A Machine Learning and Computer Vision Approach to Geomagnetic Storm Forecasting

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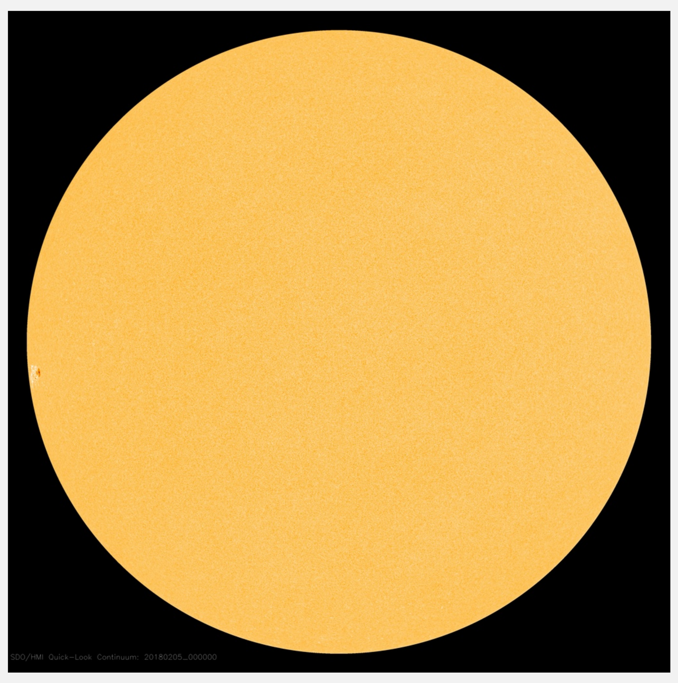
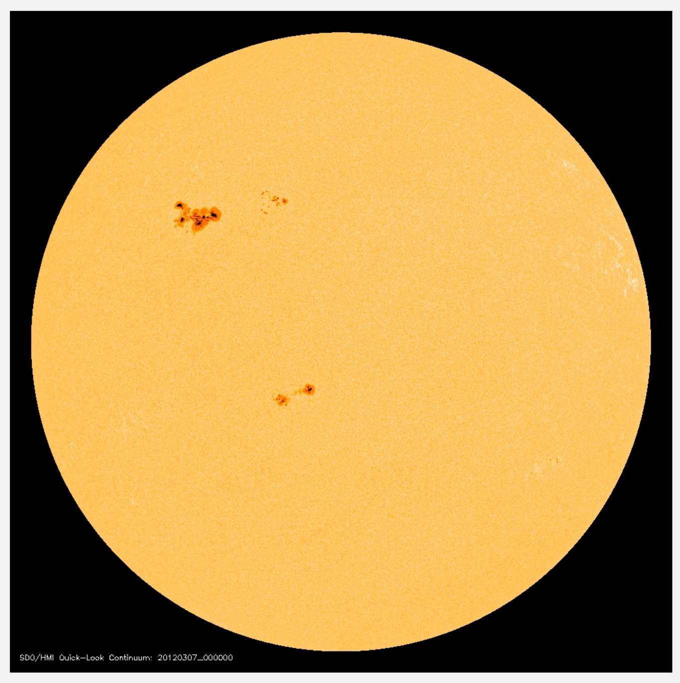
INTRODUCTION



