Early delirium detection using machine learning algorithms

Célia Figueiredo, Ana Braga, José Mariz

Célia Figueiredo
celianlfg@hotmail.com

July 6, 2022

CENTROALGORITMI

Agenda

- Introduction
- Background
- Goals
- Data
- Data preparation
- Machine Learning algorithms
- Evaluation metrics
- Results
- Conclusion

Introduction

- Over the past few years, the average life expectancy has increased. But along with the ageing population, chronic diseases have increased significantly.
- Delirium is a common manifestation of severe acute neuropsychiatric dysfunction
- **A disturbance in attention** (i.e., reduced ability to direct, focus, sustain, and shift attention) and **awareness** (reduced orientation to the environment).
- Prevalent in hospital settings, which due to the complex multi-factorial causes is often under-diagnosed and neglected.

Background

2012 - PREdiction of DELIRium for Intensive Care patients (PRE-DELIRIC)	• 10 predictors • AUC-ROC of 0.87
2015 - Early PREdiction of DELIRium for Intensive Care patient (E-PREDELIRIC)	• 9 predictors • AUC-ROC of 0.76
2018 - Study to evaluate the prediction of delirium using the random forest algorithm.	• AUC-ROC of 0.909
2021 - retrospective cohort study that developed and validated ML algorithms to detect delirium	• RF, GBM, and LR models achieved the best outcomes • AUCs of 0.85 to 0.86

Goals

- Develop and validate a tool for use in a hospital setting to identify delirium during the admission of a patient.

- Identify the most influential variables to predict the development of delirium using the data available when a patient is admitted to the Emergency Department

Data

Data collected between 2014 and 2016

Raw data:

- 124 features
- 511 records

Input Variables:

- **Numerical** – Age; SIRS, length of stay; analysis (glycose, CRP, pH, $HCO_{3,}$ ...)
- **Categorical** - Patient origin (Home, Inter-hospital …); Urgent admission (Ambulatory, urgent, …); Diagnosis group (Cardiovascular, neurology, …)
- **Binary** – Gender, Medicines (Sinvastatine, Captopril, Quetiapine,…); Alcohol; *Delirium*

Output Variable:

- Richmond Agitation Sedation Scale (RASS) was used to diagnose delirium

High quantity of missing data

Data Preparation

Data cleaning

Identify and correct mistakes or errors in the data

Data Transforms

Change the scale or distribution of variables

Feature Selection

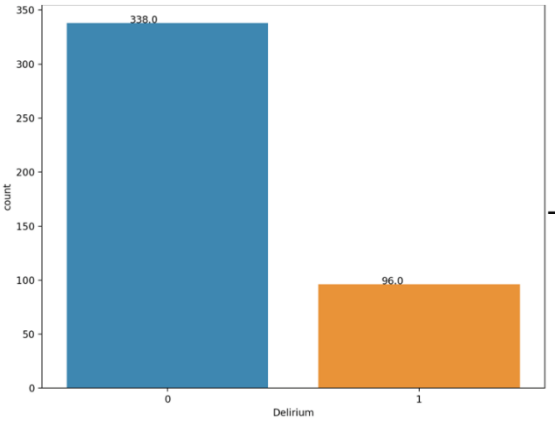
Identify those input variables that are most relevant to the task

Data Preparation

Imbalanced data

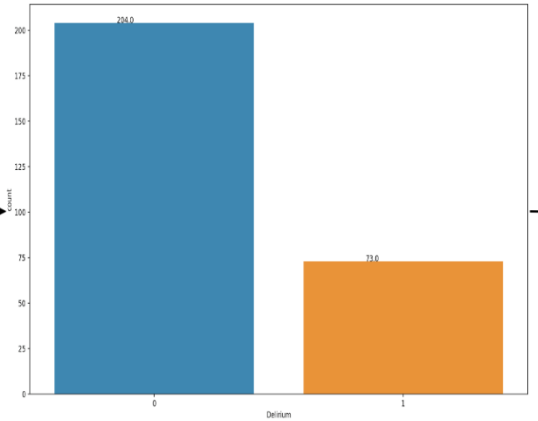
- Apply data balancing techniques to the training data

(A) Category count of the feature 'Delirium' before splitting the data



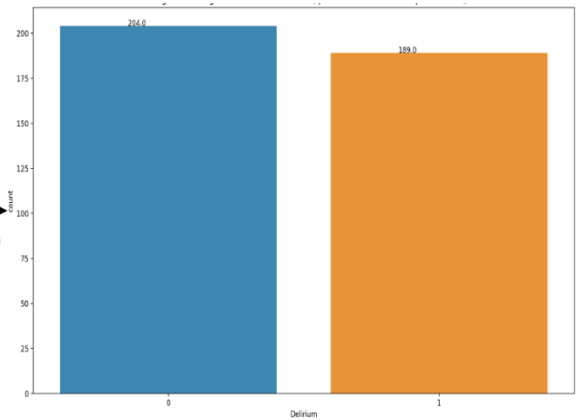
Train (64%)

