

IEEE Big Data 2018  
Computer Science Department at UFMG & Kunumi

# Dynamic Prediction of ICU Mortality Risk Using Domain Adaptation

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December, 2018

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- ▶ Data from patients in the ICU are complex, extensive.
- ▶ Monitoring patients in ICU can become a complex task as data becomes larger.

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- ▶ Models often lacks generalization as we change the population.

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- ▶ Model's explanation

- ▶ PhysioNet 2012 Challenge dataset [Silva et al., 2012].

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- ▶ Records from 4000 patients.
- ▶ Age, gender, height, weight and 37 time-stamped physiological parameters.
- ▶ First 48 hours of ICU stay.
- ▶ Target is in-hospital death.

## 4 Different ICU

- ▶ Cardiac Surgery Recovery Unit
- ▶ Coronary Care Unit
- ▶ Medical ICU
- ▶ Surgical ICU

Average patient physiological data.

	Cardiac	Coronary	Medical	Surgical
N	874	577	1,481	1,067
Age	67.91	69.22	62.83	60.50
Mortality Rate	4.9%	14.0%	18.6%	14.5%

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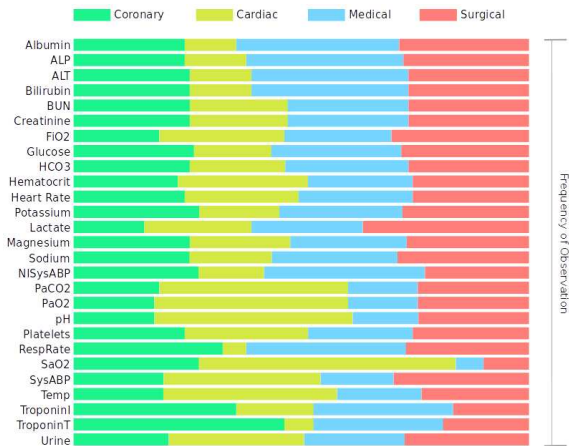
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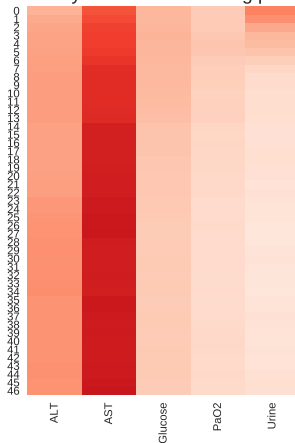
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Relative frequency in which physiological parameters are measured in different ICU domains.



Mean value for non-surviving patients at the Coronary ICU through time.

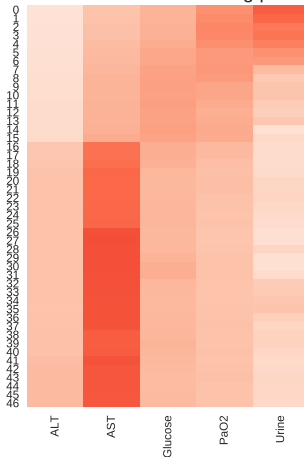
Coronary ICU - Non-surviving patients



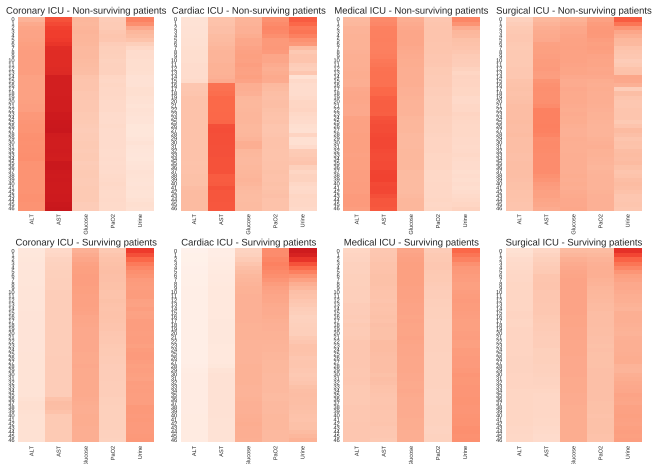


Mean value for non-surviving patients at the Cardiac ICU through time.

