

Material Removal Rate Prediction in Chemical-Mechanical Planarization

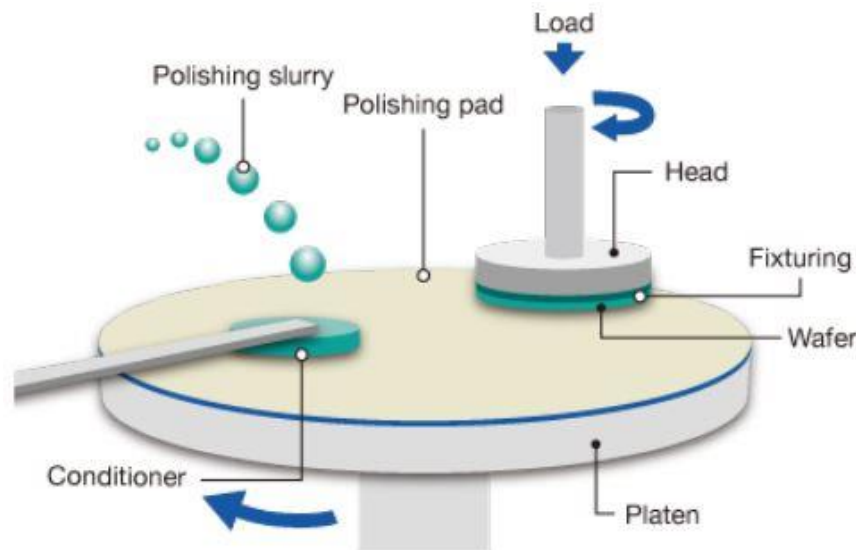
CS591 Data Mining Project

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Chemical-mechanical planarization (CMP)

- Process of polishing surfaces with the combination of chemical etching and mechanical abrasive polishing
- Widely used in the semiconductor industry for silicon wafer polishing
- Material removal rate (MRR) is important for process monitoring and process control of CMP

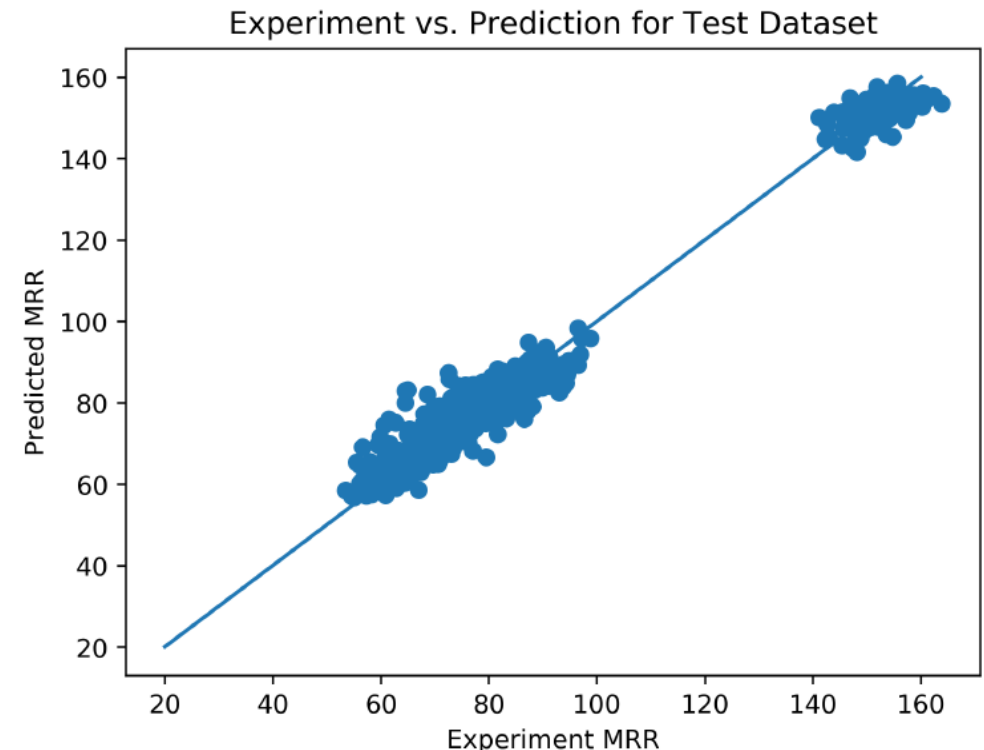
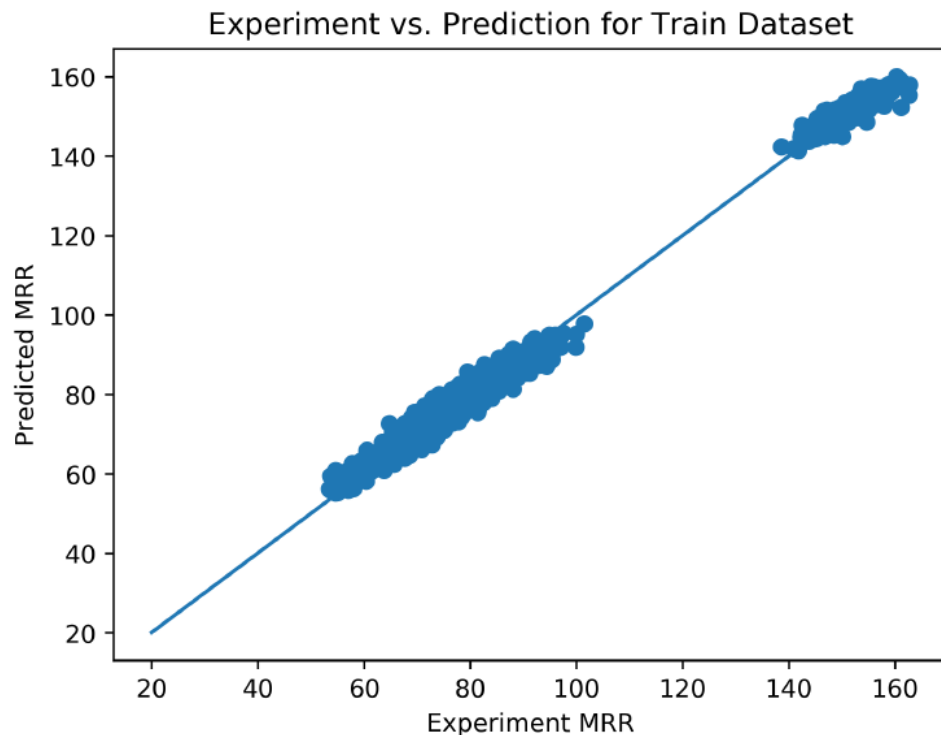


