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MOTION ENHANCED INFORMATION MURAL FOR CLIMATE DATA VISUALISATION

Abstract

This paper discusses visualisation of climate data. The possible use of an information mural for this purpose is explored as well as the potential of enhancing the visualisation with motion. It is investigated how these techniques help in the analysis of data distribution regarding different data dimensions such as temperature and precipitation. The work is accompanied by a presentation of the method's implementation.

keywords: *Visualisation, Motion, Information Mural, Climate Data.*

1 INTRODUCTION

A major challenge when dealing with climate data is in communicating any possible hidden information to the user. As much as for any other area dealing with information processing it is the task of information visualisation to allow users to browse the information space and focus on items of interest. For these *overview and focus* tasks, visualisation techniques are helpful that provide a means to display as much of the information space as possible.

One such technique is the information mural (Jerding and Stasko, 1998). Using such a mural, a visual representation is created that fits the *complete* information space within a display. This is achieved by creating a dense pixel mapping. Possibly overlapping pixels are accordingly emphasised.

The visualisation of climate data requires appropriate handling of possibly large data sets. Depending on user requirements, an information mural might help in composing expressive data representations. Section 4 and 5 outline the design and an implementation of a motion enhanced mural. Motion is thereby considered as an presentation variable of its own (Jesse and Strothotte, 2001) that is both: expressive and easily perceivable by the user.

Some details about the example data used throughout this paper are presented in section 2. This is followed by a brief overview of existing approaches for climate data visualisation. After the above mentioned discussion of a motion enhanced mural, section 6 concludes this work.

2 SCENARIO

Possible interest in climate data spans a wide range of potential analysis areas. A common approach is the investigation of a curvilinear grid defined by longitude, latitude, and altitude. This allows to compare different area's data and is useful for weather forecasts. Another approach is to investigate data for a specific location only by sampling data at concrete location points. This preserves a reasonable amount of data and allows to examine data spanning a more extensive time frame. This latter case forms the basis of the work presented here. Precisely, daily weather data are used.

As available weather databases provide incomplete data in this regard, ClimGen is used to generate synthetic daily climate data.[1] This tool allows for the generation of data containing total solar radiation, maximum and minimum temperature, rainfall, and windrun. In order to generate any reliable data, the simulator needs to be parameterised accordingly. This is done by specifying a set of *location parameters*.

As an exemplary location, the place Magdeburg (Germany) is used. The location "Magdeburg" is described by a latitude of $52.13°$, a longitude of $11.62°$, and an elevation of $79.00\ m$. ClimGen allows various degrees of input data completeness. Eventually missing parameters are estimated by the program. The following monthly mean values for minimum temperature, maximum temperature, and precipitation are used as basis for data generation:

month	$mean(T_{min})$	$mean(T_{max})$	$mean(prec.)$
January	$-1.8°C$	$13.0°C$	$34.8\ mm$
February	$-0.6°C$	$12.0°C$	$30.0\ mm$
March	$0.6°C$	$13.0°C$	$35.0\ mm$
April	$4.6°C$	$16.9°C$	$39.2\ mm$
May	$6.1°C$	$37.1°C$	$47.6\ mm$
June	$14.3°C$	$24.3°C$	$63.8\ mm$
July	$13.0°C$	$29.0°C$	$58.4\ mm$
August	$12.4°C$	$24.5°C$	$52.3\ mm$
September	$10.5°C$	$20.5°C$	$38.1\ mm$
October	$5.4°C$	$15.7°C$	$33.8\ mm$
November	$-5.6°C$	$10.9°C$	$37.3\ mm$
December	$-7.0°C$	$11.2°C$	$39.2\ mm$

Using this input, ClimGen generates useable data about precipitation and temperature. As some parameters were only estimated, possibly generated data about solar radiation and windspeed are not of reliable nature and therefore not used.

3 APPROACHES FOR CLIMATE DATA VISUALISATION

The field of climate data visualisation is very diverse and only a brief overview of existing techniques is outlined here.

