FFRAUD-ER: Development of a Computational Model for identifying food fraud incidents as drivers for food safety Emerging Risks

Trusted science for safe food

Project overview

The Scope

The scope is to build a **computational model** that classifies **food fraud incidents** as **food safety issues** for EFSA**.** This included assembling a labelled dataset and to train, evaluate, test and fine-tune machine learning models to automate the identification of food safety issues.

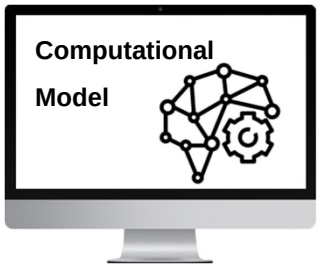
What we did

To assist EFSA in the identification of emerging risks in food safety, we developed a **large language model** which **classifies food fraud incident descriptions as food safety** with **high accuracy.**

- Gathered **over 23.000 food fraud text descriptions** from various different sources.
- Worked in collaboration with academics to label data to train models.
- Trained and tested large language models for text classification tasks.
- Tested and evaluated the models and chose the best performing one (XLNet) for **fine-tuning**.

Text input (FF description)

Binary output (FS or non FS)



✓ ***Rapid incident evaluation***: Process large amounts of data quickly to **identify potential hazardous situations** that can affect public's safety.

✓ ***Early detection of trends and identification of emerging risks***: Can be used as an **early warning mechanism** by prioritising them and prevent potential hazardous situations.

Rapid incident evaluation

Early detection of trends and identification of emerging risks

Assembling the labelled dataset

1. Identification of data sources
2. Prioritisation and selection of most relevant data sources using PRISMA approach

The first step in the process of developing the computational model was to identify the **data sources** to gather data for training and testing. To achieve this, we performed **desk research**, creating a pool of sources, and we used **qualitative criteria** to select the most appropriate ones for our scope.

Using the PRISMA approach we prioritised the most appropriate data sources for our scope, with Multi-Criteria Decision Analysis (MCDA).

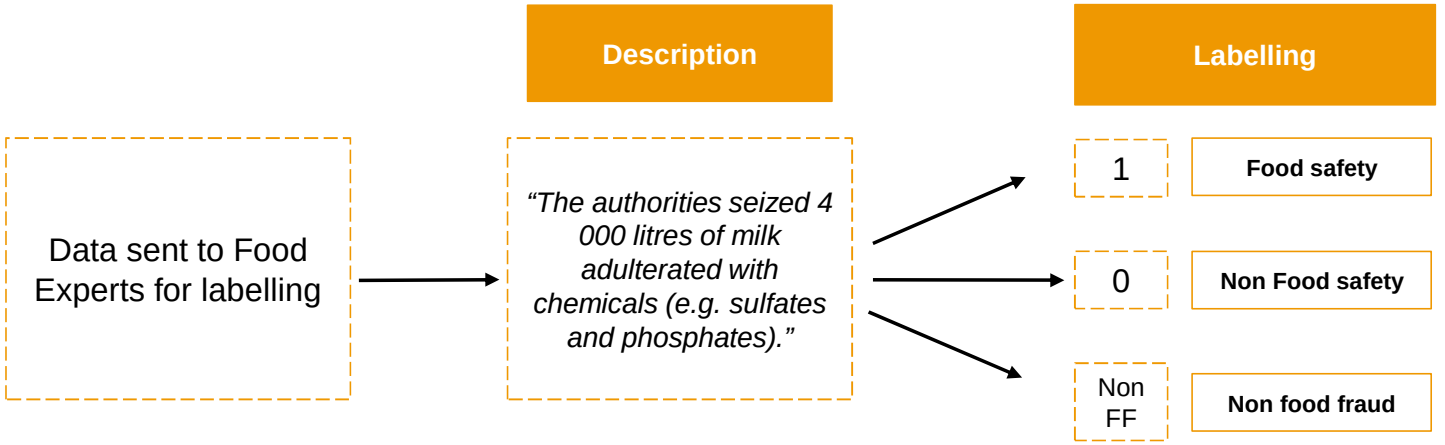
DATA SOURCES	
JRC	RASFF
Food Fraud Risk Information Database	HorizonScan

Data cleaning and labelling

1. Identification of data sources
2. Prioritisation and selection of most relevant data sources using PRISMA approach
3. Data gathering from selected data sources
4. Data cleaning and preprocessing
5. Data labelling of food fraud incidents on whether they have a food safety risk

Since data is the fuel of all Artificial Intelligence models, it was necessary to check if the data was **clean** and **well-prepared for modelling**.

