

Fourth Mexican AstroComoStatistic School
June 28 - July 2, 2021



INSTITUTO DE
CIENCIAS
FÍSICAS



Machine Learning Basics I

Bases del ML y redes neuronales

IV Mexican AstroCosmoStatistics School

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Machine Learning Basics I

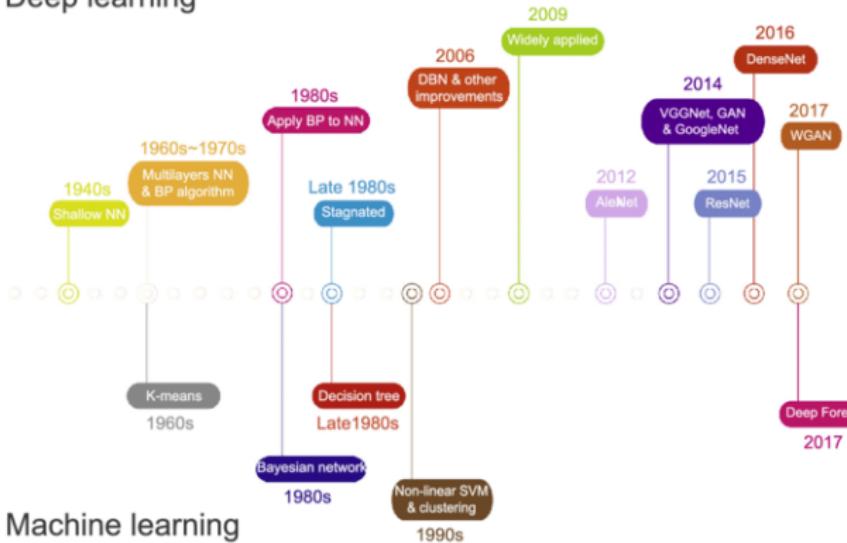
CDT	Monday June 28	Tuesday June 29	Wednesday June 30	Thursday July 1	Friday July 2				
9:00 - 10:0	Welcome	Plenary Activity	Plenary (Elisa Chisari)	Plenary (Agnès Ferté)	Plenary (Alma González)				
10:00 - 11:30	Introduction to Bayesian inference and ML in cosmology (David Kirkby)	Introduction to Bayesian inference and ML in cosmology (David Kirkby)	Introduction to Bayesian inference and ML in cosmology (David Kirkby)	Strong Lensing (Simon Birrer)	Machine Learning Basics (A. Vazquez)	Neural Networks (Miguel Aragon)	Photo-z (S. Fromenteau)		
11:30 - 12:00	Break: wonder.me	Break: wonder.me	Break: wonder.me	Break: wonder.me	Break: wonder.me	Break: wonder.me	Break: wonder.me		
12:00 - 13:30	Photo-z (S. Fromenteau)	Machine Learning Basics (A- Vazquez)	Strong Lensing (Simon Birrer)	Machine Learning Basics (A- Vazquez)	Neural Networks (Miguel Aragon)(Lecture)	Photo-z (S. Fromenteau)	Neural Networks (Miguel Aragon)	Neural Networks (Miguel Aragon)	Strong Lensing (Simon Birrer)
13:30 -	Work on your own	Work on your own	Work on your own	Work on your own	Work on your own	Work on your own	Work on your own		

