Research Statement

Zizhen Chen

zizhenc@smu.edu http://lyle.smu.edu/~zizhenc

My general research interests lie in Visualized Algorithm Engineering. I study algorithms in computer science department and visual arts in the division of art department at Southern Methodist University (SMU). With combining the two areas, my particular interest focused on algorithms for partitioning in Graph Theory. Not only algorithm visualization and algorithm theory I concern, but also practical efficient applications of algorithms in software engineering I love to build. My teaching and learning experience in the two distinct schools at SMU will elevate my algorithm visualization work to another level.

Algorithms and visualization are two distinct research fields within computer science that can be complementary in many ways. Algorithms are a fascinating use case for visualization. Visualization can support algorithm development, especially when working with actual implementations and refinements of theoretic algorithms. Visualization of performance helps analyzing the improvement of new algorithms. Visualizing and then analyzing the results of an algorithm provides clues to establish new theories and algorithms. Traditional computer science researchers focus on algorithms, data/machine learning and/or software engineering without creating new graphic coding. They normally rely on existing packages in python or javascript to create standard data visualization. My experience in coding visual arts released the limitation. Besides static 2D visualizations, sometimes I prefer 3D animated visualizations for exploring the result space to extract insightful directions.

Current Research and Thesis work

My current research covers several distinct topic areas including wireless sensor networks, operations research, data clustering, and visualization of arithmetic computation. During the pursuit of my Ph.D. degree at SMU, I did three projects: 1). Wireless sensor networks (WSN), 2). Hierarchical Maximum Concurrent Flow Problem (HMCFP), 3). Graphical Representation of Natural Numbers. Visualization plays a key role in all of them which leveraged and strengthened integrated further research.

In the WSN project, I implemented the existing algorithms via a coded graphic animated application and we discovered new algorithms for backbone determination. Here by backbone we mean a large bipartite subgraph. All the algorithms we created and used in this project are linear time in efficiency. Then an implementation according to best practice in software engineering (respecting operating system and hardware capabilities) confirmed the performance of the program created. Specifically, it was possible to run benchmarks on a simulated network of one million wireless sensors. This project also led me into research activity on the foundations of graph partitioning. I did the whole project individually with my supervisor.

The second HMCFP project used the existing application (“AMPL”) which is popular in operations research. We applied it to calculate maximum concurrent flows iteratively determining hierarchical levels in social networks. From the flow data visualizations, we found new structure (we termed a “Backbone”) which is a kind of distance measurement of network data, also created new algorithm for calculating these backbone structures. We found it also applicable in data clustering area especially for social networks. This project also gave me experience doing research with people from other area (here an operations research expert).

In the third project, from the tree structure of Matula Numbers, we found a new relation between natural numbers and graphic representation. The foundation rests on the relation between prime numbers and integers. In this project, I also supervised another Master’s student who joined the research project.

We emphasized that each project used visualization in its own way. Although my research covers different areas, all of them could be categorized as graph partitioning problems. Thus my thesis focuses on the use of visualization in graph partitioning problems. Besides, this research also furthered my research ability in numerous ways.

Future work

I am extremely thrilled by the potential of my research area. I plan to extend my current work in various directions. First, all three projects have their own original ideas and algorithms which are worthy of practical application. Second, I love implementation, my experience in graphic coding of visual arts also helps my capability to create more artistic animated visualization. I have found unnecessary limitations in existing visualization libraries and I am willing to build my own data/algorithm visualization library. A synergy formed by the graphic input/output and the processing of big data would hopefully provide a new direction in computer science.