Large Scale 3D Clustering and Abstraction

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Abstract

Typically, a user can understand a clear textual description of a small amount of relational information. However, when dealing with large amounts of relational information, a vast amount of text quickly becomes cumbersome. Existing methods and techniques, for the visualization of relational information, tend to effectively deal with only relatively small data sets. Here we present methods to generate a hierarchical compound graph for the large 3D visualisation of relational information. These large compound graphs can effectively be drawn using a modified force-directed algorithm with horizon drawings.

Keywords: Clustering, Visualisation, Graph Drawing

1 Introduction

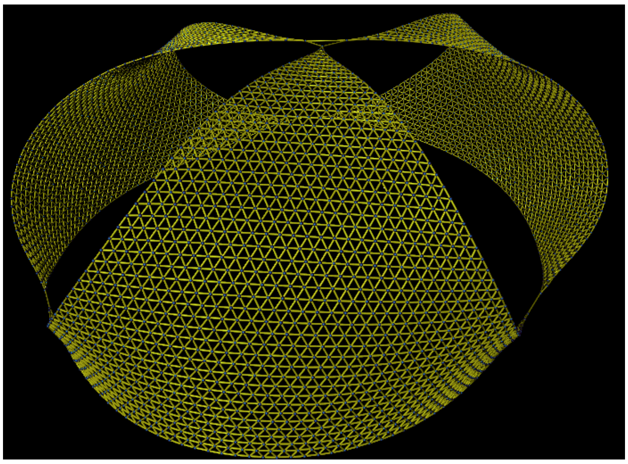

Figure 1: Layout of 3825 node graph produced by 3DFADEx.

Graphs are often used to model relational information, see (Di Battista 1999). A graph drawing method assigns a location for every node and a route for every edge, which can then be rendered or drawn to produce a graph drawing. Classical approaches to three dimensional graph drawing have typically dealt with relatively small graphs see for example (Di Battista 1999). Here we address the layout and *abstract representation* of large undirected graphs in three dimensions. This paper introduces the 3DFADEx algorithm, which is part of the FADE paradigm for approximate graph representation and horizon viewing, see (Quigley 2000) for more details. Generally, FADE methods generate a recursive geometric decomposition of space, which induces a clustering of the nodes of the graph. The clusters produced by this graph clustering method have no inherent interrelationships (edges), but instead can have "implied edges".

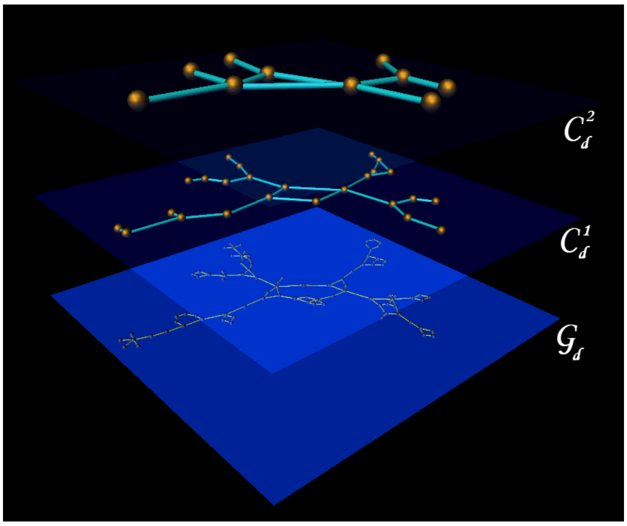

Figure 2: Representation of a Hierarchical Compound Graph

A hierarchical compound graph is one that consists of an underlying graph *G*, a rooted tree *T* and an implied edge set *I*. Suppose that (*G*,*T*,*I*) forms a hierarchical compound graph and C_1, C_2, … , C_k are nodes in *T* such that every leaf of *T* is a descendant of exactly one Ci. The *horizon* defined by C_1, C_k, …, C_k is a graph whose node set is (C_1, C_2, …, C_k) with implied edges between the clusters. If higher-level clusters are included in the horizon, then the horizon is a compacted version of the underlying graph, a so called a *précis*. This model differs from the clustered graph model of (Feng 1997) with regard to implied edges, it is quite close to the "compound graph model" of (Misue and Sugiyama 1991). This extended graph model, with an implied edge set, allows a variety of horizons to be extracted from the hierarchical compound graph. A 3D horizon is a three dimensional projection of a multilevel précis extracted from a compound graph, where the leaves of the cluster tree are the nodes of the graph.

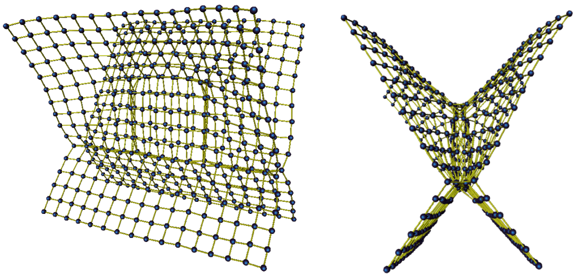

Figure 3: Two 3D projections of a graph representation of a square dielectric problem.