Dataset

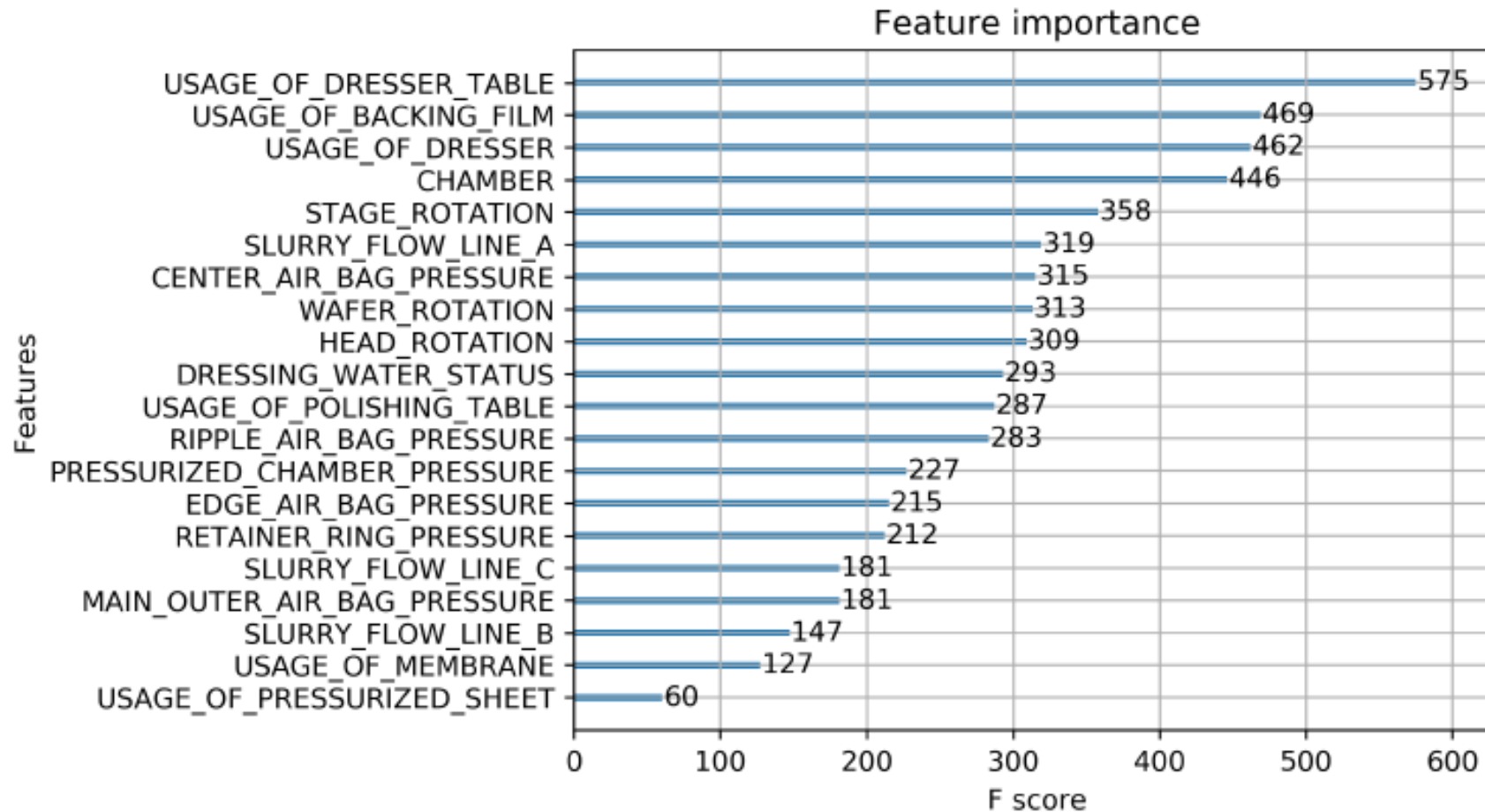
- The dataset is provided by PHM (Prognostic Health Management) 2016 data competition
- Target/response: MRR
- Predictors: process parameters
 - rotational speed, pressure, dressing table, ... (dimension: 20)
- Training set has 1972 records and test set has 848 records

