Predicting disruption in future tokamaks with fewer data by more physics-guided

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How to reduce the data requirement

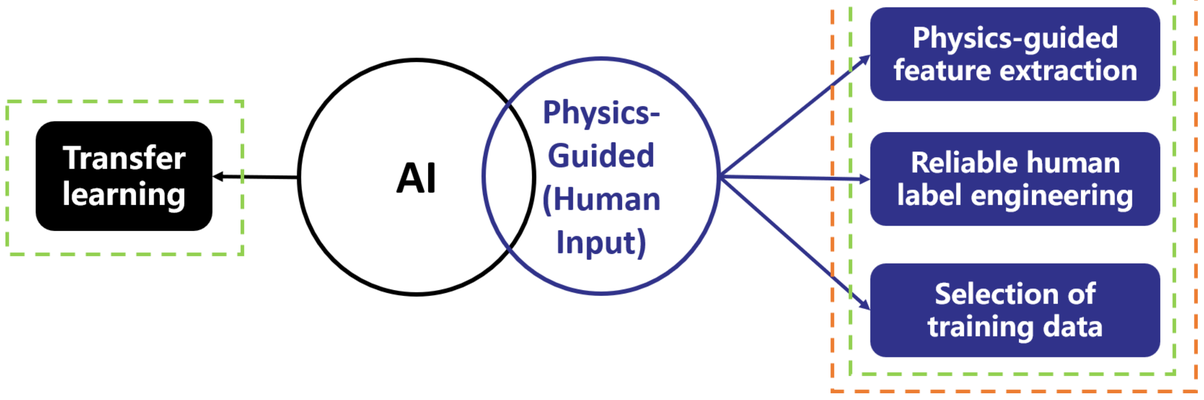
Performance of the target domain

$$\varepsilon_t(h) \le \varepsilon_s(h) + d_{\tilde{\mathcal{H}}}(\mathcal{D}_s, \mathcal{D}_t) + \min\{\mathbb{E}_{\mathcal{D}_s}[l_d(f_s, f_t)], \mathbb{E}_{\mathcal{D}_t}[l_d(f_s, f_t)]\}$$

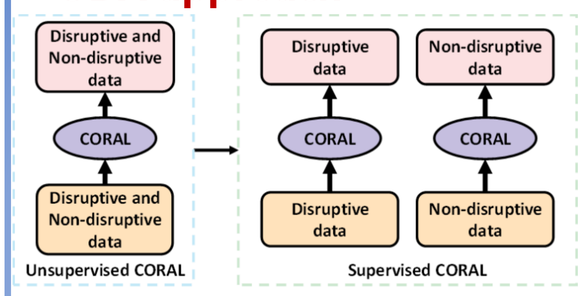
→ Reduce the distance of source and target domain

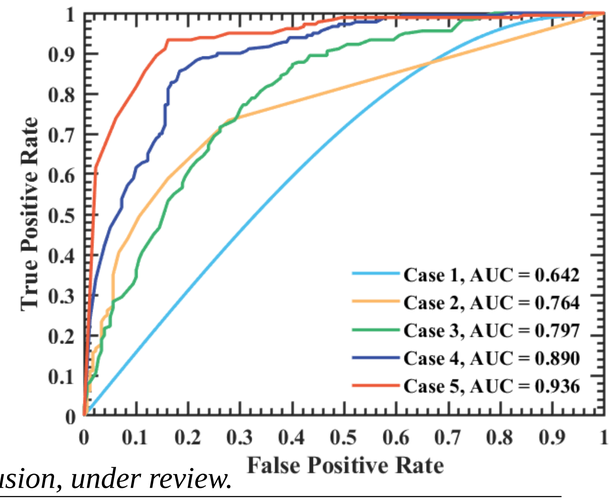
→ Improve the performance of source domain

