CONSTRUCTION ACCIDENT REPORT CLASSIFICATION

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INTRODUCTION

According to the ILO, about 2.78 million workers die annually from occupational accidents, with one in six occurring in the construction industry.

Following an accident, detailed **reports** are usually compiled, which include also unstructured narrative data. Their unstructured nature poses considerable challenges for analysis and knowledge extraction.

The objective of this project is to develop a **classification model** capable of assigning **construction accident reports** to their **correct category**.

Accident: 114404.015 - Employee Falls From Roof And Dies From Multiple Injuries				
Open Date	Establishment Name	End-Use	Project Type	···
03/13/2019	Hough Roofing, Inc.	Commercial building	Maintenance or repair	···
At 4:00 p.m. on March 12, 2019, Employee #1, employed by a roofing company, was engaged in roofing work at a two-story commercial building... It began to rain slightly. Employee #1 fell, a fall height of 23.5 feet··· Employee #1 died later that night from his injuries.				
Keywords: roofer, fall, fall protection, construction, ···				

Employee #	Age	Sex	···	Construction	Inspection
1	52	M	···	FatCause: Fall from roof	1384743.015

Inspection: 1384743.015 - Hough Roofing, Inc.				
Violation Items				
ID	Type	Standard	Curr$	Init$
01001	Serious	19260501 B11	$11,934	$13,260
01002	Serious	19260503 A01	$2,652	$5,304
···				

DATASET

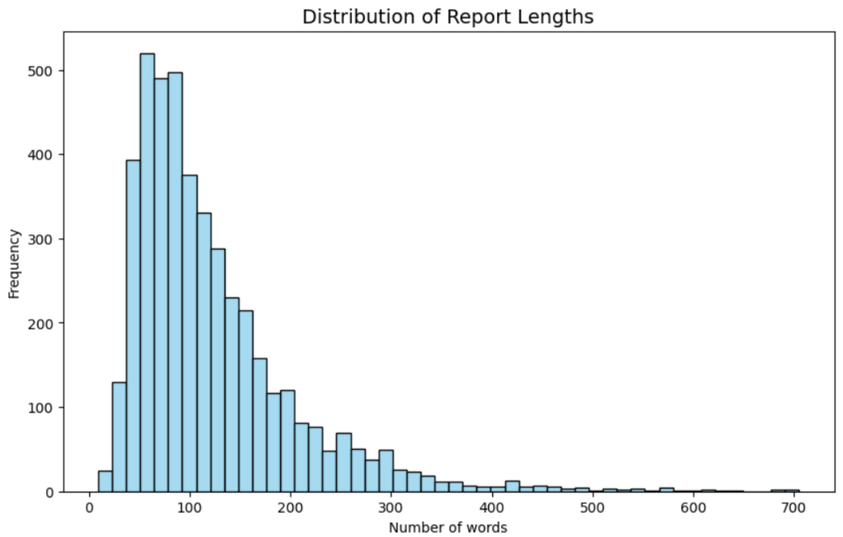
4,770 construction accident reports from the Occupational Safety and Health Administration (OSHA).

There are several fields, but we are interested in the following:

• **title and SUMMARY**: The title and the narrative text describing the details of the accident;

