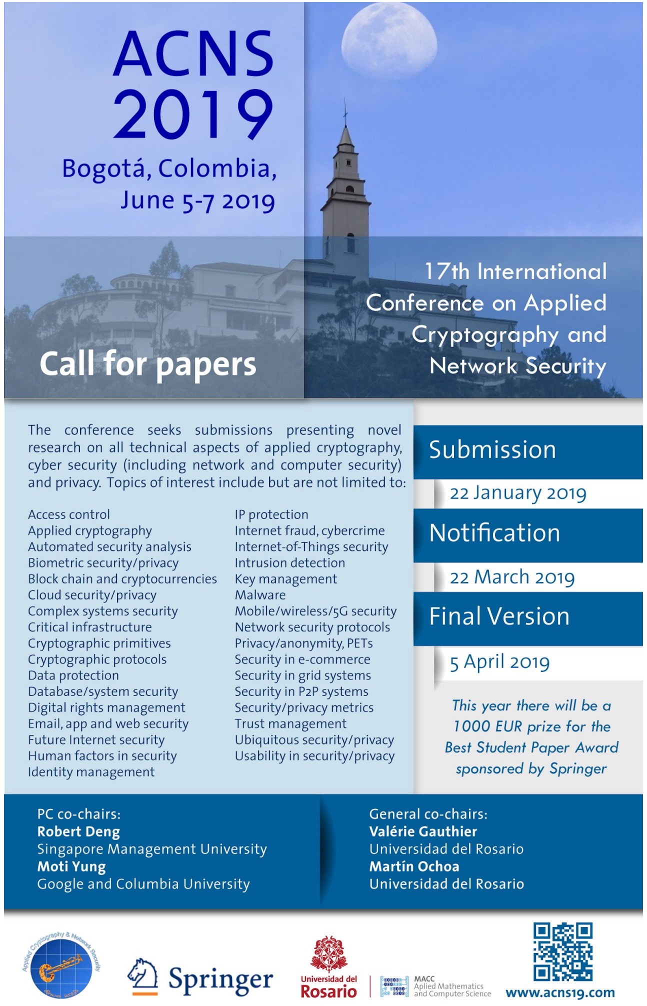
Classification and visualization of web attacks using HTTP headers and machine learning techniques

Nicolas Ricardo Enciso

UNSECURE



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Privacy/anonymity, PETs
Security in e-commerce
Security in grid systems
Security in P2P systems
Security/privacy metrics
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22 January 2019

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Final Version
5 April 2019

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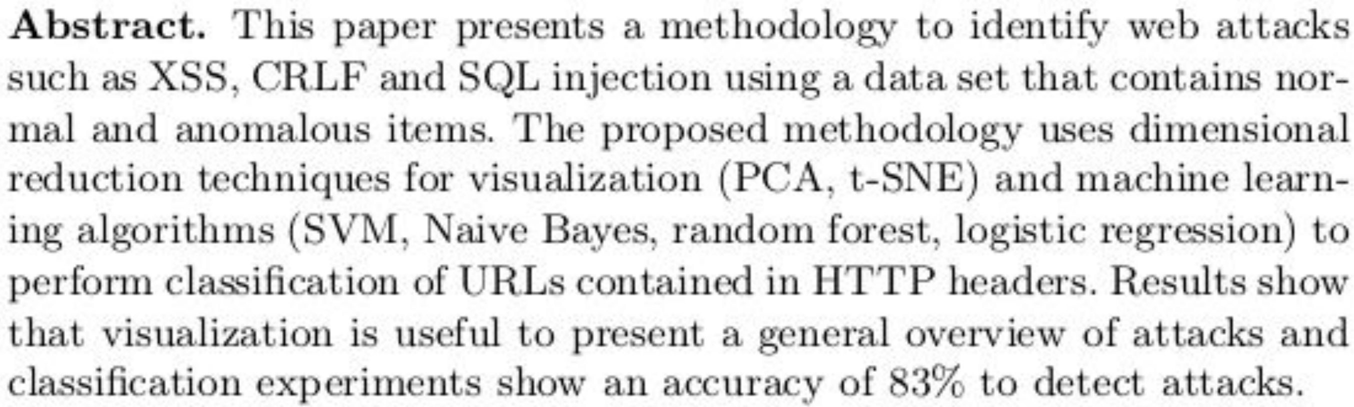
GENERAL OVERVIEW



Abstract. This paper presents a methodology to identify web attacks such as XSS, CRLF and SQL injection using a data set that contains normal and anomalous items. The proposed methodology uses dimensional reduction techniques for visualization (PCA, t-SNE) and machine learning algorithms (SVM, Naive Bayes, random forest, logistic regression) to perform classification of URLs contained in HTTP headers. Results show that visualization is useful to present a general overview of attacks and classification experiments show an accuracy of 83% to detect attacks.

