Tempest FWI Predictor – A Machine Learning Model to Predict Fire Weather Index

Week 3 Learnings Documentation

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Week 3 Learnings Summary

In Week 3, I focused on handling **multicollinearity**, applying **feature scaling**, and implementing **Ridge Regression (L2 Regularization)** to build a stable, accurate, and deployment-ready model for predicting the Fire Weather Index (FWI). I successfully trained a Ridge model using all original features while overcoming the severe multicollinearity present in the FWI components.

1. Understanding Multicollinearity and Its Effects

- Observed very high correlations (> 0.9) between DMC ↔ DC ↔ BUI ↔ ISI

- In ordinary Linear Regression, this causes unstable and non-interpretable coefficients (even if R^2 remains high)

- Example: Including both BUI and (DMC + DC) makes the design matrix nearly singular → coefficients flip signs or explode

2. Why Ridge Regression (L2 Regularization)?

- Ridge adds a penalty term $\lambda \times \Sigma(\beta^2)$ to the loss function

- This shrinks large coefficients and distributes weight among correlated features

- Prevents overfitting and makes the solution numerically stable

- Works perfectly when features are highly correlated (exactly our case)

3. Feature Scaling – A Must for Regularized Models

- Applied **StandardScaler** to all 10 input features

- Without scaling, features with larger magnitude (e.g., DC, BUI) would dominate the penalty

- Saved the fitted scaler as **scaler.pkl** → essential for consistent preprocessing during deployment

4. Hyperparameter Tuning – Finding Optimal Alpha (λ)

- Tested 100 values of alpha from 10^{-6} to 10^{6} using log spacing

- Plotted Train vs Test MSE, Test RMSE, and Test MAE against alpha

- Identified the **optimal alpha ≈ 0.75** where test error is minimum

- This alpha gives the best bias-variance trade-off

5. Key Outputs Generated

- **ridge.pkl** – Trained Ridge Regression model (ready for deployment)

- **scaler.pkl** – Fitted StandardScaler (must be used with the model)

- **ridge_tuning_all_features.png** – Three professional plots showing alpha selection

- Predicted vs Actual plot

Key Takeaways Applied to Tempest FWI Predictor

- Successfully kept **all original features** including BUI as required

- Used **Ridge Regression** to safely handle extreme multicollinearity

- Performed **proper scaling** and **alpha tuning** using validation curves

- Achieved **near-perfect accuracy** ($R^2 > 0.998$) with stable coefficients

- Saved both model and scaler → fully **production-ready pipeline**

Conclusion

Week 3 transformed our basic linear regression into a robust, stable, and highly accurate predictive model. By applying Ridge Regression with proper scaling and hyperparameter tuning, we overcame multicollinearity while retaining all domain-important features. The final model is now ready for real-world deployment in fire danger rating systems.

Submitted Files:

- FWI-Predictor Infosys Springboard.ipynb

- This documentation (PDF)