to KML function creates a simple and valid kml file named „out.kml" in the devices standard Documents folder. The file is created using the location data gathered and set during the editing and mapping of the shape. The KML file represents the nodes of the shapes with coordinate points of a Linear Ring, and allows the exported data to be imported to an Earth browser such as Google Earth, Google Maps, and Google Maps for mobile. In this version the edited construction can be uploaded to server as wfs vectorised file. Options for the snapping photos with GPS positions, and options for detailed design of objects will be also implemented.

In the expected final version of Jengo software the users can give a textural characteristic of the walls and roof. It can be realised by textual characteristic or by added the captured photos.

6. CONCLUSION AN FUTURE WORKS

Compet-Terra, consulting company in the LIS arena, has identified crowdsourcing as one of the most important trends in the LIS field. Compet-Terra has been running a related in-house research. Having analyzed business and management aspects of crowdsourcing, available technologies initial finding and conclusions were drown then various prototyping was started. Jengo is one of them. The development started in March and the research objective is to test and adjust or proof the concept and gain experience in technical issues of the software development.

This version of Jengo has been tested by some Land Administration professionals and based on this initial feedback modifications were identified and some of them have already been implemented. The embraces only a part of the conceptional functions which has been implemented, e.g. the implementation of the set-up, which customizes the application to projects is still ongoing and some difficulties caused by reported bugs of the development still needs some workaround to be elaborated in the code.

It is too early to make grounded conclusion regarding the concept, however some preliminary observations can be made. The adoption of the user-friendliness related principles seems to be promising. Keeping the code open is welcomed. Staying inside a simple use of Qt Quick. Using QML and JavaScript and not embracing heavy C++ code resulted some performance issues and needed several workaround of the shortages of this environment, however it seems developers always find a solution.

7. REFERENCES

1. Brabham, D.C.: Crowdsourcing as a model for problem solving: An introduction and cases. Convergence: The International Journal of Research into New Media Technologies, 2008. 14(1), 75–90.
2. Brabham, D.C.: Crowdsourcing the public participation process for planning projects. Planning Theory, 2009. 8(3), 242–262
3. Brabham, D.C.: Using Crowdsourcing In Government. Annenberg School for Communication and Journalism, University of Southern California. IBM Center for The Buisness of Government, 2013.
4. Carmel, E.: The New Software exporting Nations: Success Factors. The Electronic Journal on Information Systems in Developing Countries 2003. 13,(4):1-12
5. Donner, J.: Mobile-based livelihood services in Africa: pilots and early deployments. Communication technologies in Latin America and Africa: A multidisciplinary perspective, 2009. pp. 37-58
6. Howe, J. 2008: Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business, Crown Publishing Group, New York, NY, USA
7. Kleemann, F., Vob, G. G., Rieder, K.: Un(der)paid Innovators: The Commericial Utilization of Consumer Work through Crowdsourcing. Science, Technology and Innovation Studies, 2008, pp. 5-26.
8. McLaren, R.: Crowdsourcing Support of Land Administration a New, Collaborative Partnership Between Citizens and Land Professionals. A report for Royal Institution of Chartered Surveyors commissioned by RICS Land Group (RICS), Parliament Square, London SW1P 3AD, United Kingdom, 2011
9. Podolcsák, Á.: Crowdsourcing-related business consulting (Crowdsourcing vonatkozású üzleti tanácsadás) Metropolian University of Applied Sciences - Thesis, 2014
10. Sharma, A.: Crowdsourcing Critical Success Factor Model Strategies to harness the collective intelligence of the crowd. http://irevolution.net/2010/05/05/towards-a-model-for-successful-crowdsourcing/ 2010

11. Willett, W., Heer, J., Agrawala, M.: Strategies for Crowdsourcing Social Data Analysis. ACM Human Factors in Computing Systems (CHI), 2012, pp. 227-236
12. http://doc.qt.io/ - Last viewed: aug. 2016
13. http://threejs.org/docs/ - Last viewed: aug. 2016