Data set

- 25065 attacks (anomalous) marked as 1
- 36000 normal (normal) marked as 0
- Total 61065 cases in the dataset.

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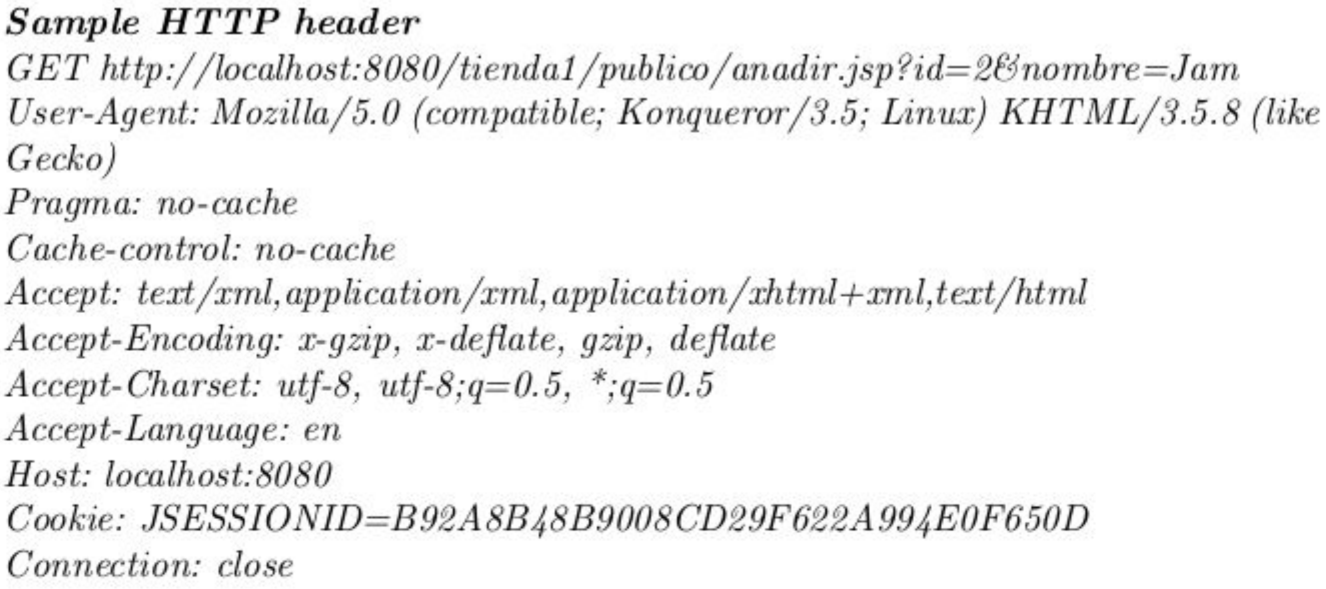
Splitted data

- 70% for training
- 30% for testing
- Random election of the cases from the data
- Dataset :
    - Original : 8 features with no changes

