



MUNI
MED



LESS LABELING, MORE INSIGHT

*HOW SELF-SUPERVISED LEARNING LETS AI LEARN ECGS WITH
MINIMAL EXPERT ANNOTATIONS*

Richard Ředina, 11. 11. 2025, Olomouc

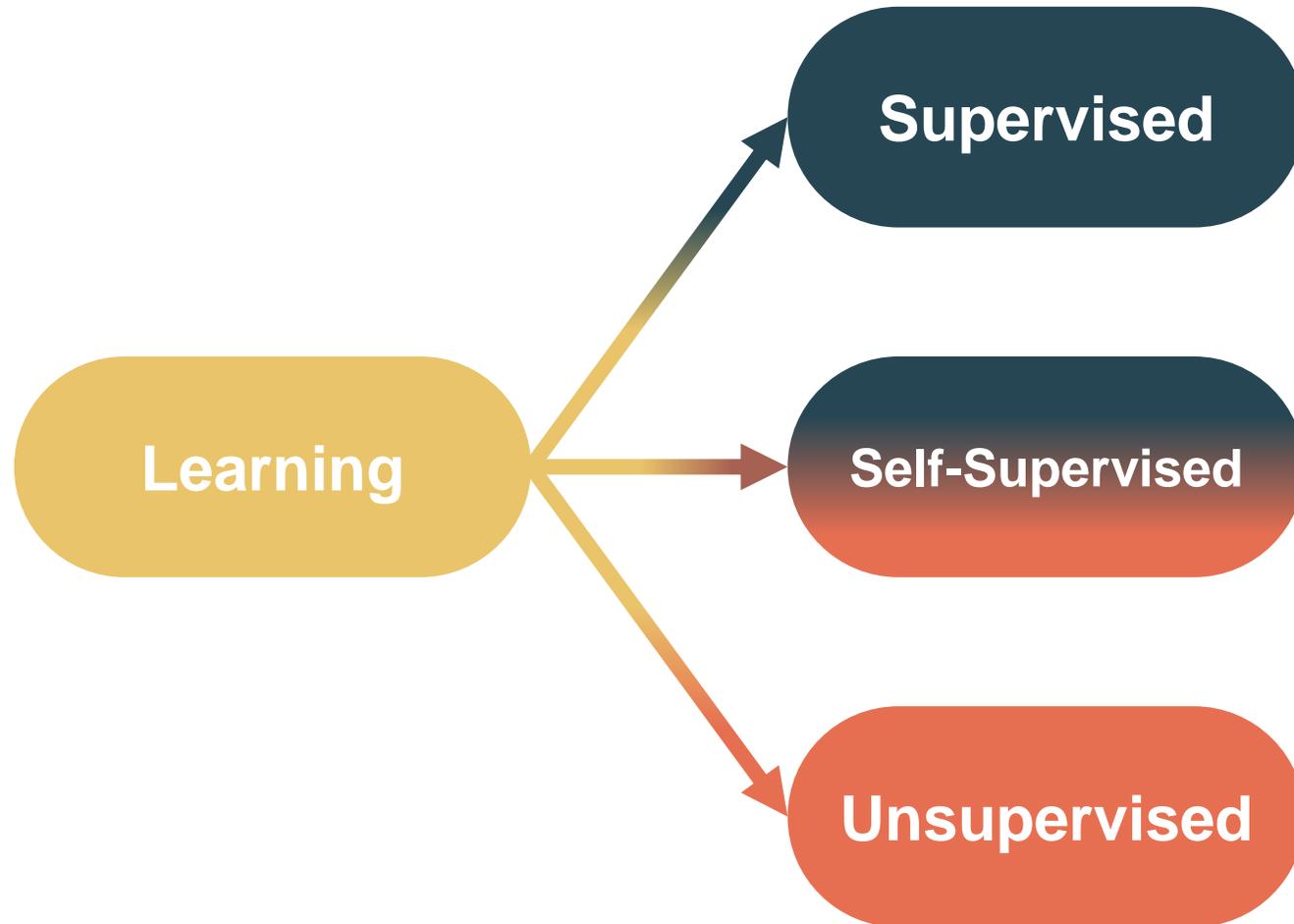
Jakub Hejč, Zdeněk Stárek

The Annotation Problem

- Teacher-Student analogy
- Underfitting/Overfitting
- Bias
- **Importance of expert annotation**



AI Learning



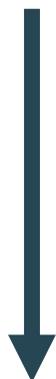
- **Predicts labels**

- **Uncovers the data's logic**

- **Discovers patterns**

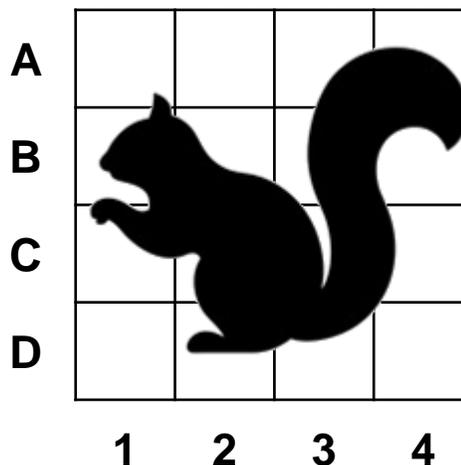
...in a Kid's World....