<https://www.fis.unam.mx/~javazquez/MACSS2021.html>

Machine Learning

Cronología ML

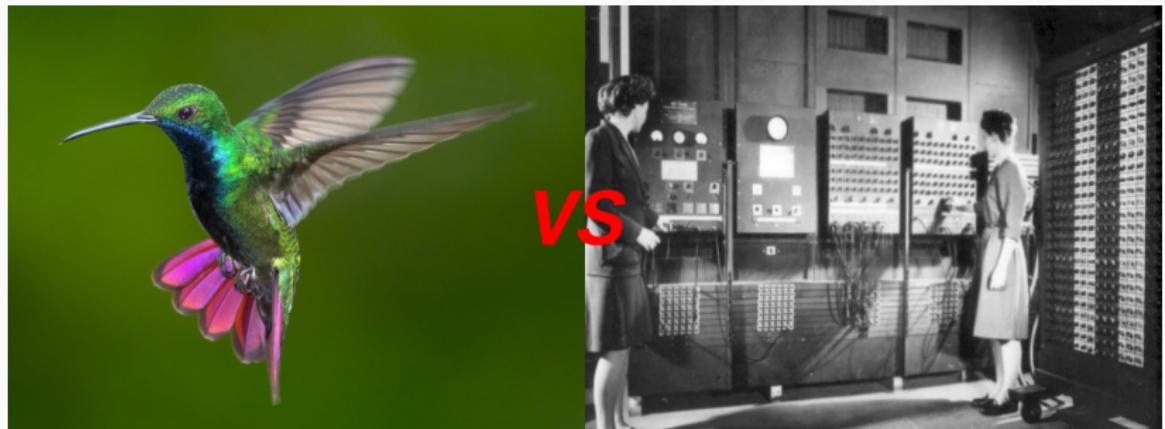
Deep learning



Machine learning

Aprendizaje máquina

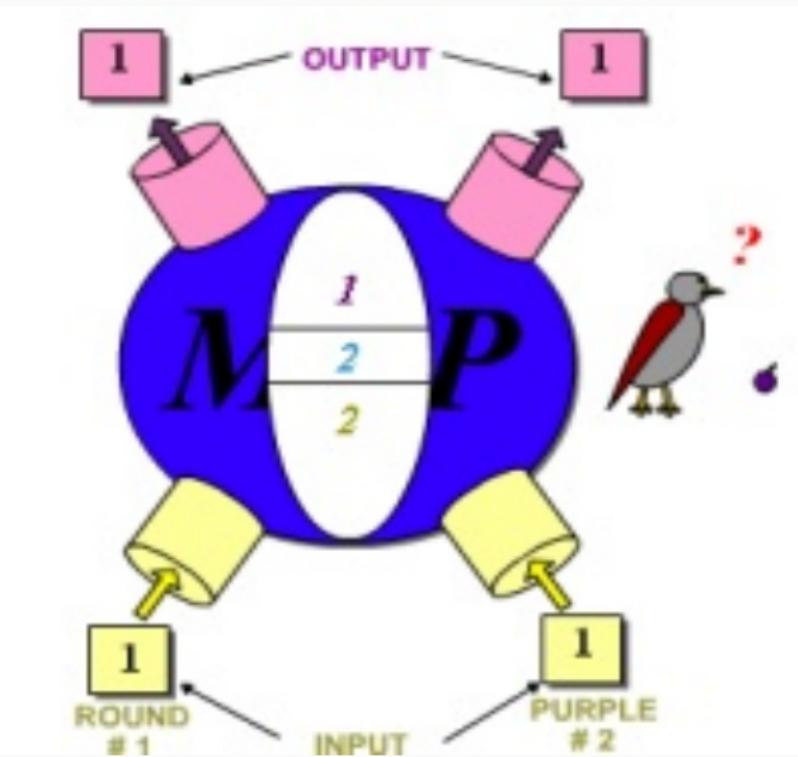
1940s



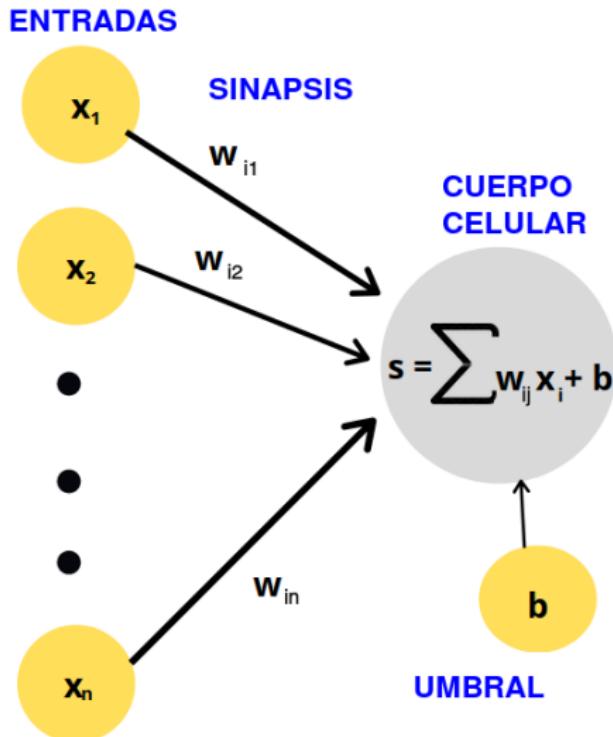
Neurona



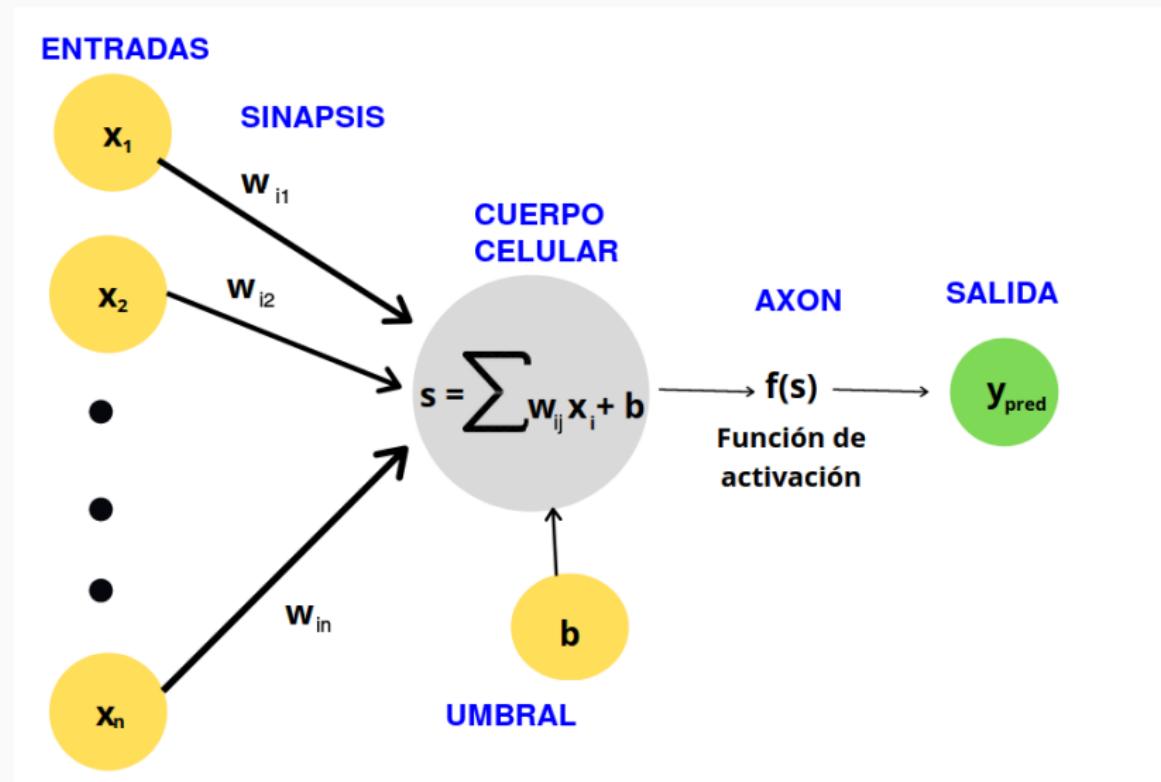
Modelo neuronal de McCullough-Pitts



Una sola neurona artificial

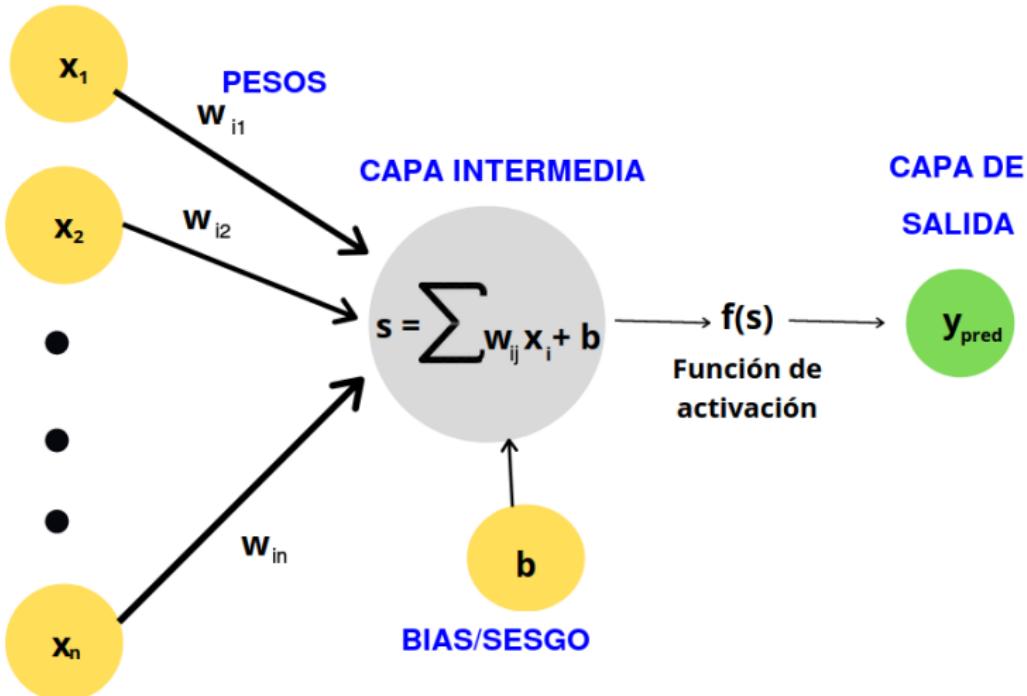


Una sola neurona artificial

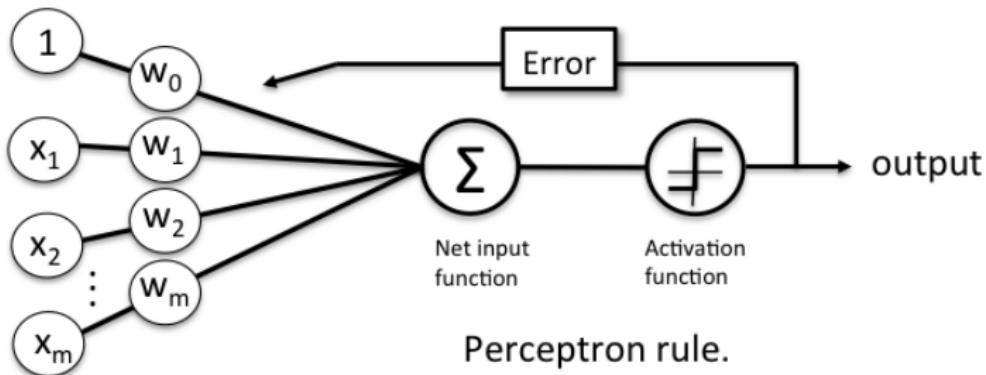


Una sola neurona artificial

CAPA DE ENTRADA

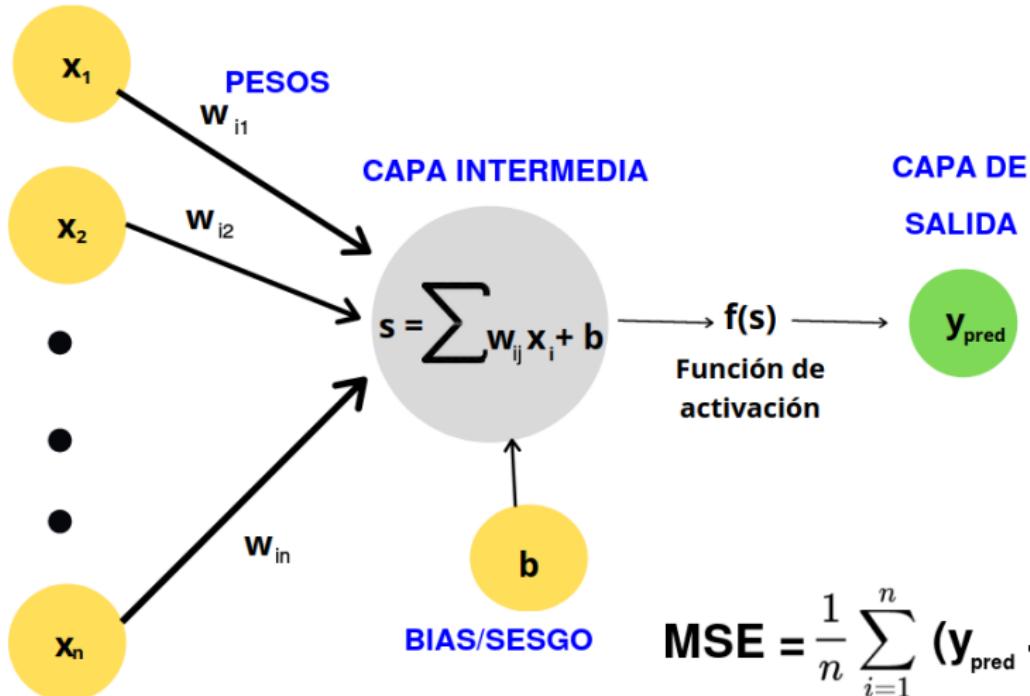


Algoritmo de aprendizaje del perceptrón



El perceptrón: una sola neurona artificial

CAPA DE ENTRADA



$$MSE = \frac{1}{n} \sum_{i=1}^n (y_{pred} - y)^2$$

Algoritmo de aprendizaje del perceptrón

Vol. VI, No. 2, Summer 1958

research trends
CORNELL AERONAUTICAL LABORATORY, INC., BUFFALO 21, NEW YORK



The Design of an



by FRANK ROSENBLATT

