

BlendGIS: An Open Source tool for 3d and 4d visualization of ecology related spatial data

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Abstract

We developed a plugin for the open source modelling, animation and rendering software Blender to import and visualize ecology related spatial data created with the open source GIS QuantumGIS in 3d and 4d. The main goal is on the one hand side to provide a tool that helps to increase the social acceptance in obligatory public participation processes for public funded ecosystem restoration measures and research programmes. And on the other hand side to provide a toolkit for visualization of ecological data that also satisfies the scientific needs. We successfully used it in two case studies concerning stream ecology.

Categories and Subject Descriptors (according to ACM CCS): I.6.8 [SIMULATION AND MODELING]: Types of Simulation—Visual

1. Introduction

Geographic Information Systems (GIS) are a fundamental tool in environmental planning to store, analyze, manage and present ecologic related spatial data [SH09] [GB08]. Viewing spatial data in three dimensions often gives new perspectives but often results were displayed on a planimetric map or in a Web-GIS application. However, 3d or even 4d visualizations can provide insights that would not be easily apparent from a simple two-dimensional map of the same data [WSLS08] [PP06] [Bry03] [Kre00]. Information can get lost or at least - depending on the audience - the intelligibility decreases when 3d data is projected on a two-dimensional surface. Nevertheless, the full potential of 3d visualization in environmental planning is not yet exhausted. [HL01] and [TT03] suggest that 3d visualization should represent a core element in stakeholder participation processes.

One reason could be that on the one hand the field of high resolution 3d animation and modelling is currently mostly limited to cost intensive proprietary software solutions (e.g. 3D Analyst und ArcGlobe/ArcScene in ArcGIS, AutoCAD Map 3D, VisualNatureStudio, Cinema 4D). And on the other hand there is still a huge gap when it comes to combining the spatially exact processing of a GIS with the modelling and animation abilities of 3d visualization applications. Al-

though the boundaries continuously dissolve its application is limited due to proprietary exchange formats and restricted extendability (closed source). Especially if restricted to a single OS.

We developed a tool to fill that gap that works on most platforms (Windows, MacOS, Linux). It is highly flexible and easily extendable. We also created some visualization templates for predefined animations. To test the tool and to determine the needed range of functions we used it in two case studies. Both are linked to stream habitat restoration plans and research activities on stream biota. In this context a main interest is to provide information on topical scientific and restoration measures in a visual language that is also understandable to the scientifically interested but non-specialist citizen. This concern is strongly relevant since the Aarhus Convention of 1998 established a number of rights of the public such as the access to environmental information and public participation in environmental decision-making [UNECfE98]. These principles are also essential to the European Water Framework Directive (WFD) since the involvement of the general public has played a key role in implementing the WFD. Further more the main goal of the WFD - all surface water bodies have to achieve the "good ecological status" - is obtained only by 9,5 % [RV10] and

restoration measures are obligatory. Possible restrictions on use of and access to large areas may result in a significant public dissatisfaction. To ensure social acceptance and gain support for large public spendings on conservation measures innovative governance processes to enhance citizen's participation and knowledge transfer are needed [WLSL08]. This tool may contribute to this process.

2. The case studies

2.1. River Twiste

At river Twiste, a small highland river, restoration measures took place in spring 2013. The aim was to increase the habitat suitability for the target species brook lamprey (*Lampetra planeri*). Straightening of the river at the end of the 19th century has caused a significant habitat loss corresponding to a dramatically decrease in species richness and population densities in general. To achieve the "good ecological status" according to the Water Framework Directive cost intensive measures are necessary. At two sections measures have been made to increase habitat quality. The river morphology was measured by cross sectional survey (tachymeter) under low-flow conditions with distances of 2 to 5 m between the cross sections two month before and one week after the restoration.

A non-representative survey during the stakeholders participation process in 2011 showed that most people were not aware of the fundamental changes in the rivers morphology in the past and its fatal impact on the biological communities. Therefore the public support for restoration measures can be considered as relatively low. At this stage BlendGIS could be used in order to visualize the whole process including the results of the accompanying monitoring. The main goals are:

1. Visualize the deficiency river bed morphology before the restoration and highlight missing habitats
2. Plastically visualize the deformation of the river morphology after restoration measures took place and localize new emerged habitats
3. Visualize possible (or predicted) future development (e.g. changing stream morphology over time)

2.2. River Eder

At river Eder, a large highland river in central Germany, a research project started in Spring 2012 to analyze the habitat quality for brown trout (*Salmo trutta*). The studied area is characterized by contrasting environmental conditions (high/low flow) mainly driven by current management goals of an upstream located reservoir: supply for the national waterways, flood control and hydroelectricity. In April 2012 49 brown trouts were tagged using radio transmitters. The fish were manually tracked continuously from the shore. The collected locations were stored in the field in a

database using Quantum GIS and digital orthophotos (dop) on a convertible notebook with built-in GPS receiver. The river morphology was measured by cross sectional survey (tachymeter) under low-flow conditions with distances of 15 to 35 m between the cross sections, depending on the heterogeneity of river morphology. Records of discharge were obtained from the gauging station (German Water and Shipping Authority) about 2 km upstream from the study site. Water temperature, pH value, electric conductivity, oxygen content and saturation were measured continuously every 30 minutes at four sites equally distributed along the study area using four YSI 600XLM V2 sondes. The main goal is to visualize the habitat use at different scales:

1. Small scale: fish movements due to changes in habitat suitability based on different flow situations
2. Medium scale: fish movements during spawning season
3. Medium scale: reaction on river restoration measures, change in habitat use
4. Medium scale: fish recruitment, habitat connectivity and suitability (adult, juvenile and spawning habitats)

3. Bridging the gap between GIS and 3d/4d visualization

3.1. Why Blender

Blender (<http://www.blender.org>) is the leading open source 3d modelling animation and rendering application. It has spawned four open movie projects that act as a showcase for its capabilities. Because it was designed to create arbitrary objects and environments, it is also capable of creating environmental visualizations. Because of its open source nature it is very easily extensible and importers for any kind of data source can be easily written. It brings its own Python interpreter as an integrated scripting language that allows access and manipulation of every internal data structure as well as access to every other functionality that either Blender or any other Blender plugin supports. In addition to its primary function of creating still images or video animations, Blender also incorporates a game engine, that allows for real time rendering of interactive environments. Blender is actively supported on Windows, Mac OS and GNU/Linux.

3.2. Why QGIS

QGIS (<http://www.qgis.org>) is a popular cross-platform (Linux, Windows, Mac) open source Geographic Information system. It is able to display vector and raster data in different formats and projections and to perform spatial analysis, including map algebra, terrain analysis, hydrologic modeling and network analysis. In addition to a simple "Export to Mapfile" capability it allows to publish maps on the internet using QGIS Server. Through its extensible plugin architecture QGIS is adaptable to individual needs.

3.3. Visualizing QGIS Projects in Blender

QGIS supports a variety of data sources that contain points, shapes, images or height/intensity information. The data types can be grouped into three categories:

1. Databases, such as Shapefiles or SpatiaLite Files, providing geometric shapes or points and the ability to store additional tabular data along with them.
2. Tabular data, such as csv (comma separated value) files, providing points and additional data.
3. And matrices, providing image, depth or intensity information in a rectangular form.

Because QGIS only processes two dimensional coordinates, the Blender plugin provides its own user interface to select how to map additional data. Data can be mapped as depth information, time information or color information. Using Blender's own toolset color information can be further mapped to e.g particle systems (used for vegetation growth). Blender distinguishes between three data types that are mapped to corresponding elements of a QGIS project:

1. A QGIS layer is mapped to a Blender object.
2. The QGIS layers geometric data is mapped to a Blender mesh.
3. The QGIS layers image data is mapped to a Blender texture.

3.4. Coordinate Systems

The Blender coordinate system has a scale of one meter per unit in every direction. Upon importing the QGIS Project, it's coordinate system is centered around the origin point of Blender's coordinate system. Upon exporting the reverse transformation is performed. Because extra care has to be taken to match the depth information to the same unit as the coordinate system, a custom scale factor can be applied. Blender can scale objects in two ways: On object level and on mesh level. The scaling on object level is ignored by the export function and can thus be used without disrupting the coordinate system.

3.5. Visual Elements

As Blender is a general purpose modelling and rendering solution, it is only limited by the speed and memory of the computer used. It incorporates a particle engine, that can create hair like surfaces that can easily be tweaked to resemble grass. Said particle engine can also be used to automatically distribute arbitrary objects among different surfaces based on "weight-maps". Weight maps can be created directly in blender, where they are painted on an objects surface or loaded from image files which have to be mapped onto the surface. It is possible to create libraries of objects that can be shared among different Projects. Blender also incorporates a plugin called "sapling" that can be used to automatically create trees of various shapes. Water can be displayed as a simple plane of a semi transparent or even mirroring material

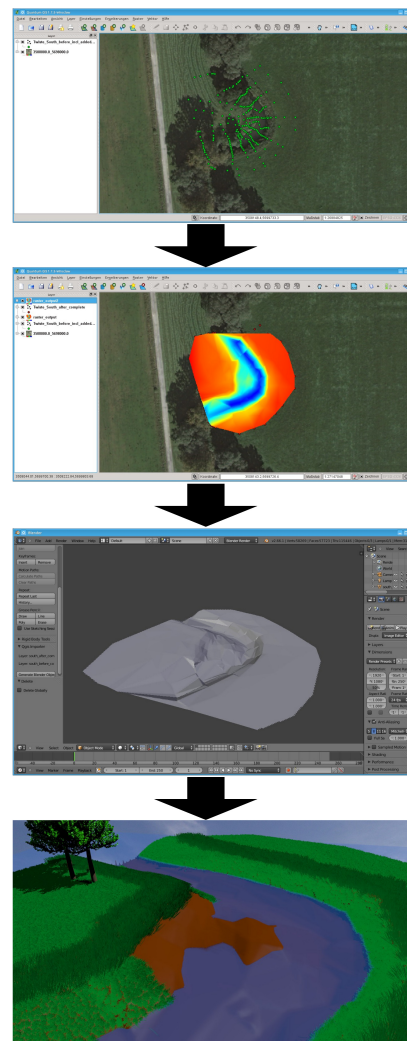


Figure 1: The work process from QGIS to Blender

(materials are collections of attributes of the simulated material. Mostly color, transparency, etc.) that intersects with the rest of the terrain surface.

