74ª REUNIÃO ANUAL DA SBPC

Ciência, independência e soberania nacional

24 a 30 de julho de 2022

SB PC

UnB 60

Advanced Methodologies & Applications of Artificial Intelligence

Dr. Alessandro Leite
Paris-Saclay University

Prof. Peng Wei
George Washington University

Prof. Paulo Costa
George Mason University

Dr. Antonio Crespo
McGill's University

Prof. Li Weigang
University of Brasilia

Virtual panel: 16:00-18:00, July 29, 2022, Brasilia, Brazil

Virtual panel: **Advanced Methodologies and Applications of Artificial Intelligence**

New achievements of Artificial Intelligence in learning and management

Prof. Li Weigang

Coordenator of TransLab, Department of Computer Science, University de Brasilia (UnB)

July 29, 2022, Brasilia, Brazil

AGENDA

- Introduction – TransLab/UnB
- New Artificial Intelligence subcategories study
- From "Once Learning" to "Few-shot learning"
- Multimodal text/image processing by Machine Learning
- AI in 4D air traffic Trajectory-based Operations

1. Introduction

University of Brasilia - UnB

UnB is one of the top public universities in Brasília, Brazil. It is ranked #801-1000 in QS World University Rankings 2023.

Department of Computer Science

The department is with four undergraduate courses including computer science and computer engineering; and also with two graduate programs. There are totally 50 docents, 9 secretaries and 1800 students.

Graduate Program of Informatics - PPGI

PPGI offers master's and doctoral courses, and its faculty has qualified professors in the areas of Computing Systems and Computing Fundamentals and Methods. PPGI is the only program in Computing grade 5 at CAPES in the Midwest Region.

TransLab/UnB

FOCUS

The main research focus of TransLab is to solve problems related to Intelligent Transportation Systems (ITS), with an emphasis on air transportation and other fields related to Artificial Inteligence.

MISSIONS

TransLab aims to be a bridge between academia and society, applying science and techniques in education, research and social services.

ACHIVMENTS

Since 1998, TransLab has advised 110 students including PhD and Post-doctor researchers, published 250 articles in scientific journals, book chapters, or conference proceedings.

QUICK FACTS

Lab name: TransLab

Affiliation: University of Brasilia

Website: http://www.translab.unb.br

Established: 1998

Research focus: Air ITS, air traffic management, and machine learning

Director: Prof. Dr. Li Weigang

2. Artificial Intelligence

Traditional classification of Artificial Intelligence (AI) theory is an effective guide for AI studies, but it is necessary to complement the theoretical architecture of AI.
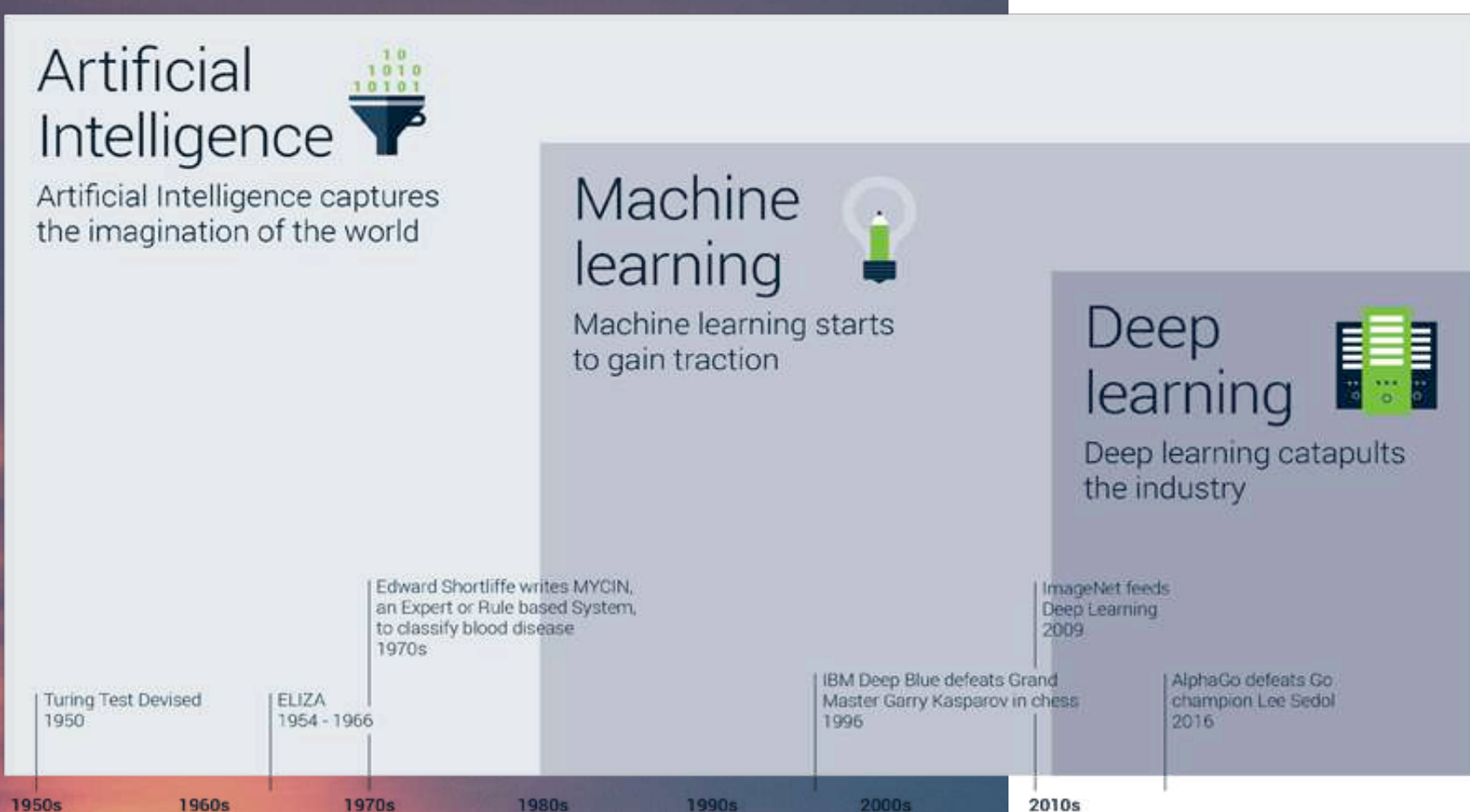
1. The research fields: robots and unmanned machines; NLP; image, audio, and other signal processing; Internet of Things; automatic driving.
2. AI technology: search; knowledge expression and reasoning; expert systems; NNs and ML/DL; data mining; pattern recognition.

