MATLAB EXPO

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Leveraging AI for Superior PV Energy Predictions: A User-Friendly Approach

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Eaton DERMS Offerings

Content

- Background
- AI No Code Low Code Workflow
- PV Analytics Methodology
- Results
- App Development
- Summary

Background

- **Problem Statement:**
  - Accurate forecasting of photovoltaic (PV) power generation is crucial for efficient grid management and energy planning. However, PV power output is highly variable due to weather conditions, seasonal changes, and geographic location. Traditional forecasting methods often struggle to handle this complexity, leading to suboptimal energy management and increased operational costs.
- **Proposed Solution:**
  - Leveraging the AI toolchain of MathWorks, including MATLAB and Simulink, to develop a robust PV power forecasting model. This solution will utilize machine learning (ML) and deep learning (DL) techniques to accurately predict PV power output.
  - Improved Accuracy: Leveraging advanced ML/DL techniques enhances the accuracy of PV power forecasts.
  - Scalability: The solution can be scaled to accommodate different geographic locations and varying data volumes.
  - Efficiency: Better forecasting leads to optimized grid management, reducing operational costs and improving energy efficiency.

Challenges in Implementing a PV Predictions System

Data quality and availability

Weather dependency

Model Complexity

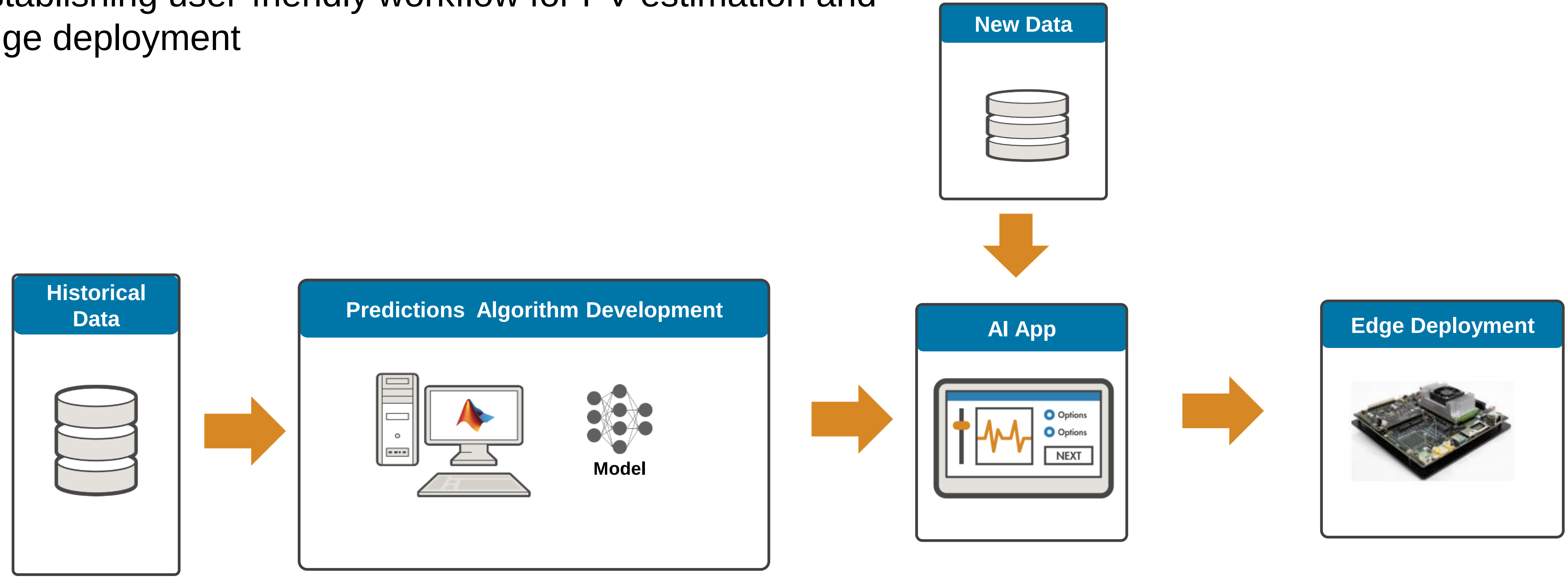
Maintenance & Updates

Integration and Deployment

Regulatory and Compliance Issues

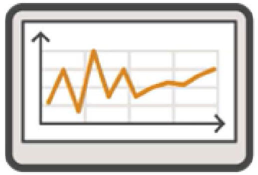
Use Case

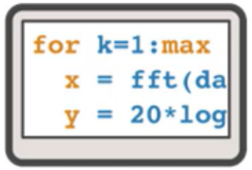
Establishing user-friendly workflow for PV estimation and edge deployment