SUPERVISED



SQUIRREL

SELF-SUPERVISED



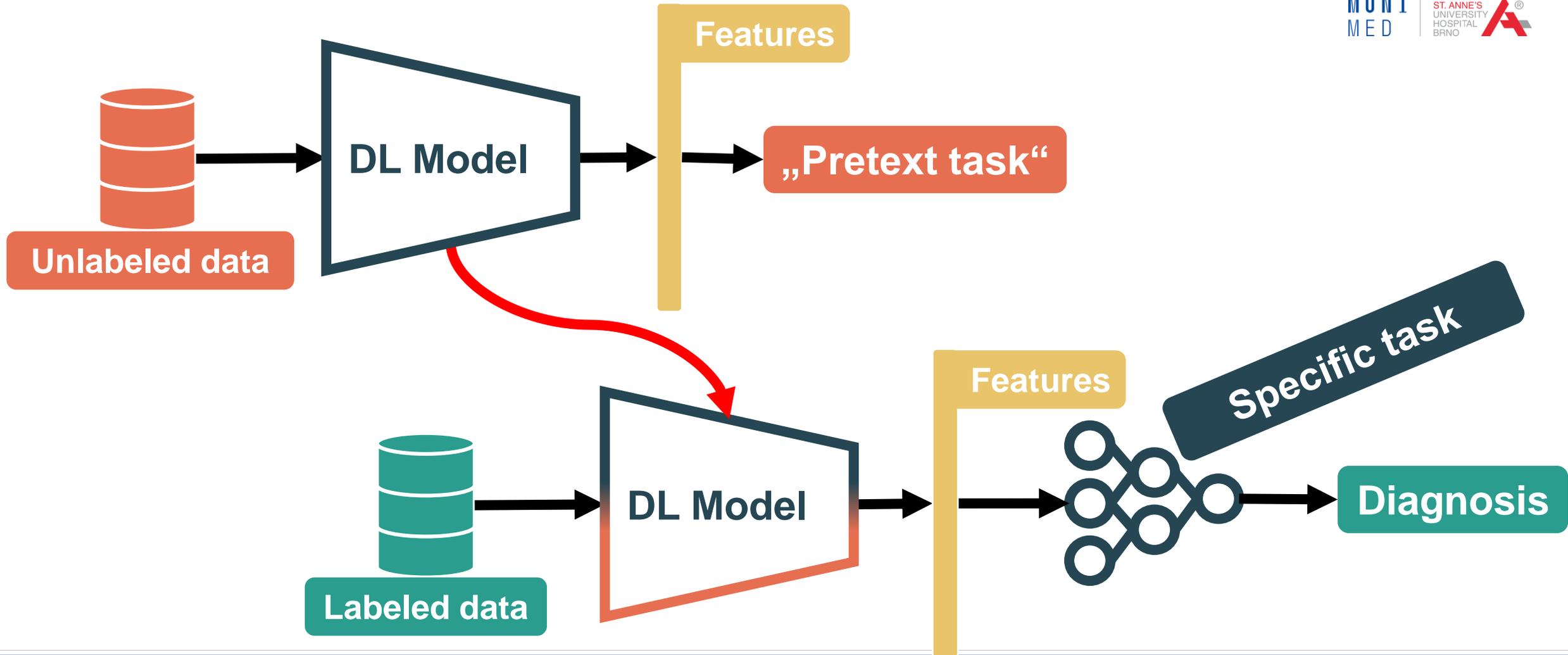
D2

UNSUPERVISED



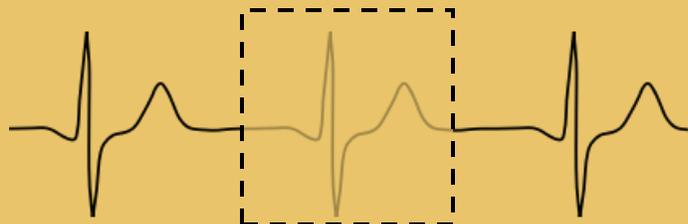
**3 animals with 4 legs
2 animals with wings**

SSL framework

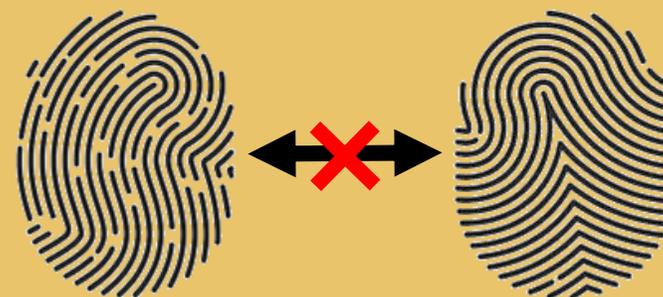


Usage Examples

ECG RANDOM MASKING



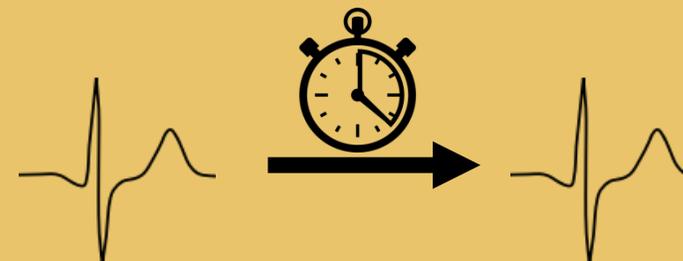
PATIENT FINGERPRINTING



LEAD RECONSTRUCTION

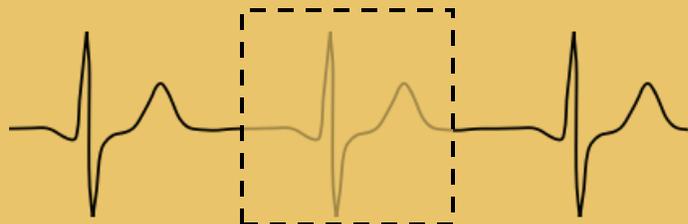


LONGITUDINAL LEARNING



Usage Examples

ECG RANDOM MASKING



PATIENT FINGERPRINTING



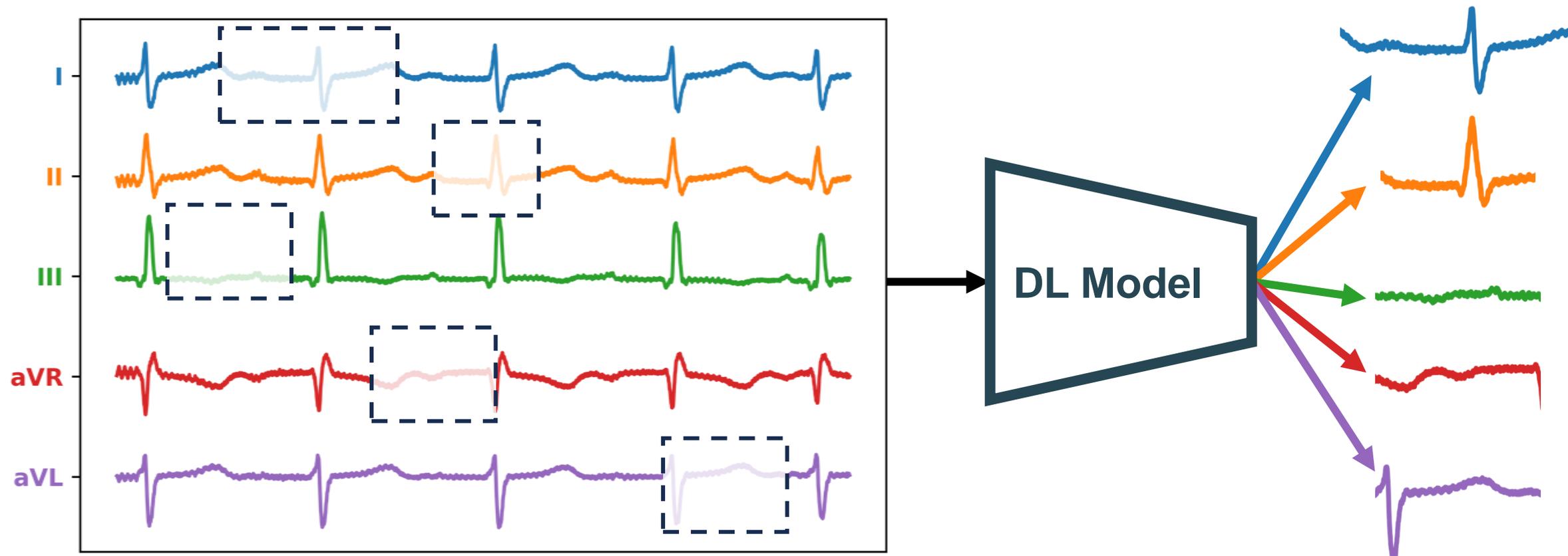
LEAD RECONSTRUCTION

I → II, III, aVL, ...

