High-quality clinical prediction models for individual assessment of post-transplant risks

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German-Canadian consortium on AI for improved kidney transplantation outcome

3nd International NephroCAGE Symposium, Aug 2, 2023

Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag

Agenda

- Data extraction and quality
- Endpoints and ML models
- Iterative training
- Deployment
- Future work and conclusion

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Development of Clinical Prediction Models (CPM)

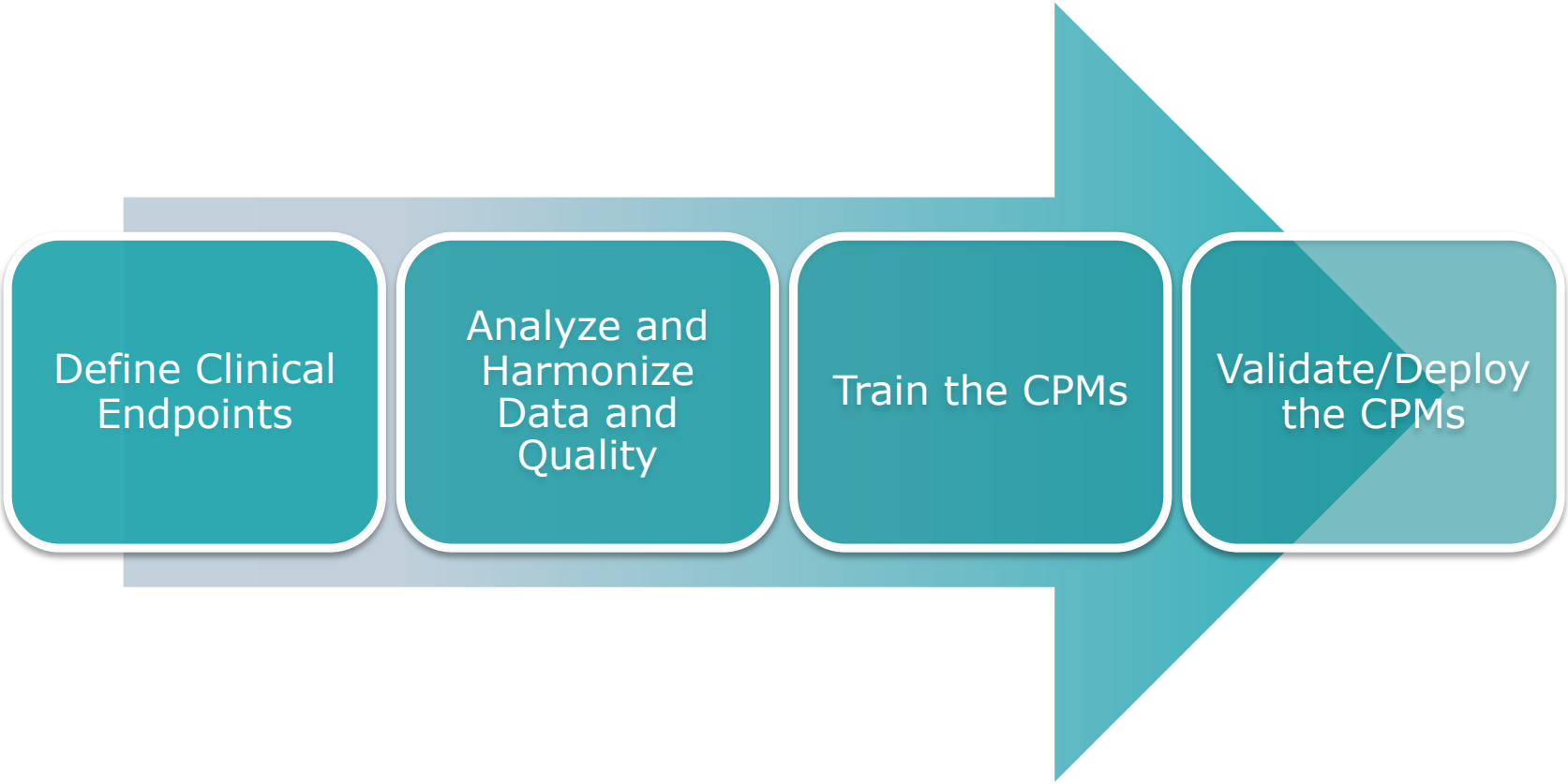

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Chart **3**

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Clinical Endpoints

- Various inter-disciplinary workshops to identify various patient outcomes.
- Risk endpoints created from patient outcomes
- Divided in various time windows
- Takes into account variable **censoring**

		Risk window		
		Short	Medium	Long
Endpoints	Graft Failure	<3	<5	<8
	Rejection	<1		<5
	Hospitalization	<1	<3	<5
	Infection	<3	<5	<8

