Use of NASA World Wind Java SDK for Three-Dimensional Accessibility Visualization of Remote Areas in Lao P.D.R.

Adrian Weber[1], Andreas Heinimann[2], Peter Messerli[2]
[1] Institute of Cartography, ETH Zurich, Zurich, Switzerland
[2] University of Berne, Centre for Development and Environment, Berne, Switzerland

1. Introduction

Laos is characterized by large mountainous regions with poor transportation infrastructure. The various dimensions of accessibility remain a crucial determinant of socio-economic development. Even nowadays a large share of villages is only accessible by foot. It is hence crucial to communicate issues related to accessibility in an easily understandable manner to a broad public. Thereby a three-dimensional visualization is a very attractive approach. This paper presents a prototype for visualizing three-dimensional geographical data and the achieved results.

2. The enclosing project in Laos

The currently ongoing project „Poverty Mapping and Socio-economic Atlas for Lao P.D.R." offered a framework to address issues of accessibility in spatial explicit manner. This project aims at generating spatially disaggregated poverty maps and developing a comprehensive socio-economic atlas of Laos. At the same time it follows the goal of building capacities of selected Lao government agencies in the domain of spatial analysis and finally disseminating the results to policymakers and the wider public (Epprecht et al., 2006).

The project is financed by the Swiss Agency for Development and Cooperation (SDC) and is implemented by the National Centre of Competence in Research NCCR North-South located at the Centre for Development and Environment (CDE) of the University of Berne in cooperation with Lao government agencies.

In the frame of this project the accessibility to and from district capitals has been computed. In this context the accessibility is measured in travel time to reach specific destinations and is used as an index for the remoteness of places. It substantially depends on cost-distance surfaces delineated mainly based on the transportation infrastructure, the relief and further natural obstacles e.g. water bodies.

The socio-economic development in remote areas is essentially dependent on the accessibility to markets, educational and governmental institutions and service provision. Accessibility may hence be considered an important criteria in the field of development cooperation.

3. State of the art in 3D visualizations

Three-dimensional visualizations are a popular way to illustrate the topography for a general public. A relief represents the given terrain very descriptively and supports the imagination of the viewer. It helps to understand the topography better than an ordinary two-dimensional map.

Traditional relief modeling is a costly handcraft, so nowadays most of the three dimensional terrain visualizations are virtual only. Since powerful computer hardware is affordable for personal computing, three dimensional visualization applications are also increasing for home use.

An example for such an application is the wide spread Google Earth software (Google, 2005). Since Google released its Google Earth application, a broad public has come in contact with three-dimensional representations of geographical data. These data are not only obtainable for experts anymore, but became available for everyone. Only a few years after the first release a lot of applications are already based on Google Earth. Meanwhile Google Earth has a lot of users who are familiar with the explorative navigation over the earth's surface and most of them do not want to miss this tool anymore.

Another interactive world viewer is the open source application World Wind, which is developed and maintained by NASA staff and community developers (WorldWind, 2008). NASA released the first ready-to-install World Wind desktop application in mid-2004. The latest version is 1.4 and was released in February 2007. This desktop application is comparable with the Google Earth software, but with a particular focus on educational aims. NASA delivers World Wind with Blue Marble and Landsat 7 satellite images, the SRTM elevation model, place names, country boundaries, etc. Beside the delivered data, users can import their own data and, due to the open source developers, can even code own add-ons with any functionalities.

The World Wind desktop application has been developed within the Microsoft .NET Framework. This framework is a part of the Microsoft Windows operating systems and thus the World Wind desktop application is only executable on Windows (WorldWindCentral, 2008). The fact that this application is not cross platform is a probable reason why NASA staff started to develop World Wind in Java, which is cross platform, and released an open Java software development kit (SDK). Unlike a ready-to-install application, a standard development kit is a library, which allows developers to create own applications using this library. With the first early release of the World Wind Java SDK, subsequently referred to as WWJ, developers were able to easily include the virtual globe in any Java applications and finally run it on any platform. However, NASA developers are not planning to develop a World Wind Java desktop application similar to the above described .NET software, but to continue and expand the SDK (WWJ FAQ, 2008).

