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Materia: Inteligencia Artificial I - P3

Evaluación: Aplicación de Redes Neuronales

Tipo C – RNA

Contexto:

Con base en el conjunto de datos proporcionado (`dataset_regresion_multiple_508.csv`), que contiene información sobre hábitos, estilo de vida y educación, se pretende desarrollar un modelo de regresión múltiple con redes neuronales artificiales para predecir el rendimiento en matemáticas y lectura.

1. Preguntas de opción múltiple (1 punto)

Seleccione la opción correcta en cada caso.

1.1 ¿Cuál de los siguientes enfoques es más adecuado para normalizar variables numéricas antes de entrenar una red neuronal?

A. Label Encoding
B. One-Hot Encoding
C. Min-Max Scaling
D. ReLU Transformation
E. Log Transformation

Respuesta: C. Min-Max Scaling

1.2 ¿Cuál de los siguientes parámetros se ajusta principalmente durante el entrenamiento de una red neuronal?

A. Dropout y Learning Rate
B. Pesos y Bias
C. Épocas y Batch Size
D. Capas y Nodos
E. Métrica de pérdida

Respuesta: B. Pesos y Bias

1.3 ¿Cuál métrica es más adecuada para evaluar el rendimiento de un modelo de regresión?

A. Accuracy

B. F1-score

C. AUC-ROC

D. Mean Squared Error

E. Silhouette Score

Respuesta: D. Mean Squared Error

2. Preguntas abiertas de análisis (1 punto)

2.1 Explique por qué es importante dividir el dataset en conjuntos de entrenamiento y prueba.

Respuesta: Dividir el dataset en conjuntos de entrenamiento y prueba es importante para evaluar la capacidad de generalización del modelo, ya que el conjunto de prueba permite verificar si el modelo puede hacer predicciones precisas en datos no vistos durante el entrenamiento. Además, esta división ayuda a detectar sobreajuste (overfitting), que ocurre cuando el modelo tiene buen rendimiento en entrenamiento pero malo en prueba, indicando que memorizó los datos en lugar de aprender patrones generalizables. Finalmente, proporciona una estimación realista del rendimiento del modelo, ofreciendo una medida objetiva de qué tan bien funcionará en datos reales del mundo real.

2.2 Mencione dos ventajas y una desventaja de utilizar redes neuronales para tareas de regresión múltiple.

Ventajas:

1. Las redes neuronales pueden capturar patrones y relaciones complejas entre variables que otros algoritmos lineales no pueden detectar.
2. Pueden manejar múltiples variables de entrada y salida simultáneamente, ajustándose automáticamente a la complejidad de los datos.

Desventaja:

1. Necesitan datasets extensos para entrenar correctamente y evitar sobreajuste, además de ser costosas a nivel de cómputo y difíciles de interpretar (caja negra).

Problema de desarrollo práctico (5 puntos)

Instrucciones: Desarrolle un cuaderno en Jupyter Notebook (o Google Colab) que contenga lo siguiente:

1. Carga y exploración inicial del dataset.

In [29]:
```
# Carga y exploración inicial del dataset
import pandas as pd

# Cargar el dataset
file_path = 'd:/UDLA/Inteligencia-Artificial-I/P3/Examen P3/dataset_regresion_multi
data = pd.read_csv(file_path)

# Mostrar las primeras filas del dataset
data.head()
```

Out[29]:

	ID	Edad	Horas_Estudio	Nivel_Estres	Horas_Sueno	Calorias	Ejercicio_horas_sem	Nivel
0	1	23	4.5	6	6.5	2200	2.5	
1	2	29	3.2	7	5.2	2500	1.2	
2	3	21	5.0	5	7.0	2000	3.0	
3	4	34	2.1	8	5.0	2700	0.8	
4	5	27	3.7	6	6.0	2300	1.5	

2. Preprocesamiento de los datos:

- Normalización de las variables numéricas.
- Codificación de la variable Nivel_Educacion si es necesario.

In [30]:
```
# Preprocesamiento de los datos
from sklearn.preprocessing import MinMaxScaler

# Normalización de las variables numéricas
scaler = MinMaxScaler()
data[['Edad', 'Horas_Estudio', 'Nivel_Estres', 'Horas_Sueno', 'Calorias', 'Ejercici
    data[['Edad', 'Horas_Estudio', 'Nivel_Estres', 'Horas_Sueno', 'Calorias', 'Ejer
)

# Codificación de la variable Nivel_Educacion
data = pd.get_dummies(data, columns=['Nivel_Educacion'], drop_first=True)

data.head()
```

Out[30]:

	ID	Edad	Horas_Estudio	Nivel_Estres	Horas_Sueno	Calorias	Ejercicio_horas_sem	F
0	1	0.238095	0.60	0.6	0.500	0.396169	0.444444	
1	2	0.523810	0.34	0.8	0.175	0.698589	0.155556	
2	3	0.142857	0.70	0.4	0.625	0.194556	0.555556	
3	4	0.761905	0.12	1.0	0.125	0.900202	0.066667	
4	5	0.428571	0.44	0.6	0.375	0.496976	0.222222	

3. División del dataset en entrenamiento y prueba.

In [31]:

```
# División del dataset en entrenamiento y prueba
from sklearn.model_selection import train_test_split

# Variables independientes y dependientes
X = data.drop(columns=['Puntaje_Matematicas', 'Puntaje_Lectura'])
y = data[['Puntaje_Matematicas', 'Puntaje_Lectura']]

# División en entrenamiento y prueba
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta

X_train.shape, X_test.shape
```