Extreme Gradient Boosting (xgboost)

- 5-fold cross validation to tune max tree depth and number of boosting rounds
- Training RMSE: 1.87295, Test RMSE: 3.84026.



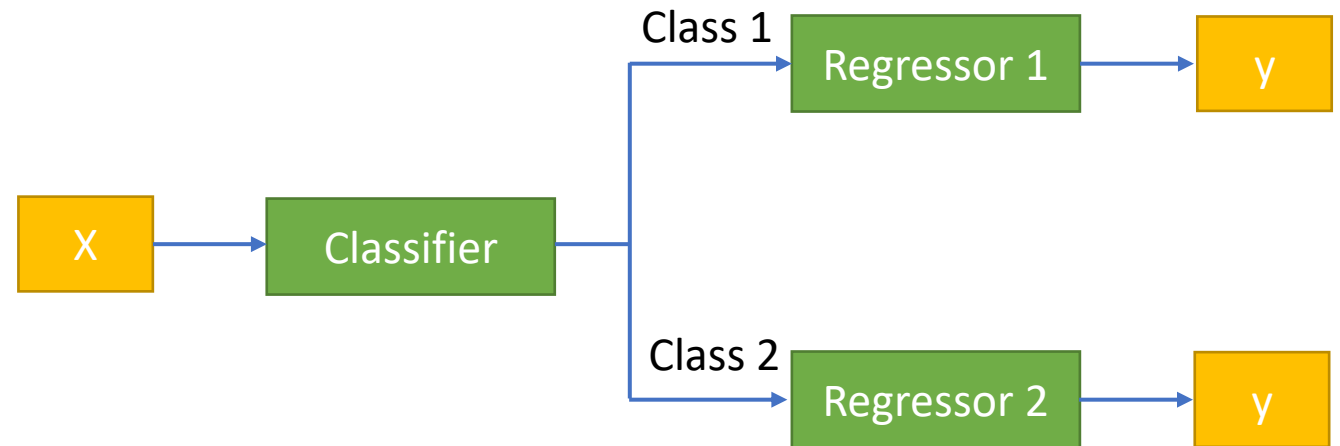
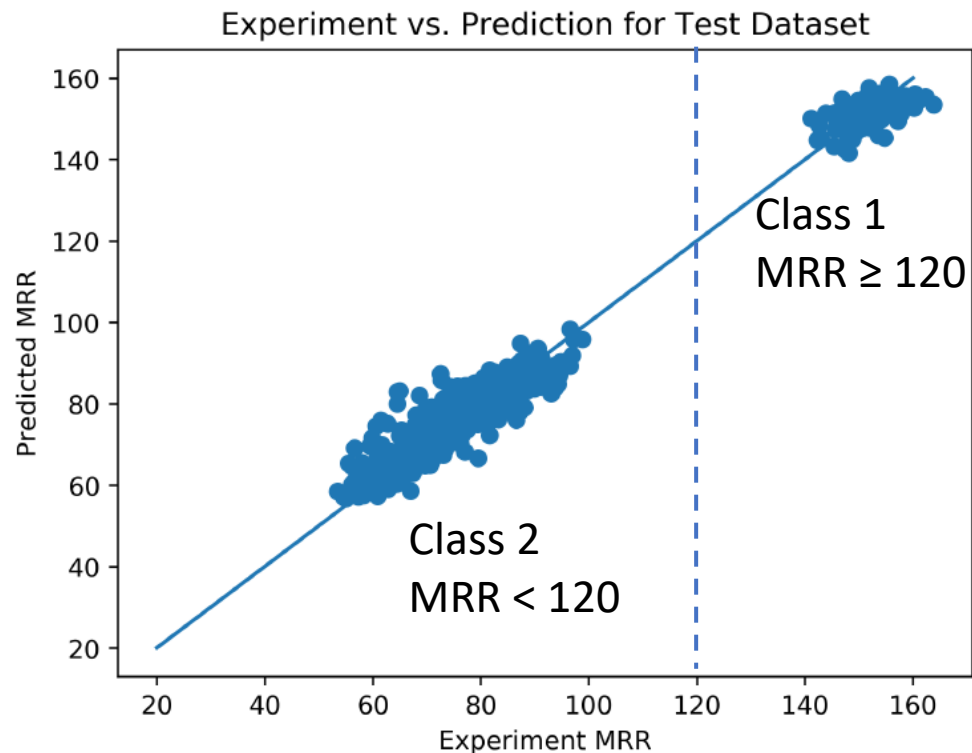
Feature Importance (Boosting)



