We build an **ensemble** model to predict sepsis in the **PhysioNet/CINC Challenge 2019** dataset. Our model is trained with different undersampling methods and achieves a **utility score of 0.378** on the heldout evaluation data.

Developing an Early Warning System for Sepsis

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1 Introduction

– **Sepsis** is a life-threatening condition that is caused by infection. Identifying sepsis before it happens and treating it earlier leads to decreased mortality and decreased lengths of stay.

– Imbalanced data is a ubiquitous problem in healthcare data. We explore this further and focus on **undersampling**.

– Our submission to the **PhysioNet 2019** challenge is an ensemble model trained using random- and cluster-based undersampling. We achieve a **utility score of 0.378** on the evaluation data.

2 Methods

Data and Pre-processing

– Challenge datasets consist of demographics, vitals, and laboratory values sampled at an hourly level from two different hospitals (hospital *A* and hospital *B*) (Reyna et al. 2019).

– We impute missing data with **last observation carried forward**, and fill remaining missing values with -1.

– We create **indicator variables** to differentiate measured features from imputed features.

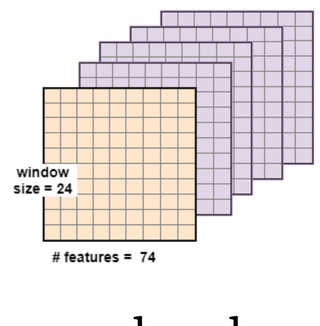
– For each row, we create **24 hour** windows of data. Earlier windows are filled with 0's.

Patient ID	ICULOS	Var1	Var2
2	3		
2	4	0.4	
2	5		
2	6	0.5	
2	6		1.2

↓

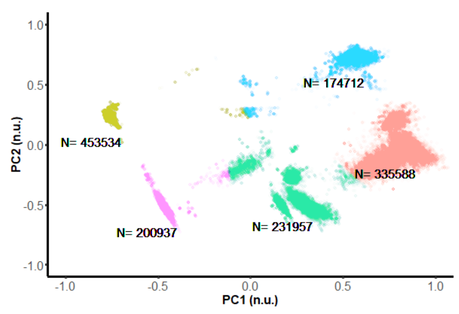
Patient ID	ICULOS	Var1	Var2	Var1_m	Var2_m
2	3	-1	-1	0	0
2	4	0.4	-1	1	0
2	5	0.4	-1	0	0
2	6	0.5	-1	1	0
2	6	0.5	1.2	0	1

↓



Clustering and undersampling

– To address **class imbalance**, we undersample the majority class (i.e., windows that don't experience sepsis) by sampling **randomly** or based on **clusters**.



– For cluster-based undersampling, we train **k-means** on the first two **PCA** components, and we sample equal number of data from each cluster of the majority class.

– *Intuition*: Data from the same cluster are similar to each other and we want an adequate representation of the majority class.

Models

– We train **convolutional neural network** (CNN) and **random forest** (RF) models on different subsets of the data, varying in sampling method (random vs. cluster) and ratio of sepsis:non-sepsis.

– Our final model is an ensemble (**logistic regression**) which takes as input the scores of the following models: 1) RF trained on *random* subset, 2) CNN trained on *random* subset, and 3) CNN trained on subset sampled *based on K-means clusters*.

– The data for training the models were all sampled at a ratio of *1:2*.

3 Results

– Results on validation data (80/20 split).

Dataset	AUROC	AUPRC	Accuracy	F-measure	Utility
A	0.794	0.101	0.761	0.126	0.432
B	0.816	0.056	0.863	0.094	0.247
Combined	0.809	0.089	0.772	0.105	0.375
Heldout	–	–	–	–	0.378

– We run different experiments with undersampling and find that *random-based undersampling performs better than cluster-based undersampling*, however *including models trained on a cluster-based sample of the data in our ensemble lead to better results* (refer to preprint for details).

4 Conclusion

– We use an ensemble-based approach for predicting sepsis in ICU hospital patients.

– For the PhysioNet dataset, cluster-based undersampling is useful as part of an ensemble, but not on its own.

– **Future work**: Account for distance in cluster-based sampling.

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