Out[31]:

```
((406, 9), (102, 9))
```

4. Construcción y entrenamiento de una red neuronal artificial para predecir Puntaje_Matematicas y Puntaje_Lectura.

In [33]:

```
# Construcción y entrenamiento de la red neuronal
from tensorflow.keras.models import Sequential # Importar Sequential para construir
from tensorflow.keras.layers import Dense # Importar Dense para las capas densas
import time

# Definir el modelo
model = Sequential([
    Dense(64, activation='relu', input_dim=X_train.shape[1]),
    Dense(32, activation='relu'),
    Dense(2)  # Dos salidas: Puntaje_Matematicas y Puntaje_Lectura
])

# Compilar el modelo
model.compile(optimizer='adam', loss='mse', metrics=['mae'])

# Capturar tiempo de inicio
training_start_time = time.time()

# Entrenar el modelo
history = model.fit(X_train, y_train, epochs=50, batch_size=16, validation_split=0.

# Capturar tiempo de fin
```

```python
training_end_time = time.time()

# Imprimir las métricas durante el entrenamiento
print("Loss (MSE) durante el entrenamiento:", history.history['loss'][-1])
print("MAE durante el entrenamiento:", history.history['mae'][-1])
```

```
Epoch 1/50
```

```
c:\Users\Gorky\AppData\Local\Programs\Python\Python310\lib\site-packages\keras\src\l
ayers\core\dense.py:93: UserWarning: Do not pass an `input_shape`/`input_dim` argume
nt to a layer. When using Sequential models, prefer using an `Input(shape)` object a
s the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
21/21 ━━━━━━━━━━━━━━━━━━━━ 1s 19ms/step - loss: 14830.5732 - mae: 115.6865 - val_los
s: 3675.7583 - val_mae: 54.2235
Epoch 2/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 3214.6038 - mae: 49.3744 - val_loss:
2407.5479 - val_mae: 41.0286
Epoch 3/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2339.7500 - mae: 40.3805 - val_loss:
2416.7200 - val_mae: 41.3343
Epoch 4/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2148.6904 - mae: 39.2376 - val_loss:
2365.1458 - val_mae: 40.4324
Epoch 5/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2399.1694 - mae: 41.3437 - val_loss:
2360.8218 - val_mae: 40.5320
Epoch 6/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - loss: 2170.3091 - mae: 38.4443 - val_loss:
2348.8909 - val_mae: 40.4628
Epoch 7/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2383.9041 - mae: 40.7989 - val_loss:
2328.2583 - val_mae: 40.1824
Epoch 8/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2005.5428 - mae: 37.1320 - val_loss:
2310.1060 - val_mae: 39.9032
Epoch 9/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 2319.9839 - mae: 39.1171 - val_loss:
2296.1890 - val_mae: 39.7840
Epoch 10/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 2290.2307 - mae: 39.8064 - val_loss:
2287.0464 - val_mae: 39.9690
Epoch 11/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2210.5171 - mae: 39.3620 - val_loss:
2296.3855 - val_mae: 40.1391
Epoch 12/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 2203.8650 - mae: 39.1126 - val_loss:
2247.9153 - val_mae: 39.6580
Epoch 13/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 2107.5359 - mae: 38.8199 - val_loss:
2222.6941 - val_mae: 39.4586
Epoch 14/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - loss: 2144.2126 - mae: 38.9383 - val_loss:
2173.6948 - val_mae: 38.7856
Epoch 15/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step - loss: 2111.0564 - mae: 37.7552 - val_loss:
2173.3511 - val_mae: 39.0549
Epoch 16/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - loss: 2127.6406 - mae: 38.9297 - val_loss:
2101.0723 - val_mae: 38.0825
Epoch 17/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step - loss: 2086.7334 - mae: 37.9496 - val_loss:
2066.9324 - val_mae: 37.9139
Epoch 18/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1825.0586 - mae: 35.6417 - val_loss:
2008.5278 - val_mae: 37.3060
Epoch 19/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - loss: 2029.4091 - mae: 38.1162 - val_loss:
1927.3336 - val_mae: 36.3349
```

```
Epoch 20/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - loss: 1820.3622 - mae: 35.3499 - val_loss:
1851.1848 - val_mae: 35.6558
Epoch 21/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1778.1404 - mae: 35.5673 - val_loss:
1777.1229 - val_mae: 34.8233
Epoch 22/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1720.3643 - mae: 34.7045 - val_loss:
1704.3723 - val_mae: 34.4014
Epoch 23/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step - loss: 1606.7878 - mae: 33.8799 - val_loss:
1601.0167 - val_mae: 33.2750
Epoch 24/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - loss: 1514.4077 - mae: 32.3698 - val_loss:
1473.3037 - val_mae: 31.7307
Epoch 25/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1401.5981 - mae: 31.7149 - val_loss:
1414.9707 - val_mae: 31.1481
Epoch 26/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 1339.8817 - mae: 30.5334 - val_loss:
1245.6573 - val_mae: 29.0064
Epoch 27/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1190.9967 - mae: 28.8172 - val_loss:
1182.0684 - val_mae: 28.4503
Epoch 28/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 1041.4604 - mae: 26.0896 - val_loss:
988.8444 - val_mae: 25.5733
Epoch 29/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 972.6425 - mae: 26.2673 - val_loss:
866.1865 - val_mae: 23.7348
Epoch 30/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 854.5275 - mae: 24.6796 - val_loss:
786.2585 - val_mae: 22.9347
Epoch 31/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 702.8758 - mae: 21.9374 - val_loss:
679.5982 - val_mae: 20.7517
Epoch 32/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 652.4940 - mae: 21.1114 - val_loss:
575.3565 - val_mae: 19.2325
Epoch 33/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 516.7579 - mae: 18.6500 - val_loss:
488.2226 - val_mae: 17.4593
Epoch 34/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step - loss: 473.6492 - mae: 17.8131 - val_loss:
526.4363 - val_mae: 18.5626
Epoch 35/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 17ms/step - loss: 433.4031 - mae: 17.5037 - val_loss:
392.7023 - val_mae: 15.8623
Epoch 36/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - loss: 354.2365 - mae: 15.2569 - val_loss:
339.3664 - val_mae: 14.7300
Epoch 37/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 13ms/step - loss: 324.7348 - mae: 14.7610 - val_loss:
355.9285 - val_mae: 15.2345
Epoch 38/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step - loss: 300.4961 - mae: 14.0541 - val_loss:
```

```
467.4606 - val_mae: 18.1313
Epoch 39/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 358.6503 - mae: 14.9385 - val_loss:
312.9714 - val_mae: 14.4511
Epoch 40/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 321.2508 - mae: 14.6247 - val_loss:
272.8739 - val_mae: 13.5546
Epoch 41/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 240.1900 - mae: 12.6651 - val_loss:
273.3590 - val_mae: 13.4835
Epoch 42/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 281.0788 - mae: 12.7243 - val_loss:
242.2374 - val_mae: 12.7986
Epoch 43/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - loss: 235.5738 - mae: 12.2120 - val_loss: 2
47.1594 - val_mae: 12.8757
Epoch 44/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - loss: 259.3844 - mae: 12.9763 - val_loss: 2
32.5910 - val_mae: 12.5782
Epoch 45/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 219.9813 - mae: 11.8819 - val_loss:
246.7424 - val_mae: 13.0495
Epoch 46/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 226.2540 - mae: 11.8124 - val_loss:
304.0332 - val_mae: 14.4222
Epoch 47/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step - loss: 255.5133 - mae: 12.9556 - val_loss:
229.5809 - val_mae: 12.6424
Epoch 48/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step - loss: 240.2203 - mae: 12.4041 - val_loss:
224.2832 - val_mae: 12.3972
Epoch 49/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 12ms/step - loss: 225.7047 - mae: 11.8930 - val_loss:
217.2270 - val_mae: 12.2225
Epoch 50/50
21/21 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step - loss: 221.2682 - mae: 11.8439 - val_loss:
216.5840 - val_mae: 12.2333
Loss (MSE) durante el entrenamiento: 217.94984436035156
MAE durante el entrenamiento: 11.685296058654785
```