Intersection of AI and physics



Improved CORAL as an SDA approach from the UDA approach





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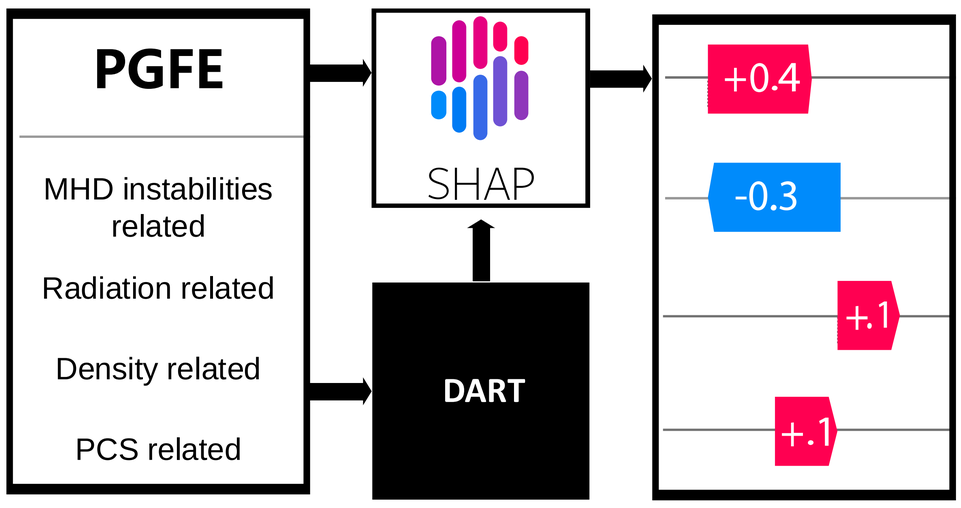
Case No.	EAST Data	Data Strategy	CORAL Strategy	AUC
1	None	/	/	0.642
2	110 (10)	Mixing	/	0.764
3	110 (10)	CORAL	Unsupervised	0.797
4	110 (10)	CORAL	**Supervised**	**0.890**
5	**1896 (355)**	**Full data**	/	**0.936**

➢ **TPR = 90 %, FPR = 25.56%, AUC = 0.89** ➢ Supervised CORAL reaches the BEST

CORAL and PGFE could Reduce the distance of source and target domain

20 disruptive shots + 120 nondisruptive shots: IDP-PGFE



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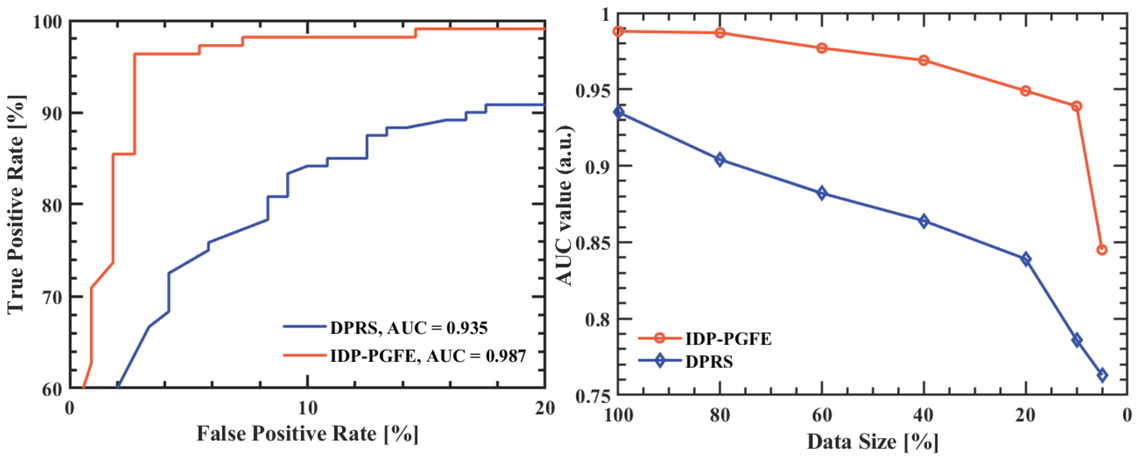
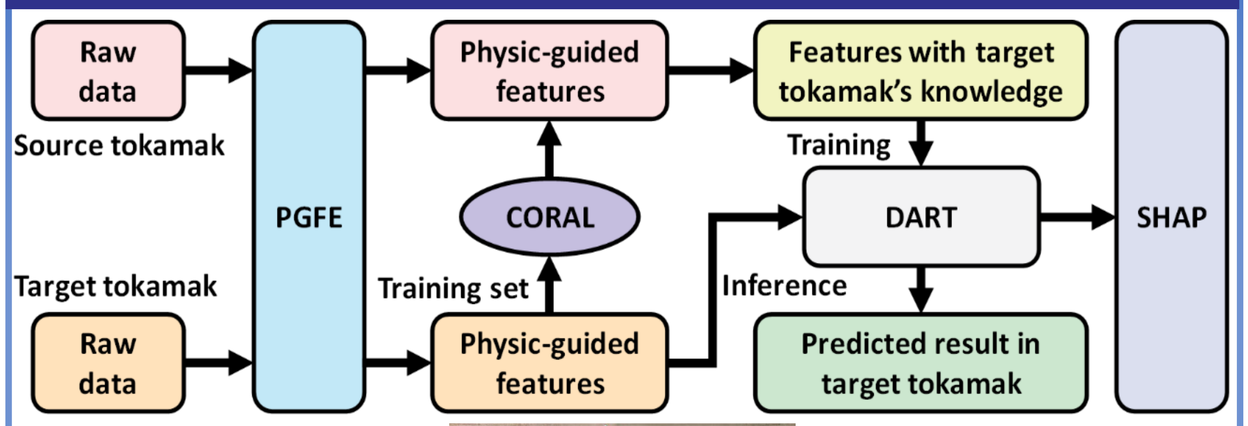
➢ **TPR~97.27%, FPR~5.45%, AUC ~0.98** ➢ **20 dis and 120 non, AUC ~0.93**