2 3DFADEx

The layouts of the FADE paradigm are based on the computing a force directed layout. Using a space decomposition tree, such as an oct-tree in three dimensions, the non-edge force on an individual node from other nodes close by is, on average, evaluated by direct node-to-node interaction, whereas the force due to more distant nodes is included as a node-to-cluster contribution. This method for approximating the forces reduces the complexity of the layout from $O(n^2)$ to $O(n \, log \, n)$ in practice, see (Quigley 2000) for more details.

Since it is computational expensive to render large amount of three-dimensional data the FADE paradigm introduces a new technique, called horizon viewing, for the multilevel visualization of relational information using a compound graph, built from an underlying graph.

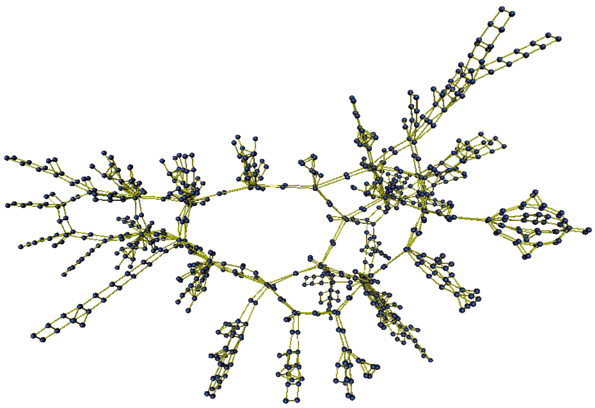

Figure5: 3D drawing of small-signal model from a power station application.

The time required to render in real-time the full graph drawing in Figure 1, is prohibitive for most applications. Instead an approximate drawing, showing a horizon extracted from the compound graph clearly reduces the visual complexity and computational effort in creating the visualisation.

3 Horizon Viewing

The drawing of the 3825 graph shown in Figure 1, can be represented on a much higher level of abstraction using a horizon drawing extracted from the compound graph, that is generated from a recursive hierarchical space decomposition of the nodes of the graph. The drawing shown in Figure 6 can easily be rendered in real-time and it stills displays the overall structure of the underlying graph albeit as a very approximate level. Finally, this approach differs from the *focus+context* exploration approach taken in the Hyperbolic Browser, see (Lamping 1995) since we are looking to visualise the entire graph on a more abstract level rather than simply explore it.

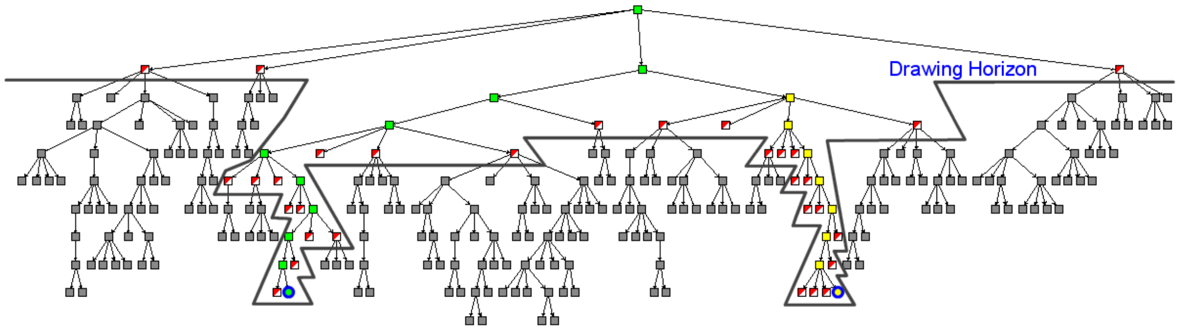

Figure 4: Set of Horizon nodes extracted from the compound graph.

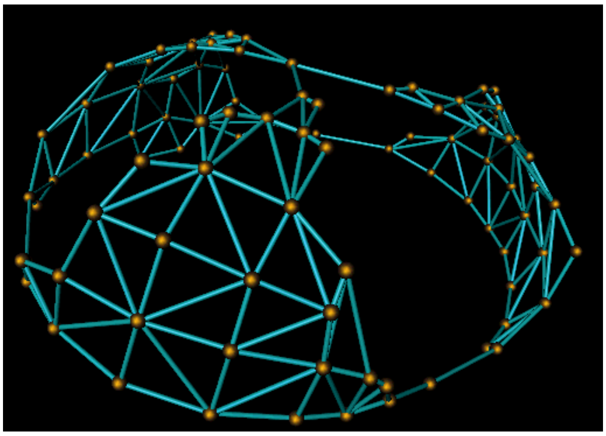

Figure 6: Horizon view with 99.97% reduction on the full graph shown in Figure 1.

4 References

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