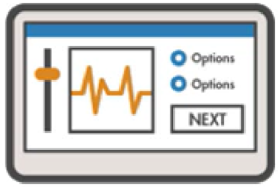


- Model Retraining
- PV Estimation

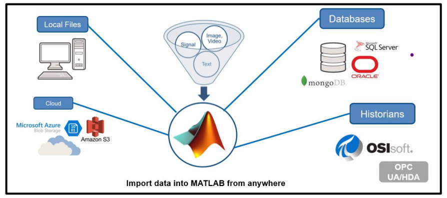
Low Code AI Workflow

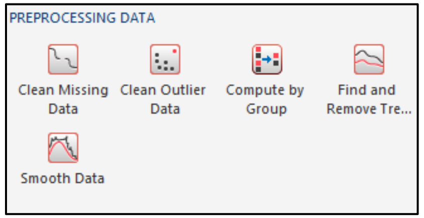


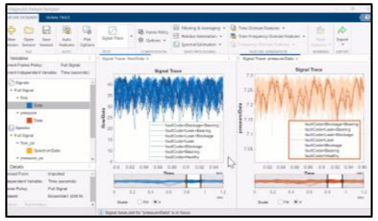


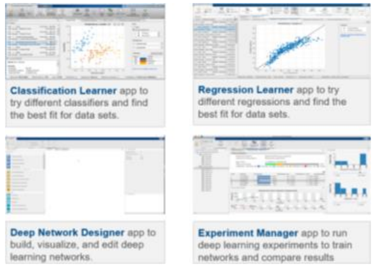


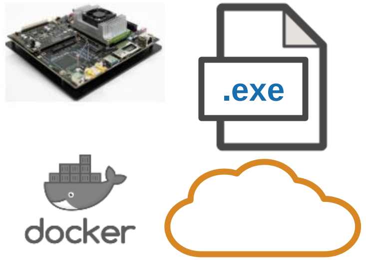
Acquire / Generate Data → Preprocess Data → Feature Engineering → Train Model → Deploy and Integrate





