



DCA0305

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# Machine Learning Based Systems Design

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## Linear Algebra & Math

Matrices & vector arithmetics, types, operations factorization, derivatives

## Data Science

EDA, measurements of centrality (mean, mode, median, variand, std, z-score), data pipeline

## Deep Learning

Fundamentals of Deep Learning, Better Generalization vs Better Learning, Hyperparameter Tuning, Batch Normalization, CNN, Transfer Learning

## Probability & Statistics

Cond. prob., distributions, bayesian prob., data viz., central limit theorem, hypothesis tests, correlation, resampling methods

## Machine Learning

Supervised Learning (KNN, Linear Regression, Logistic Regression, DT, RF, Ensemble, XGBoost, MLP), Unsupervised Learning (K-means, PCA)

### **TinyML**

Optimization,  
quantization, deploy  
into a microcontroller

### **But ....**

If a model is not  
deployed, it does not  
generate value

Cont.

### **New Models**

Transformers, Difusion, GAN,  
LLM, GNN, Generative Flow  
Networks, Agents

2016

Pandas

2017

Scikit-Learn

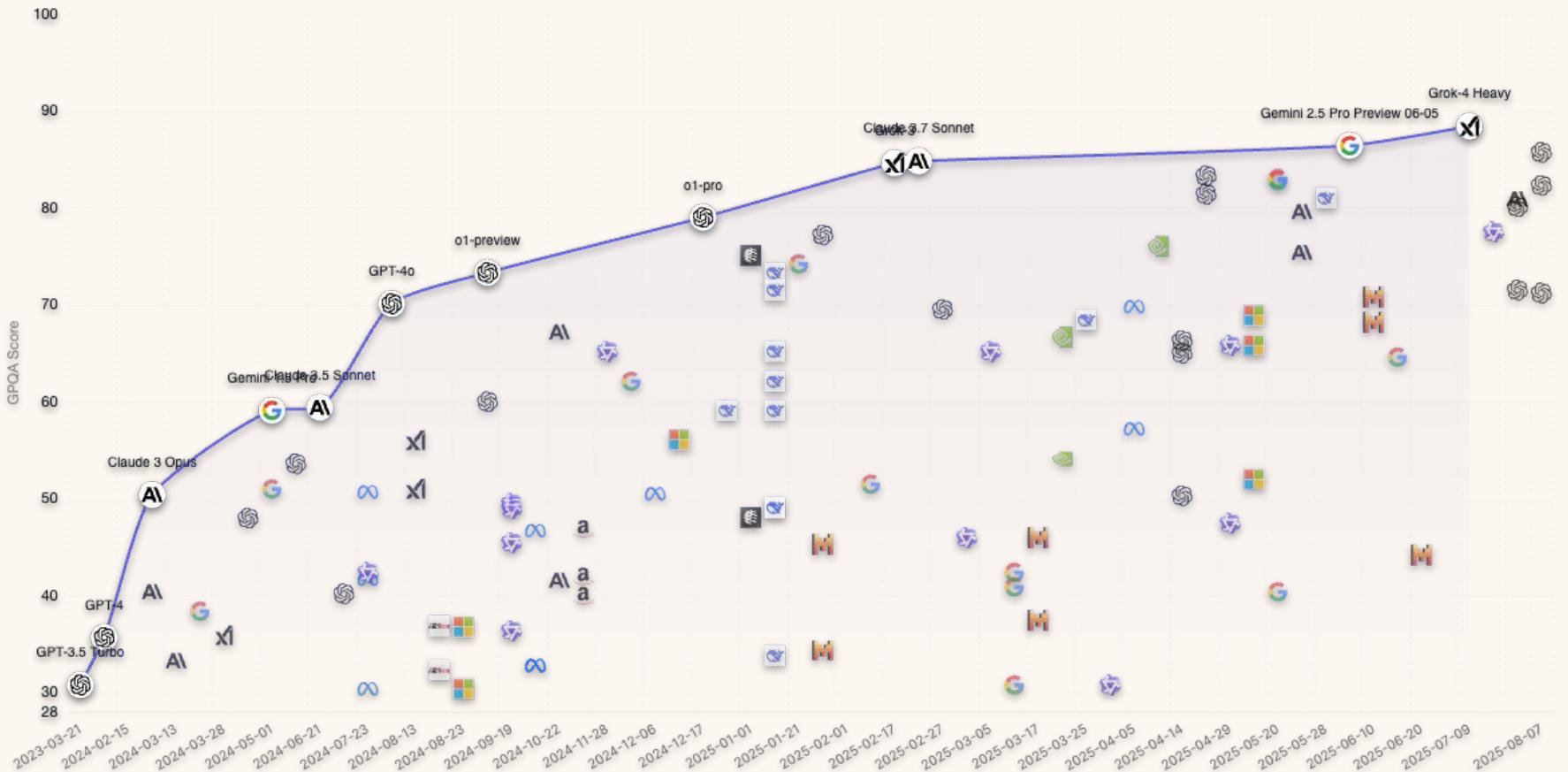
2018-2020

TensorFlow, Keras, Pytorch,  
Covid-19

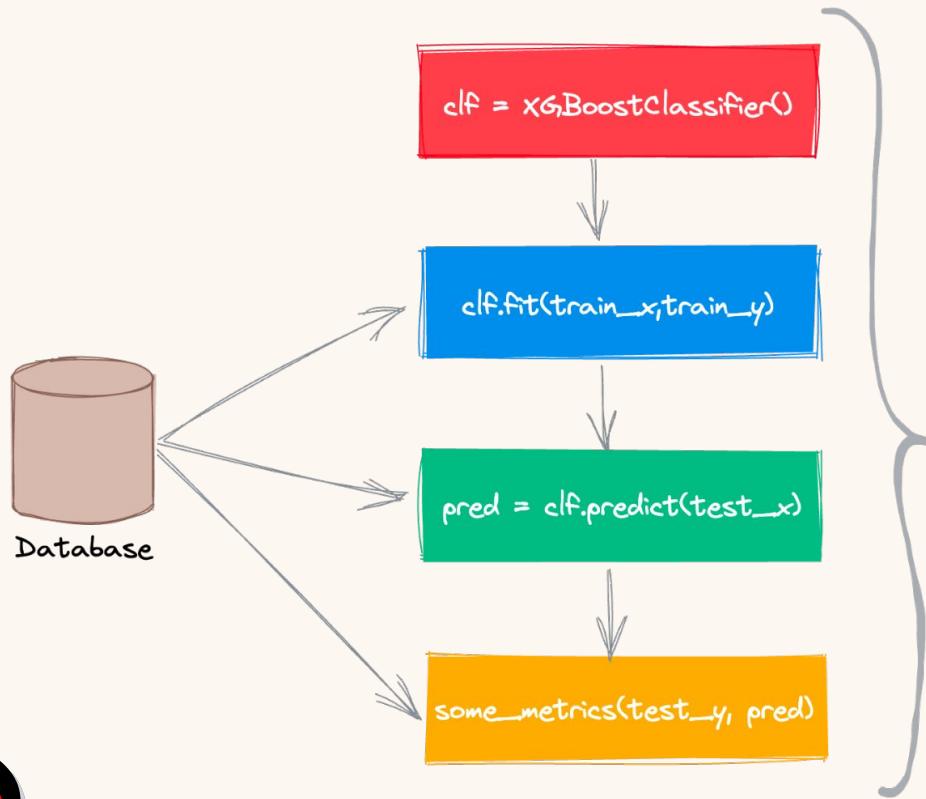
2021-2023

MLOps, GAN, LLM, GPT-3,  
OpenAI

# LLM Leaderboard & Vibe Coding



How to project a  
typical machine  
learning workflow?



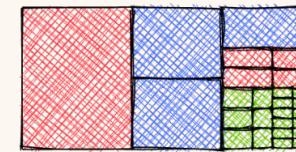
What is the issue  
with this solution?