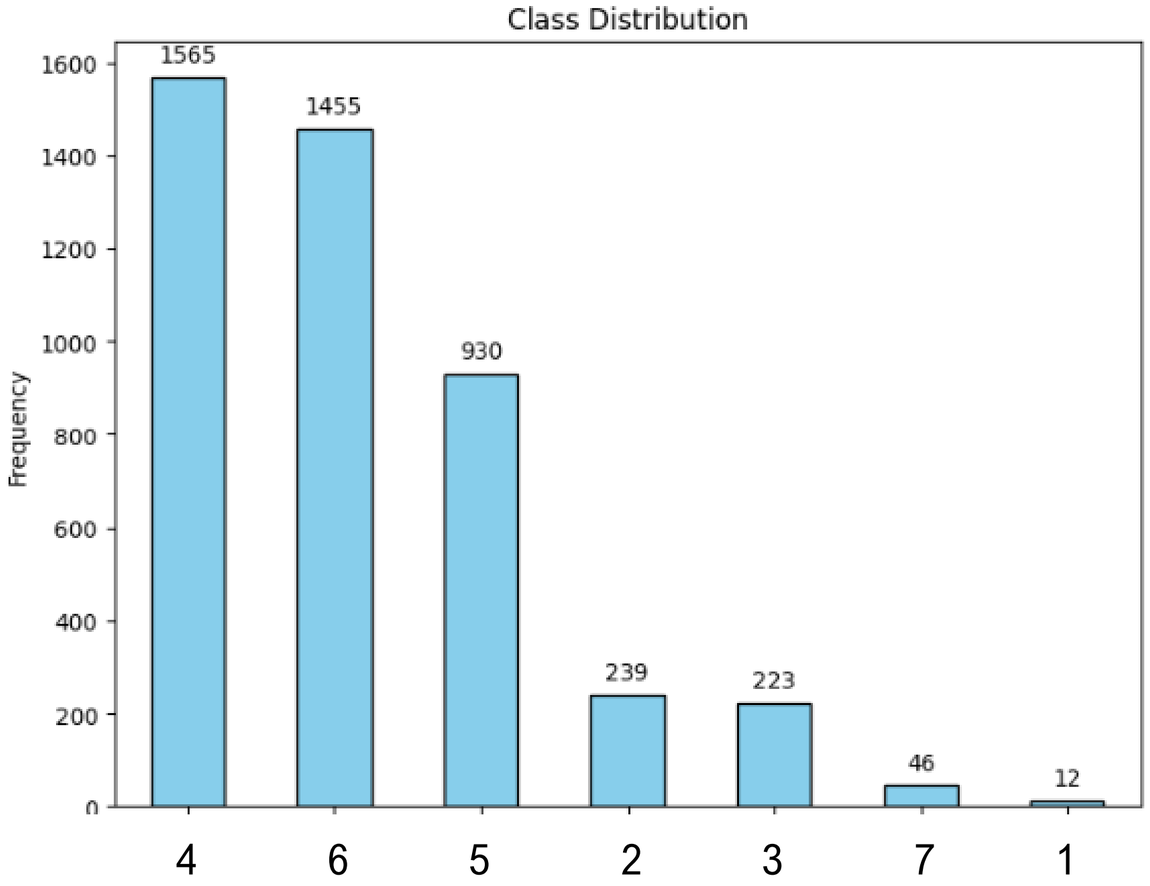
• **TaggedL1**: This is the primary label of the accident. There are seven distinct categories:

– 1 VIOLENCE AND OTHER INJURIES BY PERSONS OR ANIMALS
– 2 TRANSPORTATION INCIDENTS
– 3 FIRES AND EXPLOSIONS
– 4 FALLS, SLIPS, TRIPS
– 5 EXPOSURE TO HARMFUL SUBSTANCES OR ENVIRONMENTS
– 6 CONTACT WITH OBJECTS AND EQUIPMENT
– 7 OVEREXERTION AND BODILY REACTION



CLASS DISTRIBUTION

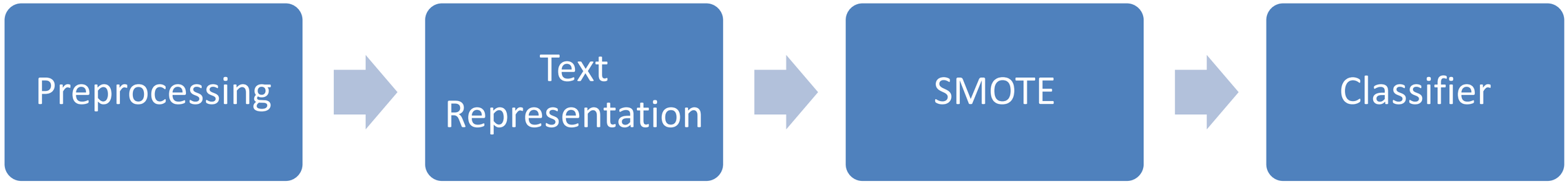
- Highly **imbalanced problem;**
- Class overlap, especially for minority classes (harder to recognize them) [1][2].