3. The application fields: intelligent transportation systems; smart cities; e-commerce; smart recommendations; social networks; data science; others.
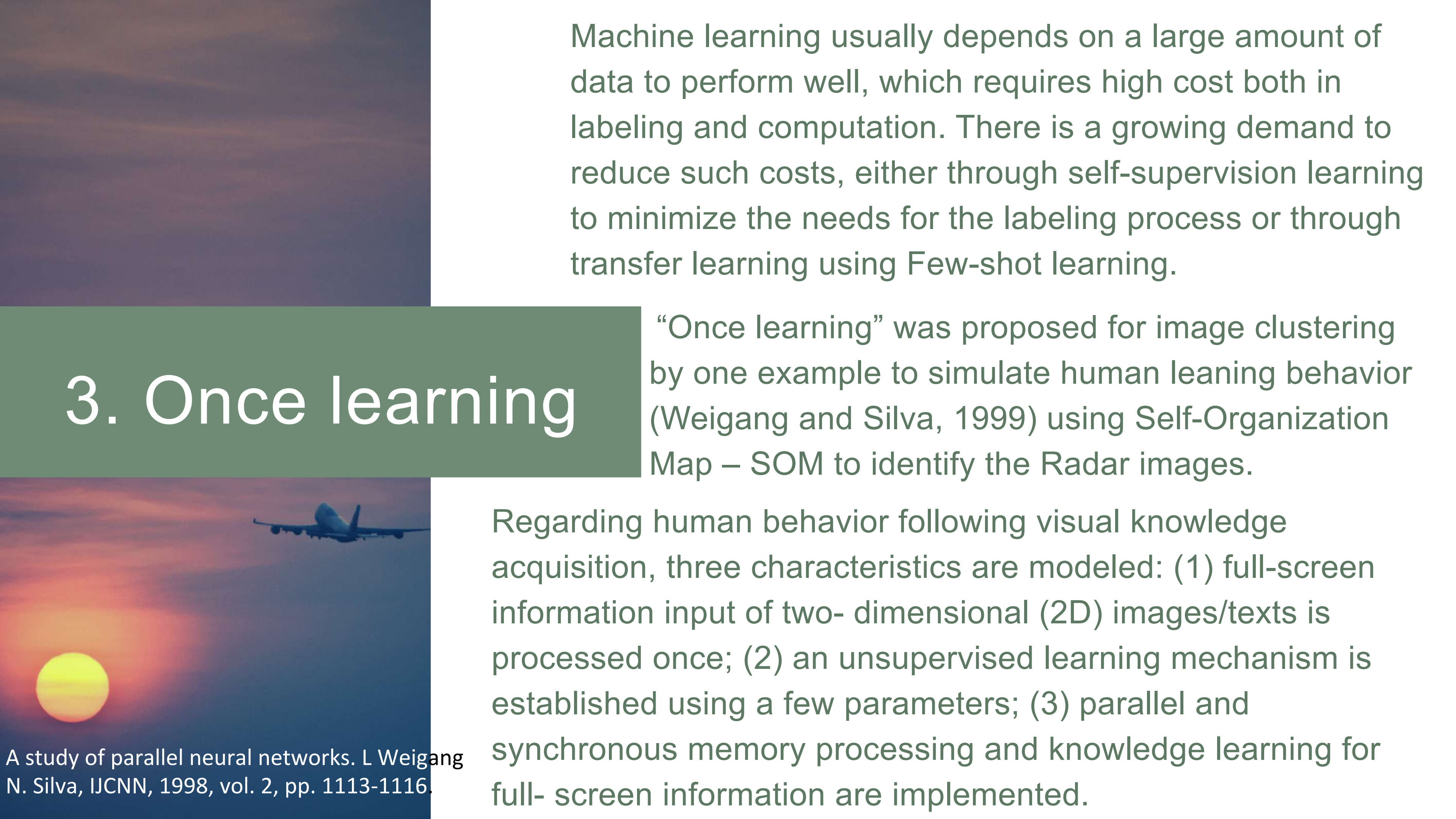
AI new categories

	Artificial Intelligence - AI			
	ABI	AHI	AMI	AQI
AI object	Biological -oriented	Human -oriented	Machine -oriented	Quantum -oriented
Input	Dimension Up		Dimension reduction	
Sample	Few data		Big data	
Learning	Heuristic	Human -like	ML/DL	Quantum Learning
Knowledge	+ Symbolic		+ Numeric	
Robots	Bio- robotics	Human -like	Machine -like	-

Upon analyzing the current state of research in AI, we propose to divide AI into the following categories:

1. Artificial human intelligence (AHI),

2. Artificial machine intelligence (AMI),

3. Artificial biological intelligence (ABI), and

4. Artificial quantum intelligence (AQI).

These can also be considered as the main directions of the R&D within AI.

New directions for artificial intelligence: Human, machine, biological, and quantum intelligence. L Weigang, et al., FITEE, 2022, vol. 23(6), pp. 984-990.

3. Once learning

Machine learning usually depends on a large amount of data to perform well, which requires high cost both in labeling and computation. There is a growing demand to reduce such costs, either through self-supervision learning to minimize the needs for the labeling process or through transfer learning using Few-shot learning.

"Once learning" was proposed for image clustering by one example to simulate human leaning behavior (Weigang and Silva, 1999) using Self-Organization Map – SOM to identify the Radar images.

Regarding human behavior following visual knowledge acquisition, three characteristics are modeled: (1) full-screen information input of two- dimensional (2D) images/texts is processed once; (2) an unsupervised learning mechanism is established using a few parameters; (3) parallel and synchronous memory processing and knowledge learning for full- screen information are implemented.
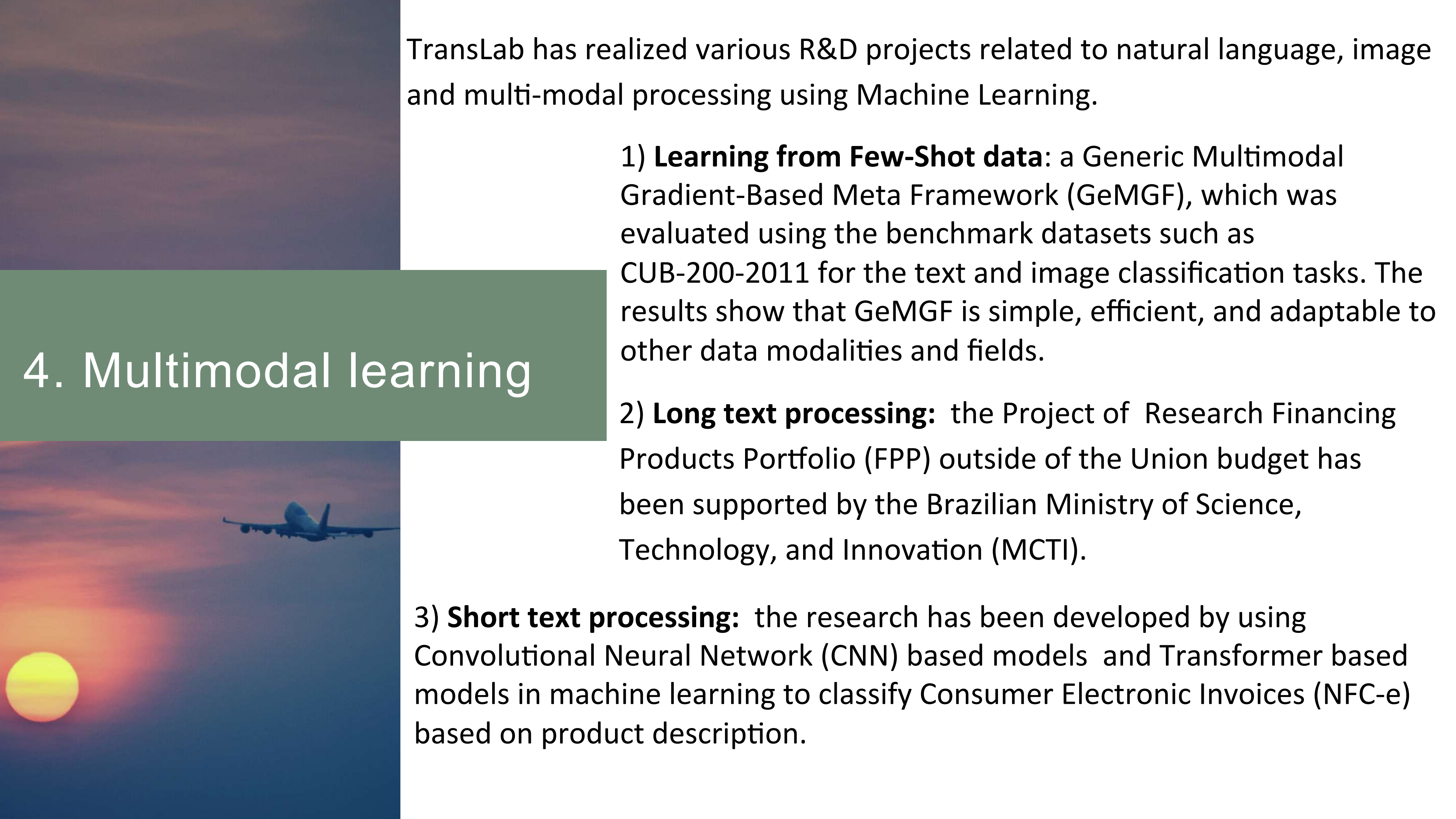
A study of parallel neural networks. L Weigang N. Silva, IJCNN, 1998, vol. 2, pp. 1113-1116.

