

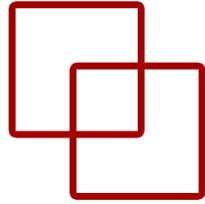
# Presentación



**Dr. Manuel Castillo-Cara**  
[www.manuelcastillo.eu](http://www.manuelcastillo.eu)

Departamento de Inteligencia Artificial  
Escuela Técnica Superior de Ingeniería Informática  
Universidad Nacional de Educación a Distancia (UNED)

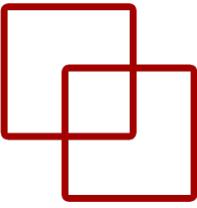
# Preliminar



- Improving Deep Learning by Exploiting Synthetic Images © 2024 by Manuel Castillo-Cara is licensed under Attribution-NonCommercial 4.0 International



# Índice



- Curriculum Vitae
- Estudiar en la UNED
- Líneas de investigación
- Indoor Localization
- BeeGOns!
- Federated Fog-Computing
- Imágenes Sintéticas
- TINTOlib
- Caso de Uso 1
- Caso de Uso 2

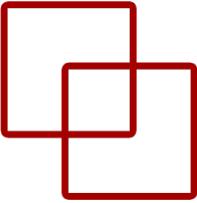
# Curriculum Vitae

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Ingeniería  
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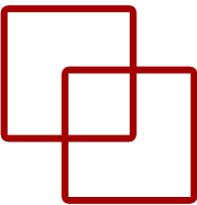


UNED

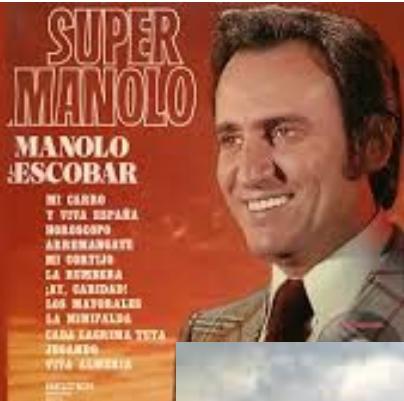
# Almería



# Almería



01. Pájaro Ciego  
02. Madrecita M<sup>a</sup> Del Carmen  
03. Que Viva España  
04. Tu Nombre Aníta  
05. Mi Canción Es Para Ti  
06. Mi Pequeña Flor  
07. Que Bonita Es Mi Niña  
08. Niña De Los Ojos Verdes  
09. Mi Carruaje  
10. Mientras Tú Me Vivirás  
11. Ni Se Compra Ni Se Vende  
12. Escribiente  
13. Los Mayarales  
14. Ay, Mi Sombra  
15. Solo Te Pido  
16. El Positivo No Se Equivoca  
17. La Morena De Mi Copia  
18. En Tierra Exótica  
19. Valencia  
20. Mi Canción Es Para Ti



Nicolás Salmerón fotografiado por Compañy,  
publicado en la revista *Nuevo Mundo*  
el 24 de septiembre de 1908.



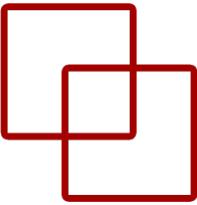
Presidente del Poder Ejecutivo de la  
República Española

18 de julio de 1873-7 de septiembre de 1873

Predecesor Francisco Pi y Margall

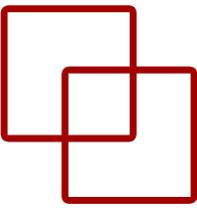
Sucesor Emilio Castelar

# Doctorado - UCLM Albacete



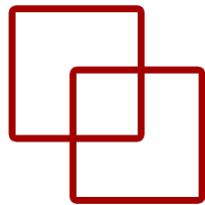
Imágenes tomadas de diferentes sitios de internet para una finalidad interna y no pública

# UNI

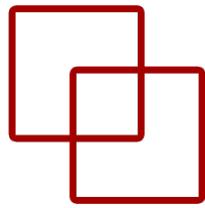


Imágenes tomadas de diferentes sitios de internet para una finalidad interna y no pública

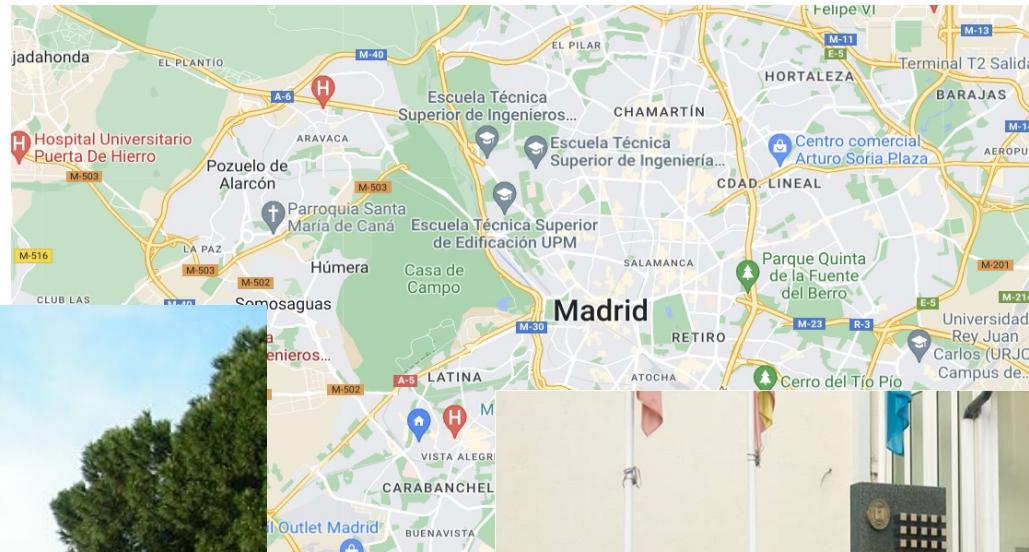
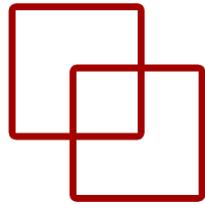
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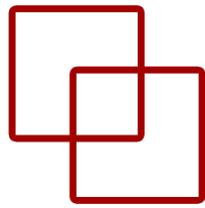
Imágenes tomadas de diferentes sitios de internet para una finalidad interna y no pública



# OEG - UPM



# UNED

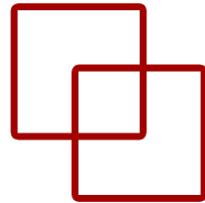


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# UNED - México



- Universidad pública con representación internacional.
  - Tasas muy bajas con una exigencia alta.
  - Títulos europeos oficiales
- En México, hay centro [UNED](#). [Ubicación](#).
- Posibilidad de estudiar pregrado y posgrado:
  - [Máster de Inteligencia Artificial](#)
  - [Otros másteres de informática](#)



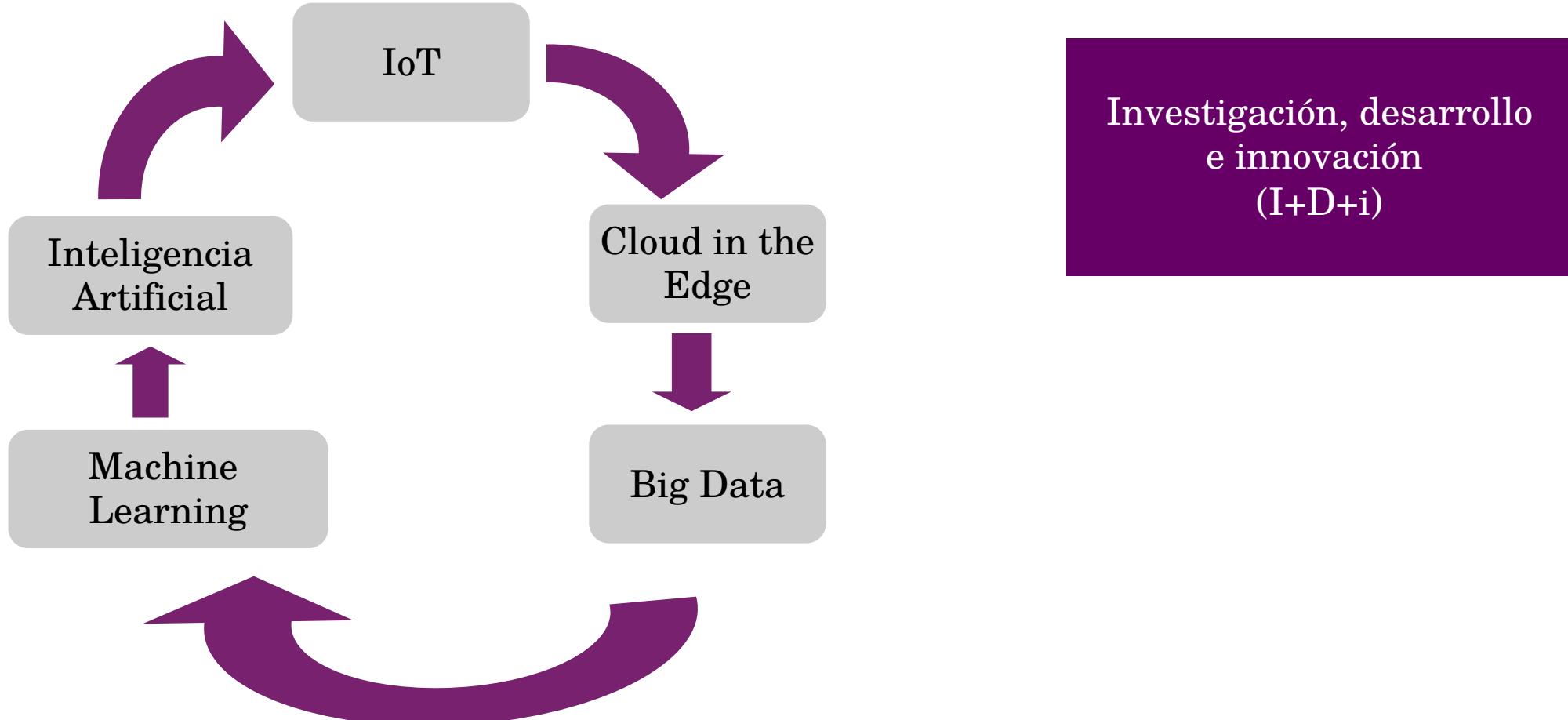
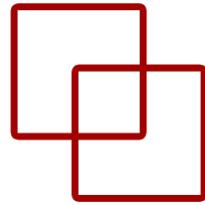
# Líneas de investigación

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# ICBM-AI



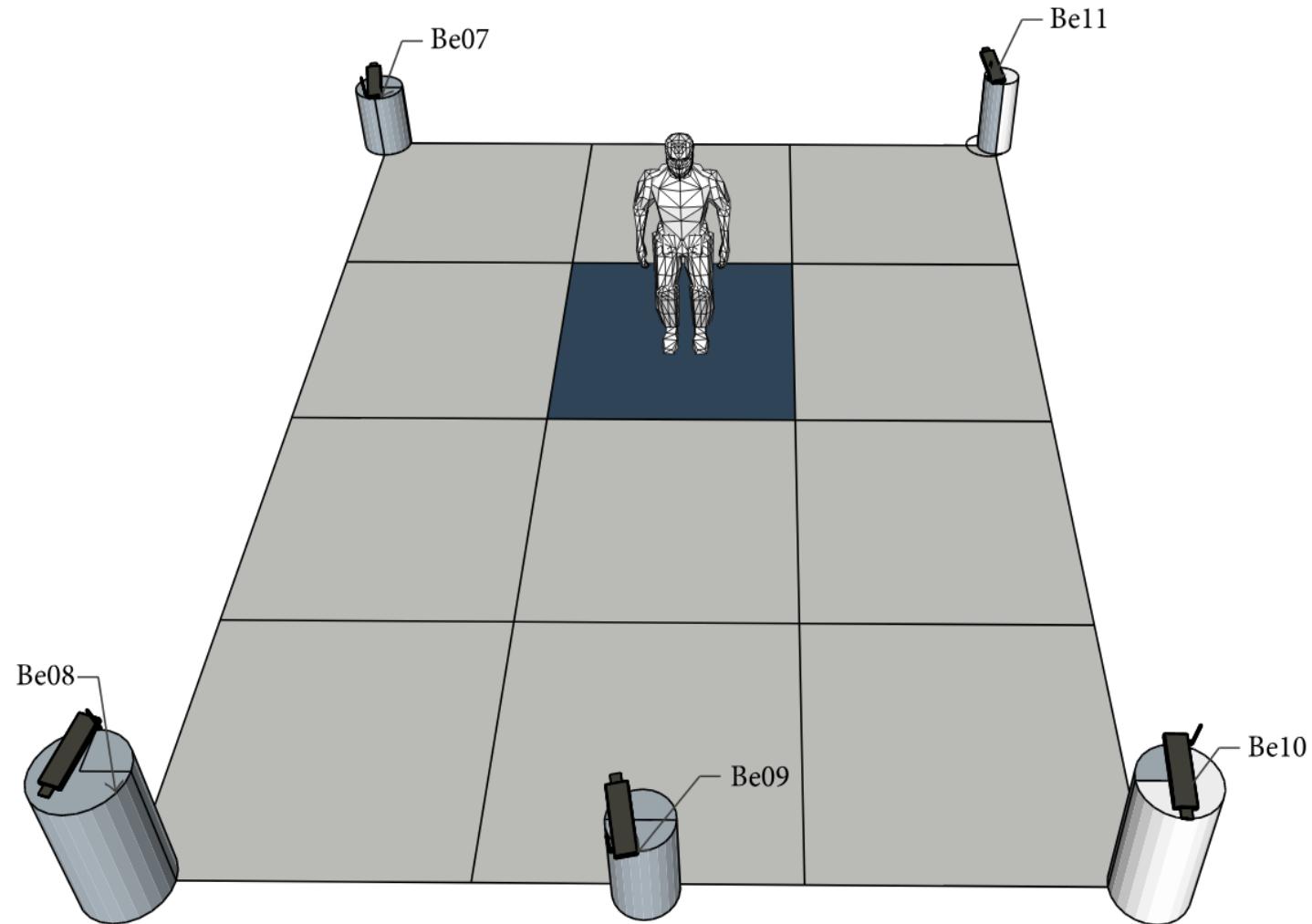
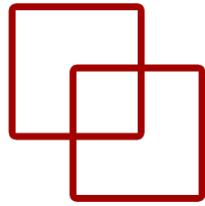
# Indoor Localization

