



Forensics Analysis for Bone Pair Matching Using Bipartite Graphs in Commingled Remains



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DESCRIPTION

Countries are founded on certain ideals or traditions or history that tie us together. While this is true, ideals conflict and countries argue. When this happens wars break out. When two countries begin fighting often allies join the battle which create very large scale wars. World war I and II

are examples of such wars. These wars took the lives of tens of millions of people. On the battlefield often retrieving deceased bodies was the last priority on the list. This meant that bodies were often not organized when located. Bones eventually became commingled due to improper storage. When bones are recovered the job of anthropologists is to sort and identify who the bones belong to. This job is not an easy one to accomplish and can take years to complete. Being able to bury the bones of a family member can mean a lot to the family. Knowing the importance and meaning to families, sorting with accuracy and speed is essential. The Defense POW/MIA Accounting Agency (DPAA) is in charge of a number of

these sorting projects. The USS Oklahoma project is just one project where bodies are being returned to families. This project has almost 13,000 specimens that anthropologists have to sort through. A new government project called CoRA (Commingled Remains and Analytics) has started that plans to make better use of computing power to help these anthropologists sort through the many bones they have recovered.

A: USS Oklahoma



B: POW/MIA



PROBLEM DEFINITION & TERMINOLOGY

The process of sorting through commingled remains involves many steps. The picture to the side is an example of an area where anthropologists sort through war bones. With so many bones there are many different methods and tools used to help identify skeletons. One method used to piece together skeletons is pair matching. Pair matching is not perfect and can be a long process with no great way for anthropologists to view all the data. Some basic terminology for this project includes the following:

Graph = (V,E), V is set of vertices and E is set of edges between vertices.
Bipartite Graph– Graphs with two sets of vertices such that no two vertices in the same set have an edge between them.