Introducing the perceptron — A machine which senses, recognizes, remembers, and responds like the human mind.

STORIES about the creation of machines having human qualities have long been a fascinating province in the realm of science fiction. Yet we are now about to witness the birth of such a machine, a machine capable of perceiving, recognizing, identifying, and responding without any human training or control.

Development of that machine has stemmed from a search for an understanding of the physical mechanisms which underlie human experience and intelligence. The question of the nature of these processes is at least as ancient as any other question in western science and philosophy, and indeed ranks as one of the greatest scientific challenges of our time.

Our understanding of this problem has gone perhaps as far as had the development of physics before Newton. We have some excellent descriptions of the phenomena to be explained, a number of interesting hypotheses, and a little detailed knowledge about events in the nervous system. But we lack agreement on any integrated set of principles which would allow the functioning of the nervous system to be understood.

We believe now that this ancient problem is about to yield to our theoretical investigation for three reasons:

First, in recent years our knowledge of the functioning of individual cells in the central nervous system has vastly increased.

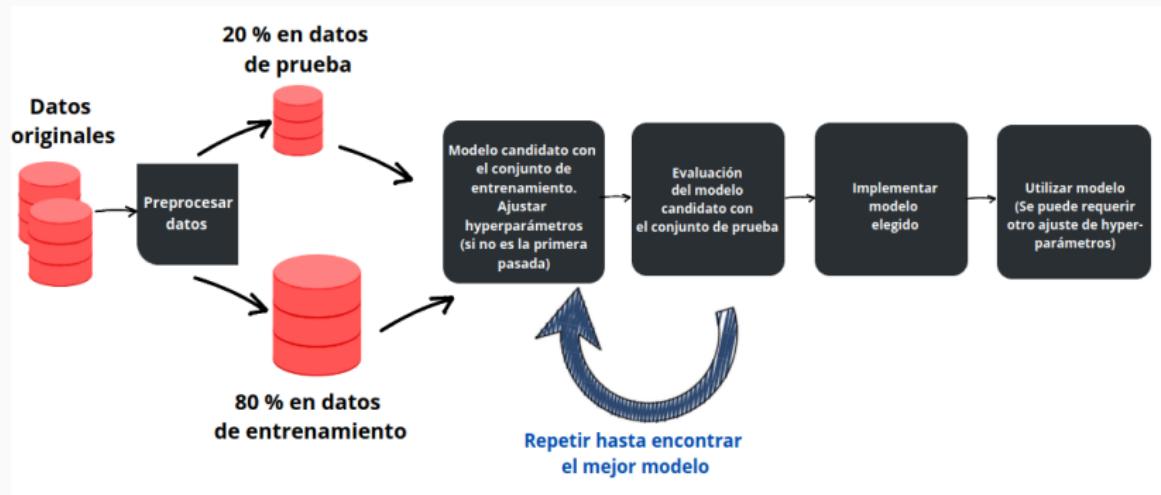
Second, large numbers of engineers and mathematicians are, for the first time, undertaking serious study of the mathematical basis for thinking, perception, and the handling of information by the central nervous system, thus providing the hope that these problems may be within our intellectual grasp.

Third, recent developments in probability theory and in mathematics, in particular, provide new tools for the study of events in the nervous system, where only the gross statistical organization is known and the precise cell-by-cell "wiring diagram" may never be obtained.