Max and Crawfis (1995) present cloud rendering methods for the purpose of analysing clouds and their behaviour over time. The presented methods include mapping of a 3-D texture to cloudiness contour surfaces as well as volume rendering of clouds by splatting.

A set of web based applications is available that target the collection, handling, visualisation, and interpretation of climate data. Such a system is presented by Collins and Schweitzer (1997). Their GrADS system provides a variety of techniques to present climate data. These

[1] More information about ClimGen, its availability, and a comparison compendium of ClimGen and other climate data generators is available at `http://c100.bsyse.wsu.edu/climgen/`.

techniques include but are not limited to graphs, scatter plots, contours,and streamlines. Another example of a web based climate data visualisation application is FERRET (Hankin et al., 1998). Its set of provided techniques spans from various plots to different contour displays.

A different approach is shown by de Leeuw and van Liere (1999). They use textures as expression variables for the purpose of presenting temporal dataflow. As input data changes over time, texture does too. An exemplary application shows the temporal relation between atmospheric pollution and changes in wind fields.

Most GIS are capable of handling some amount of climate data. Their purpose is in management of geographic knowledge. A GIS usually works map based and provides support for raster analysis of complex areas. Exemplary GIS systems are ArcInfo and ArcView.

4 MOTION ENHANCED INFORMATION MURAL

A slight modified version of the information mural technique is used to construct a visualisation that displays the complete set of available input data. To support detail browsing, this presentation is enhanced by applying motion to a user controllable subset of the scene. This combination allows a structural analysis of temperature and precipitation distribution.

