EFFICIENT INTEGRATION OF DATA GRAPHICS INTO VIRTUAL 3D ENVIRONMENTS

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Abstract

Maps employing thematic map symbols, such as bar or pie charts are often used and constitute a standard method of displaying thematic data with geospatial reference. With the increasing popularity of virtual earth technologies, such as Google Earth, these methods of displaying thematic data are adopted for virtual 3D environments. The efficient creation of data graphics for the integration into virtual 3D environments calls for suitable data structures and processes. The research presented in this paper shows the development of a prototype for the generation of data graphics.

The developed prototype is based on several existing technologies. The representation of the diagrams is described using a profile of DiaML (Diagram Markup Language) (Schnabel 2007). As geo data input format we devised a simple XML format. The formal diagram description in DiaML and the thematic data with spatial references are then transformed in one of three output formats (X3D, SVG and KML and COLLADA) depending on control parameters which are specified in a separate document. The different templates of the XSL transformation are kept as generic as possible to make them reusable for different diagram types and output formats. The prototype has successfully been tested with different sets of uni- and multi-dimensional data.

Introduction

Thematic maps employing 2D data graphics or thematic map symbols, such as bar or pie charts, for the display of statistical data or other abstract data values are often used and constitute a standard method of displaying thematic data with geospatial reference. With the increasing popularity of virtual earth technologies, such as Google Earth or Bing Maps 3D, these methods of displaying thematic data are adopted for virtual 3D environments (e.g. Sgrillo 2009 or Sandvik 2009). We believe that the visual

combination of data graphics with the quite naturally perceived virtual 3D landscape, in which the data was collected in, is a valuable complement to traditional 2D representations. Ongoing research (Bleisch et al. 2008) evaluates the appropriateness of such a combination in different experimental and applied settings.

The goal of the research presented in this paper is to define suitable data structures and processes for an efficient creation of data graphics for the integration into virtual 3D environments. The processes need to be flexible enough to be adaptable to different text-based 3D display formats and standards, data and diagram types. This paper presents the development of a prototype that fulfils the above mentioned requirements. It illustrates the difficulties and the developed solution and presents the results from evaluating the prototype with different data sets, 3D display formats and diagram types.

Concepts and formats

The diagram generation prototype is developed based on several existing technologies. The core of the prototype is a XSL (eXtensible Stylesheet Language) transformation combining the thematic geo data which is to be displayed with the formal description of the diagrams (Figure 1). The output of the transformation process is one of three different 3D display formats.
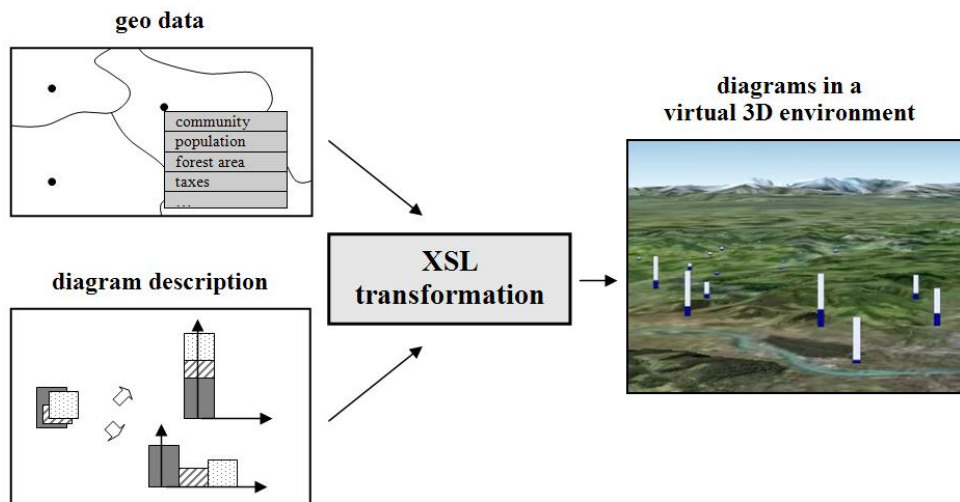