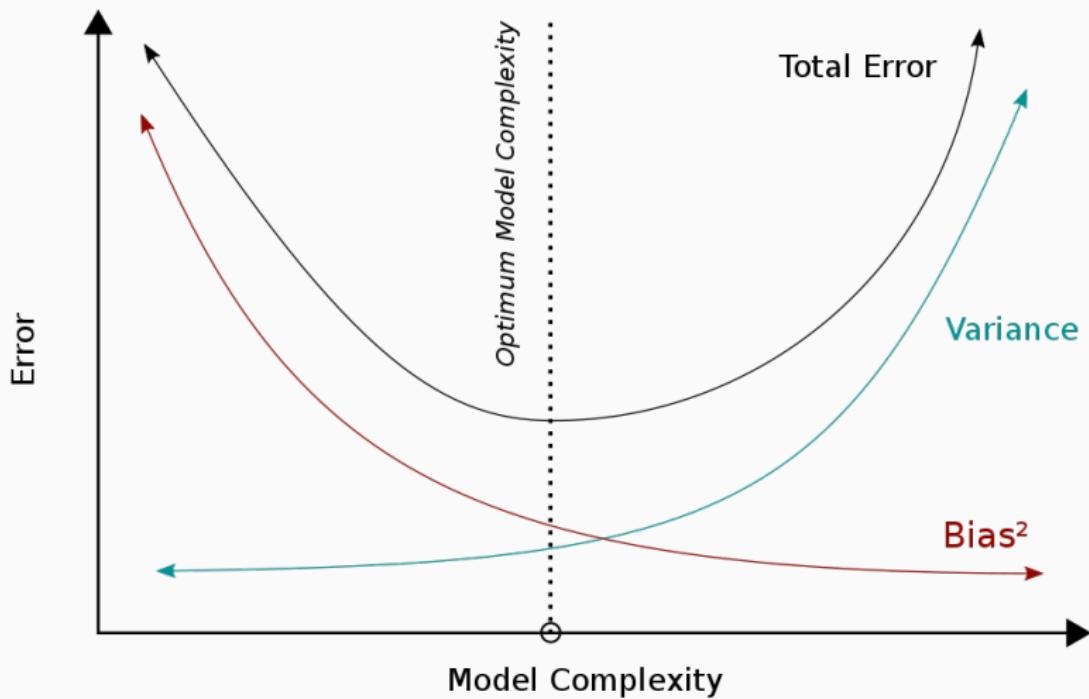
Received Navy Support

In July, 1957, Project PARA (Perceiving and Recognizing Automaton), an experimental research program which had been in progress for over a year at Cornell Aeronautical Laboratory, received the support of the Office of Naval Research. The program had been concerned primarily with the application of probability theory to

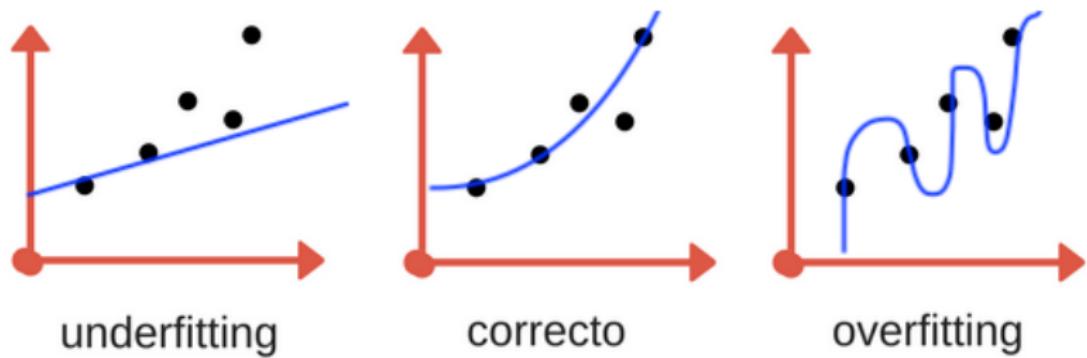
Aprendizaje máquina



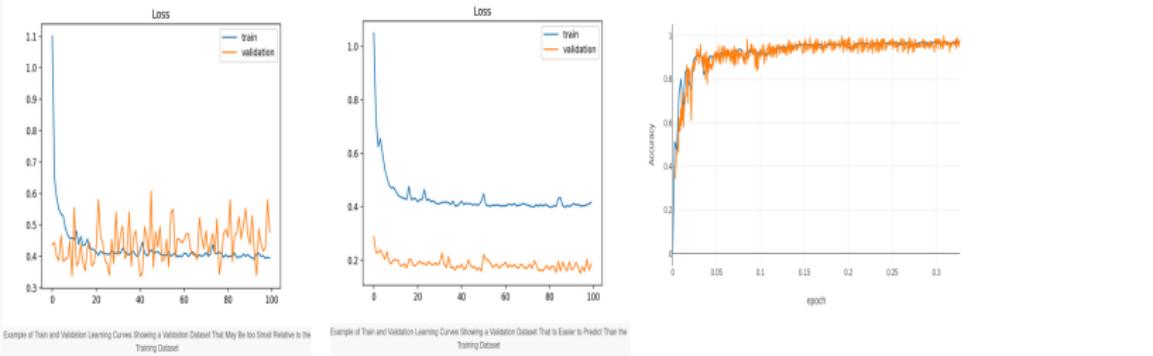
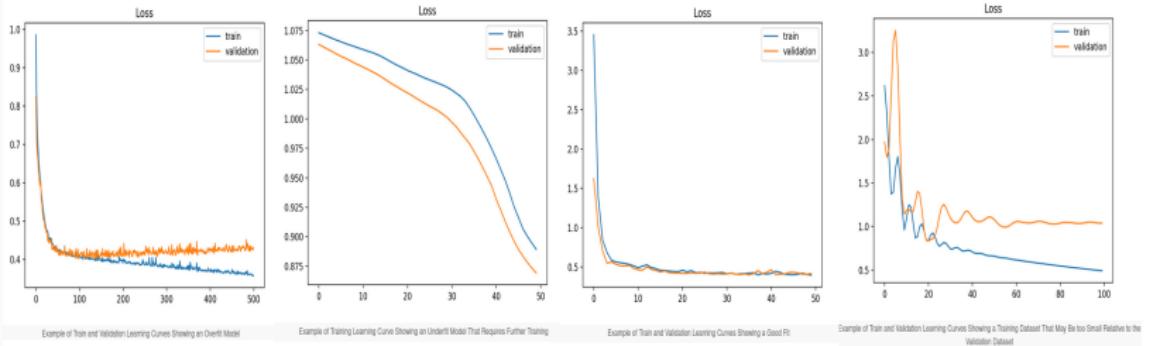
Generalización



