Identifying Unknown Satellites

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Identifying Unknown Satellites

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Introduction

Satellites are used for a wide range of purposes and by a wide range of organizations from private companies to governments. Specifically, what was of interest to us and the Air Force Research Laboratory (AFRL) with whom we collaborated was the need to identify different satellites using telescopes and determine their purpose. Finding a cheap way to determine the design of a satellite and its use would be of great interest to national security in determining whether a previously unknown satellite is potentially harmful to our own country’s satellites in orbit around the Earth.

Methodology

The project required two pieces: a way to analyze the data gathered and a system to interpret the results in order to actually classify the satellite. My portion of the project was creating and improving the data processing once we have obtained the images. The images gathered with our telescope were typical astronomical photographs, but because our satellites are geosynchronous, meaning they stay in the same spot relative to us all night, the stars behind them appear to move through them. This led to the occasional star streak through one of our satellites, adding unnecessary light to our data. This, combined with other issues inherent in observing objects in the night sky meant that the existing software available for analyzing astronomy images would not work for exactly what we needed.

To remedy this, I made our own software using python. I chose python because it is widely used in astronomy, free, and easy to work with making it the best programming language I knew for the task. I created a system to display the FITS image file (the standard astronomy image file type) and allowed the user to click on the satellites they wished to observe. After selecting targets, the user would click a “track” button which would add all of the light within the clicked region, subtract out the light from the sky, go to the next image and search for the satellite, starting in the same region that it was on the previous screen, and repeat the process for every image taken that night. The special features I added to it that are not standard or as easy to use on other systems was the program’s ability to stop if it encountered an error and allow the user to fix it, and the automatic deletion of frames in which stars streaked through our satellite. If during tracking the program was unable to find the satellite on the next image, it would pause, tell the user, and allow the user to manually adjust the aperture location before clicking “continue” to resume the process.

I also implemented a feature to detect star streaks through our object using a recursive function to check the extent of the bright region. Because this data was not usable for us, the program automatically deleted it and resumed normally. After all of the data had been processed, the user could create a plot of the light curve to see how the signature had changed throughout the night. After creating this software, I worked to optimize it and improve its usability. Even after I had finished creating the software, I spent a good deal of time fixing bugs and optimizing it for speed and memory usage to make it practical, resulting in a program that runs as fast or faster than many commercial software available with added features needed for our project.
The other part of the project was left to Dr. Moody, Daniel Jones (Another student in the Physics and Astronomy Department), and the AFRL. They worked on taking data and analyzing the results in order to determine how to classify a satellite based solely on its light signature. This would allow easy and accurate classification of unknown satellites.

Results

My portion of the project resulted in a powerful piece of software that will allow satellite research to continue at BYU without the need to send data down to the AFRL in Albuquerque. This program will also result in much faster data processing and analysis than what was used during the development of the identification method, allowing us to process much more data.

The method itself, developed by Dr. Moody, uses features easily visible from an earth-based telescope to classify attributes of satellites and help us figure out the design of the object in question. Using the brightness, polarization, and even color of the light, Dr. Moody and the AFRL were able to find out how different orientation angles, materials, and structures correspond to certain effects in the brightness and polarization of the object observed overnight throughout the year.

Discussion

Although still new, the system developed by Dr. Moody and the AFRL has shown to be extremely accurate in its classification of previously known satellites and their features so we now know that this a viable solution to our problem of interest. Because of the wide range of uses for satellites, this method can very much aid in monitoring the purpose of man-made objects in orbit around the Earth to ensure our own security and the safety of our own satellites.

The software itself is a tool created to support this new method, but because of the seriousness of this research, it is important that we have a reliable program to analyze the results to avoid ambiguity and to make it easier so as to eliminate human error in the process. Every step in the analysis of satellites needs to be as efficient and effective as possible. This ensures that the data can be taken and results obtained as quickly and correctly as possible to analyze in time for important decisions to be made, if needed.

Conclusion

More data are needed in order to refine the method developed, but the results so far are promising. The software has been developed and optimized well to make it usable for this project and any further maintenance and updating should be within the abilities of future undergraduates working on this project. This past year, much progress has been made in being able to classify satellites, and there is likely not much more left to do other than gather data and verify what has been made.

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