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Clinical NephroCAGE Dataset

- **Data quality** validation with interoperable data dictionary(https://nephrocage.github.io/data_dictionary/#baseline)
- Two Kinds of datasets:
  - **Minimal Dataset (DI)** includes features readily available
  - **Extended dataset(DII)**: including features requiring more effort in extractiom
- Duration: 1998-2020
- Total (n= 8539)

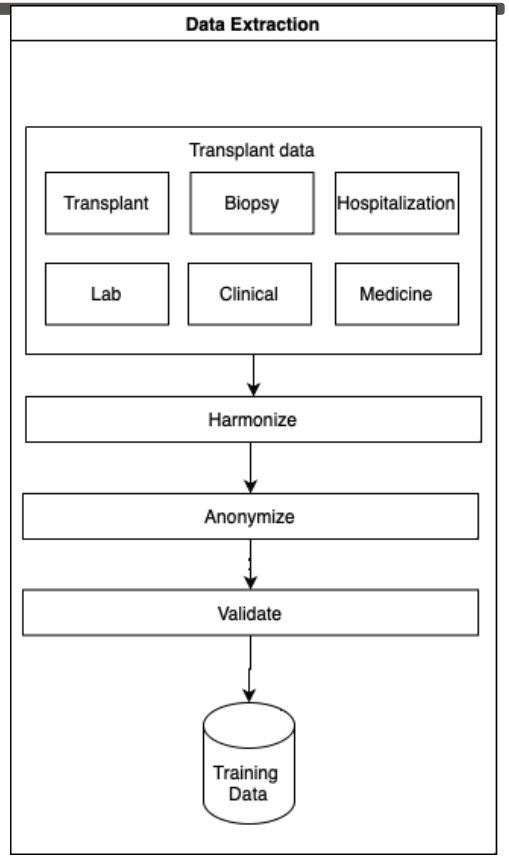

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Chart **5**

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Data analysis

Parameter	Center A	Center B	Center C
time period	1998-2020	2012-2019	2011-2019
N	4742	415	401
Recipient			
male (%)	62.4	66.6	64.4
Age at transplantation (years)	51.3 ± 14	55.5 ± 12.4	57.9 ± 12.8
Previous transplant (%)	12.9	0	0
Donor			
Age (years)	52.4 ±14.8	54.0 ± 15.5	48.6 ± 14.7
Female (%)	49.8	46.5	48.3
Transplant			
Cold ischemia time (hours)	8.6 ± 5.9	13.7 ± 7.9	8.8 ± 5.3

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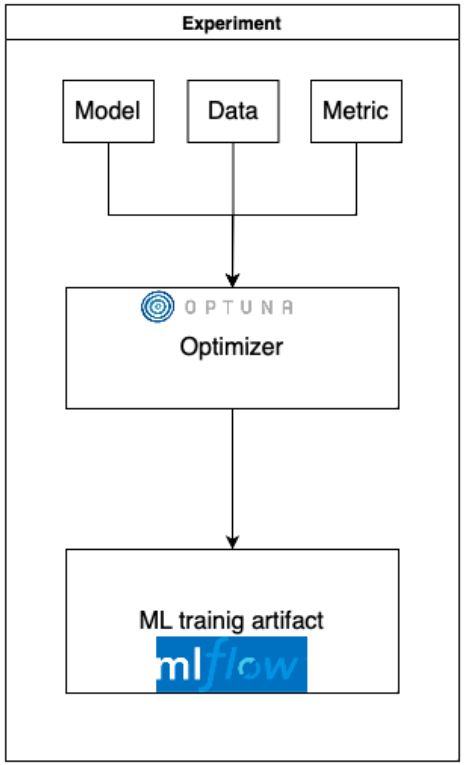
Reproducible Model training

- Iterative Model optimized logged as **Experiments** on **MLFLOW** server setup for all partners
- Progressively add variable form DS I + DSII
- Final performance is **validated** on independent test set and at other sites



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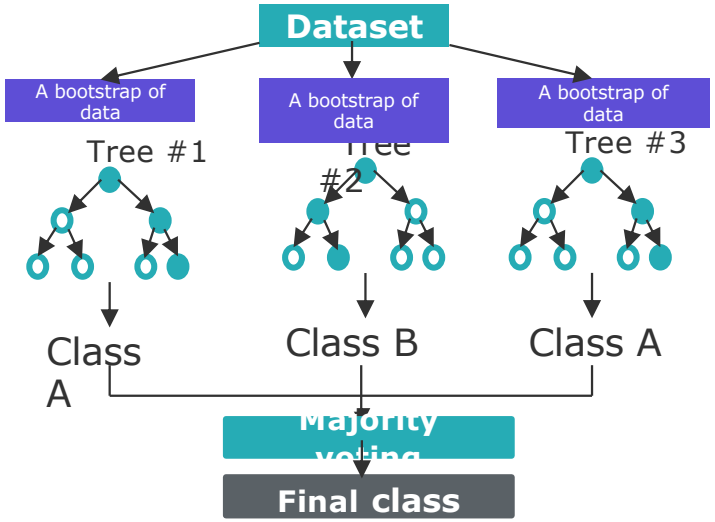
ML models

