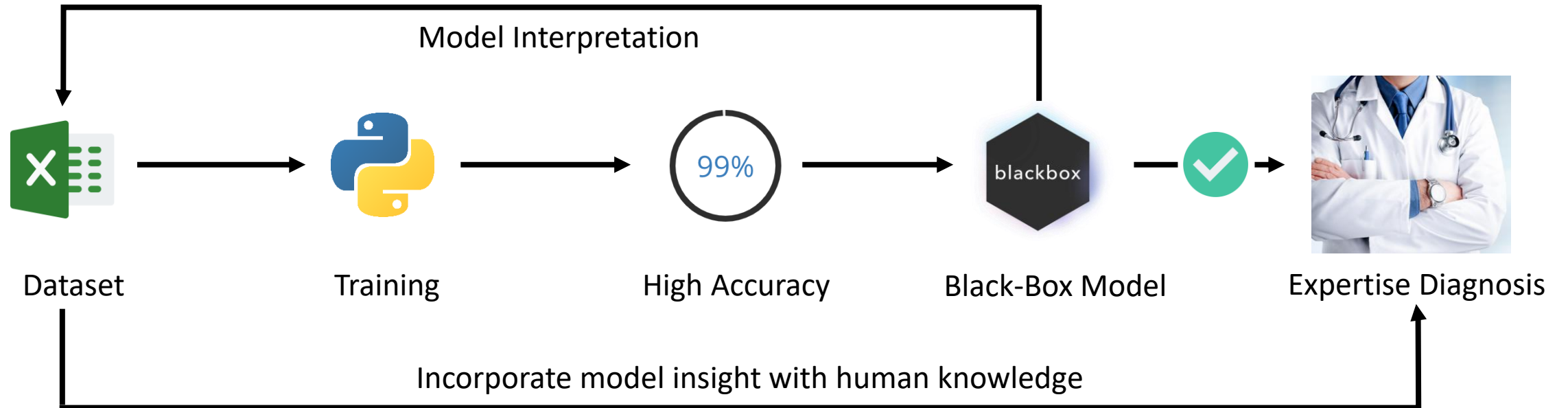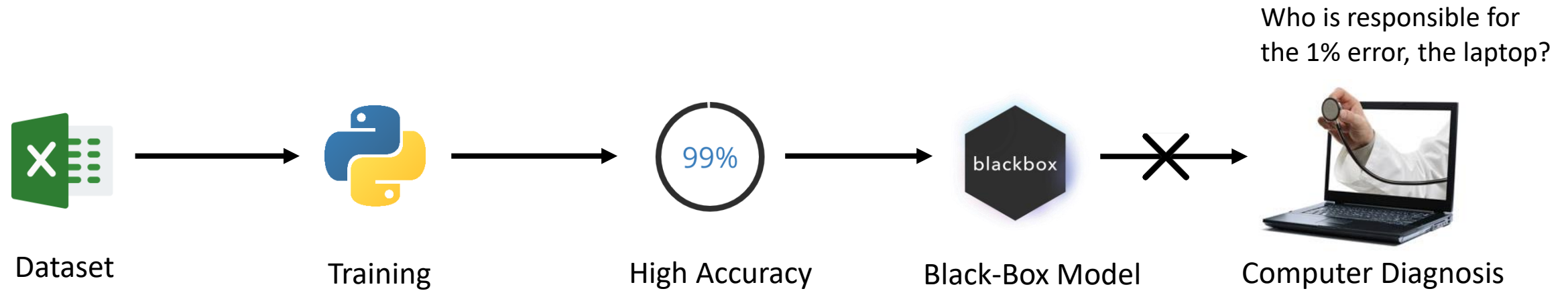# Interpretable Machine Learning for COVID-19:

An Empirical Study on Severity Prediction Task

- Background
- Dataset & Models
- Interpretation
- Conclusion

Background

Background

Dataset → Training → High Accuracy (99%) → Black-Box Model (blackbox) ✗→ Computer Diagnosis

Who is responsible for the 1% error, the laptop?

