# Similarity Mapping of the Milky Way using Neural-Network Style Transfer


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## Abstract


Deep neural networks have shown capability of quantifying the style of an image using neural representations to separate the style from the content. We cut the Wisconsin H-Alpha Mapper Sky Survey of the Milky Way into hundreds of images. The style layer of each image was extracted and then compared to the one which contained the Orion Molecular Cloud Complex (OMCC). Using the OMCC as our reference, we found which areas had high similarity of style. This lays the foundation for quick analysis of new data to target areas of interest that formerly required a trained eye to look at.


## Style Transfer

Neural style transfer allows us to extract the content layer and style layer statistics separately from an image using a convolutional network. This can be used to transfer the style layer onto an image as seen below. In other usages, analyzing the statistics can discern between an original artwork and duplications because minute differences can be detected in the style layer. We are interested in comparing the style layers of astrophysics data to see if the style of one region of interest is detected in other areas.

Figure 1 shows that content layers and style layers can be analyzed separately. The content layer of the first image is added to the style layer of the second to generate a new image. https://www.tensorflow.org/tutorials/generative/style_transfer

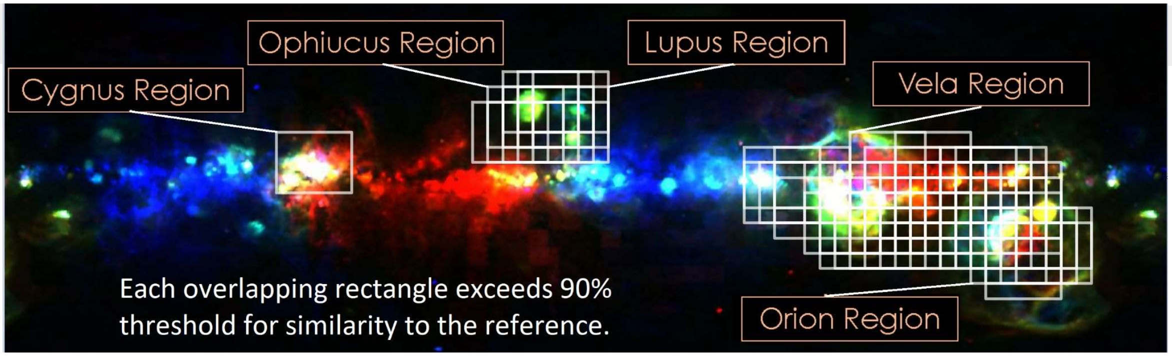


Figure 2 above has our results overlaid onto the Milky Way background. The grid formed is actually the result of many overlapping rectangles. When comparing its style to Orion, the image in each rectangle shown gave a value greater than 0.90 in maximum cosine similarity.

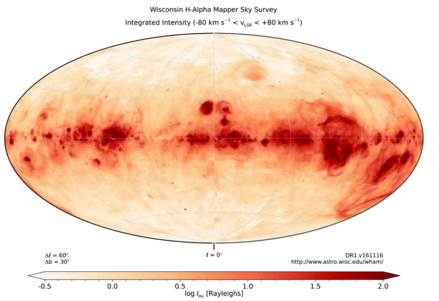


Figure 3 maps velocity-integrated Hα gas emission in the Milky Way. The color map corresponds to flux intensity at wavelength λ = 0.686 μm.

http://www.astro.wisc.edu/wham-site//

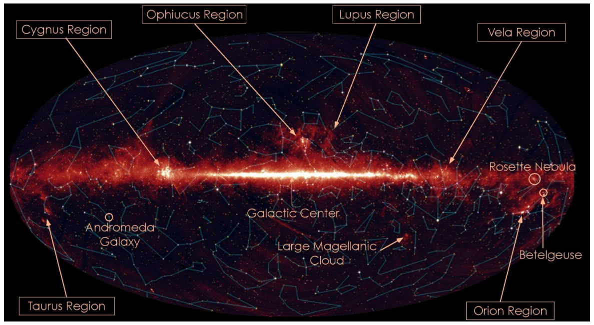


Figure 4 is a mid-infrared image (at λ = 9 μm) of the Milky Way as observed by the AKARI all-sky survey, annotated with several well-known star-forming regions. Similarity mapping of the OMCC in figure 2 was able to identify a majority of these regions.

https://www.ir.isas.jaxa.jp/AKARI/topics/20070711_AKARI/

## Style Reference

The velocity data was used to apply RGB values to the areas of hydrogen gas. We selected the sector below as our reference due to it containing the OMCC which is a well documented and interesting feature. The Milky Way was cut into multiple overlapping grids to generate all the sectors to compare to this image. The calculation was only to find sectors that were similar in style.

## Results

Even though we only asked the program to return high cosine similarity values between the style layers, it was able to determine areas that shared similarities in other ways such as rate of star formation. This shows that it could be applied in the future as large data sets are being generated to provide a heat map of priority areas to target for study due to their style similarity to known sectors.