Rotational speed and pressure are strictly controlled in production, the variations in those parameters are small, thus has relative little effect

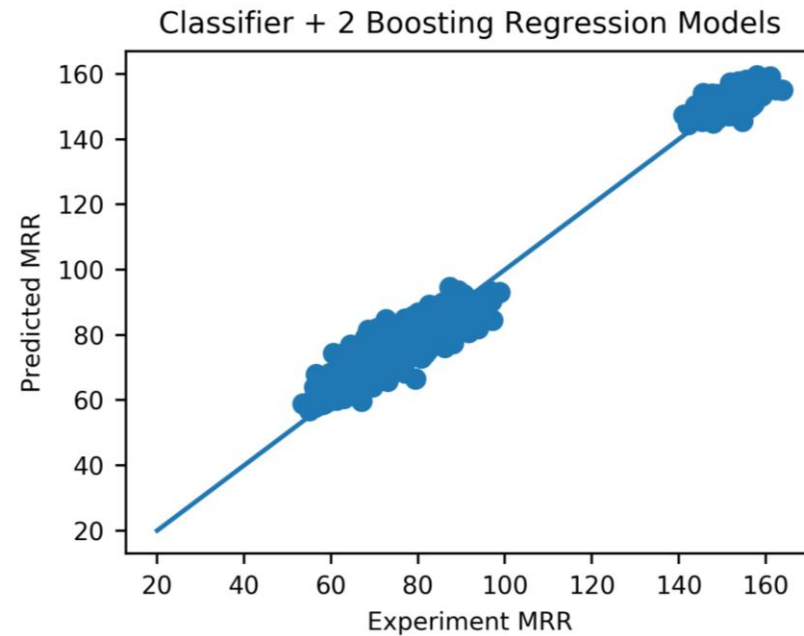
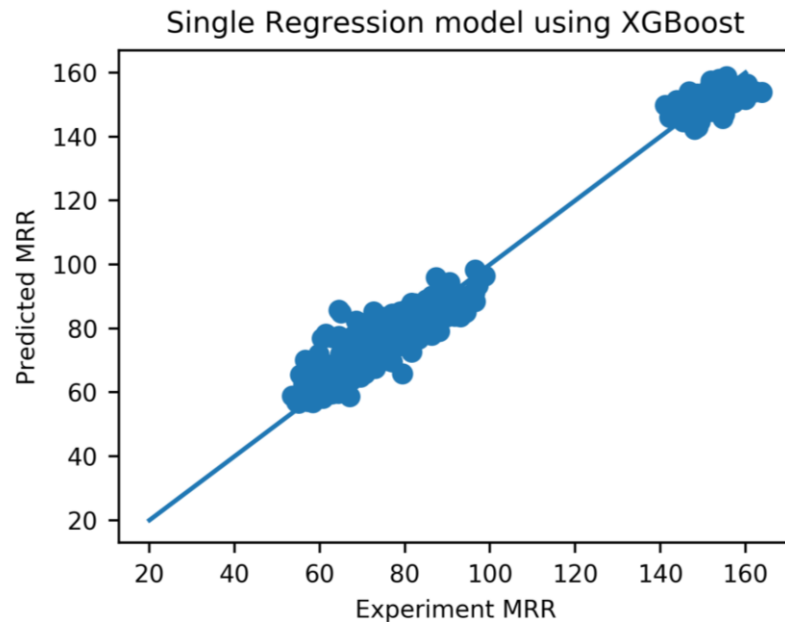
Classifier + 2 Regression Models

