Towards visually assisted navigation of large parameter spaces

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Abstract

In this extended abstract we discuss a quantitative approach for the visually assisted parameter space navigation of procedural textures as example for the exploration of large parameter spaces of visual representations. With our recently published example-based parameter retrieval technique [3], we demonstrate a compelling compromise between quality and performance by combining data-driven and procedural principles.

Keywords: Procedural textures, parameter space navigation.

1 Introduction

In the age of big data, visual representations are essential for handling, navigating and understanding large and complex data sets. Many of these representations are parameterized in order to provide extensive interaction options. However, the exploration of the parameter spaces are often tedious and time consuming for a human user. One might have to deal with a large number of parameters which in many cases behave non-intuitively. To find efficient control mechanisms for such parametrized visual computing techniques is an on-going research challenge. One possible approach is to offer the user visual assistance for the navigation of the parameter space. In this abstract, we summarize our recently published article [3] about example-based parameter retrieval for procedural textures, exploiting a quantitative solution layout. We see our work as first step towards an overall applicable parameter space navigation system for any visual representation.

2 Related Work on Visual Parameter Space Exploration

There are several techniques that will make the exploration of a large parameter space of a visual representation, such as a procedural texture, more manageable. The following summarized methods contribute independently towards an efficient navigation.

Firstly, critical for handling parameters of visualizations is the modulation of the parameters and their ranges. In practice, all parameters should be based on a perceptually linear scaling as introduced by Lindow et al. [6]. Based on measuring the variation of the visual result of parameter changes with a perceptual image metric, a non-linear function maps a new parameter to the original parameter. In terms of a visual representation of parameter ranges, Lasram et al. [5] improved the usability of a system by summarizing in a preview-image all possible appearances produced by a given representation. The modification of the search space itself also offers powerful interaction improvements. This can be based on the reduction of a search spaces dimensionality by separating features and processing specific characteristics independently.

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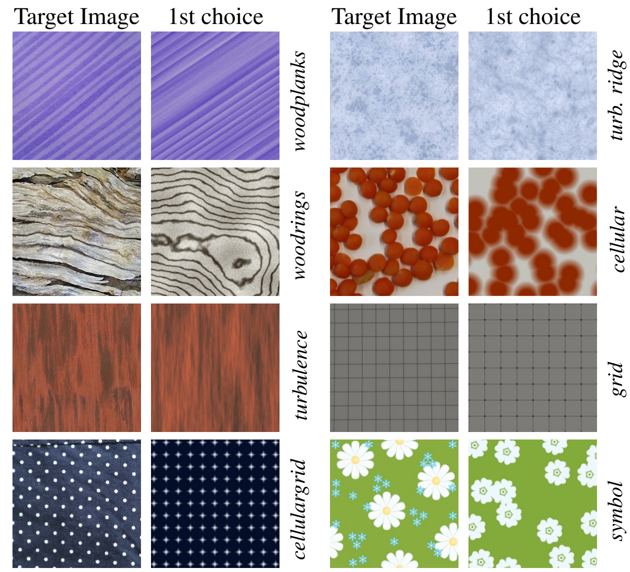

Figure 1: Results showing the best texture matches within their class.

For instance, for parameters of a procedural texture, the processing of colors and rotation samples are decoupled from the exploration of the structural feature space. Next to the separation of features, their abstraction can also lead to a more intuitive exploration. Bhagavatula et al. [1] map the parameters of a volume rendering application to a smaller set of the high-level features: sketchiness, realism, contrast, detail, smoothness and flatness. This technique is applicable for any visual representation for whose characteristics these the high-level parameters can be associated with.

If there is a certain visual navigation mark at hand, such as a reference image, an example-based navigation maximizes efficiency. Such a technique either transfers model specific parameters from the reference to the representation or minimizes an image distance metric. For the latter, the selection of the closest match of a parameter combination to a target input is either computed by non-linear optimization as implemented by Bourque and Dudek [2] and Gilet and Dischler [4] or by a discrete sampling of the search space, as it is described in more detail in the following Section 3.