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# Indoor Localization





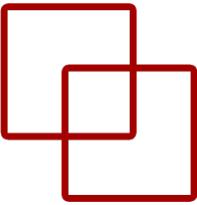
BeeGons!

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Informática

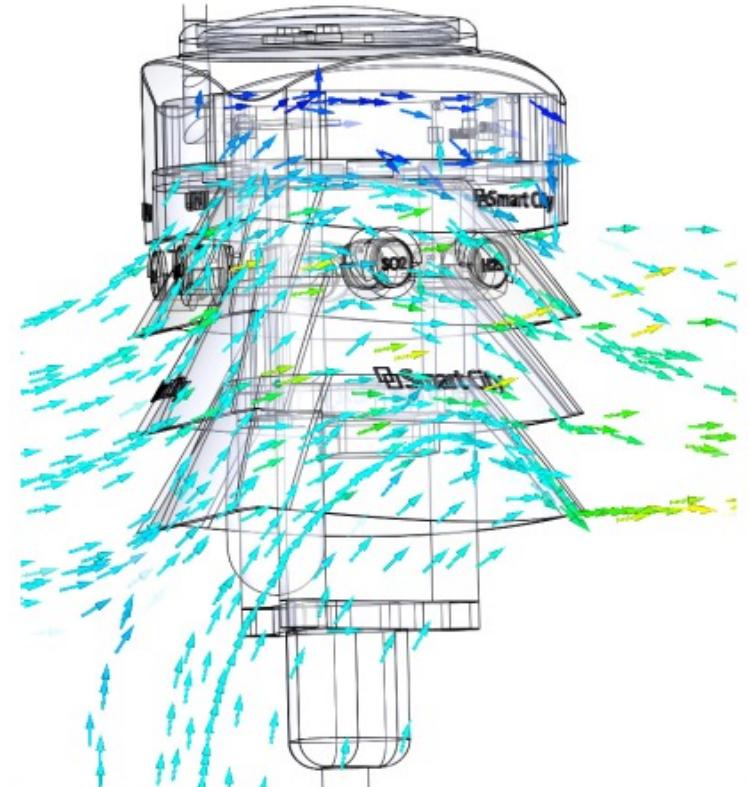
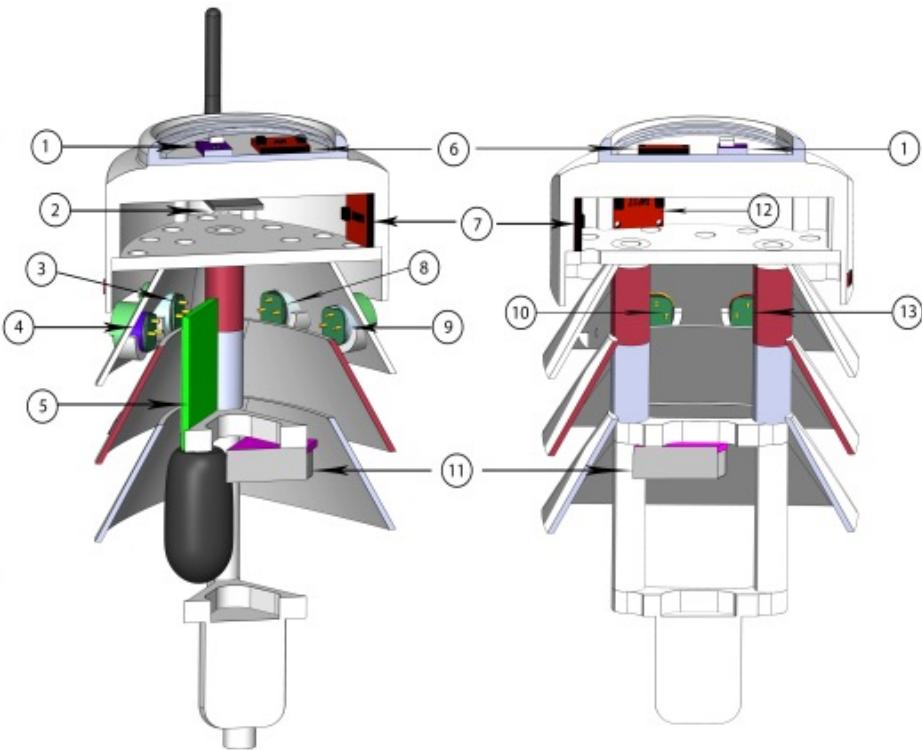


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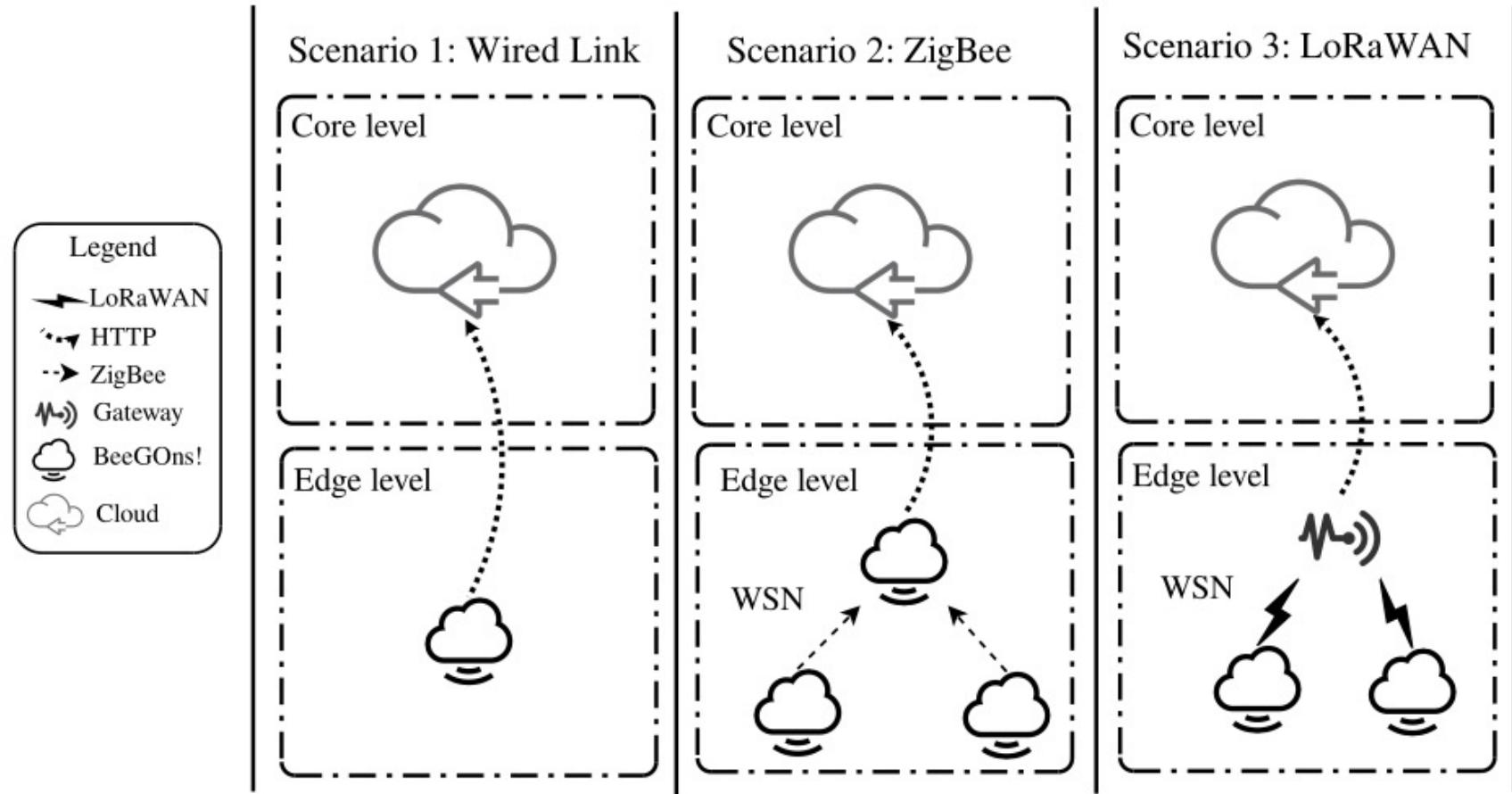
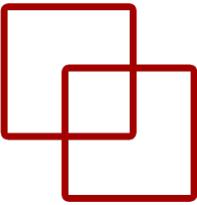
# BeeGOns!



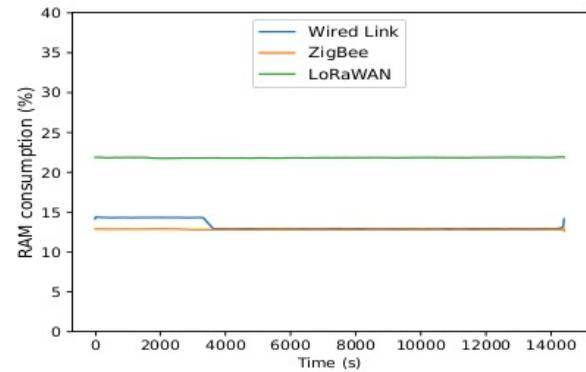
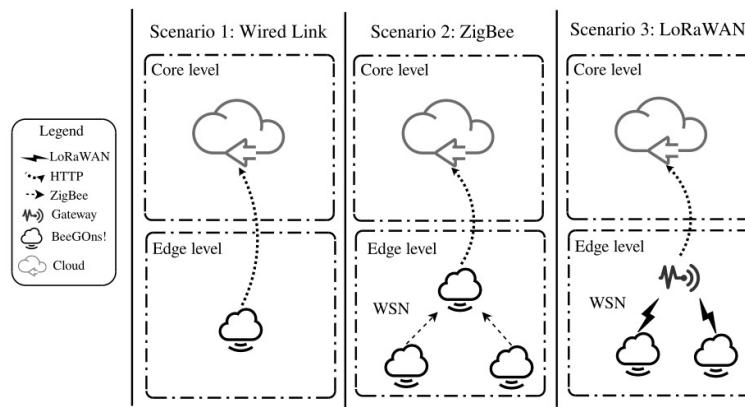
Legend	
1.	TSL2561
2.	LoRaWAN / ZigBee
3.	O <sub>3</sub>
4.	NO <sub>2</sub>
5.	ZC-DONGGE
6.	VEML6075
7.	BME680
8.	CO
9.	NO
10.	H <sub>2</sub> S
11.	PMSA003I
12.	TMP117
13.	SO <sub>2</sub>



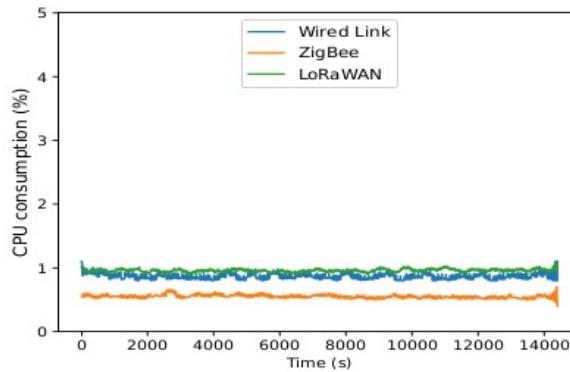
# BeeGOns!