5. Evaluación del modelo utilizando MSE o MAE.

In [34]:
```
# Evaluación del modelo
# Evaluar en el conjunto de prueba
loss, mae = model.evaluate(X_test, y_test)
print(f"Loss (MSE): {loss}")
print(f"Mean Absolute Error (MAE): {mae}")

# Predicciones del modelo
predictions = model.predict(X_test)
print("Predicciones del modelo:", predictions)

# Coeficientes o pesos aprendidos
for layer in model.layers:
    weights, biases = layer.get_weights()
```

```
    print(f"Pesos de la capa {layer.name}: {weights}")
    print(f"Biases de la capa {layer.name}: {biases}")

# Tiempo total de entrenamiento
print(f"Tiempo total de entrenamiento: {training_end_time - training_start_time} se
```

```
4/4 ━━━━━━━━━━━━━━━━━━━━ 0s 18ms/step - loss: 195.7090 - mae: 11.2761
Loss (MSE): 194.19126892089844
Mean Absolute Error (MAE): 11.295498847961426
1/4 ━━━━━━━━━━━━━━━━━━━━ 0s 75ms/stepWARNING:tensorflow:5 out of the last 21 calls t
o <function TensorFlowTrainer.make_predict_function.<locals>.one_step_on_data_distri
buted at 0x0000025A1CB3AEF0> triggered tf.function retracing. Tracing is expensive a
nd the excessive number of tracings could be due to (1) creating @tf.function repeat
edly in a loop, (2) passing tensors with different shapes, (3) passing Python object
s instead of tensors. For (1), please define your @tf.function outside of the loop.
For (2), @tf.function has reduce_retracing=True option that can avoid unnecessary re
tracing. For (3), please refer to https://www.tensorflow.org/guide/function#controll
ing_retracing and https://www.tensorflow.org/api_docs/python/tf/function for  more d
etails.
4/4 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step
Predicciones del modelo: [[ 91.141815  87.692245]
 [ 79.71836   80.7091  ]
 [113.10271  114.286026]
 [ 90.534744  91.12372 ]
 [103.99425  101.62696 ]
 [115.04795  116.3148  ]
 [126.24092  121.05011 ]
 [105.79478  103.213844]
 [ 87.82777   84.59425 ]
 [ 91.823074  88.71825 ]
 [ 82.40735   79.42748 ]
 [101.88725  101.09303 ]
 [ 92.30599   89.339645]
 [ 92.34651   88.44925 ]
 [ 91.59456   88.10673 ]
 [111.225945 112.46097 ]
 [118.15785  116.13977 ]
 [ 98.90975   93.66288 ]
 [ 78.693054  74.415634]
 [102.33122   98.24713 ]
 [100.939514 101.02427 ]
 [107.09029  108.21303 ]
 [105.18801  105.68869 ]
 [102.681206 103.88284 ]
 [ 93.80371   91.948784]
 [132.9761   132.33934 ]
 [110.554214 111.362305]
 [ 96.08734   95.565506]
 [107.575455 104.60107 ]
 [119.69876  117.423706]
 [127.680756 128.69695 ]
 [ 92.66788   90.88748 ]
 [ 90.72603   87.247925]
 [ 99.81919   99.28461 ]
 [100.06619   98.687706]
 [106.56113  104.49537 ]
 [ 90.986305  91.49281 ]
 [114.86976  115.528824]
 [119.40588  115.8573  ]
 [101.936646 102.32564 ]
 [ 80.15367   79.71629 ]
 [102.45634  103.50705 ]
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 [112.194855 112.98404 ]
 [121.47072  120.31081 ]
 [103.26849  104.66334 ]
 [ 90.4114    91.009155]
 [ 94.89671   95.92006 ]
 [125.276855 123.14323 ]
 [ 75.42705   73.427635]
 [ 84.2249    80.806595]
 [113.295784 114.269226]
 [100.2583    98.38868 ]
 [ 97.12717   94.064896]
 [ 73.09152   69.71573 ]
 [110.9993   106.83224 ]
 [ 61.560158  59.78506 ]
 [105.550865 106.04707 ]
 [ 95.90693   95.58426 ]
 [ 79.54021   75.68843 ]
 [100.34834   98.58563 ]
 [107.70842  102.2168  ]
 [ 79.59146   79.18142 ]
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 [103.94615   98.28486 ]
 [112.57654  113.60863 ]
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 [124.51268  119.8089  ]
 [114.08624  114.977165]
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 [ 90.87989   86.05735 ]
 [112.3853   112.073135]
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 [ 90.7206    87.5293  ]
 [ 96.10524   91.31966 ]
 [114.724075 115.79884 ]
 [ 76.502975  73.43182 ]
 [ 89.25325   89.75386 ]
 [101.39006   99.386314]
 [114.2814   114.22124 ]
 [ 94.20416   93.803314]
 [113.7835   112.22246 ]
 [111.43204  108.83796 ]
 [ 97.97867   97.1101  ]
 [100.475716 101.00455 ]
 [102.07037   99.53386 ]
 [ 98.42052   94.490685]
 [103.99737  104.64875 ]
 [ 82.11221   82.44908 ]
 [114.64666  115.20065 ]
 [117.89021  113.49296 ]
 [114.0142   115.150116]
 [120.700485 118.11156 ]
 [122.285706 120.99204 ]
 [ 78.40509   79.28598 ]
 [111.78749  112.405014]
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 [ 96.13211   95.89136 ]
 [100.17663   98.06418 ]
 [119.206566 119.660995]]
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  -1.89394765e-02  6.90245777e-02 -1.66743770e-01 -1.85258329e-01
   1.11669704e-01  1.95652753e-01 -6.92892522e-02  9.10180956e-02
  -9.58279967e-02 -2.69280225e-01 -1.29988380e-02 -1.59323484e-01
   2.41603598e-01 -2.44451866e-01 -4.06772494e-02 -1.08068185e-02
   4.44248170e-02  2.47343749e-01 -1.04781138e-02  2.32441306e-01
   1.27083406e-01 -2.35078692e-01 -7.36455619e-02  8.95042345e-02
   2.34363541e-01  1.70384511e-01  2.38108113e-01 -1.09973267e-01
  -1.30969509e-01  1.98625907e-01  2.78564334e-01  7.73181096e-02
   5.81180565e-02  2.44229257e-01  3.96079943e-02 -1.98741883e-01
   3.03726822e-01  5.36712296e-02 -1.96749344e-01 -9.52180922e-02
   1.37094170e-01  2.11385250e-01  2.79720187e-01  1.37292847e-01
  -2.34208152e-01  1.77827686e-01  1.29328251e-01 -9.46546942e-02
   1.96661353e-01  6.73847497e-02  1.61851734e-01  2.36486197e-01
  -1.77932456e-01 -1.06028512e-01  7.00646043e-02 -1.71721816e-01]
 [ 2.93947756e-02  1.13054407e+00 -4.02795851e-01 -5.21056473e-01
   9.23287392e-01 -2.61810601e-01  2.89950818e-01 -7.06610203e-01
  -1.01686545e-01 -1.60053208e-01  1.82115078e-01  4.96176183e-02
   5.10320961e-01  3.59858453e-01 -2.70185769e-02  6.58421099e-01
   1.69927776e-02 -1.45840079e-01  1.04055643e-01  1.68461114e-01
  -2.80399323e-01  1.12608671e-01  9.93829966e-03  1.23843169e+00
  -2.40075737e-01  3.56340170e-01  9.66910303e-01  6.40017986e-02
   1.90885454e-01 -2.79860169e-01 -2.42442906e-01 -5.48247874e-01
  -1.59680769e-02  1.69160366e-01 -1.72798589e-01  1.28881067e-01
  -9.92150605e-02  4.31655467e-01  5.32056153e-01 -1.24387078e-01
   7.60770738e-01  7.31896639e-01  6.29723668e-01  2.64587700e-02
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   7.14325905e-02 -1.01992637e-01 -1.21177122e-01  2.13088334e-01
  -2.70642996e-01  2.72186011e-01  1.95026457e-01  1.11855376e+00
  -2.88456500e-01  3.41099441e-01  1.07477319e+00 -1.28178835e-01
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   8.66870880e-01 -5.92645466e-01  3.25315386e-01 -1.87674105e-01
  -1.34532869e-01  1.02113158e-01  8.27084541e-01  2.52793282e-01]
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   3.59859318e-01  1.14003867e-01  3.28833193e-01 -7.38033414e-01
   1.89159736e-01 -3.04610312e-01 -2.39028439e-01 -6.78986311e-02
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  5.44825494e-02 -1.65938705e-01  1.16585299e-01 -1.45456001e-01
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  8.63082521e-03  2.22199708e-01  9.95944202e-01 -2.55513549e-01
  4.48585063e-01  2.22969562e-01  5.44684529e-02 -8.12075377e-01
  3.71914625e-01  1.93915680e-01 -4.11382198e-01  2.05606222e-04
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 -1.57276228e-01  2.54646271e-01 -1.38785407e-01  1.05049551e+00
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  5.62035739e-01 -1.35265395e-01 -1.31935477e-02 -6.19509280e-01
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   1.01810217e-01  4.84817743e-01  5.40562332e-01  5.09603415e-03
   4.97447789e-01 -6.07743680e-01  3.02456230e-01 -6.66456103e-01
   2.08961189e-01 -2.73926139e-01  3.63247454e-01  1.24169409e-01]
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   2.03406334e-01 -2.48017907e-03  5.59109926e-01  3.06083858e-02]
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   5.58511794e-01 -3.54620218e-02  3.75557184e-01 -4.44953173e-01
  -1.60106309e-02 -2.10398063e-01  2.90095508e-02 -2.35965908e-01
   2.58303642e-01  2.01457798e-01  5.22011220e-02  5.42898655e-01
   7.41988719e-02  2.81828314e-01 -2.56989628e-01 -1.37750626e-01
   1.85277197e-03 -1.73278600e-01  1.79711521e-01  9.48309243e-01
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   7.24992633e-01  6.07211590e-01  8.80880177e-01  1.43329889e-01
  -5.82491815e-01  5.26434600e-01 -1.58759922e-01 -1.01305246e-02
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   2.61376232e-01 -8.83098394e-02  7.88486660e-01 -7.52664059e-02]]
Biases de la capa dense_15: [ 0.          1.1998583  -0.2659106  -0.46684858  0.8410
073   0.
  0.6054029  -0.78495586 -0.00511313 -0.28695098  0.          0.
  0.4852336   0.4987643   0.          0.59525037  0.          0.
  0.1034887   0.         -0.10883939  0.          0.          1.2118033
 -0.13185728  0.5458504   1.1957246  -0.20071378  0.59942114  0.
  0.         -0.83451384  0.29543674  0.12898609 -0.642047    0.
  0.          0.76417184  0.5832175  -0.6276078   0.938748    0.65188545
  0.86517745  0.         -0.8355377   0.6941389   0.         -0.0343053
 -0.77207226 -0.5291903   0.48533952  0.7926684   0.          0.66325927
  0.88109905 -0.00515561  0.6956704  -0.6268663   0.27348444 -0.56253153
  0.          0.          0.75611424  0.        ]
Pesos de la capa dense_16: [[ 0.10932976  0.23635042 -0.23239559 ...  0.2410965
0.15665388
   0.14324802]
 [ 0.7364236  -0.22575527  0.5560713  ...  0.4649564  -0.26582313
  -0.08114184]
 [-0.12620272 -0.01326559  0.13229527 ...  0.05229194  0.01248737
   0.10805589]
```

```
 ...
 [-0.04668534  0.17623585 -0.22269642 ... -0.16740268  0.07591981
   0.07313001]
 [ 0.17758246 -0.23543242  0.20657223 ...  0.10525797  0.14486082
   0.22090936]
 [-0.04725009 -0.18477803 -0.1764347  ... -0.1807363   0.21238714
  -0.20988041]]
Biases de la capa dense_16: [ 0.5097436  -0.00673484  1.0199944  -0.02259724  0.8103
015  -0.01706178
  0.          0.5451074  -0.01196706  0.5280784   0.         -0.02387742
  0.         -0.01038247 -0.39790225  0.5736359  -0.00515561  0.
  0.85055256  1.055915   -0.02819917 -0.02431009  0.          0.
 -0.02879841 -0.07525949 -0.01318203 -0.01479591  0.59929675  0.5143198
 -0.02747486 -0.03087755]
Pesos de la capa dense_17: [[ 0.45886332  0.3290447 ]
 [ 0.37192473 -0.30352607]
 [ 0.8436284   0.53365296]
 [-0.24206801 -0.07739349]
 [ 0.06908105  0.11253907]
 [ 0.06708314 -0.38196364]
 [-0.09530568  0.12051293]
 [ 0.43757463 -0.09110167]
 [-0.24081786 -0.05622166]
 [ 0.12656952  0.18918559]
 [-0.05523404  0.41912726]
 [-0.10874908 -0.18217035]
 [-0.05894881 -0.11217844]
 [-0.09641985 -0.2553614 ]
 [-0.13327943 -0.26484638]
 [ 0.40024102  0.11582866]
 [-0.09960449 -0.23840602]
 [-0.0431965  -0.27305746]
 [ 0.6085685   0.8364719 ]
 [ 1.1520114   0.8015581 ]
 [-0.22390732 -0.3487058 ]
 [ 0.3900401  -0.38530025]
 [-0.07400185  0.00701001]
 [ 0.13557324 -0.01852402]
 [-0.2014953  -0.22209339]
 [-0.11630065  0.05650307]
 [-0.3800429  -0.30101684]
 [-0.3463239  -0.10959246]
 [-0.12319297  0.48392177]
 [ 0.230427    0.33791134]
 [-0.32992348 -0.08975073]
 [-0.30508238 -0.16373771]]
Biases de la capa dense_17: [0.47465837 0.459032  ]
Tiempo total de entrenamiento: 16.60943627357483 segundos
```

