5
Conclusion

Random walk filter. This dissertation first proposes a vector field denoising technique based on random walks, whose main characteristic is the preservation of coherent discontinuities while removing noise under the vanishing-mean *per continuous* region model. Initially, the vectors are updated through weighted averaging of the neighboring vectors, with the weights being determined by probabilities of random walk steps between each face and its neighbors. Theses probabilities in turn depend on the differences in a feature such as vector magnitude and direction or a combination of the two. To do so, a suitable similarity function with weighted additive distance for the point/vector pair was proposed.

We then show several applications of the method to PIV images, SPH and granular flows simulation data. These experiments presented a visual comparison between our approach and gaussian filtering. In the majority of the results, the random walk filter method outperforms the gaussian filtering by preserving the field's main features. In the PIV data set, the random walk filter was unable to deal with the fact that the information present was not at a constant scale compared to the noise. To address this problem we developed the topology-aware denoising methodology in Chapter 4.

Topology-aware denoising. To circumvent the problem mentioned above, we proposed a methodology to denoise vector fields taking advantage of the user knowledge of the data. With the singularity detection detailed in Chapter 2, our interface displays topological changes throughout the scale space generated by successive filters to give the user global information of the field. As a consequence, the user can easily adapt the local filtering scale in order to preserve important information while aggressively removing noise. The result is generated by is to smoothly interpolating the field. The method supports different techniques for singularity detection, scale function interpolation, and scale-space generation.

Discussion and future work

Random walk filter. While our algorithm is effective for feature-preserving vector field denoising, it is still has certain problems that other filters also possess. The tuning of parameters is a weak point of the random walk filter, where it can have from 2 to 4 parameters to adjust when filtering. Even though suggestions were made in this dissertation for each parameter, this is clearly data-dependent. One example is that we have to interactively determine the number iterations. Using a small number of iterations fails to fully remove the noise the vector field, while too many causes too much smoothing. Future work is needed to find an automatic method of determining the optimal number of iterations.

Also when trying to preserve a certain feature such as a discontinuity another problem arises; the random walk filter might destroy or displace another feature such as a singularity. We address a part of this problem with the topology-aware methodology by giving the user direct control.

Topology-aware denoising. The methodology proposed has a few shortcomings with the topology detections. First of all the current detection of singularities is only done locally and the reconstruction is done on a local base. Therefore, it does not handle non-local singularities such as a closed orbit. Also the methodology does not include the tracking of the singularities and only displays topological changes, which would have improve the robustness of the method and the visualization for the user.

Unlike the random walk filter, the methodology only works on a structured grid, while many recent vector field datasets are unstructured to better take into account errors in the measure-point localization. In the future we plan on implementing the techniques for singularity detection and classification to unstructured vector fields with a interpolation such as the SPH interpolation (22).

Finally, as mentioned above, large-scale denoising may displace the location of the singularity and it is very problematic since in this case our interface displays two very close topological changes, which are not relevant. In the future, a study of the behavior of critical points in vector field, at first, under gaussian filtering would be imperative. This will allow us to design filters to minimize the dislocation of the singularities.