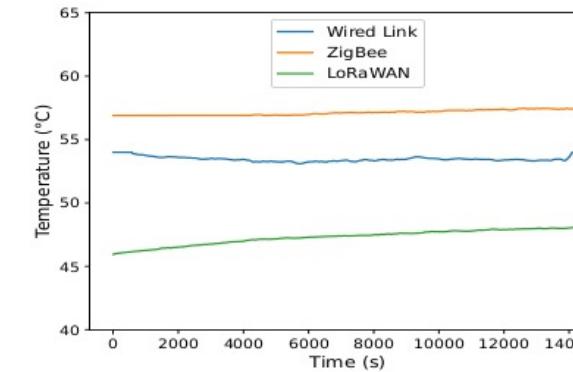
# BeeGOns!



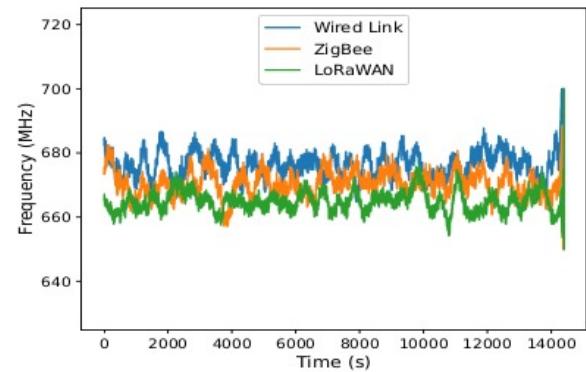
(a)



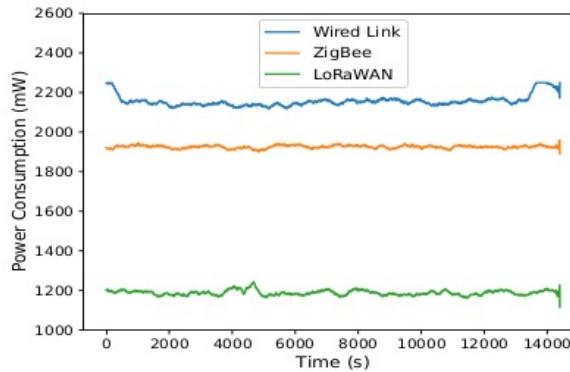
(b)



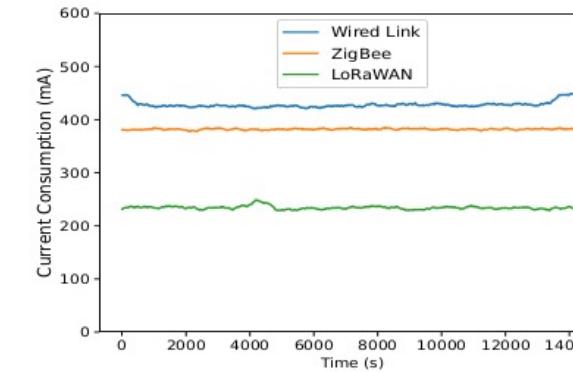
(c)



(d)



(e)



(f)

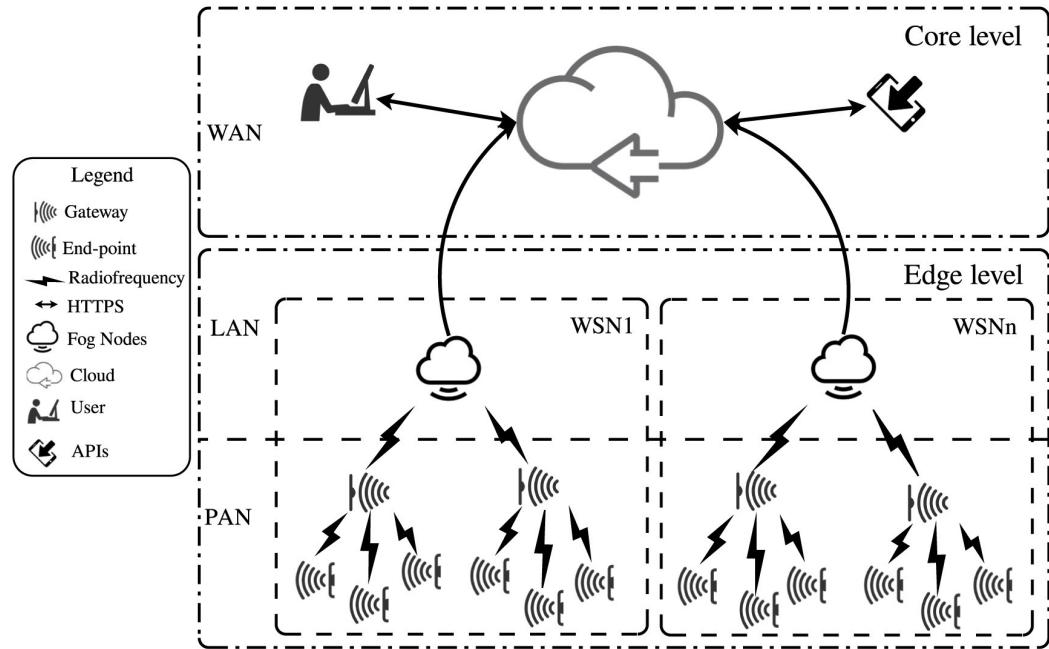
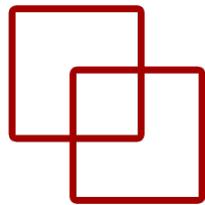
# Federated- Fog Computing

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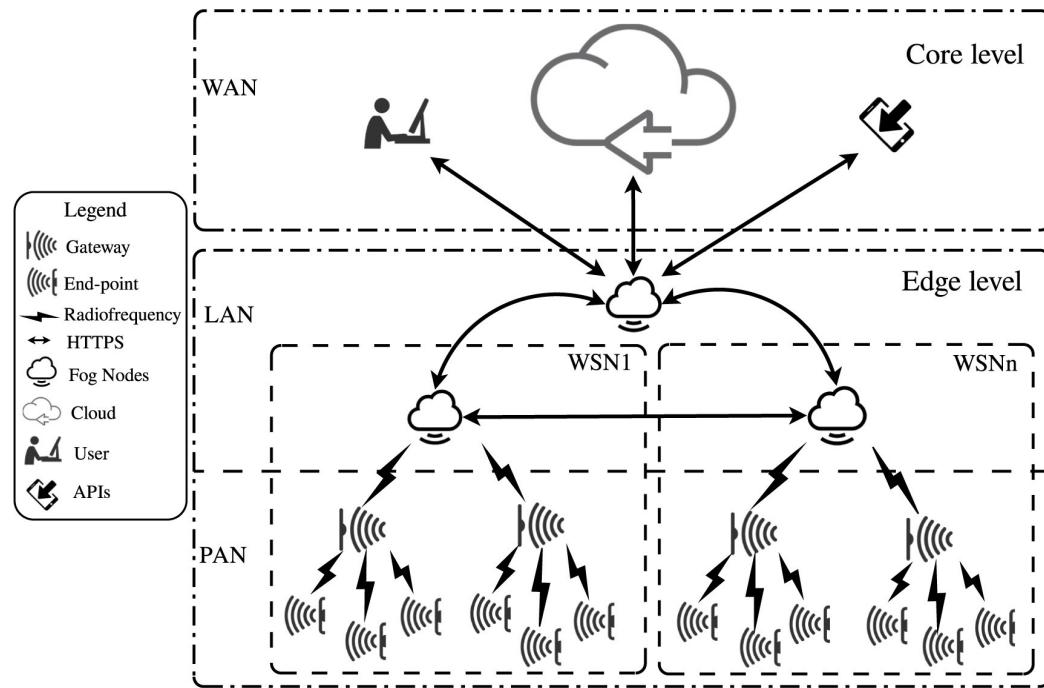


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# Arquitectura



(a) Cloud and fog computing.



(b) Inverted- and federated-fog computing.

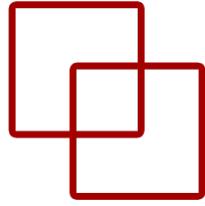
# Imágenes sintéticas

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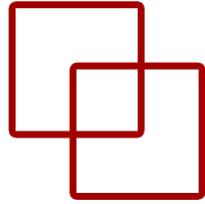
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# Transformación de datos

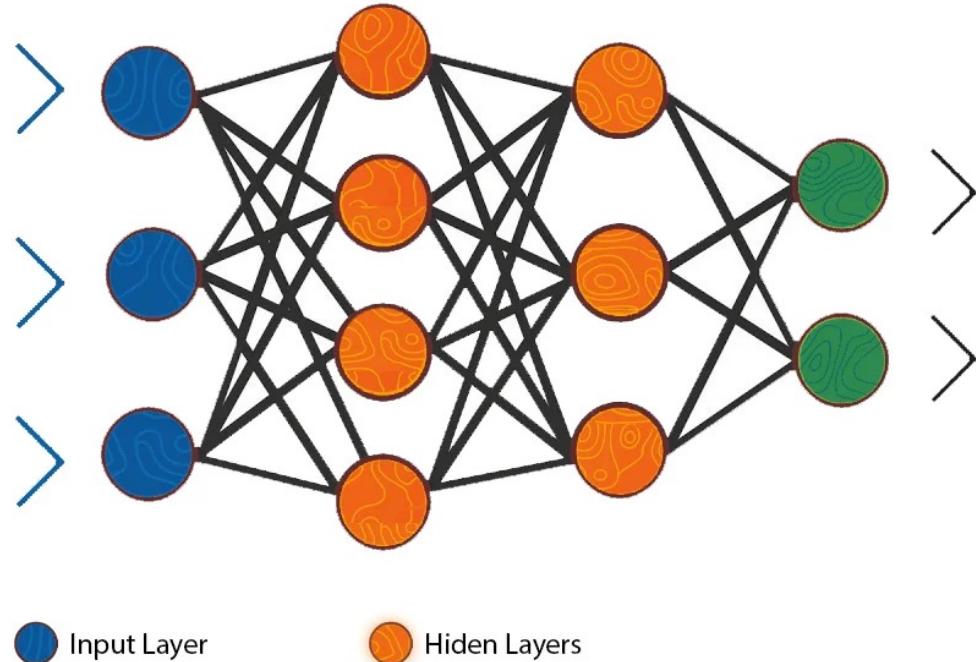
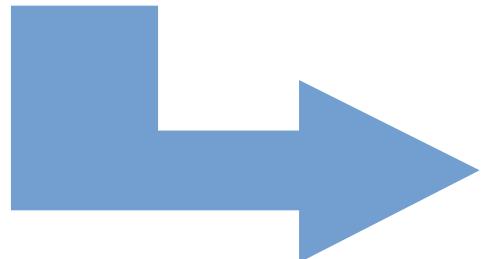


Be07	Be08	Be09	Be10	Be11	Sector
-65	-61	-74	-73	-67	1
-60	-57	-83	-62	-69	2
-66	-70	-78	-63	-73	3
...	...	...	...	...	...
-58	-66	-71	-73	-69	14
-60	-62	-73	-69	-57	15

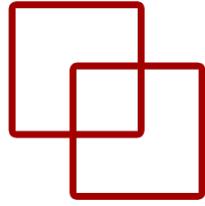
# Transformación de datos



Be07	Be08	Be09	Be10	Be11	Sector
-65	-61	-74	-73	-67	1
-60	-57	-83	-62	-69	2
-66	-70	-78	-63	-73	3
...	...	...	...	...	...
-58	-66	-71	-73	-69	14
-60	-62	-73	-69	-57	15

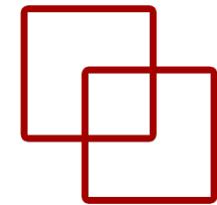


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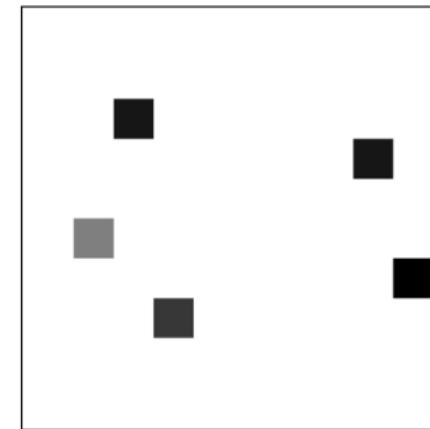
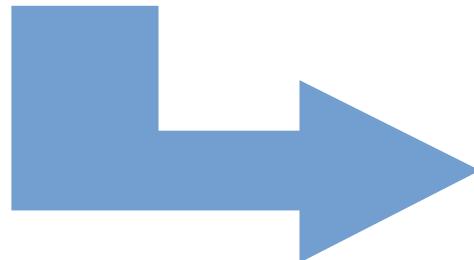


