MOL2NET'21, Conference on Molecular, Biomedical, and Computational Sciences and Engineering, 7th ed.

NICXSM-07: North-Ibero-American Congress on Exp. & Simul. Methods, Valencia, Spain-Miami, USA, 2021

IBRO International Brain Research Organization
Bringing neuroscience to the world

NEURODAT'21: IBRO-PERC Soft Skills Training

Models, Simulation, and Self-awareness

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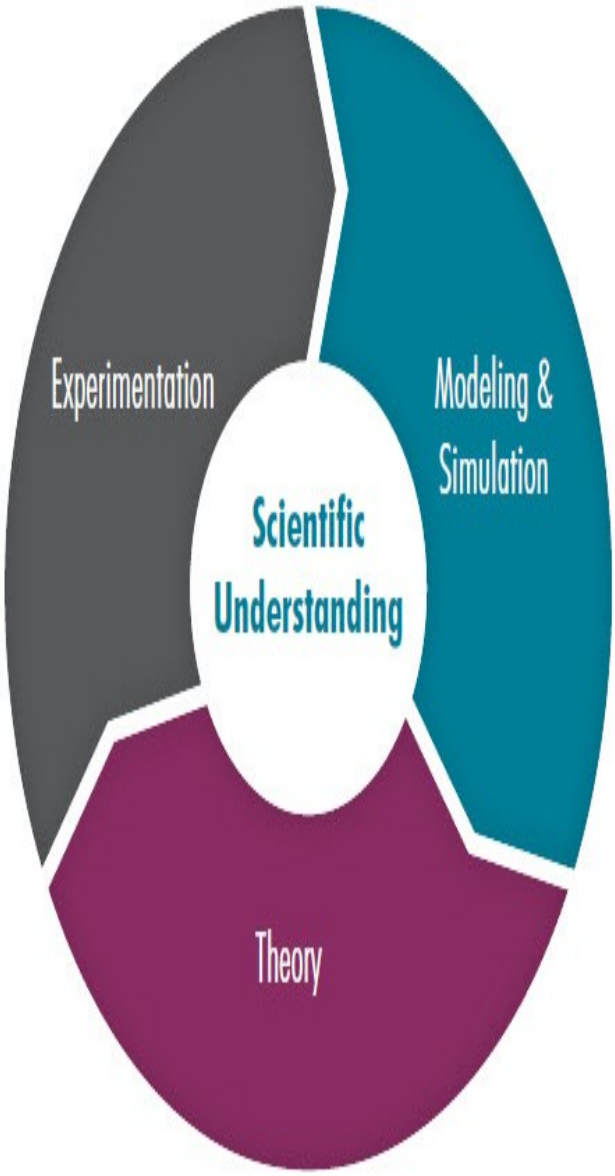
Abstract

This is the 4th talk by Dr. Romero Duran from a series presented as part of the NEURODAT'21 training program funded by IBRO-PERC Soft Skills Training call of the International Brain Research Organization (IBRO) and the Pan-Europe Regional Committee (PERC). NEURODAT'21 is devoted to promote soft skills on entry level medicine and also STEMS area students interested on neurosciences. It is an introductory talk about the development of new models, the use of these models to run simulations, the feasibility of building matrix like virtual worlds and the possibility of reaching self-awarness by artificial intelligences. ***English-Spanish bi-lingual talk and text***

Modelos

Tercer Paradigma Científico



Modelos

Un modelo de un sistema es un conjunto de instrucciones, reglas, ecuaciones o algoritmos que reproducen el comportamiento del sistema

Podemos experimentar con el sistema real o su modelo

Mental, Verbal, Físico, matemático

Modelos

¿Por qué construir modelos?