Model Interpretation

Dataset → Training → High Accuracy (99%) → Black-Box Model (blackbox) → ✓ → Expertise Diagnosis

Incorporate model insight with human knowledge

Dataset & Models

Dataset & Models

Dataset Description

Source Code

Preprocessing

1. Remove clinical irrelevant columns ['MedNum', 'No']
2. Remove columns that have no data ['LVEF', 'SO2', 'PO2', 'YHZS', 'RML', 'RUL', 'RLL', 'LUL', 'LLL']
3. Remove columns with fewer records ['Onset2Admi', 'Onset2CT1', 'Onset2CTPositive1', 'Onset2CTPeak']
4. Remove patients that have incomplete records. [Height == "", cTnl == ""]

Train Test Split (86 patients, 21 severe, 65 normal, with 55 features)

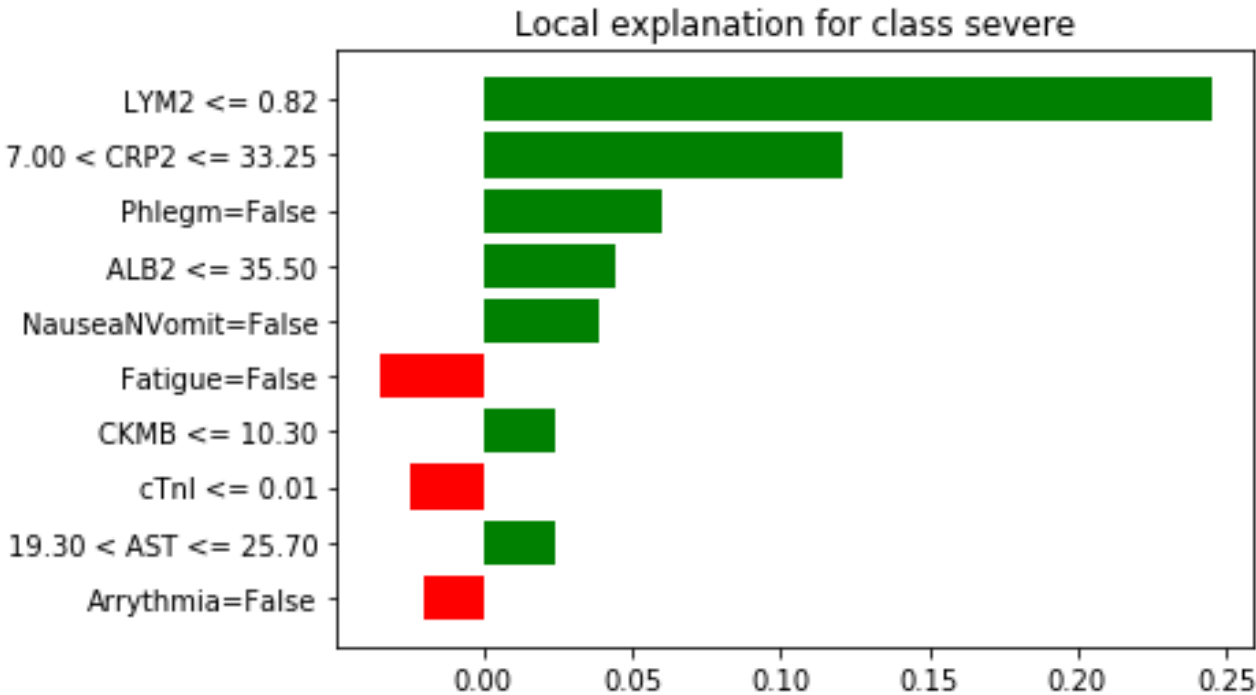1. 90% as Training Set, 10% as Testing Set
2. Five folds Cross Validation

In this research, we focus on model **interpretation**. **Interpretation** gives us valuable insights even if these are not 99% perfect models.

Classifier	Cross Validation	Test Set			95% confidence-interval
------------------------------------	F1	Precision	Recall	F1	------------------------------
Decision Tree	0.56	0.67	0.50	0.57	0.307
Random Forest	0.64	0.56	0.25	0.33	0.324
XGBoost	0.62	0.78	1.00	0.80	0.271
Neural Network	0.53	0.78	1.00	0.80	0.271

Interpretation

Correct Predictions

Local explanation for class severe

Feature	Value
LYM2	0.46
CRP2	22.20
Phlegm=False	True
ALB2	35.30
NauseaNVomit=False	True
Fatigue=False	True
CKMB	8.30
cTnI	0.01
AST	19.70
Arrythmia=False	True

Prediction probabilities

normal	0.02
severe	0.98

Feature	Patients Data	Normal Range	Conclusion
LYM <= 0.82	0.46	(1.1, 3.2)	↓
CRP (7.00, 33.25)	22.20	(0, 5)	↑
No Phlegm	**True**	**-**	**No Symptom**
ALB <= 35.50	*35.30*	*(35, 55)*	*Normal*
No Nausea and Vomit	**True**	**-**	**No Symptom**
CKMB <= 10.30	*8.30*	*(0, 18)*	*Normal*
AST (19.30, 25.70)	19.70	(29, 35)	↓

Feature	Patients Data	Normal	Conclusion
No Fatigue	True	-	Normal
cTnI <= 0.1	0.01		
No Arrythmia	True	-	Normal

No Phlegm, No Nausea and Vomit is more likely to turn severe?

