Citizens and cities facing new hazards and threats

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IA, cybersecurity and IT

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Artificial Intelligence to Assist and Optimize Fire Brigade Services

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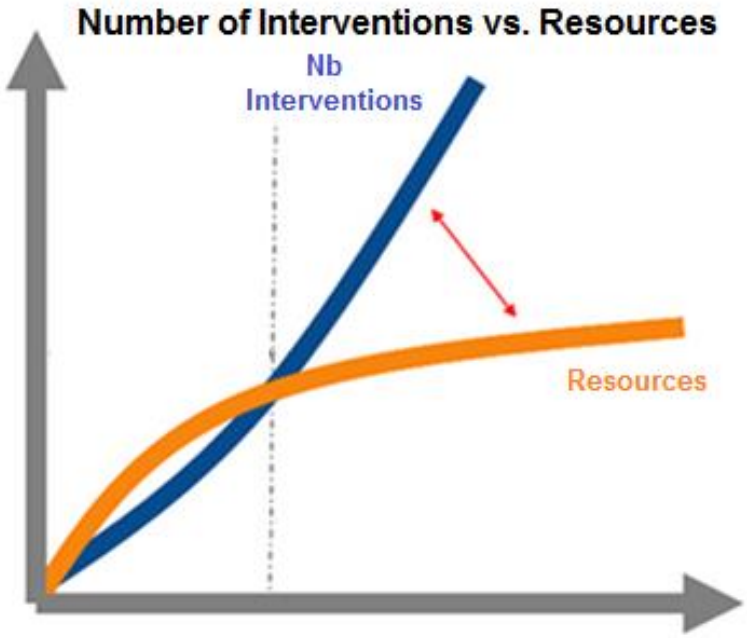
1. Context of the Problem

The scissor effect:

- Fire brigade of Doubs (SDIS 25):
  - Operational load: nearly 40 000 interventions per year
  - Resources: 71 centres and 3 000 firefighters (87% are volunteers).

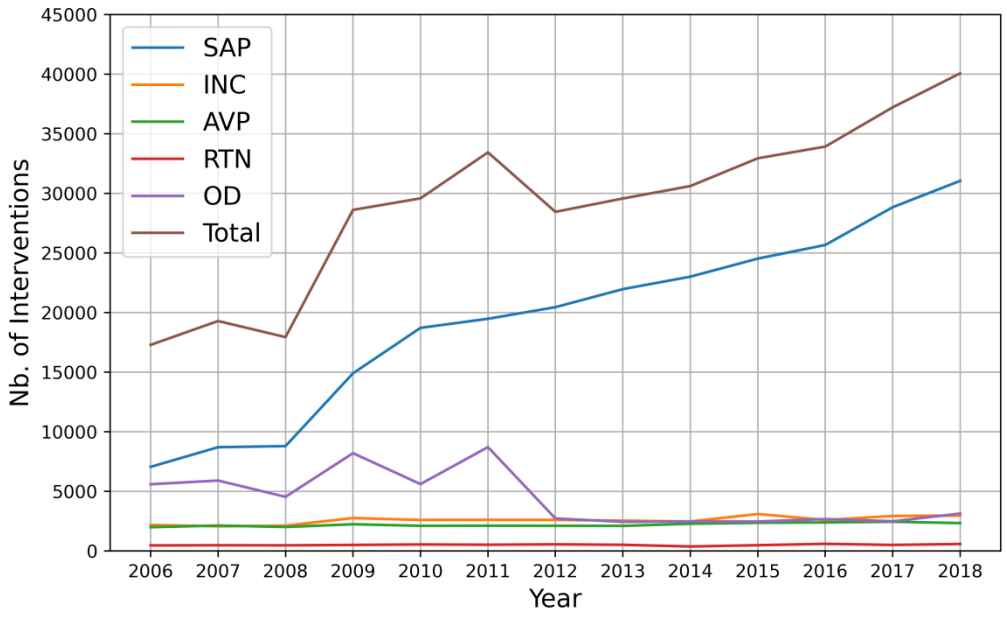
- During the last twenty years, the number of interventions has continued to grow but during the last five years the resources have decreased.