LONGITUDINAL LEARNING



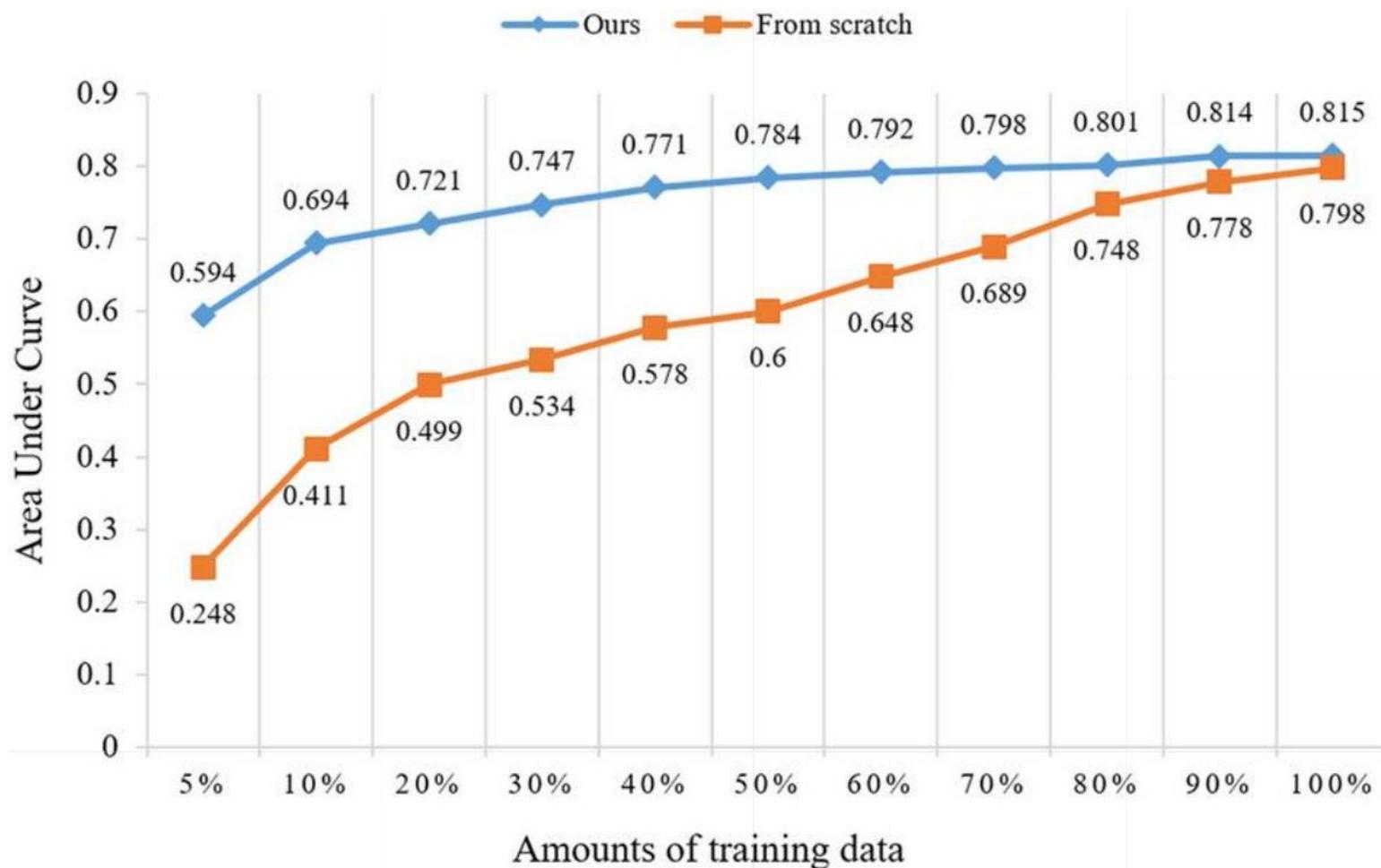
ECG Random Masking



ECG Random Masking – study

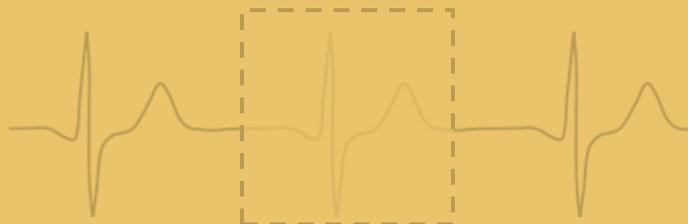
F1-score	LSTM	Bi-LSTM	VGG-16	Resnet-18	Resnet-34	DenseNet	Presented
Supervised	0.568	0.567	0.541	0.639	0.647	0.650	0.659
Pretrained	0.571	0.577	0.589	0.655	0.658	0.659	0.664

ECG Random Masking – study

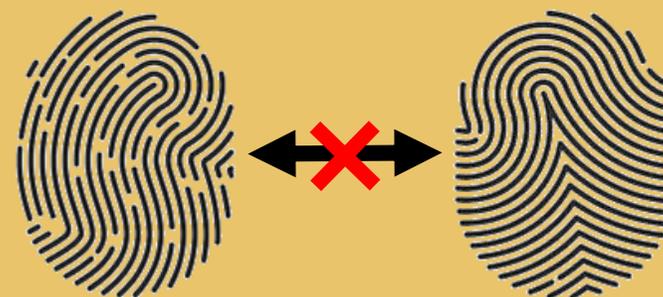


Usage Examples

ECG RANDOM MASKING



PATIENT FINGERPRINTING



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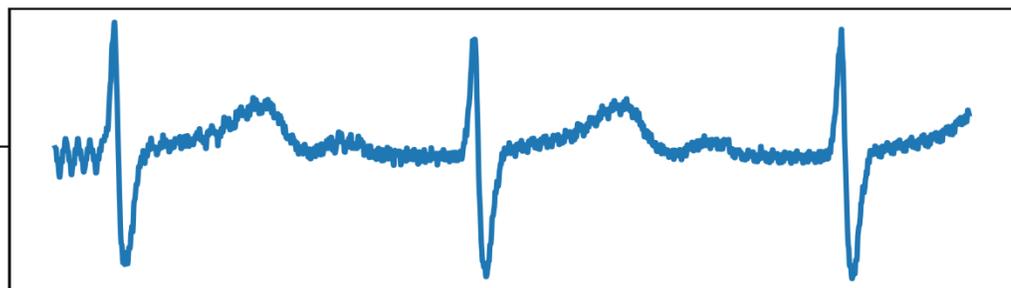
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LONGITUDINAL LEARNING