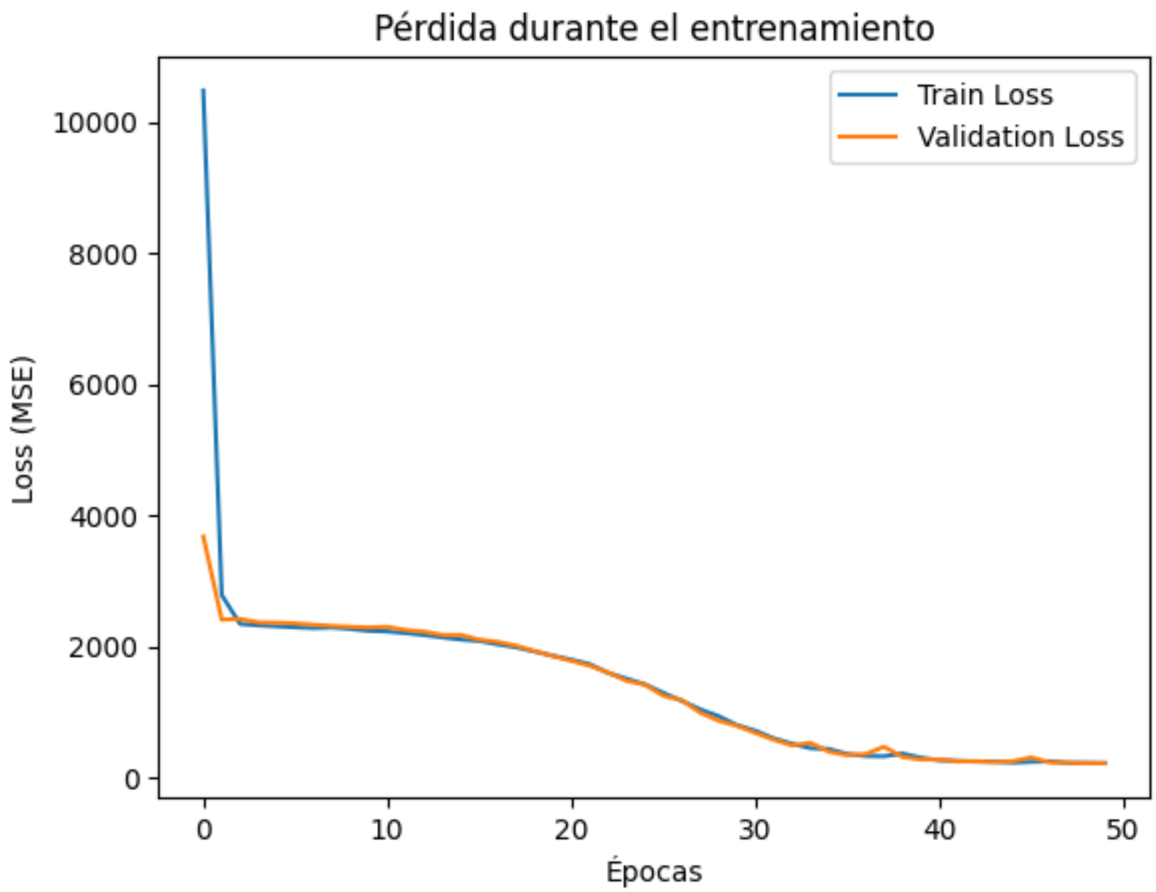
6. Visualización de los errores o resultados.