1. Context of the Problem

Operational activity:

- Emergency assistance to people (SAP) : 76% interventions
- Fires (INC) : 7% interventions.
- Public road accidents (AVP) : 6% interventions
- Various operations (OD) and actions to combat natural and technological risks (RTN) : 11% interventions



Hourly intervention statistics

Year	Total Int.	Average	Std. Dev.	Max. Int.
2006	17,375	1.98	2.04	30
2007	19,368	2.21	2.06	13
2008	18,037	2.05	1.95	16
2009	28,719	3.27	3.34	84
2010	29,656	3.38	3.05	93
2011	33,715	3.84	3.66	48
2012	29,070	3.31	2.50	26
2013	29,830	3.40	2.48	30
2014	30,689	3.50	2.55	22
2015	33,586	3.83	2.68	21
2016	34,434	3.93	3.13	85
2017	37,674	4.30	2.94	22
2018	40,957	4.28	3.23	35

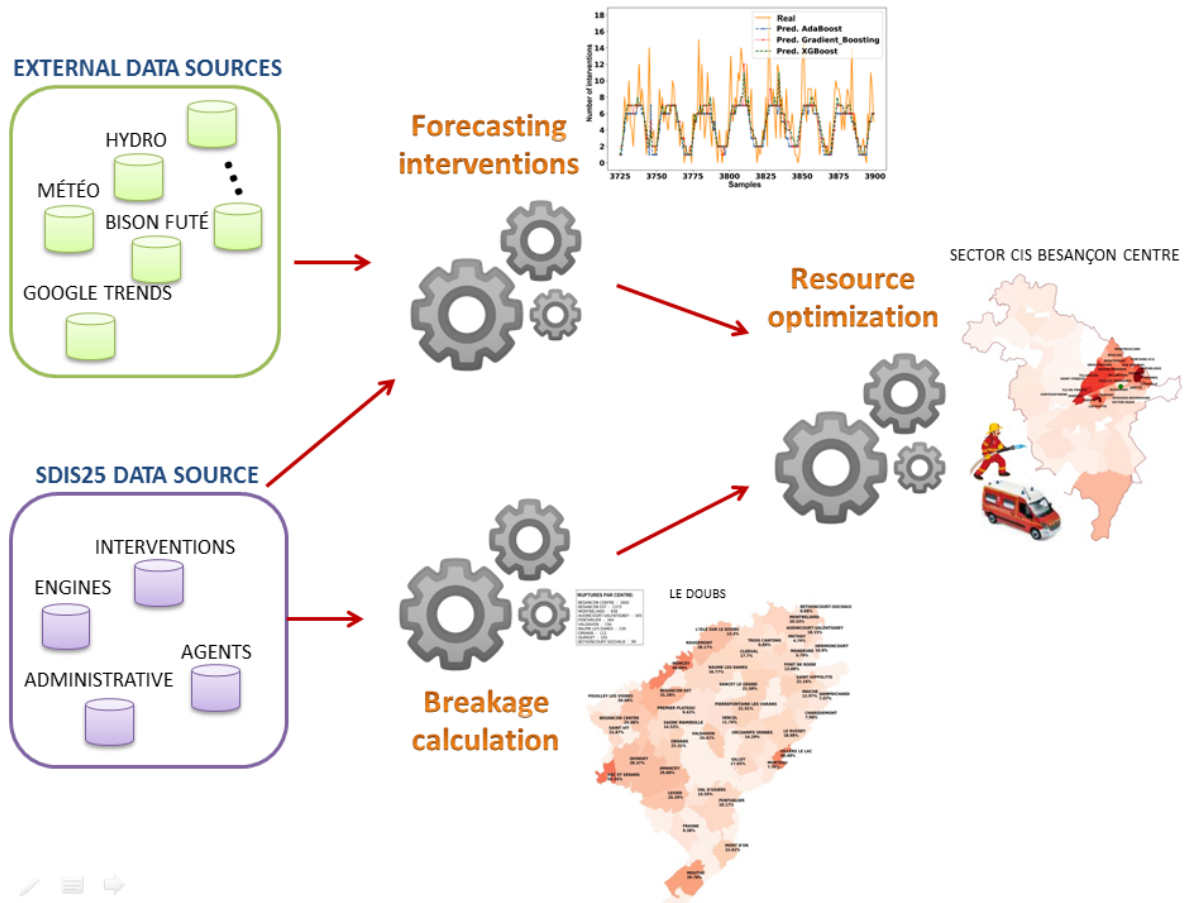
2. Objectives

Forecasting interventions:

- Determine the most influential variables.
- Develop methodologies to predict the number of interventions.
- Develop methodologies for forecasting rare events (storms, fires, etc).