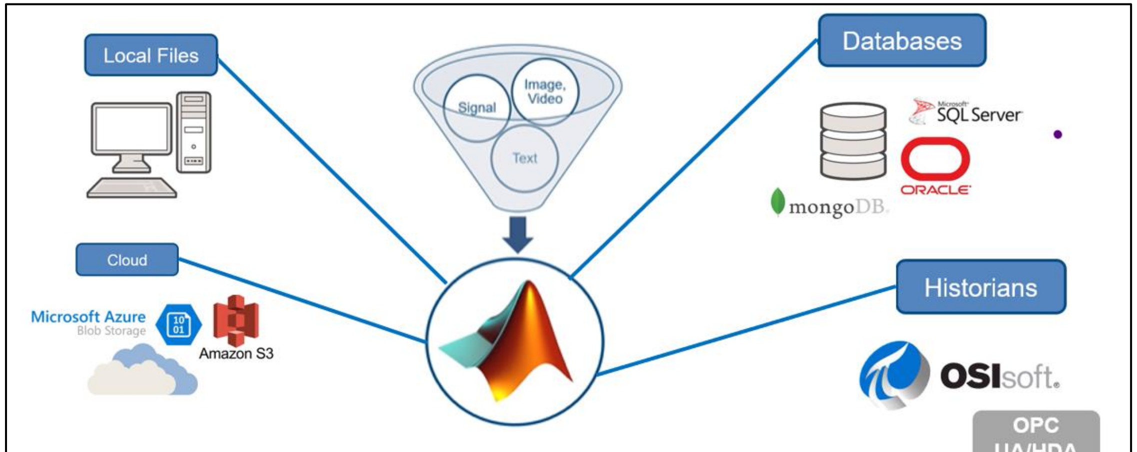




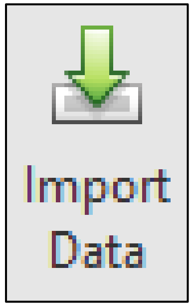


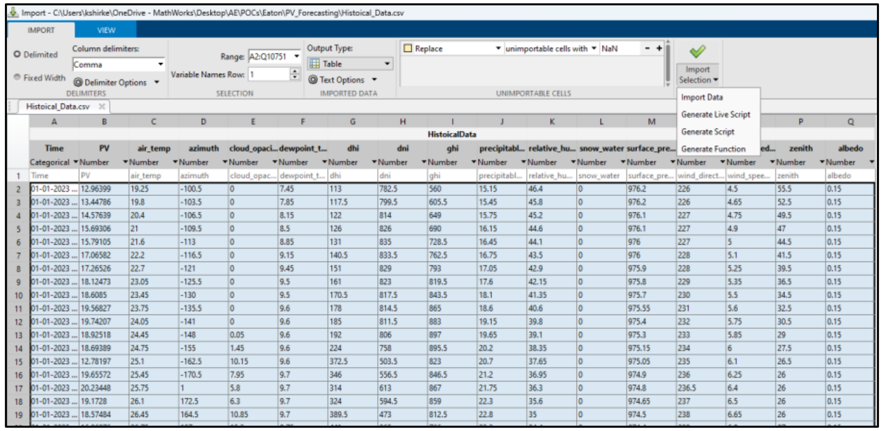
Photovoltaic Analytics Methodology

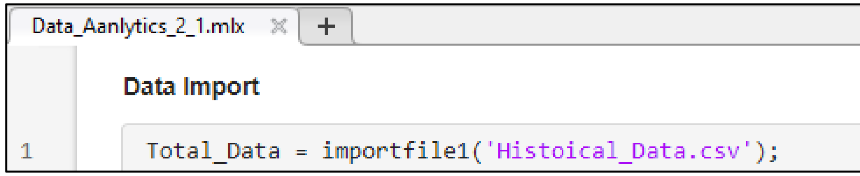
Acquire / Generate Data



Import data into MATLAB from anywhere







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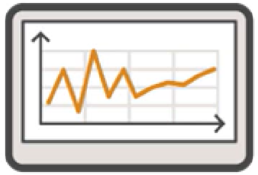
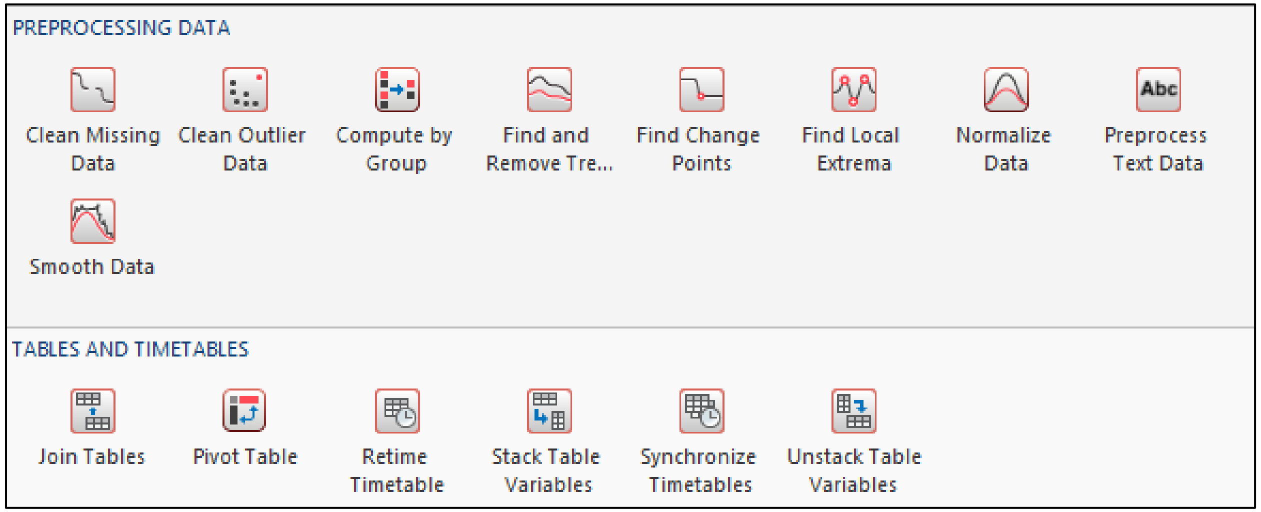
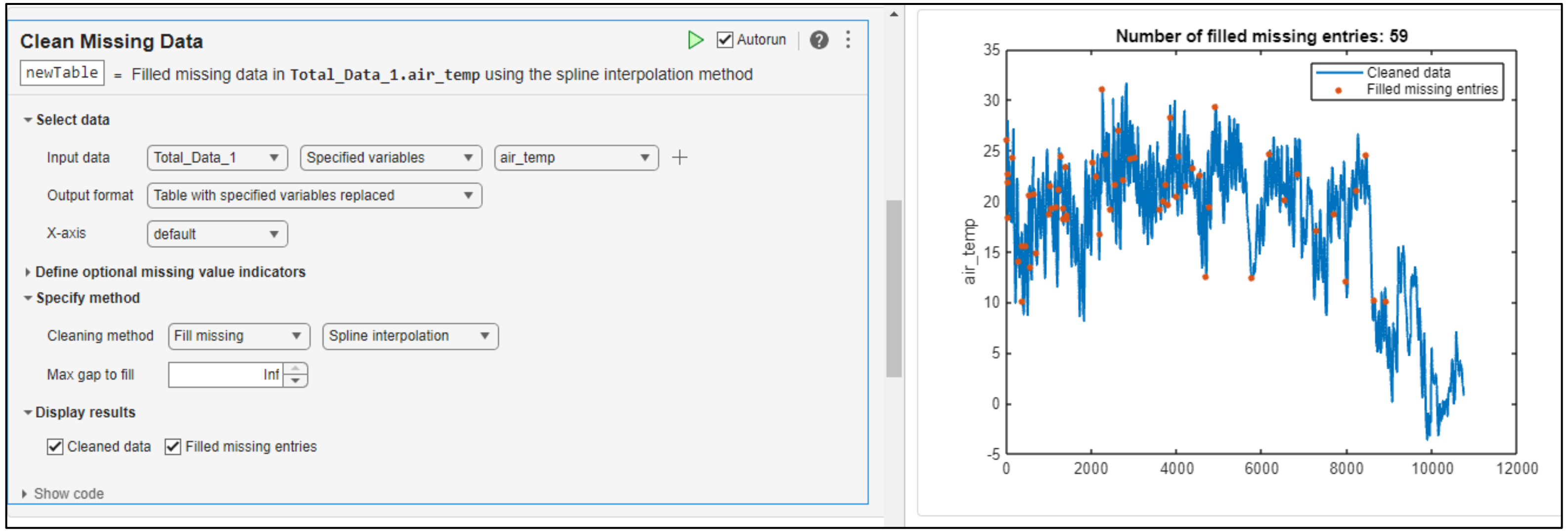
Data Preprocessing