DATA PREPARATION

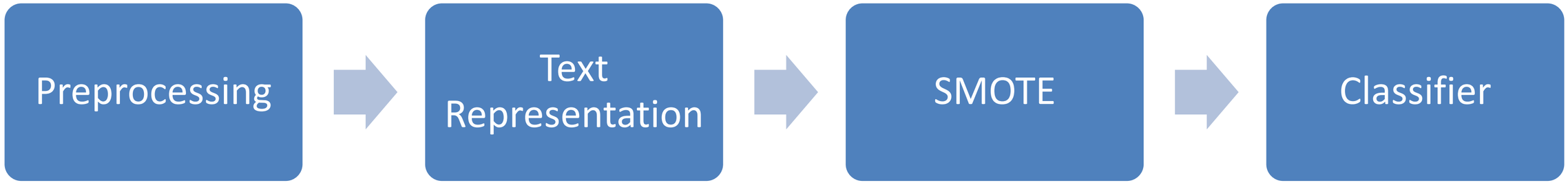
- Combined the **title** and **SUMMARY** fields to create the input texts (**X**);
- Used **TaggedL1** as the target labels (**y**);
- Performed a 70/30 train – test split.

PIPELINE BUILD



- Tokenization;
- Convert to lowercase;
- Removal of punctuation and stopwords;
- Stemming.

PIPELINE BUILD



- Word Embedding: Word2Vec
- Text Vectorizer: Weighted Class TF-IDF[3]

TEXT REPRESENTATION

WCTF-IDF Algorithm:

1. Set `f` as the maximum total number of features.

2. Sort the classes in descending order of document frequency.

3. For each class `i`:
   - Compute the number of features to assign:
     $f_i = f \times (n_i / n)$

     where n_i = number of documents in class i,
     and n = total number of documents.

   - Fit a TF-IDF vectorizer on the documents of class i
     using f_i as the max_features parameter.

   - Pass the selected terms as stopwords to the next class
     to reduce vocabulary overlap.

4. Merge all resulting vocabularies to form the final TF-IDF vectorizer.

MODEL EVALUATION

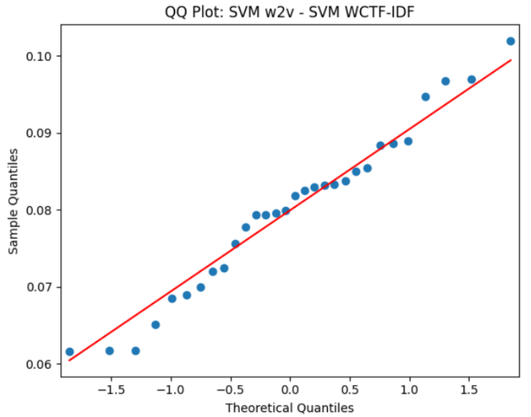
- Several different classifiers;
- **Nested 5-fold cross-validation:** (Inner and outer loops);
- **Stratified sampling** to ensure balanced classes.