Be07	Be08	Be09	Be10	Be11	Sector
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-66	-70	-78	-63	-73	3
...	...	...	...	...	...
-58	-66	-71	-73	-69	14
-60	-62	-73	-69	-57	15

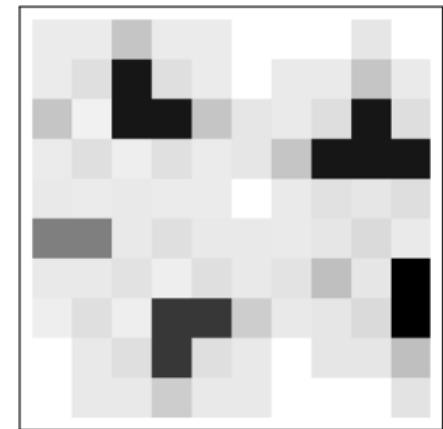
# Transformación de datos



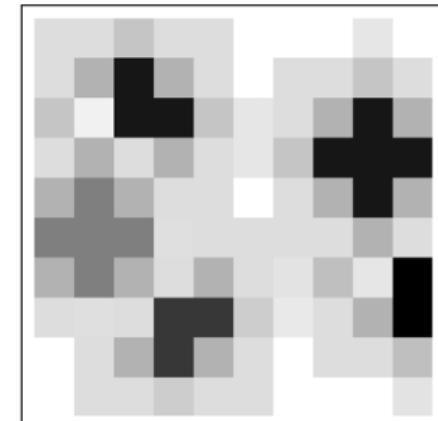
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-60	-57	-83	-62	-69	2
-66	-70	-78	-63	-73	3
...	...	...	...	...	...
-58	-66	-71	-73	-69	14
-60	-62	-73	-69	-57	15



(a) Without blurring.



(b) Blurring with average value.



(c) Blurring with maximum value.



**TINTOlib**

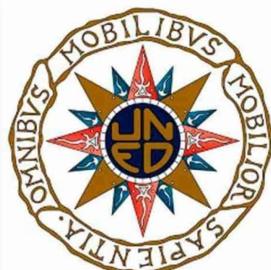
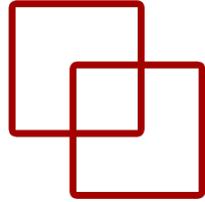


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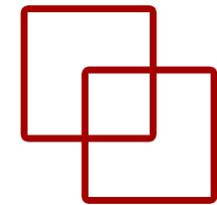
# TINTOlib



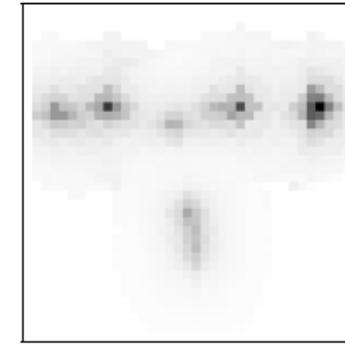
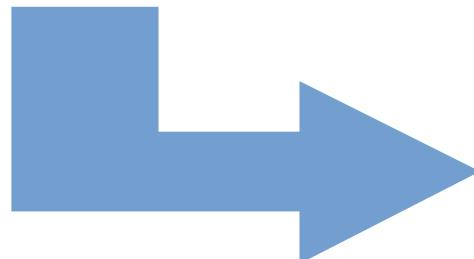
POLITÉCNICA



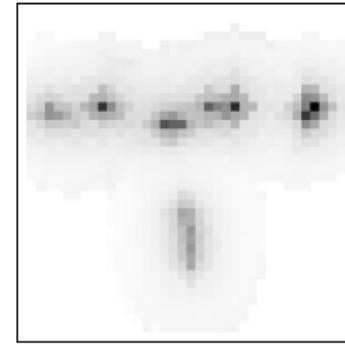
# Transformación de datos



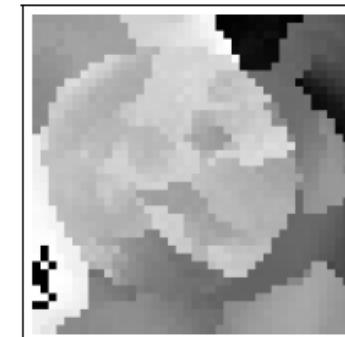
Be07	Be08	Be09	Be10	Be11	Sector
-65	-61	-74	-73	-67	1
-60	-57	-83	-62	-69	2
-66	-70	-78	-63	-73	3
...	...	...	...	...	...
-58	-66	-71	-73	-69	14
-60	-62	-73	-69	-57	15



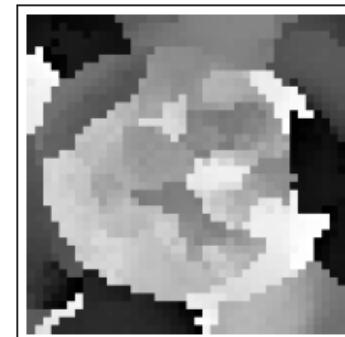
(a) TINTO - Sample 1.



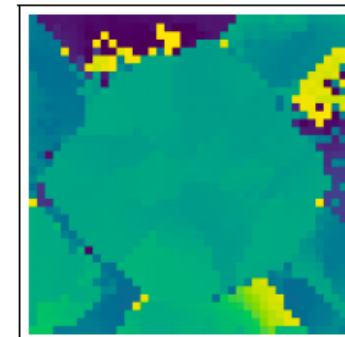
(b) TINTO - Sample 50,000.



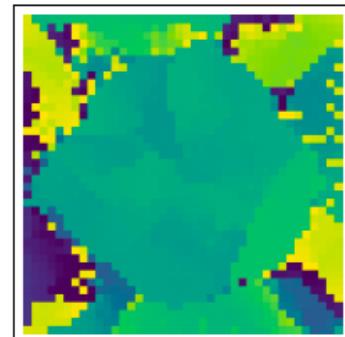
(c) IGTD - Sample 1.



(d) IGTD - Sample 50,000.

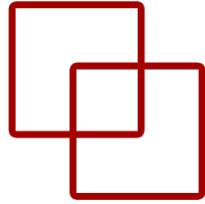


(e) REFINED - Sample 1.



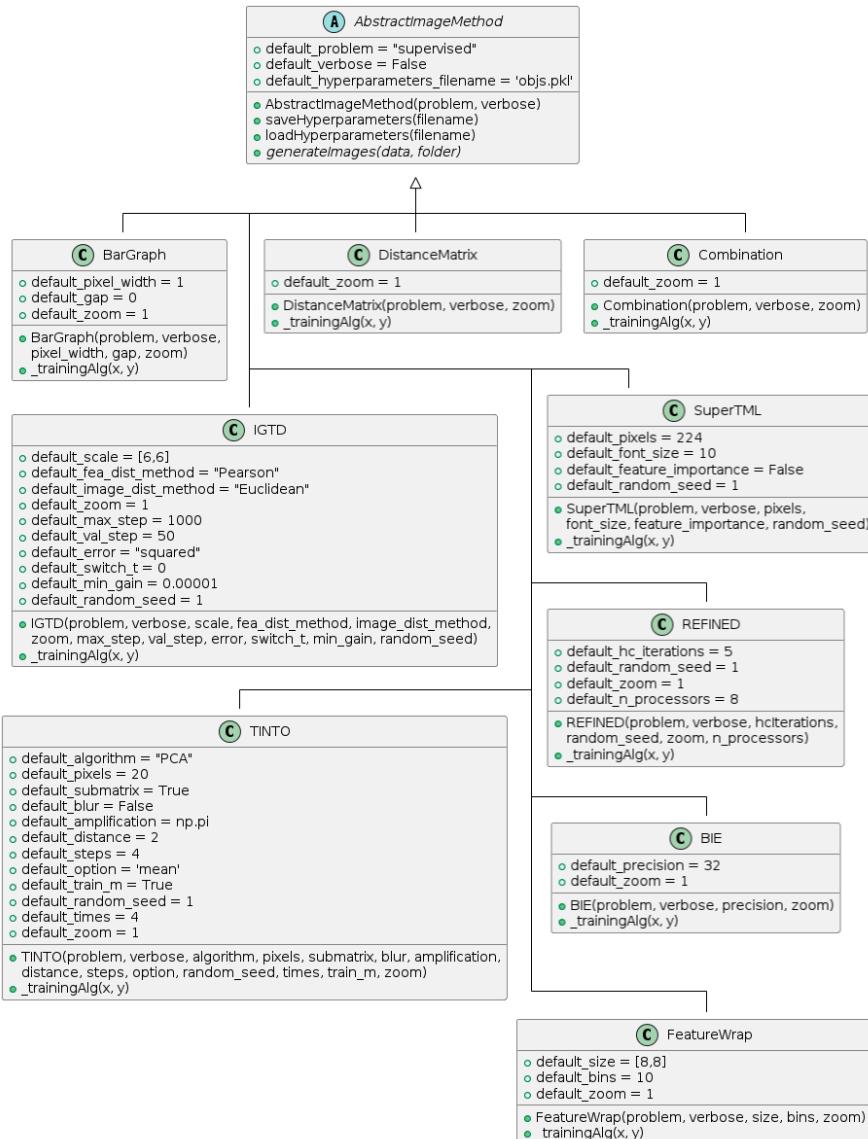
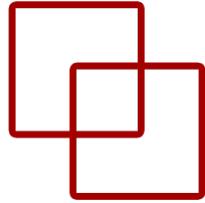
(f) REFINED - Sample 50,000.

# Métodos de transformación

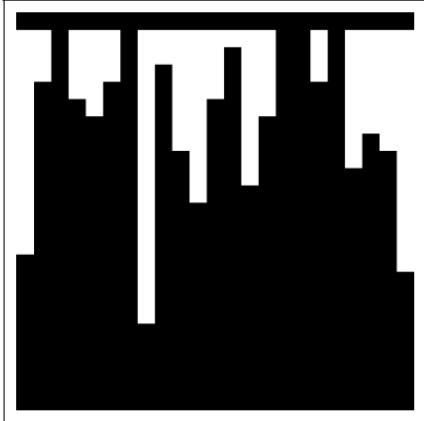
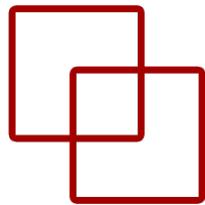


Model	Class	Features	Hyperparameters
<a href="#">BarGraph</a>	<code>BarGraph()</code>		<code>problem</code> <code>verbose</code> <code>pixel_width</code> <code>gap</code> <code>zoom</code>
<a href="#">BIE</a>	<code>BIE()</code>		<code>problem</code> <code>verbose</code> <code>precision</code> <code>zoom</code>
<a href="#">Combination</a>	<code>Combination()</code>		<code>problem</code> <code>verbose</code> <code>zoom</code>
<a href="#">DistanceMatrix</a>	<code>DistanceMatrix()</code>		<code>problem</code> <code>verbose</code> <code>zoom</code>
<a href="#">FeatureWrap</a>	<code>FeatureWrap()</code>		<code>problem</code> <code>verbose</code> <code>size</code> <code>bins</code> <code>zoom</code>
<a href="#">IGTD</a>	<code>IGTD()</code>		<code>problem</code> <code>verbose</code> <code>scale</code> <code>fea_dist_method</code> <code>image_dist_method</code> <code>max_step</code> <code>val_step</code> <code>error</code> <code>switch_t</code> <code>min_gain</code> <code>random_seed</code> <code>zoom</code>
<a href="#">REFINED</a>	<code>REFINED()</code>		<code>problem</code> <code>verbose</code> <code>hcIterations</code> <code>random_seed</code> <code>zoom</code> <code>n_processors</code>
<a href="#">SuperTML</a>	<code>SuperTML()</code>		<code>problem</code> <code>columns</code> <code>font_size</code> <code>image_size</code> <code>verbose</code>
<a href="#">TINTO</a>	<code>TINTO()</code>	<code>blur</code>	<code>problem</code> <code>algorithm</code> <code>pixels</code> <code>blur</code> <code>amplification</code> <code>distance</code> <code>steps</code> <code>option</code> <code>seed</code> <code>times</code> <code>verbose</code>