Preprocess Data





Feature Engineering

Redundancy check

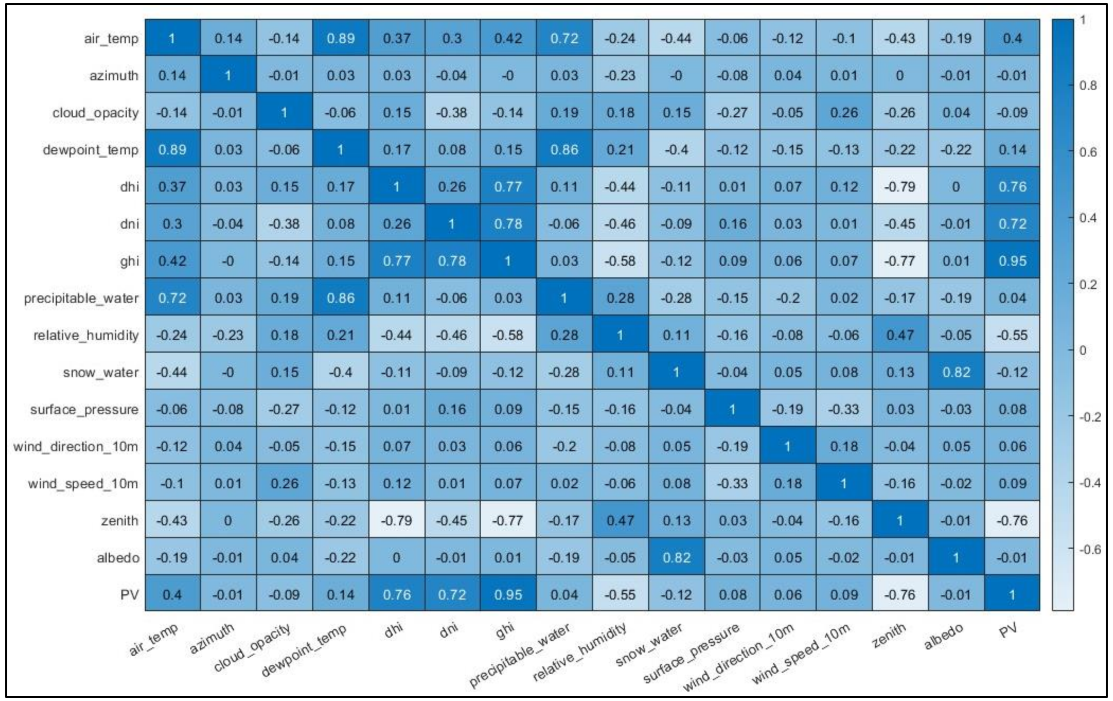
Feature Engineering

Correlation matrix of the feature

High correlation between two features suggests redundancy.

Why to remove redundant features?

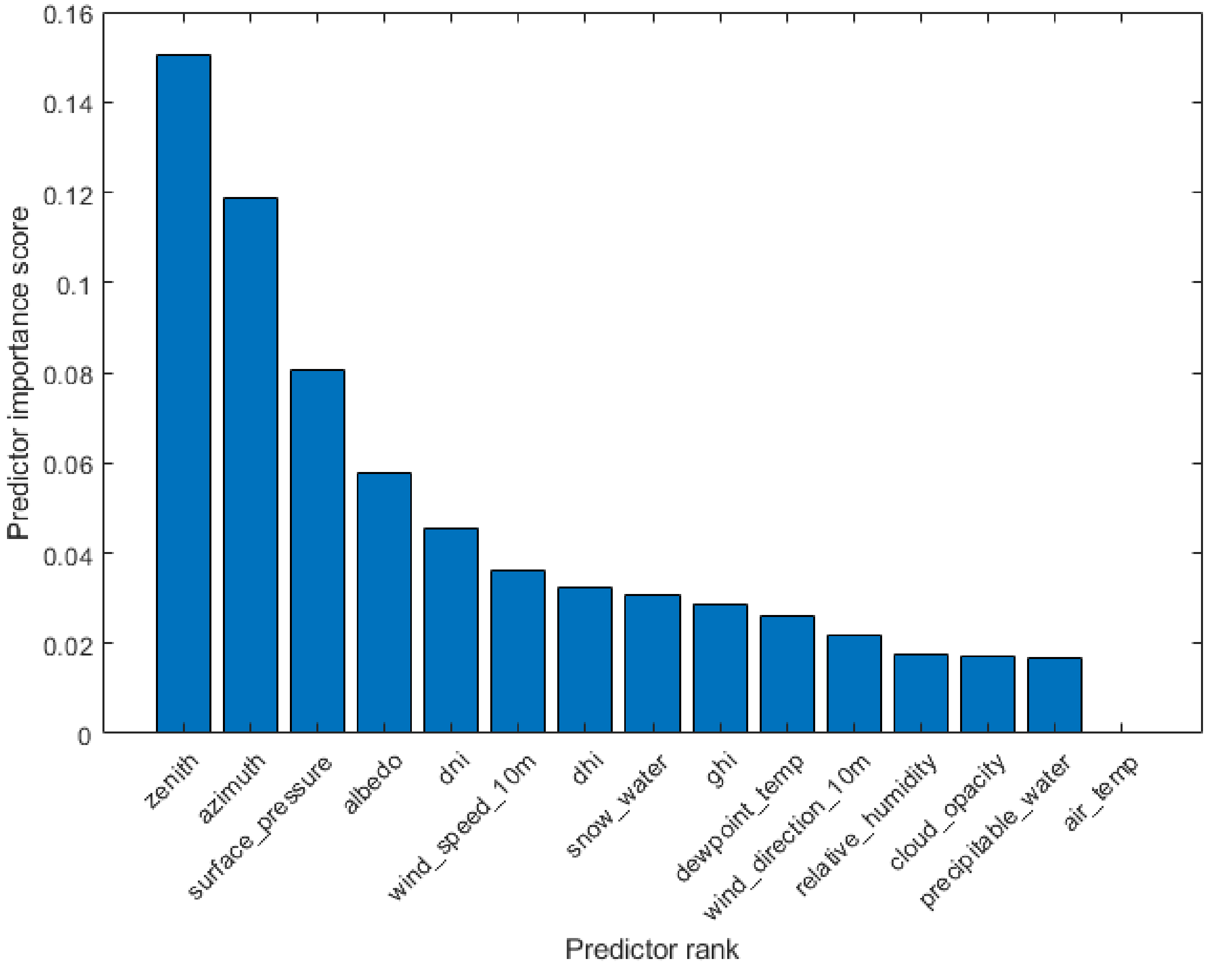
- Redundant features can cause the model to learn noise instead of the actual patterns
- Removing redundant features can simplify the model
- Fewer features mean less computational resources