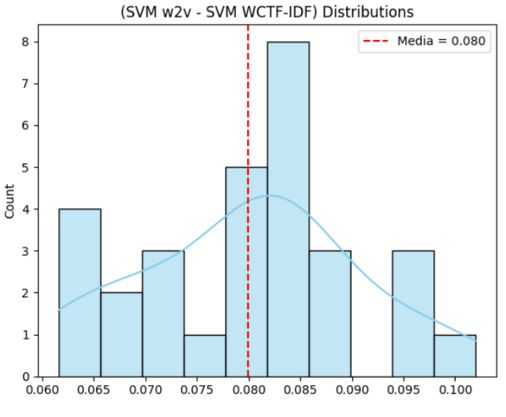
Model	WCTF-IDF		Word2Vec	
	Accuracy	Weighted F1-score	Accuracy	Weighted F1-score
Random Forest	0.883 ± 0.007	0.879 ± 0.007	0.817 ± 0.010	0.815 ± 0.012
Logistic Regression	$\mathbf{0.903 \pm 0.007}$	$\mathbf{0.903 \pm 0.007}$	0.808 ± 0.005	0.818 ± 0.003
Linear SVM	0.901 ± 0.008	0.901 ± 0.008	0.820 ± 0.009	0.826 ± 0.007
XGBoost	0.891 ± 0.006	0.889 ± 0.006	0.826 ± 0.008	0.825 ± 0.007
Bagging	0.824 ± 0.015	0.829 ± 0.012	0.786 ± 0.019	0.787 ± 0.017
Decision Tree	0.794 ± 0.014	0.798 ± 0.013	0.680 ± 0.016	0.688 ± 0.015
KNN	0.680 ± 0.007	0.705 ± 0.008	0.727 ± 0.013	0.744 ± 0.012
MultinomialNB	0.856 ± 0.017	0.856 ± 0.016	—	—

MODEL SELECTION

- SVM WCTF-IDF vs SVM word2vec (Wilcoxon Test)

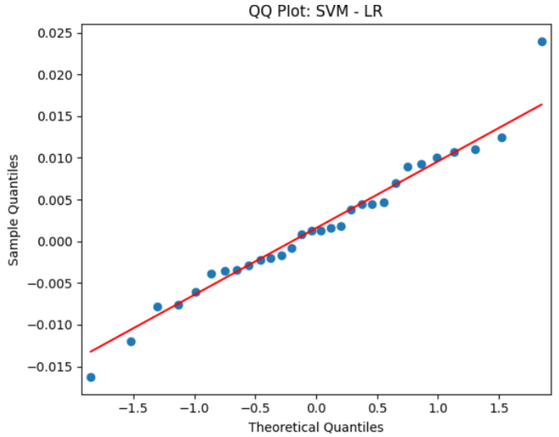
p-value = 0.0000000019 → Statistical evidence of difference.

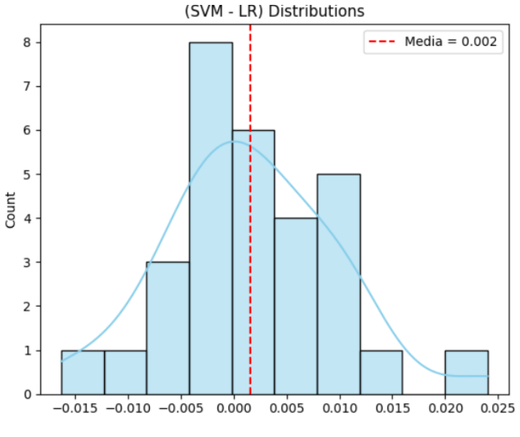




- SVM WCTF-IDF vs LR WCTF-IDF (Wilcoxon Test)

p-value = 0.36 → No statistical evidence of difference.

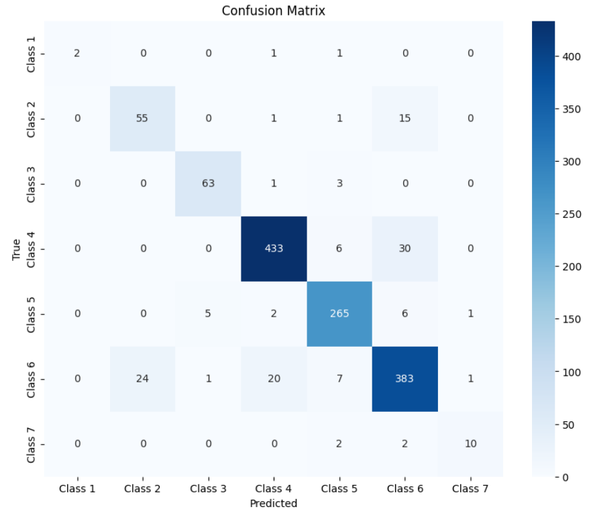




PERFORMANCE EVALUATION (Test set)