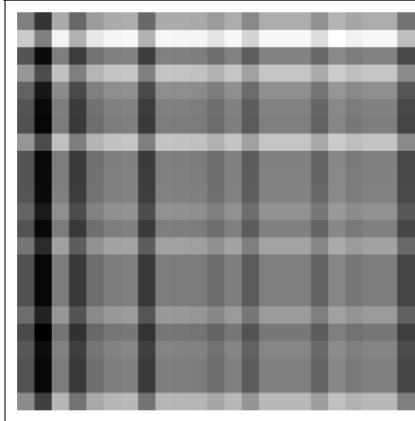
# Métodos de transformación



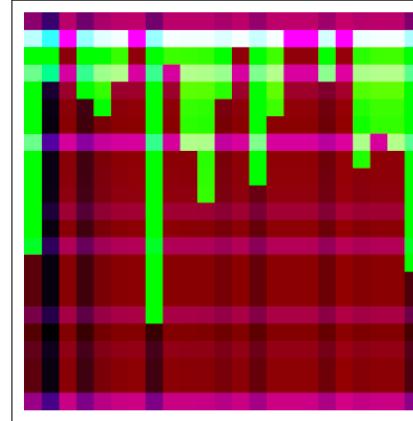
# Métodos de transformación



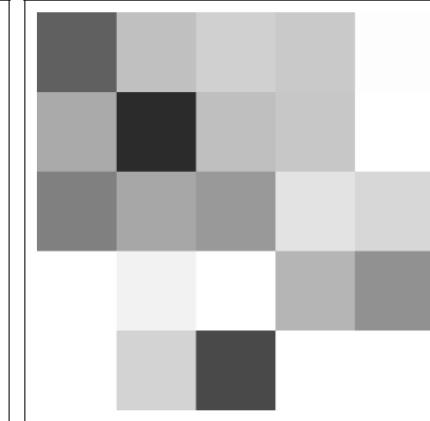
BarGraph



DistanceMatrix



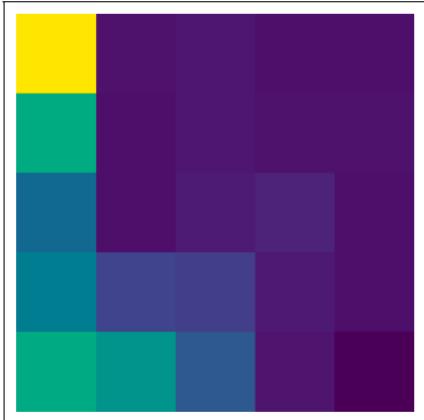
Combination



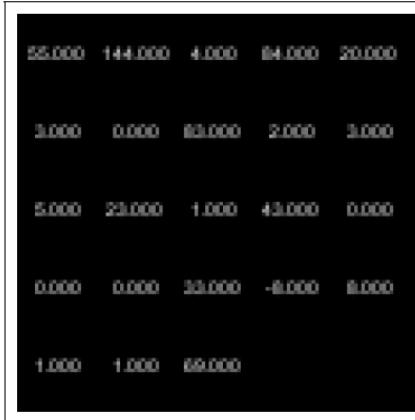
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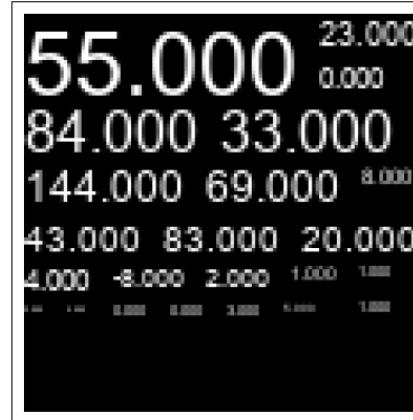
BIE



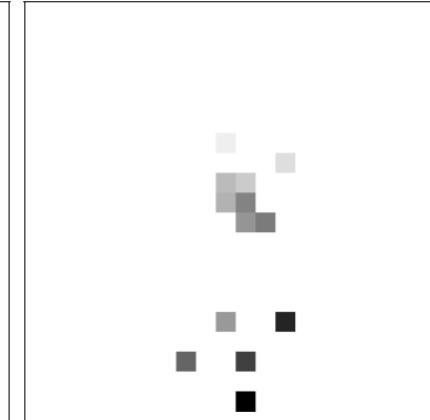
REFINED



SuperTML-EF



SuperTML-VF



TINTO



Feature Wrap

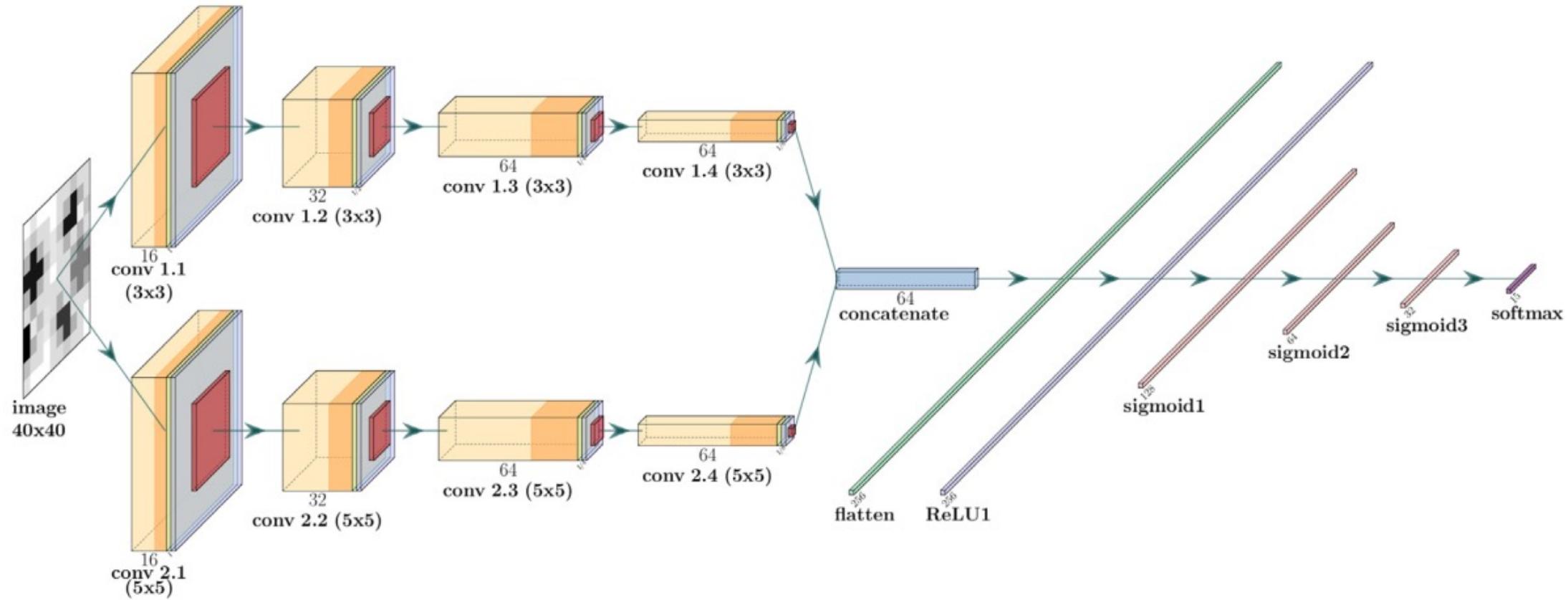
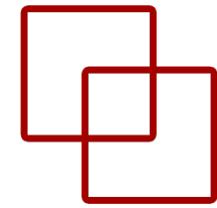
# \Arquitecturas Neuronales

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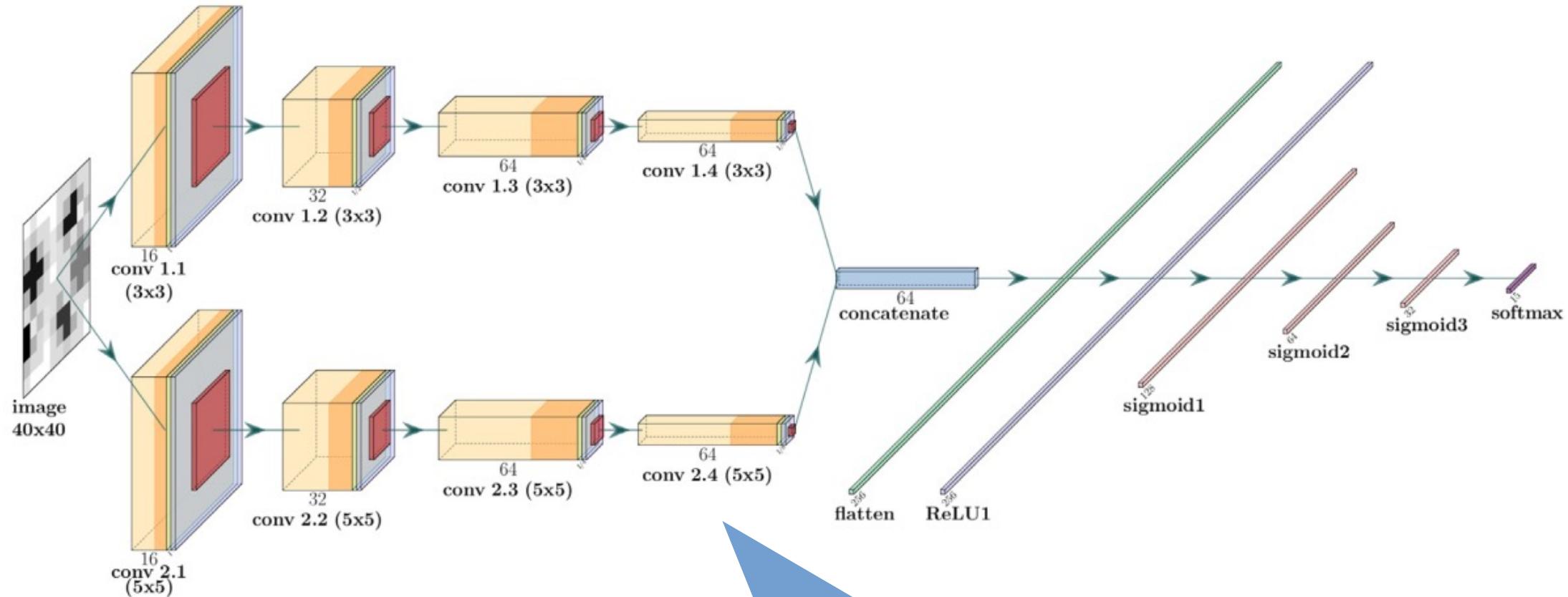
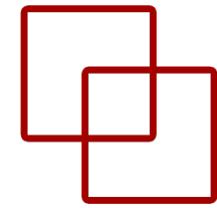


