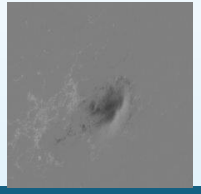
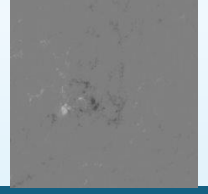


SOLAR FLARE FORECASTING AND ACTIVE REGION MONITORING USING MULTIMODAL MACHINE LEARNING

Zaid Abuhassan and Jonathan Davis



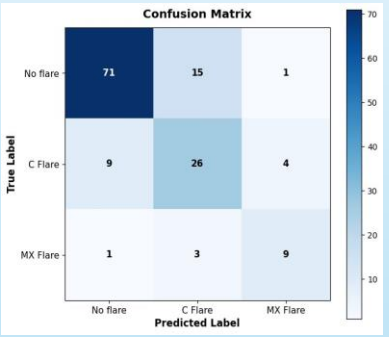
Engineering Problem and Objectives

- In 2024 a large geomagnetic storm caused **severe damage** to power grids, GPS and radio interruptions, and satellite disruption
- Solar flares are **precursors** to such geomagnetic storms
- Current solar flare detection technology identifies if a solar flare will occur, **not how the active region develops**
- Understanding and characterizing the development of active regions into solar flares would provide astronomers with **greater understanding of solar weather** and help Earth prepare for the effects

Engineering Goal: Develop models that **predict solar flares** and characterizes the **development of active regions** through the prediction of active region magnetic field features with **strong performance.**

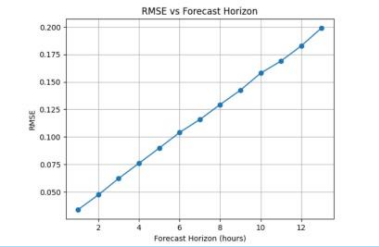
Data Analysis and Results

Best Solar Flare Forecasting Model:



	Performance
ROCAUC macro OVR	0.8731
TSS	0.6125
HSS	0.5789

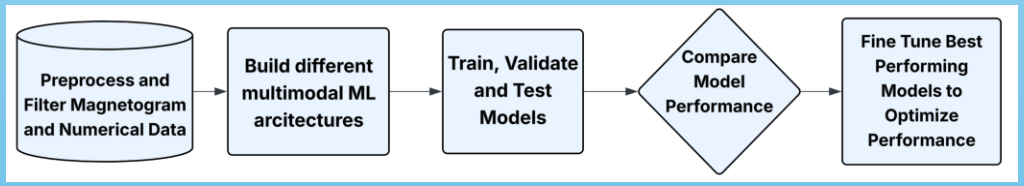
Best Active Region Characterization Model:



	Performance
MAE	0.0681
RMSE	0.1202
R^2	0.9886

Project Methodology

1. **Preprocess data** into 24-hour time sequences of magnetogram images, then normalize and filter images
2. Build **various multimodal machine learning architectures** with different strengths and weaknesses
3. Use magnetogram images and numerical measurements to train, validate, and test models
4. Identify and retest models with the **strongest performance** and fine tune
5. Retest after fine tuning



Conclusion and Application

Conclusions

- Machine learning models were able to forecast solar flares and prediction active region characteristics, **meeting all criteria** of the engineering goal

Real-Life Applications

- Can be utilized by researchers to find trends and better understand solar flare development from active regions
- Can help astronomers **better anticipate solar flares** and coronal mass ejections, providing **more time to prepare sensitive infrastructure**
- Introduces machine learning for active region monitoring via numerical parameters, **encouraging further research**