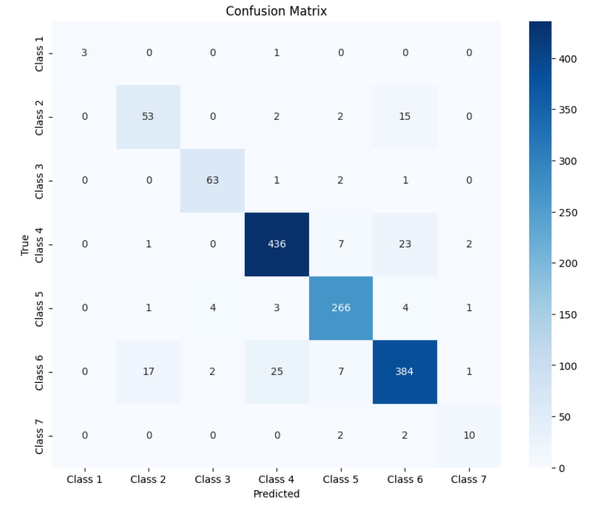
- SVM

Class	Precision	Recall	F1-Score	Support
Class 1	1.00	0.50	0.67	4
Class 2	0.70	0.76	0.73	72
Class 3	0.93	0.94	0.93	67
Class 4	0.95	0.92	0.93	469
Class 5	0.93	0.95	0.94	279
Class 6	0.88	0.88	0.88	436
Class 7	0.83	0.71	0.77	14
Accuracy		0.90		1341
Macro Average	0.89	0.81	0.83	1341
Weighted Average	0.90	0.90	0.90	1341



- Logistic Regression

Class	Precision	Recall	F1-Score	Support
Class 1	1.00	0.75	0.86	4
Class 2	0.74	0.74	0.74	72
Class 3	0.91	0.94	0.93	67
Class 4	0.93	0.93	0.93	469
Class 5	0.93	0.95	0.94	279
Class 6	0.90	0.88	0.89	436
Class 7	0.71	0.71	0.71	14
Accuracy		0.91		1341
Macro avg	0.87	0.84	0.86	1341
Weighted avg	0.91	0.91	0.91	1341