Generalización



Generalización

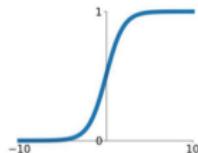


Redes neuronales

Funciones de activación

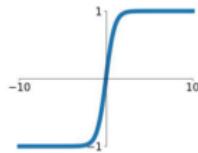
Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



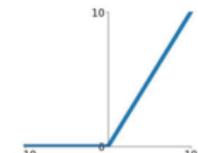
tanh

$$\tanh(x)$$



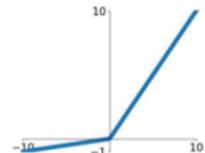
ReLU

$$\max(0, x)$$



Leaky ReLU

$$\max(0.1x, x)$$



ELU

$$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$$



Multilayer Feedforward Networks are Universal Approximators

KURT HORNIK

Technische Universität Wien

MAXWELL STINCHCOMBE AND HALBERT WHITE

University of California, San Diego

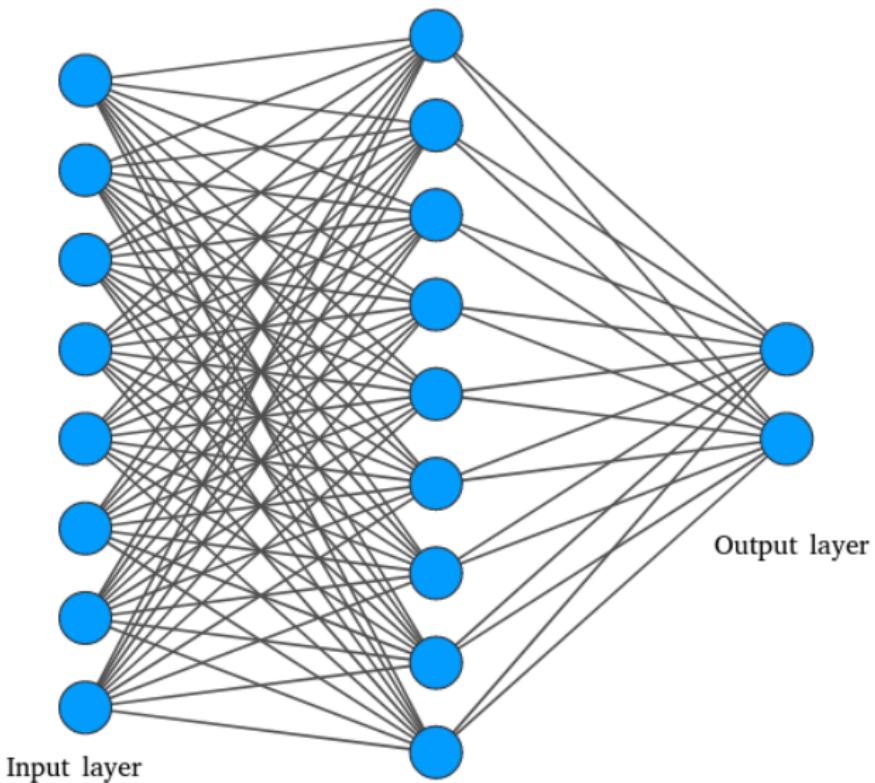
(Received 16 September 1988; revised and accepted 9 March 1989)

Abstract—*This paper rigorously establishes that standard multilayer feedforward networks with as few as one hidden layer using arbitrary squashing functions are capable of approximating any Borel measurable function from one finite dimensional space to another to any desired degree of accuracy, provided sufficiently many hidden units are available. In this sense, multilayer feedforward networks are a class of universal approximators.*

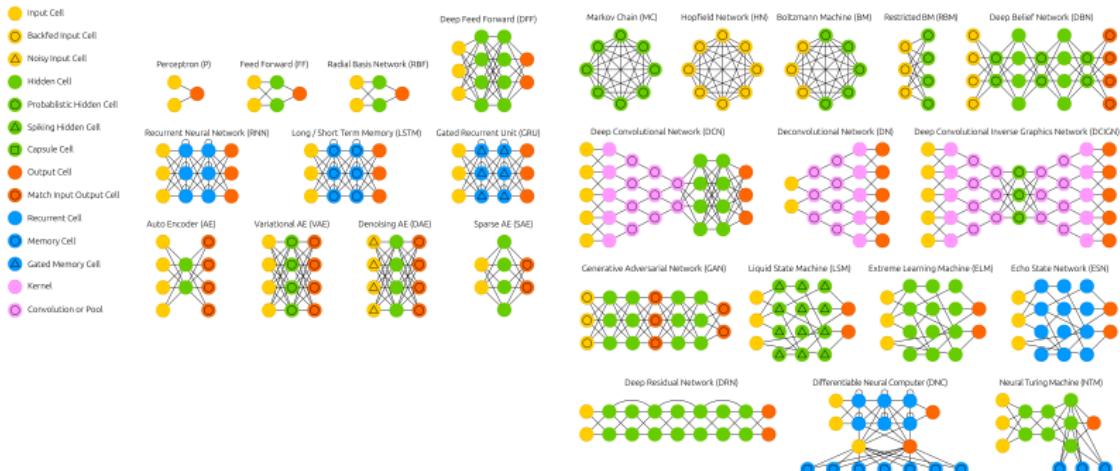
Keywords—Feedforward networks, Universal approximation, Mapping networks, Network representation capability, Stone-Weierstrass Theorem, Squashing functions, Sigma-Pi networks, Back-propagation networks.

Perceptrón multicapa

También llamado *red profunda de propagación hacia adelante*.