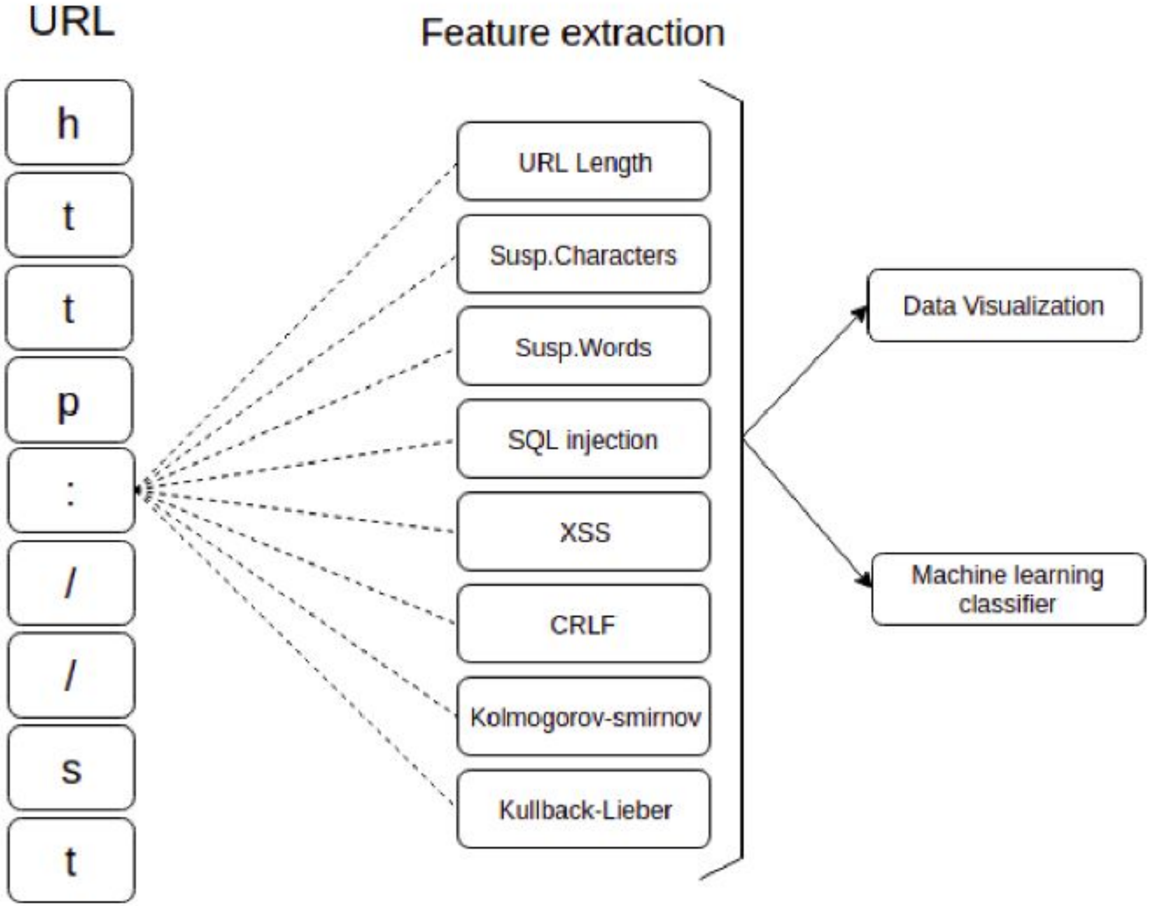
Feature extraction



Sample HTTP header

```
GET http://localhost:8080/tienda1/publico/anadir.jsp?id=2&nombre=Jam
User-Agent: Mozilla/5.0 (compatible; Konqueror/3.5; Linux) KHTML/3.5.8 (like
Gecko)
Pragma: no-cache
Cache-control: no-cache
Accept: text/xml,application/xml,application/xhtml+xml,text/html
Accept-Encoding: x-gzip, x-deflate, gzip, deflate
Accept-Charset: utf-8, utf-8;q=0.5, *;q=0.5
Accept-Language: en
Host: localhost:8080
Cookie: JSESSIONID=B92A8B48B9008CD29F622A994E0F650D
Connection: close
```

Feature extraction



Classifier algorithms

- Naive Bayes classifier:
    - Gaussian classifier
    - Multinomial classifier
- Support Vector Machine:
    - Linear
    - Gaussian (C = 1.11 and gamma = 0.09)
    - Sigmoid
- Logistic Regression
- Random Forest (estimators = 100)

