Poster: Using Non-Photorealistic Rendering Techniques for the Visualization of Uncertainty

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ABSTRACT

The whole process of information visualization - from data acquisition to the final image - includes sources of *uncertainties* (e.g., during measuring, aggregation, sampling, mapping,...) that may significantly influence the assumptions about the data and the decisions made. Although there is no universal representation of uncertainties, a somehow common approach is to use fuzzy or blurred representations of that data. In this work, we use non-photorealistic rendering (NPR) as it offers different parameterizable techniques to produce fuzzy representations – for the purpose of a more widespread uncertainty visualization. We demonstrate our approach by two exemplary NPR-techniques applied to information visualization to visualize uncertainties along with the related data.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Screen Design; H.5.0 [Information Interfaces and Presentation]: General

1 INTRODUCTION

Due to the abstractness of data in information visualization there is no natural representation for that data resulting in a great latitude of mapping data to visual attributes. Since uncertainties are a problem in strongly differing domains, the term covers a wide spectrum (e.g., missing data, reliability, accuracy, see [3]) resulting in different general approaches to visualize uncertainties (see [4]): adding glyphs, adding geometry, modifying geometry, modifying attributes, animation and sonification. For that reason, a combined visualization of data and the belonging uncertainties often requires additional explanations to distinguish data and uncertainties concerning the used attributes. Hence, MacEachren [2] proposes the introduction of an extended set of visual variables for the visualization of uncertainty. Color saturation and ”fog” can be used to visually suppress uncertain data. Furthermore, edge crispness, fill clarity and (reduced) resolution are visual clues for the uncertainty/fuzziness of data. Although there is no generally acknowledged representation of uncertainty, disguising clear shapes within the visual representation is somehow natural and intuitive to depict the missing certainty concerning these shapes (e.g., in [6]...). Moreover, this approach is a subtle enhancement and the visual representation is only slightly changed. A well-known example for that approach in information visualization is *Semantic Depth of Field* [1]. It has been designed for focus and context visualizations but is also used to visualize uncertainties. However, the amount of blurring is the only variable to depict an uncertainty value upon.

In the field of non-photorealistic rendering (NPR), many techniques generate fuzzy images as a matter of principle and bare many facilities for manipulation and showing different visual effects. Moreover, a common aim in NPR is to mimic the human imperfectness while producing drawings. The different technique-specific effects differ from known visual variables and thus, those effects may also contribute to the extended set of visual variables as discussed in [2].

Since there is no widespread approach to produce fuzzy uncertainty representations in information visualization allowing for a more complex parameterization, we examined techniques from NPR. To the best of our knowledge, NPR-techniques have not been used for uncertainty visualization in information visualization. Within this work we present a first approach: We use two NPR-techniques (water color simulation and simplified strokes) that bare scalable effects for depicting different levels and kinds of uncertainty and that generate fuzzy representations. In the following Section 2 we describe the used NPR-techniques in more detail and demonstrate the complexity of parameterization to gain different effects. Their application is demonstrated briefly.

2 TWO EXEMPLARY NPR-TECHNIQUES

There are many ways to visualize data by mapping it to visual attributes like shape, color, positions, lengths,... Two primitives that are often used are areal shapes (like map regions,...) and line primitives (e.g., in graph visualizations, parallel coordinates,...). So we examined NPR-techniques that modify the visual appearance of those primitives to visualize data and the related uncertainties simultaneously. In doing so, the most difficult part is to find sufficient parameter combinations due to complex parameterization facilities.

Watercolor Simulation Watercolor simulation by cellular automatons (see [5]) offers global as well as local parameters to realize varying watercolor effects. Overall, there are eleven parameters baring a high degree of freedom for data encoding – necessary for different uncertainties and their belonging value ranges. The eight global parameters (e.g., number of calculation loops, weight of color pigments) are precise values set equally in all cells. They have a big impact regarding the simulation output. For instance, if pigment weights for cyan, magenta and yellow are set differently, the color fractions blur differently in the whole simulation.

The three local parameters (initial wetness, material capacity and absorption ability) can be set differently per cell/pixel. Since setting the local parameters of neighboring cells in a region with equal values would generate a homogeneous simulation result, those values are chosen randomly from a given but modifiable value range instead. Thus, the irregularity known from real watercolor images is generated. For instance, *capacity* influences how many pigments are ”kept” per cell and thus influences the saturation of an image region. This way, random values introduce a visible saturation noise corresponding to the real world paper grain.

According to the simulation process in [5], the different parameters influence each other in a tight manner. That means, a simultaneous manipulation of two or more parameters may compensate the effects that would be visible if the parameters were changed separately. Different parameter combinations may generate the same simulation output. Hence, using the proposed watercolor simulation for visualization purposes means to find a reduced set of parameters with distinguishable visual effects.

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As it is the aim of our work to visualize uncertainties (Section 1), we looked for parameters influencing the fuzzyness of map regions. For this reason, we chose to modify the local parameters *capacity* and *absorbability* and kept the remaining parameters constant. *Absorbability* influences the amount of blurring whereas *capacity* is able to produce the mentioned grain. Figure 1 depicts different combinations of both parameters.