The "one-shot learning" method was proposed in regard to object categories of computer vision (Li FF et al., 2003). As the basic learning mechanism of meta-learning, the current "few-shot learning" technique has become a standard learning paradigm in AI. Extended methods such as "zero-, one-, and few-shot learning" have been successfully used in NLP and Image processing by BERT, GPT and GATO.

Few-shot learning

Some computer vision developers proposed the You Only Look Once (YOLO) and Single Shot Detector (SSD) models for object detection. Unlike the previous region-based method, these methods demonstrate the practicality of region-free skill and have achieved successful applications.

"Once learning" is not limited only to the planar graph and text learning of 2D information, but can also be extended to multi-dimensional information. The parallel learning mechanism of "Once learning" has also been proposed for quantum computing.

Li FF et al., 2003. A Bayesian approach to unsupervised one-shot learning of object categories. Proc 9th IEEE Int Conf on Compu[...] Vision, p.1134- 1141.

4. Multimodal learning

TransLab has realized various R&D projects related to natural language, image and multi-modal processing using Machine Learning.

1) **Learning from Few-Shot data**: a Generic Multimodal Gradient-Based Meta Framework (GeMGF), which was evaluated using the benchmark datasets such as CUB-200-2011 for the text and image classification tasks. The results show that GeMGF is simple, efficient, and adaptable to other data modalities and fields.

2) **Long text processing:** the Project of Research Financing Products Portfolio (FPP) outside of the Union budget has been supported by the Brazilian Ministry of Science, Technology, and Innovation (MCTI).

3) **Short text processing:** the research has been developed by using Convolutional Neural Network (CNN) based models and Transformer based models in machine learning to classify Consumer Electronic Invoices (NFC-e) based on product description.

Model	5-way 5-shot	5-way 1-shot
Pahde et al. (2021)	85.30 ± 0.54	75.01 ± 0.81
Zhao et al. (2021)	-	73.90 ± 1.00
GeMGF(ours)	$\mathbf{93.20 \pm 0.07}$	$\mathbf{85.60 \pm 0.06}$

4.1 Learning Few-Shot data

FSL	Accuracy(%)	Precision(%)	F1-score(%)
5-way 5-shot	93.20 ± 0.07	93.80 ± 0.06	93.20 ± 0.07
5-way 1-shot	85.60 ± 0.07	88.50 ± 0.06	85.50 ± 0.07

In this research a Generic Multimodal Gradient Based Meta Framework (GeMGF) is proposed, in which the model acquires knowledge across different modalities through a few samples. The learning process occurs continuously, acquiring new knowledge without forgetting previous learning experiences .

A novel multimodal framework with Few-Shot learning that can alleviate performance degradation trained over a limited and a few samples of data (CUB-200-2011, mean accu-racy(%) ± standard deviation).

The framework of GeMGF is simple, adaptable with in- dependent sub-models, and can be applied to different fields because it does not need large annotated datasets.

Generic framework for multilingual short text categorization using convolutional neural network. L. Enamoto, L Weigang, PR Geraldo Filho,, Multimedia Tools and Applications, vol. 80(9), pp. 13475-13490, 2021.

4.2 Project of MCTI

This project focus on a more specific problem, creating a Research Financing Products Portfolio (FPP) outside of the Union budget, supported by the Brazilian Ministry of Science, Technology, and Innovation (MCTI).