Figure 1. Overview diagram generation workflow

The input geo data and its associated attribute values need to be available in a generic format. We devised a simple XML (eXtensible Markup Language) format as input of the transformation process. A number of XML elements allow the description of the input geo data such as a spatial point reference for each data set, the attribute values and their description (Figure 2). The XML format is described using XMLSchema which allows validation of created input files. Using an XML format for the description of the

input data has several advantages, for example, it is a text based format and easily generated out of most databases or other storage forms of existing geo data.

```
<geoData referenceSystem="…" projection="…" heightMode="…">
    <attributeDefinition>
            <att id="…" data="…" descr="…" units="…"/>
            …
    </attributeDefinition>
    <point id="…" descr="…">
            <coordinates units="…">
                    <easting>…</easting>
                    <northing>…</northing>
                    <height>…</height>
            </coordinates>
            <attributes>
                    <attribute attRef="…"/>
                    …
            </attributes>
    </point>
    …
</geoData>
```

Figure 2. XML file format of the input geo data
(original XML element names in German)

The different diagram types are formally described using a profile of DiaML (Diagram Markup Language) (Schnabel 2007). DiaML is a XML language developed for the description of several different thematic map symbols and charts in 2D (Figure 3). It employs construction rules that parameterise different variations of diagrams. For the prototype development we use a profile of DiaML that is restricted to different bar charts. This is a necessity in order to keep the complexity of the prototype development manageable. However, it shall be possible to add further DiaML diagram definitions to the prototype in future developments phases.

```
<?xml version="1.0" encoding="UTF-8"?>
<symbol xmlns="http://www.carto.net/schnabel/mapsymbolbrewer"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.carto.net/schnabel/mapsymbolbrewer
http://www.carto.net/schnabel/mapsymbolbrewer/schemas/diaml.xsd">
    <style id="s1">
            <fill>0,255,0</fill>
            <stroke>0,0,0</stroke>
    </style>
    <primitive id="p1">
            <rectangle proportional="length">
                    <width scale="fixed">15</width>
                    <height scale="dataValue">80</height>
            </rectangle>
    </primitive>
    <diagram areaRatio="10.0" minSize="3">
            <diagramArrangement>
                    <linear>
                            <groups distance="20">1</groups>
                            <parts arrangement="stacked">3</parts>
                    </linear>
```

```
            </diagramArrangement>
            <diagramRelation>
                    <dataRef>data1</dataRef>
                    <dataRef>data2</dataRef>
                    <dataRef>data3</dataRef>
                    <primitiveRef>p1</primitiveRef>
                    <styleRef>s1</styleRef>
            </diagramRelation>
            <guides/>
            <labelData>no</labelData>
    </diagram>
</symbol>
```

Figure 3. DiaML code example, diagram description - stacked, linear bar chart,
using green rectangles with stroke

As the two input formats (the geo data XML file and the diagram description in DiaML)
as well as several output 3D display formats and standards are text-based it makes sense
to use XSLT (eXtensible Stylesheet Language Transformation) as processing language.
For the prototype development we defined three output formats for the data graphics:

a) X3D (eXtensible 3D) billboards
b) SVG (Scalable Vector Graphics) and KML for Google Earth placemarks, and
c) COLLADA (COLLAborative Design Activity for interactive 3D applications).

Google Earth cannot handle SVG graphics as placemarks. Thus, we employ the Batik
Rasterizer (Apache 2009) to rasterise the generated SVG graphics into PNG graphics
which can be used in Google Earth. COLLADA is a standard 3D exchange format that
can be handled by most 3D visualization software and also be imported into our own
virtual globe technology i3D (Nebiker and Christen 2009). Importantly, it needs to be
mentioned that the transformation process basically only produces the data graphics
which are to be included in a virtual 3D environments. Except for KML, which can be
used in Google Earth, the background landscape for the data graphics needs to be
defined separately (e.g. for X3D) or the graphics be imported into a different virtual
globe application (e.g. by using COLLADA). Beside these three momentarily
implemented output formats the process is kept open to be adaptable to further output
formats at a later stage.