C: CIL Mausoleum, Scholfield Barracks HI

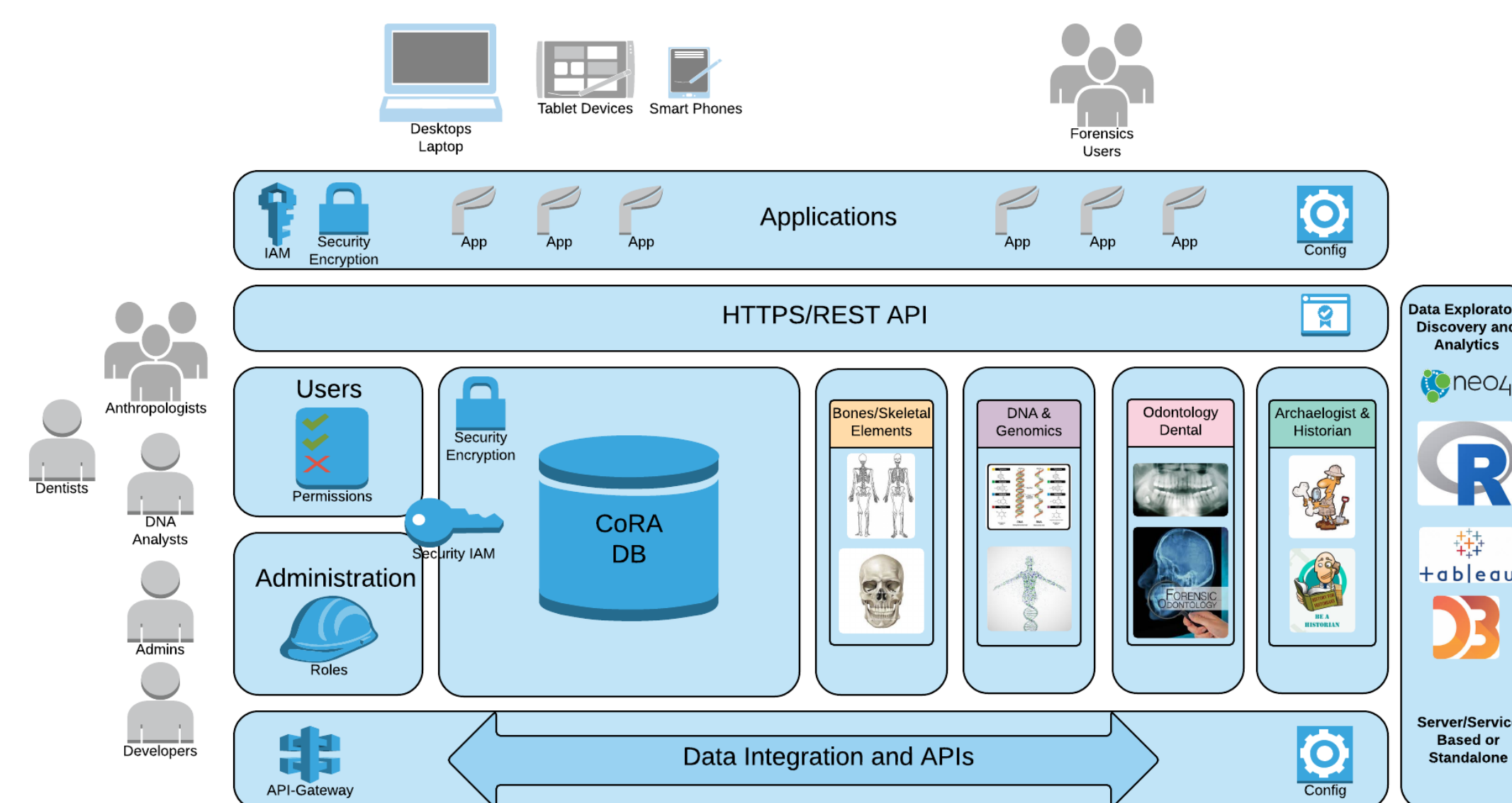


PROPOSED SOLUTION

My proposed solution is a part of the larger application of CoRA. The funding for this research came from the FUSE Grant. My proposed solution is to use graph theory to help use the data from the pair matching process to help anthropologists more efficiently create pair matches. The pair matching process involves first running all of the pairs through a process called osteometric sorting which gives the anthropologists possible pairs for a specimen based on measurements. The anthropologists must then sort through the list by process of elimination and choose one final pair that they believe is the true pair for that specimen. Pair matching is a great candidate for a graph for many reasons. The main reason being that the graph created from pair matching is a bipartite graph. CoRA is an application that's base purpose is to store information. A sample page from the CoRA application is shown below. The next part to the CoRA application