The input data includes the text of financing opportunities offered by many institutions worldwide on their websites, such as scholarships, grants, fellowships, and others.
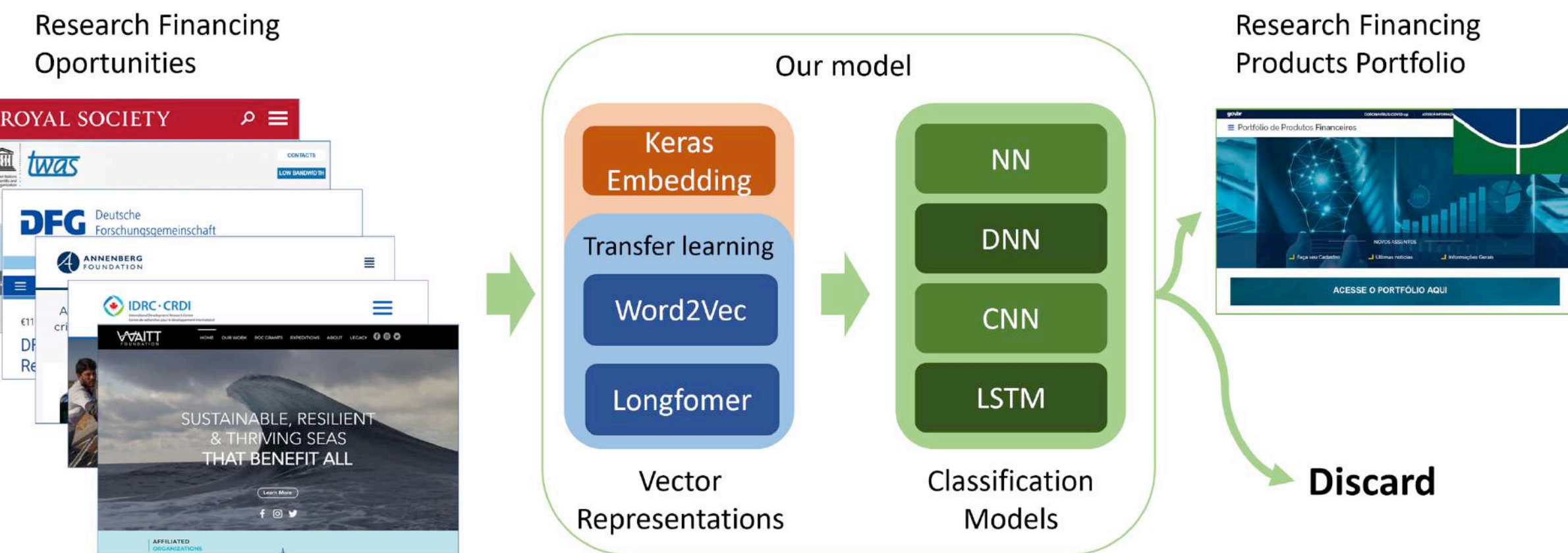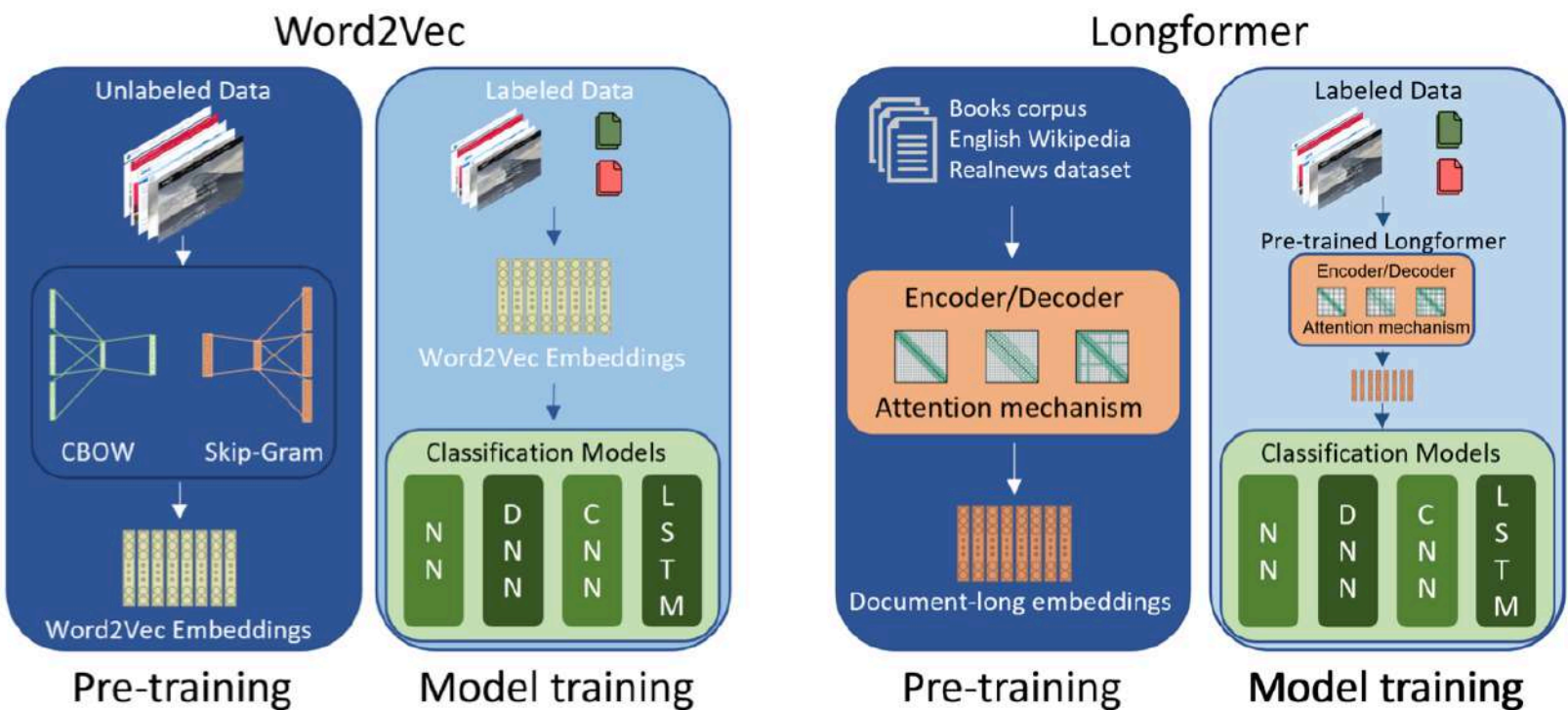
The implementation of the project is described in the following steps: Data Scraping, Classification, Summarization, and Recommendation.

Long text classification

As the main contribution, we use pre-training and word embedding solutions to learn the relationship of the words from other datasets with high similarity and larger scale.

| Model	Accuracy	F1 Score	Precision	Recall
Baseline				
Bag of words	0.81	-	-	-
Key words	0.78	-	-	-
Keras Word-embedding				
NN	0.8269	0.8620	0.8212	0.9129
DNN	0.8269	0.8650	0.8952	0.8447
CNN	0.8462	0.8756	1.0000	0.7803
LSTM	0.8269	0.8675	0.8276	0.9129
Pre-trained Word2Vec Embeddings				
NN	0.8269	0.8545	0.8392	0.8712
DNN	0.7115	0.7794	0.7255	0.8485
CNN	0.8654	0.9083	08486	0.9773
LSTM	0.8846	0.9139	0.9056	0.9318
Pre-trained Longformer				
NN	0.8269	0.8754	0.7950	0.9773
DNN	0.8462	0.8776	0.8474	0.9123
CNN	0.8462	0.8776	0.8474	0.9123
LSTM	0.8269	0.8801	0.8571	0.9091

Using the acquired features, based on the available dataset from MCTI, we apply fine-tuning and transfer learning plus deep learning models to improve the comprehension of each sentence to describe the information of the websites.

Compared to the baseline accuracy rate of 81%, the pro-posed Word2Vec-based approach in the classification improves the accuracy rate to 88%.

Using transfer learning to classify long unstructured texts with small amounts of labeled data. CA Rocha, MV Dib, L Weigang et al., accepted by WEBIST 2022.

4.3 Project of NFC-e

Invoices document the transactions of goods and services between two parties. Invoicing is a core component in daily commercial and financial operations. They are a rich source of information for financial analysis, fraud detection, value chain analysis, product tracking, and hazard alarms. Extracting useful information from invoice documents can lead to valuable applications.

