MAPPING THE UNIVERSE

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ABSTRACT

This paper presents an overview of research involving the mapping of large-scale structure in our Local Supercluster. A primary goal of the project is to create a three-dimensional rendering of this space for use in a television documentary as well as in an informational CD-ROM. Databases of galaxy positions and velocities have been utilized, and evaluating the completeness of these sources will be an important step toward the completion of the model. In addition, images of galaxies from various sources have been collected for use in the actual rendering. Having a complete mapping of the structure that surrounds us, important questions concerning the large-scale phenomena in the universe may be answered. These include galactic flows, the origin of structure, and the distribution of dark matter in the universe.

INTRODUCTION

The objective of this project is to create an accurate three-dimensional representation of the galaxies surrounding our own to provide a glimpse of the large scale structure of the universe. This neighborhood contains approximately 40,000 nearby galaxies within about 300 million light years. To construct the model, different databases of galaxies including names, positions, and velocities have been interpreted, but the final version incorporates information primarily from the ZCAT and another database of nearby clusters of galaxies. The rendering will feature large-scale structures including the Great Attractor, the Virgo and Coma Clusters, and the Local Group, and analyses of general trends in the motion of galaxies will aid in understanding the mass distribution of the universe.

In addition to an accurate portrayal of the spatial distribution of catalogued, nearby galaxies, the computer rendering will also feature actual images of selected objects including the Andromeda galaxy and the Magellanic Clouds. Navigating through the interactive rendering, the viewer will be able to manipulate the environment so that individual galaxies will have accurate illustrations, visible from various sides and angles. These selected galaxies will yield their actual telescopic images upon further zooming. This digital atlas will be a useful educational tool and help to create a clearer picture of the Local Supercluster.

The Local Supercluster is the only feasible candidate for a three-dimensional mapping because of its proximity and our location within it. By focusing upon the large-scale structure nearby, it is possible to create a more comprehensive survey. Conversely, analysis of a more distant region of space would be incomplete because of the limited capacity to observe fainter galaxies in remote superclusters. An accurate rendering of the Local Supercluster will result in an extensive galactic map that is more accessible than related two-dimensional slices of the universe.

METHODS

The primary difficulty in preparing the databases for rendering is the assessment of incompleteness with increasing distance. One expects that the number of galaxies should increase proportionally to the volume of space observed. However, incompleteness arises because distant objects are more difficult to observe than those nearby. This is due to the decreased intensity of luminosity observed from such objects. Consequently, there is an apparent clustering of galaxies about our own, with an increasing sparsity of galaxies at greater distances. Because imaginary galaxies cannot be simply put into the catalog to compensate for this loss of distant objects, a correction factor has been calculated to account for the missing galaxies statistically and will be used in the final three-dimensional rendering of the galaxies.

Further analysis on the databases of galaxies included the degree of obscuration caused by the galactic plane. Gas and dust contained within the disk of our own galaxy effectively block any attempt to observe galaxies in this plane via their infrared radiation. To measure the extent of this obscuration, graphs were created of the distribution of galaxies as a function of their galactic latitude. Ideally, the graph would show that the number of galaxies within any two latitudinal cross-sections of equal area is constant, and this is in fact the case for latitudes greater than 12°. However, a noticeable decrease in galaxy number is evident as the latitudes tend towards the galactic plane.

One problem encountered while working on one catalog of galaxies, the PSCz, was a malfunction which caused the satellite to miss observations in a relatively small portion of the whole sky survey. To fill this void, galaxies from another catalog, the ORS, were inserted. To accomplish this task, the coordinates of both the gap and the ORS were jointly analyzed to determine which galaxies in the ORS coincided with the empty space. Approximately 260 galaxies of the ORS within the boundaries of the gap were all added to the main catalog of galaxies. The catalog at this point contained the galactic latitudes and longitudes, magnitudes, and velocities of approximately 15,000 galaxies and was planned to be the source for the three-dimensional rendering.

Various two-dimensional slices of the universe were then observed to eliminate the fingers of god phenomenon. This effect is due to the presence of rich clusters of galaxies is simply an artifact of the plot used to observe the distribution of galaxies. They can be easily detected because they appear as an apparent line of galaxies pointing radially toward the center of the plot. To make the catalog an accurate picture of the actual distribution of nearby galaxies, the fingers of god were corrected using an algorithm. The function of the algorithm is to effectively center the line of galaxies forming the finger of god onto the cluster itself.

One of the last steps in finalizing the catalog was the elimination of anomalous and inaccurate galaxy listings. The first problem was that of "doubles" in the catalog, which were galaxies that had been catalogued two or more times, possibly by different observers. To correct the problem, a list of potential candidates was compiled, in which galaxies with similar locations and velocities were noted. The STScI digitized sky survey on the internet was employed to determine whether the listed galaxies were in fact doubles, or two separate galaxies in close proximity. Redundant galaxies were consequently eliminated from the catalogue. The second problem concerned galaxies observed by different individuals with large discrepancies in recorded velocities. The digitized sky survey was again employed to determine which of the recorded velocities actually corresponded to the galaxy seen at that particular location. Elimination of

duplicates and other anomalies yielded the final version of the catalog, ready for the computer rendering.

The three-dimensional model is being constructed using a silicon graphics computer. Actual images of galaxies and solar system objects have been collected from the internet, primarily from NASA related websites. Information contained on these sites about the pictured objects should also be a useful component of the final representation.

DISCUSSION

Before the rendering of catalogued galaxies could take place, a number of unforeseen problems and technological limitations needed to be addressed. The analysis of incompleteness versus distance, resulting from the inability to record faint objects as one looks to greater distances, was an integral step towards improving the accuracy of the model. As mentioned above, a correction factor was calculated and used to describe the true distribution of objects in the Local Supercluster. To do this, the model will include surface density contour maps which account for the incompleteness in addition to the visual images of the individual catalogued galaxies. These surface density contour maps are also useful because they are a good representation of the distribution of dark matter in the universe.

Another difficulty is the obscuration due to the galactic plane, which is unavoidable using current optical and infrared viewing techniques. Analyses of this phenomenon have produced an estimate of where obscuration due to the galactic plane takes effect, and this information may also be helpful in predicting the unseen distribution of galaxies blocked by the disk. Currently, there is little that can be done to view the hidden region of space in question, but the area of obscuration will be taken into account during the computer rendering.

Although much of the preliminary work was done on two catalogs of galaxies, the PSCz and the ORS, another larger catalog of galaxies, the ZCAT, containing approximately 40,000 nearby galaxies will now be employed in the final version. This catalog will enable the model to be more comprehensive and provide greater detail of the large-scale structure of the Local Supercluster. In addition to the ZCAT, a catalog of galaxy clusters has been used to indicate the location and distribution of these objects.

CONCLUSION

A three-dimensional computer rendering of the Local Supercluster is currently in development and, upon completion, will provide an accurate and comprehensive portrayal of the large-scale filamentary structure in the Universe. This mapping will be featured in a documentary film sponsored by NOVA as well as in a digital atlas contained on a CD-ROM. The digital atlas will enable the viewer to navigate through space, encountering actual images of well known galaxies and observing the structure that surrounds us firsthand. Using various types of media, the mapping will serve as an educational tool and a strong foundation for further work on important unanswered questions facing modern cosmology.

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