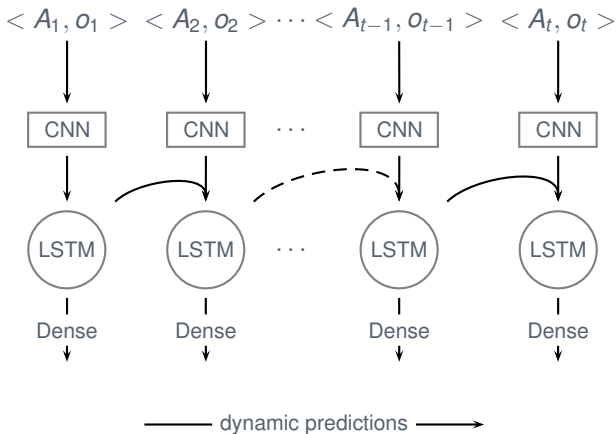
Cardiac ICU - Non-surviving patients



### Mean value by ICU and outcome through time.



Network architecture for predicting patient outcomes over time.



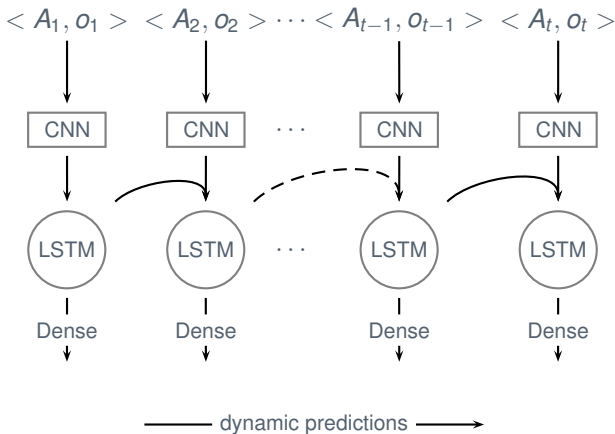
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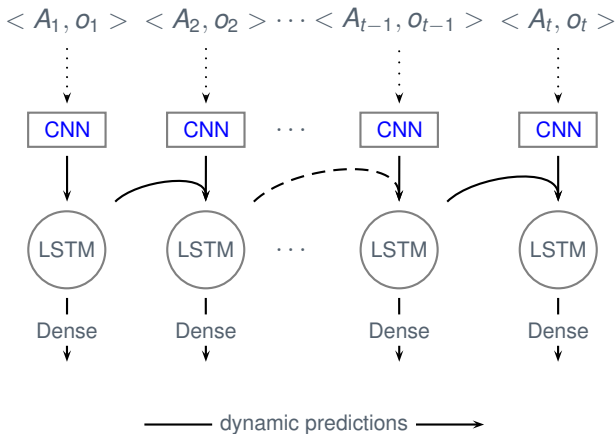
- ▶ Learn from source domain, specifies for target
- ▶ Train over all available data
- ▶ Fine-tune for the desired ICU
- ▶ First layers extract more general features

NF: No layers are frozen during fine-tuning.