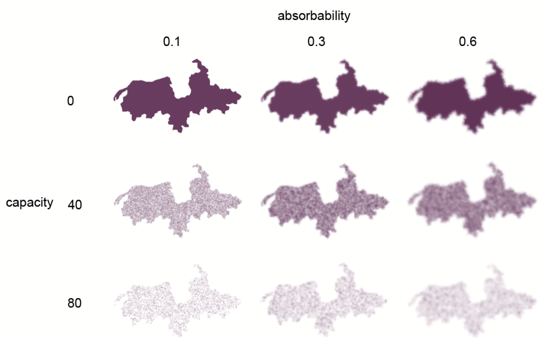

Figure 1: Producing grainy and blurry effects by different parameters.

In the following example, we applied the described technique to a one year health data set of northern Germany containing missing data and aggregation uncertainties. We used a color coded map to visualize the amount of influenza cases of one day. For each of the 18 municipalities the data was acquired by averaging the underlying zip code region data – regardless of missing data or a high variance in data. Since both values are important for a correct interpretation of the visualized data, we used the proposed watercolor simulation to modify the map regions appearance accordingly. We mapped the missing data of a municipality onto the *absorbability* of a region. Hence, missing data values result in a blurring (and "shrinking") of the corresponding region. The standard deviation of a region is mapped onto the amount of a visible grain within the region using the *capacity* parameter. With that approach, the data value itself and the belonging uncertainties are visually distinguishable, whereby the uncertainties produce fuzzyness.

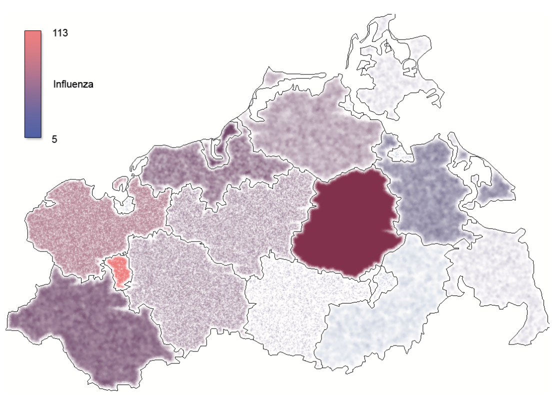

Figure 2: Using watercolor simulation to visualize uncertainties.

Simplified Strokes Strokes are a powerful approach to mimic different line-creating tools (pencil, brush,. . .) and thus to generate differently styled "lines". At the same time, they also provide a rich set of parameters onto wich uncertainties could be mapped (e.g., width, end-caps, texture,. . .). Generally, the stroke effects become visible only if the stroke is rendered with a width higher than one pixel. To avoid visual clutter from overlapping broad lines within a visualization, many parameters are not usable for visualization purposes in principle. Hence, we chose a more naïve approach that is normally applied to draw irregular wiggly lines within hatchings (see [7]). The approach uses control points at nearly equally distributed positions alongside the original line. Their distance to the straight line is randomly chosen from a given range. Those control points finally define a Bézier curve – the wiggly line. Its parameter *frequency* is bound by the line length whereas the *maximum amplitude* is freely adjustable. Another parameter is the *dashing pattern*.

Since the *frequency*'s effect is not visible without any *amplitude*, we modify only the *maximum amplitude* and the *dashing pattern* parameters. In Figure 3 we applied our simplified strokes to a parallel coordinates visualization of the same data set mentioned above. In that visualization the data of the different diseases was aggregated for each month by averaging the corresponding days. The visualization contains $\approx$ 2000 partially overlapping polylines representing the zip code region's data at different months. In that visualization a wiggly line would not be visible at all and would even introduce more clutter. So we propose to use the simplified strokes as an *uncertainty lens*: If a polyline of interest is highlighted, the associated uncertainties are visualized by showing the wiggly line.

To visualize the uncertainties (missing data and standard deviation) belonging to the axes, each axis-connecting line has been divided at the middle, whereas the left part belongs to the left axis and vice versa. The amount of missing data is mapped onto the size of gaps within the *dashing pattern* whereas a high standard deviation results in a large *amplitude*. Thus, different uncertainties can be extracted at a first glance. Although similar and more deterministic images can be generated with classical mapping strategies, the wiggly line character points to the visualization of uncertainties (see Section 1). Current investigations aim at more complex stroke effects that can be used if overlapping lines are likely to be avoided e.g., in graph visualizations.

The presented work describes an exemplary combination of fuzzy NPR-techniques and information visualization to depict uncertainties. The facility of producing fuzzy representations is bound by visualization needs rather than by aesthetical issues. Although the results are worth a discussion, they encourage further research in using extended visual variables from NPR for visualization.

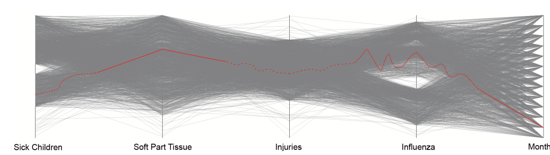

Figure 3: Using dashed simplified strokes to visualize uncertainties.

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