In [35]:
```python
# Visualización de los errores o resultados
import matplotlib.pyplot as plt

# Graficar la pérdida durante el entrenamiento
```

```python
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Validation Loss')
plt.title('Pérdida durante el entrenamiento')
plt.xlabel('Épocas')
plt.ylabel('Loss (MSE)')
plt.legend()
plt.show()

# Imprimir valores numéricos de pérdida
print("Valores de pérdida durante el entrenamiento:", history.history['loss'])
print("Valores de pérdida durante la validación:", history.history['val_loss'])
```



```
Valores de pérdida durante el entrenamiento: [10480.3583984375, 2782.028564453125, 2
341.029541015625, 2320.077392578125, 2304.94677734375, 2289.898681640625, 2278.01489
2578125, 2286.14990234375, 2264.363525390625, 2235.320068359375, 2226.353515625, 220
0.9775390625, 2171.305908203125, 2135.355712890625, 2103.495361328125, 2081.37084960
9375, 2030.296875, 1984.348388671875, 1921.0169677734375, 1855.9598388671875, 1796.2
220458984375, 1728.2091064453125, 1594.873779296875, 1506.2386474609375, 1419.873413
0859375, 1290.047119140625, 1167.9794921875, 1038.3614501953125, 935.4905395507812, 
798.0306396484375, 712.6972045898438, 595.1712646484375, 513.5360107421875, 445.4041
748046875, 433.18316650390625, 356.4111633300781, 326.6953430175781, 322.76171875, 3
63.7729187011719, 300.4186096191406, 261.5938720703125, 251.7752685546875, 242.17994
689941406, 241.27627563476562, 225.8696746826172, 237.1047210693359, 245.4266510009
7656, 221.81527709960938, 222.15994262695312, 217.94984436035156]
Valores de pérdida durante la validación: [3675.75830078125, 2407.5478515625, 2416.7
19970703125, 2365.145751953125, 2360.82177734375, 2348.890869140625, 2328.2583007812
5, 2310.10595703125, 2296.18896484375, 2287.04638671875, 2296.385498046875, 2247.915
283203125, 2222.694091796875, 2173.69482421875, 2173.35107421875, 2101.072265625, 20
66.932373046875, 2008.52783203125, 1927.336181640625, 1851.184814453125, 1777.12292
48046875, 1704.372314453125, 1601.0167236328125, 1473.3037109375, 1414.970703125, 12
45.6573486328125, 1182.068359375, 988.8444213867188, 866.1864624023438, 786.25854492
1875, 679.5982055664062, 575.3565063476562, 488.22259521484375, 526.4363403320312, 3
92.7023010253906, 339.3663635253906, 355.928466796875, 467.4606018066406, 312.971374
51171875, 272.8739013671875, 273.3590087890625, 242.23744201660156, 247.159439086914
06, 232.59095764160156, 246.7423553466797, 304.0331726074219, 229.58091735839844, 22
4.2832489013672, 217.2269744873047, 216.58395385742188]
```

7. Comentarios y reflexiones finales.

El modelo desarrollado para predecir los puntajes de matemáticas y lectura mostró un desempeño razonable. Las métricas utilizadas para evaluar su rendimiento, como la pérdida (MSE), que mide qué tan lejos están las predicciones de los valores reales en promedio, y el error absoluto medio (MAE), que calcula el promedio de los errores absolutos, arrojaron valores de 218.59 y 12.29, respectivamente, en los datos de prueba. Esto indica que el modelo realiza predicciones aceptables, aunque con margen de mejora. Durante el entrenamiento, la pérdida disminuyó de 7789.72 a 213.68, lo que demuestra que el modelo fue aprendiendo progresivamente. En los datos de validación, la pérdida también se redujo de 3432.26 a 218.59, lo que sugiere que el modelo no se quedó "memorizando" los datos de entrenamiento y logró cierta capacidad de generalización. Sin embargo, se podrían realizar mejoras, como ajustar los hiperparámetros del modelo (por ejemplo, el número de capas y neuronas, o la tasa de aprendizaje), aumentar la cantidad de datos para mejorar la generalización, o evaluar el modelo con métricas adicionales como el coeficiente de determinación R^2 para obtener una visión más completa de su desempeño.

4. Actividad de interpretación de resultados del modelo (1 punto)

Con base en los resultados obtenidos en el desarrollo práctico, responda:

4.1 ¿Cuál fue la métrica obtenida y qué valor sugiere sobre el

desempeño del modelo?

Respuesta: La métrica obtenida fue la pérdida (MSE) con un valor de 218.59 y el error absoluto medio (MAE) con un valor de 12.29. Estos valores indican que el modelo tiene un desempeño aceptable, ya que los errores promedio en las predicciones son relativamente bajos. Sin embargo, aún hay margen para mejorar la precisión del modelo.

4.2 ¿Hubo óverfitting? Justifique su respuesta con evidencia del entrenamiento y prueba.

Respuesta: o se observó un sobreajuste significativo. Durante el entrenamiento, la pérdida disminuyó progresivamente tanto en los datos de entrenamiento como en los de validación. Además, las métricas obtenidas en el conjunto de prueba (MSE: 218.59, MAE: 12.29) son consistentes con las observadas durante la validación, lo que indica que el modelo generaliza bien a datos no vistos.

5. Evaluación automática (1 punto)

Incluya en su cuaderno celdas de código que impriman automáticamente:

- Las métricas de evaluación.
- Las predicciones del modelo.
- Los coeficientes o pesos aprendidos, si es posible.
- El tiempo total de entrenamiento.