publish a journal/conference  
paper, report



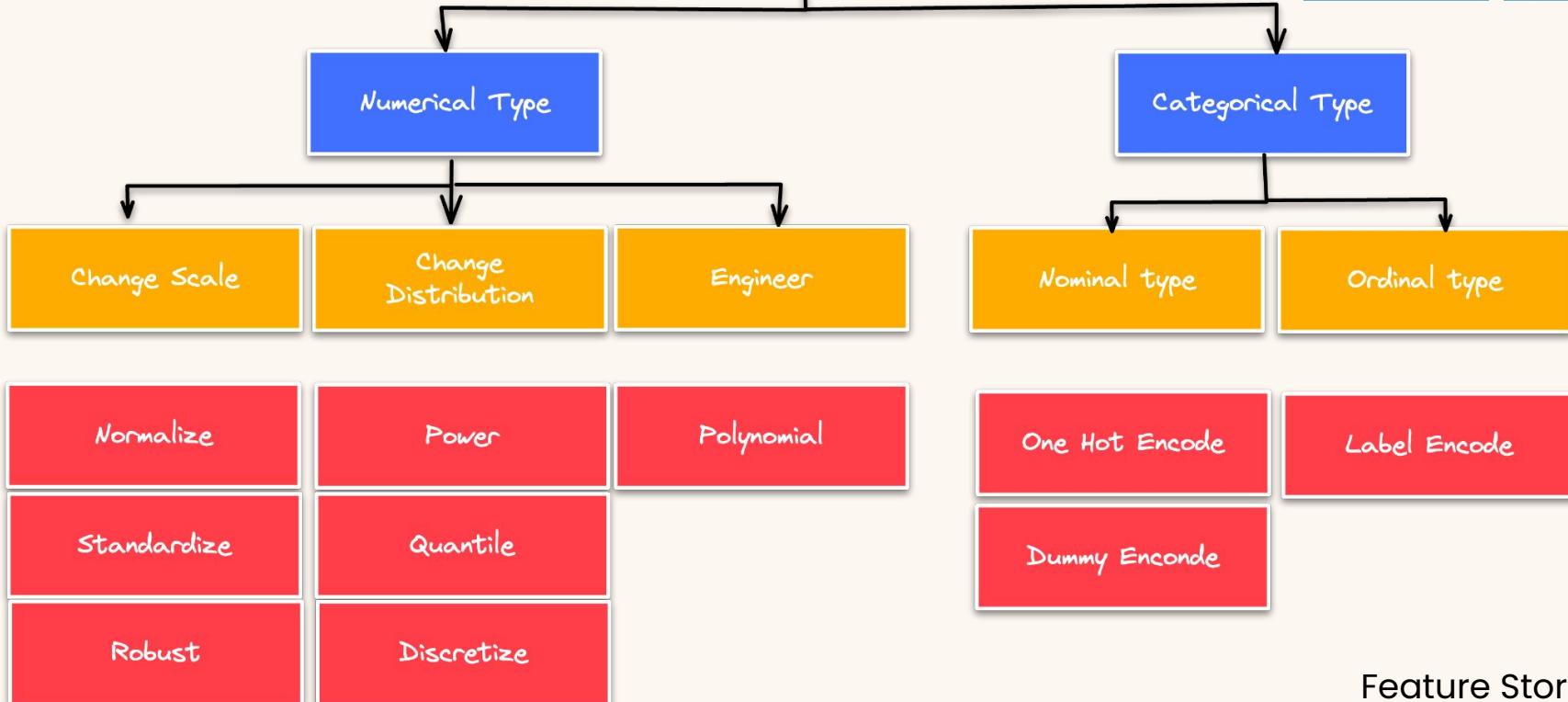
Stakeholders



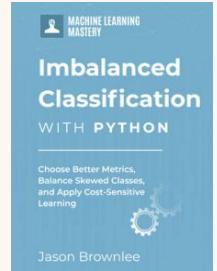
Automate data preprocessing  
Store preprocessing statistics (e.g., normalization)  
Track generated artifacts  
Deploy model to production  
Document process

Guarantee the same Feature  
Engineering artifacts are used in  
train/test and production env.

## Data Transforms



Feature Store



Article

# Predictive Models for Imbalanced Data: A School Dropout Perspective

Thiago M. Barros <sup>1,\*†</sup>, Plácido A. Souza Neto <sup>1,†</sup> and Ivanovitch Silva <sup>2,†</sup>  
and Luiz Affonso Guedes <sup>2,†</sup>

<sup>1</sup> Federal Institute of Rio Grande do Norte (IFRN), 1559 Tirol Natal, Brazil; placido.neto@ifrn.edu.br

<sup>2</sup> Federal University of Rio Grande do Norte (UFRN), 59078-970 Natal, Brazil; ivan@imd.ufrn.br (I.S.); affonso@dca.ufrn.br (L.A.G.)

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† These authors contributed equally to this work.

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**Abstract:** Predicting school dropout rates is an important issue for the smooth execution of an educational system. This problem is solved by classifying students into two classes using educational activities related statistical datasets. One of the classes must identify the students who have the tendency to persist. The other class must identify the students who have the tendency to dropout. This problem often encounters a phenomenon that masks out the obtainable information into this phenomenon and provides a reliable educational data mining solution. In this paper, we predict the dropout rates. In particular, the three data classifying techniques, namely, Decision Tree, Artificial Neural Networks and Balanced Bagging, are used. The performances of these classifiers with and without the use of a downsample, SMOTE and ADASYN data balancing techniques, and other parameters geometric mean and UAR provides reliable results with respect to the dropout rates using Balanced Bagging classifying techniques.

**Keywords:** dropout rates; accuracy paradox; imbalanced learning; decision tree; MLP; balanced bagging; UAR; SMOTE; ADASYN

## Concept/ Data Drift

# Evasão escolar de crianças e adolescente aumenta 171% na pandemia, diz estudo

Levantamento da organização Todos Pela Educação mostra que 244 mil crianças de 6 a 14 anos estavam fora da escola no segundo trimestre de 2021.