After the cleaning and pre-processing, the data was sent to out Food Experts for labelling.



Data labelling is necessary for the computational model to learn which food fraud incident descriptions are food safety issues or not, and later be able to provide a label on its own in new, unseen food fraud descriptions.

The data was sent to the Food Experts for labelling in the form of xlsx files. The experts had **three options** for labelling:

- Labelling the FF description as **1** if they judged that it could pose a food safety concern
- Labelling the FF description as **0** if they judged that it would not pose a food safety concern
- Labelling the FF description as **NonFF**, if they judged that the case was not food fraud, and therefore out of our scope

Final labelled dataset

1. Identification of data sources
2. Prioritisation and selection of most relevant data sources using PRISMA approach
3. Data gathering from selected data sources
4. Data cleaning and preprocessing
5. Data labelling of food fraud incidents on whether they have a food safety risk

Description	Safety Issue Label
Violation of standard of use - Sodium benzoate detected (0.731g/kg) in berry, lingonberry and cranberry beverage	0
The authorities seized 21 000 cans of contraband alcohol (total value of almost 9 000 Euros).	1
Ossido di etilene nel pancroccante con semi di sesamo e chia	1
absence of labelling (German) on fried yellow croaker from China, via the United Kingdom	0
Recall of cocoa balls due to Order of Permanent Injunction. The products are misbranded and deemed unapproved drugs based on labeling claims.	0
Sheep meat is being mislabelled as goat at high rates in parts of the United Kingdom.	0
unauthorised irradiation (Glow ratio 0,61) and unlabelled irradiation of food supplement made of fruit and vegetable extract concentrate from the United States, via the Netherlands	0
Potatoes found to be of different variety than that declared	0
FDA Import Refusal for HERBALS & BOTANICALS (NOT TEAS), N.E.C. from Canada. The article appears to be misbranded in that the label or labeling bears an unauthorized nutrient content/health claim.	0
Conductivity of honey found to be lower than specified for honeydew honeys, suggesting a different botanical source to that declared on packaging	0
FDA Import Refusal for FIG, DRIED OR PASTE from Turkey. The article appears to be misbranded in that the label or labeling fails to bear the required nutrition information.	0
absence of health certificate(s) and absence of certified analytical report for Indian peanut product from India	1
FDA Import Refusal for HERBALS & BOTANICAL TEAS, N.E.C. from Honduras. The article is subject to refusal of admission pursuant to Section 801(a)(3) of the FD&C Act in that it appears to be misbranded within the meaning of Section 403(i)(2) of the FD&C Act.	0
FDA Import Refusal for TOMATOES, JUICE from United States. The article appears to be misbranded in that the label or labeling fails to bear the required nutrition information.	0
FDA Import Refusal for ORIENTAL NOODLES (FLAVORED WITH SHRIMP,CHICKEN,BEEF,LOBSTER,CRAB,PLAIN,ETC.). Fabricated from two or more ingredients and the label fails to bear the common or usual name of each such ingredient.	0
Canned beef containing more fat than stated on label	0
food additives - guar gum powder	0

Final labelled dataset

We will now demonstrate our final labelled dataset characteristics through a dashboard we created using Microsoft's Power BI

Power BI

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The final labelled dataset

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Process for the development of the model

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5. Data labelling of food fraud incidents on whether they have a food safety risk
6. Create a preliminary list of models to use
7. Identify metrics to be used to choose the best performing model

Model	BERT	XLNET	ELMo	ELECTRA
Accuracy				
Efficiency				
Scalability				
Interpretability				
Robustness				
Adaptability				
Resource requirements				
Open source				