Feature Engineering

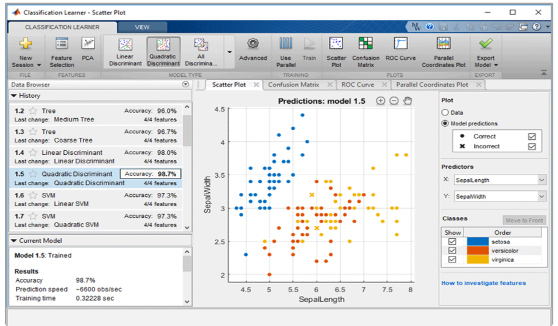
Relevance check

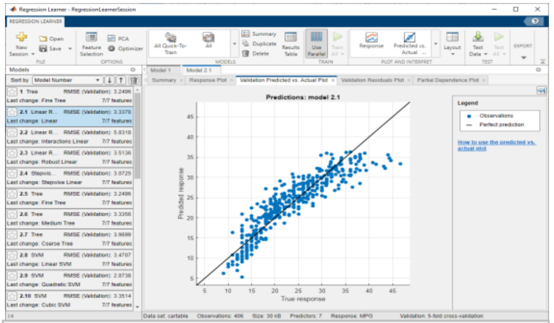
Feature Engineering



fscmrmr function : Rank features using minimum redundancy maximum relevance (MRMR) algorithm

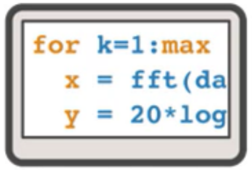
Model Training



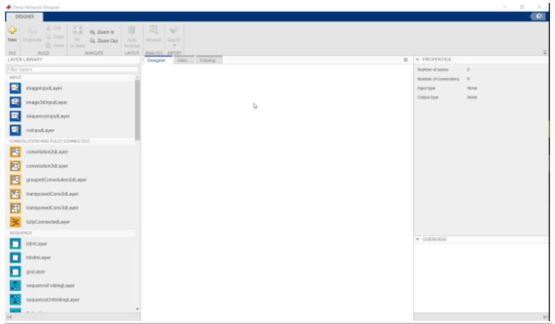


Classification Learner app to try different classifiers and find the best fit for data sets.

Regression Learner app to try different regressions and find the best fit for data sets.



Train Model

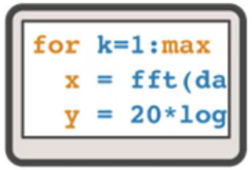


Deep Network Designer app to build, visualize, and edit deep learning networks.

Experiment Manager app to run deep learning experiments to train networks and compare results

The data is divided into training (70%) and testing dataset (30%)

