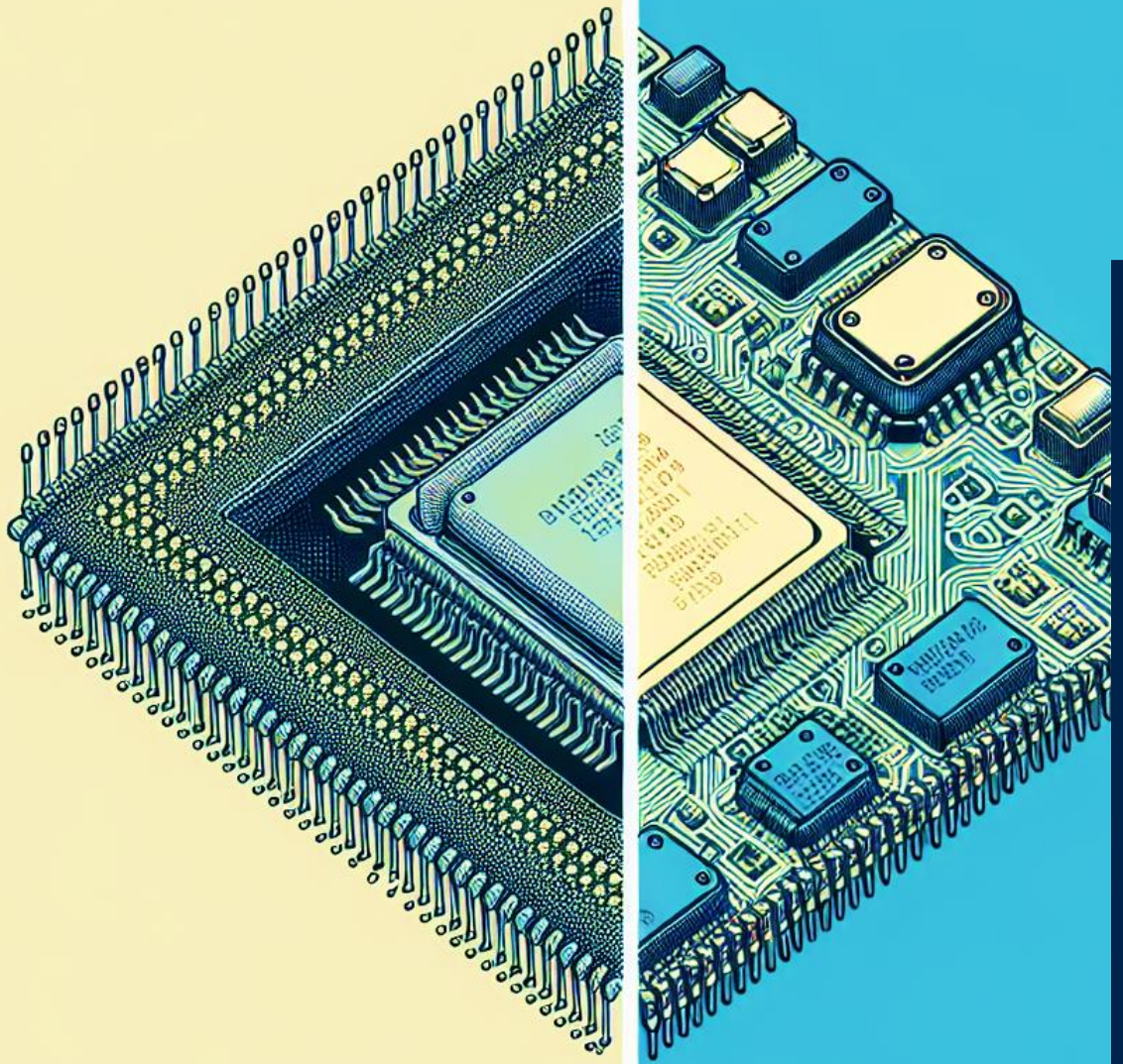

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ENSTA Paris PIE XRef Project

STMicroelectronics - Corporate Strategy team

Agenda

1 Project Context

2 Sub-Projects & Teams

3 Available Files & Test Method

4 Next Steps

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Project Context

We are creators and makers of technology

One of the world's largest semiconductor companies

Over **50,000** employees of which **9,500+** in R&D

$17.3 billion revenues in 2023

Over **80** sales & marketing offices serving over **200,000** customers across the globe

14 main manufacturing sites

Signatory of the United Nations Global Compact (UNGC)
Member of the Responsible Business Alliance (RBA)

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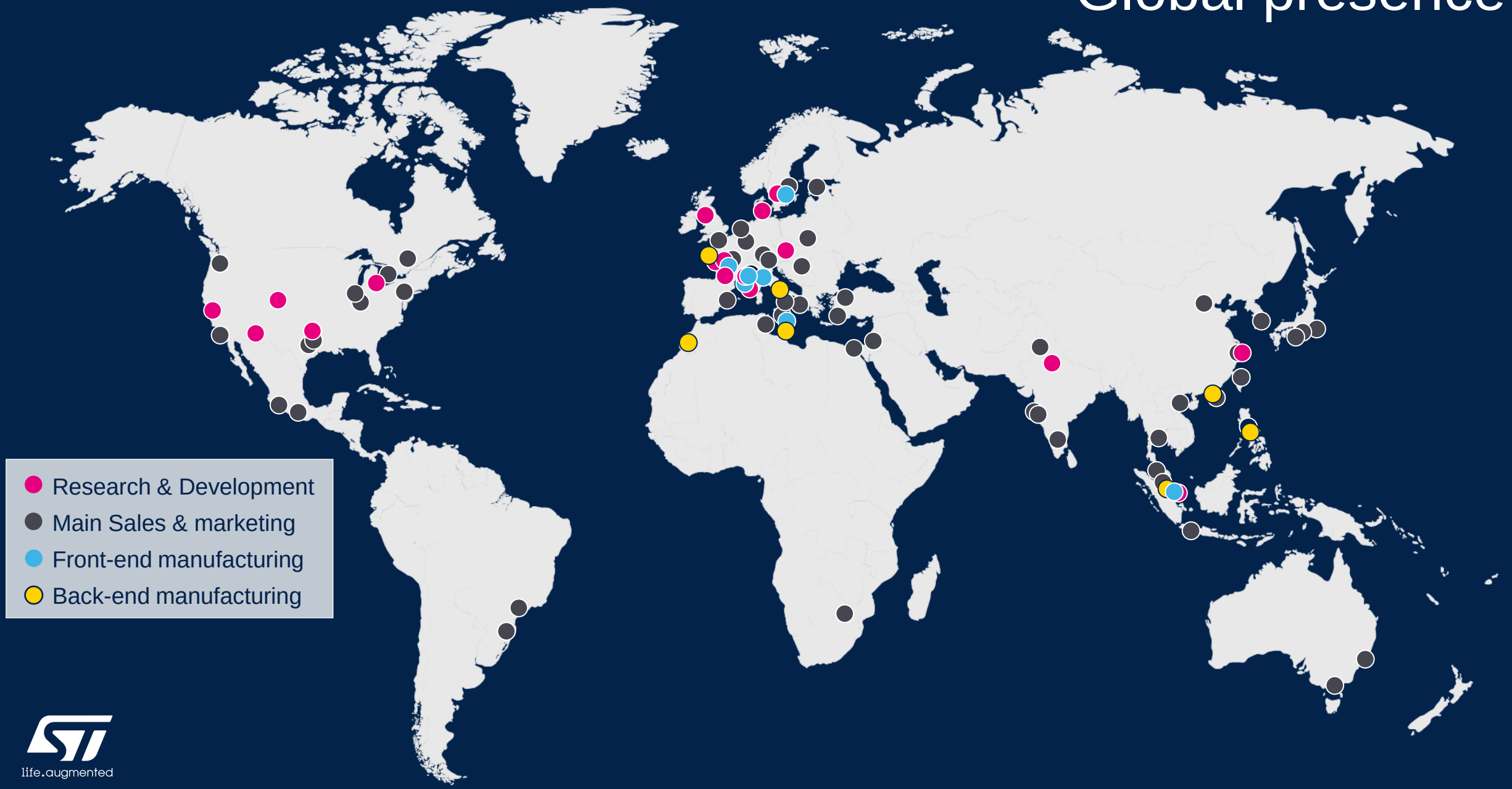
As of December 31, 2023

Global presence



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ST Executive Committee

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Jean-Marc Chery
President &
Chief Executive Officer

Marco Cassis
Analog, Power & Discrete, MEMS and Sensors Group

- **Alexandre Balmefrezol** — Imaging
- **Stefano Cantù** — Smart Power Solutions
- **Matteo Lo Presti** — Analog
- **Edoardo Merli** — Power Transistors
- **Alessandro Cremonesi** ** — System Research & Applications, Innovation