The output data graphics are defined as billboards (sprites in Computer Graphics) in all
three output formats. A digital billboard can be thought of as a 2D drawing board placed
at a specific location in the virtual 3D environment. It always faces the camera or the
viewpoint of the user by rotating around two of its axes. The generated diagram is
rendered onto the billboard. Using billboards instead of 3D objects, such as pillars or
cubes for the data display has the advantage of avoiding misjudgements of data values
by showing the diagrams always oriented to the viewer and not in sidewise views.

Transformation process

The transformation process which generates the different diagrams out of the input thematic geo data employs the technologies XSLT 2.0 and XPath 2.0 (Bongers 2008). Even though these technologies are no fully-fledged programming languages their functionalities are sufficient for the task at hand. The use of XSLT templates allows building a modular structure of the transformation process that is started with a master XSL file which calls the different other XSL files and their specific templates when needed (Figure 4). This allows output generation in different file formats, such as the above mentioned SVG, KML, X3D or COLLADA formats. Additionally, it has the advantage that it allows reusing the same code blocks at different stages of the transformation process. The diverse templates of the XSL transformation are kept as generic as possible to make them reusable for different diagram types and output formats. Transformation parts that are specific to a certain output format are stored in separate XSLT files that are imported when needed.
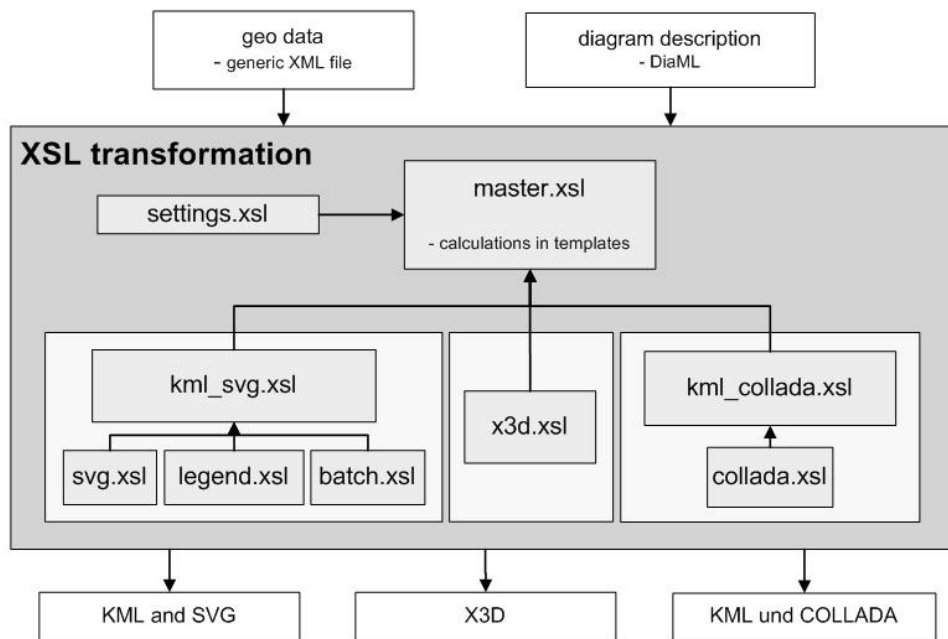
Figure 4. Modular structure of the transformation process - the master.xsl file calls the other XSL files depending on the output format defined in the settings.xsl file.