Múltiples arquitecturas-> Deep learning



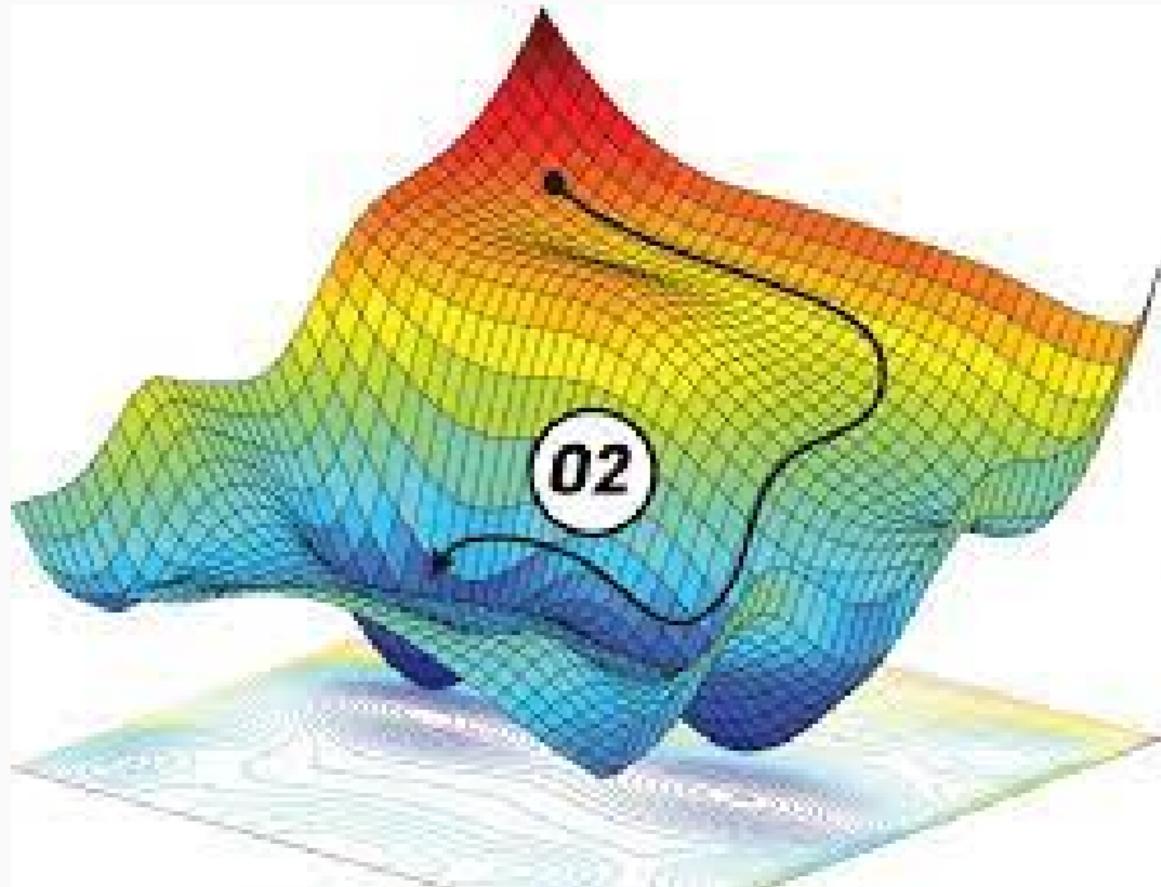
Múltiples arquitecturas-> Deep learning



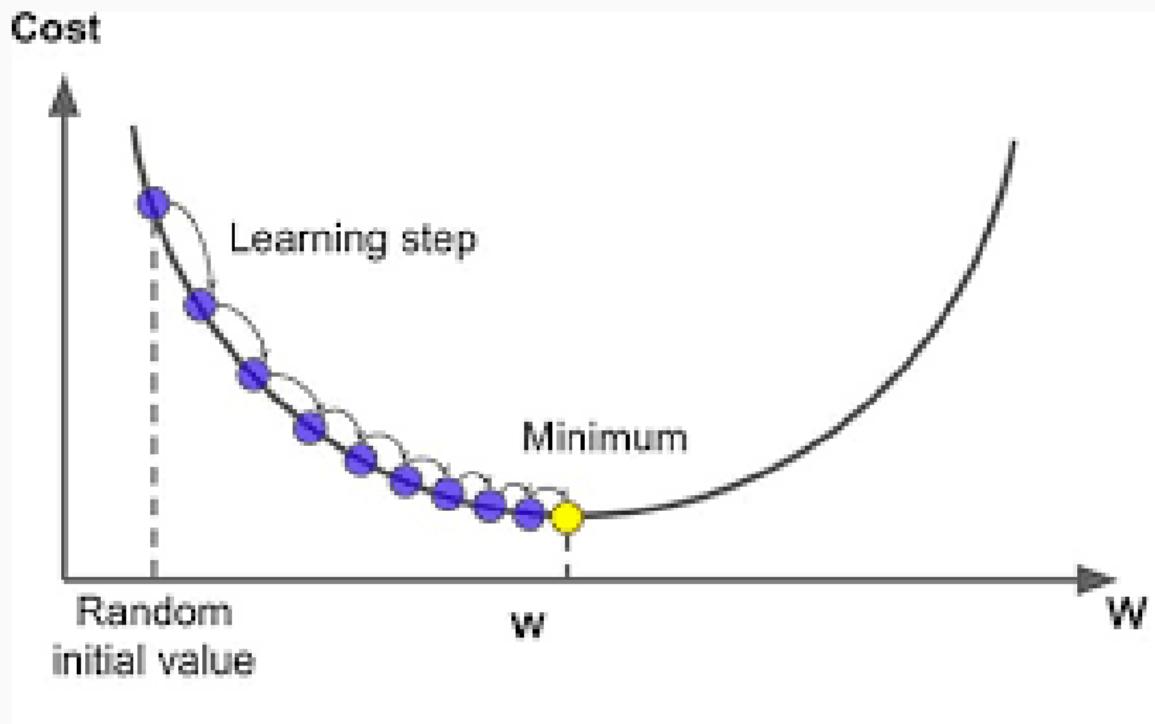
Terminología (hiper-parámetros)

