The Search for Propellers in Saturn's A Ring

Christen Gerhart[a,b], Kelly Perry[b]

[a]Los Angeles Valley College, Van Nuys, California
[b]Jet Propulsion Laboratory, Pasadena, California

Abstract

This project aims to resolve images of Propeller features in Saturn's A Ring through various methods of image enhancement using images downloaded from the Planetary Data System (PDS). There were 26 propeller images identified in Dr. Tiscareno's paper "The Population of Propellers In Saturn's A Ring". Image resolution ranged from about 0.05 – 0.28km/pixel during the Saturn Orbit Insertion (SOI). The analysis of these 26 images became the reference point for future image processing to search for new propeller features. This effort is being done in conjunction with Dr. Tiscareno and Dr. Burns at Cornell University.

Introduction

Propellers were first discovered on July 1, 2004 upon the Cassini SOI. They are believed to be the signatures of small (40 – 500 m diameter) embedded moonlets within Saturn's A Ring. They are concentrated within three narrow (1000km) bands in Saturn's mid-A ring. The moonlets within the propellers have yet to be seen. Researchers attribute their lack of brightening to them being composed of macroscopic particles instead of dust.

These propeller features are observed exclusively in Saturn's A Ring and are localized within three belts in the mid-A ring, between 126,750 km and 132,000 km from Saturn's center. This is the same region of the mid-A ring in which self-gravity wakes, constant clumping together and shearing apart of ring particles as their mutual gravity is balanced against Saturn's tides, and the azimuthal brightness asymmetry are at their peaks. Though the nature of these effects' connection, if any, with propeller activity is currently unknown.

Tiscareno et al. (2006) explained that mildly strong spiral density waves locally disturb the propeller population by increasing collision velocities and/or disrupting the development of self-gravity wakes as a possible reason for the limited propeller population.

Background/Setup

The goal of this project was to use publicly available software to search for propeller features. The first priority was to exhaust all options of math based image enhancement software before moving to non-math based software.

Dr. Tiscareno used image software Cisscal, publicly available from the PDS, to conduct his research using PDS images. However Cisscal only accepts VICAR formatted pictures. The software needed to convert images to VICAR is exclusively available through few JPL scientists and is only available via CD-rom. Though this route was pursued, the attempt to obtain a copy was unsuccessful.

The use of the Rings node of the PDS (the PDS archives and distributes scientific data from planetary missions, astronomical observations, and lab measurements) was implemented to download images of known propellers and images for furthering the search for unidentified propellers. The PDS images of the rings were takes by ISS, Imaging Science Subsystem on board Cassini.

First it was important to downloaded PDS images that are known to contain propellers. This would provide a basis for comparison when searching for propellers in other images. The observing information used in Dr. Tiscareno's paper "The Population of Propellers In Saturn's A Ring" provided dates and times of images containing propellers that were mentioned in his paper. The PDS allows images to be searched by a number of different criteria. We were able to find the images used by Dr. Tiscareno's by the information provided in his paper, which identified 158 localized features that were successfully resolved to show a characteristic propeller shape.

Method

Image enhancement software, written by Cassini scientist David Seal, was used to convert the downloaded PDS .img images to .tif files. This increased the image pixel size from 256 to 1024. However, even with that size increase the propellers were much too small to see.

Image software Casvu, donated by Dr. Jeff Cuzzi, JPL, was then implemented to further enhance the propeller images. The software was successful in increasing the resolution of the PDS images, though not to the degree which was needed. Casvu had limited options in image processing so alternate software was desired.

Then, Multispectral Image Data Analysis System, Multispec, from Purdue University, was implemented with more success in increasing resolution and other enhancement techniques, such as creating classes of objects that could be dealt with separately from their host images. However Multispec didn't offer the ability to magnify the images to the degree needed without compromising image quality.

Finally, Photoshop was used to resolve the propeller images to a much larger size than previous software. Photoshop came with beneficial tools such as image inversion, despeckle and noise reducing options, as well as creating multiple layers of images that could be combined or enhanced separately. These tools were the most effective in identifying propellers in the PDS images.

Results

The previously identified propellers published in Dr. Tiscareno's papers could be seen with Photoshop. The average resolution used to see these features was 1050 pixels/inch. Each image was enhanced to the above resolution, the noise was reduced and the color levels were adjusted to ensure a high contrast image.

About 50 additional PDS images were searched for unidentified propellers and around 20 features were flagged. The few objects found in alternate images have not been confirmed as propellers.

Conclusion

These small mysterious features are still elusive to the scientists that study them. It is clear that in order to successfully resolve these features, more specialized software and image conversion programs are needed.

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References

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