Visualization of Large Graph in Immersive Environments

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Abstract – Network and graph visualizations pose extreme challenges due to the density and interconnectedness of data. Many tools attempt to solve this through intelligent layout and interactivity with limited success. While applying the principles of network/graph layout and interactivity with an immersive environment (AR – Augmented Reality or VR – Virtual reality) we can immerse end users in a much larger set of data while interactively presenting valuable insights.

Keywords – Augmented Reality, Graphs, Networks, Virtual Reality, Visualizations

I. INTRODUCTION

Graph and network visualizations due to limited visualization space and the density of nodes and edges can cause plots to appear chaotic. Overlaying additional edge and node properties such as weight utilizing colors, weight and line thickness often add to the complexity of the visualization.

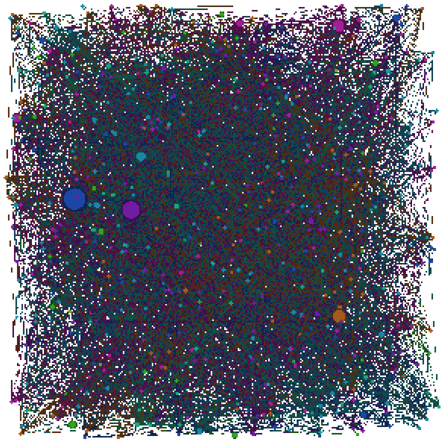

Figure 1-Arbitrary Graph Layout

Applying a force directed graph algorithm to graph can intelligently optimize graph layout allowing pleasing results with little to no oversight by users [1]. There are many advantages provided including flexibility, intuitive layout, simplicity, interactivity with the negatives of higher running time and poor local minima [2] It can provide interactivity with the graph as shown in the figure below.

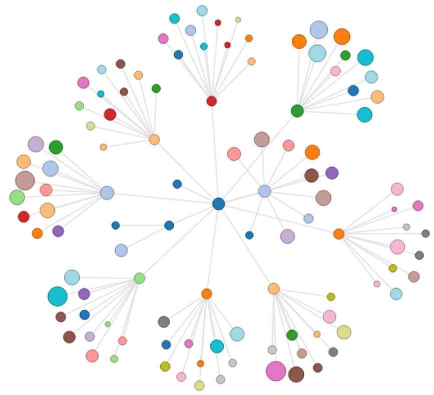

Figure 2-Force Directed Graph [3]

Further enhancements to graph layout have occurred as advancements to 3D software and hardware have become more mainstream. This has enabled even more graph properties to be displayed.

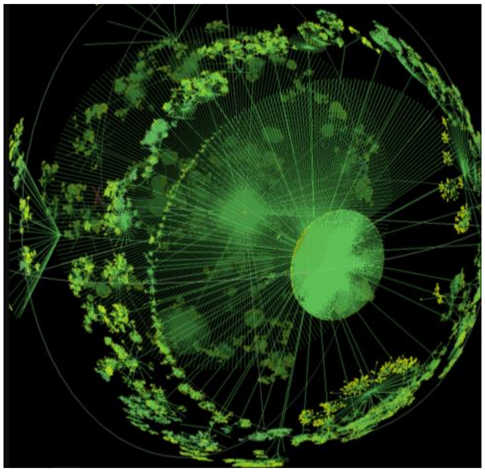

Figure 3-3D Graph Layout

The penultimate layout appears to be rendering graphs into an immersive environment, leveraging all the interactivity of the previous layout while providing a nearly infinite canvas and numerous intuitive methods of interactivity, touch, gaze, and voice.

