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ENGH 302 – AN1

6/21/2020

Research Proposal and Annotated Bibliography

Research Proposal

I plan to show the timeline of research on image processing in spatial imagery by using a chronologically ordered paper leading up to the most modern of techniques provided that they are available, with the first methods being introduced in the late ‘70s and the most modern obviously in the last ten years or so. With the information gathered in this annotated bibliography, the number of sources will be more than plentiful since it seems that a lot of research has been done surrounding this topic.

Just having a simple chronologically ordered paper is a little bland, so I also plan to show the methods used with both their pros and cons. It is worth noting that not all the articles use image processing on the same imagery since some researchers use it on light waves and some use it on physical galaxy images. While not all of the images are the same, the techniques are useful to understand as well as how they have changed over time to understand how the techniques will change in the future.

The idea of image processing is to take any image and then process it to find patterns and symbols in the image, hidden or not. By doing so, we can learn about an image or about how to improve machine learning, including other data science topics such as natural language processing, ancient language processing, symbol processing, and artificial intelligence. All of these topics allow society to learn of better ways or opportunities to accomplish literally anything. After taking a look at the brief history of image processing in spatial imagery, I will then proceed to apply the idea to everyday applications.

With spatial imagery being the main topic of this article, it is worth mentioning that geospatial imagery also plays a part. Many of the techniques here can also be used or applied to geospatial imagery, such as maps, buildings, 3d models of our world, etc. These methods are currently being used today by companies such as Google, Microsoft, Amazon, and many more. These companies also combine image processing with network software like NetworkX, a package for python, to create the maps and road networks that we see on our phones in GPS' today, although that is a topic for another discussion.

Annotated Bibliography

Amicis R.D., Conti G., Piffer S., Simões B. (2009) Geospatial Visual Analytics. In: Amicis R.D., Stojanovic R., Conti G. (eds) GeoSpatial Visual Analytics. NATO Science for Peace and Security Series C: Environmental Security. Springer, Dordrecht. 260 – 85. Retrieved June 8, 2020, from https://link-springer-com.mutex.gmu.edu/chapter/10.1007/978-90-481-2899-0_21#citeas

DOI: https://doi-org.mutex.gmu.edu/10.1007/978-90-481-2899-0_21

Pages 260 to 285 of GeoSpatial Visual Analytics covers the context of using image processing to show events or environmental data of the earth from satellite imagery. Using image processing aids in our ability to see road networks, rivers, ocean plastic pollution, volcanic ash clouds, etc. All of these applications allow us to have a better understanding of our world, and this is also true for other planets, since the applications of image processing on earth will also apply to other worlds when we eventually reach beyond our moon. This article, part of a larger collection of articles, allows us to see the applications of image processing on our planet, rather than just in astronomical images.

I plan to use this article to show the applications of image processing on Earth and other worlds. Spatial imagery also includes geospatial, or rather physical imagery of planets, not just astronomical.

Diganta, M., Sparsha, M., & Bhargav, A. (2018, December 23). Advanced Image Processing for Astronomical Images. Retrieved June 08, 2020, from https://arxiv.org/ftp/arxiv/papers/1812/1812.09702.pdf

This article goes in depth with the general method for image processing for spatial imagery, namely the gaussian-gradient method, which allows for orientation, direction, and initial detection of a galaxy. The first half of the article contains mathematical equations as well as mathematical methods to solve the necessary components. It is worth noting that this contains higher level calculus techniques for solving the gradient, as well as vectors to solve for the gaussian.

Later in the article, the authors use noise removal to better detect the galaxy, which uses Random Walker Segmentation (RWS) to remove noisy edge points. RWS works to mark the detected noise points and then remove them and leave the user with a segmented image, which only contains a galaxy in this case. These are all methods used in general machine learning and data mining processes. There are also other methods for computing the result of RWS as well as general image processing techniques.

I plan to use this article to show one of the main techniques used in detecting astronomical bodies. I want to see the viability to each of the methods of image detection, and this is a good start. During my research, this seems to be a strong article to use as opposed to other articles with less useful information.

Lorre, J. (1979). *Application of digital image processing techniques to astronomical imagery, 1979.* National Aeronautics and Space Administration, Jet Propulsion Laboratory, California Institute of Technology. Retrieved June 8, 2020, from https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19800011714.pdf

This is a 70-page book (unsure of if it is part of a larger book) on different methods of image processing in spatial imagery published by NASA. It was published in the late 70's by a man named Jean J. Lorre. The article has approx. six different applications that could be idealized that image processing could be used for and goes over the Maximum Entropy concept which just means that the method with the maximum measurable entropy is the best outcome, which in this case would be true for image processing; hence the six different applications.

By far, the best practical methods have used calculus for processing images, and this article is no stranger to that method. This article uses the polarization to transform an image into three dimensions, with the resulting image having noise amplified, causing there to be a cross in the center of the image. Resulting images using this method did not produce perfect results; however, for the time that this article was released, 1979, this was very game changing research and aided in the discovery of further galaxies and planets.

I plan to use this research on early methods of image processing to help my chronological ordering of my literature review. This is the first article that will be mentioned since image processing has become more developed since the release of this article in 1979.

Moschini, U. (2016). Efficient morphological tools for astronomical image processing. [Groningen]: University of Groningen. Retrieved June 15, 2020, from https://www.rug.nl/research/portal/publications/efficient-morphological-tools-for-astronomical-image-processing(bde405b7-eeae-4391-a19f-90e40b56eab7).html

Efficient Morphological Tools for Astronomical Image Processing, written by Ugo Moschini for his PhD thesis, goes over multiple methods used for processing imagery, namely the ones that I will include in this literature review, Statistical Attribute Filtering and Parallel Max-Tree. Both algorithms are extremely useful and like before, use calculus-based mathematics for determining patterns and recognition of objects. I will mainly be using chapters three (3) and four (4), which is the respective individual methods mentioned in the first half of this summary.

Chapter three (3) of this book build on the methodical approach that was taken in *Advanced Image Processing for Astronomical Images* using the Gaussian method to detect the image. Chapter four (4) of this book uses an entirely different method called Max-Tree. This method is meant for more extreme images, with wide dynamic ranges. The method pulls parts the image in hierarchical ways to represent connected components. This hierarchical method combines flooding and merging max-tree algorithms.

I plan to use this article to show another method which is faster than the method in *Advanced Image Processing for Astronomical Images*. These methods are useful for quicker processing of larger images.