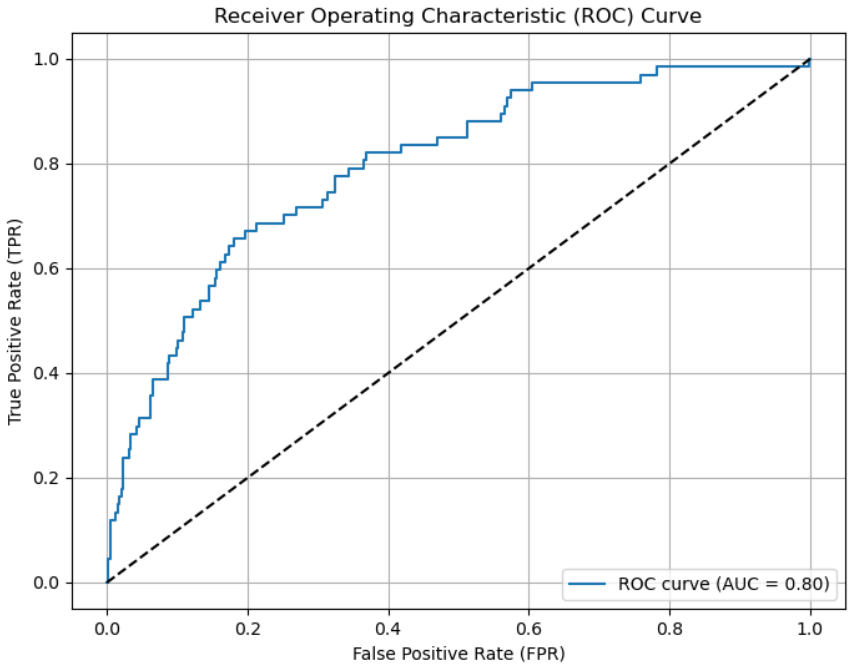
- Requirements for CPMs
  - Explainability
  - Structured data
  - Handle data imbalance
- Models Selected
  - Random Forest
  - Gradient boosting trees
  - XGBoost
- Metrics
  - AUC score – better for probability based decision
  - Precision – better for class-based decision



- Guo, Rui, et al. "Degradation state recognition of piston pump based on ICEEMDAN and XGBoost." *Applied Sciences* 10.18 (2020): 6593.

Result

- End point: Graft failure < 5
- Model: Xgboost
- Data: Baseline Transplant
- Most important feature:
  - Delayed Graft function
  - Donor Type
  - AGE



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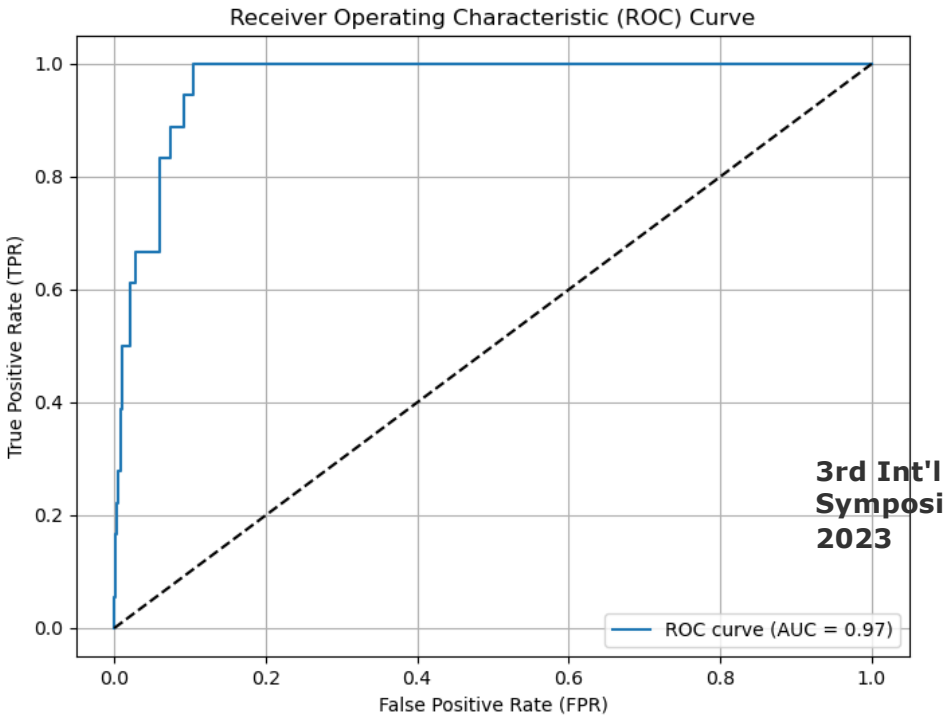
Result