Predecir **Explicar**

Guiar la recogida de datos

Iluminar los principios básicos

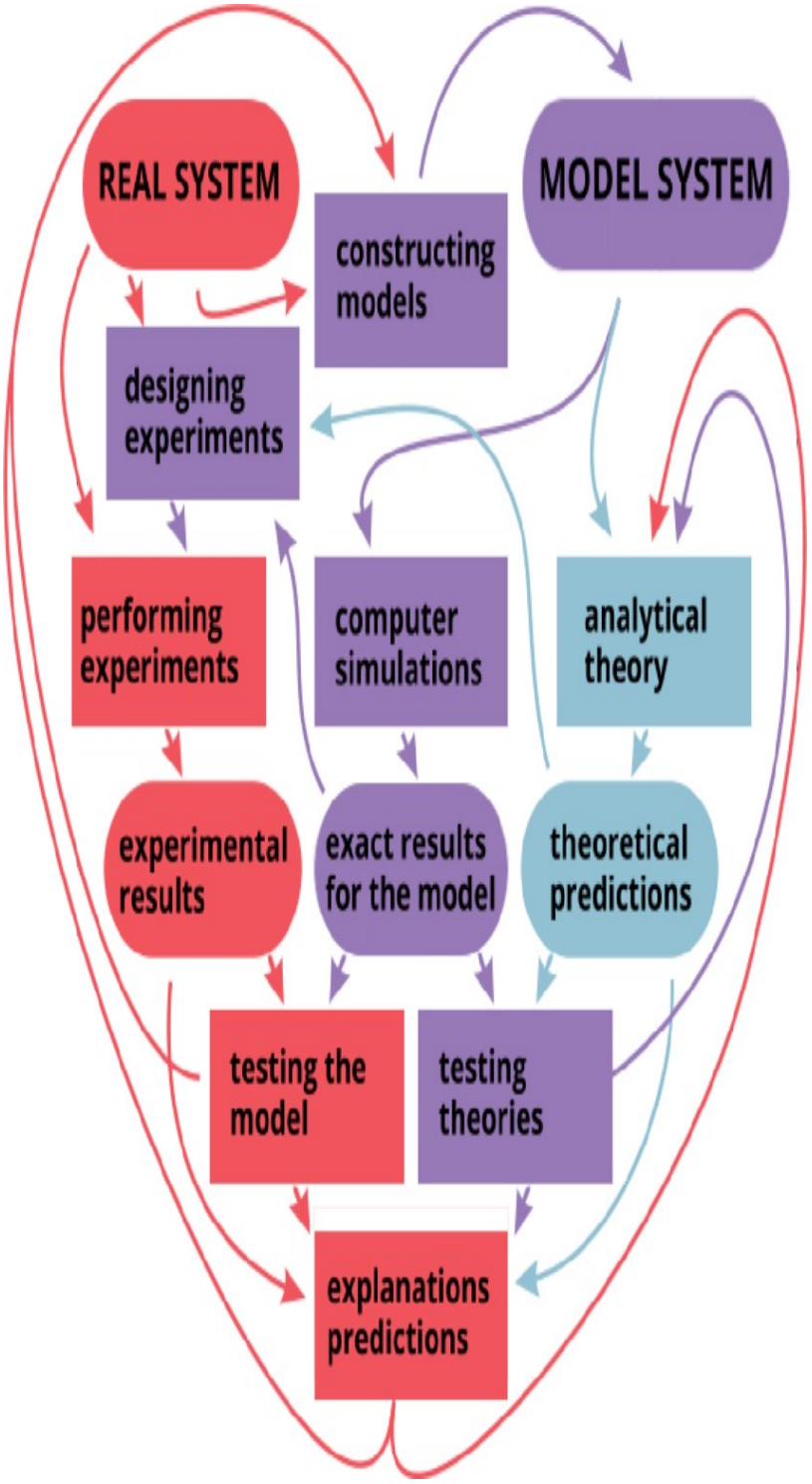
Sugerir analogías

Plantear nuevos interrogantes

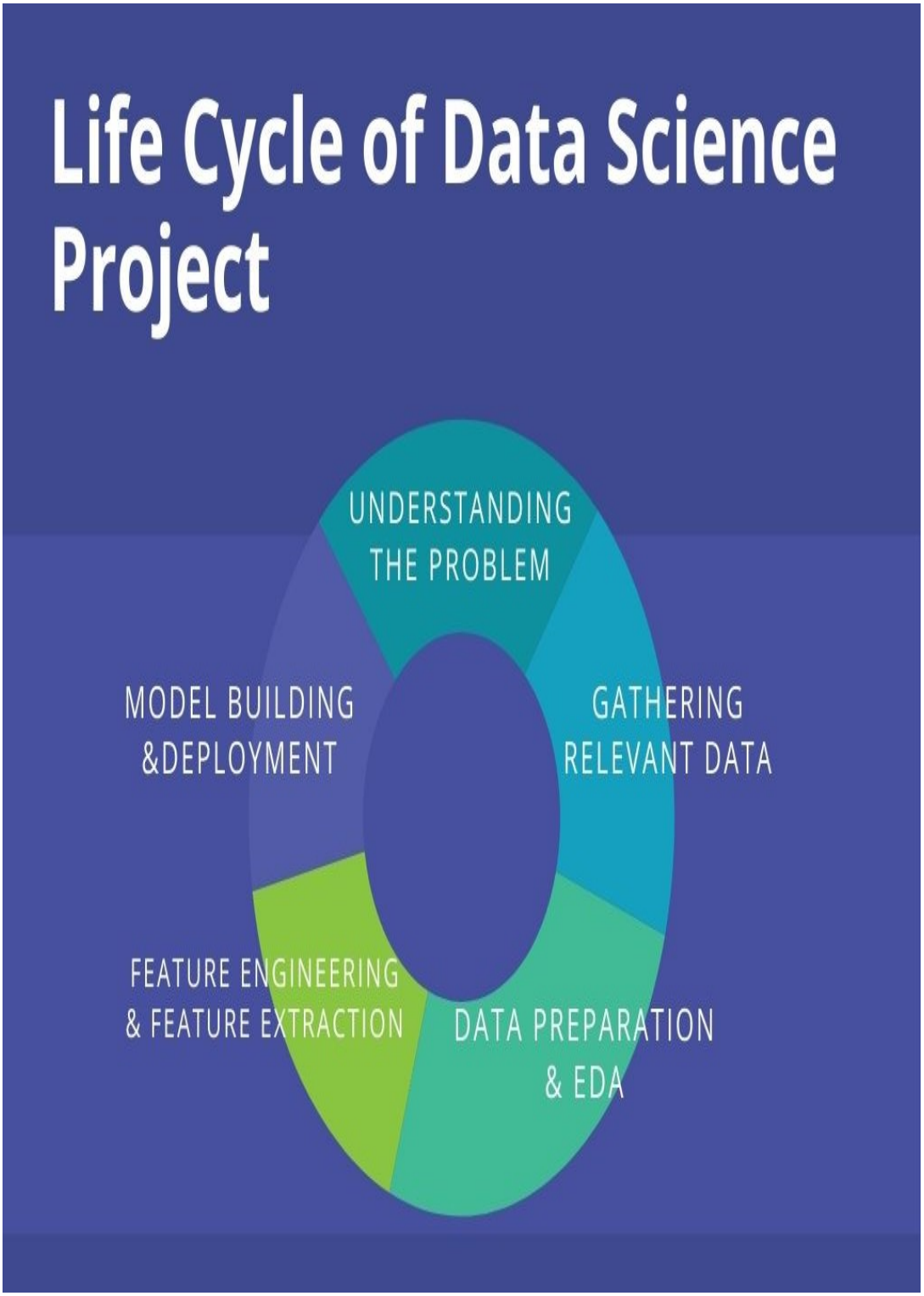
Promover un hábito mental científico

Sondear los límites de las teorías vigentes

Modelos


REAL SYSTEM
MODEL SYSTEM
constructing models
designing experiments
performing experiments
computer simulations
analytical theory
experimental results
exact results for the model
theoretical predictions
testing the model
testing theories
explanations predictions

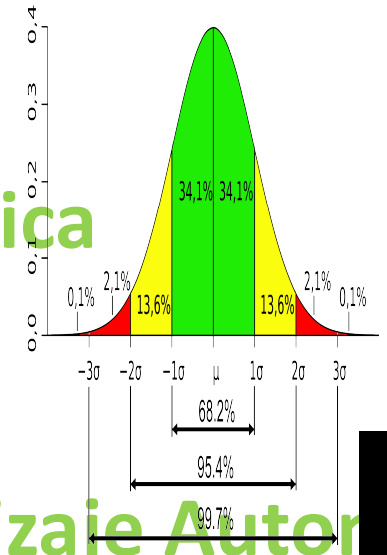
Modelos


Life Cycle of Data Science Project
UNDERSTANDING THE PROBLEM
GATHERING RELEVANT DATA
DATA PREPARATION & EDA
FEATURE ENGINEERING & FEATURE EXTRACTION
MODEL BUILDING &DEPLOYMENT

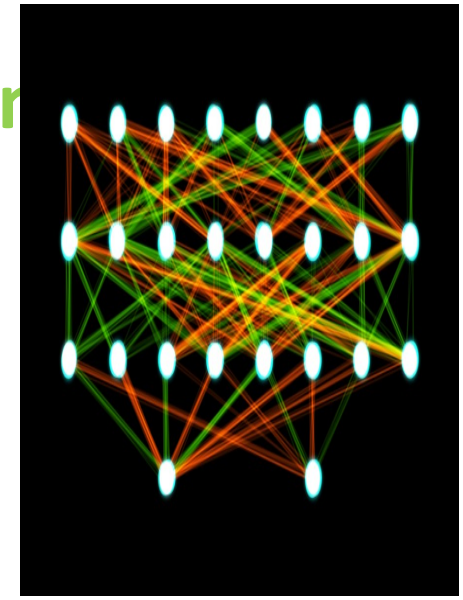
Modelos

Dos Tipos de Culturas de Análisis de Datos:

Estadística



Aprendizaje Autor



Modelos

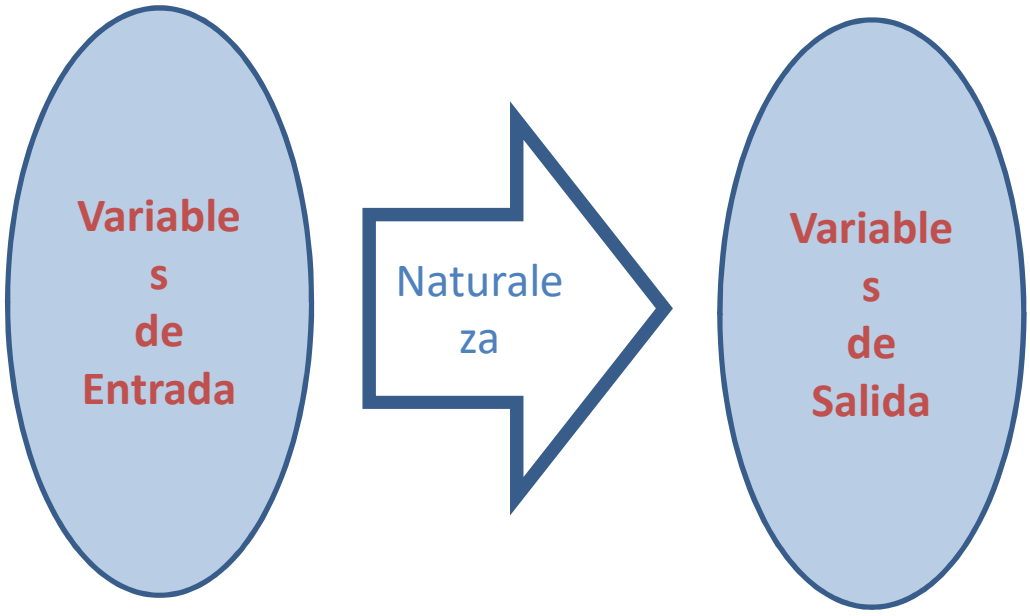
Dos Tipos de Culturas de Análisis de Datos:

Estadística Impone relación a priori entre variables de entrada y salida

Aprendizaje Automático Asume relación desconocida, trata de suponerla adaptándose de forma más flexible a cada conjunto concreto de datos

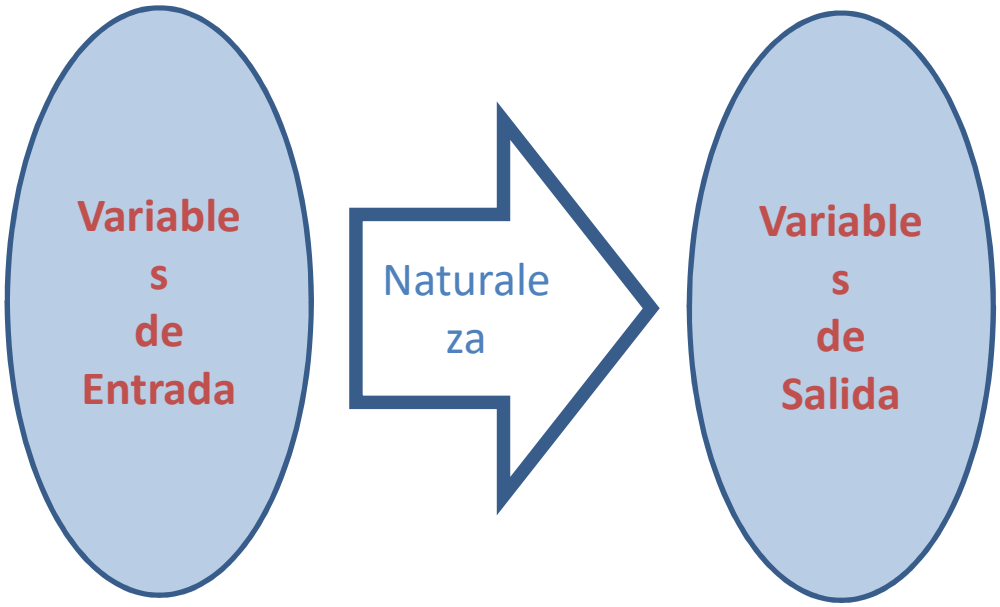
Modelos

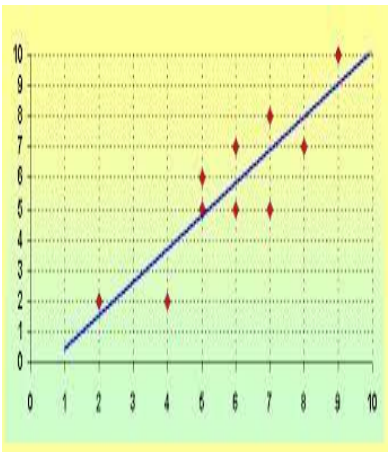
Dos Tipos de Culturas de Análisis de Datos:



Modelos

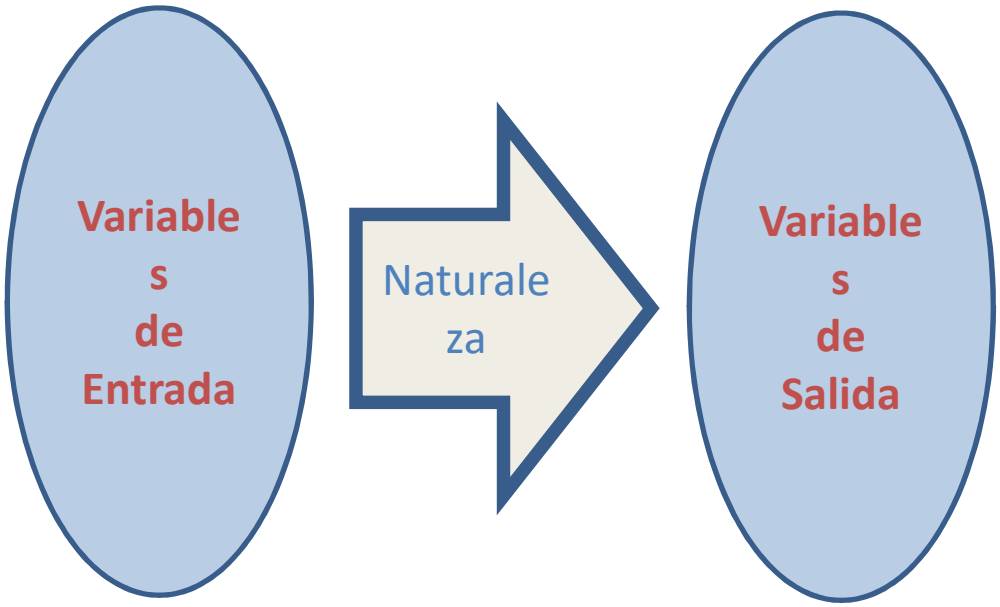
Estadística

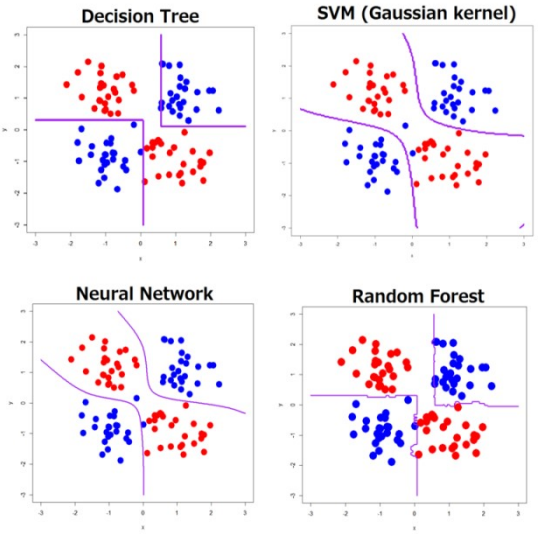




Modelos

Aprendizaje Automático





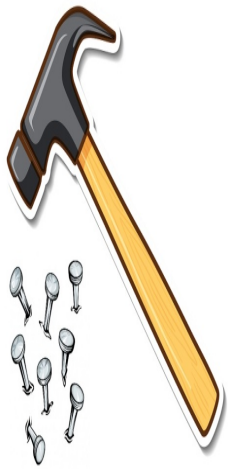
Modelos

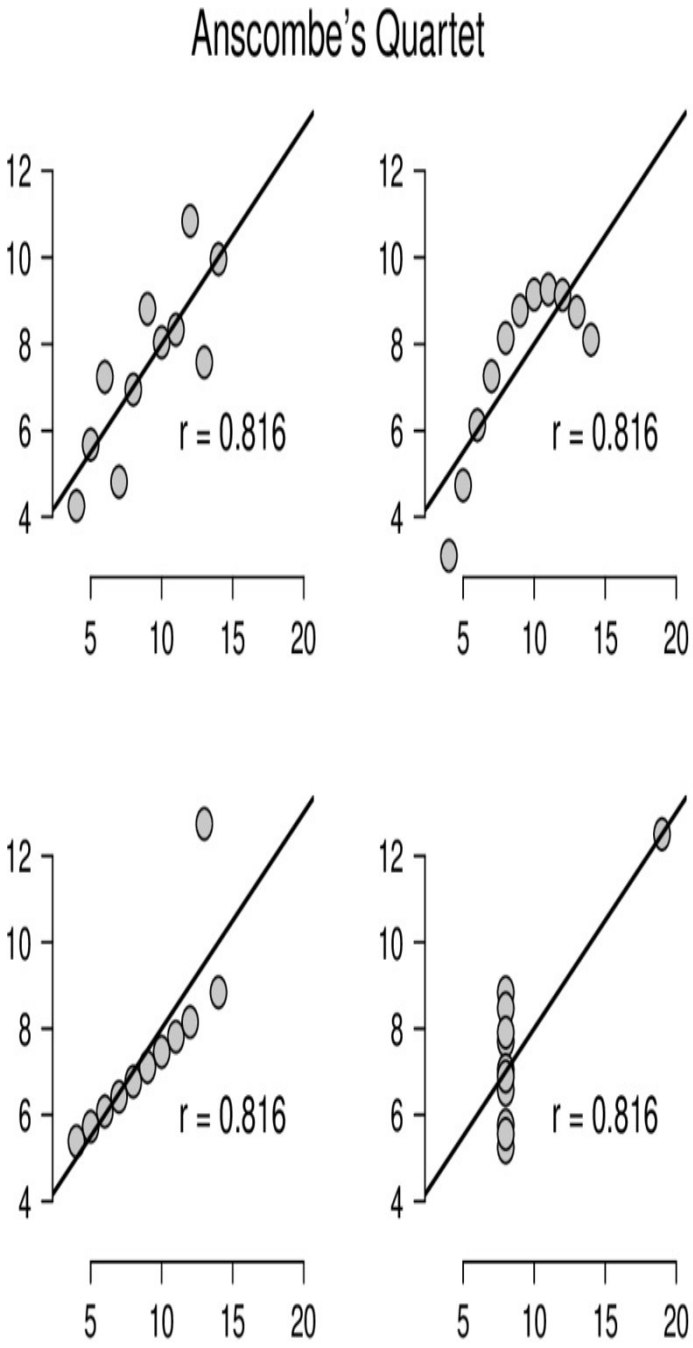
Ejemplo de la imposición de un modelo de datos a priori (recta):

IGUAL CORRELACIÓN

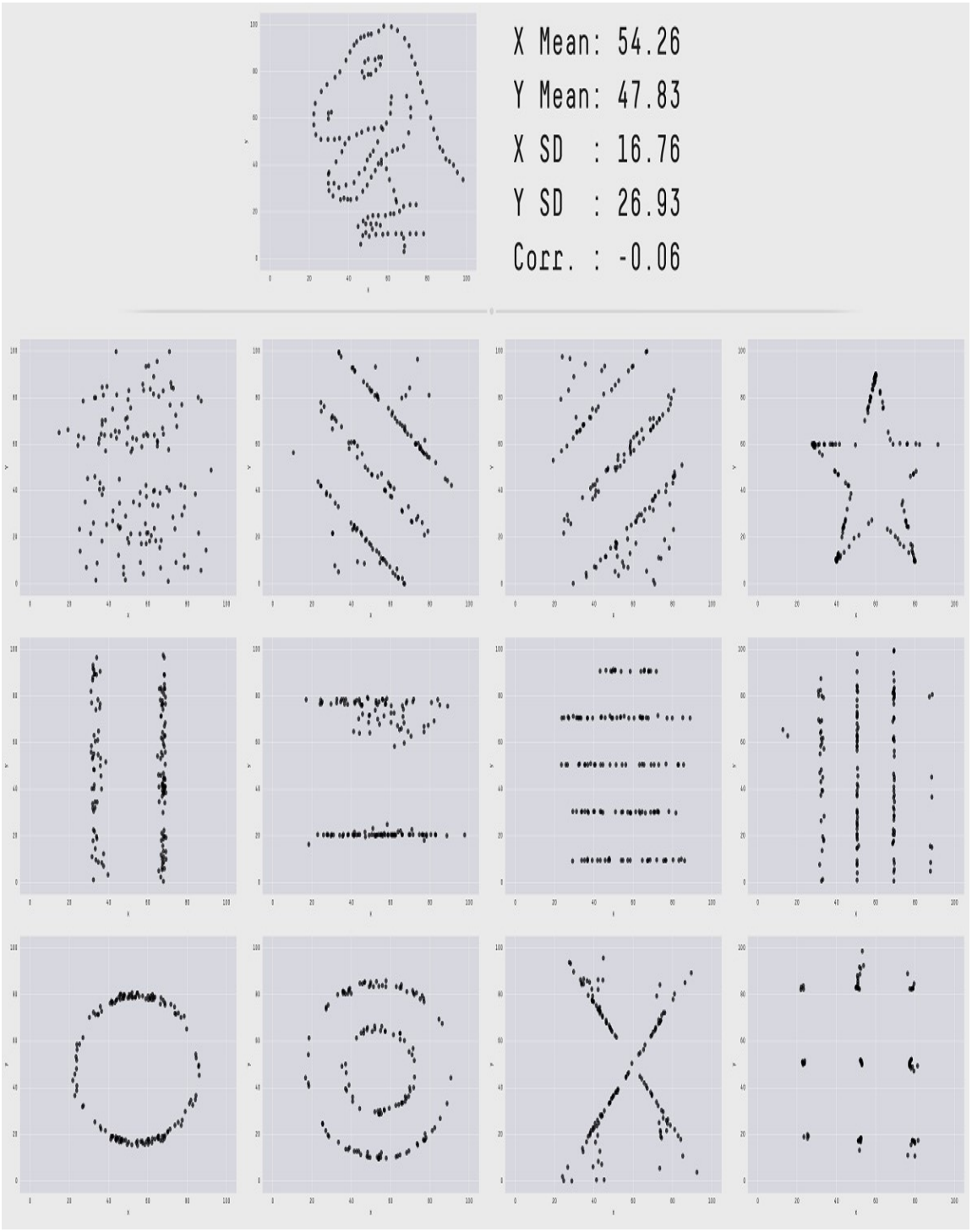
PERO…

RELACIÓN MUY DIFERENTE ENTRE VARIABLES !!