Por g1 — São Paulo  
02/12/2021 13h28 · Atualizado há um ano



## Pandemia aumenta evasão escolar, diz relatório do Unicef

A quantidade de alunos, com idades entre 6 e 17 anos, que abandonaram as instituições de ensino foi de 1,38 milhão



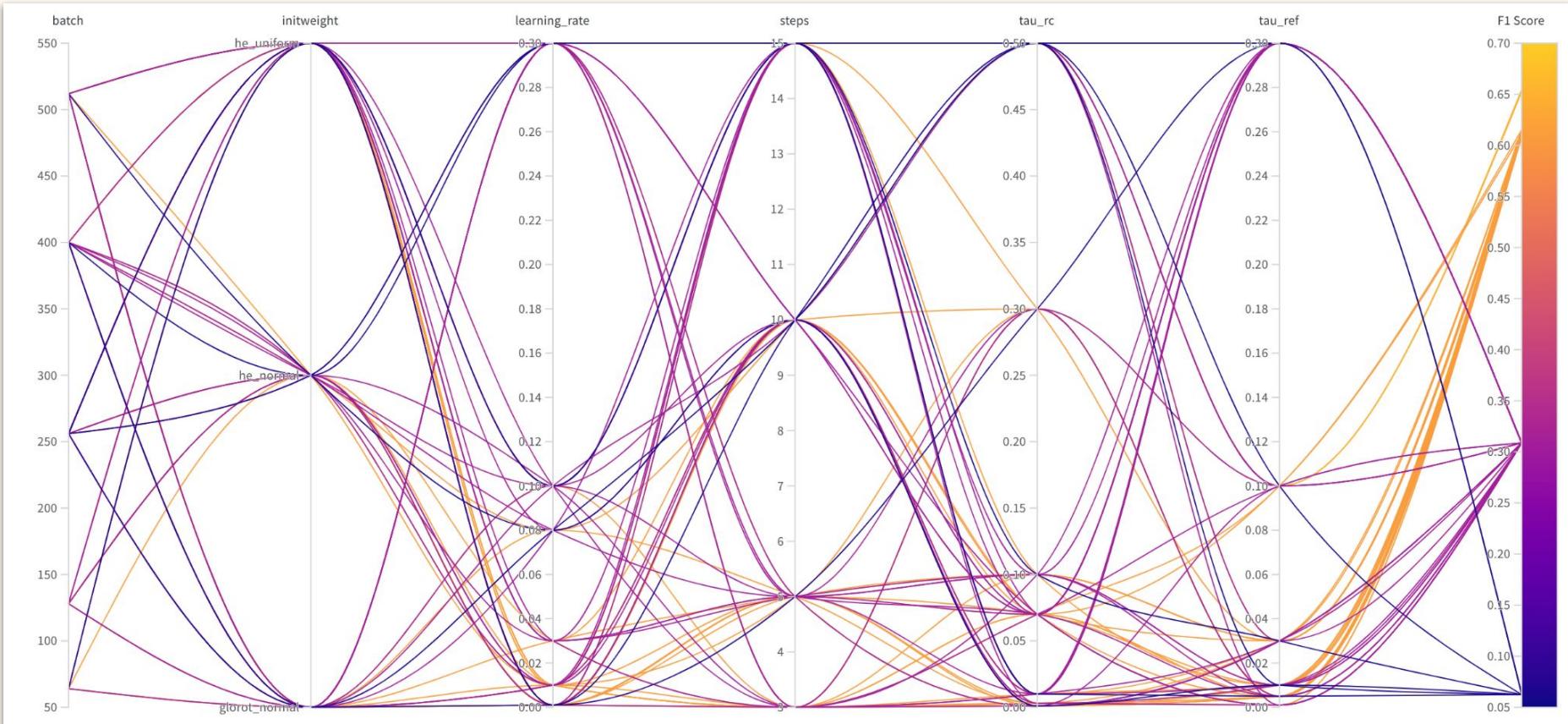
## Educadores alertam para aumento de evasão escolar durante a pandemia

Para debatedores, desafio agora é atrair estudantes de volta à escola e recuperar o aprendizado