- Conjunto de prueba, entrenamiento y *split*
- Épocas
- Batch size
- Número de nodos/neuronas
- Número de paredes/capas
- Learning rate (tasa de aprendizaje)

Learning rate (tasa de aprendizaje)



Learning rate (tasa de aprendizaje)



Dinámica de trabajo

Plan del mini-curso

- 12:00-12:10. Introducción.
- 12:10-12:30. Primeras neuronas artificiales (Notebook 1).
- 12:30-12:50. Red neuronal con diferentes funciones de activacion y propagación de errores hacia atrás (backpropagation). (Notebook 2).
- 12:50-13:10. Redes neuronales con múltiples capas (Notebook 3).
- 13:10-13:40. Sesión de preguntas y/o trabajar algún ejercicio en grupo.

Preparando las notebooks

- Se requiere una cuenta de Google para usar Google Colab.
- Hay 5 opciones para usar el repositorio con las notebooks:
 1. Clonar repositorio (requiere tener instalado git).
 2. Descargar repositorio.
 3. **Fork del repositorio (requiere tener cuenta de GitHub).**
 4. **Copiar repositorio desde Google Colab en Drive.**
 5. Tan solo abrir y ejecutar en Google Colab (no se guardan cambios).

Preparando las notebooks

igomezv / MACS_2021_ML_basics_neural_networks

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

main · 1 branch · 0 tags

igomezv update notebook 2

data	update notebooks
figures	add fig
1-Primeras_neuronas_artificiales.ipynb	update notebook 1
2-Red_neuronal_backpropagation.ip...	update notebook 2
3-Redes_neuronales_keras.ipynb	add exercise
README.md	update readme

Clone
HTTPS SSH GitHub CLI
https://github.com/igomezv/MACS_2021_1

Use Git or checkout with SVN using the web URL.

Download ZIP

README.md

MACS 2021. Machine Learning Basics I

La primera parte del curso **Machine Learning Basics** de la **IV Mexican AstroCosmoStatistics School (MACS)** consiste en un curso básico y breve sobre Redes Neuronales Artificiales.

Fecha: Lunes 28 de junio de 2021.

Unwatch 2 · Star 0 · Fork 0

About

Mini-course about artificial neural networks as part of the lecture Machine Learning Basics in the IV Mexican School of AstroCosmostatistics (MACS).

machine-learning · neural-networks · cosmology

Readme

Releases

No releases published · Create a new release

Packages

No packages published · Publish your first package

Google Colab

The screenshot shows the Google Colab interface with a modal window open for searching GitHub repositories. The modal has the following elements:

- Header:** Te damos la bienvenida a Colaboratory.
- Toolbar:** Archivo, Editar, Ver, GitHub, Ejemplos, Recientes, Google Drive, GitHub, Subir.
- Search Bar:** Ingresá una URL de GitHub o realiza una búsqueda por organización o usuario. A text input field contains "igomezv". To the right is a checkbox labeled "Incluir repositorios privados" which is checked, and a magnifying glass icon.
- Repository Selection:** Repository: igomezv/MACS_2021_ML_basics_neural_networks. Rama: main.
- File List:** A list of files in the repository:
 - 1-Primeras_neuronas_artificiales.ipynb
 - 2-Red_neuronal_backpropagation.ipynb
 - 3-Redes_neuronales_keras.ipynbEach file entry includes a small thumbnail icon and two small icons for sharing or more options.
- Buttons at the bottom:** Bloq de notas nuevo (New notebook) and Cancelar (Cancel).

Google Colab (copiar en Drive) para poder guardar cambios

The image shows a side-by-side comparison. On the left is a detailed anatomical diagram of a biological neuron. It features a central cell body with a large blue oval labeled 'Cell nucleus'. Extending from the top are several blue, branching processes labeled 'Axon terminals'. A single long, thin blue process labeled 'Axon' extends downwards, wrapped in a series of grey, segmented layers labeled 'Myelin sheath'. On the right is a screenshot of a Google Colab notebook titled '1-Primeras_neuronas_artificiales.ipynb'. The notebook interface includes a menu bar with 'Archivo', 'Editar', 'Ver', 'Insertar', 'Entorno de ejecución', 'Herramientas', and 'Ayuda'. A dropdown menu under 'Archivo' is open, showing options like 'Guardar una copia en Drive' (highlighted in grey), 'Guardar una copia como Gist en GitHub', 'Guardar una copia en GitHub', 'Guardar', 'Historial de revisión', 'Descargar', and 'Imprimir'. Below the menu is a toolbar with various icons. The main workspace is currently empty, ready for code input.

Ejercicios optionales

Por votación se elegirá uno para trabajarla la última media hora.

1. Compuertas lógicas (Notebook 1).
2. Clasificación lineal (Notebook 1).
3. Aproximar función con red neuronal de una capa (Notebook 2).
4. Aprender funciones con redes de múltiples capas y neuronas (Notebook 3).
5. Reducir tiempos (Notebook 3).
6. Modelar datos de Supernovas del tipo IA de la compilación JLA (Notebook 3).
7. Clasificar estrellas, galaxias y cuásares del SDSS-DR14 (Notebook 1 y notebook 3).

Acción