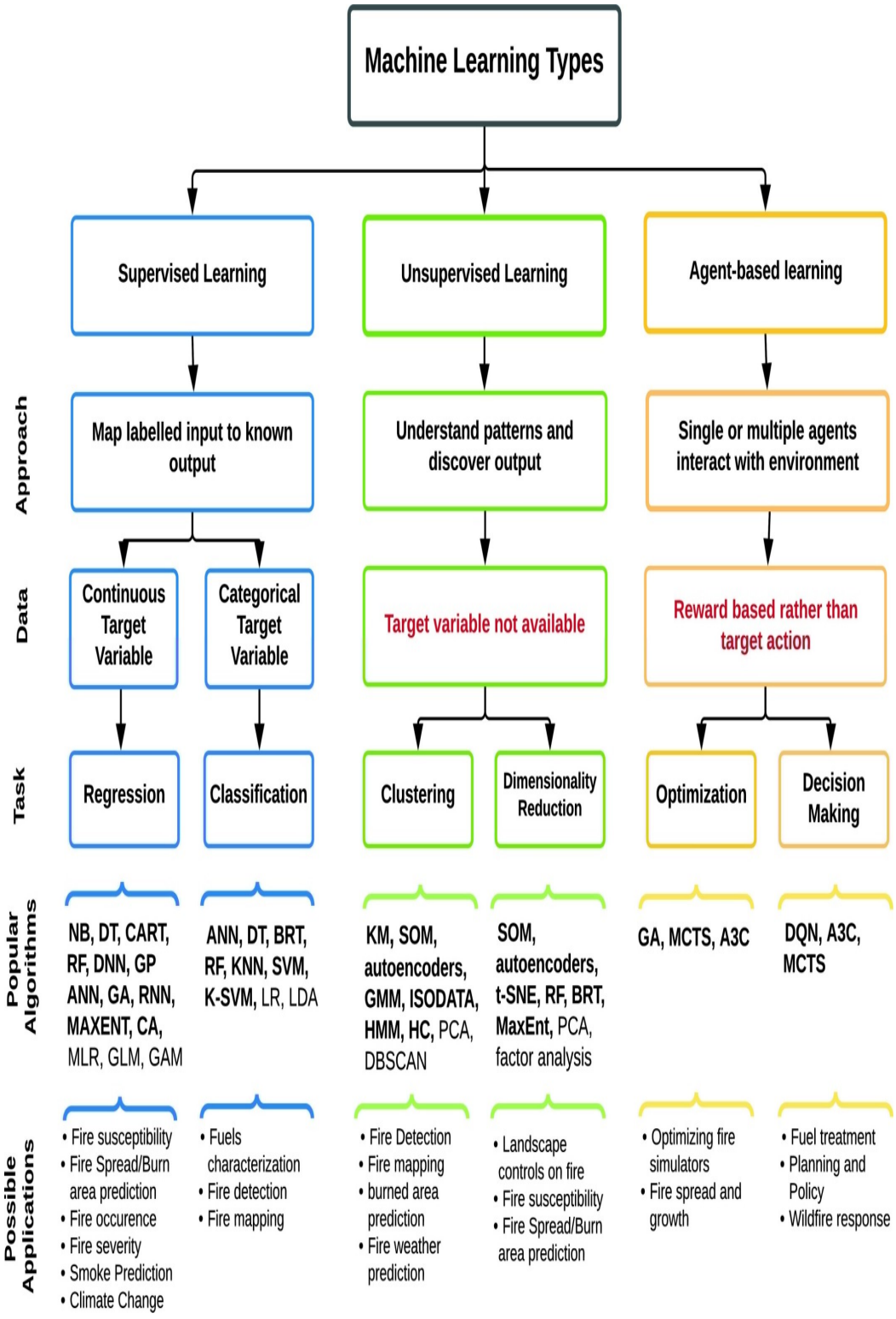




Modelos

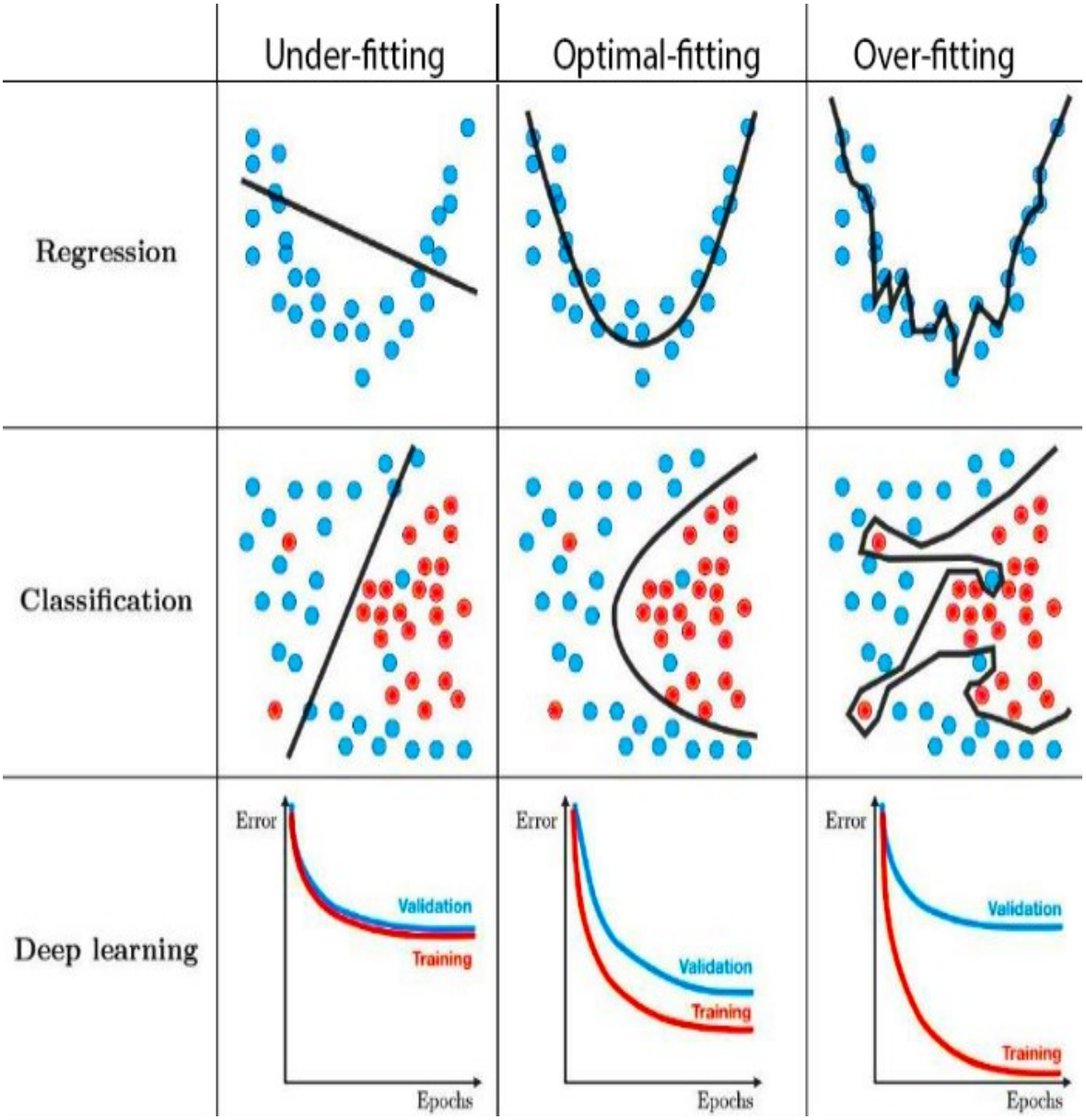


Modelos


Machine Learning Types
Supervised Learning
Unsupervised Learning
Agent-based learning
Approach
Map labelled input to known output
Understand patterns and discover output
Single or multiple agents interact with environment
Data
Continuous Target Variable
Categorical Target Variable
Target variable not available
Reward based rather than target action
Task
Regression
Classification
Clustering
Dimensionality Reduction
Optimization
Decision Making
Popular Algorithms
NB, DT, CART, RF, DNN, GP ANN, GA, RNN, MAXENT, CA, MLR, GLM, GAM
ANN, DT, BRT, RF, KNN, SVM, K-SVM, LR, LDA
KM, SOM, autoencoders, GMM, ISODATA, HMM, HC, PCA, DBSCAN
SOM, autoencoders, t-SNE, RF, BRT, MaxEnt, PCA, factor analysis
GA, MCTS, A3C
DQN, A3C, MCTS
Possible Applications
• Fire susceptibility
• Fire Spread/Burn area prediction
• Fire occurence
• Fire severity
• Smoke Prediction
• Climate Change
• Fuels characterization
• Fire detection
• Fire mapping
• Fire Detection
• Fire mapping
• burned area prediction
• Fire weather prediction
• Landscape controls on fire
• Fire susceptibility
• Fire Spread/Burn area prediction
• Optimizing fire simulators
• Fire spread and growth
• Fuel treatment
• Planning and Policy
• Wildfire response