Model Training



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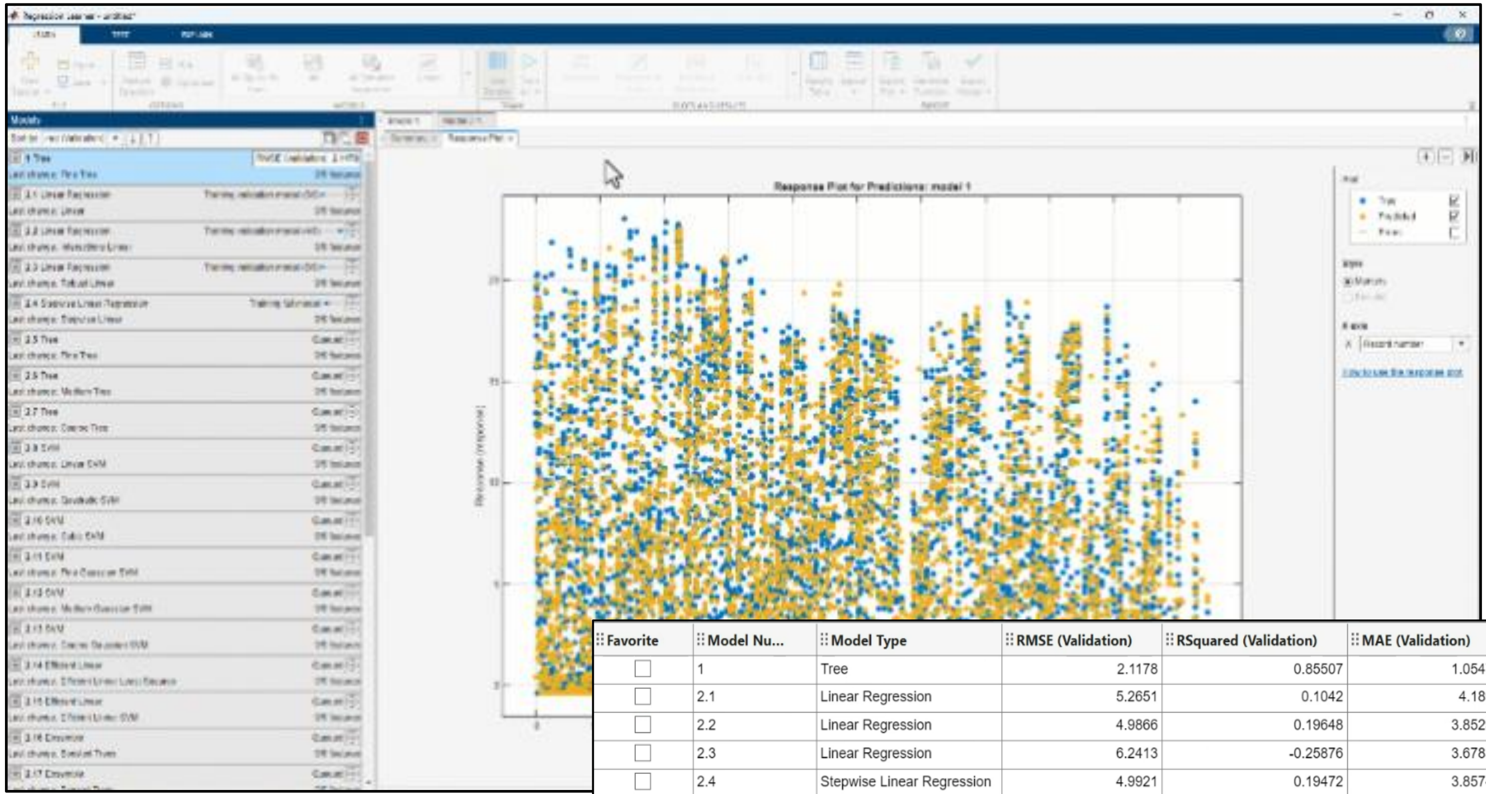
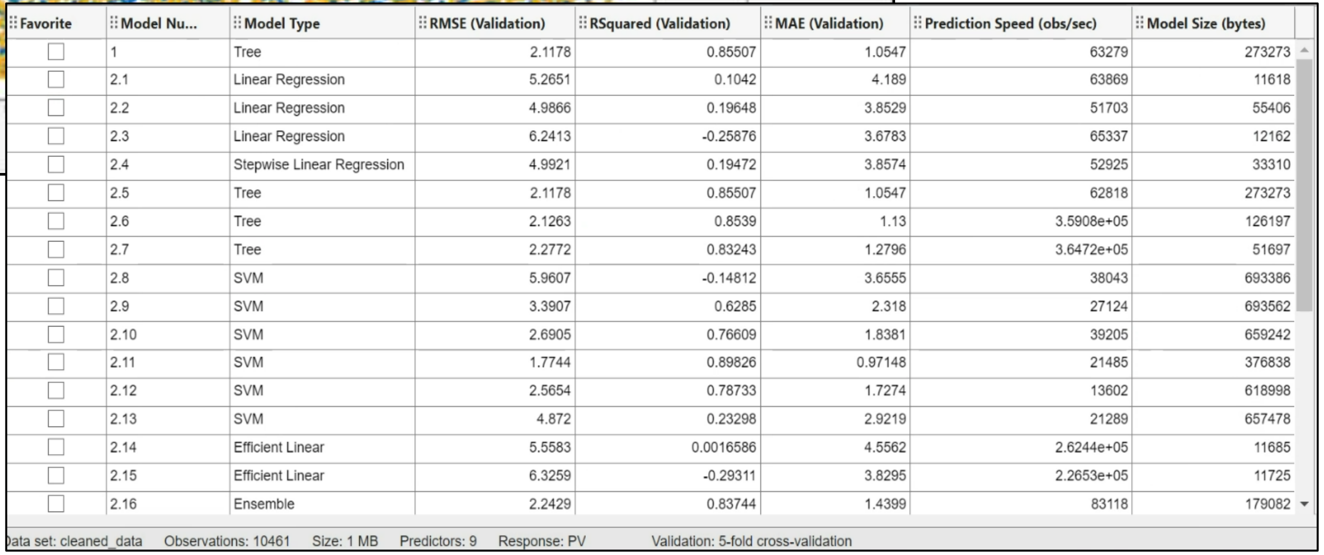
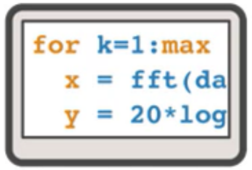