(B) Category count of the feature 'Delirium', after splitting the data, for training



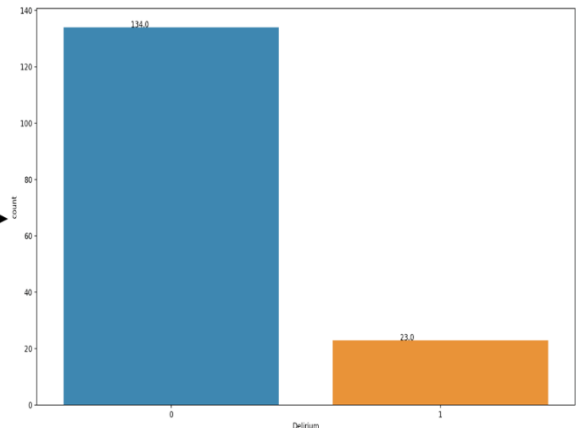
After *ADASYN()*

(D) Category count of the feature 'Delirium', for the training data after ADASYN()



Test (36%)

(C) Category count of the feature 'Delirium', after splitting the data, for testing



Feature Selection Methods

- SelectFromModel
- Recursive Feature Elimination (RFE)
- Recursive Feature Elimination with Cross Validation (RFECV)
- SequentialFeatureSelector (SFS)

Machine Learning algorithms

Random Forest

- It is a combination of tree classifiers where each tree depending on a set of random variables, that combines the performance of a wide range of decision tree algorithms to classify or predict the value of a variable

Logistic Regression

- It is a statistical technique that allows the prediction of values taken by a categorical variable, based on one or several continuous and/or binary independent variables.

Evaluation metrics

Recall

- This measure assesses the ability of the test to detect delirium when it is indeed present

Precision

- Measures the probability of the classifier labelled a person with delirium, given that the person does not have delirium.

F1

- This metric is the harmonic mean of precision and recall, giving equal weight to both. It evaluates models by considering both FP and FN

AUC-ROC

- It is a graphical plot used to show the diagnostic ability of binary classifiers.

AUC-Precision-recall curve

- This measure is useful to evaluate the quality classifier's results in cases involving imbalanced datasets

Random Forest Results

Random Forest								
	Feature selection method	Features	Acuracy	Recall	Precision	F1	AUC-PR	AUC-ROC
0	---	38	78,34	37,14	52	43,33	0,42	0,789
1	SelectFromModel threshold= 0,01	37	82,8	45,71	66,67	54,24	0,47	0,808
2	SelectFromModel threshold= 0,015	17	75,16	31,43	42,31	36,07	0,417	0,765
3	SelectFromModel threshold= 0,02	14	78,34	31,43	52,38	39,29	0,425	0,796
4	SelectFromModel threshold= 0,03	13	76,43	34,14	46,43	41,27	0,43	0,76
5	SelectFromModel threshold= 0,05	9	78,34	42,86	51,72	46,88	0,428	0,748
6	**RFECV**	**31**	**78,98**	**40**	**53,85**	**45,9**	**0,508**	**0,789**
7	SFS (forward)	33	78,98	42,86	53,57	45,62	0,445	0,786
8	SFS (backward)	35	80,25	37,14	59,08	45,61	0,457	0,796
9	SFS (bidirecional backward)	34	77,71	37,14	50	42,62	0,485	0,785
10	SFS (bidirecional forward)	32	77,07	40	48,28	43,75	0,463	0,786

Logistic Regression Results

Logistic Regression								
	Feature Selection method	Features	Acuracy	Recall	Precision	F1	AUC-PR	AUC-ROC
0	---	38	83,44	60	63,64	61,76	0,579	0,8320
1	SFS (forward)	23	80,25	48,57	56,67	52,31	0,506	0,766
2	SFS (backward)	26	78,98	57,14	52,63	54,79	0,500	0,802
3	SFS (bidirecional forward)	27	70,06	54,529	38	44,71	0,4590	0,755
4	SFS (bidirecional backward)	19	78,98	57,14	52,63	54,79	0,5260	0,788
5	RFE	19	80,25	60	55,26	57,53	0,565	0,7827
6	RFECV	18	78,34	51,43	51,43	51,43	0,543	0,755
7	SelectFromModel (threshold=0,02)	38	83,44	60	63,64	61,76	0,579	0,8320
8	**SelectFromModel (threshold=0,09)**	**36**	**84,71**	**60**	**67,74**	**63,64**	**0,582**	**0,8333**
9	SelectFromModel (threshold=0,1)	35	84,08	60	65,62	62,69	0,578	0,8311
10	SelectFromModel (threshold=0,2)	33	84,08	60	65,62	62,69	0,575	0,8278
11	SelectFromModel (threshold=0,3)	27	82,17	60	60	60	0,563	0,8290
12	SelectFromModel (threshold=0,5)	24	80,89	60	50,76	58,33	0,542	0,8208
13	SelectFromModel (threshold=1)	14	77,71	40	50	44,44	0,499	0,7250
14	SelectFromModel (threshold=1,5)	7	70,7	54,29	38,78	45,24	0,509	0,7207