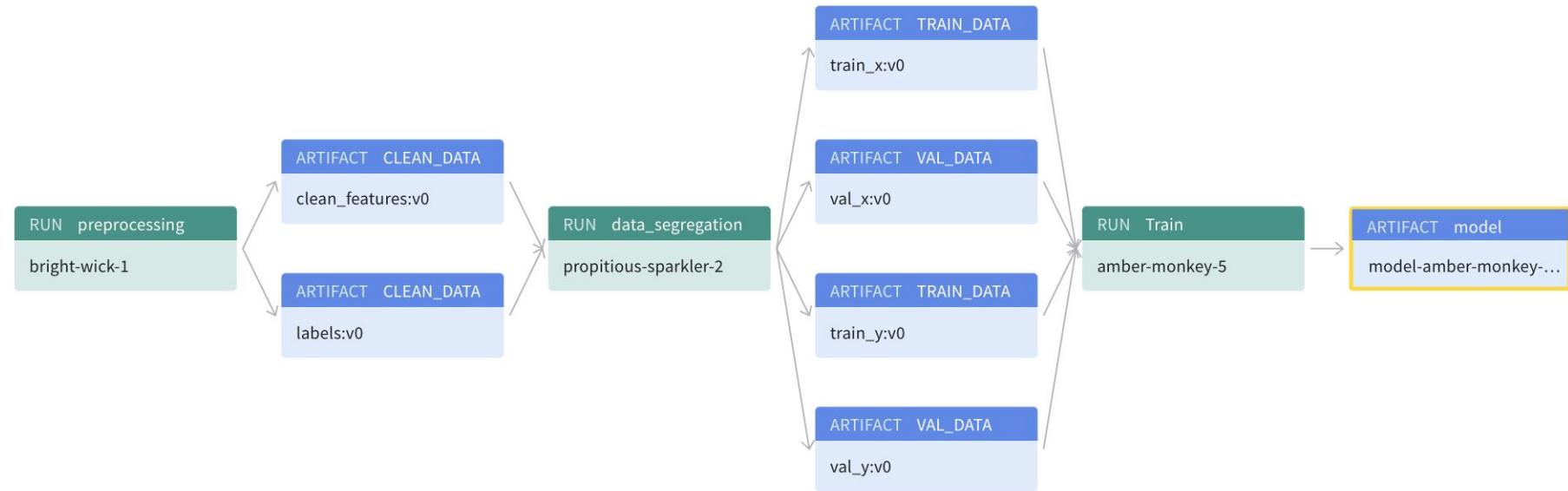
06/10/2021 - 20:04



# What settings were used in the last experiment?



# A more efficient machine learning workflow



# Advancing Tiny Machine Learning Operations: Robust Model Updates in the Internet of Intelligent Vehicles

Thommas K. S. Flores , Ivanovich Silva , Mariana B. Azevedo , Thais A. de Medeiros , and Morsinaldo de A. Medeiros , Federal University of Rio Grande do Norte, Natal, RN, 59078-970, Brazil

Daniel G. Costa , University of Porto, 4200-465, Porto, Portugal

Paolo Ferrari , and Emiliano Sisinni , University of Brescia, 25123, Brescia, Italy

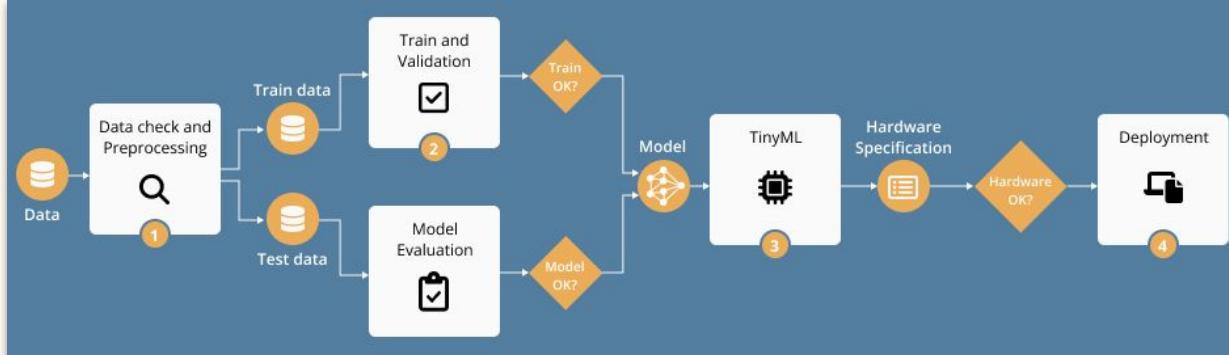
The Internet of Intelligent Vehicles is becoming increasingly important, and embedded machine learning is gaining popularity due to new development paradigms. However, the demand for machine learning model updates on embedded systems has become relevant in multiple scenarios. This article proposes a methodology for tiny machine learning operations within the context of the Internet of Intelligent Vehicles, utilizing affordable microcontrollers based on the ESP32 platform. The solution presented in the article consists of two ESP32 devices: one functioning as a radio station (RS) and the other as the microcontroller of an onboard diagnostic (OBD-II) scanner. The RS hosts the updated model and transmits it to the OBD-II scanner using the Espressif Systems Peer-to-Peer Over Wi-Fi communication protocol over 802.11 Wi-Fi. Experimental results demonstrate significant improvement in model performance postupdate, but the article also identifies critical challenges to model robustness because of the use of the interpreter method on microcontrollers.

The Internet of Intelligent Vehicles (IoIV) is a concept that involves integrating vehicles with the Internet and advanced technologies to enhance their functionality, safety, and overall performance. This idea is a subset of the broader Internet of Things (IoT) paradigm, connecting everyday vehicles to the Internet for improved communication and data exchange. With features like high-speed connectivity, advanced sensors for environmental perception, and real-time data sharing, the IoIV aims to optimize traffic, improve road safety, and facilitate autonomous driving. Additionally, it contributes to efficient traffic management, provides personalized user experiences, and raises important considerations regarding cybersecurity and public acceptance of autonomous technologies.