Remi El-Ouazzane
Microcontrollers, Digital ICs and RF products Group

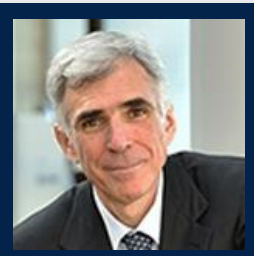
- **Ricardo De-Sa-Earp** — General Purpose Microcontrollers

Jerome Roux
Sales & Marketing

- **Michael Anfang** — EMEA & Automotive Marketing & Apps*
- **Henry Cao** — China & Power/Energy Marketing & Apps*
- **Hiroshi Noguchi** — APeC & Industrial Marketing & Apps*
- **Rino Peruzzi** — Americas & PE/CECP Marketing & Apps*

Fabio Gualandris
Quality, Manufacturing, & Technology

- **Christophe Ayela** — Analog & Power Front-End Manufacturing & Technology
- **Fabrice Gomez** — Back-End Manufacturing & Technology
- **Laurent Malier** — Digital Front-End Manufacturing & Technology
- **Nicolas Yackowlew** — Product Quality & Reliability



Lorenzo Grandi
Finance, Purchasing, ERM & Resilience, CFO

- **Franck Freymond** — Audit***, ERM & Resilience
- **Giuseppe Notarnicola** — Treasury
- **Bertrand Stoltz** — Finance, Global Business Services & Financial System
- **Geoff West** — Global Purchasing

Rajita D'Souza
Human Resources & Corporate Social Responsibility

Steven Rose
Legal Counsel & Public Affairs

- **Frédérique Le Grevès** — Europe & France Public Affairs
- **Giuseppe Notarnicola** — Italy Public Affairs
- **Bertrand Stoltz** — Asia Pacific Public Affairs

President & CEO Office

- **Alberto Della Chiesa** — Supply Chain
- **Claudia Levo** — Integrated Marketing & Communications
- **Chouaib Rokbi** — Digital Transformation & Information Technology, Corporate Development

APeC = Asia-Pacific excluding China
PE/CECP = Personal Electronics/ Communication Equipment & Computer Peripherals/
* Application marketing organization by market segment

*** Reports to the Chairman of the Supervisory Board Audit Committee and dotted line to the CEO

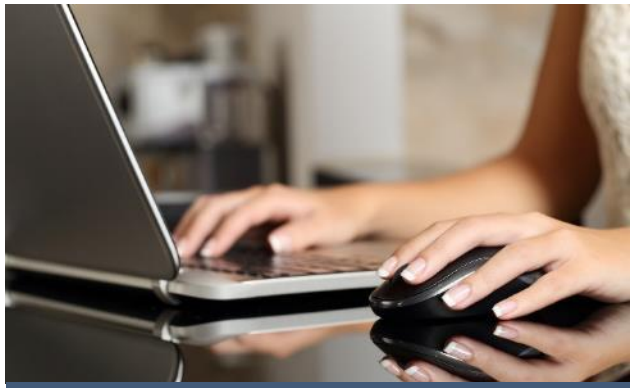
** *Reports dotted line to MDRF President*

We address four end markets

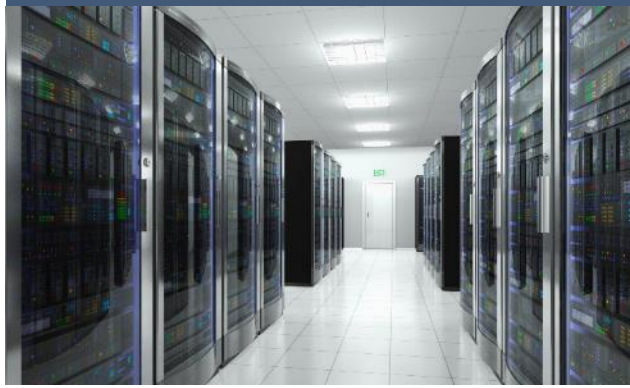
Automotive

Industrial

Personal electronics



Communications equipment, computers & peripherals



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Differentiated technologies are our foundation

MEMS
for sensors & micro-actuators

Smart Power: BCD
(Bipolar - CMOS - Power DMOS)

FD-SOI CMOS
FinFET through Foundry

Discrete, Power MOSFET, IGBT
Silicon Carbide, Gallium Nitride

Analog & RF CMOS

Vertical Intelligent Power

eNVM CMOS

Optical sensing solutions

Packaging technologies
Leadframe – Laminate – Sensor module – wafer level

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Our products and solutions enable customer innovation

Dedicated automotive ICs

Analog, industrial & power conversion ICs

GP MCU & MPU, Wireless MCU secure MCU, EEPROM

Discrete & power transistors

MEMS & optical sensing solutions

ASICs based on ST proprietary technologies

Cross-Reference for customer

Request from customer to find a replacement part for a competition product

Customers are using a specific part from the competition

E.g.: Operational amplificatory OPA2828

➔ Customers wants to check ST catalog for different reason

1. For better prices / performances
2. Part is obsolete
3. Want a 2nd source
4. …

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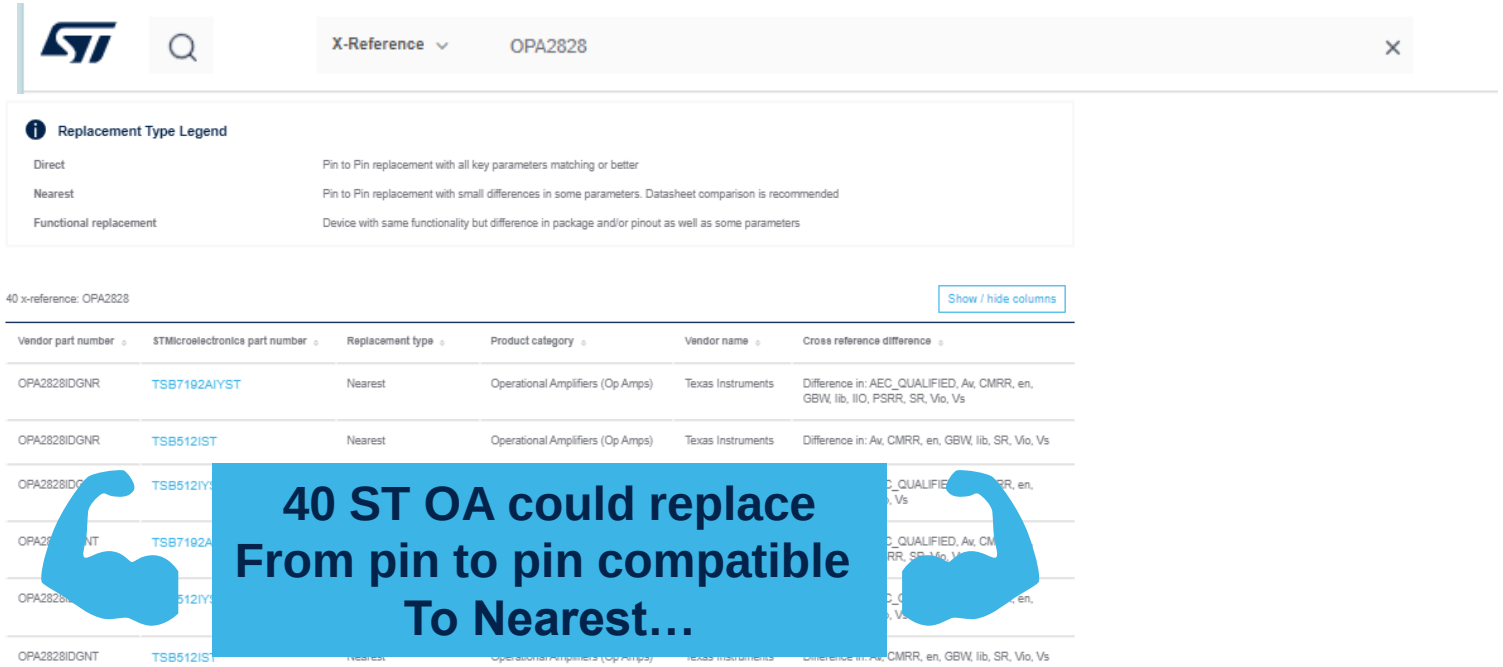
www.st.com