4. Results

4.1. Three dimensional accessibility visualization

As mentioned above the computed accessibility refers to district capitals. Highly accessible regions are colored in green and poorly accessible areas in red. Travel times range from less than two hours (green) to seven hours (yellow) to more than twelve hours (dark-red). The accessibility layer is set semi-transparent so the underlying satellite image is visible. Thereby the three-dimensional impression can be strengthened.

Fig. 1 shows extracts of the three dimensional accessibility visualization. It highlights clearly the decrease of the accessibility where the terrain gets mountainous. In contrast, regions along the main road, which mainly follows the valleys, are quite easily accessible from district capitals.

Combined with other geographical data these travel times form a base for different analyses. A simple visual analysis is shown in Fig. 1c where the accessibility is linked with the village points. This analysis points out which areas are poorly accessible and how many villages are within these areas. A more sophisticated analysis is the buffer query. Opposed to the accessibility, which is based on travel-time cost, the
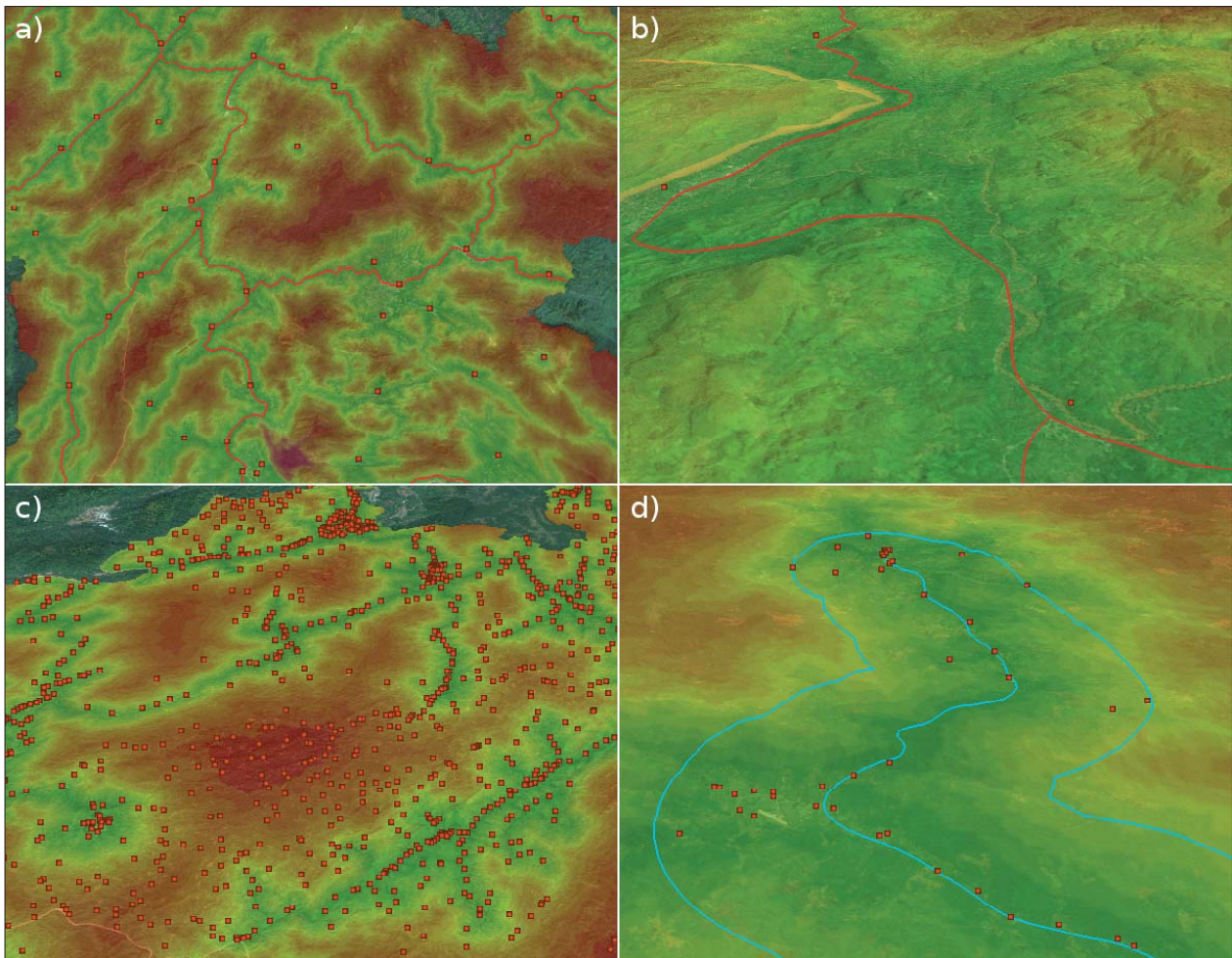