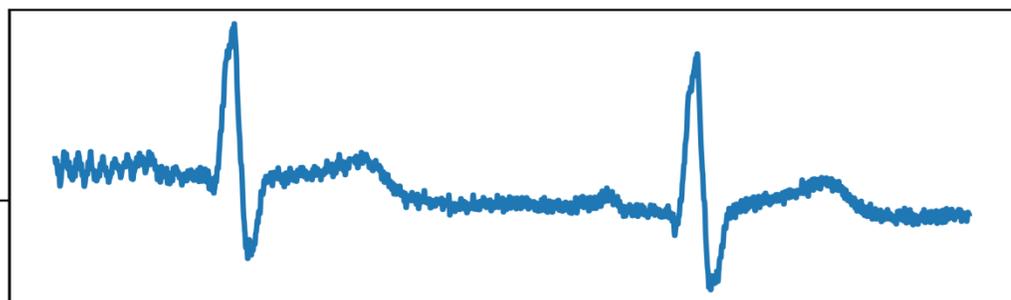


Patient Fingerprinting

PATIENT I



PATIENT II

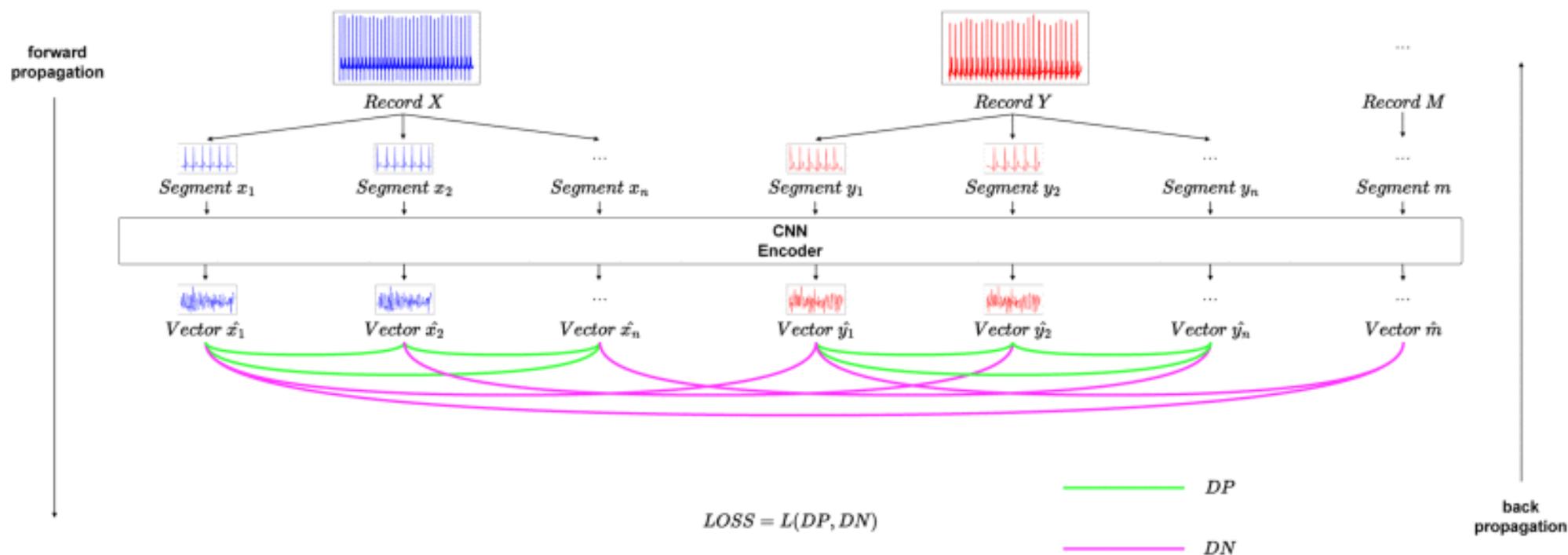


DL Model

Contrastive
learning

*Captures patient-based
features*

Patient Fingerprinting – study