Results

Feature	Coefficients	OR
Age	2,76329	15,8520
Other medications	1,58937	4,90066
Antipsychotics	1,08977	2,97360
Glucose	0,66107	1,93687
Urea	0,60483	1,83094
CO2	0,56472	1,75896
…	…	…
Digitalis	-0,14012	0,86926
Sodium	-0,18368	0,83220
Ionized calcium	-0,19973	0,81895
Antidyslipidemics	-0,30344	0,73828
pH	-0,33835	0,71294
Urgent admission	-0,54732	0,57850
…	…	…

↑ of a unit in age ⟹ ↑ of 15.85 times the probability of developing delirium

When the drug is present, the probability of developing delirium increases 2.97 times.

When the drug is present, the probability of developing delirium decreases 0.73 times.

Results

Excluded variables:

- Antihypertensives
- Anxiolytics !

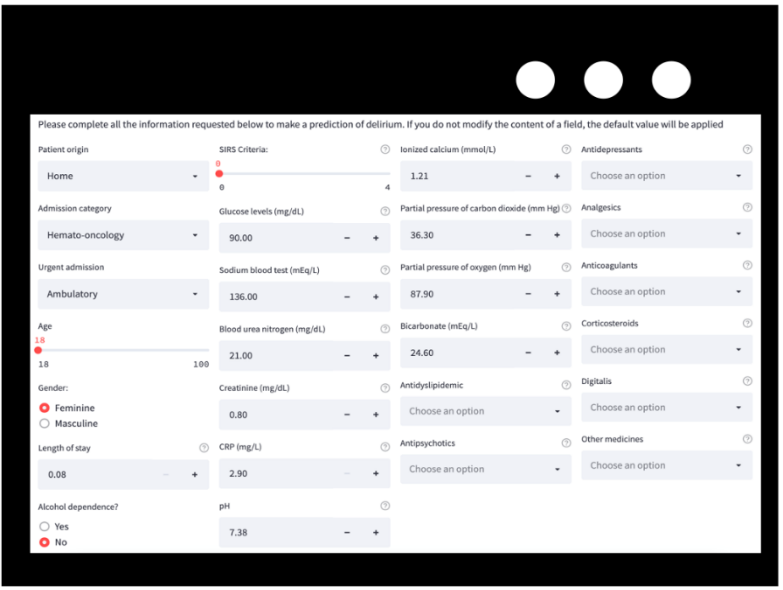
The literature reports that this group of drugs may be influential in the development of delirium.

The side effects of the drugs in this pharmacological group also indicate the possibility of developing delirium.

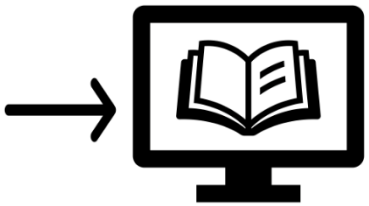
Possible explanation:

→ Low representativeness of this class of drugs in the training data (out of 59 only 10 (16.95%) presented delirium)

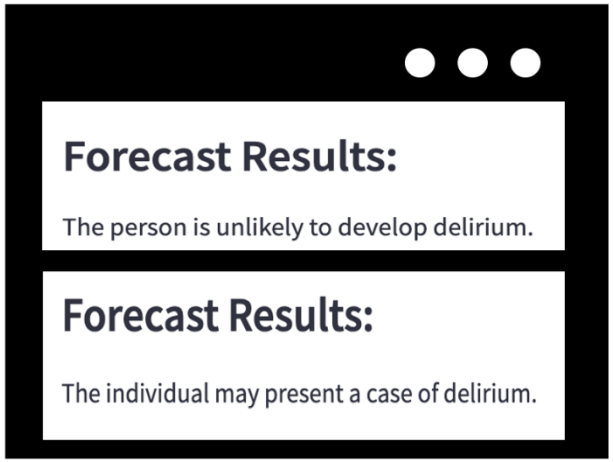
Web Application



Input data



Predictive model



Results

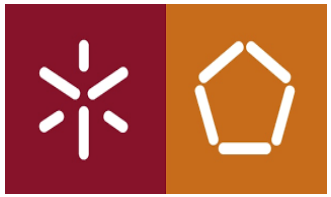
Link: https://bit.ly/3waT3T7

Final considerations

- *Delirium* is a syndrome prevalent and under-diagnosed in hospital settings.
- Data preparation was important for modelling (124 features to 36)
- Logistic regression achieved the best outcomes with an AUC-ROC of 0.833 and an AUC-PR of 0.582.
- The application developed might be a useful support tool for early delirium detection in healthcare settings
- In a future work perspective, it would be interesting to integrate this type of predictive model into an electronic record of the hospital system and carry out this process automatically in real-time.

ACKNOWLEDGEMENTS

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020



Early delirium detection using machine learning algorithms

Célia Figueiredo, Ana Braga, José Mariz

Célia Figueiredo
celianlfg@hotmail.com

July 6, 2022

CENTROALGORITMI