This is counterintuitive, but corroborated by medical research months later after the outbreak of the pandemic.

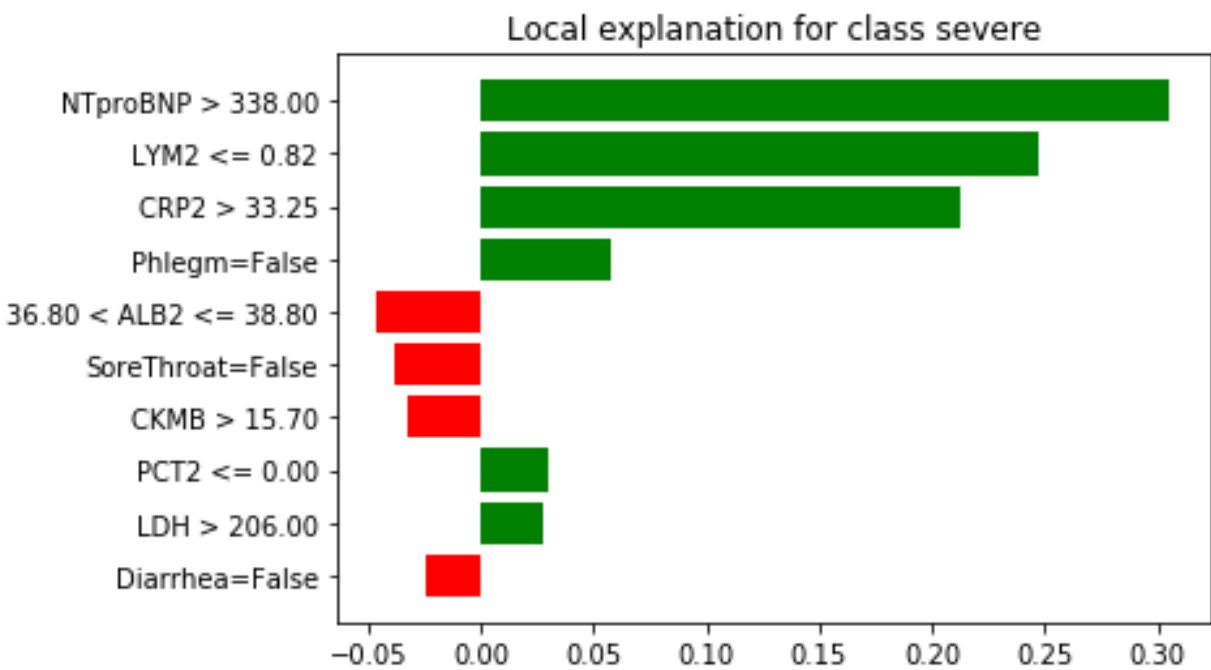Z. Xu, L. Shi, Y. Wang, J. Zhang, L. and etc. "Pathological findings of COVID-19 associated with acute respiratory distress syndrome," Lancet Respir Med, vol. 8, no. 4, pp. 420–422, 04 2020