Visualization and dimensionality reduction methods

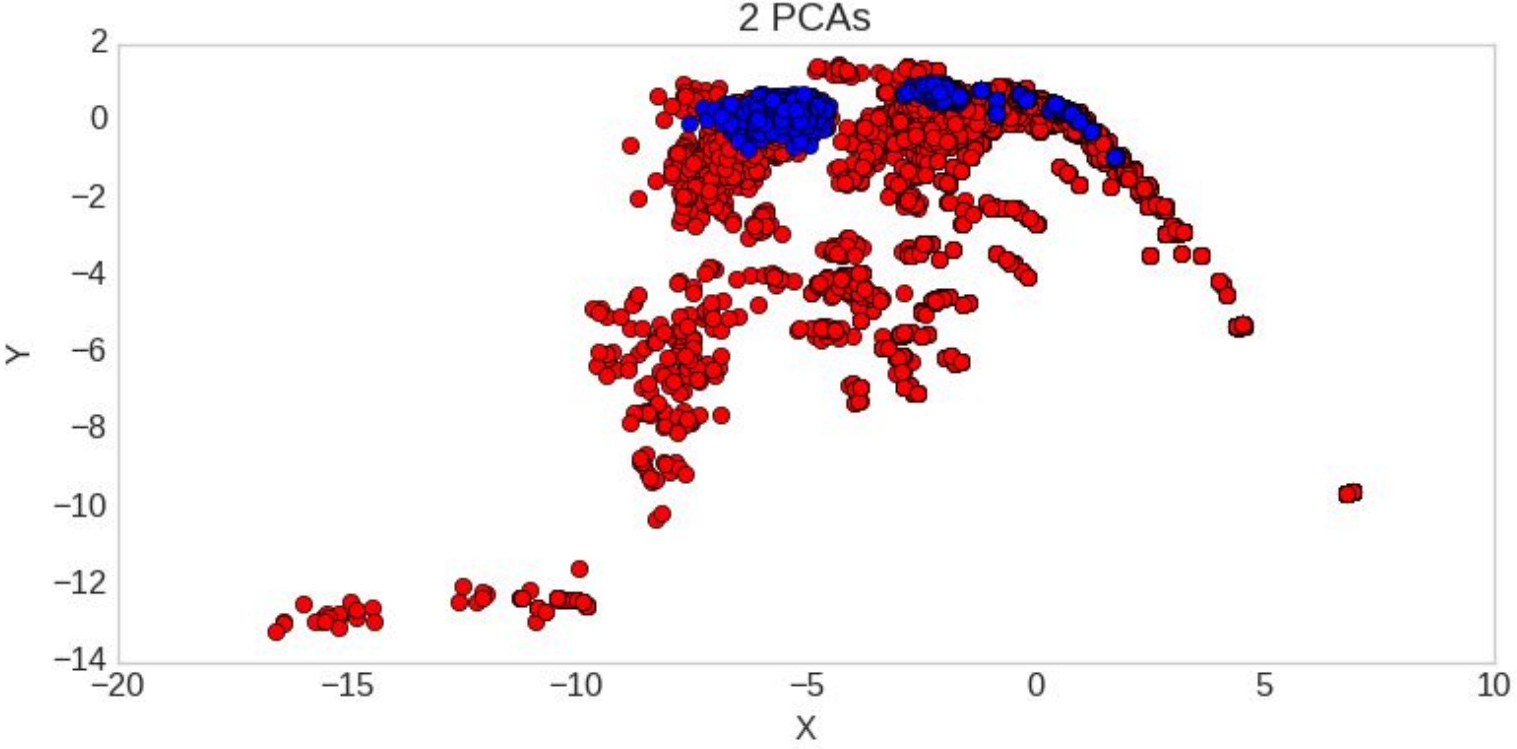
- PCA : principal component analysis

- t-SNE : t-Distributed Stochastic Neighbor Embedding