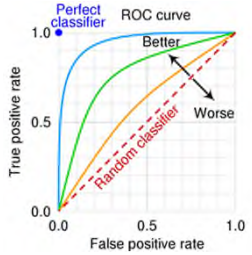
Hyper-parameter-tuning

F1 Score

$$F1\ Score = \frac{2 * Precision * Recall}{Precision + Recall}$$

Similarly performing models

ROC Curve



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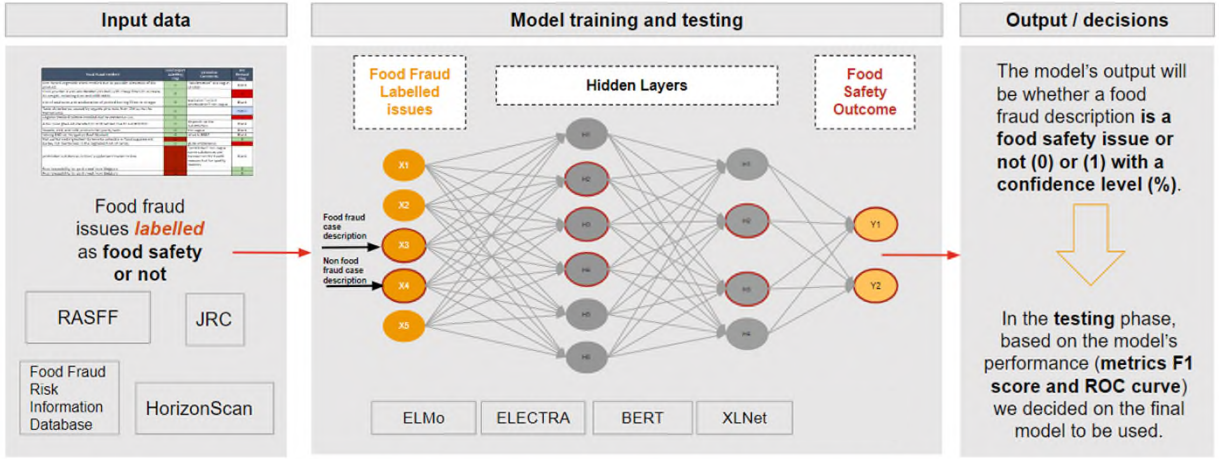
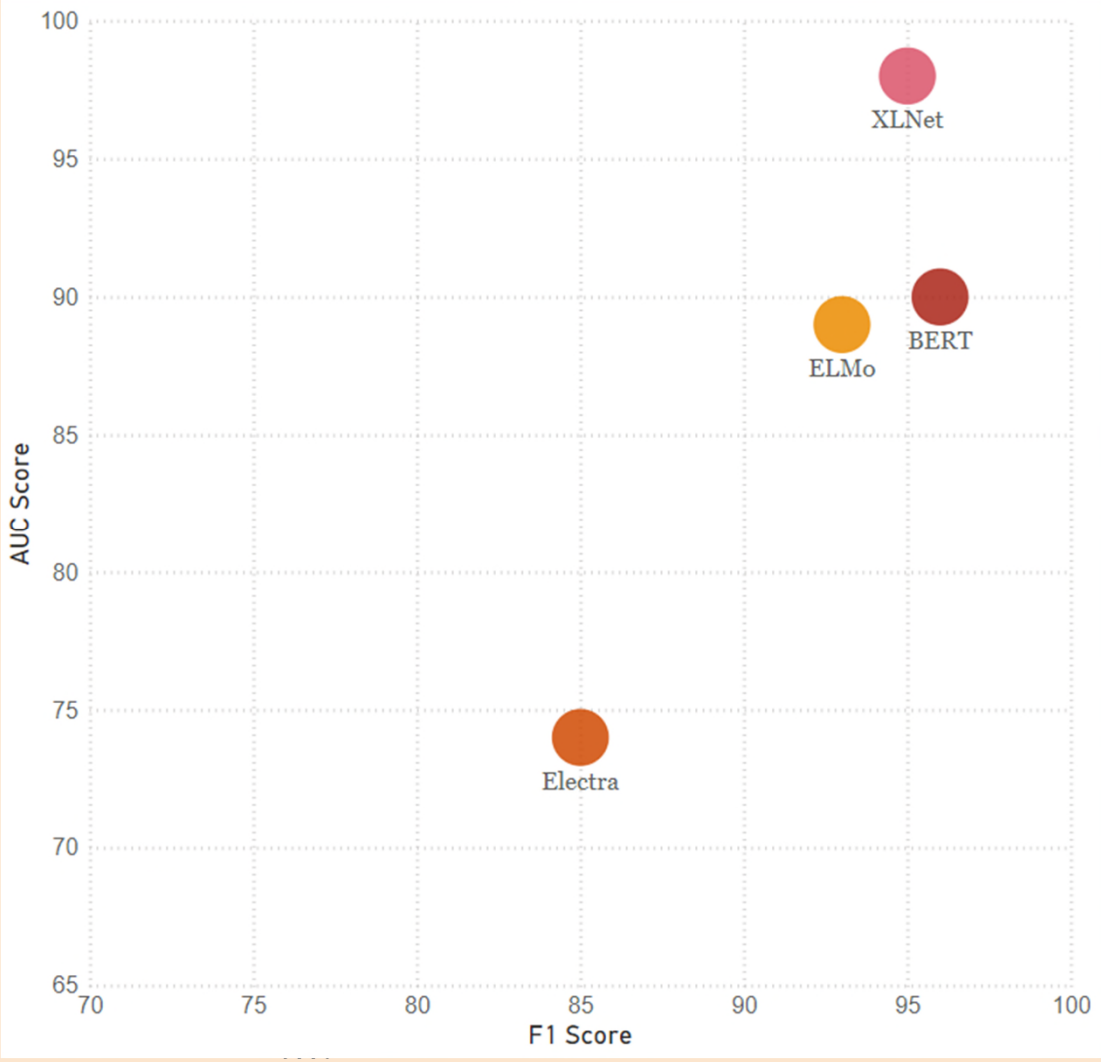
8. Finalise labelled dataset and split it into training, test and validation set
9. Develop and train the computational models using the labelled data training set
10. Tune and optimise each model's hyperparameters using the validation set