Local explanation for class severe
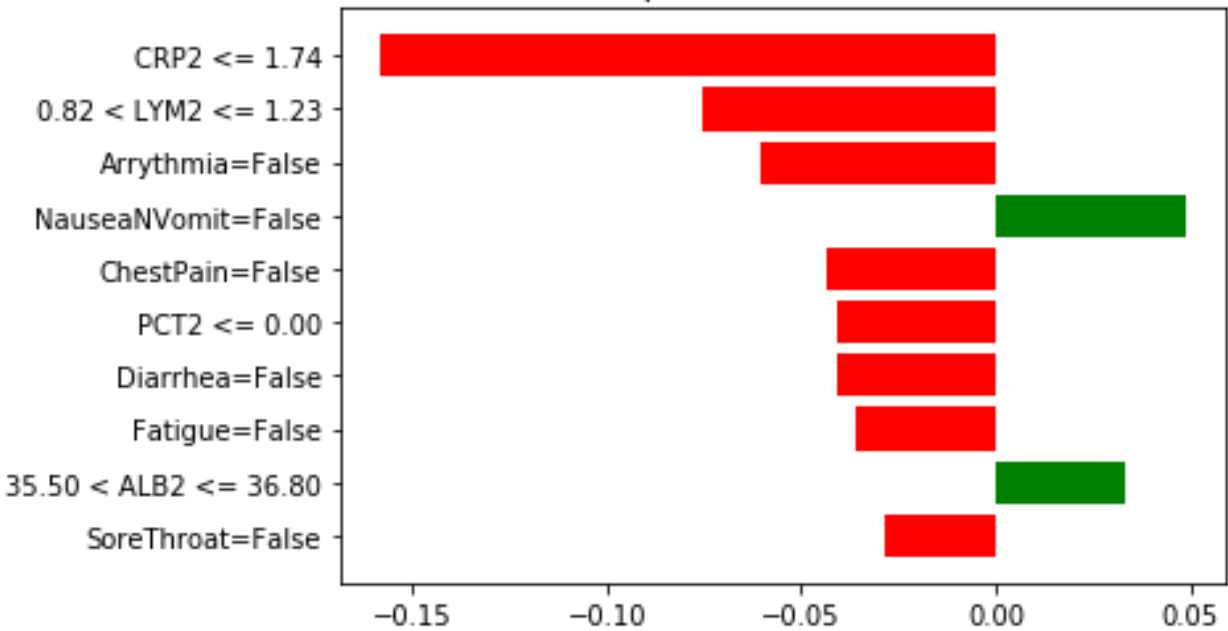
Feature	Value	Prediction probabilities
CRP2	0.46	normal 0.97
LYM2	0.84	severe 0.03
Arrythmia=False	True	
NauseaNVomit=False	True	
ChestPain=False	True	
PCT2	0.00	
Diarrhea=False	True	
Fatigue=False	True	
ALB2	36.50	
SoreThroat=False	True	

Feature	Patients Data	Normal Range	Conclusion
No Nausea and Vomit	**True**	**-**	**No Symptom**
ALB (35.50, 36.80)	*36.50*	*(35, 55)*	*Normal*

Our models notice that without some specific symptoms may indicate a higher probability of turning severe.

Feature	Patients Data	Normal	Conclusion
CRP <= 1.74	0.46	(0, 5)	Normal
LYM (0.82, 1.23)	**0.84**	**(1.1, 3.2)**	↓
No Arrythmia	True	X	
No ChestPain	True	X	
PCT <= 0.00	0.00	(0, 0.5)	Normal
No Diarrhea	True	X	
No Fatigue	True	X	
No SoreThroat	True	X	

Wrong Predictions

Local explanation for class severe

NTproBNP > 338.00	
LYM2 <= 0.82	
CRP2 > 33.25	
Phlegm=False	
36.80 < ALB2 <= 38.80	
SoreThroat=False	
CKMB > 15.70	
PCT2 <= 0.00	
LDH > 206.00	
Diarrhea=False	

Feature	Value
NTproBNP	475.00
LYM2	0.81
CRP2	78.76
Phlegm=False	True
ALB2	37.60
SoreThroat=False	True
CKMB	17.90
PCT2	0.00
LDH	263.00
Diarrhea=False	True

Prediction probabilities

normal	0.42
severe	0.58
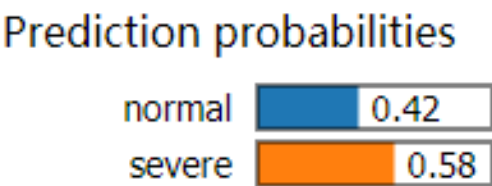
Feature	Patients Data	Normal Range	Conclusion
NTproBNP > 338.00	475.00	(0, 300)	↑
LYM <= 0.82	0.81	(1.1, 3.2)	↓
CRP > 33.25	78.76	(0, 5)	↑
No Phlegm	**True**	-	
PCT	*0.00*	*(0, 0.5)*	*Normal*
LDH	263.00	(109, 245)	↑

Feature	Patients Data	Normal Range	Conclusion
ALB (36.80, 38.80)	37.60	(35, 55)	Normal
No SoreThroat	True	-	Normal
CKMB > 15.70	17.90	(0, 18)	Normal
No Diarrhea	True	-	Normal

A normal patient is diagnosed as sever by our models.
But actually he is indeed severe from medical tests.

Conclusion

Conclusion

➤ Elderly people are more likely to turn severe.

The average age of severity level [0 – 3]: 36.8 --> 47.5 --> 54.3 --> 69.4

Interpretation

● Inflammation Indicators： High CRP (Virus Infection)

● Blood Routing Examination： Low LYM

● Biomarker： High LDH, Low ALB

● Symptoms： No Phlegm， No diarrhea, No Nausea and Vomit