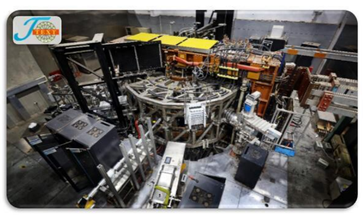


PGFE could Improve the performance of source domain

PGFE could Reduce the distance of source and target domain

10 disruptive shots + 100 nondisruptive shots: CORAL





Compare to J-TEXT, EAST just like the future tokamak.

Zero-shot: more physics guided (human input)

Improved data quality

➢ More **accurate true negative samples** for J-TEXT have been labeled through the **anomaly detection model**.

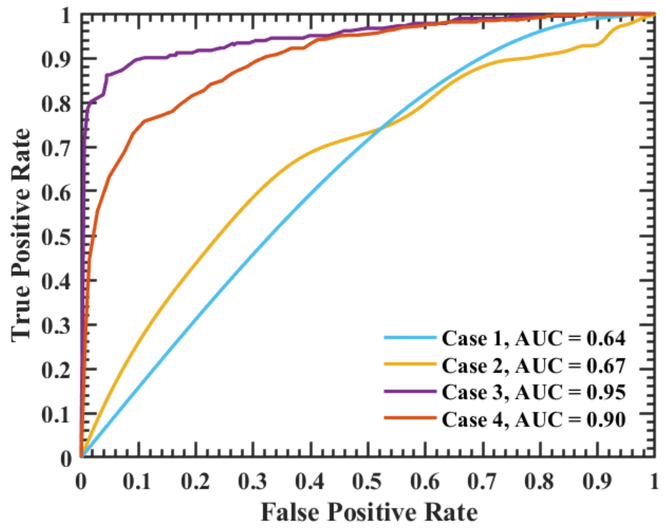
, XK. Ai, W. Zheng, CS. Shen et al. Nuclear Engineering and Technology, under review.

PGFE-Upgrade

➢ Extract MHD instabilities related features from the **whole Mirnov array** based on **SVD** rather than FFT and CSD.

➢ Selected channels with **similar chord core distances (r/a)** between the SXR and XUV arrays in J-TEXT and EAST.

➢ Added **scaled features** such as XUV_ratio, ne0/nG, dr/a, dZ/a, etc.

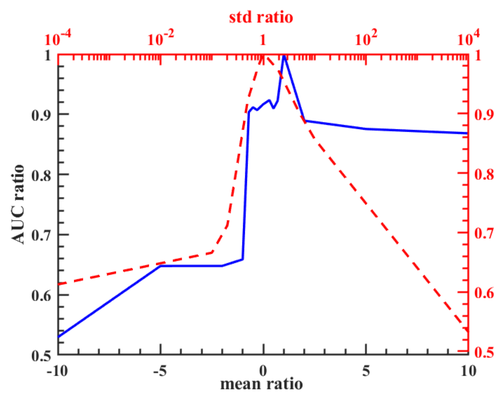


Case No.	EAST Data	Transfer Strategy	Improved data quality	PGFE-U	AUC
1	None	/	N	N	0.64
2	None	/	Y	Y	0.67
3	**1896 (355)**	**/**	**Y**	**Y**	**0.95**
4	**None**	**Estimated normalized parameters**	**Y**	**Y**	**0.90**

Sensitivity analysis of the normalized parameters

➢ Performance declines by less than **90%**

- ◆ Estimated mean ratio between **-1~2**.
- ◆ Estimated std ratio between **0.5~5**.



Summary

- ➢ **Improve the performance of source domain and reduce the distance of source and target domain are two main approaches to make the cross machine disruption prediction get higher performance and fewer data**
- ➢ **The cross machine performance could reach AUC=0.9 zero-shot performance by CORAL and physics guided approach.**

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