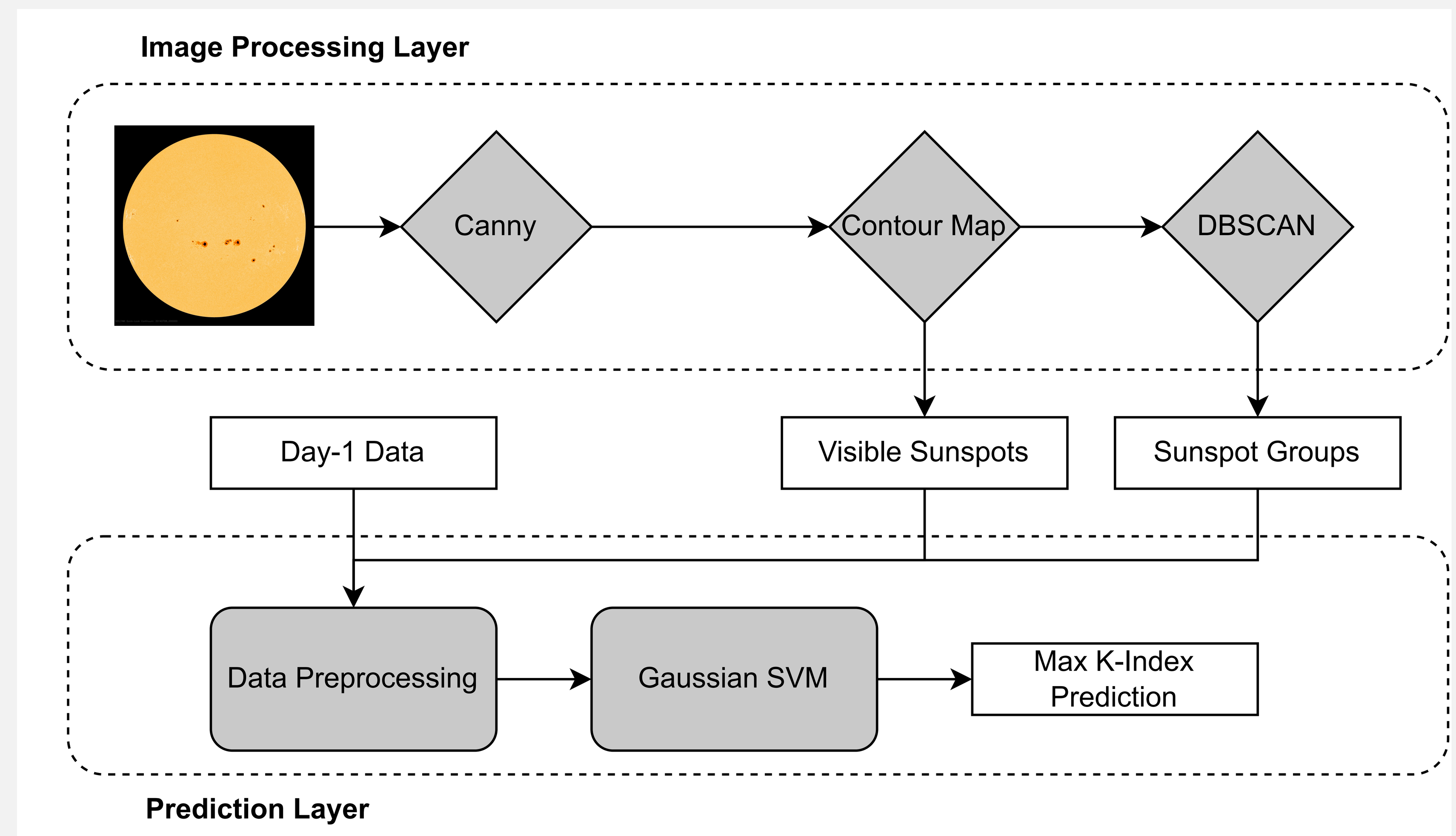
No G-Storm (02/05/2018)



G-Storm (03/07/2018)

- Forecasting geomagnetic storms is crucial to ensuring proper operation of technological systems such as orbital satellites and the power grid.
- Based on the observation that sunspot activity is correlated with high solar activity, we study if it is possible to use sunspot features on images of the Sun to predict geomagnetic storms.