Results and discussion

The result is a working prototype that transforms thematic geo data into data displays in one of the three defined output formats and the formal diagram description in DiaML. The developed prototype generates different bar chart types, such as grouped or stacked bars in linear or polar arrangements (Figure 5). Additionally, it can be defined that the

single bars or bar charts are framed by a background rectangle with a fixed size which helps faster judgement of the bars tallness (Bleisch et al. 2008).
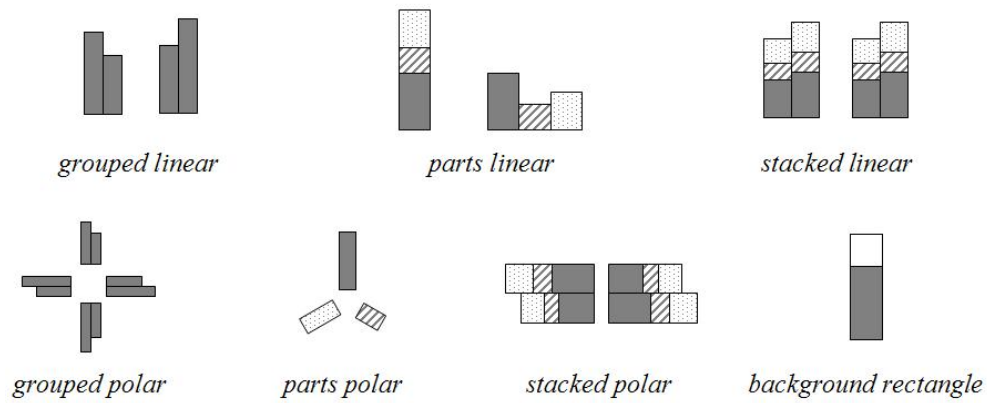

Figure 5. Different bar chart types that can be generated using the developed prototype

These different bar charts allow the representation of a wide range of data from single values to multi-variate data sets. The prototype has been tested using data sets from different application domains and varying bar chart types (Figures 6 and 7).
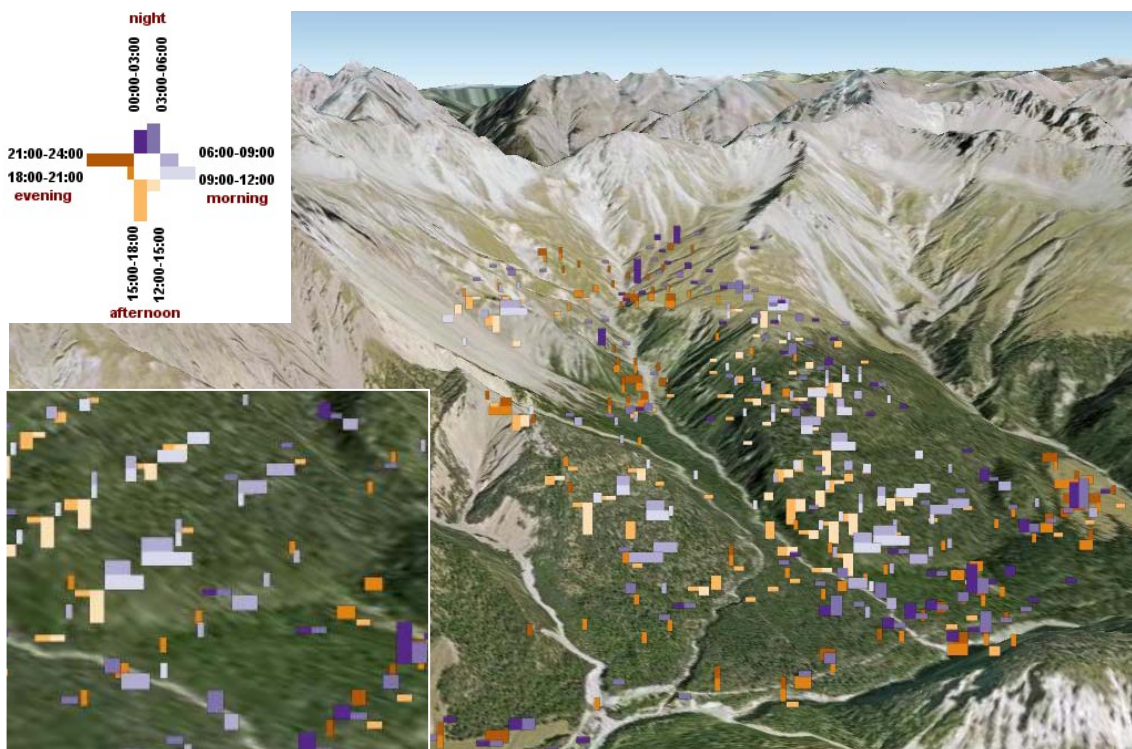
Figure 6. Grouped polar bar charts showing aggregations of deer positions in the Swiss National Parc at different times of the day (incl. legend and zoomed-in view)