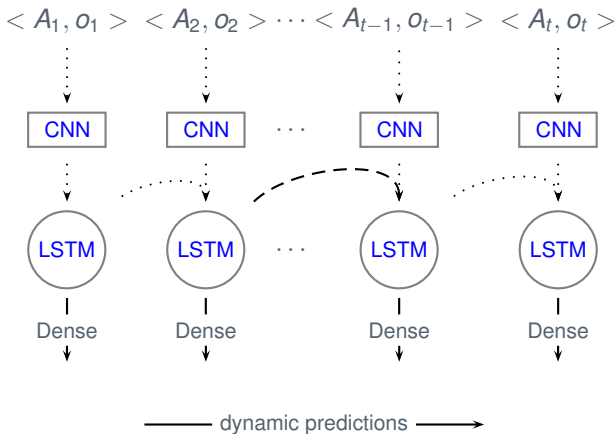




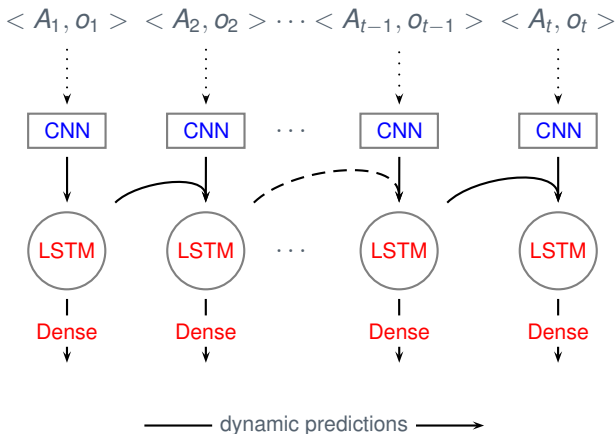
FC: Freeze CNN layers during fine-tuning.



FCL: Freeze CNN and LSTM layers during fine-tuning.



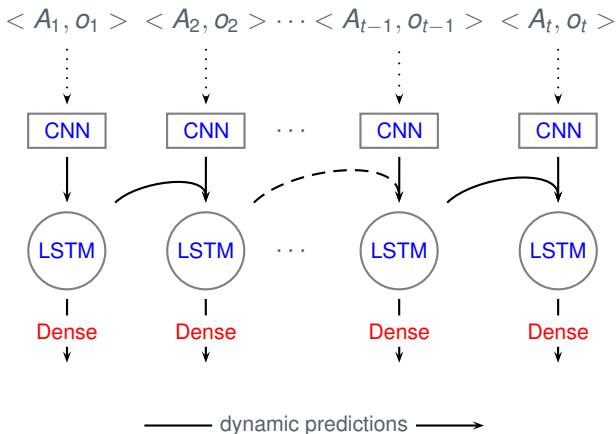
FCR: Freeze CNN layer and all other layers have their weights randomly initialized during fine-tuning.



# Feature Transferability

Methodology

FCLR: Freeze CNN and LSTM layers and all other layers have their weights randomly initialized during fine-tuning.



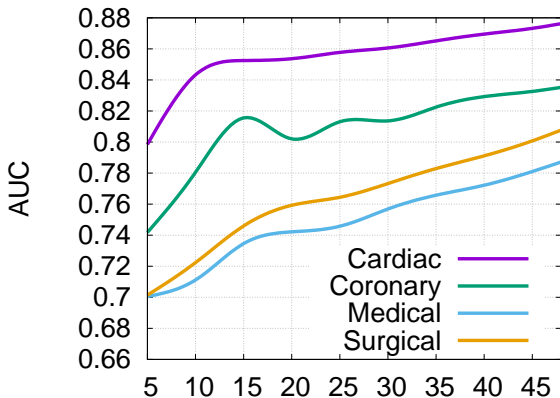
AUC numbers for different feature transference approaches

Target	NF	FC	FCL	FCR	FCLR
Cardiac	0.852	<b>0.885</b>	0.829	0.849	0.858
Coronary	<b>0.848</b>	0.812	0.807	0.793	0.784
Medical	0.754	0.763	<b>0.782</b>	0.759	0.736
Surgical	0.822	<b>0.827</b>	0.808	0.818	0.788
Overall	0.819	<b>0.822</b>	0.806	0.804	0.791

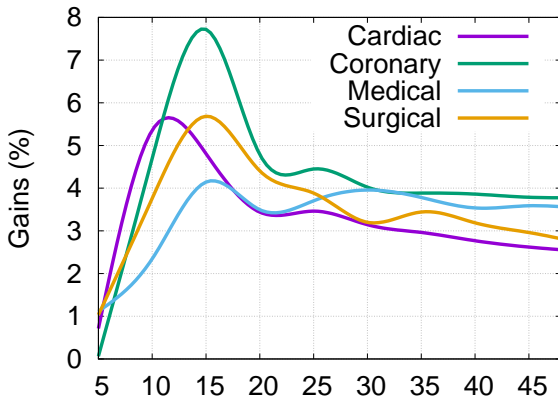
## AUC numbers for baselines and approaches