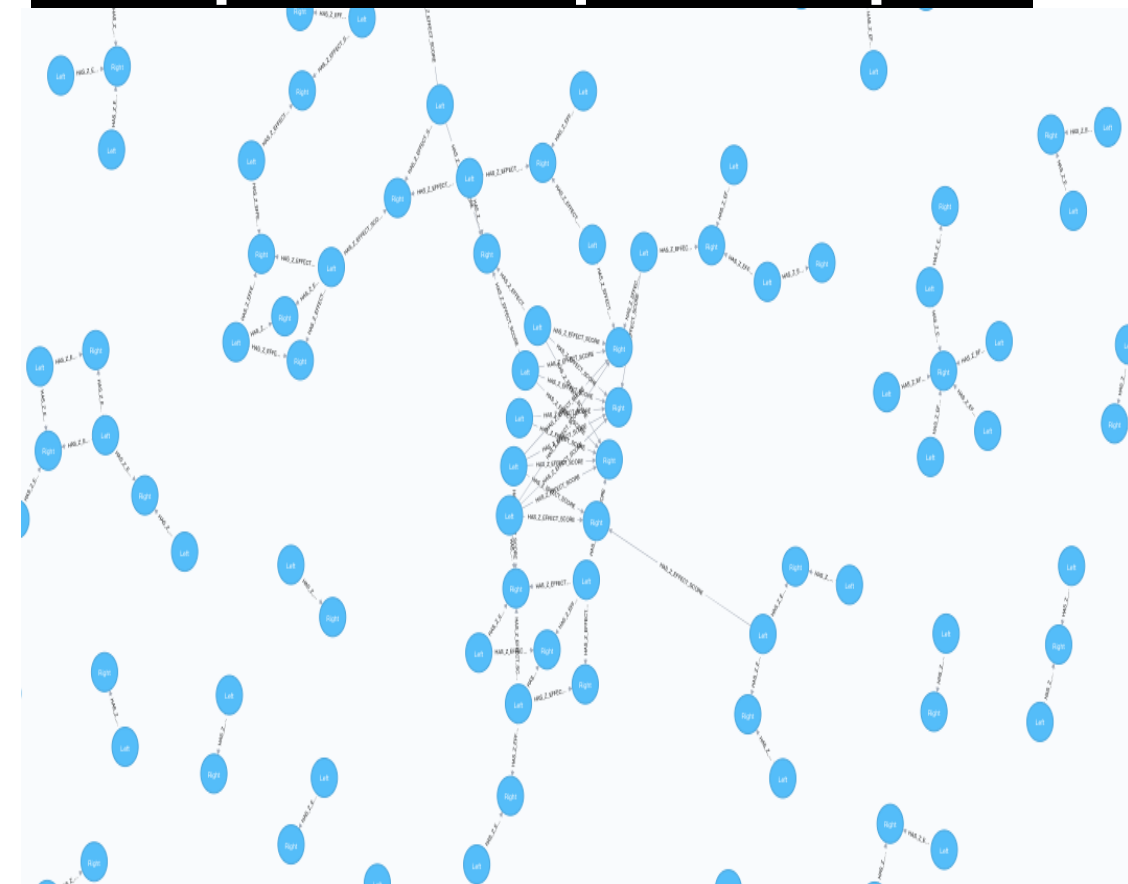
D: CoRA Architecture Diagram

CORA ECOSYSTEM MODULES DIAGRAM

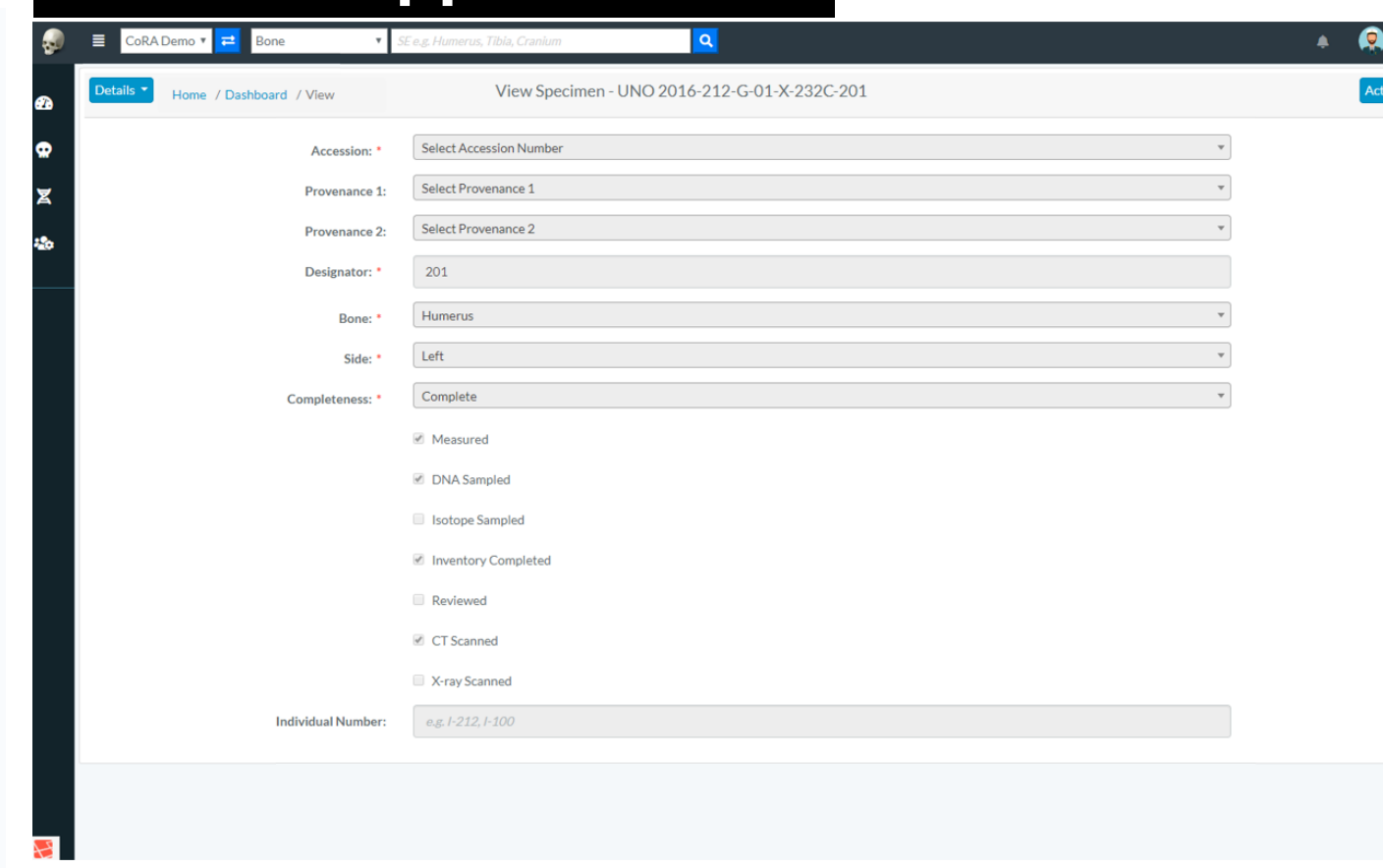


Is the analytics piece which is where my research comes into play. Graph theory was also chosen is because humans are visual learners. A graph is useful for analytics and for visually showing data to the anthropologists. As more data is used in the CoRA analytics piece, the more the pair matching graph can evolve to show even more useful information. CoRA is written using a framework called Laravel that uses php and html. My piece has been integrated with this framework and used a graphing collection called vizjs which uses D3. Below is a graph created in Neo4j of the pair matches. Also shown below is the diagram of the CoRA infrastructure which shows how the application is setup. This solution will provide anthropologists with a visual diagram of their data as well as a piece for future further analytics.