Fig. 1: Three-dimensional accessibility visualizations a) overview of northern Laos with main roads and district capitals b) close-up view around Luang Prabang with main roads and district capitals c) overview of northern Laos with villages d) close-up view around Phongsaly with 5 km buffer around main roads and enclosed villages

buffer query is computed with the geometric distance. The results shown in Fig. 1d answer the question, which villages are within a distance of five kilometers from a main road.

The showcase illustrations in Fig. 1 approve that three-dimensional visualizations are a very attractive way to display the accessibility. The representation is better than in conventional two-dimensional maps. In maps the topography is represented by techniques like contour lines or relief shading. While this representation is sufficient to practiced map readers to imagine the topography and combine it with thematic data, it is often quite hard for untrained readers to interpret the map. Especially these readers benefit from three-dimensional visualizations. Considering that the socio-economic atlas of Laos addresses not only GIS experts but also to untrained readers the three-dimensional visualization adds value to the interpretation.

4.2. The Lao-Atlas prototype

To realize the above shown visualizations an atlas prototype has been developed. Available accessibility data shall be visualized in an attractive and three-dimensional way for a broad public of experts and non-experts. In addition it has to be possible to add any existing geographical data, like infrastructure, administrative borders, capitals, etc. to enable the user to make comparisons and interpretations. Thus the prototype development follows the goal of imple-

menting an open architecture with the possibility to add data from different file formats.

To reach a wider public the prototype has to offer an easy understandable and intuitive graphical user interface (GUI) and navigation.

Fig. 2 shows a screenshot of the prototype. The main window contains the ‚Globe‘ panel and the ‚Wikipedia‘ panel.

The design and concept of the ‚Globe‘ panel is strongly inspired by common GIS designs. The main part of the panel is filled with the globe view. In this view the current visible area and layers are drawn.

An improved layer management is a typical and important concept in GIS. This approach is adapted in the left hand layer panel. All loaded layers are shown in a list, upper layers are drawn later, i.e. they are in the model on top. Like it is known from other GIS the prototype provides adding, removing and reordering of layers through the ‚Layers‘ menu. Additionally the properties of the currently selected layer are shown in the layer panel. Loaded layers can be turned on and off by the ‚Visible‘ property and the raster layers can be set opaque or transparent with the ‚Opacity‘ property.