Model	Cardiac	Coronary	Medical	Surgical	Avg
SVM	0.627	0.572	0.503	0.532	0.558
LR	0.629	0.601	0.510	0.517	0.564
RF	0.610	0.578	0.587	0.623	0.599
TT	0.821	0.769	0.722	0.727	0.759
LSTM	0.812	0.807	0.742	0.769	0.782
CNN	0.866	0.802	0.747	0.812	0.807
NT <sup>-</sup>	0.876	0.833	0.737	0.801	0.812
NT	0.876	0.837	0.757	0.812	0.820
[Che <i>et al.</i> , 2015]	0.853	0.802	0.760	0.785	0.800
[Che <i>et al.</i> , 2018]	0.868	0.824	0.775	<b>0.823</b>	0.823
CNN-LSTM	<b>0.885</b>	<b>0.848</b>	<b>0.782</b>	<b>0.827</b>	<b>0.836</b>

CNN-LSTM AUC within the first  $y$  hours ( $5 \leq y \leq 48$ ).

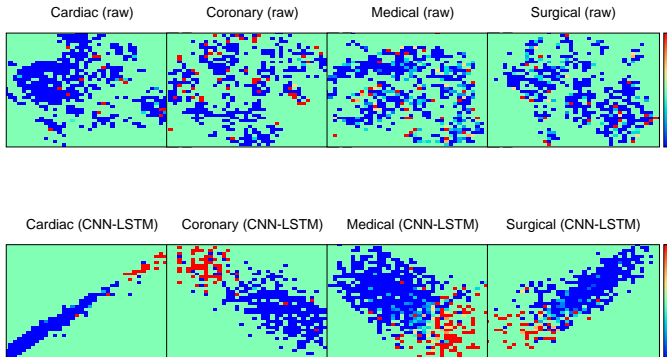


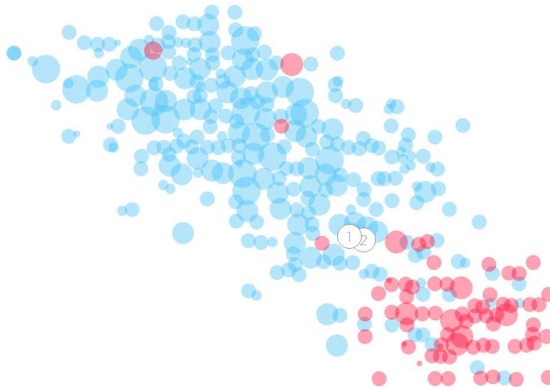
Gains over [Che et al., 2015] at different prediction times  
( $5 \leq y \leq 48$ ).