- Train a classifier to determine if $\text{MRR} \geq 120$ or $\text{MRR} < 120$
- Train 2 separate regression models for $\text{MRR} \geq 120$ and $\text{MRR} < 120$



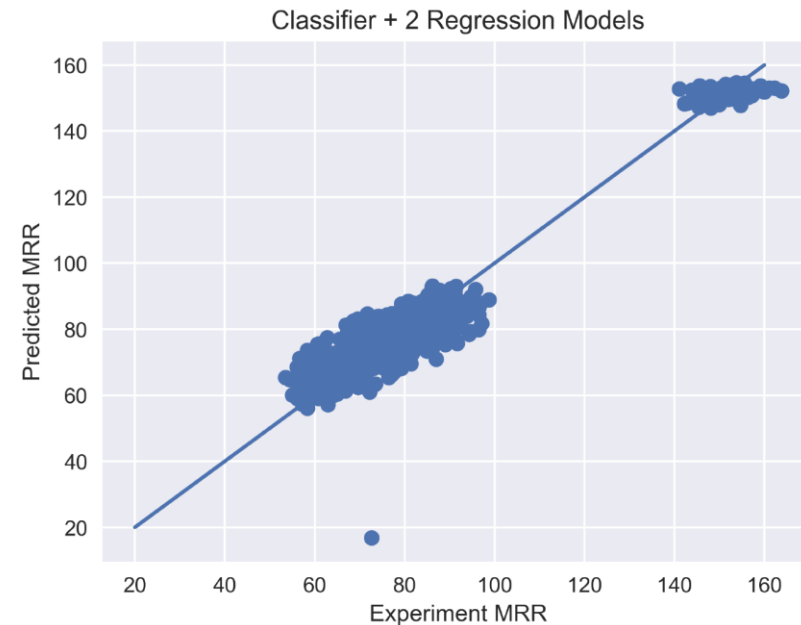
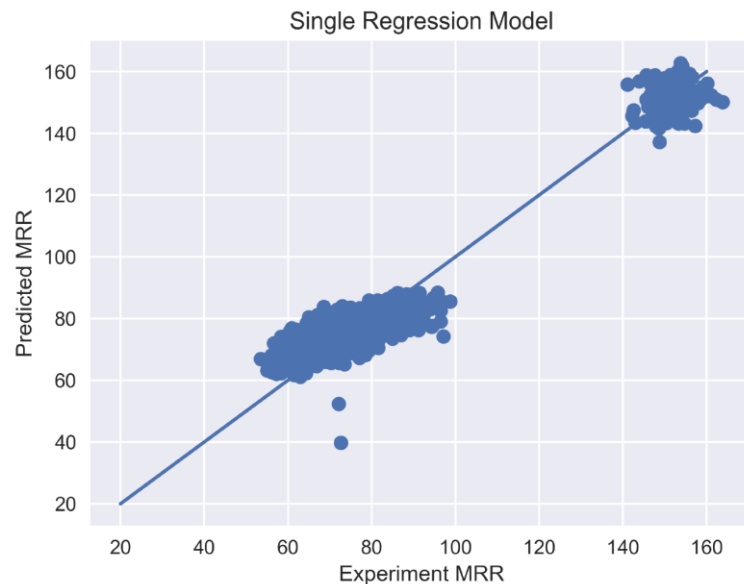
Classifier + 2 Regression Boosting Models

- Classification accuracy: 100%
- RMSE for test dataset: 3.57002
- No significant improvement than single regressor (3.84026)



Linear Regression Models

- Elastic net (combination of lasso and ridge)
- 5-fold cross validation to tune α and λ
- Single regressor model: RMSE 6.2143
- Classifier + 2 regressor model: RMSE 5.76161



Conclusions

- Tree-based boosting models (RMSE: 3.57002) outperform linear models (RMSE 5.2085)
- Classifier + 2 regressor improve boosting models slightly (~7% decrease in RMSE)
- Classifier + 2 regressor improve linear models slightly (~ 7% decrease in RMSE)

Thanks!
Any questions?