- Propose methodologies to predict the waiting time of firemen's ambulances in hospitals.

Organization of resources:

- Establish performance indicators.
- Develop the breakage calculation and identify their causes.
- Optimize the number of resources deployed in each centre.



3. Methodologies for Predicting Interventions

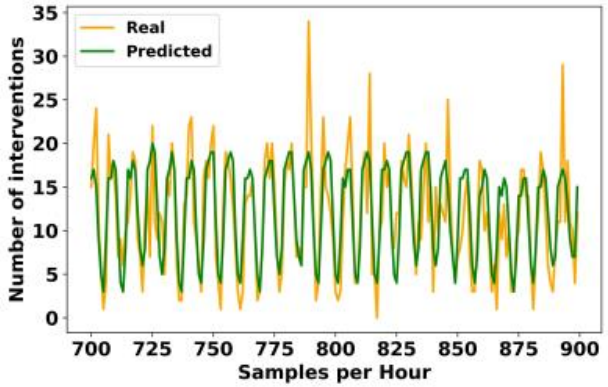


Fig. 5: Predictions for 3h future

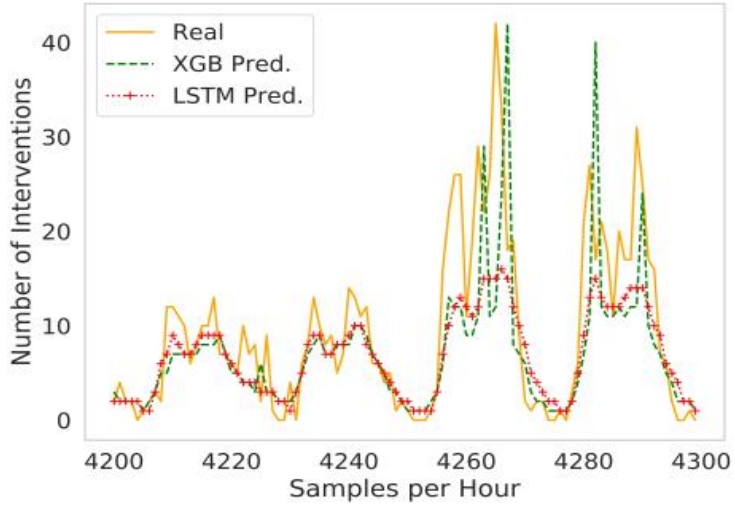


Fig. 3. Predictions for 2011.

Long Short-Term Memory for Predicting Firemen Interventions [1].

- Prediction of the number of interventions for the next hour and for the next 3h for 2017.
- Construction of a dictionary, with internal variables (beginning, end and type of intervention) and external variables (traffic, meteorological, epidemiological, holidays, temporal, etc.), where each sample represents one hour.
- Construction of LSTM models and selection of the best model through a Genetic Algorithm.

A Comparison of LSTM and XGBoost for Predicting Firemen Interventions [2].