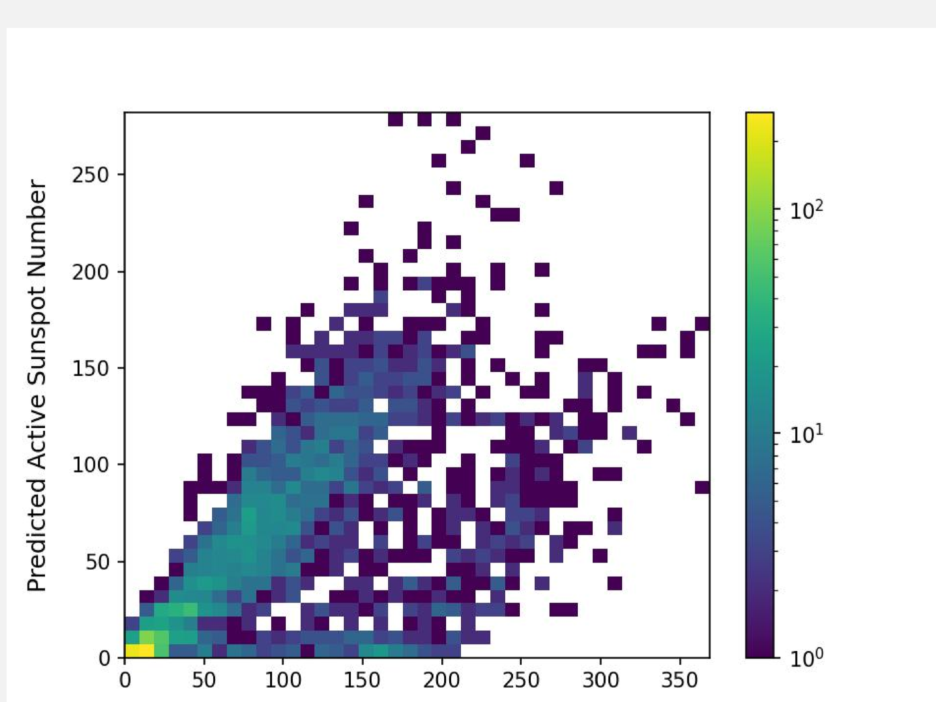
METHODS



A 2-Layer prediction pipeline design featuring edge detection, topological analysis, and supervised/unsupervised learning methods.

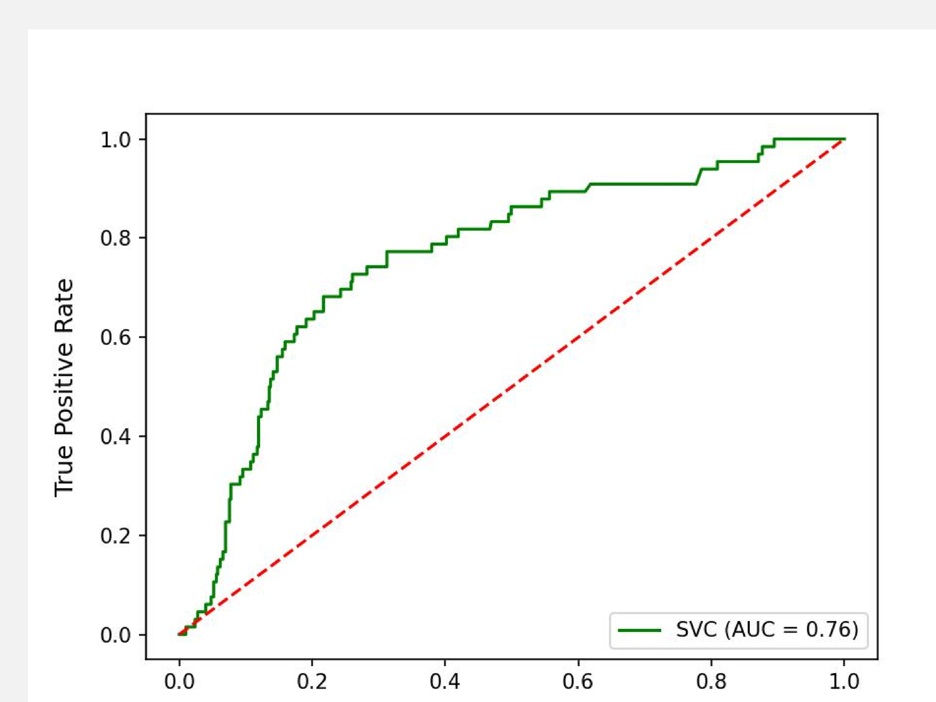
RESULTS

Sunspot Feature Extraction



A correlation graph between the sunspot number determined by our image processing techniques and the SESC Sunspot Number is plotted to evaluate the accuracy of the image processing layer. The correlation graph suggests a strong correlation between our results and the defined International Sunspot Number.

Geomagnetic Storm Prediction



A Receiver Operating Characteristic (ROC) curve on our model is used to evaluate the accuracy of the Gaussian Kernel Support Vector Machine (G-SVM) used for storm prediction. An AUC value of 0.76, in the graph, indicates that our model achieves a 76% overall weighted accuracy across both classifications.

Prediction Method Comparison

Prediction Method	Class	Precision	Recall	Accuracy
G-SVM	*no storm*	0.95	0.73	0.76
	storm	0.26	**0.73**	
SWPC	*no storm*	0.94	0.90	0.86
	storm	0.46	**0.61**	

Precision and recall scores from the table show that our model is competitive with the state-of-the-art industry prediction method with only using features collected from image processing, as opposed to collecting physical measurements from ground-based magnetometers and solar wind sensors from spacecraft in orbit.

CONCLUSION

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Sunspot features correlate to geomagnetic storms

- Active sunspot features can be reliably identified from images of the Sun
- Sunspot features extracted by computer vision correlate to geomagnetic storm forecasts

Support Vector Machines offer reliable predictions

- A Gaussian-Kernel Support Vector Machine model gave high accuracy in classifying geomagnetic storms from sunspot feature data