COMPARISON WITH OTHER STUDIES

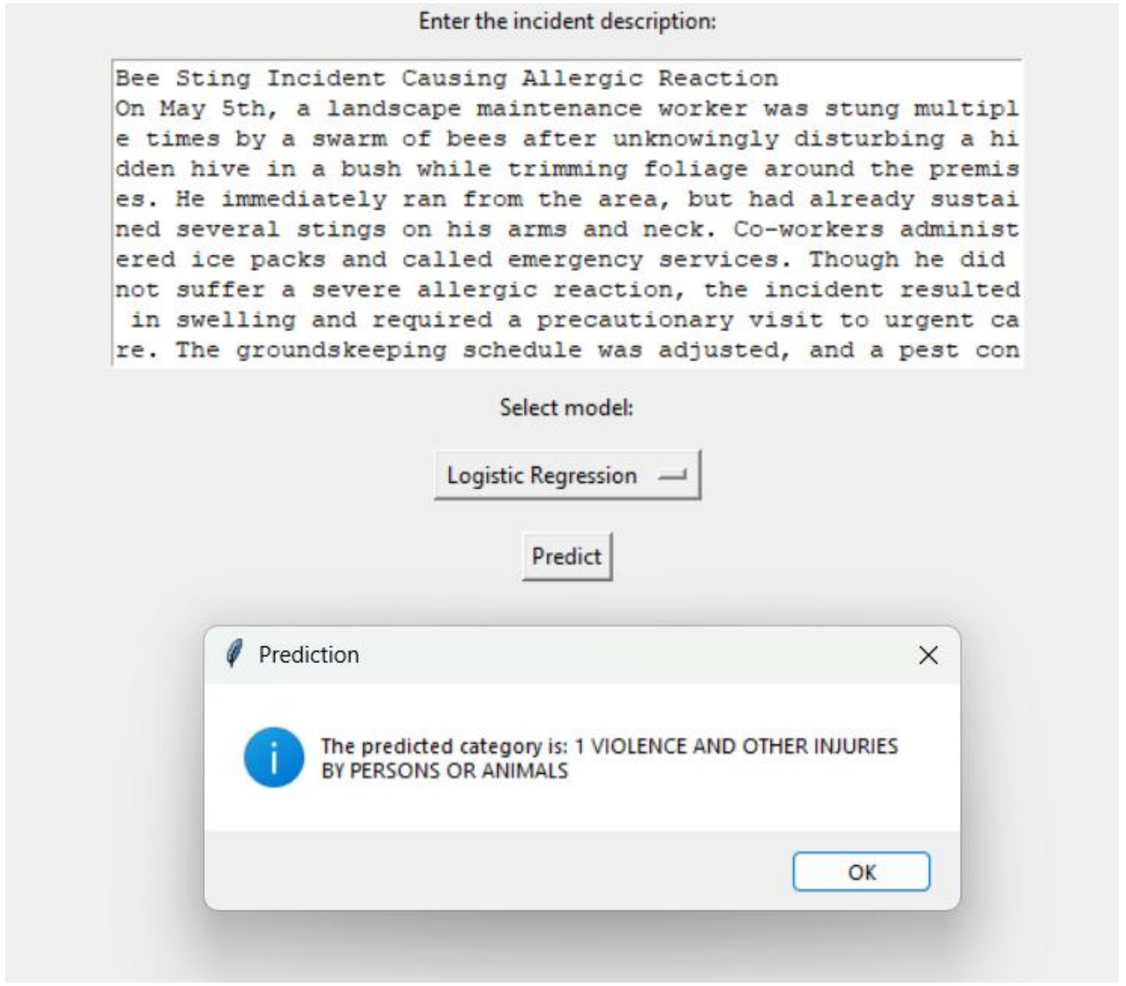
Reference paper results[2]:

- Best model: **SVM** with **8,423 features** (vs. **1,000 features** in our case);

- Overall **Accuracy** and **Weighted F1-score** around **0.91** (same as our best model);

- Class-wise F1-score for the most imbalanced classes (1 and 7):
  Paper: 0.40 and 0.62
  Our best results: **0.86** and **0.77**

INTERFACE


Enter the incident description:
Bee Sting Incident Causing Allergic Reaction
On May 5th, a landscape maintenance worker was stung multipl
e times by a swarm of bees after unknowingly disturbing a hi
dden hive in a bush while trimming foliage around the premis
es. He immediately ran from the area, but had already sustai
ned several stings on his arms and neck. Co-workers administ
ered ice packs and called emergency services. Though he did
not suffer a severe allergic reaction, the incident resulted
in swelling and required a precautionary visit to urgent ca
re. The groundskeeping schedule was adjusted, and a pest con
Select model:
Logistic Regression
Predict
Prediction
The predicted category is: 1 VIOLENCE AND OTHER INJURIES
BY PERSONS OR ANIMALS
OK

REFERENCES

[1] Cheng, M. Y., Kusoemo, D., & Gosno, R. A. (2020). Text mining-based construction site accident classification using hybrid supervised machine learning. Automation in Construction, 118, 103265.

[2] Qiao, J., Wang, C., Guan, S., & Liu, S. (2022). Construction-accident narrative classification using shallow and deep learning. Journal of Construction Engineering and Management, 148(9).

[3] Deepwiz AI. (2023). How to correctly use TF-IDF with imbalanced data. Retrieved from https://www.deepwizai.com/projects/ how-to-correctly-use-tf-idf-with-imbalanced-data

THANK YOU FOR YOUR ATTENTION