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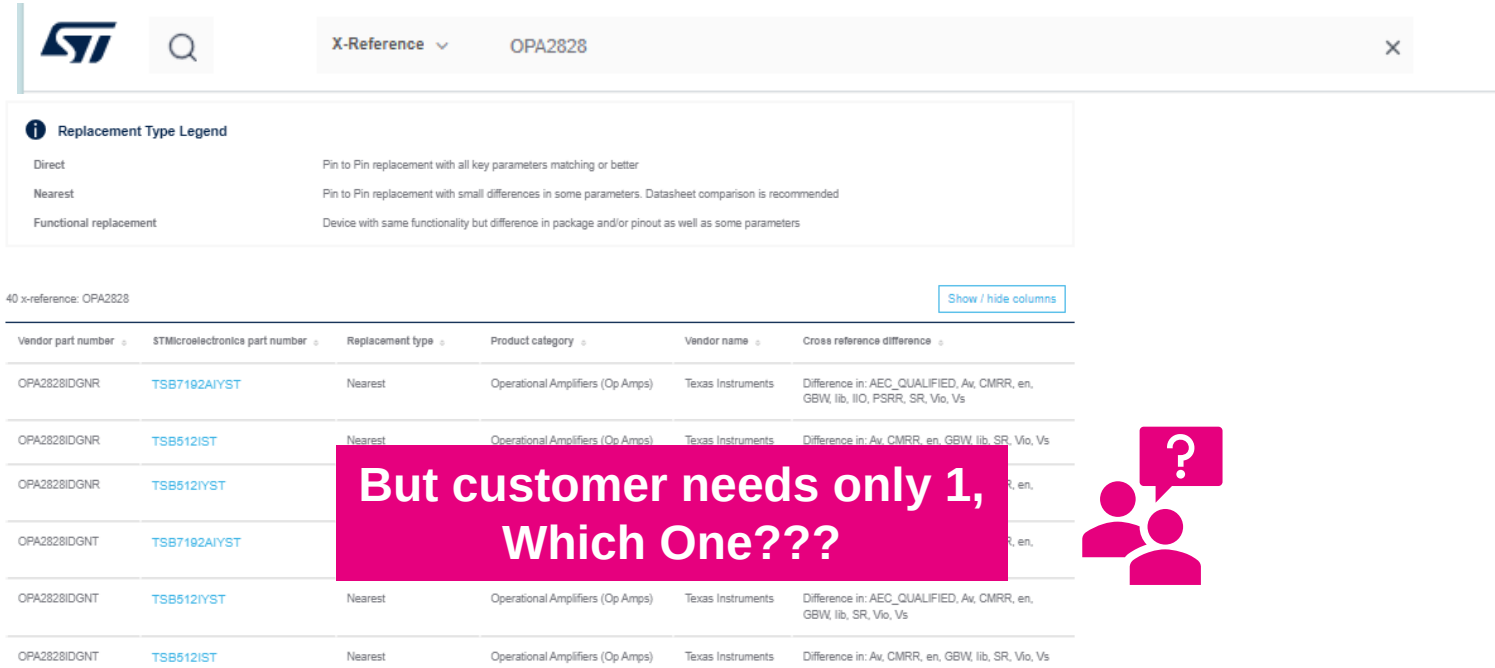
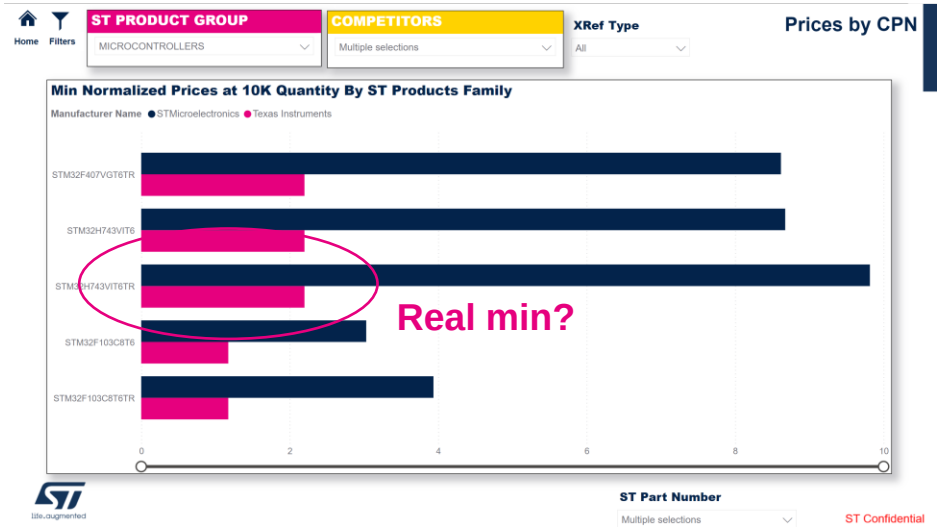
www.st.com



Cross-Reference for internal benchmarking

Current Xref is **exhaustive** but is a very large **Yes/No match** with many parts

- **Too large :** For each part, up to >100 cross-references
- **No ranking :** No score is provided (info “pin to pin” to “Nearest”)
- **Limited alternative :** Internal Xref are accurate, but limited (coverage, refresh rate)



Can’t focus on real competition

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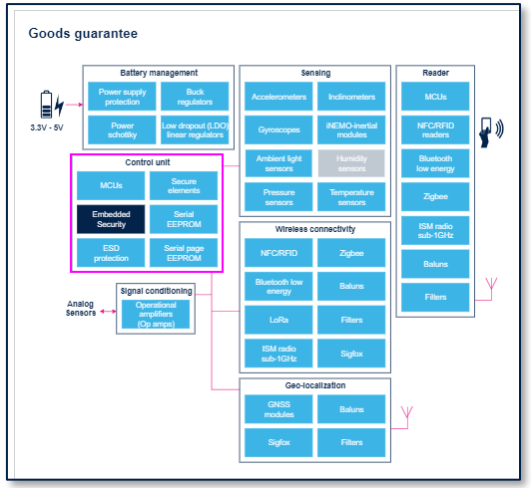
Cross-Reference by Application

Part to part is interesting, but customers are building systems

- www.st.com provides application block diagrams and associated best products for the application
- Could compare to competition

Benchmarking at application

Compare website to website



vs Competition website

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weekly delivery from external company

Cross-reference (Xref)

A competitor product that has “equivalent” features to a given ST CPN

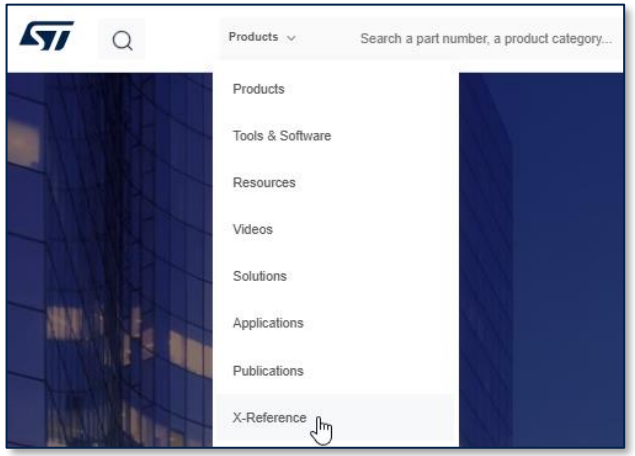
E-datasheet

Main (*) datasheet parameters
For each CPN from Xref
ST + competitor
Only Mass Market

Pricing

Distributor prices, stock and lead time
For each CPN in parameters when available

www.st.com



Portfolio & Price exploration

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Target Improvement

Class
A
B
C
D

Pin to pin

Nearest

ST Part	Competitor Part	Class
ST 1	C 1	D
ST 1	C 2	D

Score
90%
75%

Phase 1

Main Inputs

Xref by classes
e-Datasheets
Prices

Compute **Static** Scores

each week

Top X

Improve Benchmarking

Improve Customer Experience

Top 3

Target : Accuracy, acceptance criteria by marketing

Algorithm already existing
But possible improvements // Other pathes

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Target Improvement

Class
A
B
C
D

Pin to pin

↓

Nearest

ST Part	Competitor Part	Class
ST 1	C 1	D
ST 1	C 2	D

Score
90%
75%

Problem 1

Main Inputs

Xref by classes
e-Datasheets
Prices

→ Compute **Static** Scores

each week

Problem 2

Internal Xref

ST Expertise
Many Formats
Small coverage
Unregular

→ Improved **Static** Scores

"with new inputs"