The ‚Wikipedia‘ panel shows any additional information like describing text or related metadata.
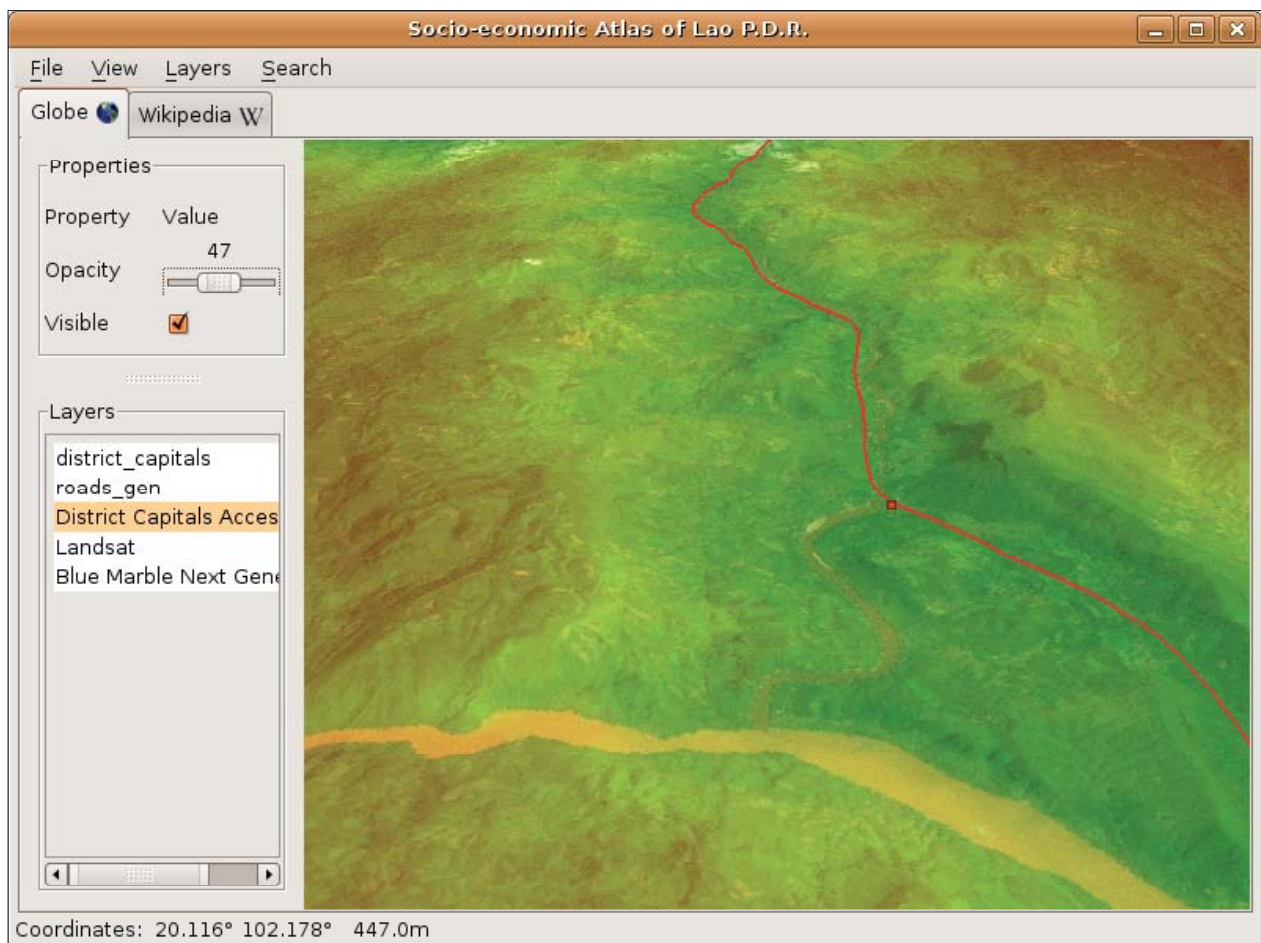