Recently, machine learning (ML) algorithms have been gaining ground in automotive applications since they can enhance a large set of processing tasks that

require very quick decisions. In this sense, the need to allow the execution of such algorithms in resource-constrained devices in embedded scenarios has also led to the creation of the tiny ML (TinyML) paradigm, with particular challenges concerning the size of the models and the processing of real-time data. Overall, the greatest innovation of the TinyML paradigm is the capacity to perform data inference through ML algorithms in tiny low-power devices,<sup>1</sup> which has opened a new trend of development that was not previously possible when implementing traditional ML algorithms. For the Internet of Vehicles paradigm, this has been an important revolution, although many challenges still remain when bringing TinyML to a more realistic setting.

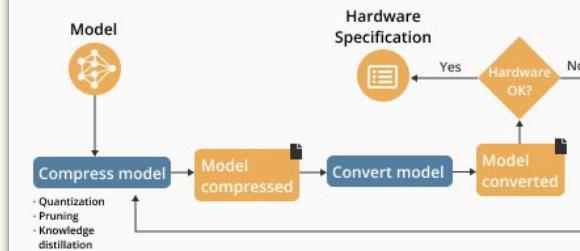
The recent literature has presented some works that address TinyML as an effective solution for the construction of intelligent vehicles. For example, Flores et al.<sup>2</sup> developed a soft-sensor to estimate carbon dioxide (CO<sub>2</sub>) emissions in vehicles using the TinyML paradigm. Additionally, Shaout et al.<sup>3</sup> compared several ML models embedded in different hardware to detect driver distraction from their position while driving. In