3.6. The 4th dimension

As an animation system, almost every setting and property in Blender can be assigned to a keyframe on a timeline. To store an objects properties, such as location, rotation, scale, color or transparency, is as simple as to hover the mouse cursor over the object and pressing a button. The assigned values can later be adjusted and moved along the timeline via a graph editor. Blender allows for morphing between meshes of different shape, as long as both have the exact same di-

mensions of vertices (points in a three dimensional space) and faces (connections of three or more vertices).

4. Workflow

To prepare the project in QGIS, the measurements from our case-study were imported as csv data. We then used the interpolation plugin that QGIS provides to create a height map from the point samples for both the before and after measurements. The QGIS project file was then loaded into Blender via our BlendGIS plugin. The two resulting Blender objects were merged as shape keys into one single object. Particle generators were added to the mesh and grass was painted onto the surface via the weight-paint-mode. Additionally two trees were added using the "sapling" plugin at approximately the point where a series of trees begins on site. After the merging animation finishes, additional grass and a tree blend in on the island to illustrate potential future development of the site. The blending is done by animating the transparency of the objects materials.

5. Results

The accompanying video gives an idea of what can be done within a reasonable effort. In this early stage we were able to produce short high resolution video sequences to visualize the changing morphology and habitat suitability through restoration measures at river Twiste (Figure 2) and the movements of brown trout (Fish-Id "18") throughout the year 2012 in the river Eder (Figure 3). The placement of the results of biotope and instream habitat mapping as well as the 95% home range worked well. It has to be emphasized that it was able to display the smooth transition between the restoration step so changes in the habitat quality become easily visible. The video sequences have been shown during stakeholder participation processes in both case studies. In following discussions it became apparent that this 3d visualization provided new perspectives and insights. [WLS08] [PP06] [Bry03] [Kre00] had to similar results. Both projects gained high public support.

6. Discussion

To create an easy workflow the BlendGIS plugin needs some additional functionality. Finding the correct settings for the materials proved to be more tricky than expected. The Plugin can easily provide functionality to automatically assign proper materials to user selected objects. Additionally annotations and highlighting areas could be improved and more easily animated. Helper functions can be created for these tasks as well. Many other fields of application are conceivable such as terrestrial ecology and urban planning. The results at this early stage were promising and well received in stakeholder participation processes.

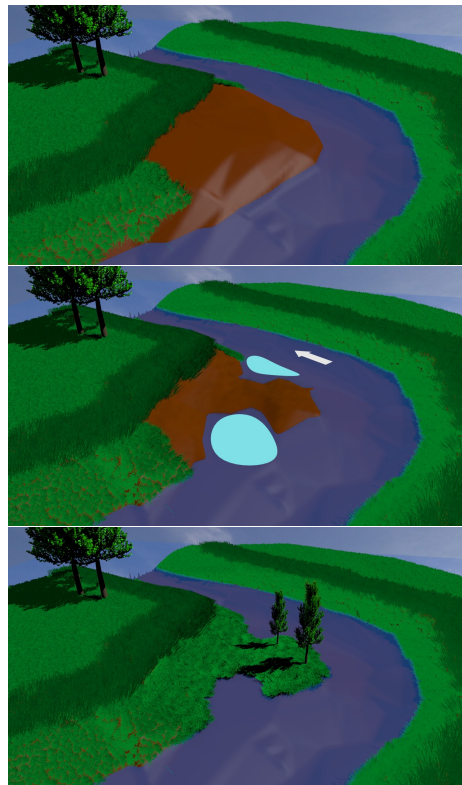


Figure 2: Before and after restoration process (top and middle), new emerged habitats (middle) and potential future development (bottom).

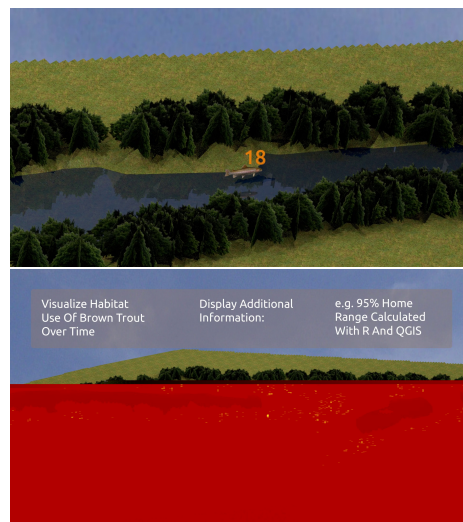


Figure 3: Close up of Fish "18" (top) and the corresponding 95% home range (bottom).

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