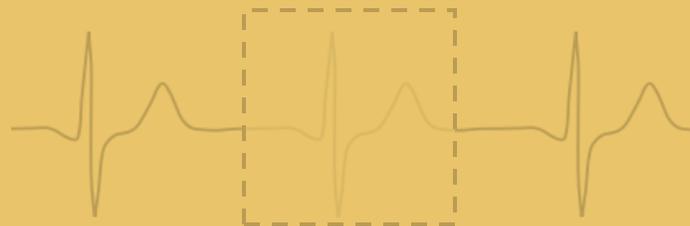


Train ACC \approx 97 %

Test ACC \approx 93 %

Usage Examples

ECG RANDOM MASKING



PATIENT FINGERPRINTING



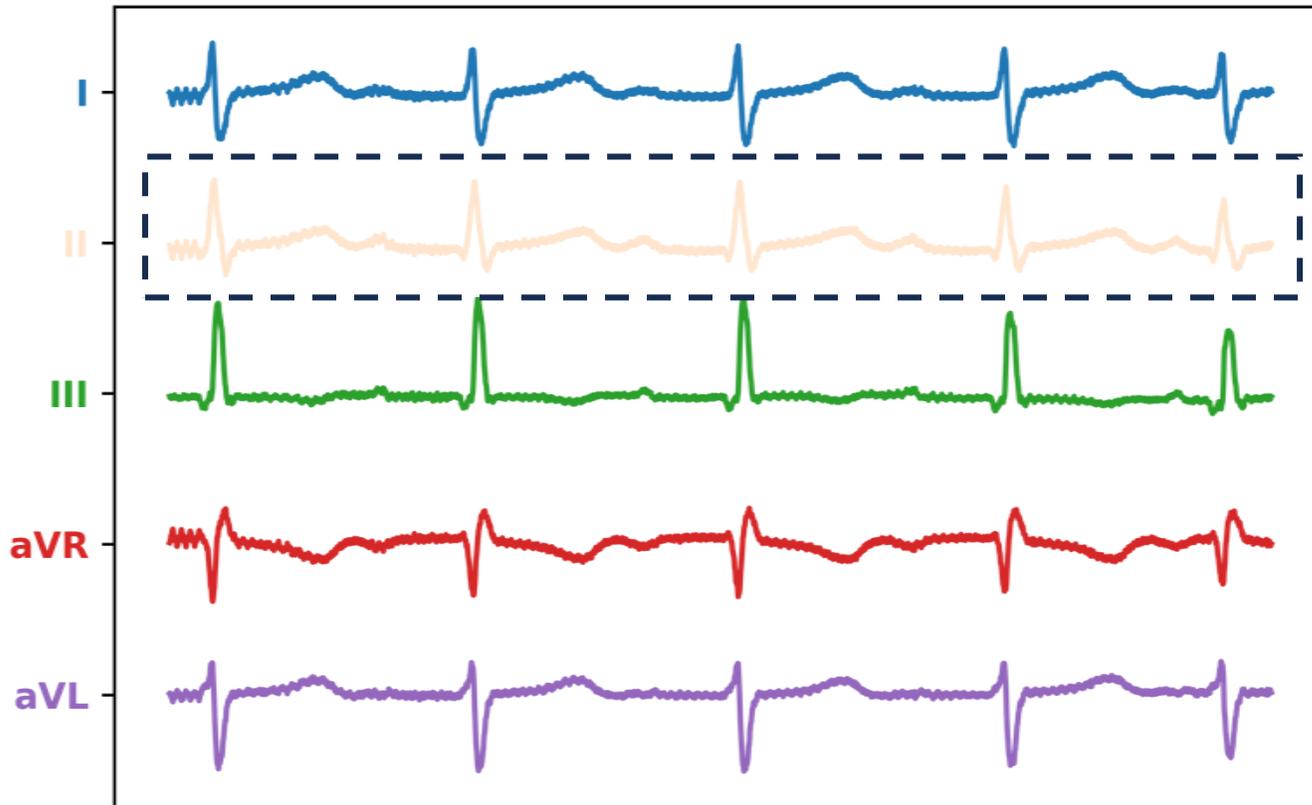
LEAD RECONSTRUCTION



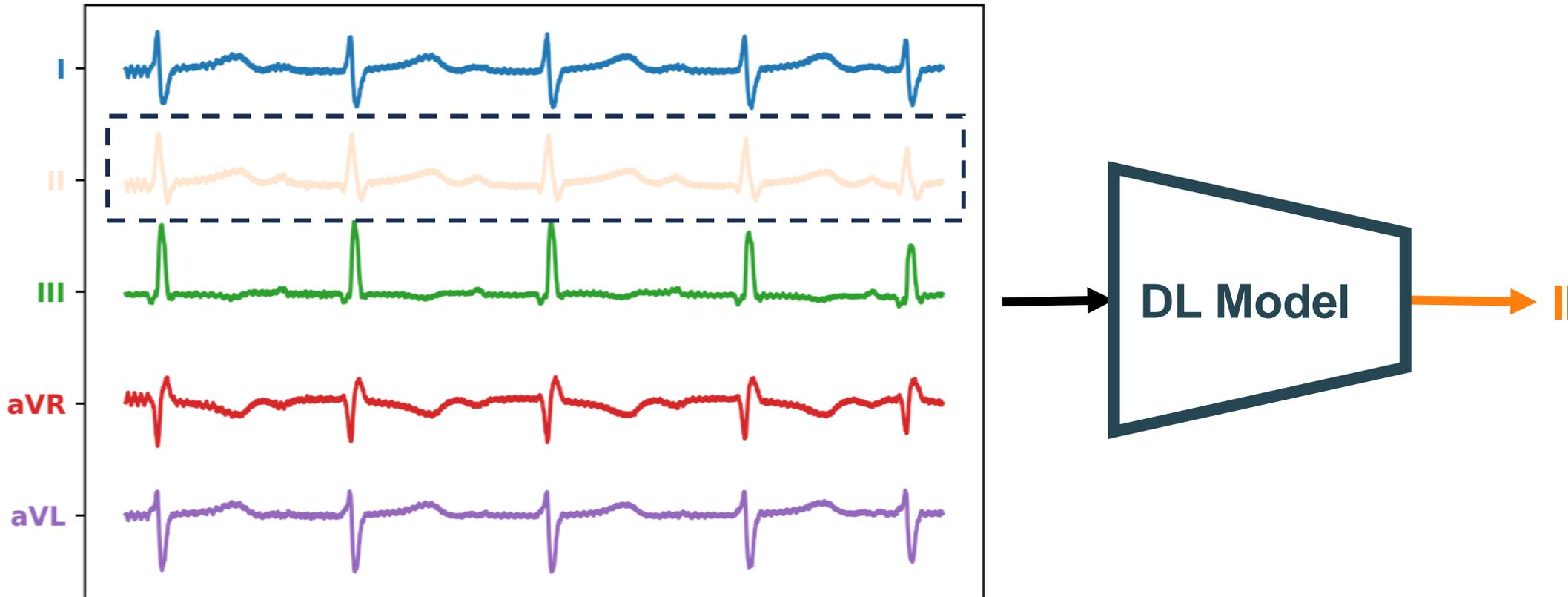
LONGITUDINAL LEARNING