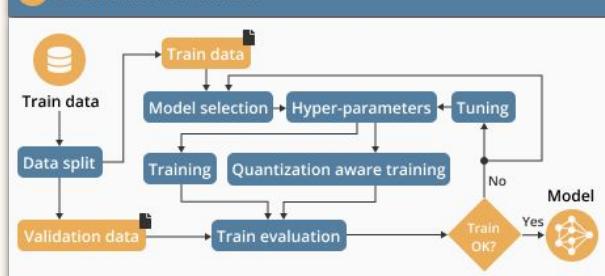
## 1 Data check and preprocessing



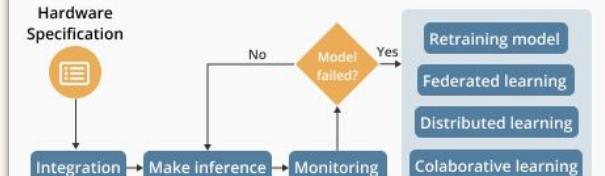
## 3 TinyML



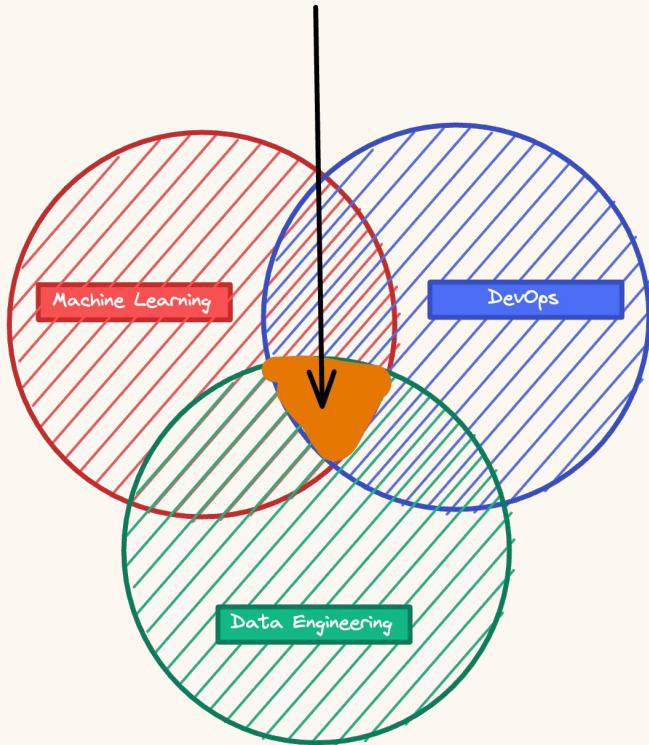
## 2 Train and validation



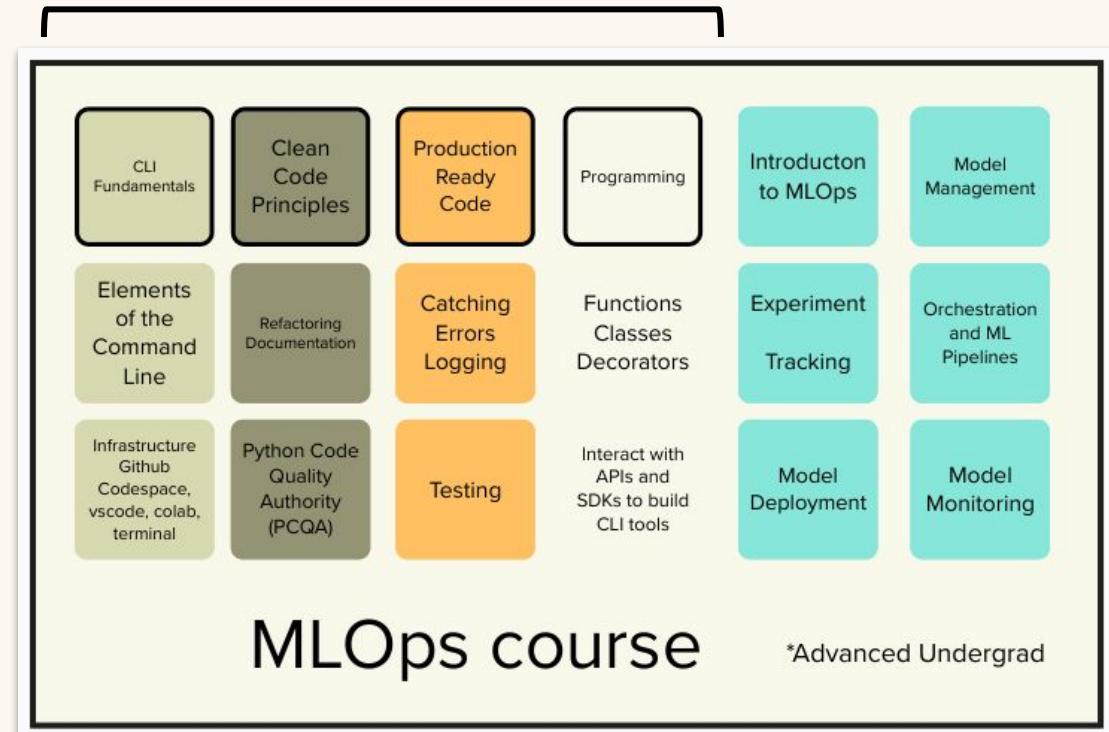
## 4 Deployment



# MLOps



## Machine Learning/Deep Learning



\*Advanced Undergrad

# 6's "How" Challenge!!!

- How to start (almost) any project?
- How to build better software (that works)?
- How to build software you can trust?
- How to serve model predictions (in a clever way)?
- How to monitor your model (drift is awful)?
- How to build continual learning and agentic systems?

# Unit 01

11/08 to 24/09

Agosto - 2025						
D	S	T	Q	Q	S	S
3	4	5	6	7	8	9
10	<b>11</b>	12	<b>13</b>	14	15	16
17	<b>18</b>	19	<b>20</b>	21	22	23
24	<b>25</b>	26	<b>27</b>	28	29	30
31						

Setembro - 2025						
D	S	T	Q	Q	S	S
	1	2	<b>3</b>	4	5	6
7	<b>8</b>	9	<b>10</b>	11	12	13
14	<b>15</b>	16	<b>17</b>	18	19	20
21	<b>22</b>	23	<b>24</b>	25	26	27
28	<b>29</b>	30				

Outubro - 2025						
D	S	T	Q	Q	S	S
	1	2	3	4	5	6
5	<b>6</b>	7	<b>8</b>	9	10	11
12	<b>13</b>	14	<b>15</b>	16	17	18
19	<b>20</b>	21	<b>22</b>	23	24	25
26	<b>27</b>	28	<b>29</b>	30	31	

Novembro - 2025						
D	S	T	Q	Q	S	S
	1	2	3	4	5	6
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16	<b>17</b>	18	<b>19</b>	20	21	22
23	<b>24</b>	25	<b>26</b>	27	28	29
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Dezembro - 2025						
D	S	T	Q	Q	S	S
	1	2	<b>3</b>	4	5	6
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14	<b>15</b>	16	<b>17</b>	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

## Week 01

11/08 and 13/08 - Planning

## Week 02

18/08 - Course Presentation

20/08 - Visualizing Gradient Descendent

## Week 03

25/08 - Rethinking the training loop

27/08 - Clean Code Principles, Documentation, Tooling, and Going Classy

## Week 04

01/09 - A simple classification problem

03/09 - [Project #01] - Description

## Week 05

08/09 - [Project #01] doing

10/09 - [Project #01] doing

## Week 06

15/09 - [Project #01] doing

17/09 - [Project #01] doing

## Week 07

22/09 - [Project #01] Presentation

24/09 - [Project #01] Presentation

# Unit 02

29/09 to 12/11

Agosto - 2025						
D	S	T	Q	Q	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Setembro - 2025						
D	S	T	Q	Q	S	S
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21	22	23	24	25	26	27
28	29	30				