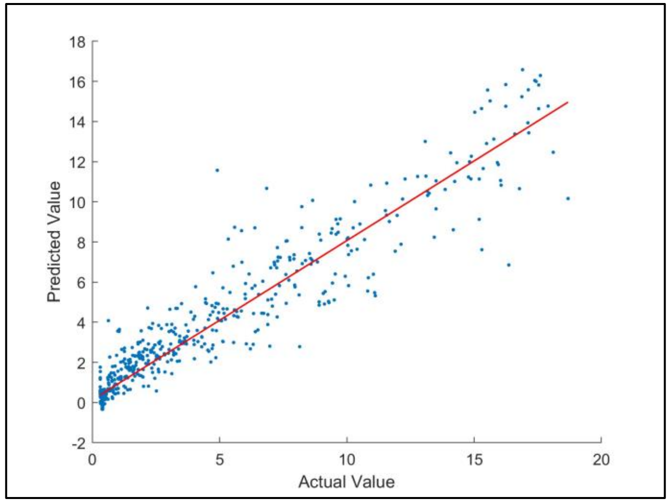


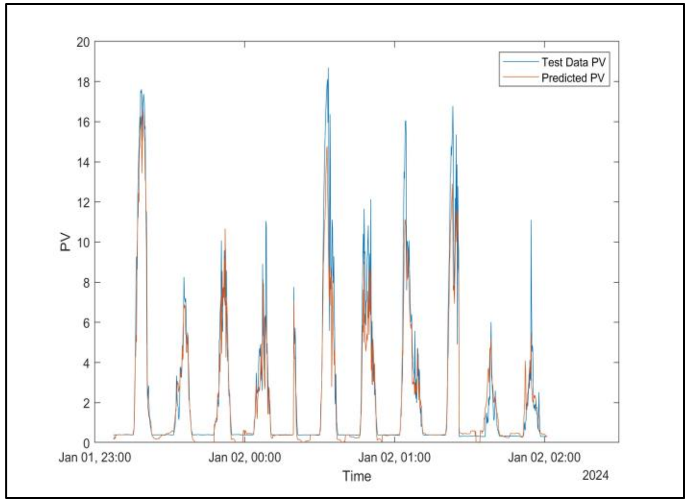
Favorite	Model Nu...	Model Type	RMSE (Validation)	RSquared (Validation)	MAE (Validation)	Prediction Speed (obs/sec)	Model Size (bytes)
☐	1	Tree	2.1178	0.85507	1.0547	63279	273273
☐	2.1	Linear Regression	5.2651	0.1042	4.189	63869	11618
☐	2.2	Linear Regression	4.9866	0.19648	3.8529	51703	55406
☐	2.3	Linear Regression	6.2413	-0.25876	3.6783	65337	12162
☐	2.4	Stepwise Linear Regression	4.9921	0.19472	3.8574	52925	33310
☐	2.5	Tree	2.1178	0.85507	1.0547	62818	273273
☐	2.6	Tree	2.1263	0.8539	1.13	3.5908e+05	126197
☐	2.7	Tree	2.2772	0.83243	1.2796	3.6472e+05	51697
☐	2.8	SVM	5.9607	-0.14812	3.6555	38043	693386
☐	2.9	SVM	3.3907	0.6285	2.318	27124	693562
☐	2.10	SVM	2.6905	0.76609	1.8381	39205	659242
☐	2.11	SVM	1.7744	0.89826	0.97148	21485	376838
☐	2.12	SVM	2.5654	0.78733	1.7274	13602	618998
☐	2.13	SVM	4.872	0.23298	2.9219	21289	657478
☐	2.14	Efficient Linear	5.5583	0.0016586	4.5562	2.6244e+05	11685
☐	2.15	Efficient Linear	6.3259	-0.29311	3.8295	2.2653e+05	11725
☐	2.16	Ensemble	2.2429	0.83744	1.4399	83118	179082

Data set: cleaned_data Observations: 10461 Size: 1 MB Predictors: 9 Response: PV Validation: 5-fold cross-validation

