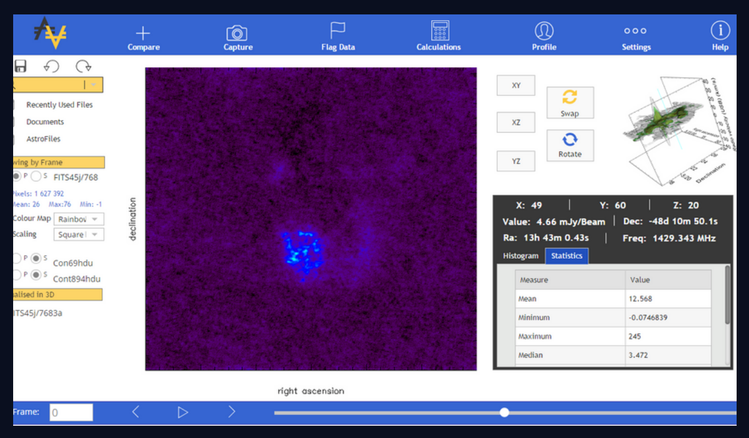
Novel Approaches To Astronomy Visualization Software

Observations from radio telescopes are stored in multi-dimensional arrays (3-dimensional data cubes or higher) which are then analysed by radio astronomers. This analysis is enabled by the use of multiple visualization tools. While these tools are incredibly powerful, they have many limitations which can be reduced. We have identified some avenues for improvement.

Usability in Astronomy Visualization Software Interfaces

Usability is one of the most important aspects of software development,. however it is often neglected in scientific software, It becomes challenging to implement due to the complexity of the subject domain. Radio astronomy is one these complex domains in which usability practices are under-utilised. Current trends indicate that astronomy visualization software interfaces are not effective.

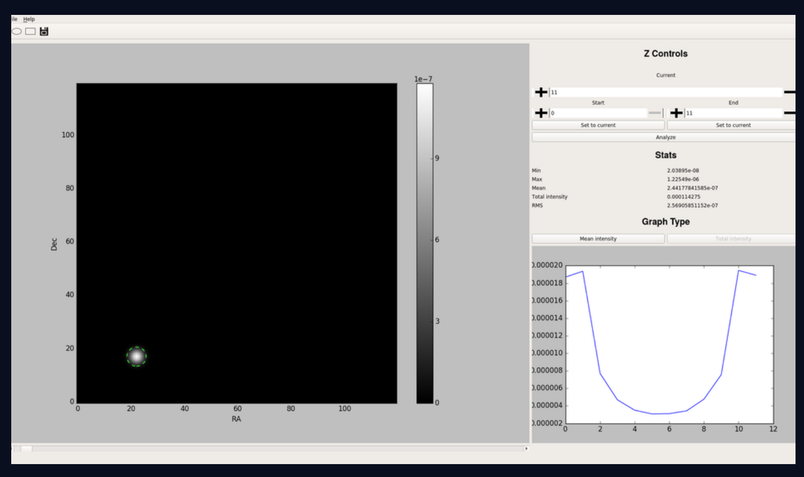
- We aim to determine whether the use of User Centred Design (UCD) principles in the design of a software interface for astronomy visualization, will produce a design that is useful, usable and effective.
- UCD methods involve intended users during the design process. We used an iterative prototyping approach. Prototypes were designed using guidelines made popular by Shneiderman and Nielsen. They were then evaluated by expert users in each iteration.
- Frequent consultation with domain experts produced a much more usable, useful and effective interface, making this approach worthwhile. The overall design improved over iterations and expert users felt the final design was an improvement on existing interfaces. Novel features such as comparisons, annotations and capturing images were highly useful additions. These findings can be applied when developing types of other scientific software as well.



Final Iteration of the Prototype Interface Design

User-defined Selection and Analysis

Currently available tools for radio astronomy, such as DS9 and Karma, have limited or non existent functionality for selecting three dimensional subvolumes of data cubes for analysis. Tools designed for other disciplines which use similarly structured data, (such as for three dimensional medical imagery) implement various selection methods which give users vital insights into the data. However, to date astronomy tools have not adopted these features.



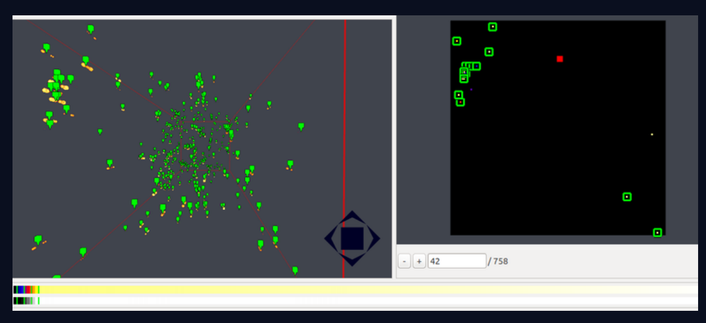
Final Prototype with Elliptical Cylinder Selection and Subvolume Analysis

- We introduce a software prototype that allows the user to rapidly define subvolumes, specifically Elliptical Cylinders, automatically calculate common statistics and export the data to a plaintext format for portability.
- Expert testing demonstrated that the features would improve existing options, with Elliptical Cylinder selection in particular would provide the biggest gains, with automated analysis and plaintext export complementing it, while still being useful in their own right.
- Implementing these features in current tools would reduce the amount of repetitive tedious work astronomers currently perform allowing them to be more productive and efficient.

Overlay of Optical Data Catalogues

Radio data cubes from radio telescope interferometers typically contain 3D information in two spatial directions and one frequency/velocity axis. Astronomers usually cross-reference objects from different datasets, by overlaying images or information from catalogues. However, it is not possible to do this in 3D using existing radio data software packages.

This is important in aiding analysis, identifying structure and finding sources in low signal-to-noise observations. The overlaying of optical data catalogues on 3D radio data cubes will help astronomers visualize information from two different wavelengths and use information about galaxies that we already know to make observations about the radio data.



Final Overlay with Optical Catalogue Loaded

- We aimed to develop the first effective method for the overlay of optical data catalogues on 3D radio data cubes. We approached this problem extending AstroVis (an existing visualization software package) to incorporate the overlay functionality.
- We tested the overlay with expert users, using simulated data to eliminate all variables which could affect the positioning differences of the overlay markers and the radio data cube galaxies.
- Results showed that the overlay is easy to use and the markers were relatively accurate. This functionality is likely to reduce the number of manual operations and help astronomers easily visualize points of interest such as galaxy clusters.

Bryce Billing - BLLBRY001@myuct.ac.za
Calvin Brizzi - BRZCAL001@myuct.ac.za
Laurisha Rampersad - RMPLAU001@myuct.ac.za
Supervisor: Michelle Kuttel - mkuttel@cs.uct.ac.za

University of Cape Town
Department of Computer Science