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# CNN Puras

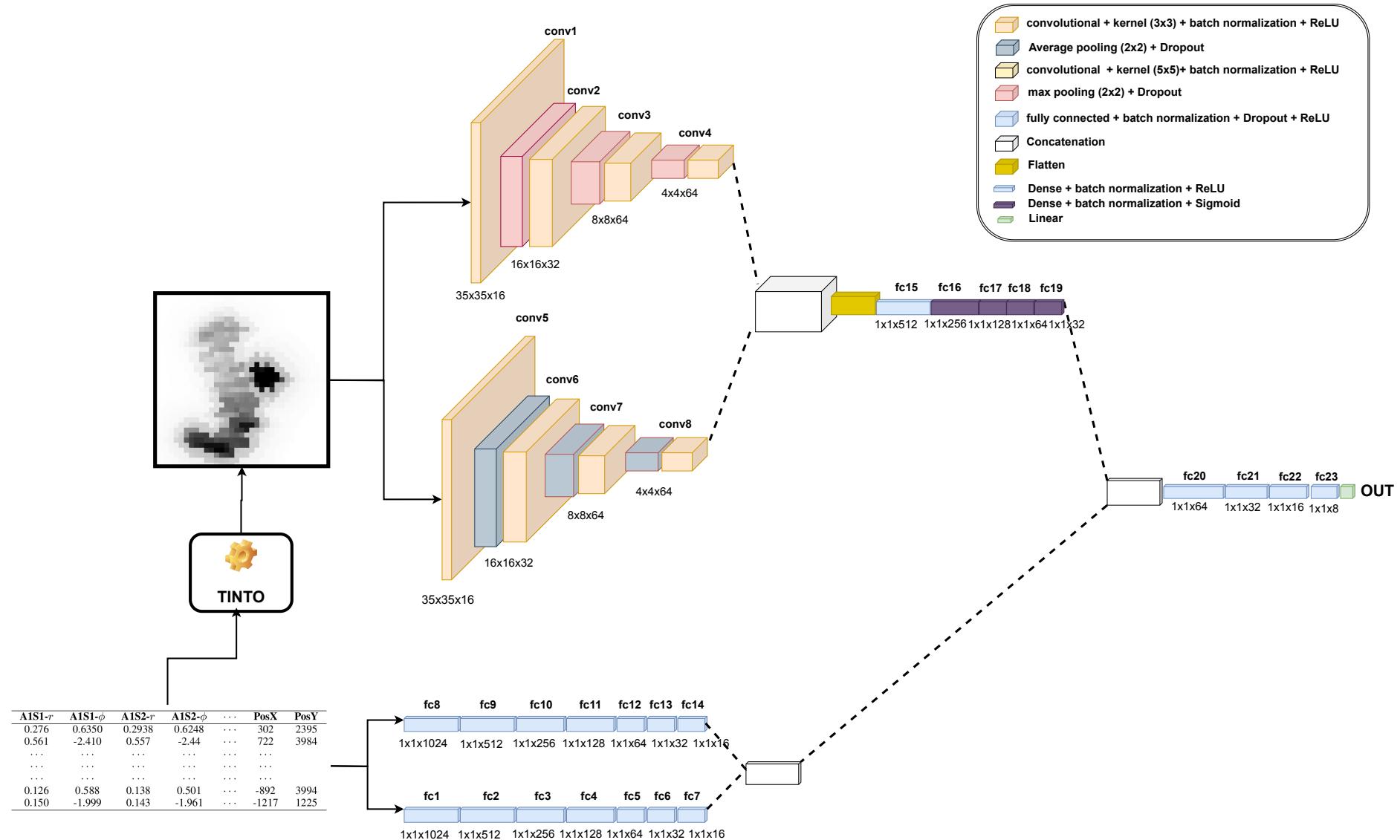
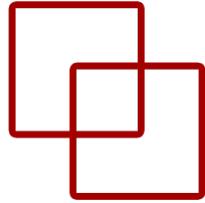


# CNN Puras

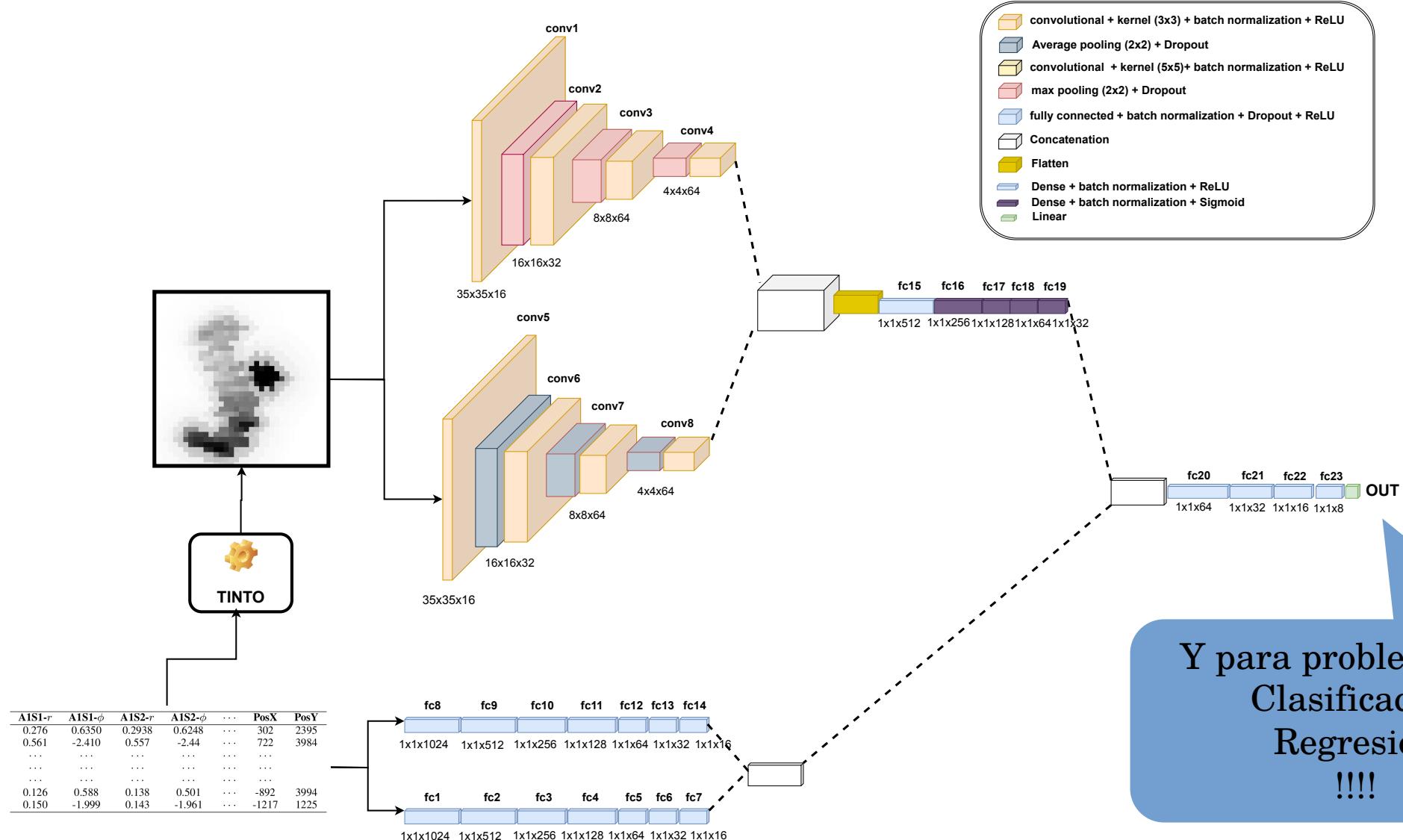
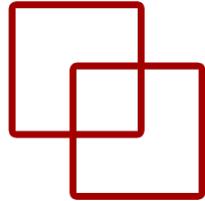


Pero no sólo  
CNNs

# Hybrid Neural Network

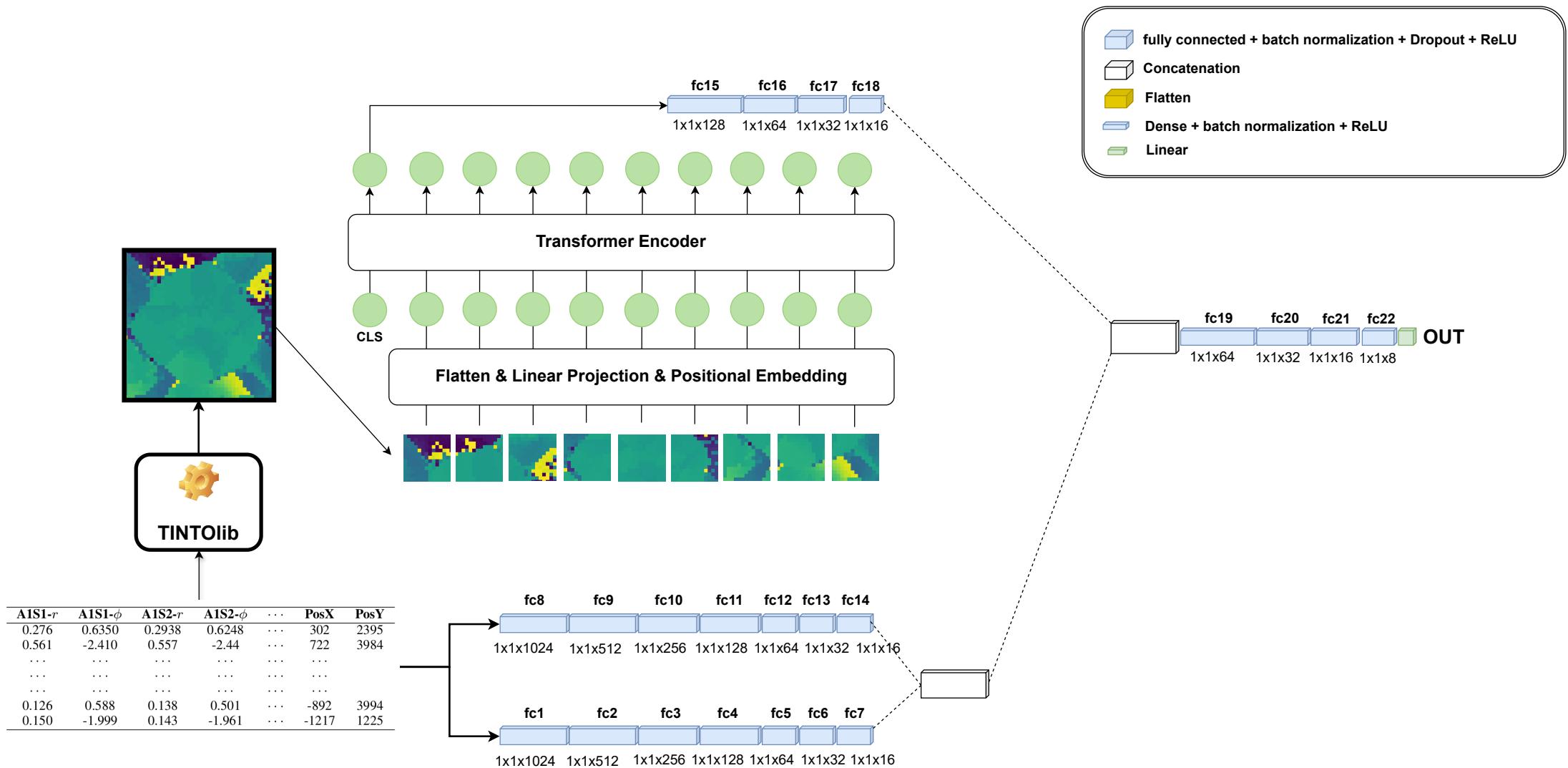
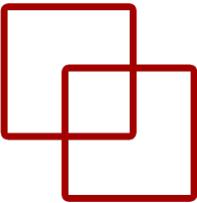


# Hybrid Neural Network



Y para problemas de:  
Clasificación  
Regresión  
!!!!