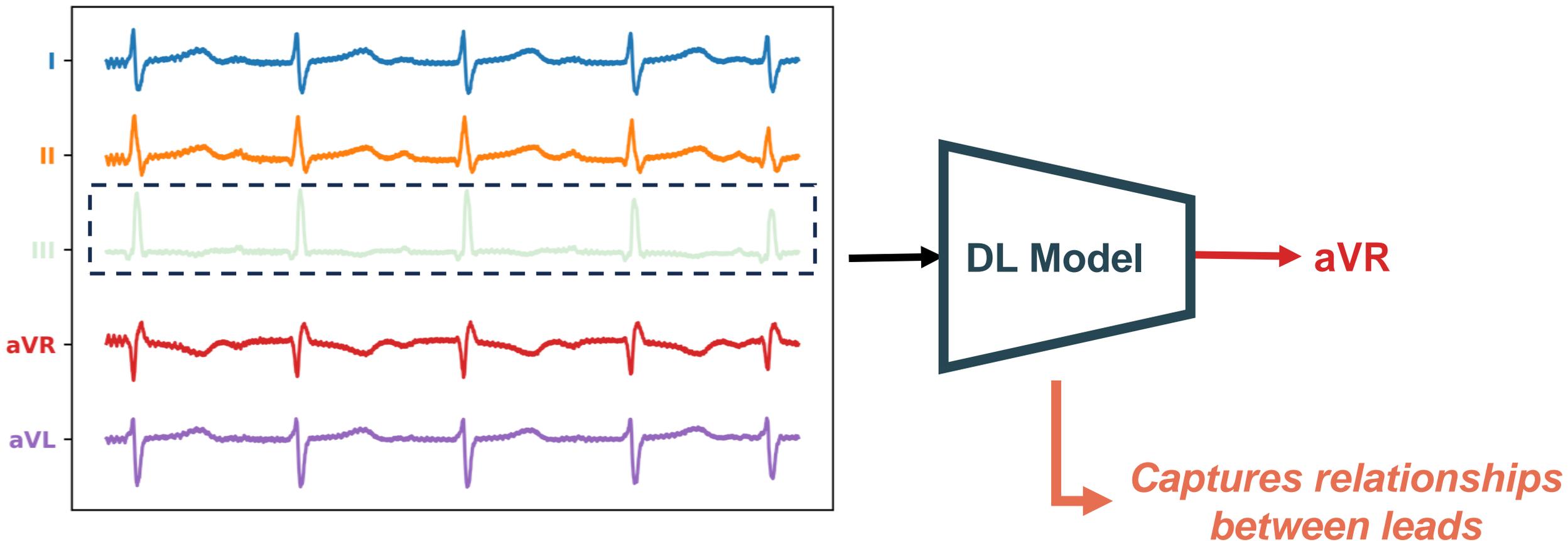
Lead Reconstruction



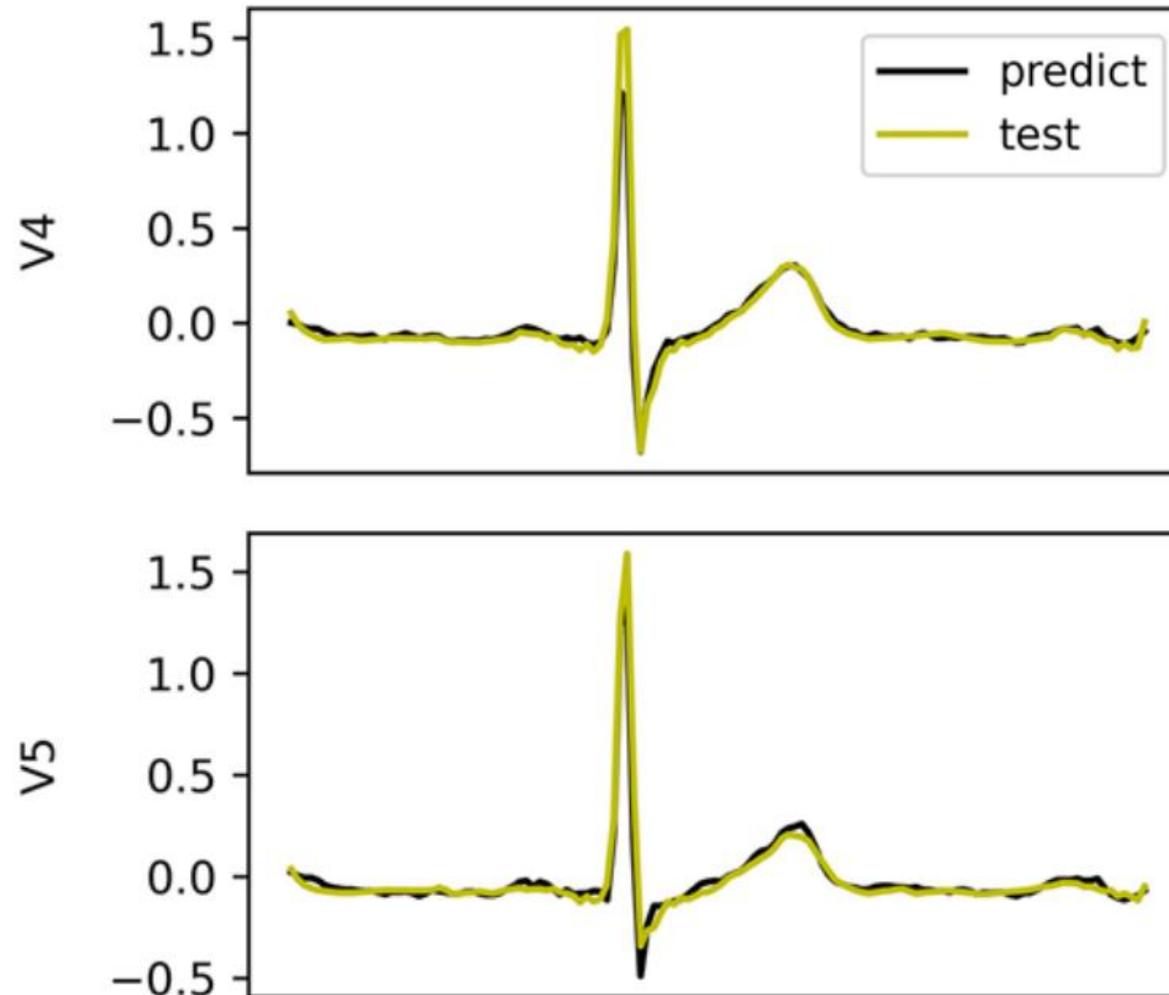
Lead Reconstruction



Lead Reconstruction



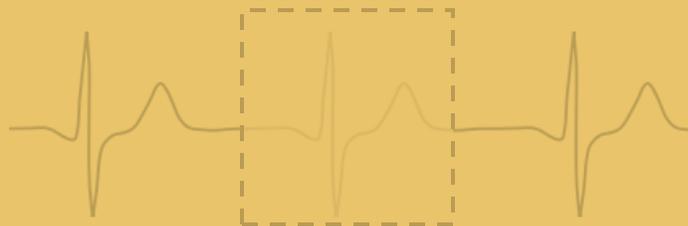
Lead Reconstruction – study



RMSE < 0.2 mV

Usage Examples