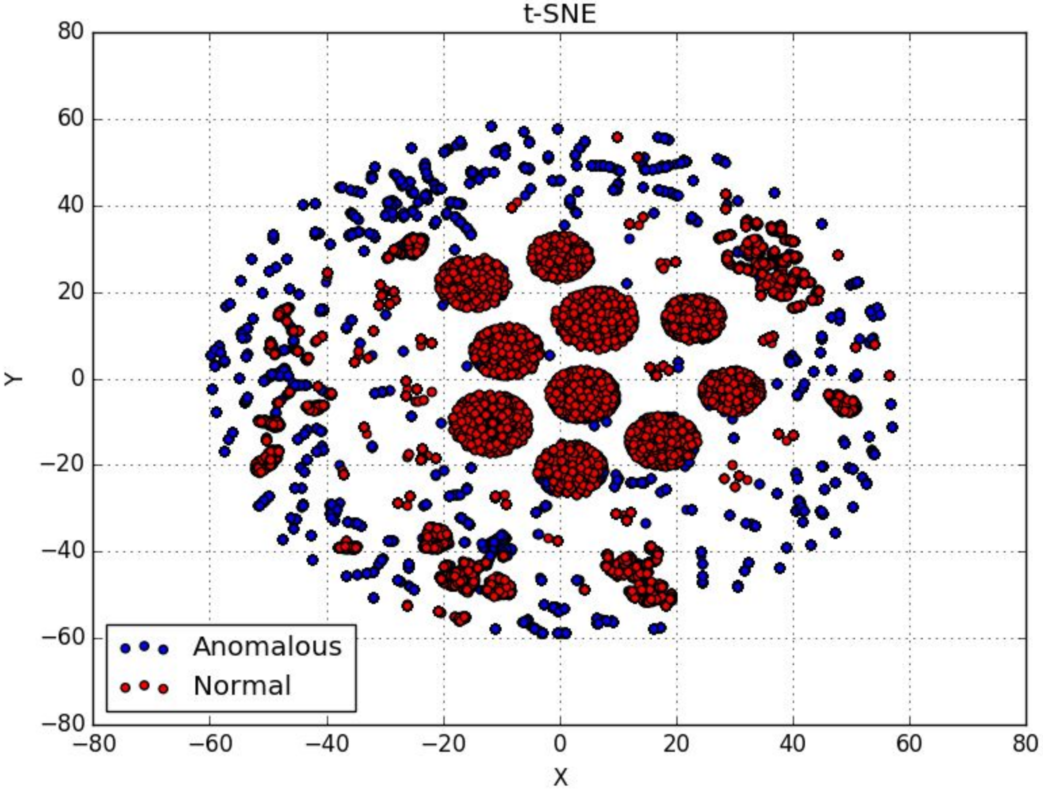
Types of attacks

- XSS cross site scripting
- CRLF Carriage return line feed
- SQL injection

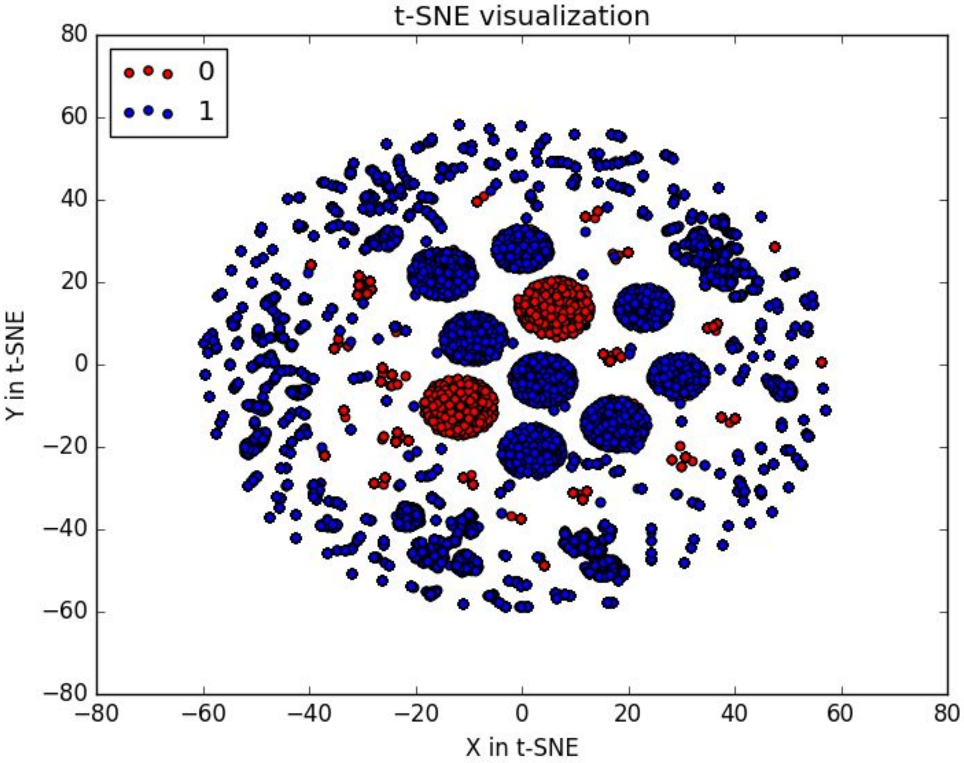
Visualization data: PCA (Anomalous in blue)