# HyViT



# ‘Caso de uso: Localización en interiores con MIMO

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# Escenario

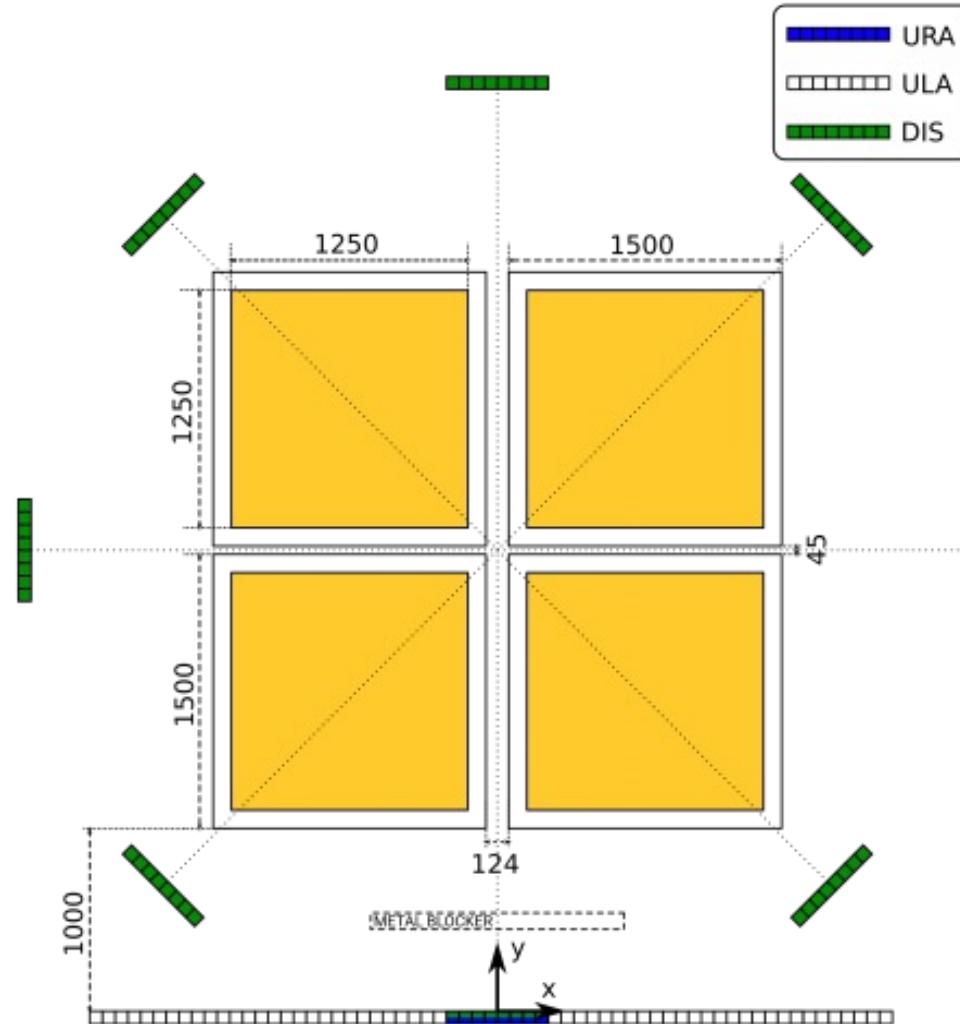
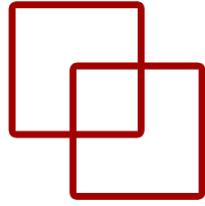
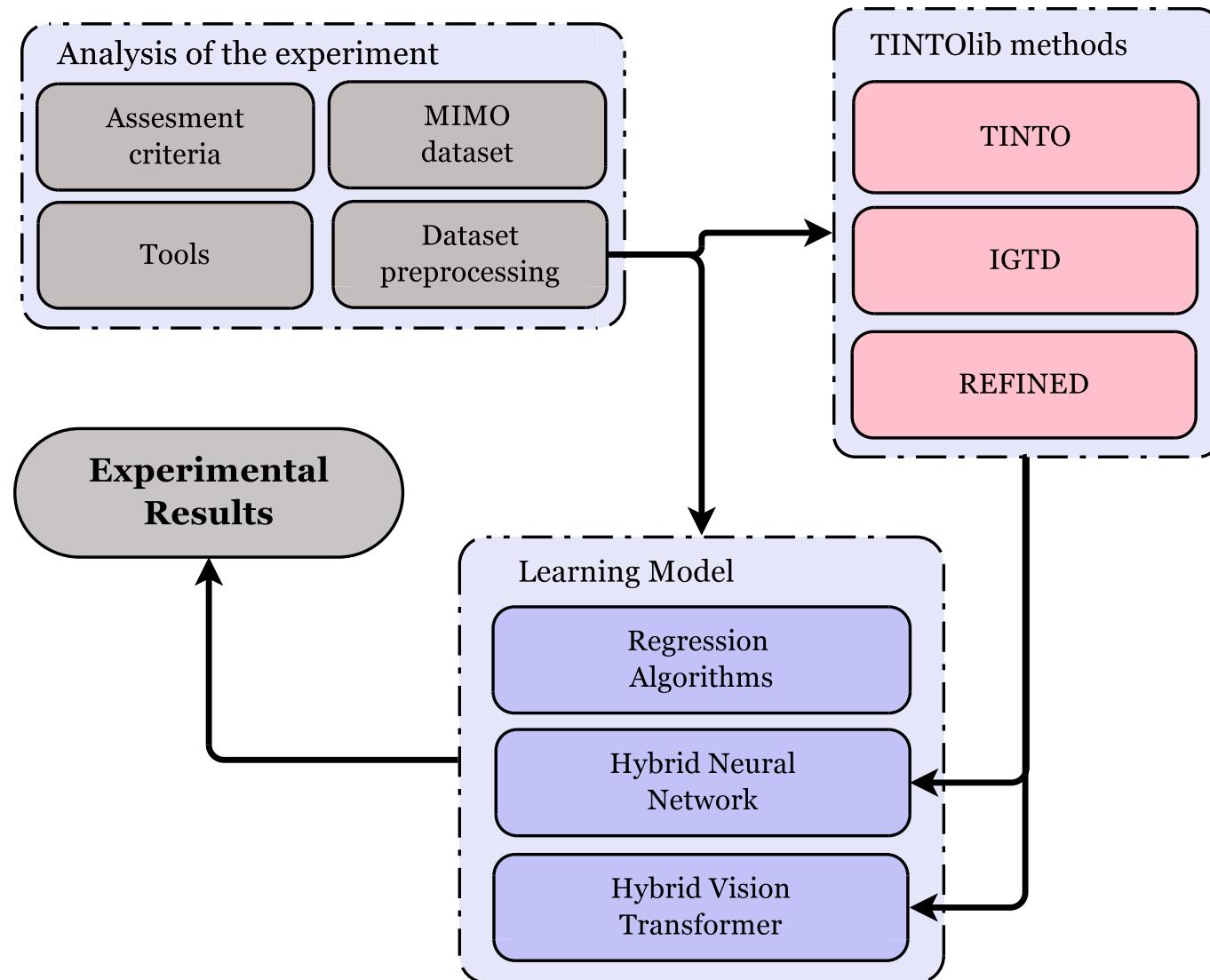
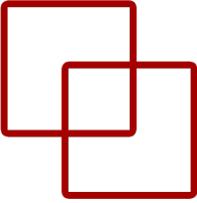
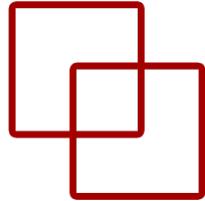


Figure taken from the paper: S. D. Bast, A. P. Guevara and S. Pollin, "CSI-based Positioning in Massive MIMO systems using Convolutional Neural Networks," 2020 IEEE 91st Vehicular Technology Conference (VTC2020-Spring), Antwerp, Belgium, 2020, pp. 1-5

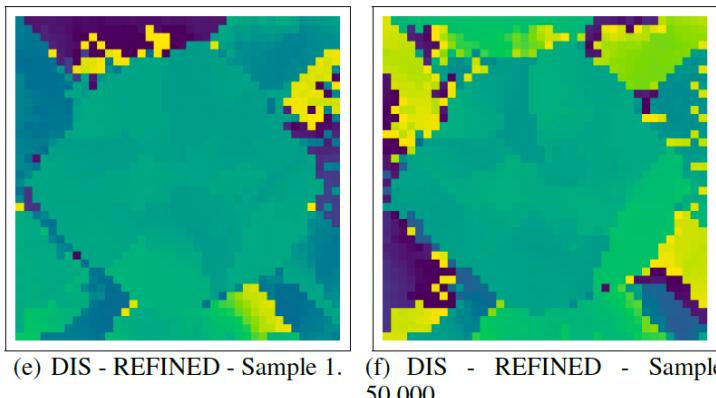
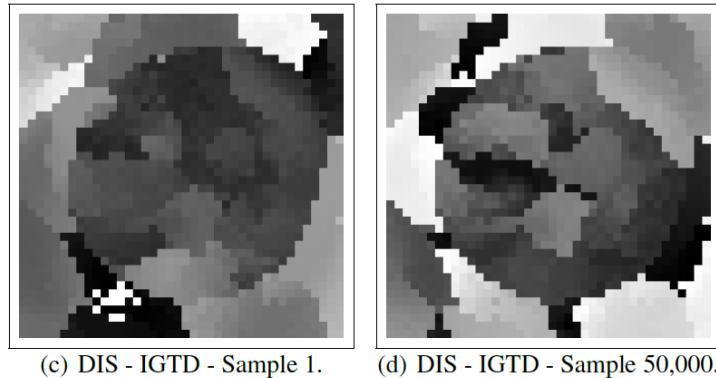
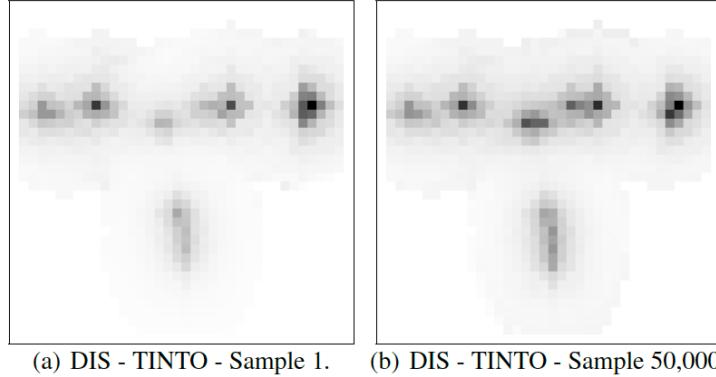
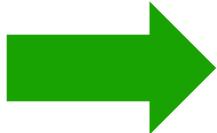
# Metodología



# Imágenes sintéticas

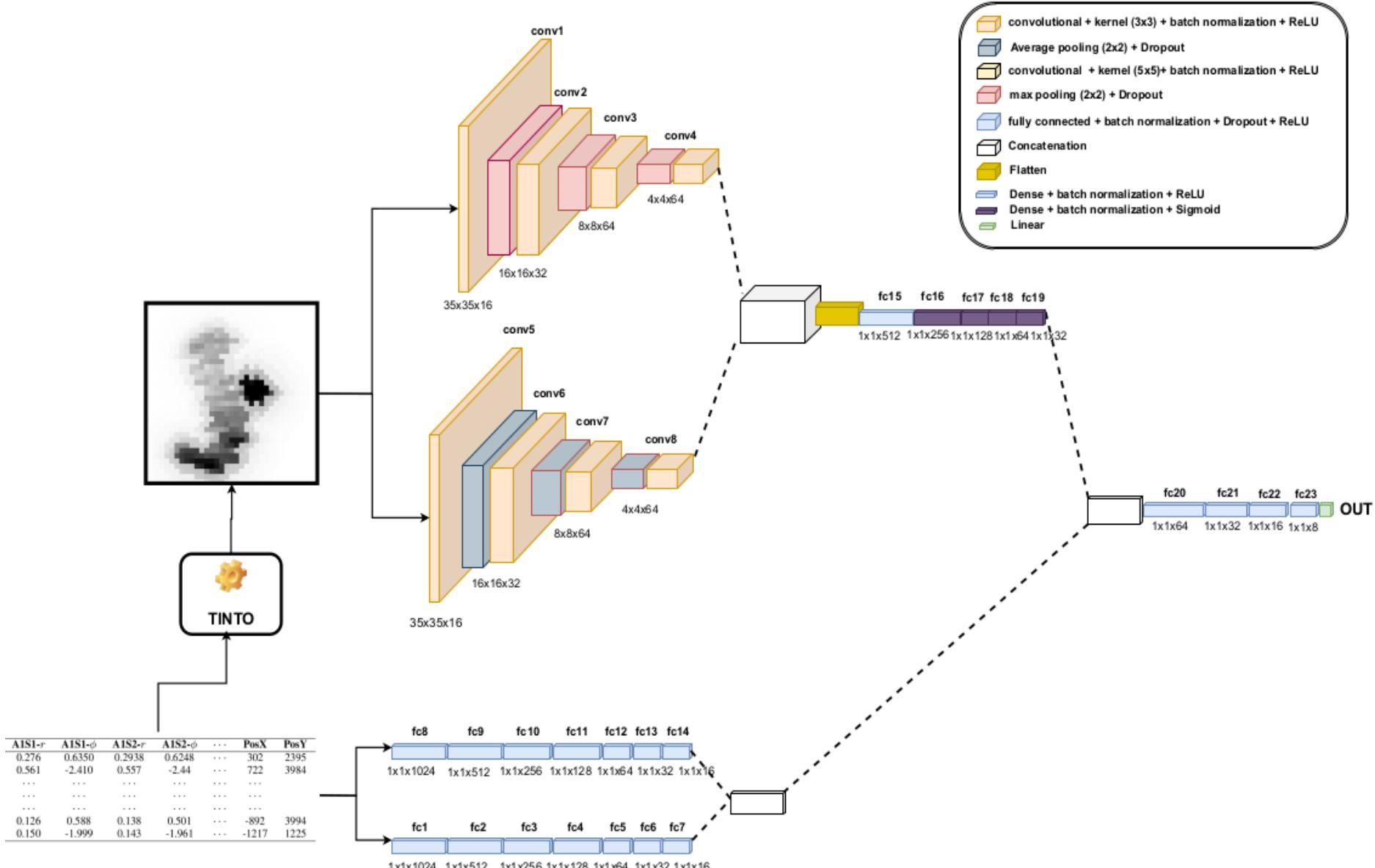
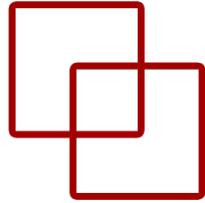


A1C1- <i>m</i>	A1C1- $\phi$	A1C2- <i>m</i>	A1C2- $\phi$	...	PosX	PosY
0.276	0.6350	0.2938	0.6248	...	302	2395
0.561	-2.410	0.557	-2.44	...	722	3984
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
0.126	0.588	0.138	0.501	...	-892	3994
0.150	-1.999	0.143	-1.961	...	-1217	1225