ECG RANDOM MASKING



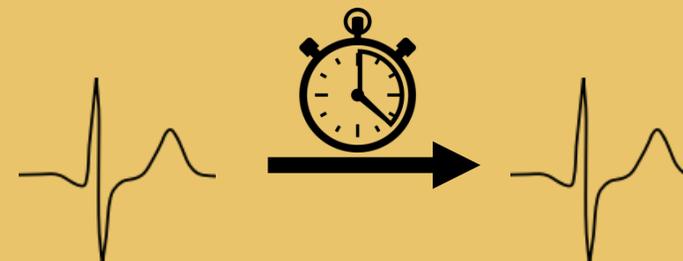
PATIENT FINGERPRINTING



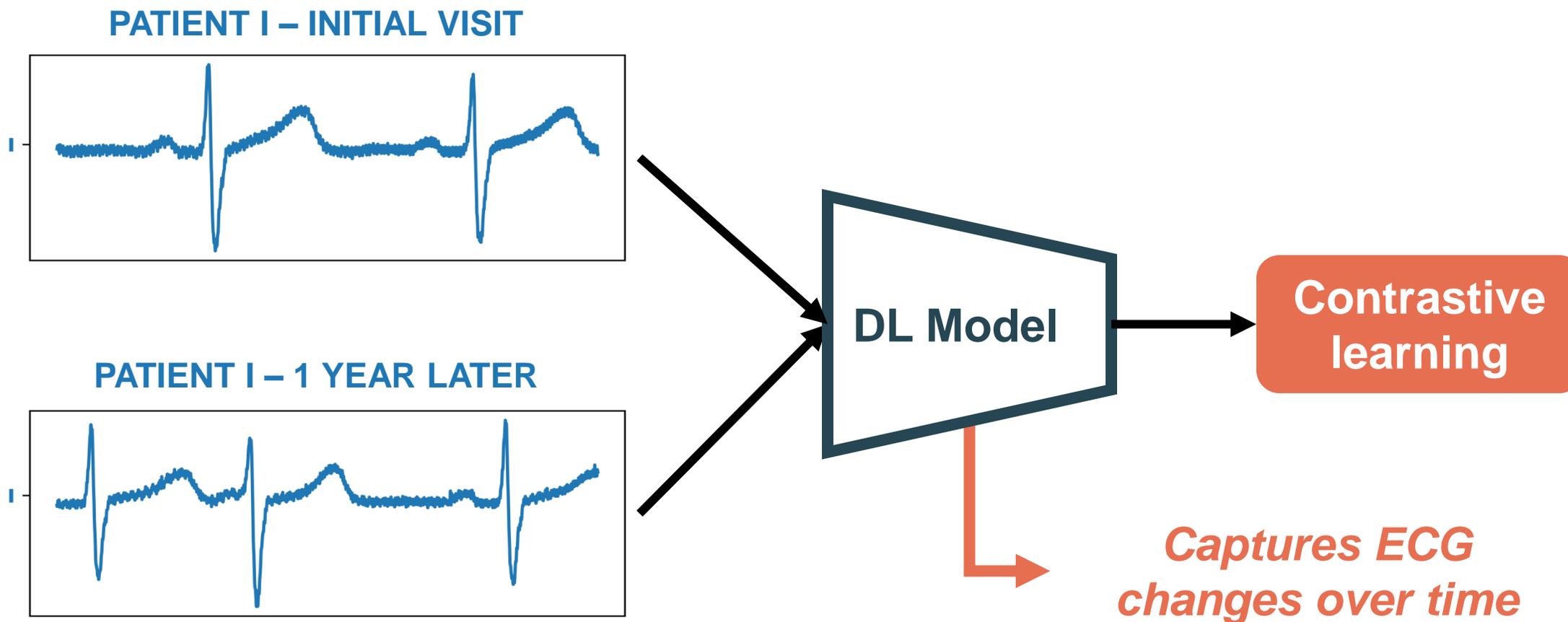
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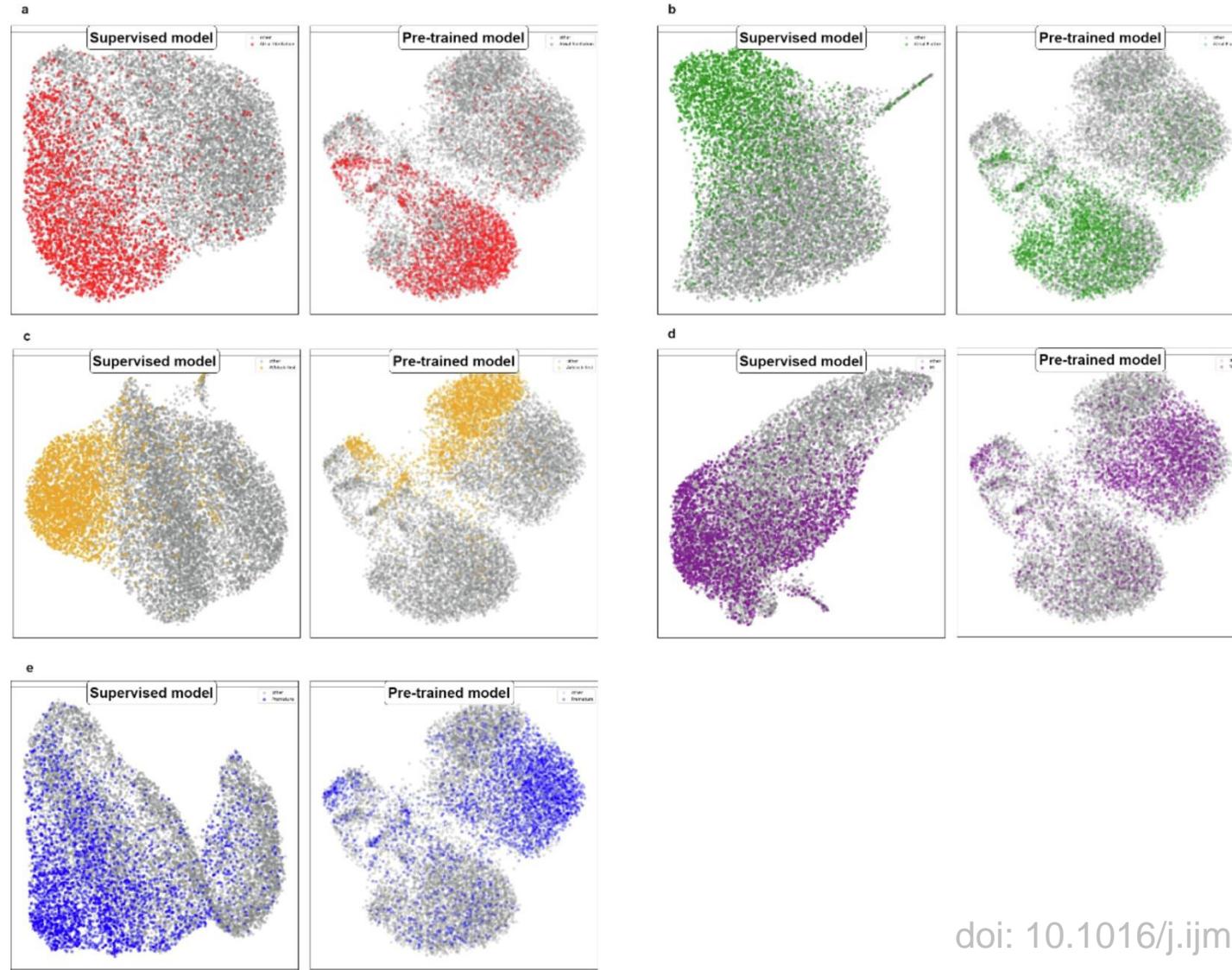
LONGITUDINAL LEARNING