- Prediction of the number of interventions for the next hour for years 2006-2017.
- Analysis of the predictions comparing LSTM and XGBoost best models.

3. Methodologies for Predicting Interventions

Boosting Methods for Predicting Firemen Interventions [3].

- It was made a performance comparison of three boosting techniques, namely AdaBoost, Gradient Boosting and XGBoost.
- Predictions of the number of interventions for 2017 and 2018.

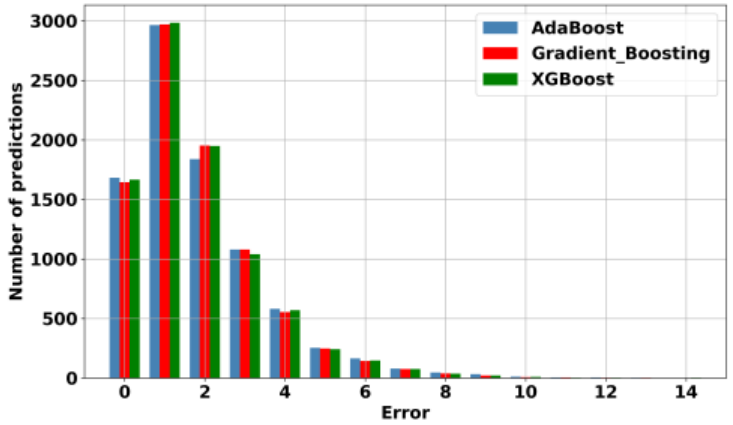
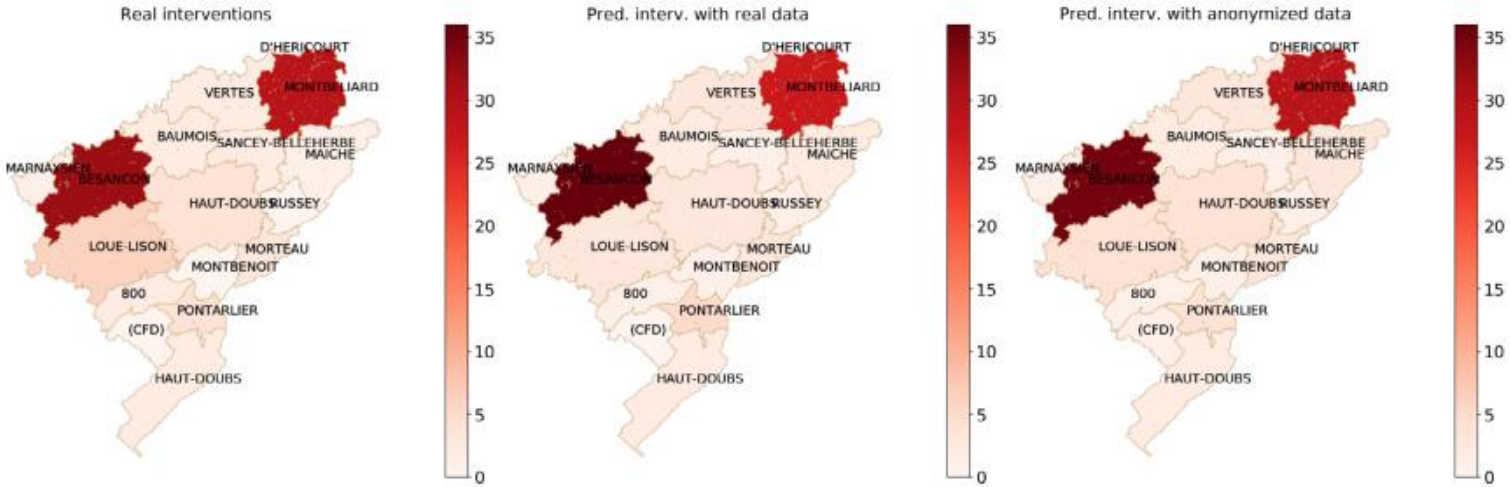


Fig. 4: Exact predictions for 1h - 2018

Forecasting the Number of Firefighter Interventions per Region with Local-Differential-Privacy-Based Data [4].