Fig. 2: Screenshot prototype showing accessibility and generalized main roads.
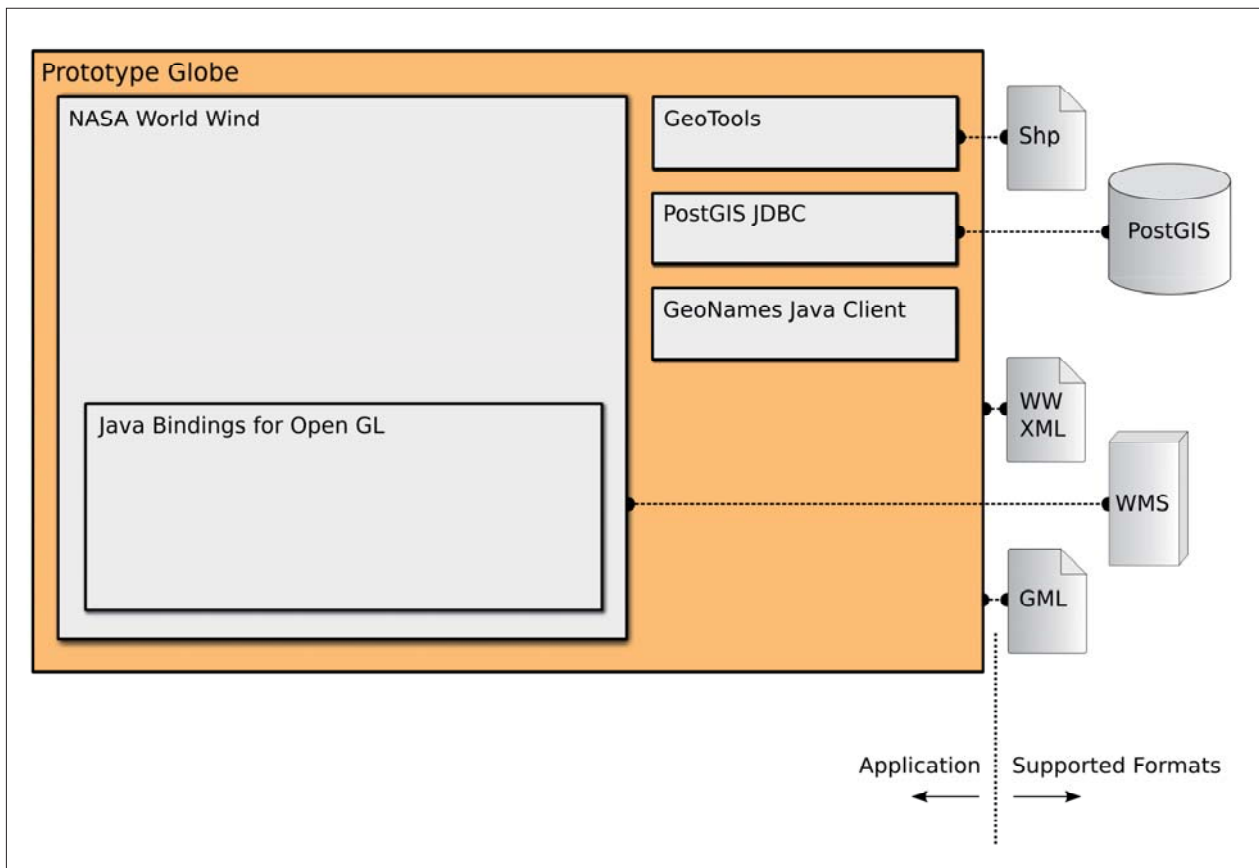
Fig. 3: Overview of used libraries and supported formats in the prototype

Fig. 3 illustrates the scheme of the prototype architecture and shows the used libraries and supported formats. The prototype is mainly based on the World Wind Java library but also uses other open-source Java libraries.

The WWJ library provides a Java Abstract Window Toolkit (AWT) canvas, which implements the rendering of the virtual globe. The model view in the ‚Globe' panel contains such a WWJ canvas.

WWJ itself is based on OpenGL through the Java bindings library JOGL. Furthermore WWJ supports Open Geospatial Consortium (OGC) compliant web map services (WMS).

Through the Java Database Connectivity (JDBC) interface PostGIS databases can be connected. Thus tables with geometry data like the district capitals, villages and main roads in Fig. 1 can be loaded. Additionally the prototype GUI allows the user to invoke PostGIS functions and therefore to execute spatial queries, e.g. the buffer analysis relative to main roads shown in Fig. 1d is performed on PostGIS (PostGIS, 2008).