→ **Top X**

Improve Benchmarking

Improve Customer Experience

Top 3

Targets :
limit workload to Marketing teams
Embed ST Expertise in the algorithm

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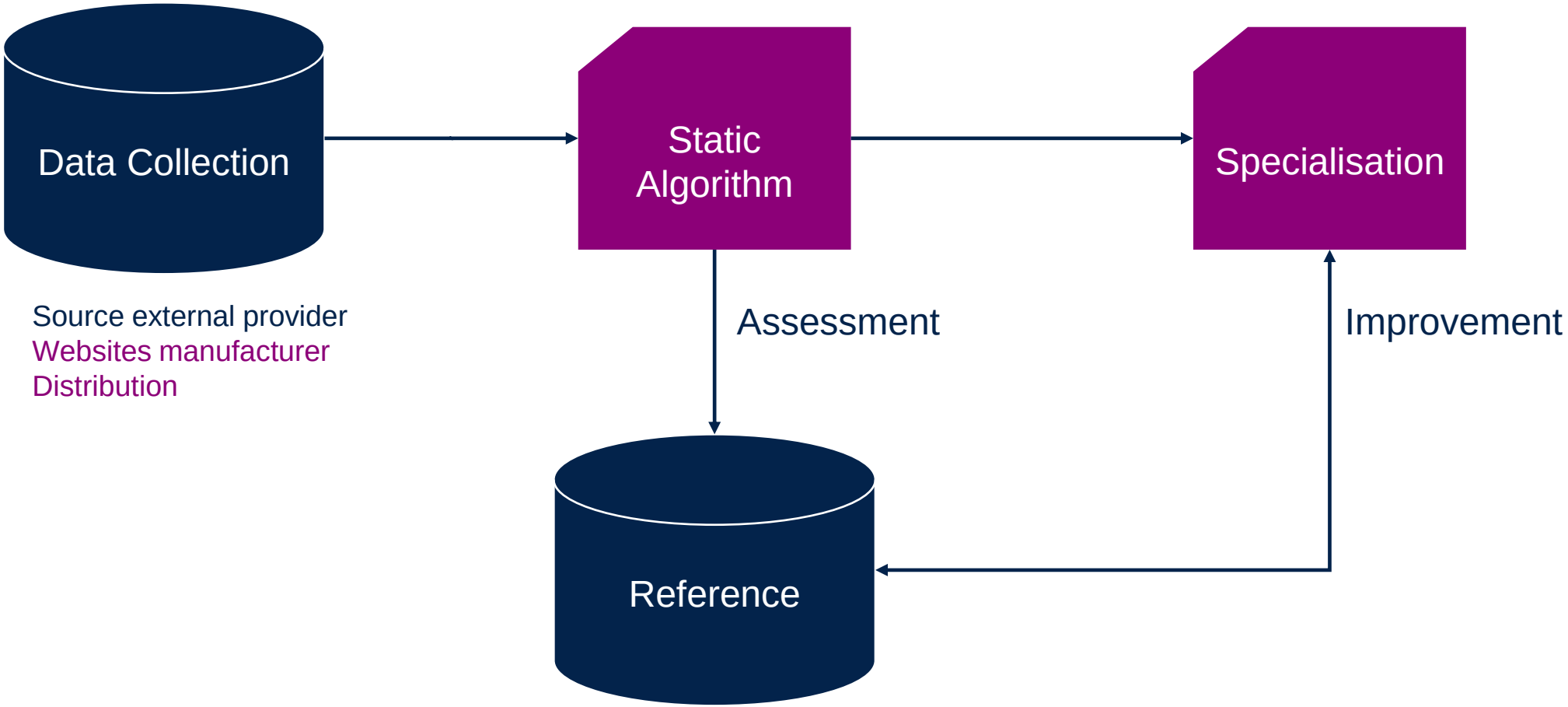
Different parts



1. Source external provider
2. Websites manufacturer
3. Distribution

1. ST Marketing extract

- Objectifs du projet :

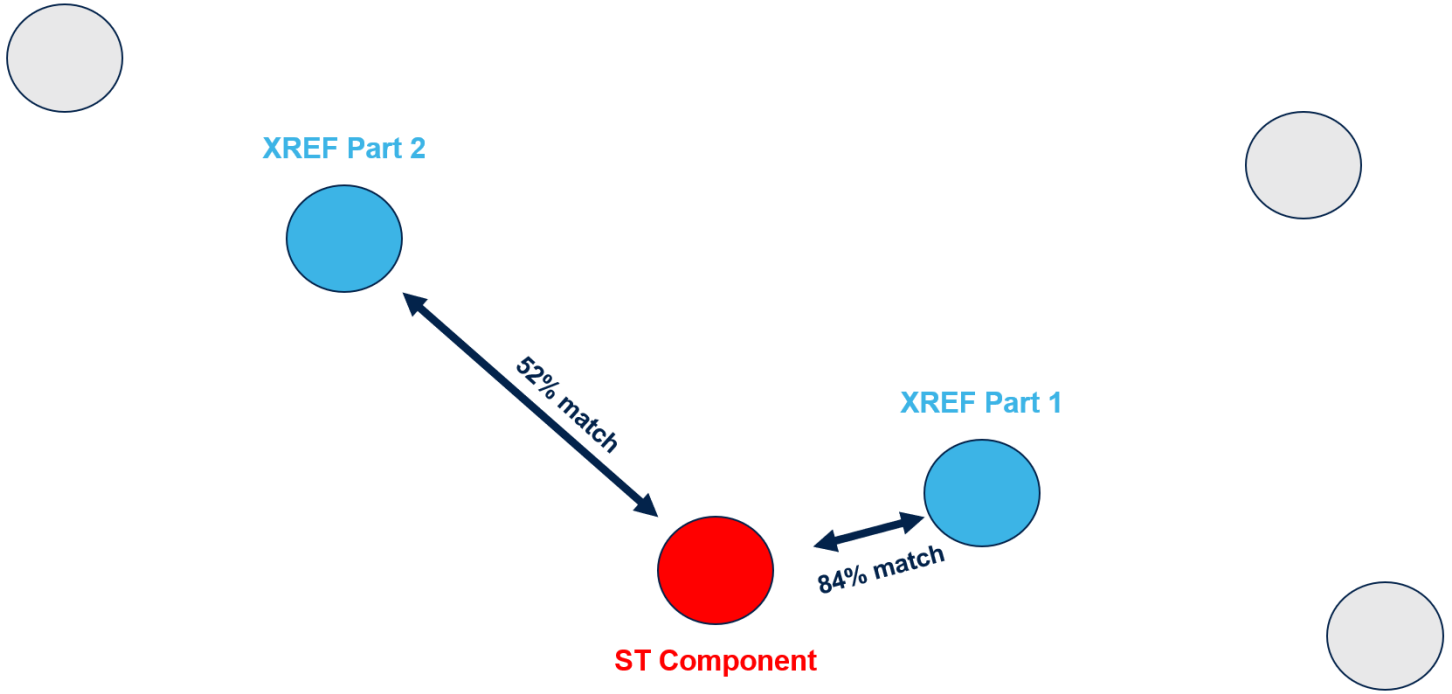
- **Utiliser des méthodes d'apprentissage supervisé** pour évaluer la similitude entre des composants en fonction de leurs caractéristiques.
- **Explorer des algorithmes de Machine Learning** et progresser vis-à-vis des thématiques d'IA et de Data Science.
- **Mettre en place un système de spécialisation du modèle** sur un nouveau dataset fourni.
- **Travailler en étroite collaboration avec des ingénieurs** pour comprendre les données et les enjeux du projet.
- **Mettre en pratique des compétences en programmation Python, en statistiques et en traitement de données.**

- Résultats attendus :

- **Algorithme qui prend en entrée deux composants microélectroniques** et renvoie un score de similitude (pourcentage).
- **Méthode qui permet de raffiner les résultats** en prenant en compte les feedbacks successifs des ingénieurs vis-à-vis de la proposition faite par l'IA.
- **Rapport final détaillant les méthodes utilisées, les résultats obtenus et les conclusions du projet**.