This research presents a study on how to automatically identify the product in each product transaction contained in invoices, based on a short text description present in each transaction. Several text processing models are investigated and evaluated. This research also presents a schema on how this models could be used to aid tax auditors, and a conceptual frameworks illustrates the complexity of tasks related to electronic invoices and associated fields with each one.
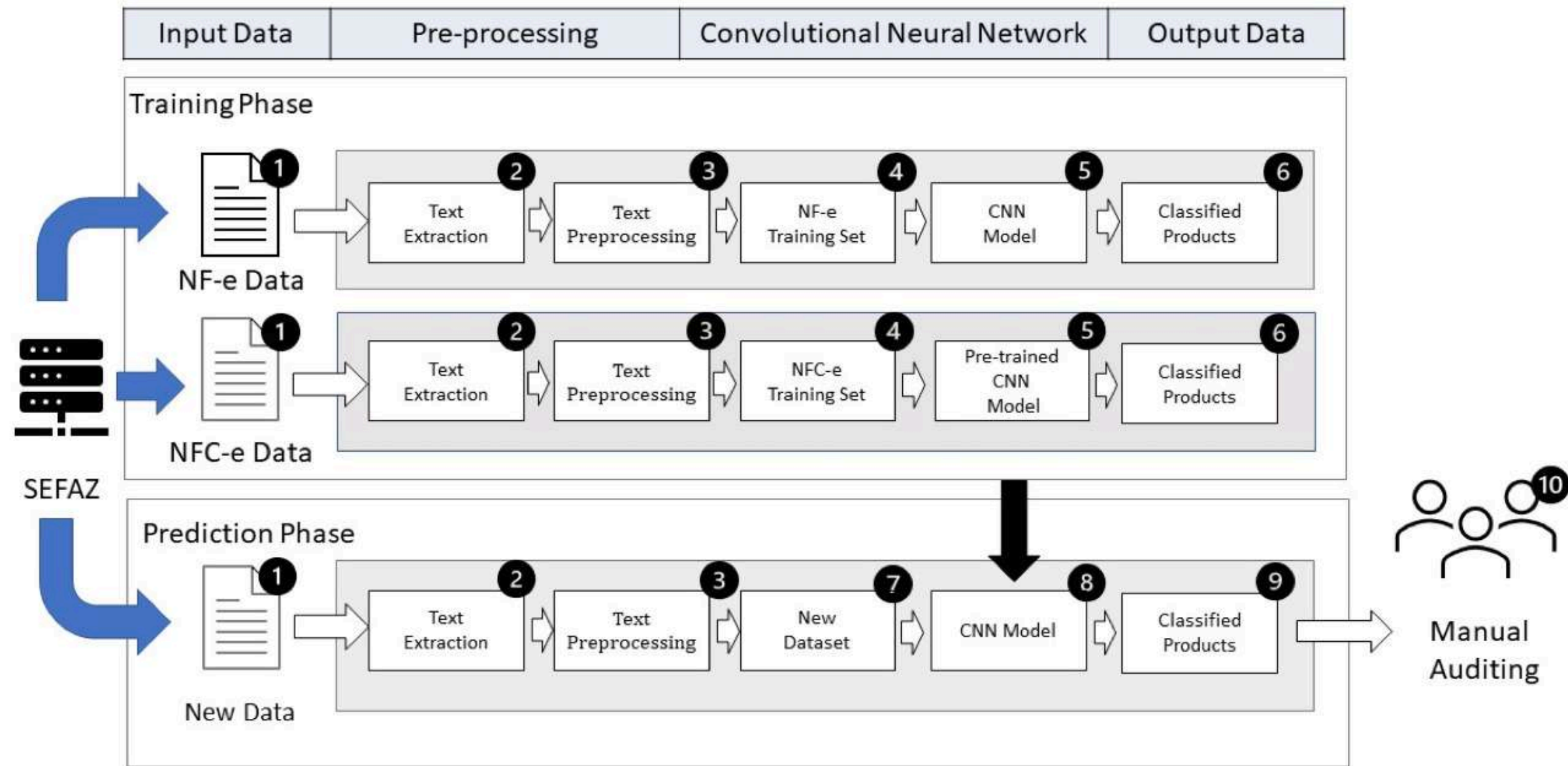
NFC-e Dataset
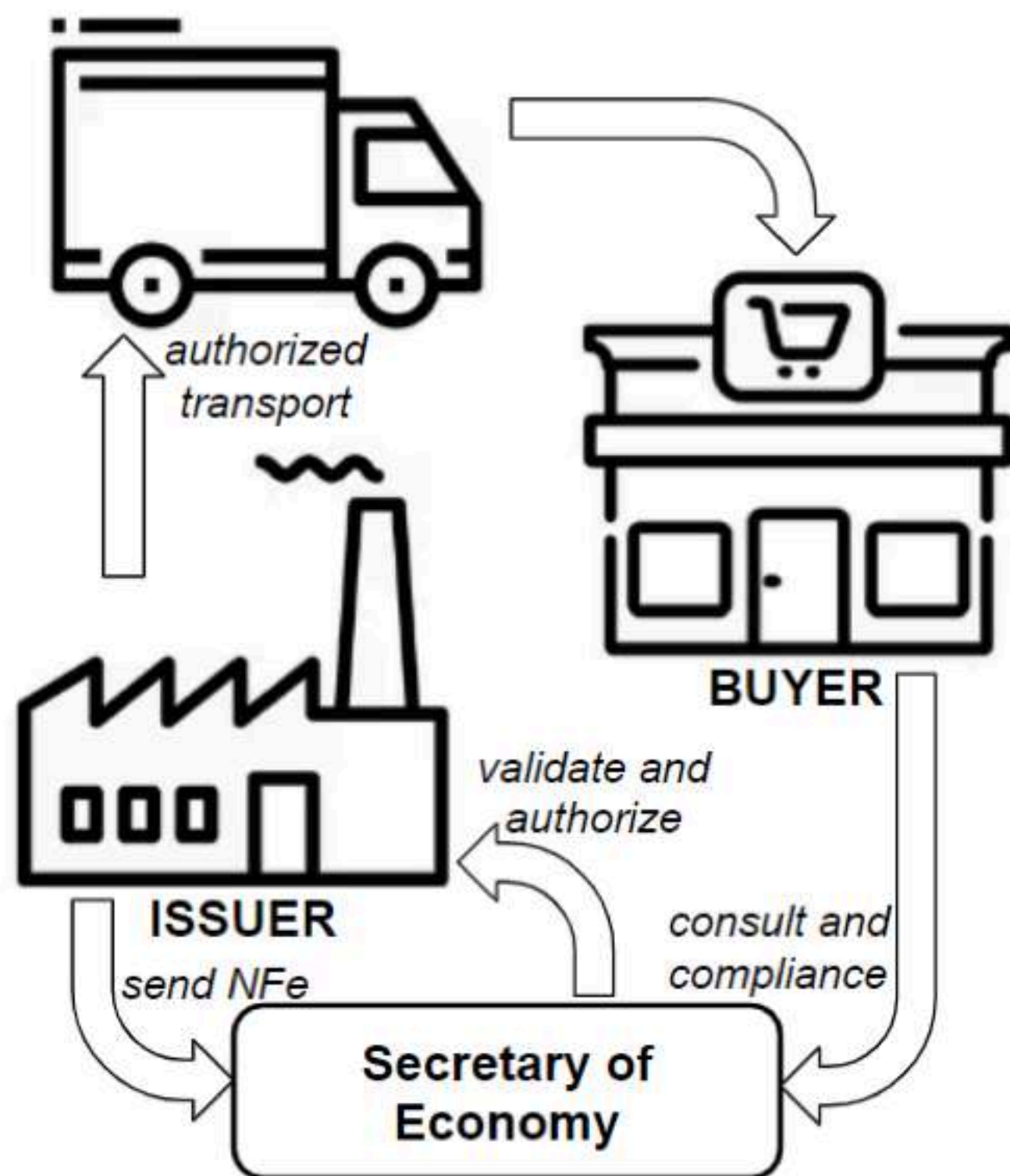
The task of classifying short text through ML models is promising and challenging for economic related sectors such as electronic invoice processing and auditing. Considering the scarcity of labeled short text data sets and the high cost of establishing new labeled short text databases for supervised learning, we proposes ELEVEN (ELEctronic inVoicEs in portuguese laNguage) Data-Set in an open data format.