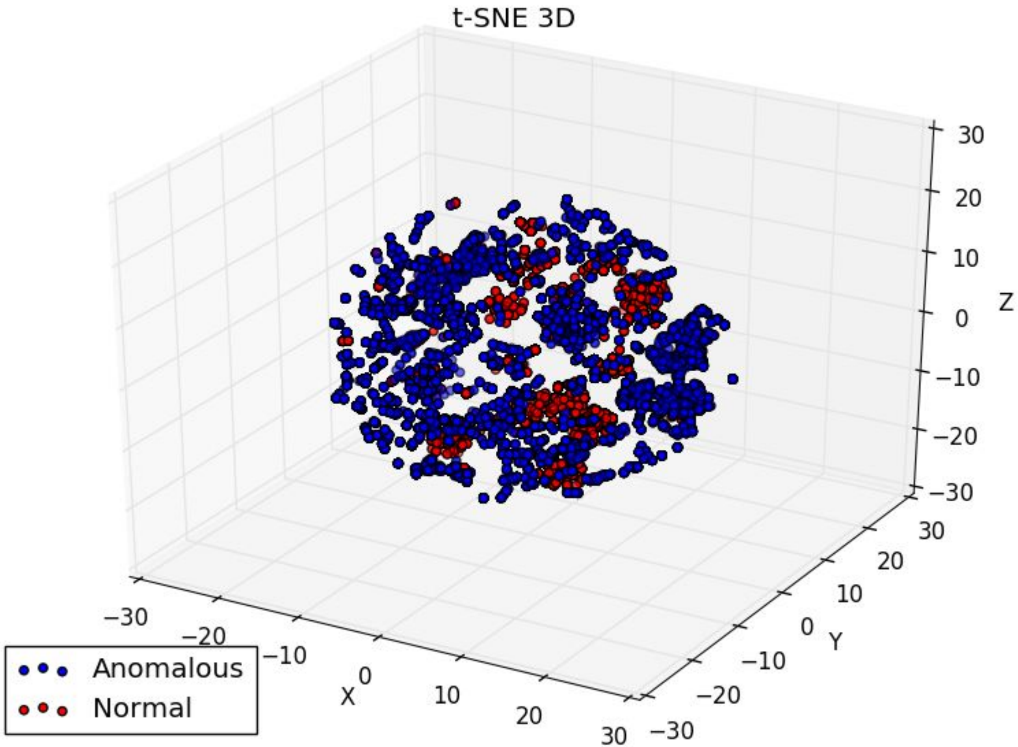
Visualization data: t-SNE 2D



Visualization data: t-SNE (1 anomalous - 0 normal

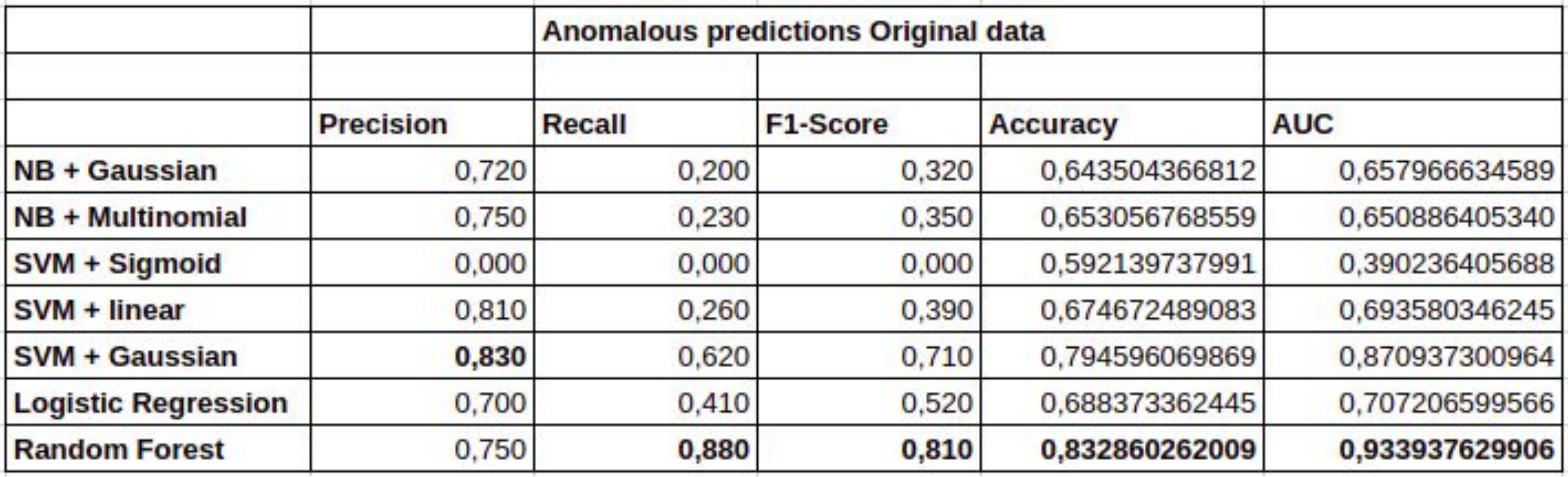


Visualization data: t-SNE 3D



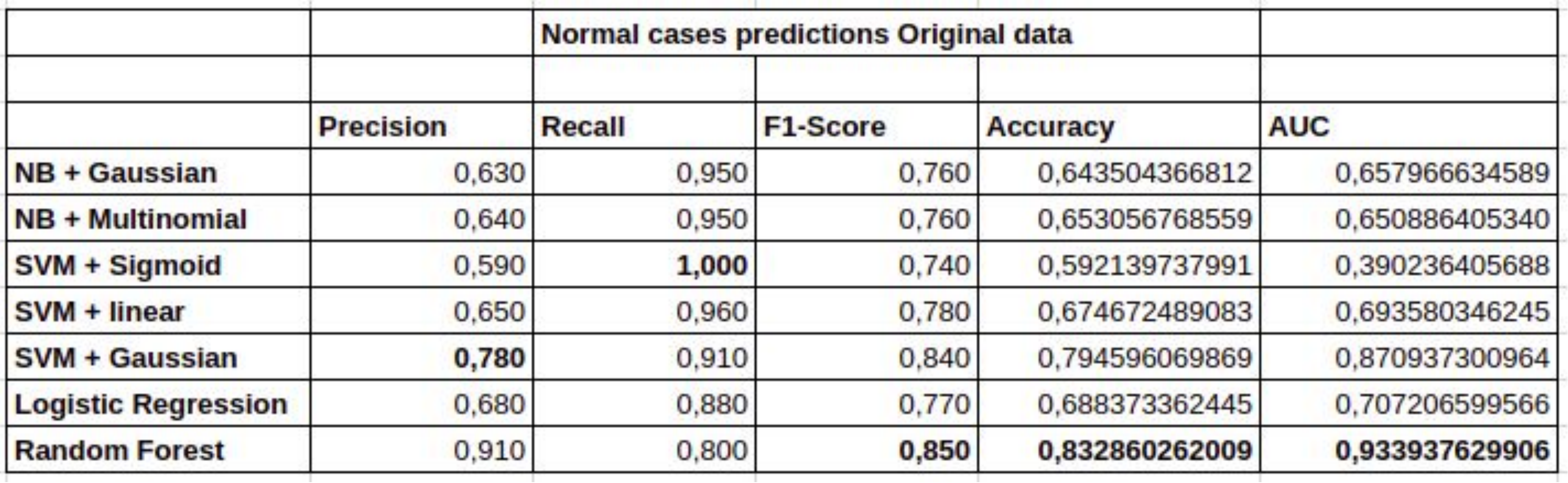
Results

Results performance classification



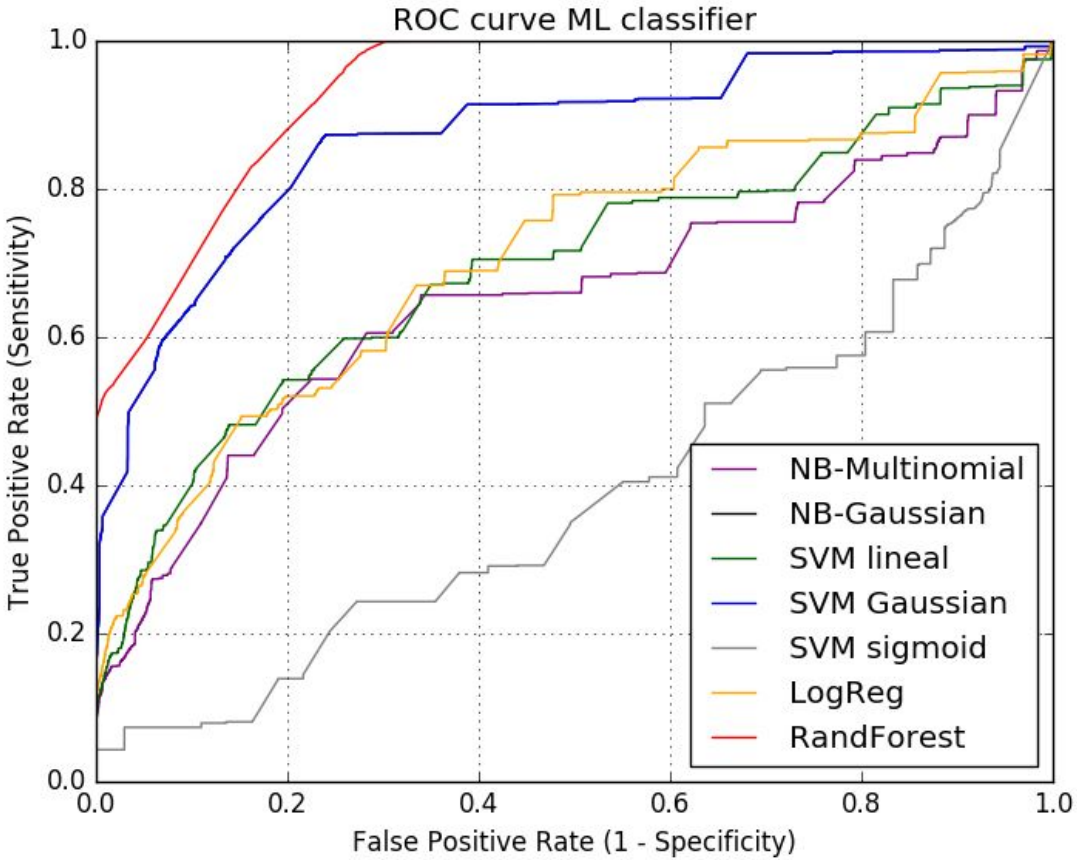
		Anomalous predictions Original data			
	Precision	Recall	F1-Score	Accuracy	AUC
NB + Gaussian	0,720	0,200	0,320	0,643504366812	0,657966634589
NB + Multinomial	0,750	0,230	0,350	0,653056768559	0,650886405340
SVM + Sigmoid	0,000	0,000	0,000	0,592139737991	0,390236405688