Necessity of Match Score

1 Matrix per Product Line



Data 1: Op Amps Features

MPN	MANUFACTURER	Family	Manufacturer Type	Maximum Input Bias Current	Maximum Input Offset Current	Maximum Input Offset Voltage	Maximum Operating Supply Voltage	Maximum Operating Temperature	Maximum Single Supply Voltage	Maximum Supply Voltage Range	Minimum CMRR	...	Power Supply Type	Shut Down Support
5962-0051701VCA	Analog Devices	Not Mentioned	Precision Amplifier	3.500000e-07	5.000000e-08	0.000200	36.0	125.0	36.0	37.0	86.0	...	Single|Dual	No
5962-0051701VDA	Analog Devices	Not Mentioned	Precision Amplifier	3.500000e-07	5.000000e-08	0.000200	36.0	125.0	36.0	37.0	86.0	...	Single|Dual	No
5962-0620601VZA	Texas Instruments	Not Mentioned	Precision Amplifier	2.700323e-06	6.000000e-12	0.000036	5.0	125.0	5.0	5.5	100.0	...	Single	No
5962-0721901VHA	Texas Instruments	Not Mentioned	High Speed Amplifier	1.200000e-05	1.000000e-06	0.004000	5.0	125.0	5.0	5.5	78.0	...	Single|Dual	No
5962-7704301VCA	Texas Instruments	Not Mentioned	High Gain Amplifier	1.500000e-07	3.000000e-08	0.005000	32.0	125.0	32.0	36.0	70.0	...	Single|Dual	No

Op Amps example: 19,868 x 31

Data 2: Op Amps XRef

STMicro MPN	STMicro Name	Competitor MPN	Competitor Name	Cross Reference Type
LD2981ABU33TR	STMicroelectronics	MIC5206-3.3BM5	Microchip Technology	D
LD2981ABU33TR	STMicroelectronics	ADP7118AUJZ-3.3-R7	Analog Devices	D
LD2981ABU33TR	STMicroelectronics	GGA1117R-3.3TR	Golden Gate Integrated Circuits Inc	D
LD2981ABU33TR	STMicroelectronics	TAR5S34U(BRA,F)	Toshiba	D
LD2981ABU33TR	STMicroelectronics	NJM2800U3342-TE1	Nisshinbo Micro Devices Inc	D
...	...	...	...	...
STM32G474VET6	STMicroelectronics	R5F524T8ADFP#30	Renesas Electronics	D
SMC50J10A	STMicroelectronics	SMCJ10A	Yageo	C
STM32F437IGT6	STMicroelectronics	S6E2DH5J0AGV20000	Infineon Technologies AG	D
STTH30L06WY	STMicroelectronics	VS-HFA30PB120-N3	Vishay	C
STD9NM50N	STMicroelectronics	PJD60R900S_L2_00201	PANJIT International Inc.	C

SE XRef data

Cross Reference Type	STMicro MPN	STMicro Name	Competitor MPN	Competitor Name
A	8	8	8	8
B	30708	30708	30708	30708
B-	363	363	363	363
C	36315	36315	36315	36315
C-	1172	1172	1172	1172
D	50746	50746	50746	50746
P	10500	10500	10500	10500
X	13	13	13	13

Op Amps distribution of types

Cross Reference Type	Cross Reference Definition
A	Pin to Pin drop-in replacement with exact electrical features.
A/Upgrade	Pin to Pin drop-in replacement, but the crossed device has better performance in specific key parameters.
A/Downgrade	Pin to Pin drop-in replacement, but the original device has better performance in specific key parameters.
B	Pin to Pin compatible with minor electrical differences and/or minor package dimension.
B/Upgrade	Pin to Pin compatible with minor electrical differences and/or minor package dimension, but the crossed device has better performance in specific key parameters.
B/Downgrade	Pin to Pin compatible with minor electrical differences and/or minor package dimension, but the original device has better performance in specific key parameters.
C	Pin to Pin compatible with major electrical differences.
C/Upgrade	Pin to Pin compatible with major electrical differences, but the crossed device has better performance in specific key parameters.
C/Downgrade	Pin to Pin compatible with major electrical differences, but the original device has better performance in specific key parameters.
D	The two devices have similar functionality with a different package and/or pinout.

SE XRef types explanation

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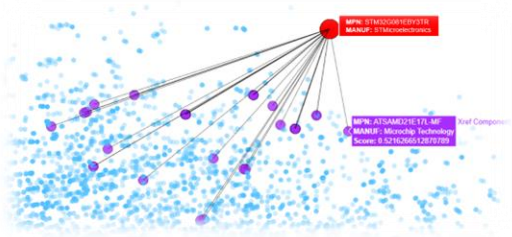
1st Method: Gower Score

Unsupervised

Manhattan Distance
For numerical Features

Dice Distance
For non numerical Features

Gower Distance
Between 0 and 1



$$S_{ij} = \frac{\sum_{k}^{n} w_{ijk} S_{ijk}}{\sum_{k}^{n} w_{ijk}}$$

- where:

S_{ijk} denotes the contribution provided by the $k-$th variable, and

w_{ijk} is usually 1 or 0 depending if the comparison is valid for the $k-$th variable.

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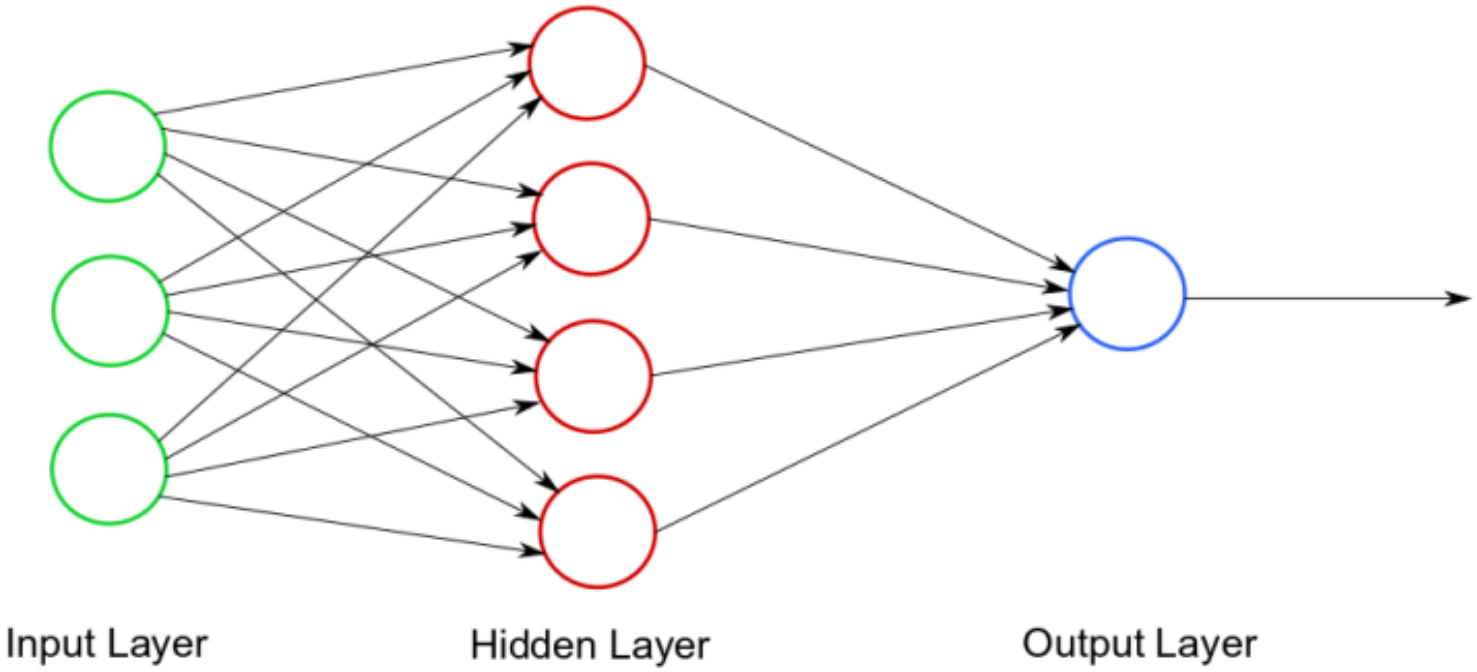
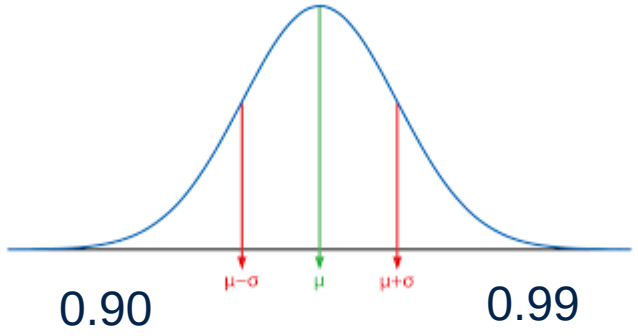
2nd Method: Neural Network Regressor