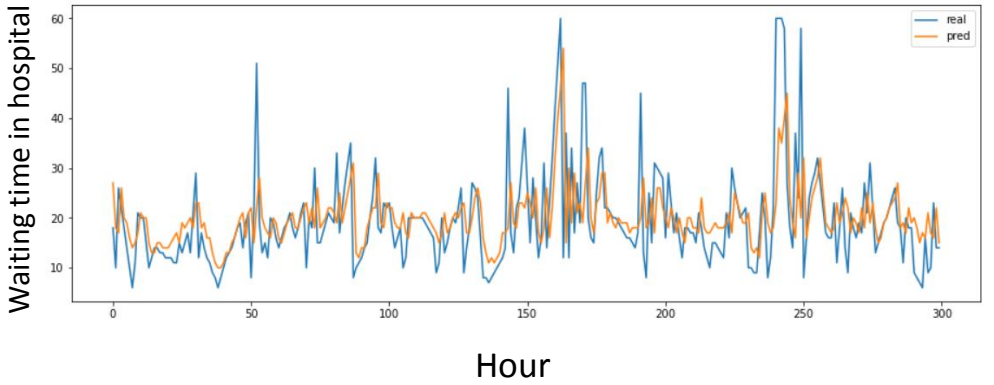
- The location of the interventions was anonymized using the local-differential-privacy approach.
- It was performed the reconstruction of a synthetic data set.
- Predictions were made using XGBoost.



3. Methodologies for Predicting Interventions

Forecasting the Firemen Ambulances' Waiting Time in Hospitals.

- The data set considered external variables such as Google Trends and Data Gouv.
- It is being used time series and classification techniques.
- It would be applied the breakage calculation for the 1st semester of 2020 (pandemic period and lockdown) and for the 1st semester of 2019 (normal year) to examine the impact of COVID-19.



Predicting Rare Events with Natural Language Processing.

- The texts are extracted from Météo-France bulletins and are being classified into categories such as storms and fire risk.
- The techniques used are LSTM and the pre-trained model Camembert.

Bulletins de Météo France → **LSTM**

Storms

```
Prediction results:
Accuracy: 71.55
Balanced Accuracy: 69.46
Accuracy Class 0: 64.42
Accuracy Class 1: 74.5
Confusion Matrix:
 [[ 67  37]
 [ 64 187]]
```

Fire risk

```
Prediction results:
Accuracy: 84.79
Balanced Accuracy: 85.04
Accuracy Class 0: 84.14
Accuracy Class 1: 85.94
Confusion Matrix:
 [[191  36]
 [ 18 110]]
```