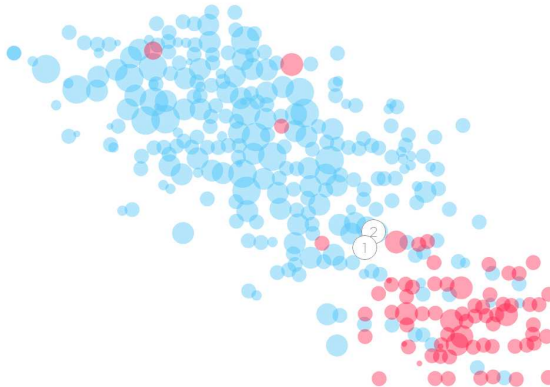


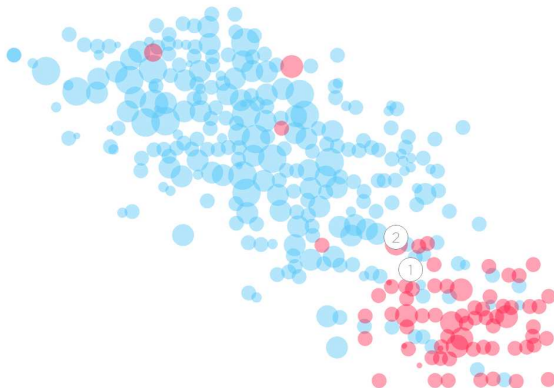


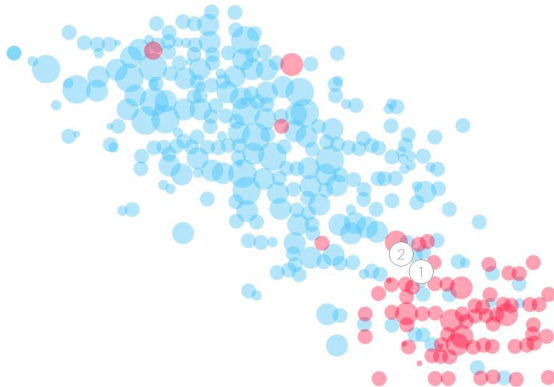
Mortality risk space for different ICU domains. Regions in red are risky.

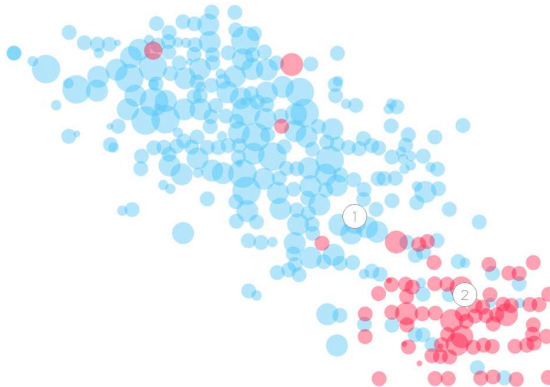








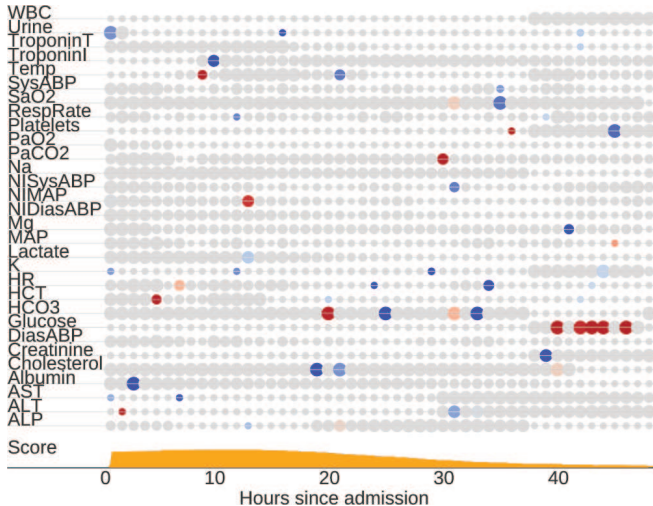




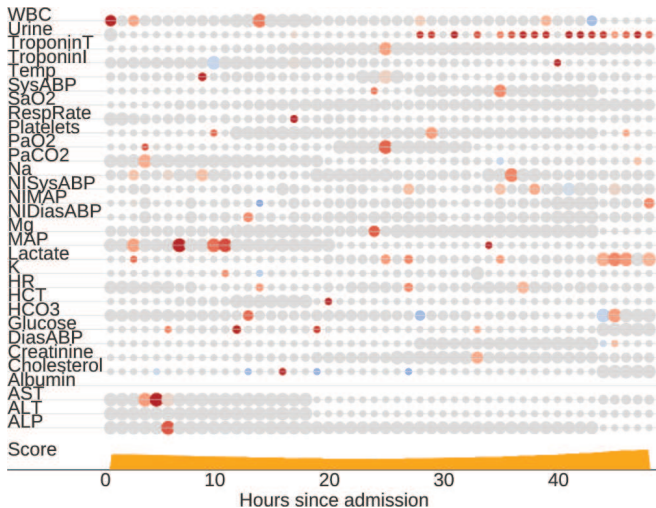
# Experimental Results

Explanation

## Explanations for a surviving patient instance



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- ▶ Patients within a specific ICU domain are different from patients within other domains.

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- ▶ Deep learning models can employ local and temporal feature extractors to perform dynamic predictions, potentially leading to earlier diagnosis.

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- ▶ Deep learning models can employ local and temporal feature extractors to perform dynamic predictions, potentially leading to earlier diagnosis.
- ▶ Specific models built with domain adaptation outperforms the general models.

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