In this step, we used the food fraud incidents that were labelled as food safety or not by our food experts as input data to our model(s). The incidents went through the model, and the model was **trained** to recognise accurately which cases are food safety or not.

Then, the model's performance was tested and the metrics (F1 score and ROC) were produced to select the best performing model for our scope.



Process for the development of the model



11 Import test set into the models as an input to test each models' performance

12 Use the metrics identified and agreed with EFSA to choose the best performing model

13 Finalise selected model and provide EFSA with the end product

The models in the preliminary list were tested on their performance based on the selected metrics (F1 Score and ROC/AUC).

XLNet when tested using the validation set, it outperformed all other models, with an **F1 score of 95%** and an **AUC score of 98%**

Therefore, because of its better performance, XLNet was the selected model used for the scope of this project.

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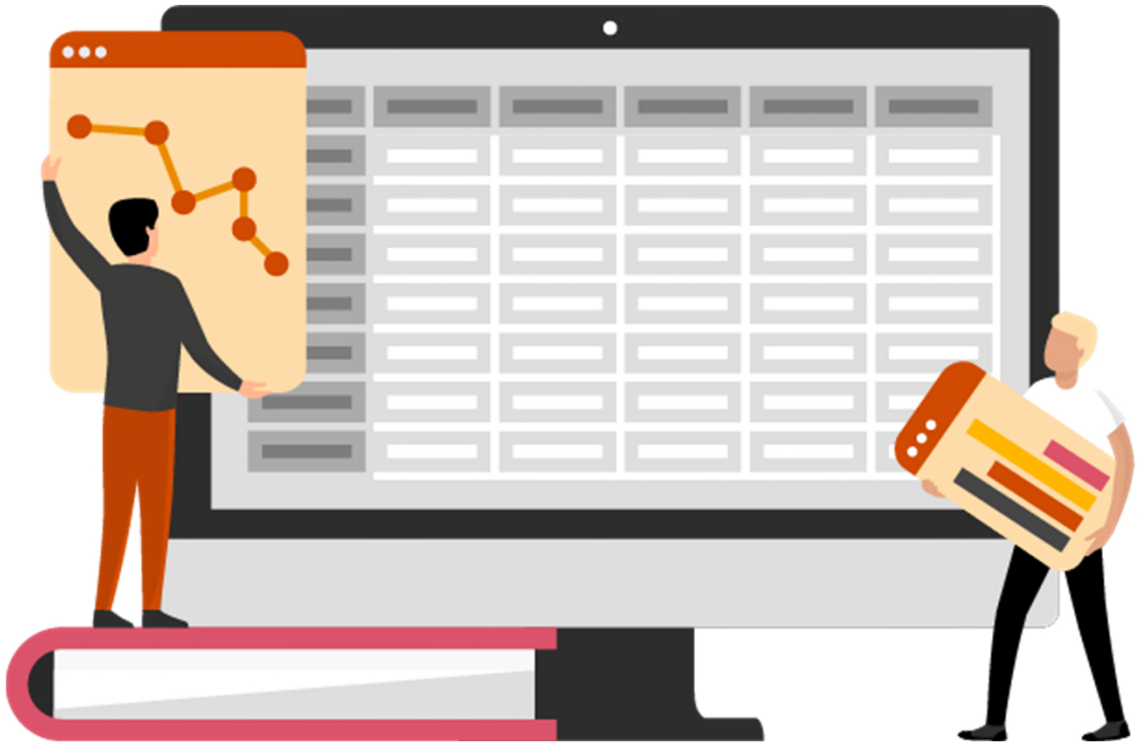
End product and model refinement

1. EFSA will gather a set of food fraud incident descriptions
2. The food fraud incidents are imported into the computational model

3. The model will assess each food fraud incident and return a food safety label and its confidence level
4. The outputs are validated by a master annotator
5. Re-train the computational model with the newly validated data

Thank you!



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