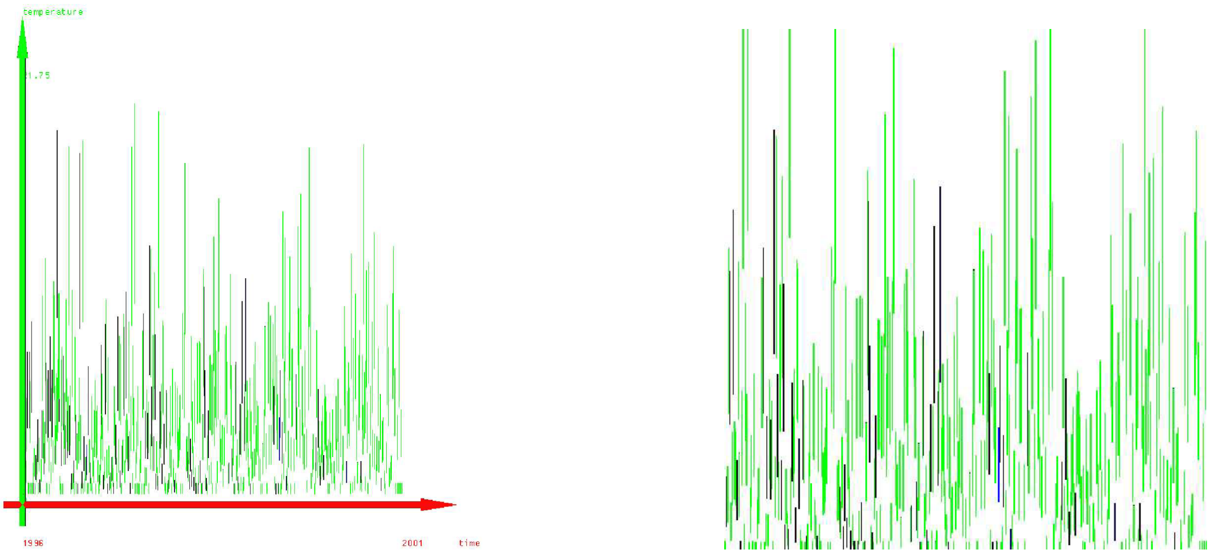
4.1 Information model

The design of the visualisation framework is formally based on the work presented by Kreuseler and Schumann (2002). Their model was developed in the context of Visual Data Mining. But its general nature allows for application in other domains as well. In principle, the model is based on the definition of *information objects* IO_i that combine to an *information space* $\mathbf{IM} = \{IO_1, \ldots, IO_n\}$ with $IO_i = IO_j \Leftrightarrow i = j$ and $i, j, n \in \mathbb{N}$. Each information object represents some real world data. In order to parameterise these objects according to their represented data characteristics, an attribute function $attr$ is provided: $\mathbf{AM} = attr(\{IO_1, IO_2, \ldots, IO_n\}) = \{A_1, A_2, \ldots, A_k\}$ with $A_i = A_j \Leftrightarrow i = j$ and $i, j, k, n \in \mathbb{N}$. Thereby, **AM** is the *attribute set* of the respective information objects. For the purpose of defining relations between IO_i the *information structure* **IS** is introduced as $\mathbf{IS} \subseteq \mathbf{IM} \times \mathbf{IM}$.

4.2 Object construction

As an information mural's main goal is to display the complete information set in a display, all $IO_i \in \mathbf{IM}$ are created initially. Any changes resulting from user interaction are expressed by a manipulation of the attribute set **AM** and the information structure **IS**.

The creation of IO_i correlates directly to the available daily weather data. That is, for each available day, an information object IO is created. The geometric shape of an object is a vertical line in 2-D respective a cuboid in 3-D. This allows to order all IO_i along the x axis. Other object characteristics as well as the mural restrictions are ensured by assigning appropriate attributes $A_i \in \mathbf{AM}$. These attributes include position, shape modification, and colour. The x position is determined by appropriately moving along the axis according to the overall coordinate maximum of the display. In contrast to the original mural implementation by Jerding and Stasko (1998), the case of overlapping pixels is not encoded in colour intensity but in scaling the lines vertically by a precomputed factor. Positioning along the y axis is done according to the temperature values of the respective day's data. The line bottom represents the temperature minimum value, the line's height represents the temperature span. Colour mapping is used to express the precipitation data in an information object. Figure 1 shows a resulting image after the object construction is completed.



(a) Complete

(b) Zoomed in

Fig. 1 . Snapshot representing the climate data information objects in a mural.

4.3 Motion mapping

In order to extract patterns from data distribution, an information structure **IS** is composed that merges similar objects into groups. The metrics used to obtain similarities and structure are parameterisable interactively. Exploration at arbitrary levels of detail are thereby possible. The user is actively involved in supervising and steering the search for patterns.

Parameters controllable by the user are the mean temperature threshold and the precipitation threshold. This allows to construct a structure **IS** containing all IO_i with a represented temperature span larger than the threshold as well as a precipitation higher than specified. If $ms(IO_i, T_{thres}, P_{thres})$ defines a function returning all objects meeting this criteria, the information structure results as **IS** $= \{IO_1, IO_2, \ldots, IO_n\}$ with $IO_i = ms(IO_i, T_{thres}, P_{thres})$ and $1 \leq i, j \leq n$.

5 IMPLEMENTATION

All objects $IO \in$ **IS** are emphasised by applying an oscillating motion. This motion is controlled by two parameters: amplitude and speed. Both are determined directly from the two threshold dimensions. The variance of a day's temperature span compared to T_{thres} specifies the amplitude. Oscillation speed correlates to the difference of the day's precipitation and P_{thres}. If one of the thresholds is not reached, the other stays unaffected. That is, if the day's temperature span is below T_{thres} as specified by the user, no motion is visible. In case only P_{thres} is not reached, a default oscillation speed of five loops per second is used. This motion technique produces vector data from scalar data for display:

$$\mathbf{pos}(t) = \mathbf{pos}(t_0) + \int_{t_0}^{t_n} \mathbf{v}(\mathbf{pos}(t), t) \quad dt$$

Thereby, $\mathbf{pos}(t)$ specifies the current position of all $IO_i \in$ **IS** that meet the above threshold criteria. The time t is interpolated between 0 and the given loop interval length. The current distance function of any given point in time is specified as $\mathbf{v}(\mathbf{pos}(t), t)$. Whereas figure 1(a) shows the initial mural view with the complete data set visible, a zoomed in view of the mural that includes emphasis by oscillating motion is shown in figure 1(b). This technique is more clearly demonstrated in the video accompanying this paper.