Modelos

Sobreajuste



Modelos

Aprendizaje Automático inspirado en el cerebro

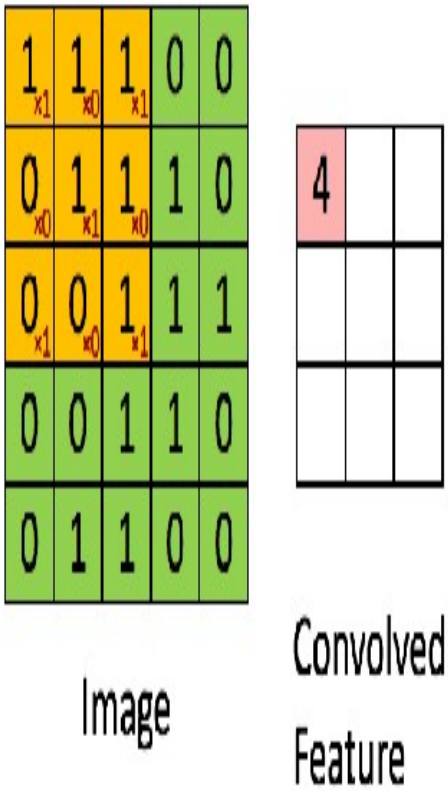
Redes Neuronales Artificiales

Aprendizaje profundo

Inspirarse en el cerebro para estudiar el cerebro

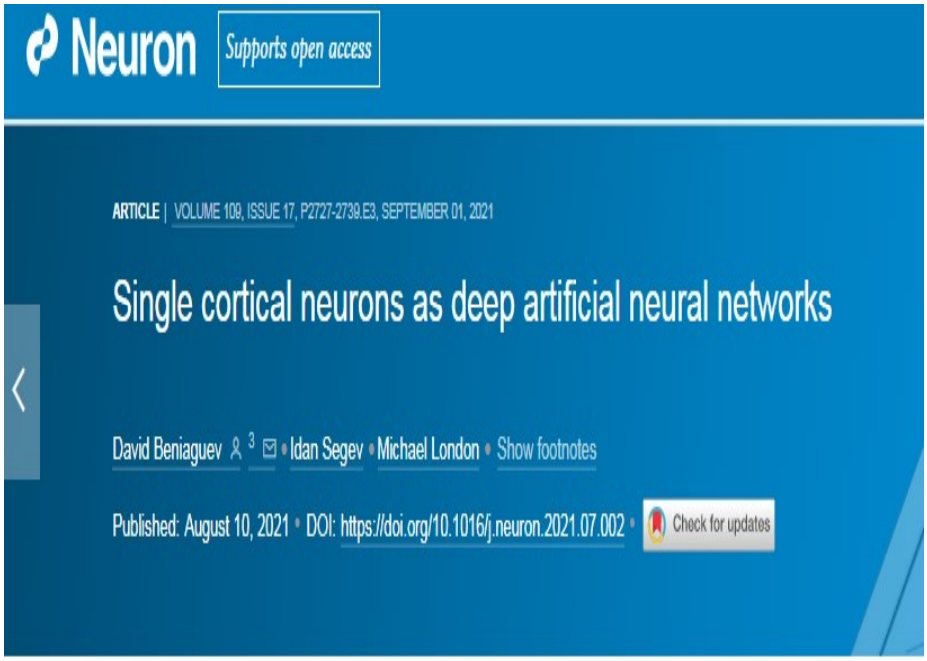
Modelos

Aprendizaje Automático inspirado en el cerebro



Modelos

Aprendizaje Automático inspirado en el cerebro: No tan Simple



Simulación

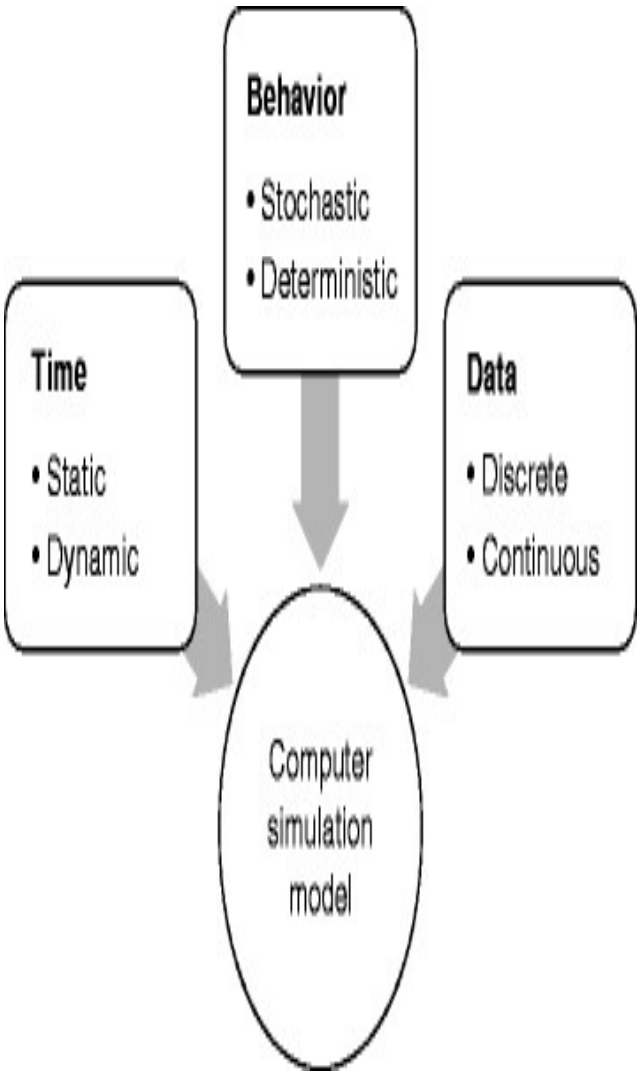
Proceso de ejecución de un modelo.

Se construye un modelo y a continuación se ejecuta una simulación

Genera el comportamiento descrito por el modelo, le da “vida”

Simulación

Proceso de ejecución de un modelo.



Simulación

Sirve para contrastar

Predicciones teóricas

Resultados Experimentales

Simulación

The Virtual Brain

Simulación de Cerebro Neuroinformática

Información Estructural, Funcional, Conectividad

EEG, RMNf, DTI

Gratuito, Código Abierto

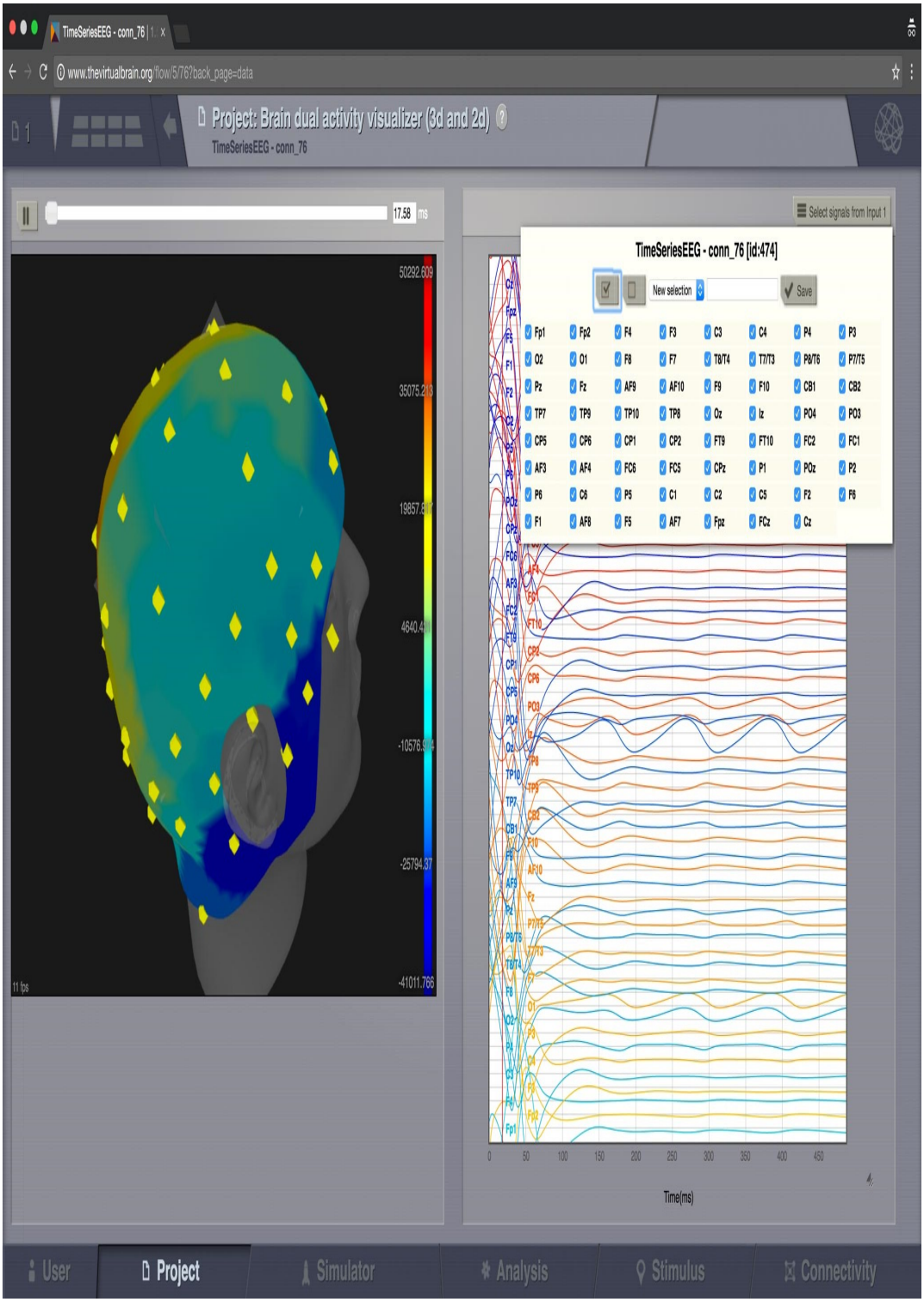
Pretende producir hipótesis comprobables y falseables