Model Evaluation





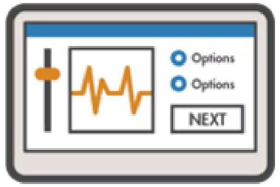


Train Model

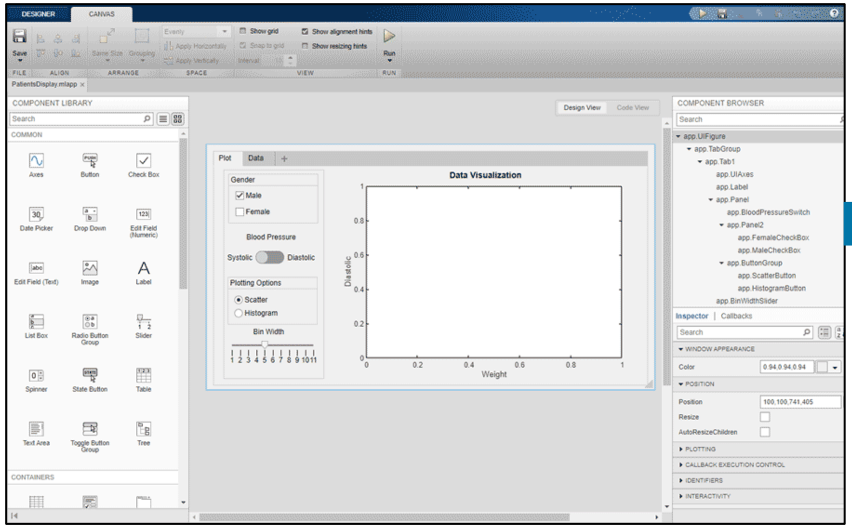
Matrices	Wide NN	Shallow NN	SVM	GPR	Bagged Tree	Boosted Trees	LSTM	CNN
RMSE	3.94	1.20	5.01	2.09	1.28	1.41	2.19	2.36
R-Squared	0.00	0.91	-0.62	0.72	0.90	0.87	0.69	0.64
MBE	-1.64	0.16	3.14	0.06	-0.36	-0.51	0.52	1.39
MDAE	1.93	0.61	5.29	0.94	0.21	0.23	1.58	1.20
MDAPE	332.40	91.50	544.54	185.05	40.69	39.70	187.01	129.18
SMAPE	132.17	67.74	134.25	95.48	45.00	42.15	97.29	74.24
MAE	2.79	0.84	4.66	1.46	0.65	0.70	1.72	1.71
MAPE	332.04	98.74	894.03	188.51	41.54	35.98	274.98	217.97

App Designer

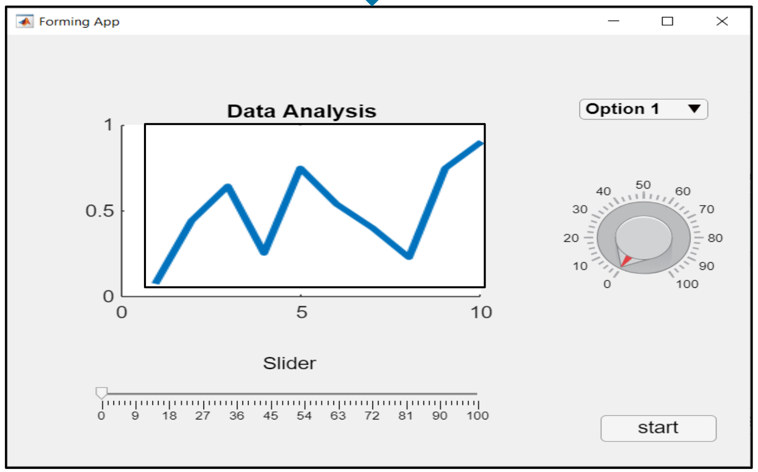
Building modern, full-featured applications using the rich set of components and custom interactions available in App Designer.



Develop UI App

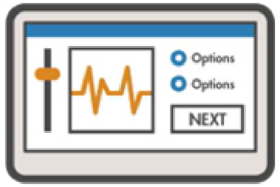


MATLAB Compiler



Create → Package → Share

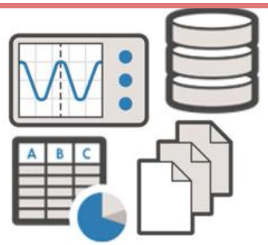
PV Analytics Methodology



Develop UI App

Conclusion

GUI



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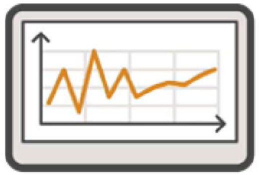
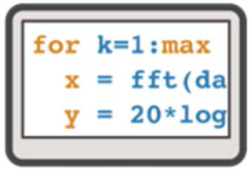


Preprocess Data

Feature Engineering



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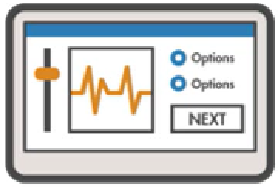

Deployment

MATLAB Analytics work with business <u>and</u> engineering data

MATLAB enables domain experts to do Data Science

MATLAB Analytics run anywhere

Supports end-to-end Workflow

Benefits and opportunities

- Faster Time To Market
- Ease in Development
- Ease in Deployment
- Streamlined Documentation
- Adherence to Standards / Compliance
- Continuous Verification

Way forward

Way forward

- Integrating into MBD approach workflow
- Hyper parameter tuning
- More options on code generation
- Integrating with multiple 3rd party APIs
- Advanced data integration
- Model enhancement (Hybrid models)

Q&A

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