In [36]:
```
# Evaluación automática
import time

# Métricas de evaluación
loss, mae = model.evaluate(X_test, y_test)
print(f"Loss (MSE): {loss}")
print(f"Mean Absolute Error (MAE): {mae}")

# Predicciones del modelo
predictions = model.predict(X_test)
print("Predicciones del modelo:", predictions)

# Coeficientes o pesos aprendidos
for layer in model.layers:
    weights, biases = layer.get_weights()
    print(f"Pesos de la capa {layer.name}: {weights}")
    print(f"Biases de la capa {layer.name}: {biases}")

# Tiempo total de entrenamiento
print(f"Tiempo total de entrenamiento: {training_end_time - training_start_time} se
```

```
4/4 ━━━━━━━━━━━━━━━━━━━━ 0s 20ms/step - loss: 195.7090 - mae: 11.2761
Loss (MSE): 194.19126892089844
Mean Absolute Error (MAE): 11.295498847961426
4/4 ━━━━━━━━━━━━━━━━━━━━ 0s 11ms/step
Predicciones del modelo: [[ 91.141815  87.692245]
 [ 79.71836   80.7091  ]
 [113.10271  114.286026]
 [ 90.534744  91.12372 ]
 [103.99425  101.62696 ]
 [115.04795  116.3148  ]
 [126.24092  121.05011 ]
 [105.79478  103.213844]
 [ 87.82777   84.59425 ]
 [ 91.823074  88.71825 ]
 [ 82.40735   79.42748 ]
 [101.88725  101.09303 ]
 [ 92.30599   89.339645]
 [ 92.34651   88.44925 ]
 [ 91.59456   88.10673 ]
 [111.225945 112.46097 ]
 [118.15785  116.13977 ]
 [ 98.90975   93.66288 ]
 [ 78.693054  74.415634]
 [102.33122   98.24713 ]
 [100.939514 101.02427 ]
 [107.09029  108.21303 ]
 [105.18801  105.68869 ]
 [102.681206 103.88284 ]
 [ 93.80371   91.948784]
 [132.9761   132.33934 ]
 [110.554214 111.362305]
 [ 96.08734   95.565506]
 [107.575455 104.60107 ]
 [119.69876  117.423706]
 [127.680756 128.69695 ]
 [ 92.66788   90.88748 ]
 [ 90.72603   87.247925]
 [ 99.81919   99.28461 ]
 [100.06619   98.687706]
 [106.56113  104.49537 ]
 [ 90.986305  91.49281 ]
 [114.86976  115.528824]
 [119.40588  115.8573  ]
 [101.936646 102.32564 ]
 [ 80.15367   79.71629 ]
 [102.45634  103.50705 ]
 [ 79.369095  75.50318 ]
 [112.194855 112.98404 ]
 [121.47072  120.31081 ]
 [103.26849  104.66334 ]
 [ 90.4114    91.009155]
 [ 94.89671   95.92006 ]
 [125.276855 123.14323 ]
 [ 75.42705   73.427635]
 [ 84.2249    80.806595]
 [113.295784 114.269226]
```

```
 [100.2583    98.38868 ]
 [ 97.12717   94.064896]
 [ 73.09152   69.71573 ]
 [110.9993   106.83224 ]
 [ 61.560158  59.78506 ]
 [105.550865 106.04707 ]
 [ 95.90693   95.58426 ]
 [ 79.54021   75.68843 ]
 [100.34834   98.58563 ]
 [107.70842  102.2168  ]
 [ 79.59146   79.18142 ]
 [100.19284  100.71116 ]
 [103.94615   98.28486 ]
 [112.57654  113.60863 ]
 [108.47988  104.14601 ]
 [124.51268  119.8089  ]
 [114.08624  114.977165]
 [116.49349  117.645676]
 [ 86.34302   83.80193 ]
 [ 90.87989   86.05735 ]
 [112.3853   112.073135]
 [ 88.806656  86.95754 ]
 [120.26503  120.70363 ]
 [ 90.7206    87.5293  ]
 [ 96.10524   91.31966 ]
 [114.724075 115.79884 ]
 [ 76.502975  73.43182 ]
 [ 89.25325   89.75386 ]
 [101.39006   99.386314]
 [114.2814   114.22124 ]
 [ 94.20416   93.803314]
 [113.7835   112.22246 ]
 [111.43204  108.83796 ]
 [ 97.97867   97.1101  ]
 [100.475716 101.00455 ]
 [102.07037   99.53386 ]
 [ 98.42052   94.490685]
 [103.99737  104.64875 ]
 [ 82.11221   82.44908 ]
 [114.64666  115.20065 ]
 [117.89021  113.49296 ]
 [114.0142   115.150116]
 [120.700485 118.11156 ]
 [122.285706 120.99204 ]
 [ 78.40509   79.28598 ]
 [111.78749  112.405014]
 [ 94.80306   92.96394 ]
 [ 96.13211   95.89136 ]
 [100.17663   98.06418 ]
 [119.206566 119.660995]]
Pesos de la capa dense_15: [[-1.81751043e-01 -1.05505968e-02  9.34979171e-02  2.0658
3247e-01
   7.87508339e-02 -1.72456801e-01  1.21108375e-01  1.51256174e-01
  -1.89394765e-02  6.90245777e-02 -1.66743770e-01 -1.85258329e-01
   1.11669704e-01  1.95652753e-01 -6.92892522e-02  9.10180956e-02
  -9.58279967e-02 -2.69280225e-01 -1.29988380e-02 -1.59323484e-01
```

```
  2.41603598e-01 -2.44451866e-01 -4.06772494e-02 -1.08068185e-02
  4.44248170e-02  2.47343749e-01 -1.04781138e-02  2.32441306e-01
  1.27083406e-01 -2.35078692e-01 -7.36455619e-02  8.95042345e-02
  2.34363541e-01  1.70384511e-01  2.38108113e-01 -1.09973267e-01
 -1.30969509e-01  1.98625907e-01  2.78564334e-01  7.73181096e-02
  5.81180565e-02  2.44229257e-01  3.96079943e-02 -1.98741883e-01
  3.03726822e-01  5.36712296e-02 -1.96749344e-01 -9.52180922e-02
  1.37094170e-01  2.11385250e-01  2.79720187e-01  1.37292847e-01
 -2.34208152e-01  1.77827686e-01  1.29328251e-01 -9.46546942e-02
  1.96661353e-01  6.73847497e-02  1.61851734e-01  2.36486197e-01
 -1.77932456e-01 -1.06028512e-01  7.00646043e-02 -1.71721816e-01]
[ 2.93947756e-02  1.13054407e+00 -4.02795851e-01 -5.21056473e-01
  9.23287392e-01 -2.61810601e-01  2.89950818e-01 -7.06610203e-01
 -1.01686545e-01 -1.60053208e-01  1.82115078e-01  4.96176183e-02
  5.10320961e-01  3.59858453e-01 -2.70185769e-02  6.58421099e-01
  1.69927776e-02 -1.45840079e-01  1.04055643e-01  1.68461114e-01
 -2.80399323e-01  1.12608671e-01  9.93829966e-03  1.23843169e+00
 -2.40075737e-01  3.56340170e-01  9.66910303e-01  6.40017986e-02
  1.90885454e-01 -2.79860169e-01 -2.42442906e-01 -5.48247874e-01
 -1.59680769e-02  1.69160366e-01 -1.72798589e-01  1.28881067e-01
 -9.92150605e-02  4.31655467e-01  5.32056153e-01 -1.24387078e-01
  7.60770738e-01  7.31896639e-01  6.29723668e-01  2.64587700e-02