Simulación

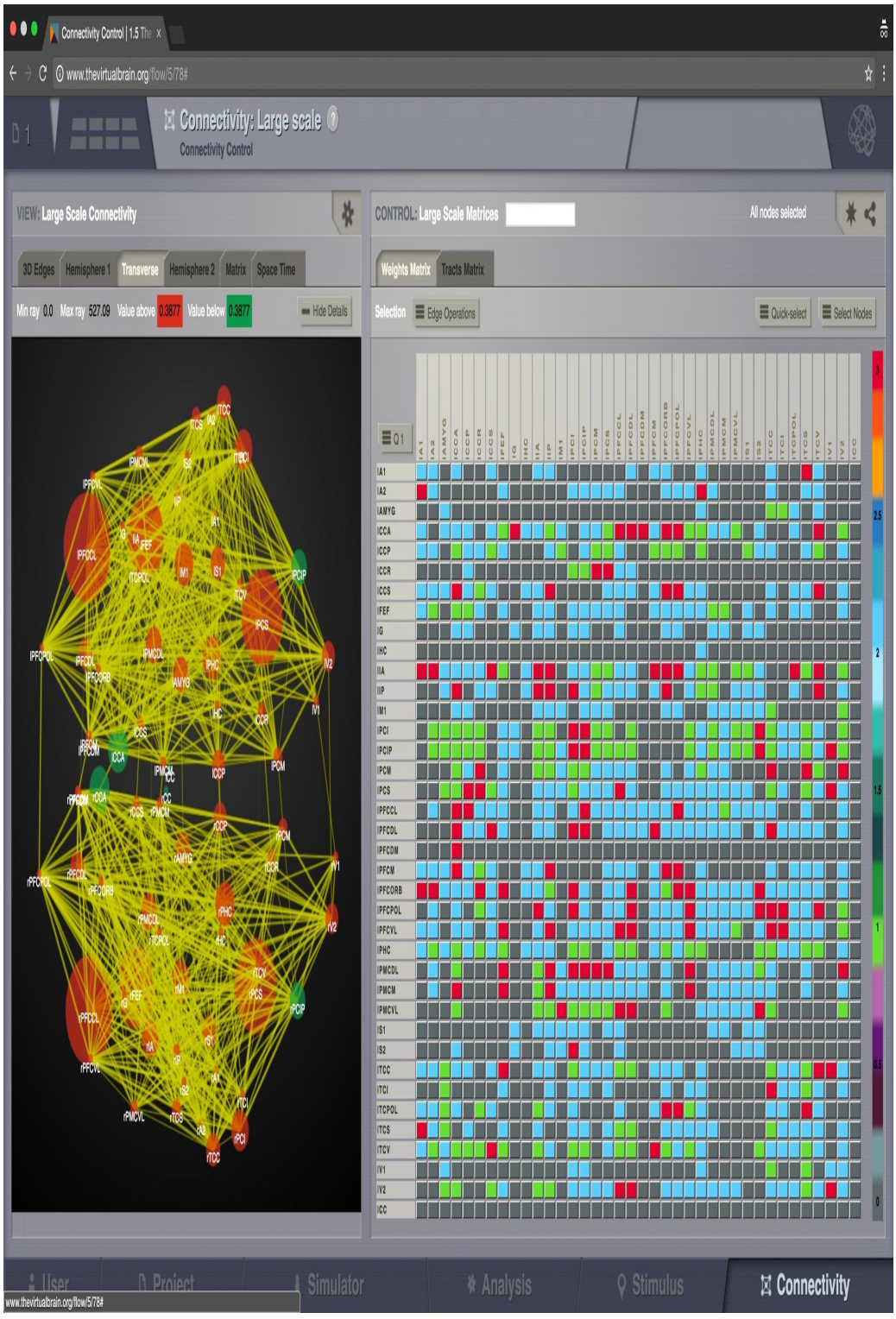
The Virtual Brain Investigaciones

Epilepsia Resistente a Fármacos
Ictus
Enfermedad de Alzheimer
Envejecimiento
Esquizofrenia
Terapia de Estimulación Cerebral

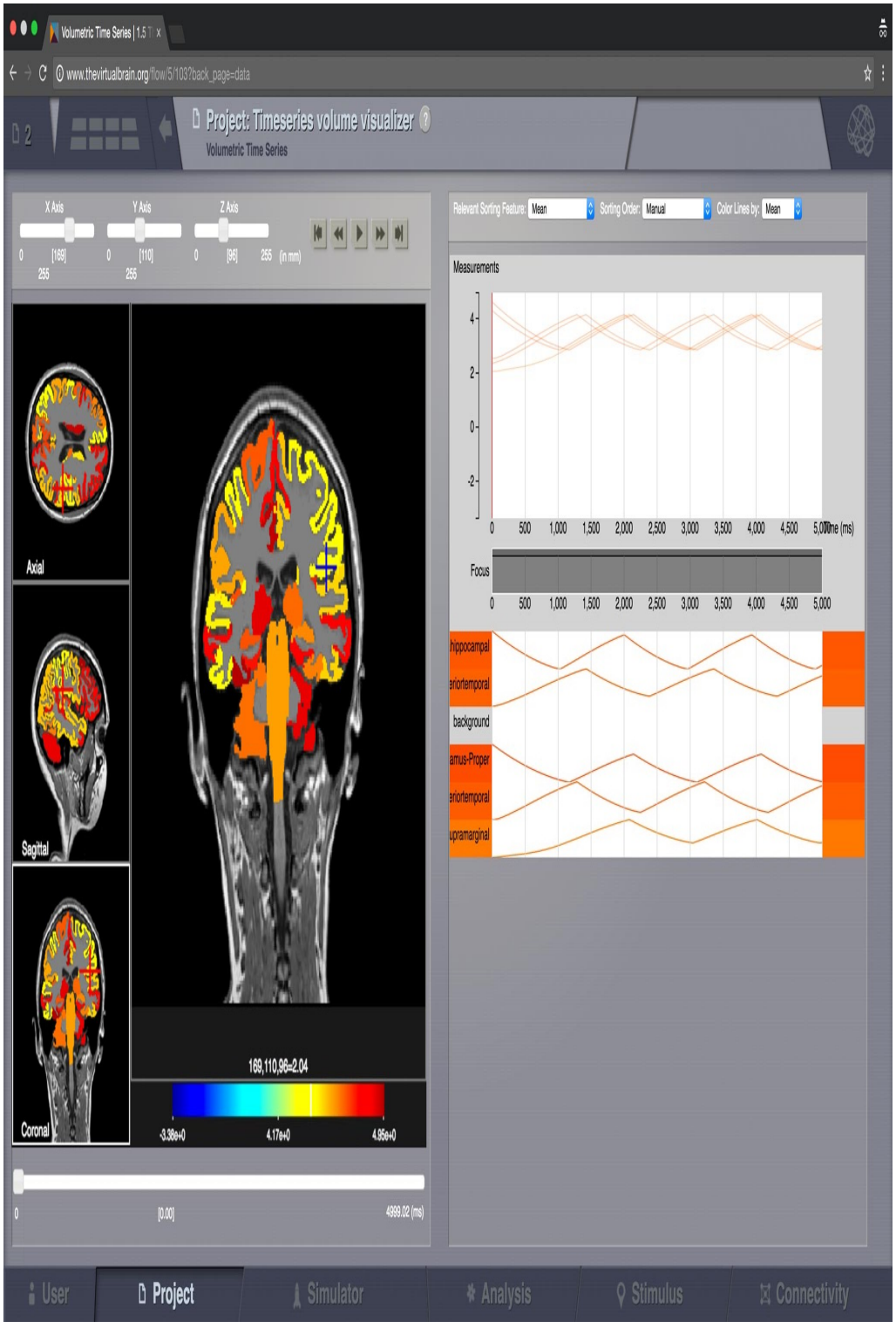
Simulación


TimeSeriesEEG - conn_76
www.thevirtualbrain.org/flow/5/76?back_page=data
Project: Brain dual activity visualizer (3d and 2d)
TimeSeriesEEG - conn_76
17.58 ms
50292.609
35075.213
19857.817
4640.4
-10576.9
-25794.37
-41011.766
11 fps
Select signals from Input 1
TimeSeriesEEG - conn_76 [id:474]
New selection
Save
Fp1 Fp2 F4 F3 C3 C4 P4 P3
O2 O1 F8 F7 T8/T4 T7/T3 P8/T6 P7/T5
Pz Fz AF9 AF10 F9 F10 CB1 CB2
TP7 TP9 TP10 TP8 Oz Iz PO4 PO3
CP5 CP6 CP1 CP2 FT9 FT10 FC2 FC1
AF3 AF4 FC6 FC5 CPz P1 POz P2
P6 C6 P5 C1 C2 C5 F2 F6
F1 AF8 F5 AF7 Fpz FCz Cz
0 50 100 150 200 250 300 350 400 450
Time(ms)
User
Project
Simulator
Analysis
Stimulus
Connectivity

Simulación


Connectivity Control | 1.5
www.thevirtualbrain.org/flow/578#
Connectivity: Large scale
Connectivity Control
VIEW: Large Scale Connectivity
CONTROL: Large Scale Matrices
All nodes selected
3D Edges
Hemisphere 1
Transverse
Hemisphere 2
Matrix
Space Time
Weights Matrix
Tracts Matrix
Min ray 0.0
Max ray 527.09
Value above 0.3877
Value below 0.3877
Hide Details
Selection
Edge Operations
Quick-select
Select Nodes
User
Project
Simulator
Analysis
Stimulus
Connectivity

Simulación


Volumetric Time Series | 1.5 T
www.thevirtualbrain.org/flow/5/103?back_page=data
Project: Timeseries volume visualizer
Volumetric Time Series
X Axis
Y Axis
Z Axis
Relevant Sorting Feature:
Mean
Sorting Order:
Manual
Color Lines by:
Mean
Measurements
Axial
Sagittal
Coronal
Focus
hippocampal
eriorlemporal
background
amus-Proper
eriorlemporal
upramarginal
169,110,96=2.04
-3.38e+0
4.17e+0
4.95e+0
4999.02 (ms)
User
Project
Simulator
Analysis
Stimulus
Connectivity

Simulación

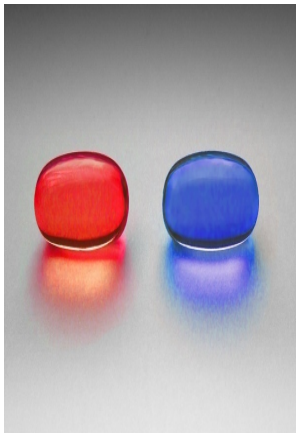
“ All models are wrong, but some are useful “

Conciencia

Nosotros construimos modelos sobre el cerebro

pero…

El cerebro también construye modelos sobre nosotros



Conciencia

Modelo Interno: Conjunto de información codificada en el complejo patrón de actividad de las neuronas

Simplificación esquemática de la realidad

Útil para hacer predicciones y facilitar el control

Conciencia

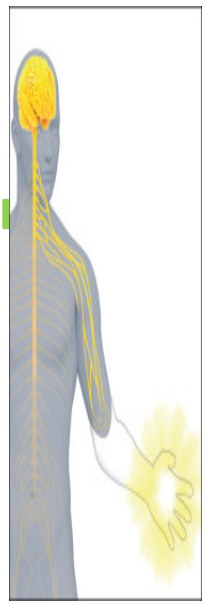
Modelo Interno del brazo y el brazo real

AMPUTACIÓN

Modelo Interno sin el brazo, Miembro Fantasma, percibe sensaciones en el brazo como si aún existiera.