This labeled short text database is composed of the product descriptions extracted from electronic invoices. These short Portuguese text descriptions are unstructured, but limited to 120 characters. We construct BERT and other models to demonstrate the short text classification using ELEVEN. For easy public use, ELEVEN is shared on GitHub by the link: *https://github.com/vinidiol/descmerc*.
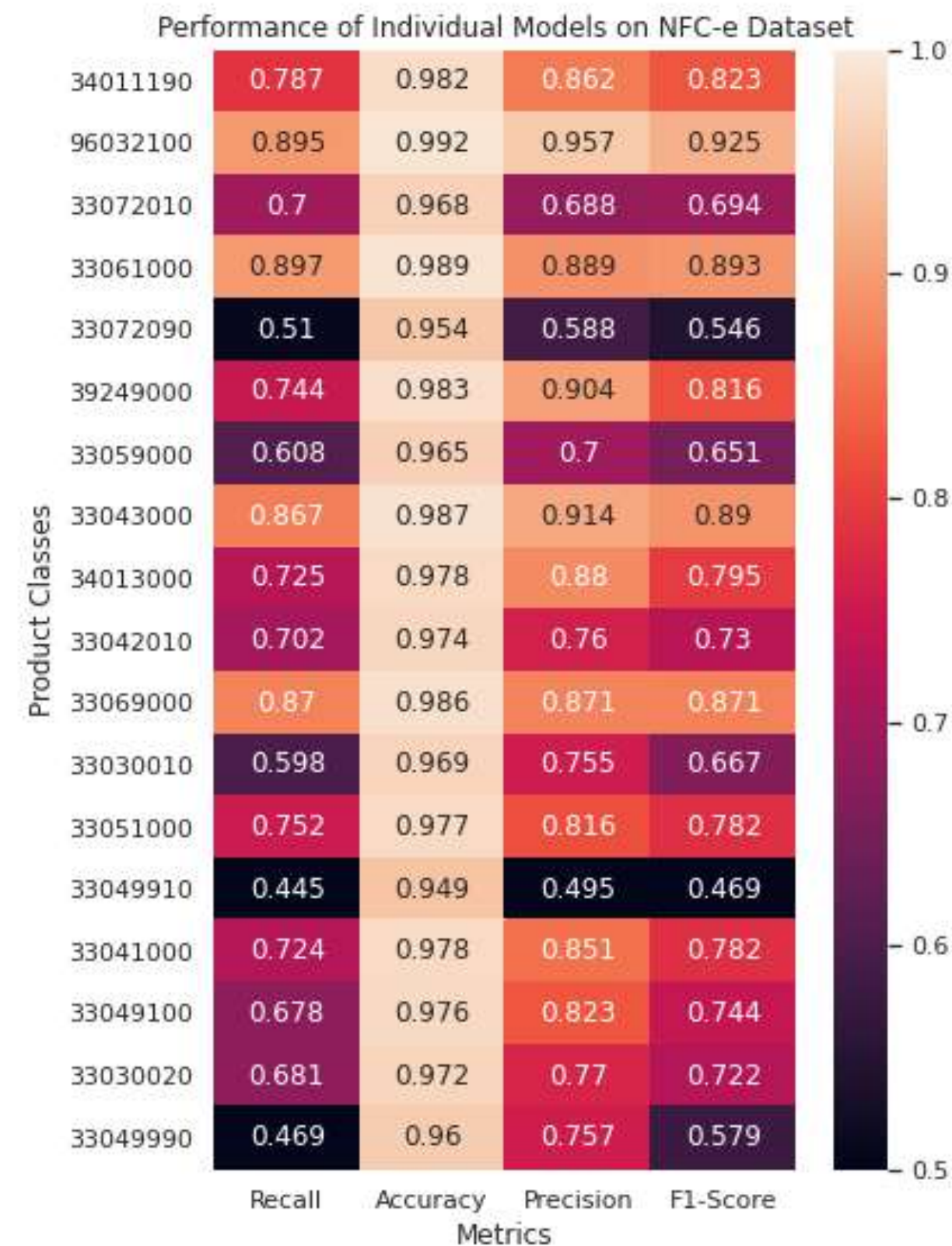
ELEVEN Data-Set: A Labeled Set of Descriptions of Goods Captured from Brazilian Electronic Invoices. V Di Oliveira, L Weigang, PR Geraldo Filho, accepted by WEBIST 2022.

Short text classification

SCAN-NF: a CNN-Based System for the Classification of Electronic Invoices Through Short-Text Product Description is an invoice classification system based on product description for tax auditing.
We presented related work on short-text and invoice classification and a set of desired properties for invoice classification.

We presented two possible configurations for the CNN models: a single model based on established sentence classification architecture and our proposed ensemble model. Both CNN configurations were validated on datasets of NFC-e and NF-e documents. Our ensemble approach presented higher precision on both datasets. Overall we managed to present an invoice classification system that can aid tax auditors in auditing a larger number of invoices and aid taxpayers in providing the correct classification of products.

Performance of Individual Models on NFC-e Dataset

Product Classes	Recall	Accuracy	Precision	F1-Score
34011190	0.787	0.982	0.862	0.823
96032100	0.895	0.992	0.957	0.925
33072010	0.7	0.968	0.688	0.694
33061000	0.897	0.989	0.889	0.893
33072090	0.51	0.954	0.588	0.546
39249000	0.744	0.983	0.904	0.816
33059000	0.608	0.965	0.7	0.651
33043000	0.867	0.987	0.914	0.89
34013000	0.725	0.978	0.88	0.795
33042010	0.702	0.974	0.76	0.73
33069000	0.87	0.986	0.871	0.871
33030010	0.598	0.969	0.755	0.667
33051000	0.752	0.977	0.816	0.782
33049910	0.445	0.949	0.495	0.469
33041000	0.724	0.978	0.851	0.782
33049100	0.678	0.976	0.823	0.744
33030020	0.681	0.972	0.77	0.722
33049990	0.469	0.96	0.757	0.579

SCAN-NF: A CNN-based System for the Classification of Electronic Invoices through Short-text Product Description. DS Kieckbusch, PR Geraldo Filho, V Di Oliveira, L Weigang, WEBIST 2021, pp. 501-508.

5. AI in ATM

TRAJECTORY-BASED OPERATIONS (TBO) in ATM

New technology that enables strategic long-term conflict resolution trajectories that combine security and efficiency in Air Traffic Management (ATM).