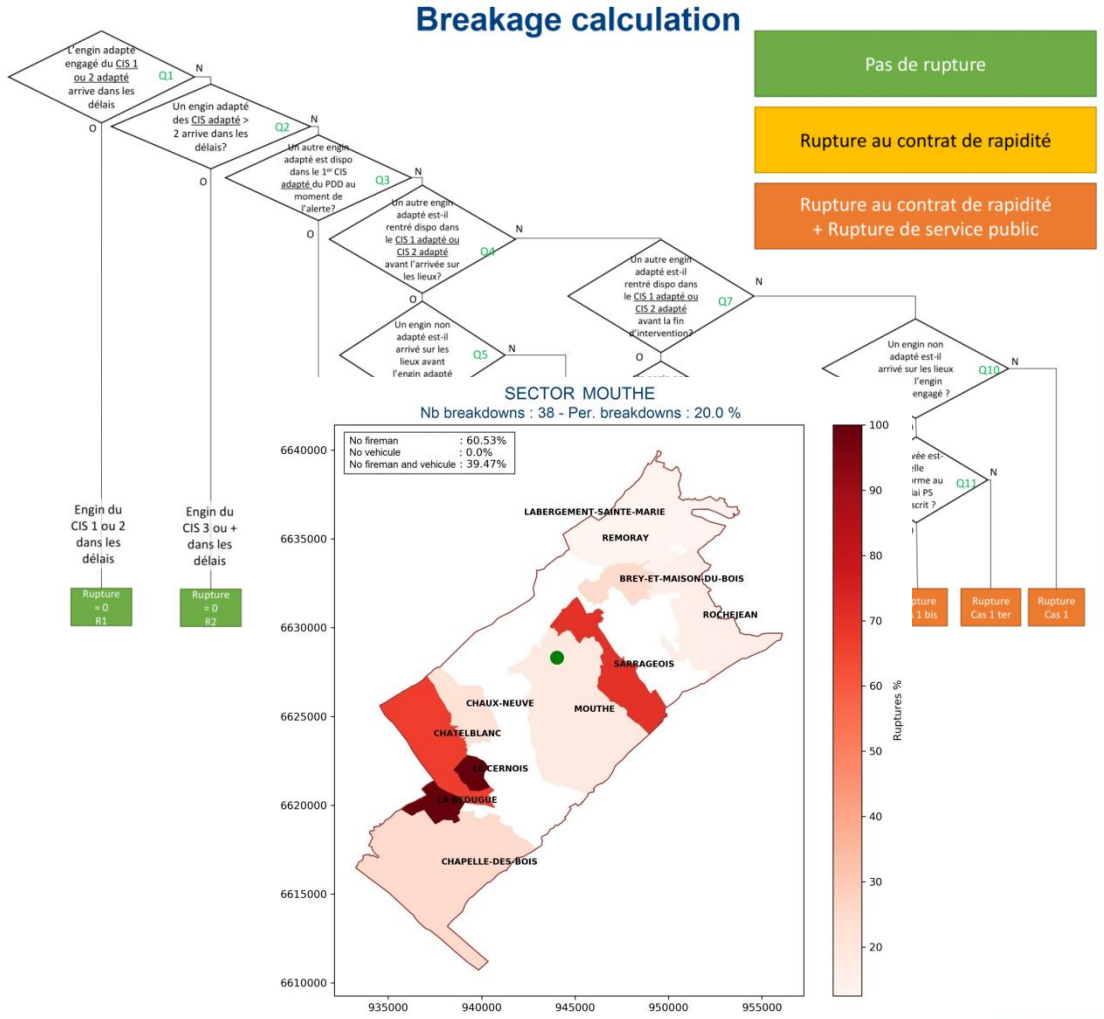
4. Methodologies for Optimizing Resources

Predicting Fire Brigades Operational Breakdowns: A Real Case Study [5].

- A methodology for the breakage calculation was constructed.
- It was developed an optimization method for searching the available adapted armament.
- The centres with the most ruptures and their causes were recognized.
- Breakdown prediction models were developed comparing 5 techniques.

Reorganization of the number of engines deployed in the region to reduce breakdowns.

- Optimize the distribution of the engines to reduce the breakdowns reached in 2018, this year corresponds to a peak in the operational activity.



5. Conclusion and Future Work

- During the data analysis, it was found a constant increment of interventions through the years, as a consequence, more workload for firefighters.
- There is a need to build an intelligent system capable of forecasting the number of interventions at any given time in the future.
- Forecasting the number of interventions for the next hour using boosting techniques is possible for fire brigades. They showed a fast execution time and recognition of outliers.
- Anonymized interventions and their predictions continued to yield good results.
- The methodology established for the breakage calculation and the algorithm for searching for available adapted armament allowed the SDIS 25 to analyse the current state of the service and to identify the most affected centres.

For future work:

- We will be testing different methodologies for the prediction of waiting time in hospitals. As well as forecasting rare events such as storms and floods which affect the region the most.
- For resource optimization, we will be testing techniques such as Bayesian optimization, as well as identifying possible areas for the location of a new centre.

6. References

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That's all folks!
Thank you!