Supervised



A ➡ 

➡ 0.937

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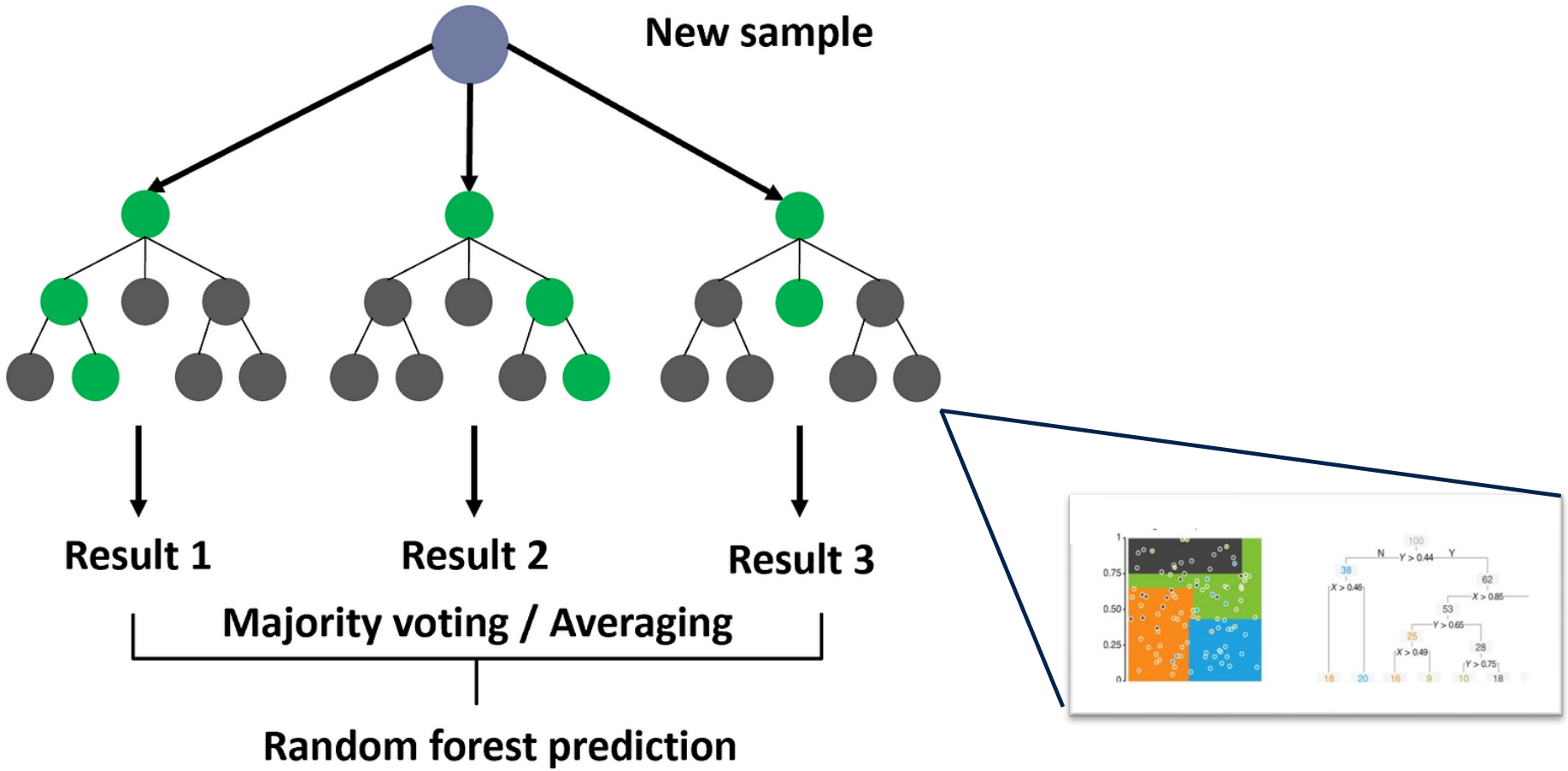
3rd Method: Random Forest Regressor

Supervised



Immune to overfitting and high dimensionality

KPI

		Gower Score	Neural Network	Random Forest
Op Amps Test set	**% in Top 6**	**51%**	**50%**	**71%**
	% in Top 5%	80%	79%	91%

Feature Filtering for Competitor

All

Competitor Part **19.85K parts**

onsemi (Competitor Name) + LM258DMR2G (Competitor MPN)

LM258DMR2G **Price @10K ($): 0.10**

Competitor Name	Competitor MPN	STMicro Part	Matching (%)	STMicro Rank	Normalized Price @10K ST
onsemi	LM258DMR2G	LM358ST	83.69	1	0.16
onsemi	LM258DMR2G	LM358WST	83.21	2	0.16
onsemi	LM258DMR2G	LM358AST	82.87	3	0.37
onsemi	LM258DMR2G	LM358AWST	82.82	4	0.15
onsemi	LM258DMR2G	LM2904ST	82.47	5	0.25

Feature Filtering for ST

All

ST Part **837 parts**

LM358ST

LM358ST **Price @10K ($): 0.16**

Competitor Name	Competitor MPN	Matching (%)	STMicro Rank	Normalized Price @10K Competitor
onsemi	LM258DMR2G	83.69	1	0
Texas Instruments	OPA2137E/250	82.34	1	1
Texas Instruments	OPA2137E/2K5	82.34	1	1
Texas Instruments	LM2904DGKR	81.36	4	0
Diodes Incorporated	LM2904M8-13	81.30	4	0
Diodes Incorporated	LM2904QM8-13	81.14	1	0