Other possible data sources to display vector geometries are Geography Markup Language (GML) files or ESRI Shape files. The latter file format is read by the included GeoTools library (GeoTools, 2008).

Last but not least, data can be loaded which are described by a World Wind XML file. This XML grammar is defined by NASA for the World Wind desktop application and supports raster as well as vector data (EarthIsSquare, 2007). The data source of the accessibility raster image is described by a World Wind XML file. The accessibility image has been pre-tiled in different zoom levels and saved on a web server. The tiles are delivered to the client application depending on the current extent and zoom level by a server script.

In order to orientate and find geographical features like villages the prototype offers a reliable location search based on the widespread GeoNames database. GeoNames is a geographical database that contains over 6.5 million unique geographical features and a lot of alternative names. This database is accessible free of charge through a number of web services (Wick, 2008). One GeoNames web service is the locating of geographical features.

5. Conclusion and outlook

A three-dimensional visualization is an appropriate way to illustrate the accessibility situation in Laos. In combination with infrastructure, administrative and socio-economic data the presented Lao-Atlas prototype is a solid analysis tool for policymakers in the government as well as in development cooperation.

Nevertheless there are different possibilities how this tool can be improved towards a more powerful application for visualizing and studying the socio-economic situation in Laos. Due to WWJ's native support of web map services (WMS), not only the accessibility but every socio-economic

indicator, which has been calculated during the project, could be visualized three-dimensionally without any programming work. For that purpose only a web map service would have to be set up.

At the moment the GUI for accessing PostGIS functions is very rudimentary, so an improved user interface would simplify the invocation of these functions. To implement more GIS functions the use of the GeoTools library is possible as well. This library allows not only to read GIS formats but also to include sophisticated GIS analysis functions.

Beside these GIS functionalities the prototype can be expanded to an information system of non-geographical data with spatial relation. The prototype implements the link to Wikipedia articles, but it would be possible just as well to attach any other information. A database could be installed with links to these additional resources. For every resource a validity area would be defined, so the user can query related information for the currently visible area.

Finally, the World Wind Java SDK is a reliable development kit to build advanced applications with sophisticated three-dimensional visualizations. Although this library is only in its early release stage, it provides already a highly developed application programming interface (API) with a wide range of functionality. If the WWJ development progresses in the same pace as until now, this library has high potential to become a wide used library in the geographical information science.

In combination with other open-source libraries WWJ enables the developer to implement comprehensive applications.

References

EarthIsSquare (2007): World Wind XML. http://www.earthissquare.com/WorldWind/index.php?title=World_Wind_XML (last access March 2008)

Epprecht, M., Heinimann, A., Messerli, P. and Minot, N. (2006): Developing Poverty Maps and a Socio-economic Atlas of Laos. A Project Proposal submitted to the Swiss Agency for Development and Cooperation (SDC). Vientiane, Hanoi and Washington D.C.

GeoTools (2008): GeoTools, The Open Source Java GIS Toolkit. http://docs.codehaus.org/display/GEOTOOLS/Home (last access March 2008)

Google (2005): Google Launches Free 3D Mapping and Search Product. http://www.google.com/press/pressrel/google_earth.html (last access March 2008)

PostGIS (2008): What is PostGIS?. http://postgis.refractions.net. (last access March 2008)

Wick, M. (2008): About GeoNames. http://www.geonames.org/about.html. (last access March 2008)

WorldWind (2008): World Wind 1.4. http://worldwind.arc.nasa.gov/index.html. (last access March 2008)

WorldWindCentral (2008): Welcome to World Wind Central, official knowledge base and support site for NASA World Wind. http://www.worldwindcentral.com/wiki/Main_page. (last access March 2008)

WWJ FAQ (2008): NASA World Wind Java Frequently Asked Questions. http://www.worldwindcentral.com/wiki/WWJava_FAQ. (last access March 2008)