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Perceptual distribution of anisotropic 2D strokes

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Résumé

From fibers spanning tissues at cellular scales to brick walls or scaffolding at our scale, 2D or 3D distributions of elongated objects are frequent in both nature and man-made environments. These distributions are usually anisotropic and the specific range and variance of object orientations, convey their unique visual structures.
This work tackles the sketch-based creation of 2D and 3D distributions from only a few user strokes in 2D. While example-based synthesis was extensively studied in the last few years, existing methods mostly focused on point distributions. They achieved statistical accuracy for noise models, studied points distributions using pair correlation functions or probability density functions, or simplified contact shapes into their centroid to study element connectivity, using a neighborhood metric and energy optimization. Only few of them tackled distributions of anisotropic shapes, using multiple point samples or proxy geometries to achieve analysis and synthesis of structured distributions, with some specific main orientations. To our best knowledge, none of them was able to capture the space and orientation inter-dependencies and variations within a distribution of bounded and unbounded elongated shapes.

Our method tackles real-time, analysis and synthesis of structured, anisotropic distributions of elongated shapes. The real-time performance of our method enables us to apply it to a mere 2D sketch, interactively drawn by the user, enabling them to seamlessly explore a larger spacial extent around their sketch as well as to navigate within the resulting 2D or 3D distribution. Real-time analysis and synthesis requires some efficient representation of elongated elements. Our insight is to introduce a representation based on coarse-to-fine supporting structures. The latter allow to encode element distributions in a compact manner and leads to a particularly simple and efficient analysis of the distribution of orientations. Supporting structures can be seen as principal directions, or line skeletons on which the strokes are wrapped. The notion of supporting structures for elements distributions introduced in this work is designed for fast anisotropy analysis and efficient domain extension in both 2D or 3D spaces, leading to the quick immersion tool that we use for illustration.

From a single analysis method, we propose two synthesis solutions depending on the desired dimension of the output domain. Indeed, while they should both maintain the input anisotropic distribution when the view-point does not change, these two solutions need to address different challenges, namely avoiding unwanted element collisions when extending the user sketch to a larger, planar texture, versus inferring depth when it is an input for volumetric texturing. Our solution is based on the following contributions:

- *a fine-to-coarse analysis method enabling to cluster user strokes depending on their proximity both in position and principal direction;*
- *a coarse-to-fine perceptually-based synthesis method for planar texturing;*
- *a perceptual solution to immerse users into a 3D distribution of elements, created from their 2D sketch, and in which they can navigate;*

We are currently preparing a user study to validate our method, and verify our hypotheses on human perception. The 2D synthesis of bounded elements will also be compared to state of the art methods in example-based synthesis.

In future work, our volumetric synthesis method could be combined with sketch-based modeling systems to directly create and distribute 3D shapes. In the long term, these shapes could potentially be put into motion and follow a flow constructed from sketched strokes and thus enabling the creation of animated sketches.