Matching Selection

Parts are Matching : Yes

Matching Scores : (100% = Perfect Match) 55 %

Competitivity Score : (<0: Competitor best, 0: equivalent, >0: ST best) 0

Selected Parts Competitors :1

onsemi	LM258DMR2G

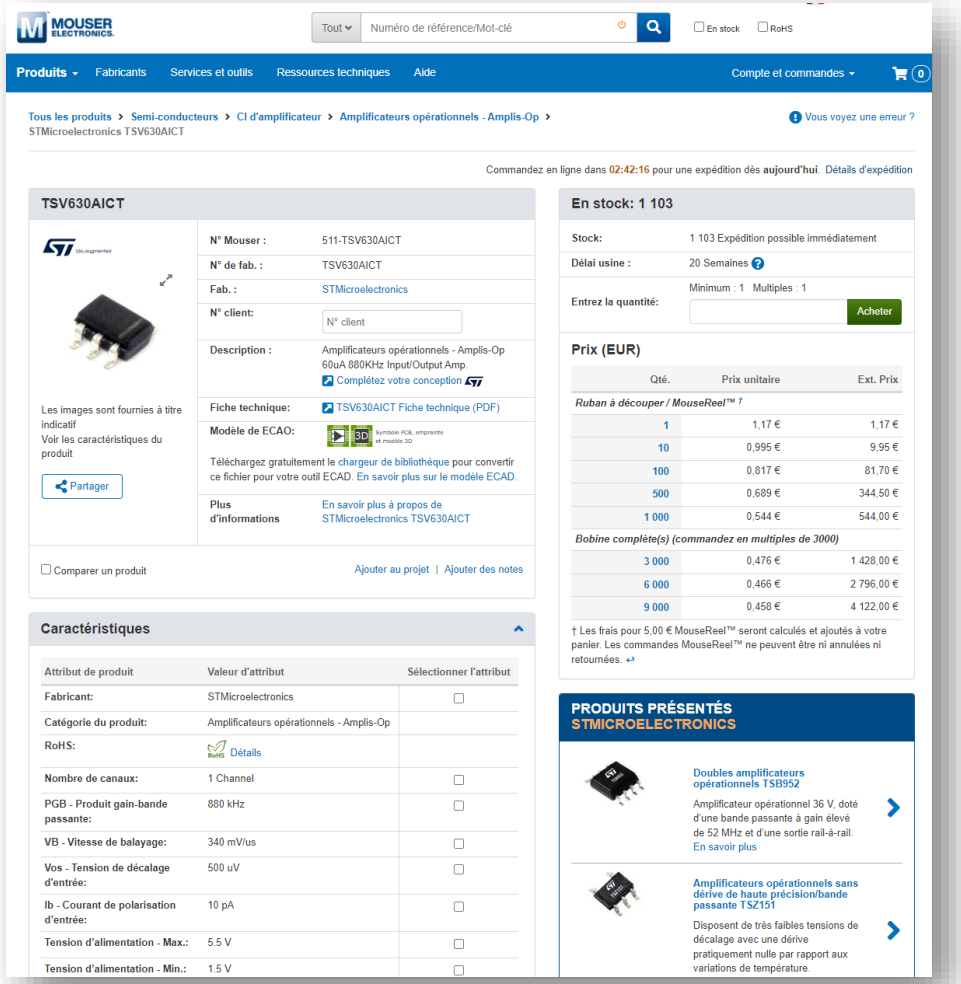
Selected Parts Reference :1

LM358ST	STMicroelectronics

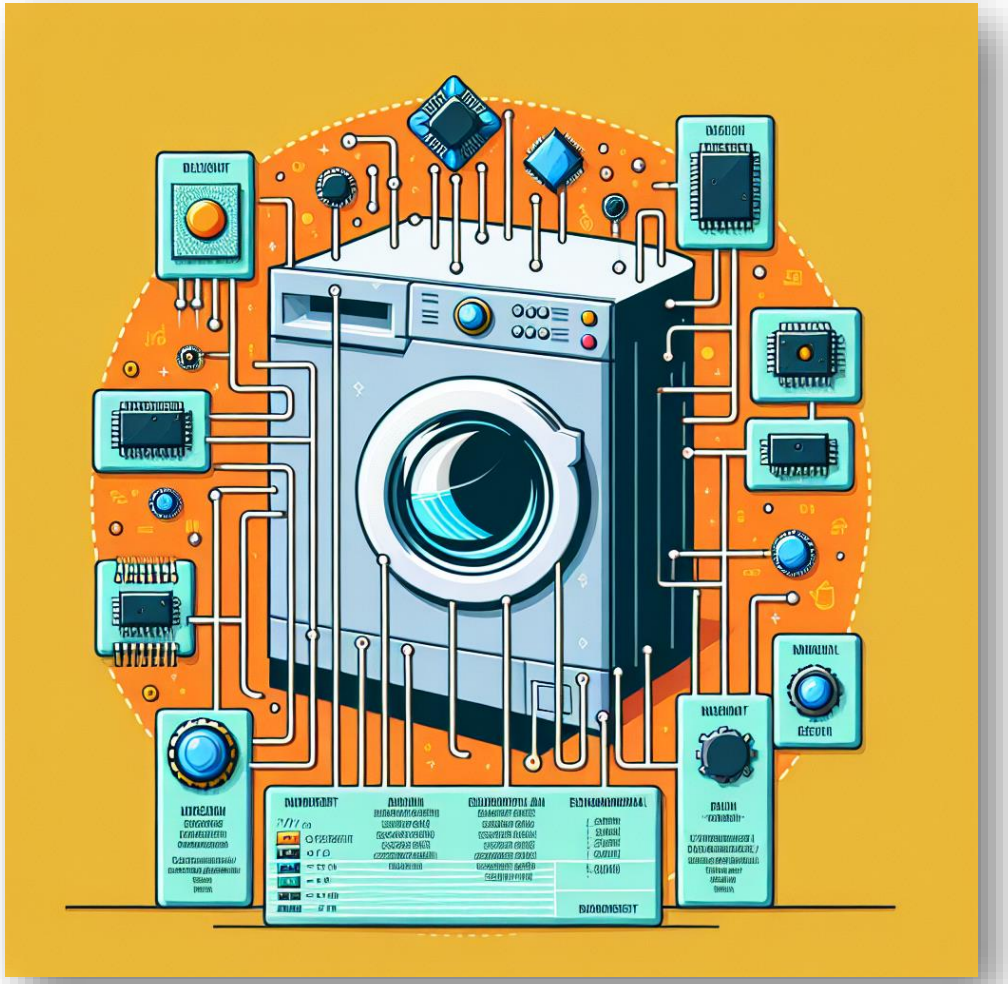
Feature Name	Competitor	.	ST	.
Part Number	LM258DMR2G		LM358ST	
Family	LM258		LM358	
Norm. Price@10k	0.10		0.16	
Manufacturer Type	General Purpose Amplifier		Low Power Amplifier	
Maximum Dual Supply Voltage	?16	V	?15	V
Maximum Input Bias Current	0.15@5V	A	0.15@5V	A
Maximum Input Offset Current	0.03@5V	A	0.03@5V	A
Maximum Input Offset Voltage	5@30V	V	7@5V	V
Maximum Operating Supply Voltage	?16|32	V	?15|30	V
Maximum Operating Temperature	85	?C	70	?C
Maximum Single Supply Voltage	32	V	30	V
Maximum Supply Voltage Range	32 to 36	V	30 to 32	V
Minimum CMRR	70	dB	70	dB
Minimum CMRR Range	70 to 71	dB	70 to 71	dB

Sub-Projects & Teams

Data Expansion



Distribution Websites



Bill of Materials

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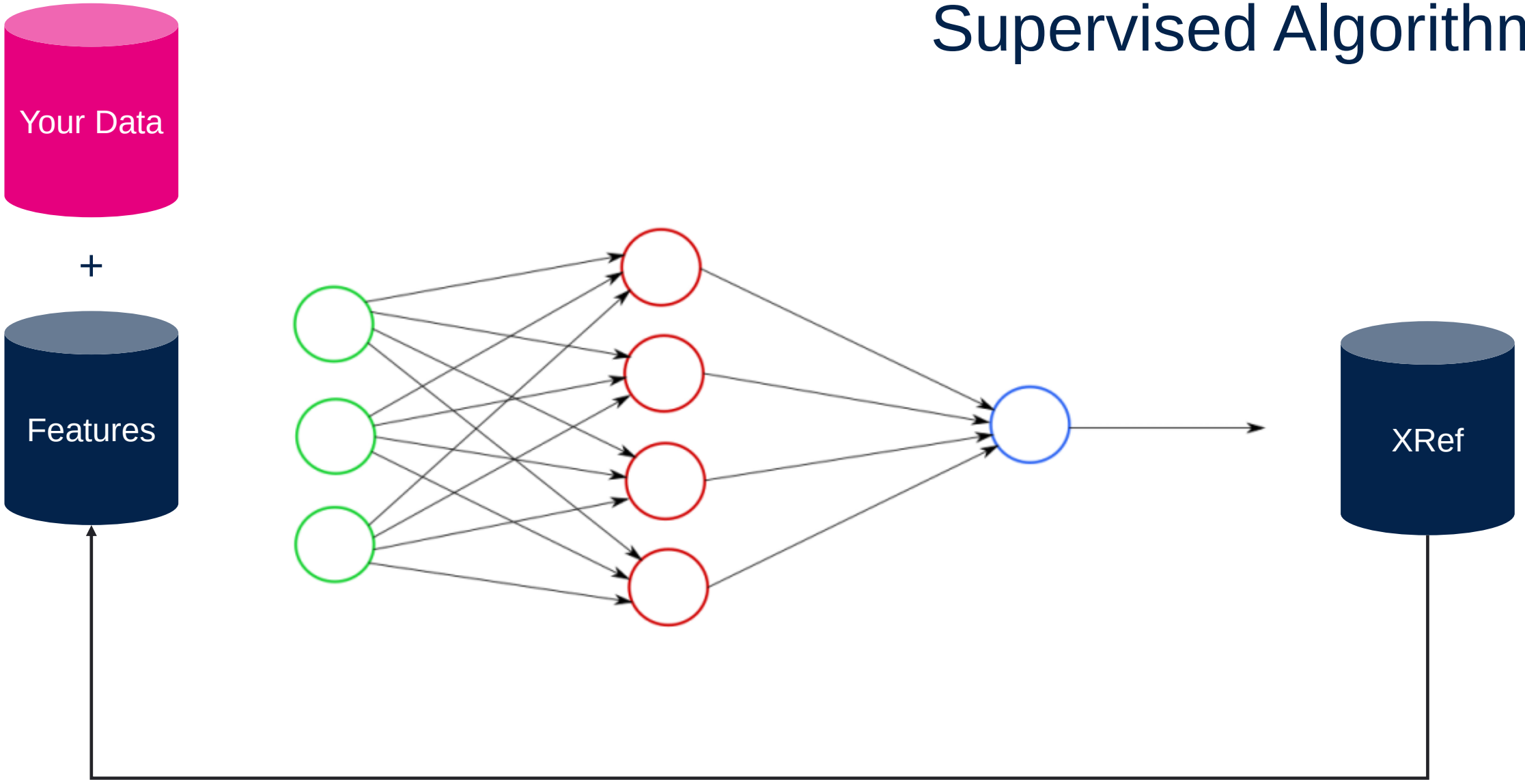
Supervised Algorithm



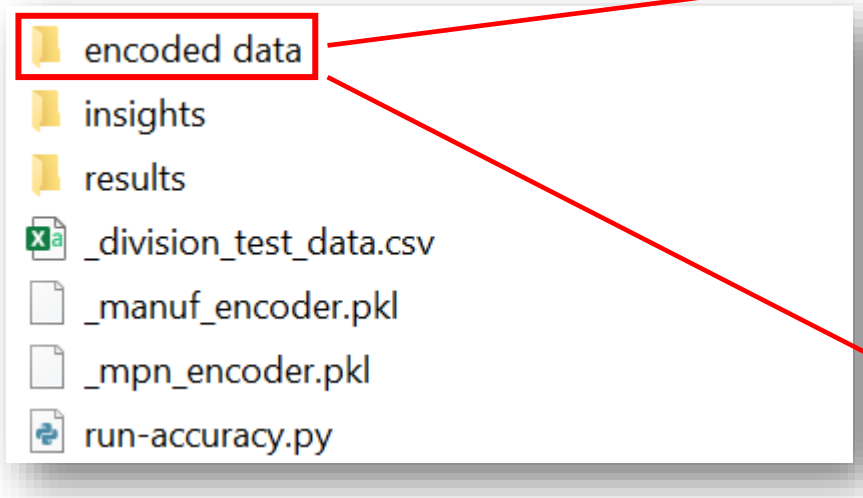
Possibility to test accuracy with provided folder