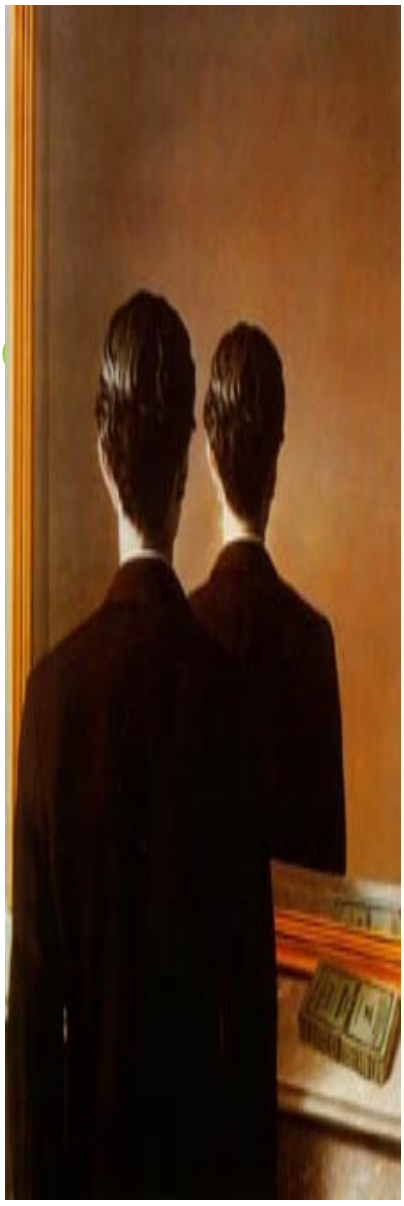
LESIÓN CEREBRAL:

Brazo sin el Modelo Interno, cree que n suyo



Conciencia

Modelo Interno del brazo y el brazo real



LESIÓN CEREBRAL:

Brazo sin el Modelo Interno, cree suyo

Tratamiento: Mirror Therapy

Cuando se ve como otro cobra conciencia de si mismo

Conciencia

El cerebro elabora automática y continuamente modelos de objetos del mundo exterior y de su propio esquema corporal para ser capaz de controlar como nos movemos e interactuamos físicamente en la realidad.

Pero puede modelar y simular funciones más abstractas e intangibles

Conciencia

Un problema fundamental de un sistema nervioso

- Sobrecarga de Información Sensorial -

Debe priorizar unas señale

Circuitos neuronales espec

Controlador centralizado d

Conciencia

El cerebro puede modelar funciones más abstractas e intangibles

Al igual que crea un modelo del brazo para planificar movimientos

Puede crear un modelo de si mismo

De una sus funciones más importantes: la Atención

Que la dirija, planifique su dinámica, informe que está haciendo y cuales son sus consecuencias

Conciencia

Este Módulo de Control de la Atención o Esquema de la Atención

Seria percibido como una esencia etérea, fantasmagórica

Lo que modela y controla no es algo inmediatamente físico

Cualquier máquina con un módulo semejante estaría convencida de se consciente

Teoría del Esquema de Atención: M Graziano

Conciencia

The attention schema theory in a neural network agent: Controlling visuospatial attention using a descriptive model of attention

Andrew I. Wilterson[a] and Michael S. A. Graziano[a,b,1]

[a]Department of Psychology, Princeton University, Princeton, NJ 08544; and [b]Princeton Neuroscience Institute, Princeton University, Princeton, NJ 08544

Edited by Gregg H. Recanzone, University of California, Davis, CA, and accepted by Editorial Board Member Michael S. Gazzaniga July 7, 2021 (received for review February 5, 2021)

In the attention schema theory (AST), the brain constructs a model of attention, the attention schema, to aid in the endogenous control of attention. Growing behavioral evidence appears to support the presence of a model of attention. However, a central question remains: does a controller of attention actually benefit by having access to an attention schema? We constructed an artificial deep Q-learning neural network agent that was trained to control a simple form of visuospatial attention, tracking a stimulus with an attention spotlight in order to solve a catch task. The agent was tested with and without access to an attention schema. In both conditions, the agent received sufficient information such that it should, theoretically, be able to learn the task. We found that with an attention schema present, the agent learned to control its attention spotlight and learned the catch task. Once the agent learned, if the attention schema was then disabled, the agent's performance was greatly reduced. If the attention schema was removed before learning began, the agent was impaired at learning. The results show how the presence of even a simple attention schema can provide a profound benefit to a controller of attention. We interpret these results as supporting the central argument of AST: the brain contains an attention schema because of its practical benefit in the endogenous control of attention.

attention | internal model | machine learning | deep learning | awareness

For at least 100 y, the study of how the brain controls movement has been heavily influenced by the principle that the brain constructs a model of the body (1–10). Sometimes the model is conceptualized as a description (a representation of the shape and jointed structure of the body, including how it is currently positioned and moving). Sometimes it is conceptualized as a prediction engine (generating predictions about the body's likely states in the immediate future and how motor commands are likely to manifest as limb movements). Both the descriptive and predictive components are important and together form the brain's complex, multicomponent model of the body, sometimes called the body schema. The body schema is probably instantiated in a distributed manner across the entire somatosensory and motor system, including high-order somatosensory areas such as cortical area 5 and frontal areas such as premotor and primary motor cortex (2, 11–14). Without a correctly functioning body schema, the control of movement is virtually impossible. Even beyond movement control, the realization that any good controller requires a model of the thing it controls has become a general principle in engineering (15–17). Yet the importance of a model for good control has been mainly absent, for more than 100 y, from the study of attention—the study of how the brain controls its own focus of processing, directing it strategically among external stimuli and internal events.

Selective attention is most often studied as a phenomenon of the cerebral cortex (although it is not limited to the cortex). Sensory events, memories, thoughts, and other items are processed in the cortex, and among them, a select few win a competition for signal strength and dominate larger cortical networks (18–23). The process allows the brain to strategically focus its limited resources, deeply processing a few items and coordinating complex responses to them, rather than superficially processing everything available. In that sense, attention is arguably one of the most fundamental tricks that nervous systems use to achieve intelligent behavior. Attention has most often been studied in the visual domain, such as in the case of spatial attention, in which visual stimuli within a spatial "spotlight" of attention are processed with an enhanced signal relative to noise (23, 24). That spotlight of attention is not necessarily always at the fovea, in central vision, but can shift around the visual field to enhance peripheral locations. Classically, that spotlight of attention can be drawn to a stimulus exogenously (such as by a sudden change that automatically attracts attention) or can be directed endogenously (such as when a person chooses to direct attention from item to item).

The attention schema theory (AST), first proposed in 2011 (25–28), posits that the brain controls its own attention partly by constructing a descriptive and predictive model of attention. The proposed "attention schema," analogous to the body schema, is a constantly updating set of information that represents the basic functional properties of attention, represents its current state, and makes predictions such as how attention is likely to transition from state to state or to affect other cognitive processes. According to AST, this model of attention evolved because it provides a robust advantage to the endogenous control of attention, and in cases in which the model of attention is disrupted or makes errors, then the endogenous control of attention should be impaired (28–30).

Significance

Attention, the deep processing of select items, is one of the most important cognitive operations in the brain. But how does the brain control its attention? One proposed part of the mechanism is that the brain builds a model, or attention schema, that helps monitor and predict the changing state of attention. Here, we show that an artificial neural network agent can be trained to control visual attention when it is given an attention schema, but its performance is greatly reduced when the schema is not available. We suggest that the brain may have evolved a model of attention because of the profound practical benefit for the control of attention.

Author contributions: A.I.W. and M.S.A.G. designed research; A.I.W. performed research; A.I.W. and M.S.A.G. analyzed data; and A.I.W. and M.S.A.G. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission. G.H.R. is a guest editor invited by the Editorial Board.

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This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2102421118/-/DCSupplemental.

Published August 12, 2021.

Conciencia

Significance

Attention, the deep processing of select items, is one of the most important cognitive operations in the brain. But how does the brain control its attention? One proposed part of the mechanism is that the brain builds a model, or attention schema, that helps monitor and predict the changing state of attention. Here, we show that an artificial neural network agent can be trained to control visual attention when it is given an attention schema, but its performance is greatly reduced when the schema is not available. We suggest that the brain may have evolved a model of attention because of the profound practical benefit for the control of attention.