E: Bipartite Graph Example



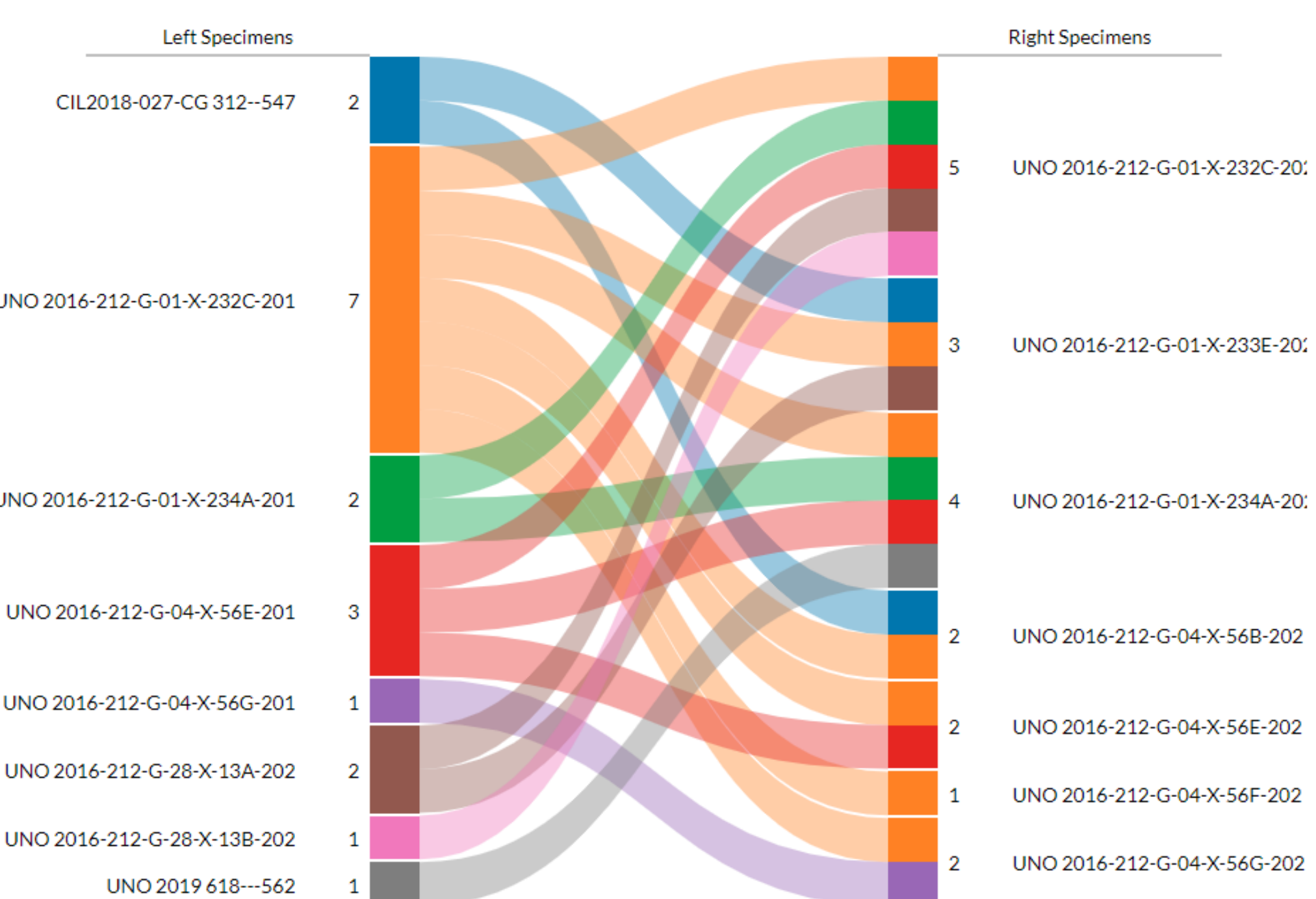
F: CoRA Application



IMPLEMENTATION AND RESULTS

The first step in the implementation was to get the components working for the graph portion of the piece. After doing some research into a few different softwares, Dr. Pawaskar pointed me towards graph.js which lead me to vizjs which is a similar package. The vizjs package integrated nicely and used components from D3 and javascript to create the graphs. The next step was to pull the data and format it to the correct format for the software. Finally, different criteria and search options were added and implemented to give the anthropologists different choices. The finished product is the bipartite graph pictured below. It shows the specimen as well as how many pairs it has. It is color coded for easier viewing. These graphs might get complex so one search criteria that was added was depth. This shows how many layers a user wants to see. If depth one is chosen, then it will only show the pairs for the element chosen. If depth two is chosen, then it will show the pairs for the element chosen and all of the pairs of the pairs and so on. This graph is currently being hosted on the live CoRA site. This graph will be a great tool for a visual component as well as a tool for analytics in the future.

G: Bipartite Graph Created From Specimens on CoRA



CONCLUSIONS

Graph theory was an excellent option to implement on the CoRA project. My research is part of a new section of CoRA for visualizations to further help anthropologists sort through the vast amounts of specimens that they have on project Oklahoma. CoRA will hopefully eventually be used on many different bone sorting projects around the world. The options surrounding CoRA are massive and it was such an honor to be able to add a new section that I know will grow and evolve as CoRA grows and evolves. I learnt many valuable new skills as well as gained a lot of experience about how to implement graphs in a project with lots of data. As the CoRA analytics grows, graph theory may not just be used as a visual component but also as algorithms to help find critical data and lessen the work that anthropologists have to do. Returning fallen soldiers to their families is important work and I am glad I got to help this project.

ACKNOWLEDGEMENTS

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