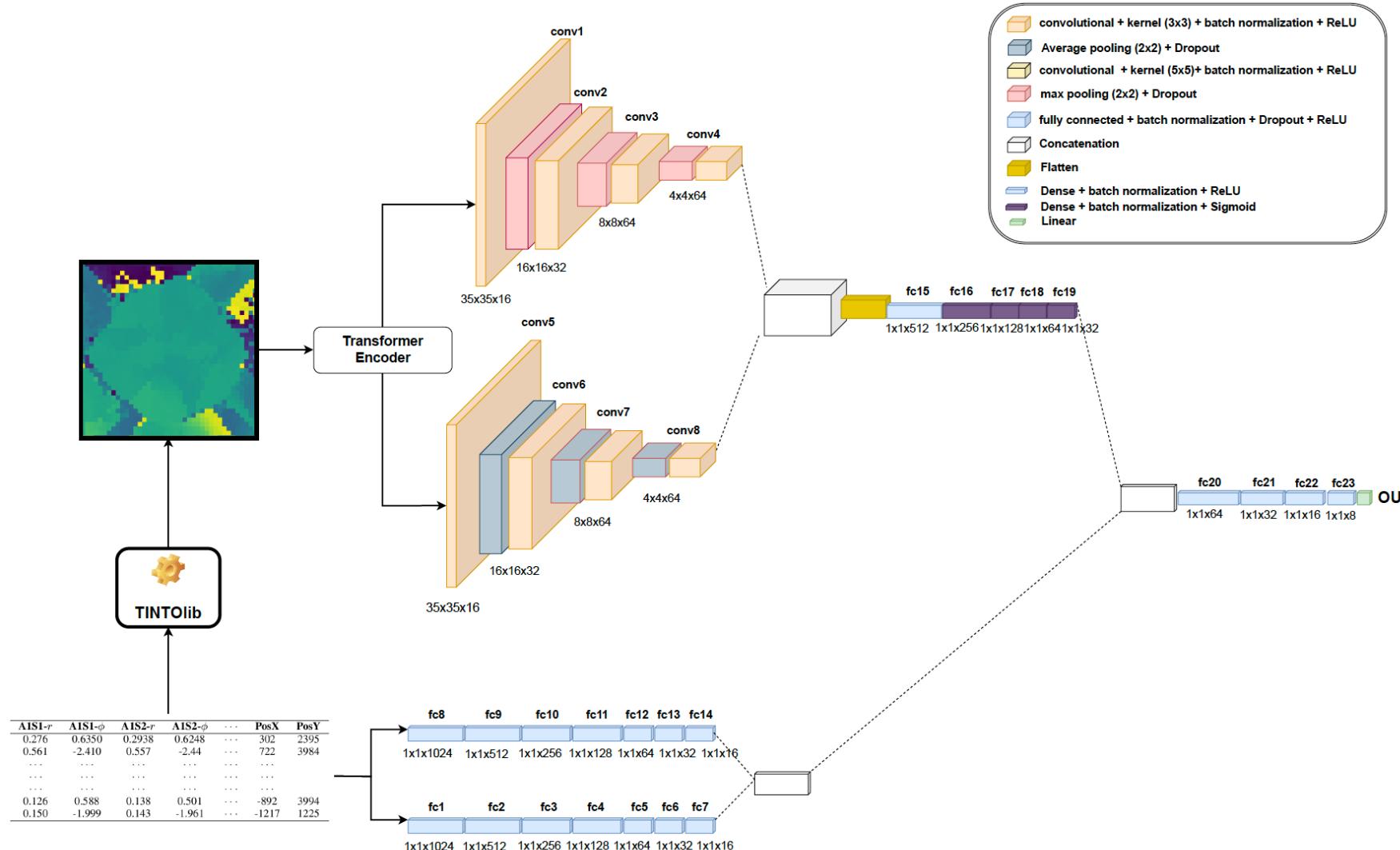
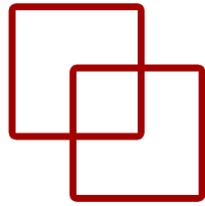


**Figure 3.** Synthetic image samples generated by TINTOlib for different samples in 8 antennas DIS scenario.

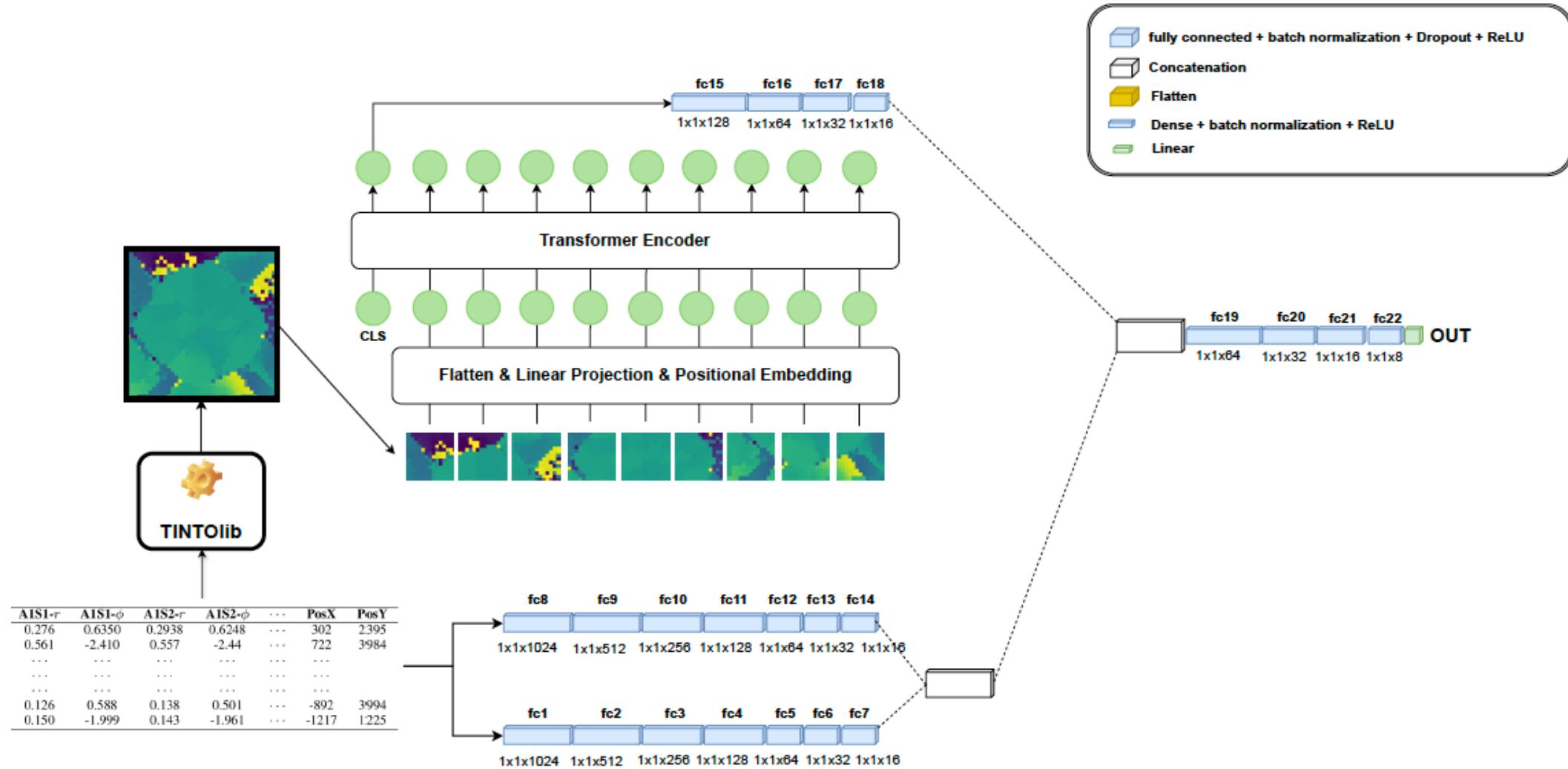
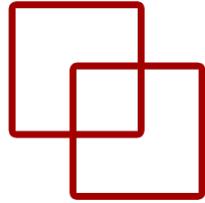
# HyNN → CNN+MLP



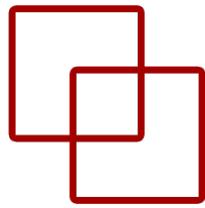
# HyNN → Transformer+CNN+MLP



# HyViT → ViT+MLP



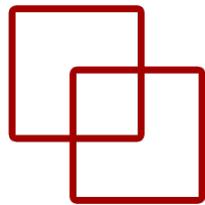
# Baseline Results



**Table 2.** RMSE (in mm) in validation (Val) and test split. Best results are shown in bold.

Algorithm	PosX		PosY	
	Val	Test	Val	Test
BR	226.05	225.00	251.43	255.54
ET	163.15	161.65	180.00	185.70
HGB	194.10	194.97	236.55	236.46
KNN	<b>110.50</b>	<b>110.54</b>	<b>133.70</b>	<b>140.16</b>
LiR	383.05	386.95	432.83	439.10
MLP	179.80	178.82	326.11	334.76
RF	226.09	225.18	251.37	255.62
RCV	383.04	386.94	432.80	439.06
XGB	178.41	180.03	202.45	201.66
LGB	194.14	194.15	231.19	232.89

# Hybrid Neural Networks Results



**Table 2.** RMSE (in mm) in validation (Val) and test split. Best results are shown in bold.

Algorithm	PosX		PosY	
	Val	Test	Val	Test
BR	226.05	225.00	251.43	255.54
ET	163.15	161.65	180.00	185.70
HGB	194.10	194.97	236.55	236.46
KNN	<b>110.50</b>	<b>110.54</b>	<b>133.70</b>	<b>140.16</b>
LiR	383.05	386.95	432.83	439.10
MLP	179.80	178.82	326.11	334.76
RF	226.09	225.18	251.37	255.62
RCV	383.04	386.94	432.80	439.06
XGB	178.41	180.03	202.45	201.66
LGB	194.14	194.15	231.19	232.89

**Table 3.** RMSE (in mm) for the different HyNNs architectures and HyViT in Validation (Val) and test. Best results are shown in bold.

Position	Model	TINTO		IGTD		REFINED	
		Val	Test	Val	Test	Val	Test
PosX	HyCNN	187.10	188.10	92.8	92.21	105.69	105.38
	HyTNN	178.28	179.25	119.59	119.62	115.90	114.98
	HyTTNN	181.96	184.19	179.01	180.05	193.56	196.09
	HyGTNN	176.71	176.43	173.42	174.20	173.38	174.02
	HyViT	<b>103.27</b>	<b>104.17</b>	<b>46.57</b>	<b>45.77</b>	<b>41.38</b>	<b>41.84</b>
PosY	HyCNN	152.19	151.94	101.01	99.45	115.40	114.69
	HyTNN	143.10	143.29	95.95	95.83	112.27	112.02
	HyTTNN	151.35	151.97	155.35	154.12	147.22	146.01
	HyGTNN	155.06	153.40	154.68	154.50	157.10	155.39
	HyViT	<b>121.77</b>	<b>123.90</b>	<b>70.84</b>	<b>68.93</b>	<b>90.11</b>	<b>90.56</b>

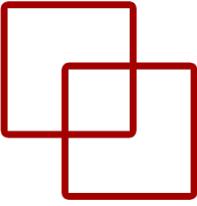
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# Más información



- Documentación oficial de TINTOlib:  
<https://tintolib.readthedocs.io/en/latest/>
- Librería TINTOlib en PyPI: <https://pypi.org/project/TINTOlib/>
- GitHub con el código de TINTOlib: <https://github.com/oeg-upm/TINTOlib>
- GitHub con el código de TINTO: <https://github.com/oeg-upm/TINTO>
- Artículo sobre TINTO y su aplicación en indoor localization. Incluye la definición formal matemática: <https://doi.org/10.1016/j.inffus.2022.10.011>
- Artículo sobre TINTO y su definición formal en Python:  
<https://doi.org/10.1016/j.softx.2023.101391>



# Materiales

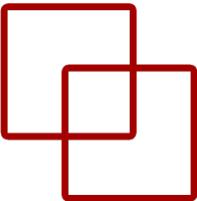
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# Más información

- Materiales en Github:  
<https://bit.ly/3MXLwP8>
- Cursos de Udemy
- Machine Learning:  
<https://bit.ly/3TIB4yH>
- Deep Learning:  
<https://bit.ly/4gC5VXG>



# ¡Gracias!



**Dr. Manuel Castillo-Cara**

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Escuela Técnica Superior de Ingeniería Informática  
Universidad Nacional de Educación a Distancia (UNED)**