The concepts of a motion enhanced mural have been implemented in the prototypical ClimVis application. Figure 2 provides an overview of the application's components and its dataflow. The input data for the application are created using the ClimGen tool as mentioned in section 2. This results in two file sets: location parameter and weather data. After parsing these files, all raw input data is collected in a data repository which is part of the application kernel called ClimVisApp. The construction of the initial information space **IM** is done in the Geometry Mapper component. After displaying the initial scene, control is passed to the user who might control any motion parameters in order to explore data of interest.

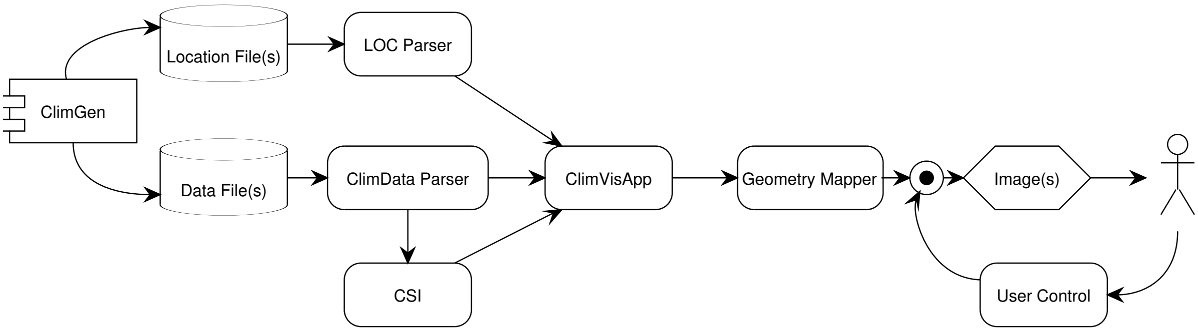


Fig. 2 . Dataflow trough the prototypical ClimVis application

The use of non-photorealistic computer graphics (NPR) as an expression capability (Strothotte and Schlechtweg, 2002) is currently being investigated. Figure 3 shows a zoomed in snapshot of applying some NPR techniques to information objects. Open questions currently being investigated include but are not limited to the suitability of NPR for the representation of temporal data characterisics as well as the expression bandwidth of multiple rendering styles employed simultaneously in a scene.

6 CONCLUSION

The presented work shows that the information mural technique is well employable for climate data visualisation. Enriching such a visualisation by motion helps to extend the set of available presentation variables and supports the user in discovering otherwise hidden data characteristics. A pragmatic approach to implementing a motion enhanced mural is shown as well as a possible extension by alternative visualisation techniques (such as NPR). This opens for further challenges such as the visual representation of existing knowledge about temporal data properties.

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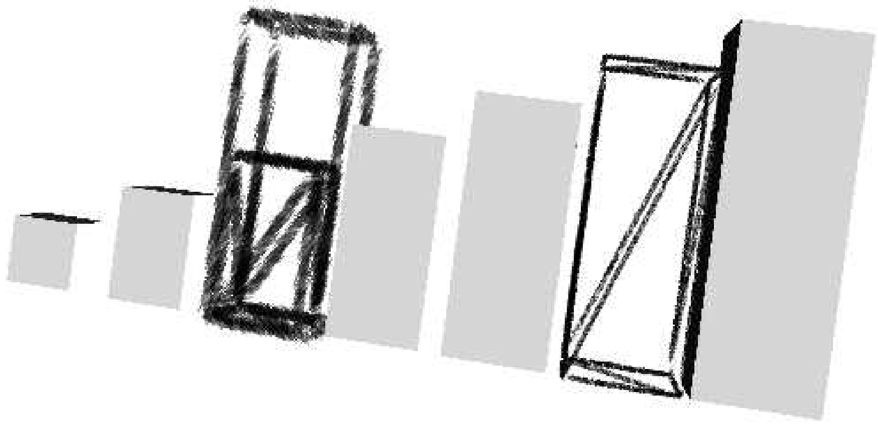

Fig. 3. Applying non-photorealistic rendering techniques to individual information objects

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