- End point: Graft failure < 3 years
- Model: Xgboost
- Data: Transplant + lab +hosp
- Most important feature:
  - EGFR Median
  - Creatinine median
  - Total hospitalization duration



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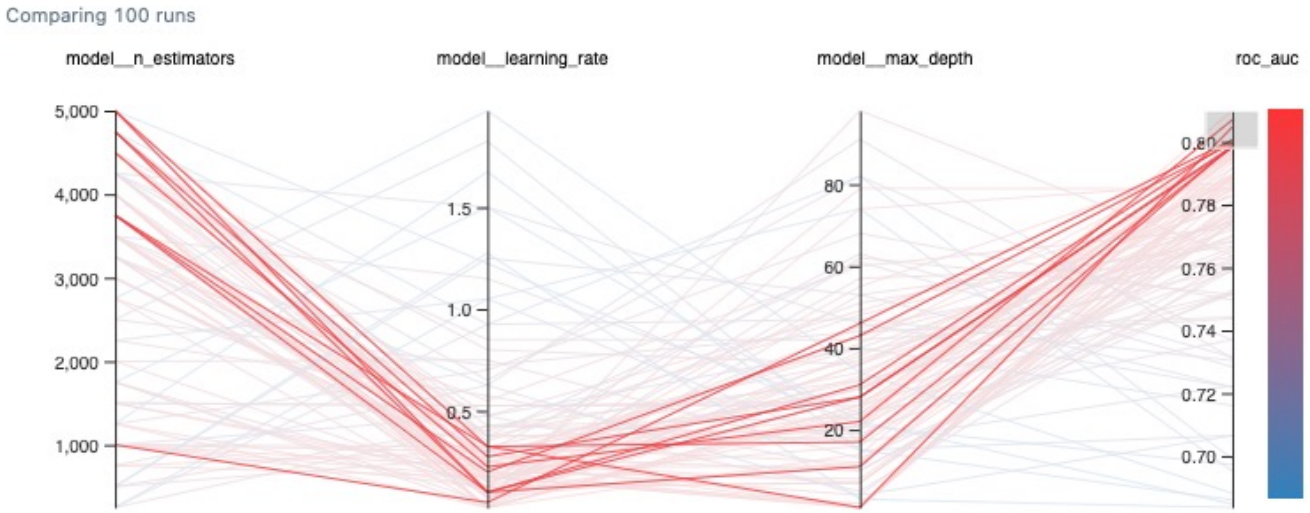
Result – Hyper parameter tuning

- XGB, <5 years, baseline + lab + hosp
- Lower learning rate nd high max depth leads to high roc, auc score
- Multiple trees with high-depth leads



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Imbalance dataset

- Oversampling and undersampling to balance the classes
- Tune balancing paramter in the model
- Higher percentage of minority class leads to better ROC

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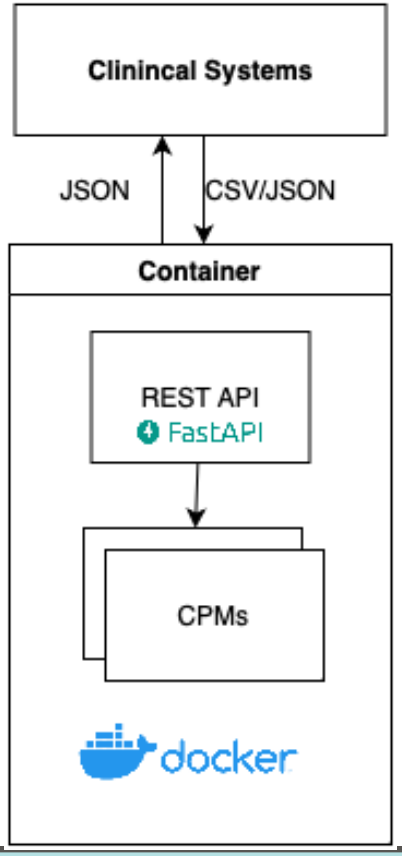
Deployment

- Rest API Services for **Trained CPMs** on new patient data hosted at charité
- Automatic set up – Docker
- Low Maintainability – CPM auto update from MLFLOW
- Can be deployed on local – More control and secured



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Lessons Learned

- Understanding the perspective of nephrologists is crucial in deriving good-quality models.
- Data cleaning and quality is the most challenging aspect.
- Experiment with various methods of federated model aggregation and training needs more research
- Train multiple models with different sub-cohort
- Deploy often and early.
- Learn more about NephroCAGE at: https://nephrocage.org

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