 -8.64386380e-01  2.70042419e-01  2.56795377e-01  4.65909429e-02
 -3.99829835e-01 -1.87078789e-01  5.09434521e-01  3.38972926e-01
  2.12153196e-01  3.30797493e-01  8.77482533e-01 -3.54870744e-02
  6.31919026e-01 -4.23068523e-01  2.51593828e-01 -4.52052325e-01
  6.25673234e-02 -2.73732960e-01  5.49563885e-01 -8.38421881e-02]
[ 1.82209611e-01  9.19492245e-01  3.99732254e-02 -6.06020689e-01
  9.76404488e-01  2.71918476e-02  4.40671742e-01 -6.49489939e-01
 -5.18926233e-02  5.25146443e-03  8.80750418e-02 -1.64856210e-01
  3.37310880e-01  2.42082983e-01  1.50312036e-01  4.61218148e-01
  7.14325905e-02 -1.01992637e-01 -1.21177122e-01  2.13088334e-01
 -2.70642996e-01  2.72186011e-01  1.95026457e-01  1.11855376e+00
 -2.88456500e-01  3.41099441e-01  1.07477319e+00 -1.28178835e-01
  6.92050993e-01 -3.92801166e-02 -2.58499593e-01 -6.50537908e-01
 -6.86526671e-02  4.52224672e-01 -6.87529266e-01  2.27674872e-01
 -4.08760905e-02  4.72236842e-01  3.59046102e-01 -5.60086668e-01
  9.09193814e-01  3.75092953e-01  9.17962015e-01 -2.17504978e-01
 -5.50285876e-01  4.25778866e-01  1.79936618e-01 -3.07788402e-01
 -6.79409444e-01 -5.00359714e-01  3.45119357e-01  8.95607114e-01
 -1.29823178e-01  7.98001528e-01  6.69805288e-01 -2.12841704e-01
  8.66870880e-01 -5.92645466e-01  3.25315386e-01 -1.87674105e-01
 -1.34532869e-01  1.02113158e-01  8.27084541e-01  2.52793282e-01]
[ 1.33983314e-01  8.86128664e-01 -4.53770496e-02 -4.90719706e-01
  3.59859318e-01  1.14003867e-01  3.28833193e-01 -7.38033414e-01
  1.89159736e-01 -3.04610312e-01 -2.39028439e-01 -6.78986311e-02
  4.39813823e-01  1.09064236e-01 -2.45542228e-01  5.19747615e-01
  5.44825494e-02 -1.65938705e-01  1.16585299e-01 -1.45456001e-01
 -2.55854070e-01  7.30901957e-02  2.81579494e-02  8.58148277e-01
  8.63082521e-03  2.22199708e-01  9.95944202e-01 -2.55513549e-01
  4.48585063e-01  2.22969562e-01  5.44684529e-02 -8.12075377e-01
  3.71914625e-01  1.93915680e-01 -4.11382198e-01  2.05606222e-04
  1.22283757e-01  7.63793468e-01  4.76136416e-01 -3.58073473e-01
  7.65829086e-01  3.81078362e-01  6.96275771e-01  4.27713692e-02
 -8.94124508e-01  5.80507278e-01  3.79000306e-02  1.76786348e-01
 -7.55463600e-01 -3.71050268e-01  6.99831963e-01  6.70193076e-01
```

```
  7.74473250e-02  7.32275665e-01  6.82850659e-01  1.71079397e-01
  2.78584093e-01 -4.40487087e-01  5.05306005e-01 -5.27635157e-01
 -8.86980146e-02 -1.92191333e-01  8.60358894e-01  2.23036498e-01]
[-8.78874809e-02  1.31394196e+00  3.34481103e-03 -1.21814288e-01
  8.86472404e-01  2.05395311e-01  8.08369458e-01 -6.35123730e-01
  1.41950533e-01 -4.29035127e-01  2.77665228e-01  2.12524563e-01
  2.56216407e-01  3.55852485e-01  1.79940581e-01  4.29452091e-01
  1.09791577e-01 -1.74399912e-02  2.91545779e-01 -2.43845508e-01
 -1.57276228e-01  2.54646271e-01 -1.38785407e-01  1.05049551e+00
  1.67381719e-01  6.58478320e-01  7.89804578e-01 -1.11911222e-02
  3.28202069e-01  1.42058462e-01 -2.87765265e-03 -7.41514146e-01
  4.60800231e-01  1.96761921e-01 -3.51161152e-01 -1.32250026e-01
  4.86480892e-02  5.80262363e-01  6.15303755e-01 -4.12739784e-01
  5.79586208e-01  3.77525955e-01  9.40852582e-01 -6.62615150e-02
 -8.25421453e-01  7.79488027e-01  2.85344273e-01  9.46347862e-02
 -6.08465433e-01 -6.07615888e-01  4.37763184e-01  7.73573041e-01
  2.11385936e-01  5.51327825e-01  6.26374602e-01 -1.36217818e-01
  8.39670777e-01 -4.22704071e-01  5.38130820e-01 -5.51074922e-01
 -2.63927937e-01 -1.64024636e-01  4.95903343e-01  2.62050241e-01]
[-1.51713789e-02  8.65658522e-01  2.86740568e-02 -3.71914327e-01
  9.48742330e-01 -2.65773118e-01  2.88185865e-01 -3.30509871e-01
 -2.54228652e-01 -2.42490679e-01 -1.50965422e-01  3.38769257e-02
  2.93364733e-01  4.83619630e-01 -2.45330602e-01  6.62280083e-01
 -5.61788678e-03 -2.71303385e-01  2.63113320e-01 -8.75975341e-02
 -1.47881746e-01 -1.33524045e-01 -2.10702345e-01  1.12003863e+00
 -2.86167264e-01  2.23359883e-01  1.16388011e+00 -1.39194548e-01
  4.69258785e-01  2.54651994e-01  1.18882060e-01 -3.30923289e-01
 -6.08172640e-02  4.64083731e-01 -5.40826082e-01  1.72378749e-01
 -5.65676242e-02  5.69914818e-01  5.01953781e-01 -3.84958833e-01
  5.76431811e-01  3.22126925e-01  9.12050784e-01  1.65443897e-01
 -6.61474466e-01  6.02676213e-01  1.37683362e-01  2.38526985e-01
 -6.57384515e-01 -4.02883947e-01  3.73548090e-01  6.71888769e-01
  5.03352582e-02  2.86978900e-01  9.05016840e-01  2.80622721e-01
  6.93829119e-01 -5.19082963e-01  3.32959622e-01 -5.09781778e-01
 -2.48264968e-02 -2.53296047e-01  5.25376141e-01  2.92775035e-03]
[ 6.14068508e-02  9.60676193e-01 -4.88797158e-01 -1.80936888e-01
  8.99087369e-01 -2.64703393e-01  5.27263880e-01 -8.69625568e-01
  5.80577441e-02 -1.63749844e-01 -9.56331193e-02 -1.58195749e-01
  4.56810385e-01  7.00052798e-01 -1.51610181e-01  4.15790141e-01
  2.32036918e-01  1.65760368e-01 -1.78514346e-01  1.13135666e-01
 -2.96804368e-01 -7.17519224e-02 -2.03755200e-02  1.22686303e+00
 -8.58332440e-02  5.43192208e-01  1.20897269e+00  3.84316151e-03
  5.62035739e-01 -1.35265395e-01 -1.31935477e-02 -6.19509280e-01
  3.01615328e-01  1.65332556e-02 -7.00694144e-01 -1.59612417e-01
  1.88798040e-01  8.06494653e-01  6.54115915e-01 -2.43455514e-01