3 Parameter Retrieval for Procedural Textures

When investigating visually assisted navigation of large parameter spaces, procedural textures constitute a challenging and useful first research task. Procedural textures represent a variety of natural phenomena algorithmically in a compact fashion. But for many procedural texture programs though, high parameter counts oppose intuitive control and parameters might behave non-linearly with overlapping effects. For an artist it takes enormous time and effort to just come close to a certain design goal before the actual creative work of finalizing a look even started. For our first research step, we want to offer an artist an automatically retrieved parameter set, which matches a procedural model to a target image, guiding

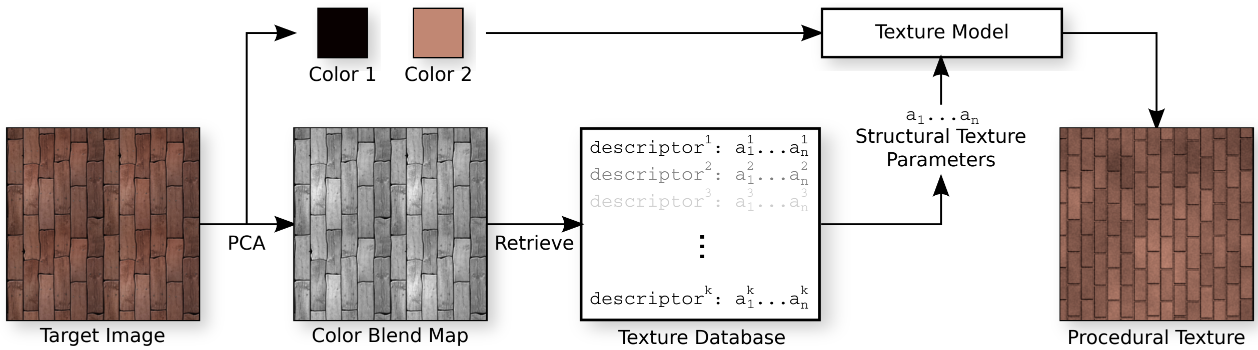

Figure 2: Parameter retrieval pipeline: Principal Component Analysis reveals the constituent colors of a two-tone input image and a corresponding blend map. By identifying the most similar image from a database of images generated by a procedural texture model according to a texture descriptor, we can retrieve structural parameters. Together with the colors, they produce an image closely matching the input (image source: [3]).

an artist the largest part of the way through the models parameter space interactively. We base our pipeline on the concept of combining a procedural- with a data-driven modeling approach, as outlined in Figure 2.

Our current solution [3] for parameter space navigation considers two-tone texture models with no further restrictions on their design. The two color tones are represented in RGB and a convex interpolation blends between them with a structure function controlled by several parameters. The two-tone assumption implies the distribution of the color values of all pixels on a straight line in the RGB cube. We compute the lines location by applying a principal component analysis of all pixel values. The final two color tones for matching a texture model are then simply those of the extremal pixel values on the line and the corresponding blend map is given by an affine transformation. By applying the PCA we therefore process the color information directly and independently, continuing with the parameter space navigation of the structures only, having reduced the search space by several dimensions in advance.

For navigating to the parameter set which generates the most similar structural map in comparison to a target, we compute a dissimilarity measure according to a texture descriptor. Such a descriptor incorporates specific features of the texture that balance the textures abstraction and the maintenance of its characteristics that are relevant for a human observer, therefore balancing performance and quality. By applying concepts of human perception, we incorporate global statistics of an image as well as the images frequencies and their distributions. For the final descriptor we calculate the mean and standard deviation for the global statistics and identify local structural orientations by employing the responses of a Gabor filter bank. All descriptor elements are also weighted proportionally to the distribution of contrast sensitivities of humans for different frequencies and the global feature elements as sum of the local weights. The dissimilarity measure is then computed as distance between two descriptor vectors. By interpreting the ultimate parameter navigation problem as an image retrieval task we utilize a pre-computed database of texture descriptor and parameter set pairs for a texture model. The most similar structural map in the database is the one with the minimal distance to the input, which we access at run-time interactively with a sequential search in the pre-computed database. Based on the retrieved parameter set, the artist has then the option to finalize the look individually.

Figure 1 shows that retrieval results, without manual adjustments, match the structures of the target pictures already closely. We are not only able to navigate through the parameter space of a specific texture model but also to identify the best fitting texture model within a pre-selected class of models. In choosing a discrete, quantified technique, we believe to have found a compelling alternative to the commonly employed continuous methods. Non-linear optimization and interpolation methods as implemented by Bourque and Dudek [2] and Gilet and Dischler [4], might precisely find a local optimum in the parameter space, however, the numerical evaluation of the gradient of a cost function alone, involving several computations of an image difference function, may take more time than our entire retrieval step [3].

4 Open Challenges

In order to transfer the presented retrieval method to a larger visual space, the most prominent challenge remains the dimensionality of the search space and finding the best possible compromise between quality, for example in terms of the feature abstraction, and the interaction performance of the exploration. Also it should be investigated how all summarized techniques can benefit from each other and how to integrate them into one application. Lastly, we are aiming towards applying our presented visually assisted parameter space navigation technique to other visual representations.

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