The strength of the XSL transformation is the easy to handle text-based format that nevertheless allows a modular structure of the transformation process. A modular structure has the advantage that it separates between general re-usable templates and others that are output format specific. Thus, the process is easily adaptable and extendable to additional output formats or diagram types. The biggest restriction on the diagram generation process is momentarily the input format. The thematic geo data need to be available in exactly the defined format. However, it is quite simple to transform most other data sets into this format by using an XSL transformation.
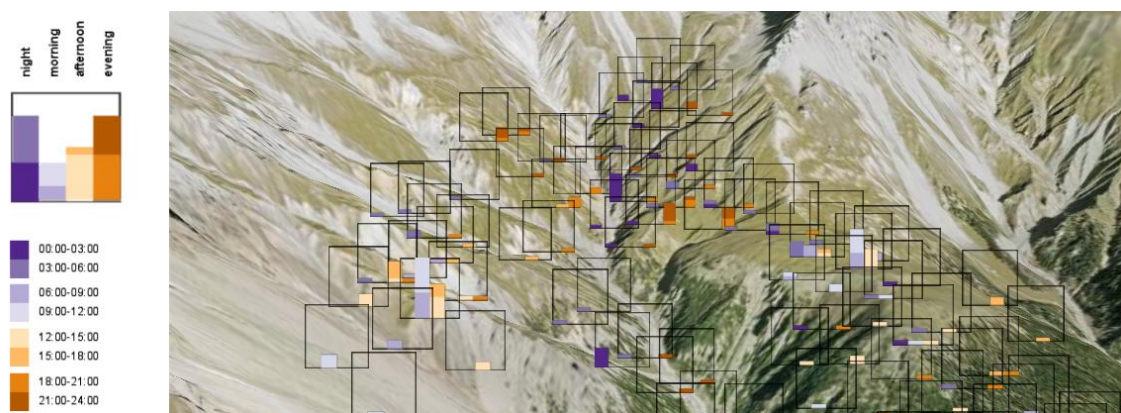

Figure 7. Subset of the same data as in Figure 6 visualised through linear stacked bar charts, employing reference frames.

Conclusions and outlook

With the development of the diagram generation prototype and its testing we have shown that using DiaML as a diagram definition language and XSL as a transformation mechanism enables us to efficiently generate thematic data displays for the integration into virtual 3D environments. The tests with the different sets of data and a number of informal users have shown that requests for additional diagram types are emerging soon. The step-wise development of the prototype and its testing ensures us that it is easily extendable to further diagrams and output formats. The use of the XML technology XSL for the transformation offers a wide range of functionality but also has some disadvantages that have to be circumvented. These may call for a later implementation of the developed process in an actual programming language.

The prototype presented here supports the creation of a range of different bar chart types. It is able to create these diagrams quite efficiently. However, it cannot judge the appropriateness of such displays. This calls for further research. In many cases, concepts from 2D displays are adapted to 3D without much questioning. As mentioned

at the beginning, ongoing research is evaluating the use of bar charts in desktop-based virtual 3D environments in several experimental and applied settings (Bleisch et al. 2008). But, there is still work to be done. While the prototype could, for example, be extended to support pie charts, the use of such charts in virtual 3D environments where a change of size could be attributed to differing data values or to influences of the perspective view may be quite questionable. Research in the area of effectiveness of data displays in virtual 3D environments will hopefully lead to recommendations or even standards for such representations. Prototype tools, such as the one presented in this paper, that help the faster creation of different displays will certainly be helpful for such research.

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