FOUR-DIMENSIONAL (4D) NAVIGATION

Time is added as a 4th dimension to the three dimensions of space.

CONFLICT DETECTION AND RESOLUTION (CD&R)

Implementing of TBO considering 4D Navigation management increases the challenge for CD&R.

Research topics: Detection of conflicts between aircraft in their trajectories

The legacy problem is to find an efficient scheme to store and manage the trajectories in the complex network with massive data and further to detect and resolve the conflicts.
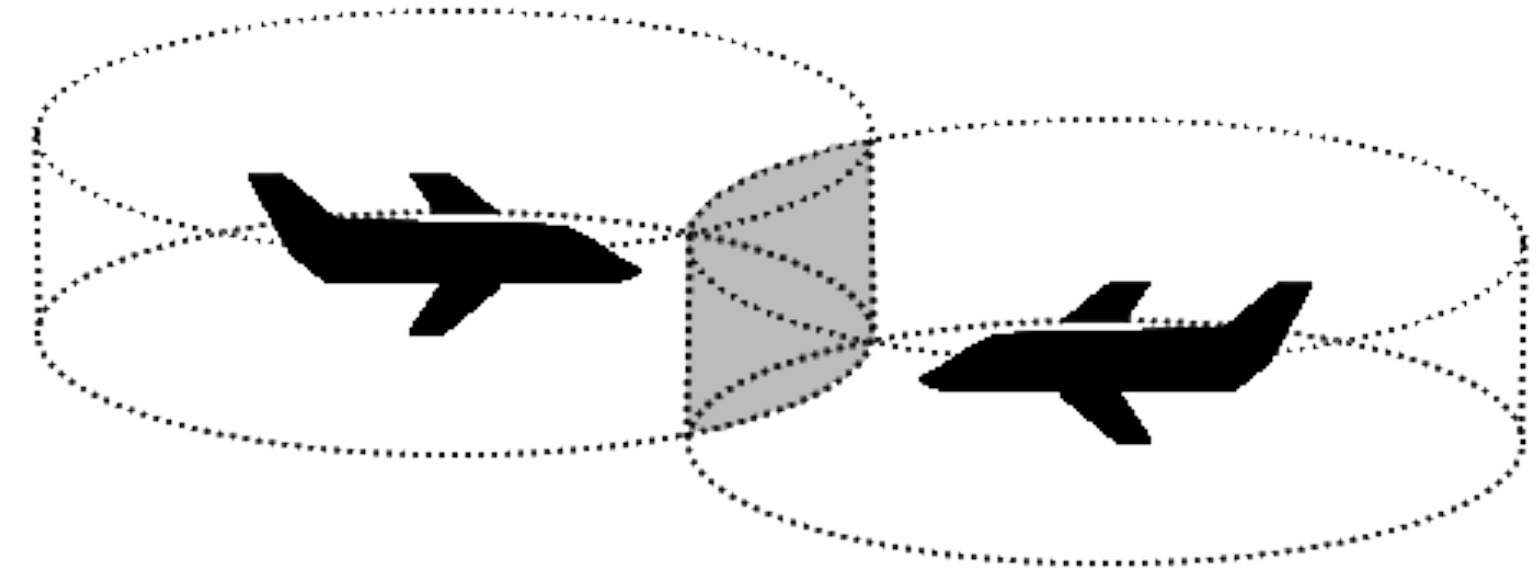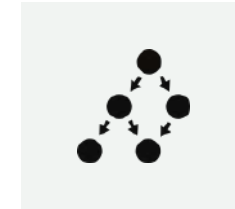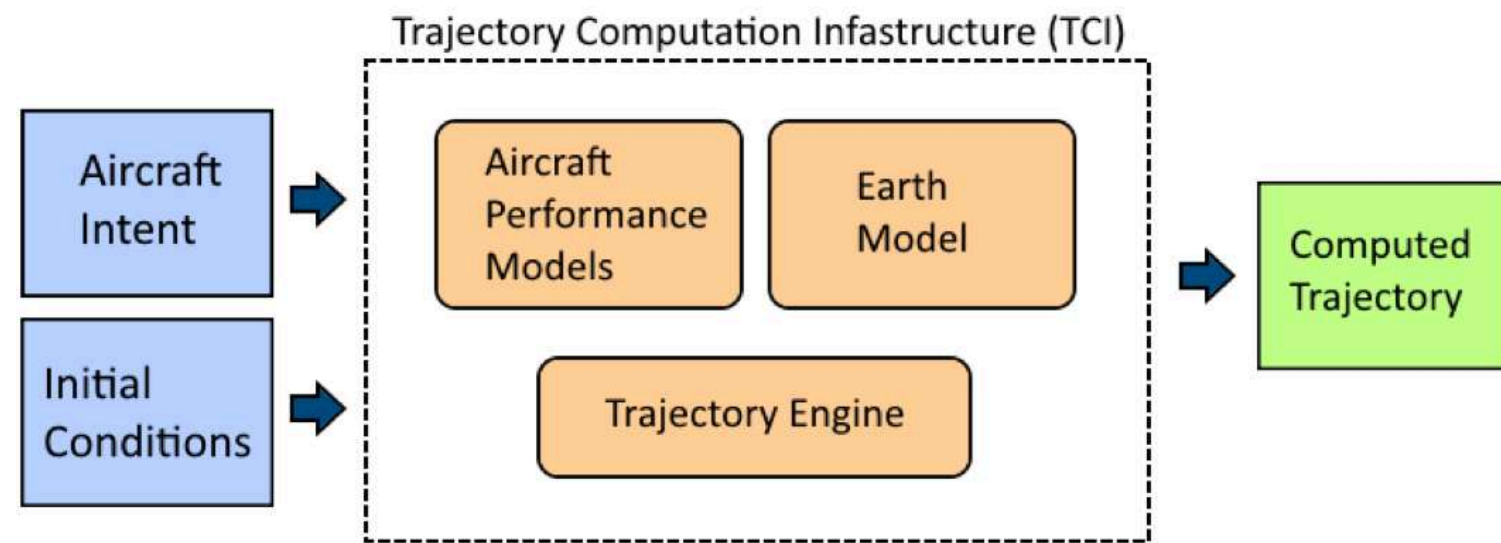

A new framework of CD&R for 4D Navigation management using Not Only SQL (NoSQL) database for conflict detection and decision tree pruning method (DTPM) for conflict resolution.
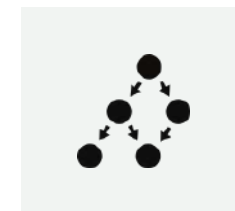

15 min
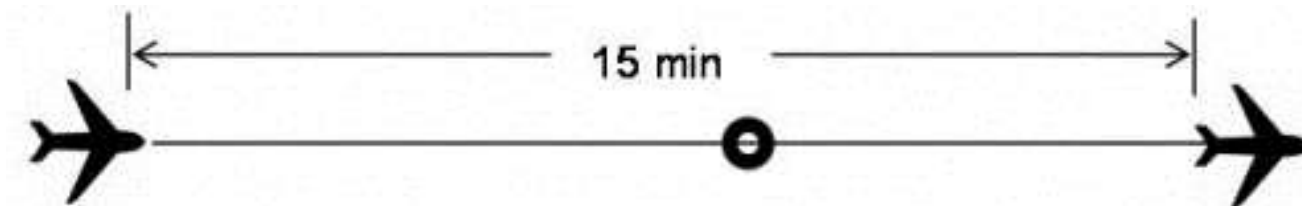
Considering time-based separation
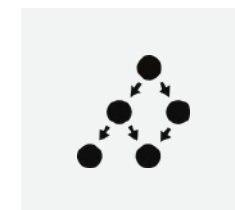
Proposed Solution

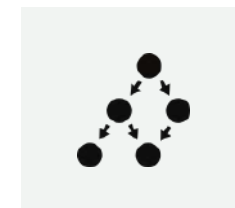## Conflict detection & resolution

Using Trajectory Predictor (TP) by Boeing to simulate the automatic classification of each 4D point sampled during the flight.