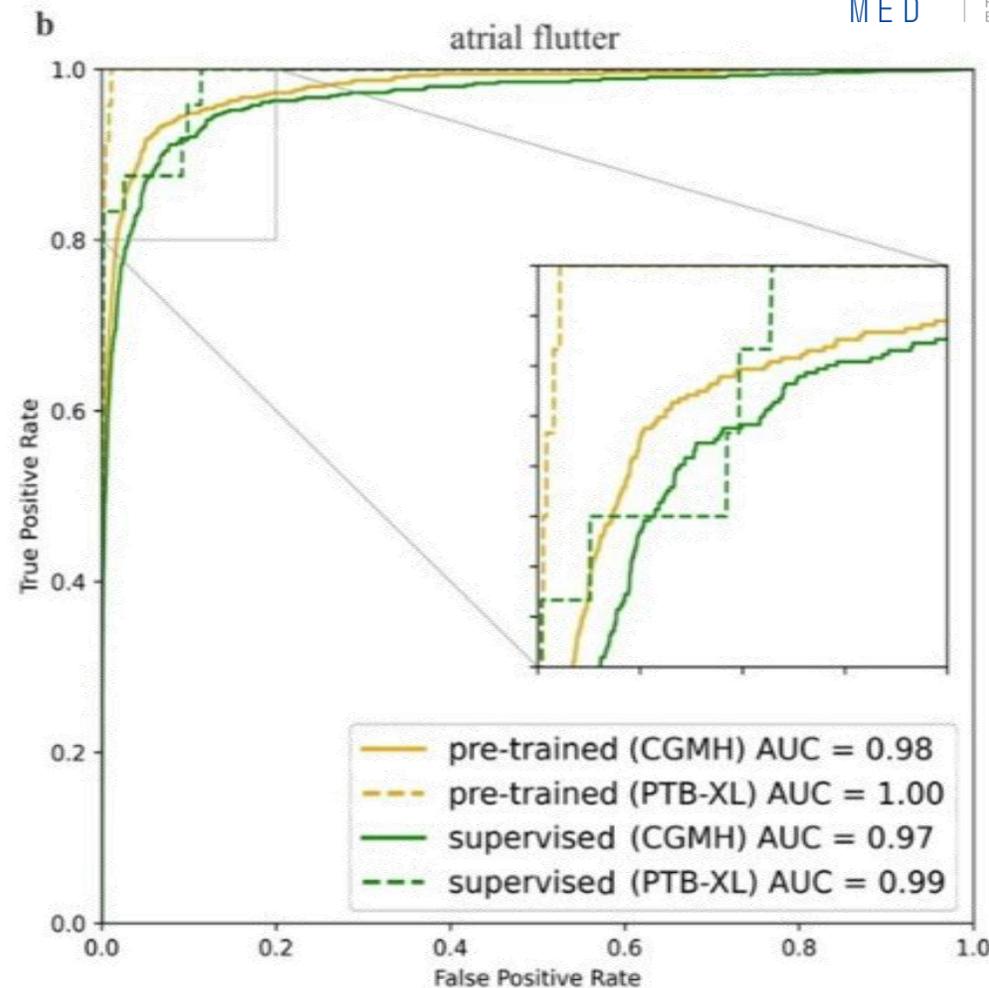
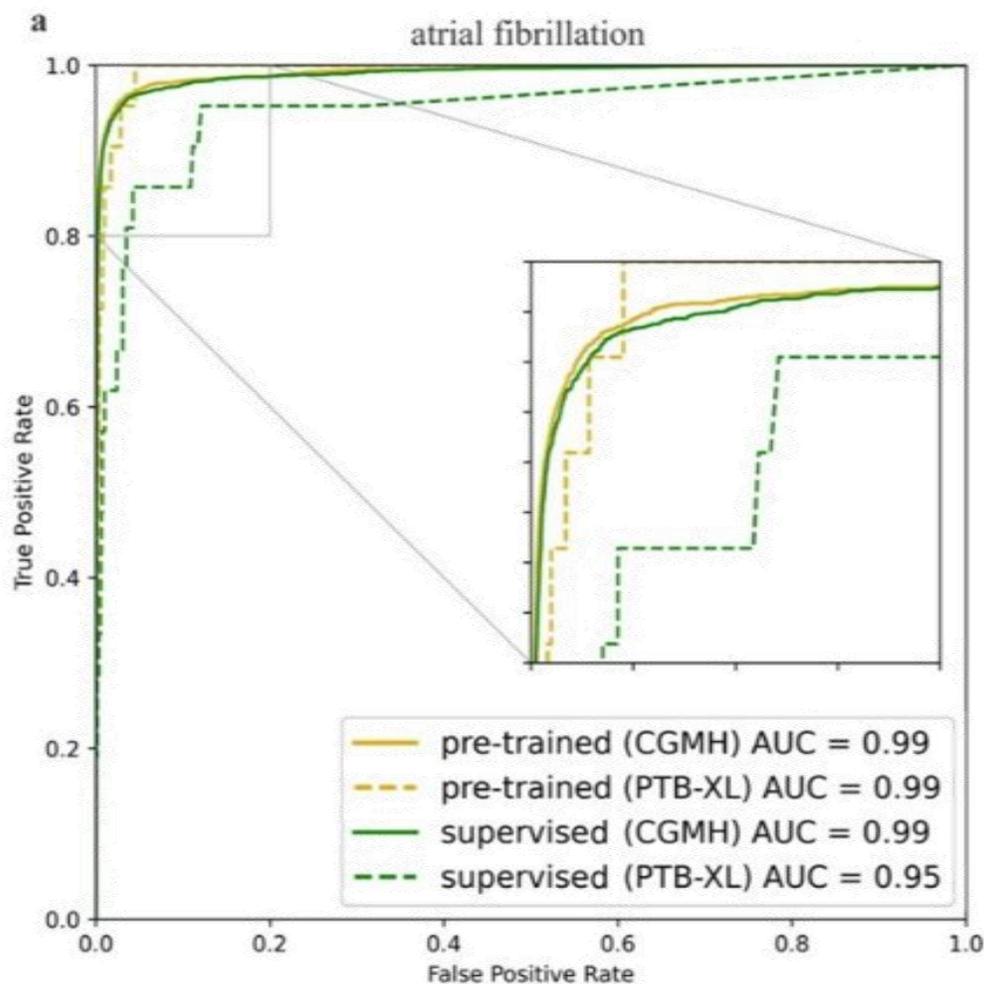
Longitudinal Learning



Longitudinal Learning – study



Longitudinal Learning – study



What to Expect?

- ↑ Accuracy and generalization
- ↓ Labeling effort
- ↑ Robustness
- ↑ Explainability

Take home message

- Adapt, generalize, and stay precise
- Let the model understand the data first
- **Don't wait for labels — start now**



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