SVM + linear	0,810	0,260	0,390	0,674672489083	0,693580346245
SVM + Gaussian	**0,830**	0,620	0,710	0,794596069869	0,870937300964
Logistic Regression	0,700	0,410	0,520	0,688373362445	0,707206599566
Random Forest	0,750	**0,880**	**0,810**	**0,832860262009**	**0,933937629906**

Results performance classification



		Normal cases predictions Original data			
	Precision	**Recall**	**F1-Score**	**Accuracy**	**AUC**
NB + Gaussian	0,630	0,950	0,760	0,643504366812	0,657966634589
NB + Multinomial	0,640	0,950	0,760	0,653056768559	0,650886405340
SVM + Sigmoid	0,590	**1,000**	0,740	0,592139737991	0,390236405688
SVM + linear	0,650	0,960	0,780	0,674672489083	0,693580346245
SVM + Gaussian	**0,780**	0,910	0,840	0,794596069869	0,870937300964
Logistic Regression	0,680	0,880	0,770	0,688373362445	0,707206599566
Random Forest	0,910	0,800	**0,850**	**0,832860262009**	**0,933937629906**

ROC


ROC curve ML classifier
True Positive Rate (Sensitivity)
False Positive Rate (1 - Specificity)
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
NB-Multinomial
NB-Gaussian
SVM lineal
SVM Gaussian
SVM sigmoid
LogReg
RandForest