Outubro - 2025						
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Novembro - 2025						
D	S	T	Q	Q	S	S
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Dezembro - 2025						
D	S	T	Q	Q	S	S
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7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

## Week 08

29/09 - From a shallow to a deep-ish classification model - Part I

01/10 - From a shallow to a deep-ish classification model - Part II

## Week 09

06/10 - Handling Errors, writing tests and logs  
08/10 - Convolutions (CNN)

## Week 10

13/10 - Multiclass problem, hooks  
15/10 - Rock, paper and scissor - Part I

## Week 11

20/10 - Rock, paper and scissor - Part II  
22/10 - [Project #02] - Description

## Week 12

27/10 - no class

29/10 - [Project #02] doing

## Week 13

03/11 - [Project #02] doing  
05/11 - [Project #02] doing

## Week 14

10/11 - [Project #02] Presentation  
12/11 - [Project #02] Presentation

# Unit 03

Agosto - 2025						
D	S	T	Q	Q	S	S
					1	2
3	4	5	6	7	8	9
10	<b>11</b>	12	<b>13</b>	14	15	16
17	<b>18</b>	19	<b>20</b>	21	22	23
24	<b>25</b>	26	<b>27</b>	28	29	30
31						

Setembro - 2025						
D	S	T	Q	Q	S	S
			1	2	3	4
7	<b>8</b>	9	<b>10</b>	11	12	13
14	<b>15</b>	16	<b>17</b>	18	19	20
21	<b>22</b>	23	<b>24</b>	25	26	27
28	<b>29</b>	30				

Outubro - 2025						
D	S	T	Q	Q	S	S
			1	2	3	4
5	<b>6</b>	7	<b>8</b>	9	10	11
12	<b>13</b>	14	<b>15</b>	16	17	18
19	<b>20</b>	21	<b>22</b>	23	24	25
26	<b>27</b>	28	<b>29</b>	30	31	

Novembro - 2025						
D	S	T	Q	Q	S	S
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16	<b>17</b>	18	<b>19</b>	20	21	22
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Dezembro - 2025						
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14	<b>15</b>	16	<b>17</b>	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

## Week 15

17/11 - Frameworks & Tools

19/11 - Frameworks & Tools

17/11 to 17/12

## Week 16

24/11 - Frameworks & Tools

26/11 - [Project #03] Description

## Week 17

01/12 - [Project #03] Doing

03/12 - [Project #03] Doing

## Week 18

08/12 - [Project #03] Doing

10/12 - [Project #02] - Doing

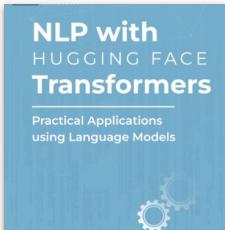
## Week 19

15/12 - [Project #03] Presentation

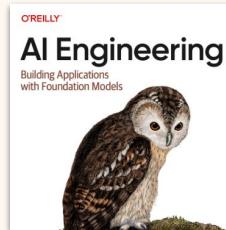
19/12 - Final Exam

# References

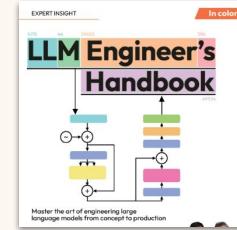
Main references: from MLOPs to LLMOps



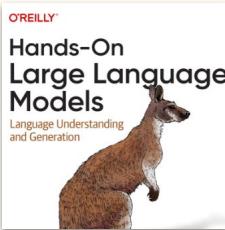
May, 2025



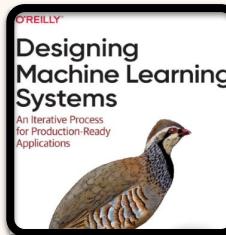
Jan, 2025



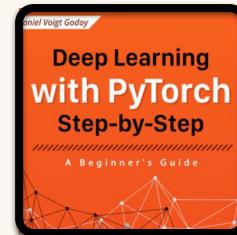
Oct, 2024



Sep, 2024



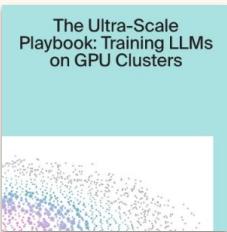
May, 2022



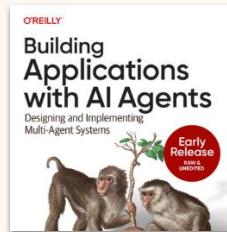
Feb, 2022

# References

## Further References: from LLM to Agents



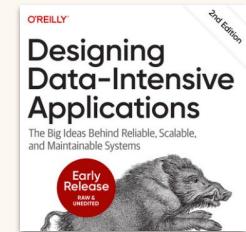
Jul, 2025



Sep, 2025



Dec, 2025



Jan, 2026

# Clone me!!!!

<https://github.com/ivanovitchm/mllops>