II. RELATED WORKS

- **AR/VR Hardware –** Microsoft is currently leading the research charge in Augmented Reality hardware providing a relatively inexpensive commercial prototype Hololens and SDK allowing companies and universities to advance research in AR [4]. As of the time of this writing Microsoft is currently working on 3rd generation hardware which will likely provide greater field of vision, better processing, and better pricing [5]. Additionally, the promise of AR innovation can be seen as Magic Leap has raised nearly $1.5Billion USD [6].
  Consumer VR has become relatively mainstream primarily for gaming as HTC, Oculus(Facebook) and Sony(PlayStation) have all released 1st Generation hardware focused on enthusiasts [7].
- **AR/VR Software –** Looker a BI platform has taken up the lead in interactive immersive 3D Visualizations providing an API to integrate with both the Oculus Rift and HTC Vive [8].
- **AR/VR Research** – AR/VR research at universities has been applied to a variety of problems Manufacturing, architecture, surgical procedures, education, auto safety, field workers, art, archeological exploration, and geospatial data [9][10][11][12][13][14][15][16][17]. There have been significant research into Visualizations to provide better insights into the bigger data sets that are provided today [18][19].

III. DESIGN OVERVIEW

The primary goal of the design will be to build a modular plug in library that can handle all the basic functionality needed to communicate with external data source, provide externally logging, store and analyze graphs in memory render in a spatial environment, provide metadata around graphs and node and edge properties, and provide interactivity through gaze, touch and voice.

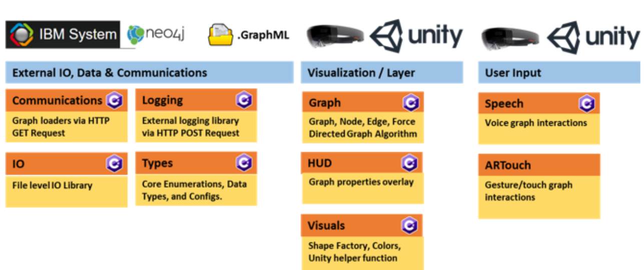

Figure 4- AR Graph Core Libraries

Graph Loading Mechanisms – As a preliminary loading mechanism the engine will use a http get command to URLs where GraphML standard files are stored. This allows the application to pull and process the Graphs which are represented as XML. Further developments to leverage the REST functionality of IBM SystemG and Neo4j will be developed. Once these standard interfaces are built the library should be extended to query these graph databases to leverage the computation power of the database rather than relying on the lightweight processors which are likely to be placed in AR headsets.

External Logging – To extract, store and analyze performance and system logs the library leverages web POST requests to Postgrest which stores all the log data for future analytics.

In memory Graph Structure and Methods – The design pattern of the graph mimics a doubly linked list with each node containing a map of all incoming and outgoing edges. Edge objects contain pointers to start and edge nodes. This architecture allows for lookup by key, traversal from node to edges, as well as looping across all notes or edges globally. Additional functionality has been partially developed to allow standard ANSI SQL commands to query edges, nodes, and properties. Additionally, as graphs can have nearly infinite properties each edge or node contains a map of object type which can store all associated properties, as well as explicitly defined fields for common types e.g. Weight.

UX of Graphs – Graph nodes are represented by spheres and edges by hyperrectangles. Scales can be adjusted for weight and color can be adjusted for additional numerical field mappings which allows the graph to represent up to 6 dimensions x,y,z,t + 2. A simplistic force directed graph and random placement algoritm(s) have been developed to provide some initialization of the graph within a defined bounding box.

Efficient Graph Algorithms – See section IV for further details.

HUD of Metadata – As a user interacts with the graph the library will provide a HUD to display to the user interactive properties of the current graph and currently selected nodes or edges.

Graph Interactivity- The core library seeks to Provide as many intuitive ways to interact with the graph as possible. By iterating over a set of voice commands the user will be able to hide and show nodes and edges with specific sets of properties e.g. edges with properties above a set threshold, or densely connected nodes. This interactivity could be expanded nearly endlessly as additional commands and metrics are needed. Touch can provide a way to manipulate the graph as well as to explicitly select edges or nodes to view their properties.

IV. ALGORITHMS & DATA STRUCTURES

To Be Completed.

V. CONCLUSION

To Be Completed.

VI. ACKNOWLEDGMENTS

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VII. REFRENCES

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