Using special schemes of Not Only SQL (NoSQL) databases, the 4D trajectories of commercial flights are presented.

Implementation of Monte Carlo Tree Search (MCTS) with NoSQL databases to detect the eventual conflicts.

The solution makes it possible to identify an optimal combination of trajectories without conflicts.

Case Study

SIMULATION SCENARIO

Simulation scenario for conflict detection is composed by a selection of nine airports in Brazil.

Those airports are responsible for 58% of the national air traffic in 2018.

Flight plans are fed to the TP.

The generated trajectories are stored on the NoSQL database for conflict detection

Cooperation between Boeing and UnB achieved an US Patent 10,553,121, 2020:
IR de Oliveira, VF Ribeiro, L Weigang, RC Garcia, "Detecting violation of aircraft separation requirements".

RESULTS

Table 7.1: Performance of conflict detection among default trajectories.

Threads	Waypoints	Conflicts	Cassandra Time (s)	MongoDB Time (s)
1	160022	330	0,936	0,518
2	160022	330	0,516	0,269
4	160022	330	0,331	0,2
8	160022	330	0,286	0,159
16	160022	330	0,298	0,19
32	160022	330	0,25	0,207

The solution proposed for trajectory evaluation demonstrated to be very efficient. Although the simulation scenarios concern only the strategic planning, conflict detection procedure was found to be suitable even for tactical planning, provided that sampled trajectories are available in the database.
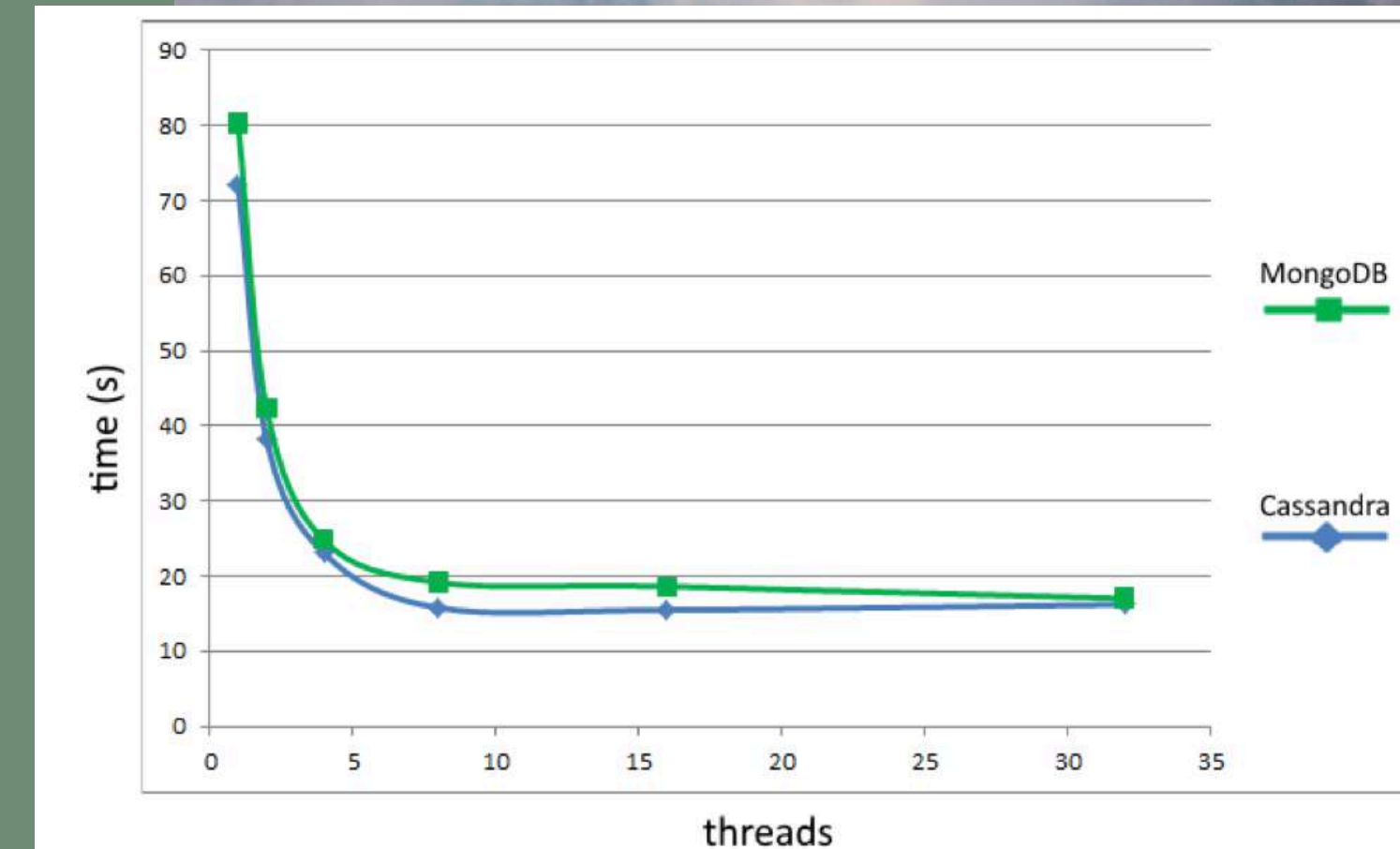
.

Figure 7.5: Performance comparison with threaded speed-up

V. Ribeiro et al., Conflict Detection and Resolution with Local Search Algorithms for 4D-Navigation in ATM, International Conference on Intelligent Systems Design and Applications, pp. 129-139, 2018.

6. Conclusions

This talk presented the recent research achievements from the TransLab of UnB in Artificial Intelligence and applications.

We studied Artificial Intelligence basic theory and giving new definition of four categories in AI. We also developed "Once learning" paradigm to contribute Machine Learning.

We applied CNN-based and Transformer-based methods to long text classification by MCTI project and short text classification by NFC-e project. We also developed new framework to process multimodal text/image information.

As the main portfolio of TransLab, we developed solutions for Conflict Detection and Resolution (CD&R) in 4 Dimensions Trajectory-based Operations (TBO) in Air Traffic Management.

Thanks all the students, researchers and partners of TransLab/UnB by their collaboration and contributions.

Thanks all the keynote speakers in this section.

And also thanks the supports from the organizers of the SBPC 2022.

THANKS !