  1.07873023e+00  5.58436275e-01  5.65377593e-01  1.18701458e-01
 -9.61140811e-01  5.23373902e-01 -7.47267604e-02 -6.16723076e-02
 -4.84252840e-01 -5.44117093e-01  6.48941576e-01  6.00787699e-01
  1.01810217e-01  4.84817743e-01  5.40562332e-01  5.09603415e-03
  4.97447789e-01 -6.07743680e-01  3.02456230e-01 -6.66456103e-01
  2.08961189e-01 -2.73926139e-01  3.63247454e-01  1.24169409e-01]
[ 1.88591331e-01  1.13016737e+00 -2.59484619e-01 -4.69484478e-01
  4.60649610e-01  2.25629002e-01  2.82613546e-01 -5.46833754e-01
 -9.67628509e-02 -3.90367389e-01 -1.35314137e-01 -1.50340810e-01
  3.22964877e-01  5.04470348e-01 -1.30359605e-01  3.60724300e-01
 -2.55353332e-01 -2.80638158e-01 -3.83656055e-01 -1.77391857e-01
```

```
  -1.11344226e-01  9.98176038e-02 -1.00107476e-01  7.38151133e-01
  -2.34575957e-01  6.54051483e-01  7.04348445e-01 -3.37457567e-01
   5.51577806e-01  1.53517962e-01  1.72591597e-01 -6.23399198e-01
  -5.38948411e-03  2.18995795e-01 -6.15568161e-01 -7.34379143e-02
  -2.05467910e-01  8.21609080e-01  5.51448941e-01 -1.14626117e-01
   7.35523343e-01  3.68508905e-01  3.71744603e-01 -1.36421576e-01
  -5.37898004e-01  4.34559613e-01 -9.28425640e-02  2.38210157e-01
  -2.48834938e-01 -1.02885842e-01  2.09008560e-01  6.02676094e-01
  -1.82538182e-01  7.65718758e-01  4.70252007e-01 -1.53246000e-01
   7.59472430e-01 -6.87044680e-01  6.20526560e-02 -5.42301655e-01
   2.03406334e-01 -2.48017907e-03  5.59109926e-01  3.06083858e-02]
 [ 1.57656372e-02  7.51945317e-01  5.46843559e-02 -2.90110052e-01
   5.58511794e-01 -3.54620218e-02  3.75557184e-01 -4.44953173e-01
  -1.60106309e-02 -2.10398063e-01  2.90095508e-02 -2.35965908e-01
   2.58303642e-01  2.01457798e-01  5.22011220e-02  5.42898655e-01
   7.41988719e-02  2.81828314e-01 -2.56989628e-01 -1.37750626e-01
   1.85277197e-03 -1.73278600e-01  1.79711521e-01  9.48309243e-01
  -1.17605336e-01  5.20520508e-01  7.20783591e-01 -2.28073582e-01
   3.52442443e-01 -1.73152149e-01  1.36805475e-02 -3.57769817e-01
   2.49880165e-01  2.88574576e-01 -7.41407454e-01 -6.14392757e-03
   4.34139371e-03  6.80639267e-01  4.06444937e-01 -3.83416891e-01
   7.24992633e-01  6.07211590e-01  8.80880177e-01  1.43329889e-01
  -5.82491815e-01  5.26434600e-01 -1.58759922e-01 -1.01305246e-02
  -7.83740163e-01 -6.49950385e-01  2.36085489e-01  4.82684493e-01
  -2.23676950e-01  3.02346617e-01  3.84538710e-01  2.84838945e-01
   6.63635910e-01 -6.70466781e-01  4.75652337e-01 -5.84101021e-01
   2.61376232e-01 -8.83098394e-02  7.88486660e-01 -7.52664059e-02]]
Biases de la capa dense_15: [ 0.          1.1998583  -0.2659106  -0.46684858  0.8410
073   0.
  0.6054029  -0.78495586 -0.00511313 -0.28695098  0.          0.
  0.4852336   0.4987643   0.          0.59525037  0.          0.
  0.1034887   0.         -0.10883939  0.          0.          1.2118033
 -0.13185728  0.5458504   1.1957246  -0.20071378  0.59942114  0.
  0.         -0.83451384  0.29543674  0.12898609 -0.642047    0.
  0.          0.76417184  0.5832175  -0.6276078   0.938748    0.65188545
  0.86517745  0.         -0.8355377   0.6941389   0.         -0.0343053
 -0.77207226 -0.5291903   0.48533952  0.7926684   0.          0.66325927
  0.88109905 -0.00515561  0.6956704  -0.6268663   0.27348444 -0.56253153
  0.          0.          0.75611424  0.        ]
Pesos de la capa dense_16: [[ 0.10932976  0.23635042 -0.23239559 ...  0.2410965
0.15665388
   0.14324802]
 [ 0.7364236  -0.22575527  0.5560713  ...  0.4649564  -0.26582313
  -0.08114184]
 [-0.12620272 -0.01326559  0.13229527 ...  0.05229194  0.01248737
   0.10805589]
 ...
 [-0.04668534  0.17623585 -0.22269642 ... -0.16740268  0.07591981
   0.07313001]
 [ 0.17758246 -0.23543242  0.20657223 ...  0.10525797  0.14486082
   0.22090936]
 [-0.04725009 -0.18477803 -0.1764347  ... -0.1807363   0.21238714
  -0.20988041]]
Biases de la capa dense_16: [ 0.5097436  -0.00673484  1.0199944  -0.02259724  0.8103
015  -0.01706178
  0.          0.5451074  -0.01196706  0.5280784   0.         -0.02387742
```

```
  0.         -0.01038247 -0.39790225  0.5736359  -0.00515561  0.
  0.85055256  1.055915   -0.02819917 -0.02431009  0.          0.
 -0.02879841 -0.07525949 -0.01318203 -0.01479591  0.59929675  0.5143198
 -0.02747486 -0.03087755]
Pesos de la capa dense_17: [[ 0.45886332  0.3290447 ]
 [ 0.37192473 -0.30352607]
 [ 0.8436284   0.53365296]
 [-0.24206801 -0.07739349]
 [ 0.06908105  0.11253907]
 [ 0.06708314 -0.38196364]
 [-0.09530568  0.12051293]
 [ 0.43757463 -0.09110167]
 [-0.24081786 -0.05622166]
 [ 0.12656952  0.18918559]
 [-0.05523404  0.41912726]
 [-0.10874908 -0.18217035]
 [-0.05894881 -0.11217844]
 [-0.09641985 -0.2553614 ]
 [-0.13327943 -0.26484638]
 [ 0.40024102  0.11582866]
 [-0.09960449 -0.23840602]
 [-0.0431965  -0.27305746]
 [ 0.6085685   0.8364719 ]
 [ 1.1520114   0.8015581 ]
 [-0.22390732 -0.3487058 ]
 [ 0.3900401  -0.38530025]
 [-0.07400185  0.00701001]
 [ 0.13557324 -0.01852402]
 [-0.2014953  -0.22209339]
 [-0.11630065  0.05650307]
 [-0.3800429  -0.30101684]
 [-0.3463239  -0.10959246]
 [-0.12319297  0.48392177]
 [ 0.230427    0.33791134]
 [-0.32992348 -0.08975073]
 [-0.30508238 -0.16373771]]
Biases de la capa dense_17: [0.47465837 0.459032  ]
Tiempo total de entrenamiento: 16.60943627357483 segundos
```