Una Red Neuronal Artificial configurada como un agente controlador de la atención se beneficia de un esquema de la atención

What’s the Matrix

Simulación interactiva neural ✓

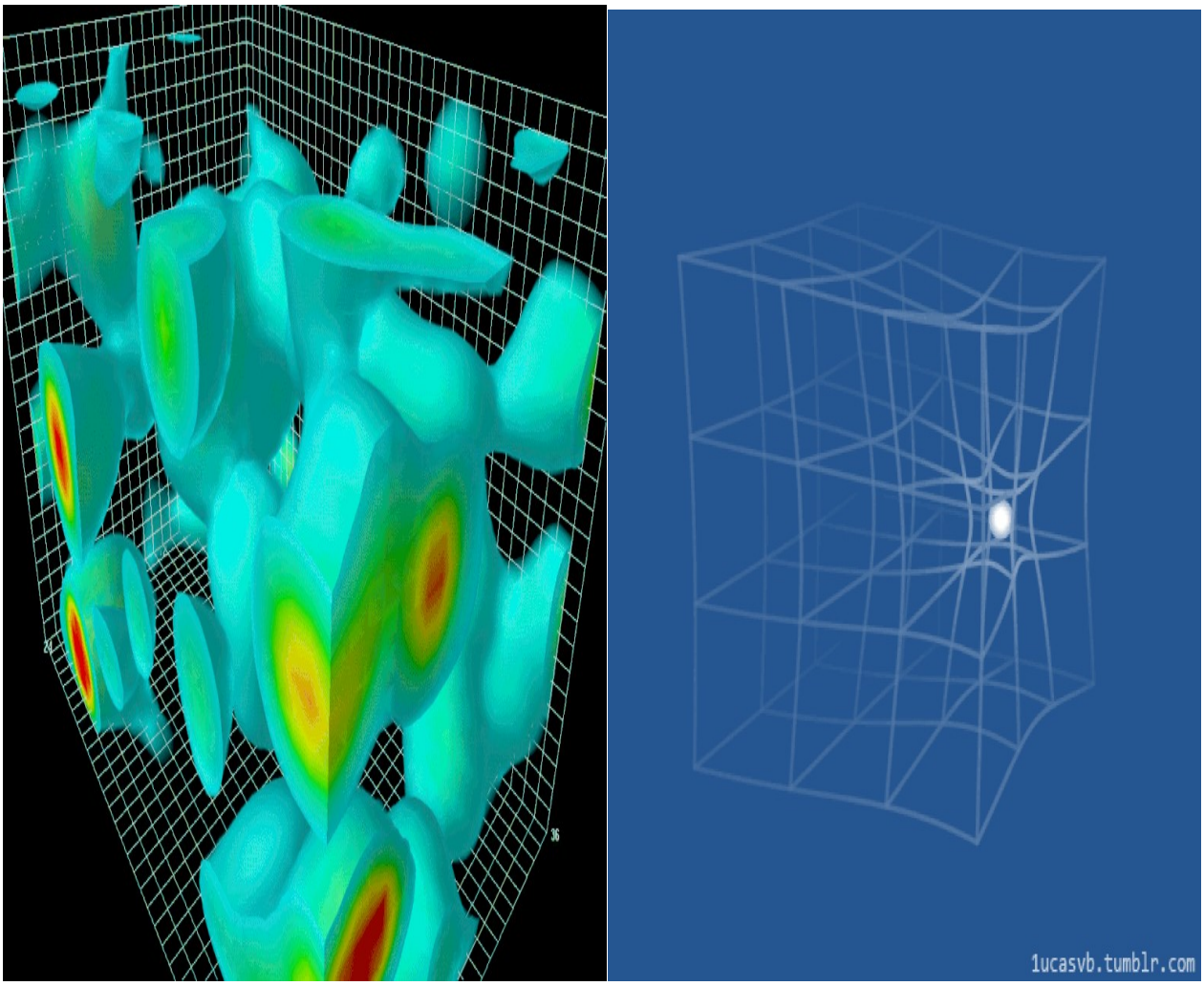
Un mundo de sueños generado por “ordenador” ✓

What’s the Matrix

El cerebro construye automáticamente modelos simplificados de la realidad

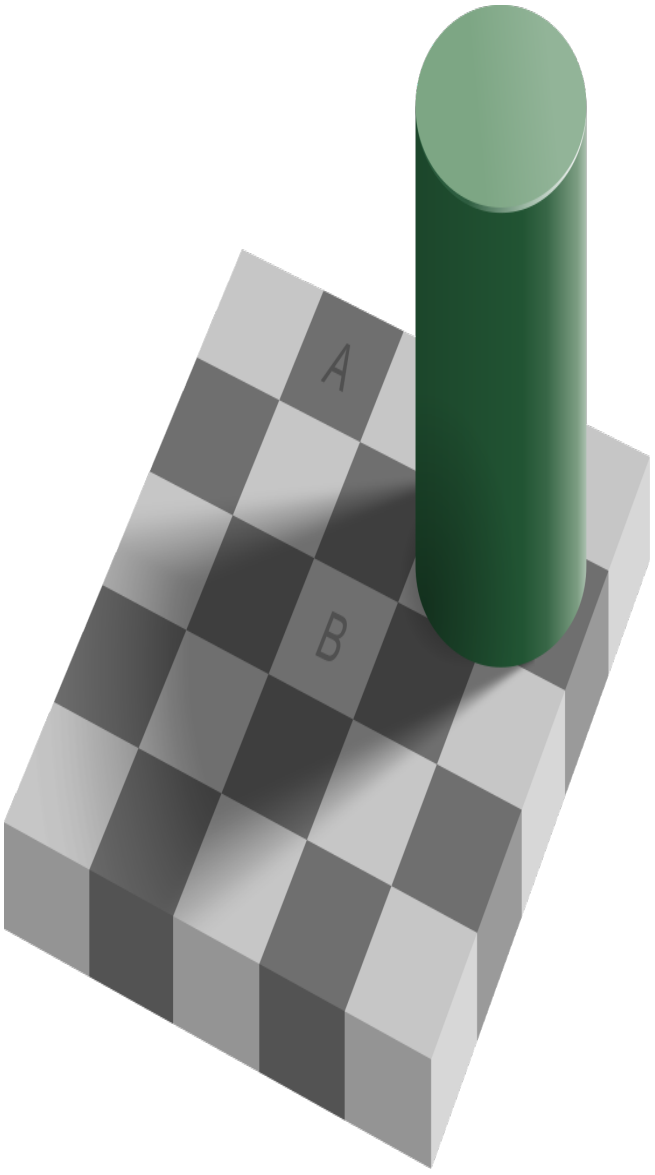
What’s the Matrix

El cerebro construye automáticamente modelos simplificados de la realidad



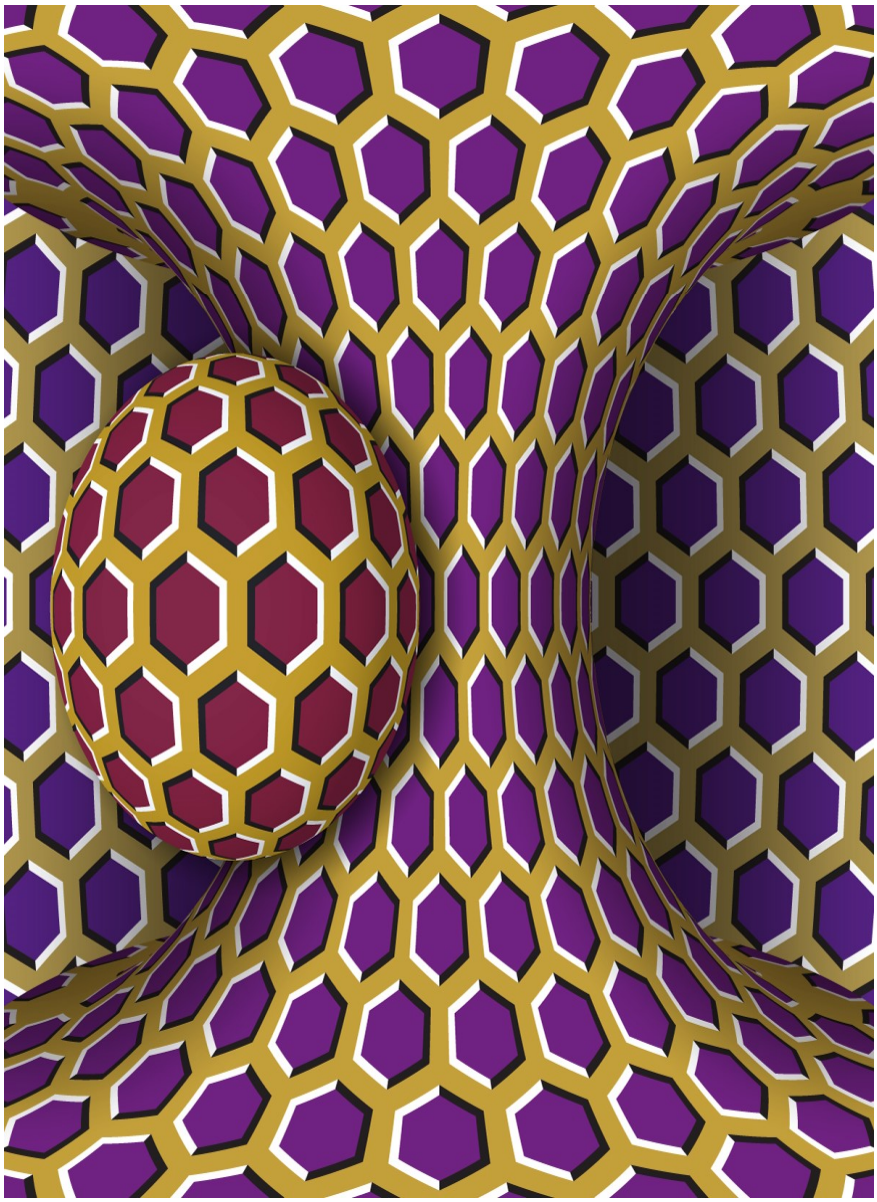
What’s the Matrix

Es prisionero de las limitaciones y errores de su propia simulación



What’s the Matrix

Es prisionero de las limitaciones y errores de su propia simulación



What’s Neuroinformatics