Once Finished first 2:

1. Specialization method for new data arrivals
2. Try many supervised models (Networks, SVR, Boosting, LLM...)
3. Try many methods (semi-supervised, self-supervised…)
4. Fine-tuning the best model

Available Files & Test Method

Provided Folder



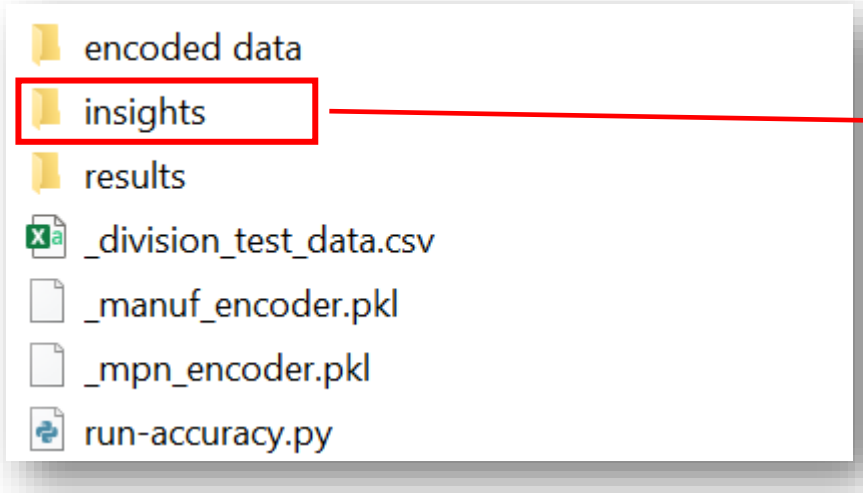
Op Amps Features

MPN	MANUFACTURER	Maximum Input C	Maximum Single	Minimum Single	Number of Chan	Supplier_Packag	Typical Gain Bandwidth Product
PN-100	MN-103	0.0002	36	2	4	CDIP	48144417.37
PN-101	MN-103	0.0002	36	2	4	CFPAK	48144417.37
PN-102	MN-1036	3.60E-05	5	2.7	2	CSOIC	3000000
PN-103	MN-1036	0.004	5	2.7	1	CFPAK	1000000000
PN-104	MN-1036	0.005	32	3	4	CDIP	1200000
PN-105	MN-1036	0.002	40	1.1	2	TO-99	48144417.37
PN-106	MN-1036	0.005	32	3	2	CLLCC	700000
PN-107	MN-1036	0.005	32	3	2	CDIP	700000
PN-108	MN-1036	0.002	32	3	2	CLLCC	700000
PN-109	MN-1036	0.002	32	3	2	TO-99	1000000
PN-1010	MN-1036	0.002	32	3	2	CDIP	700000
PN-1011	MN-1036	0.002	32	3	2	CSOIC	1000000

Op Amps XRef

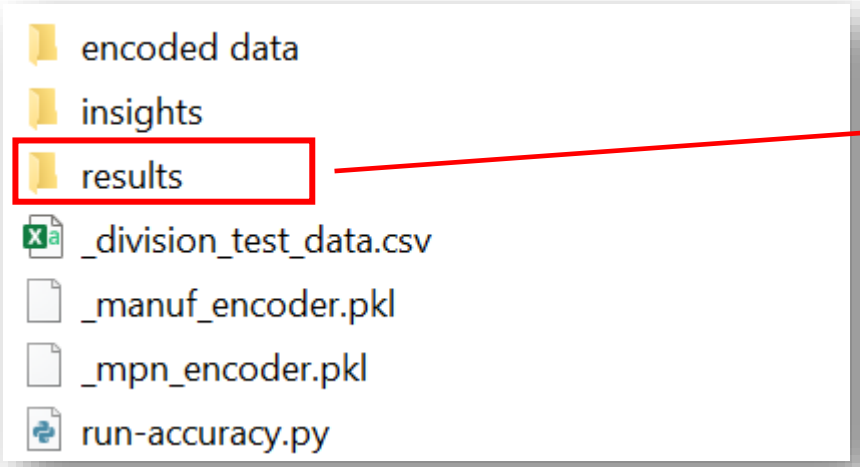
STMicro MPN	STMicro Name	Competitor MPN	Competitor Name	Cross Reference Type
PN-1017594	MN-1030	PN-1017599	MN-1036	A
PN-1017602	MN-1030	PN-1017598	MN-1036	A
PN-1017602	MN-1030	PN-1017597	MN-1036	A
PN-1017594	MN-1030	PN-1017598	MN-1036	A
PN-1017602	MN-1030	PN-1017599	MN-1036	A
PN-1017594	MN-1030	PN-1017600	MN-1036	A
PN-1017602	MN-1030	PN-1017600	MN-1036	A
PN-1017594	MN-1030	PN-1017597	MN-1036	A
PN-103390	MN-1030	PN-103428	MN-1036	B
PN-105094	MN-1030	PN-1013125	MN-1036	B
PN-105094	MN-1030	PN-105021	MN-1036	B
PN-1017551	MN-1030	PN-1010834	MN-1019	B
PN-105123	MN-1030	PN-109528	MN-103	B

Provided Folder



Cross Reference Type	Cross Reference Definition
A	Pin to Pin drop-in replacement with exact electrical features.
A/Upgrade	Pin to Pin drop-in replacement, but the crossed device has better performance in specific key parameters.
A/Downgrade	Pin to Pin drop-in replacement, but the original device has better performance in specific key parameters.
B	Pin to Pin compatible with minor electrical differences and/or minor package dimension.
B/Upgrade	Pin to Pin compatible with minor electrical differences and/or minor package dimension, but the crossed device has better performance in specific key parameters.
B/Downgrade	Pin to Pin compatible with minor electrical differences and/or minor package dimension, but the original device has better performance in specific key parameters.
C	Pin to Pin compatible with major electrical differences.
C/Upgrade	Pin to Pin compatible with major electrical differences, but the crossed device has better performance in specific key parameters.
C/Downgrade	Pin to Pin compatible with major electrical differences, but the original device has better performance in specific key parameters.
D	The two devices have similar functionality with a different package and/or pinout.
F/Upgrade	The crossed device has the same functionality with a larger number of logic cells (in FPGA | CPLD projects).
F/Downgrade	The crossed device has the same functionality with a smaller number of logic cells (in FPGA | CPLD projects).
F	The crossed device has the same functionality (in FPGA | CPLD projects).

Provided Folder

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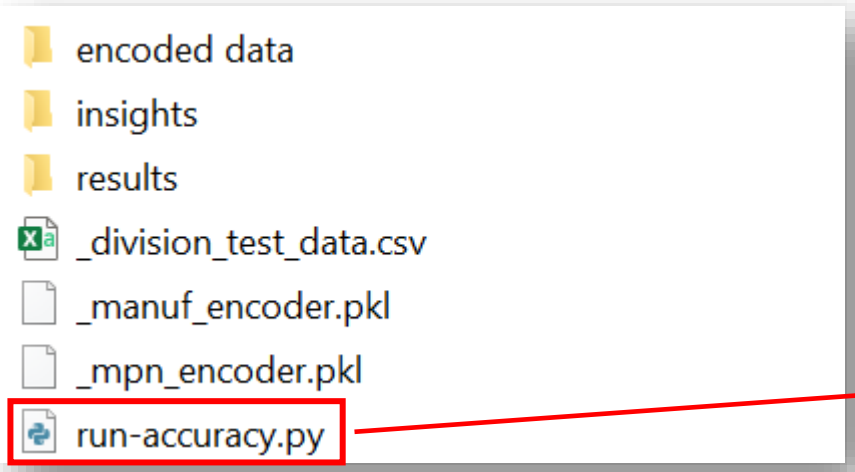
18,352 x 18,352

Provided Folder

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100%|| 2317/2317 [09:37<00:00,  4.01it/s]
> We have 792 ST Parts
> We have 1188 division XRef samples
> 70.8% of xref have at least 1 of the top 6 st in our top 6 xref predictions
> 92.4% of xref have at least 1 of the top 6 st in our top 5% xref predictions
```

Next Steps

Next Steps

1. 2 Groups (at least 1 person from each staying in 2nd semester)
2. Understand Topic, Data and provided folder
3. Study State of the Art and plan project advancement
4. Set regular meetings for questions and feedback

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