Neural Networks

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Metodos Computacionales I

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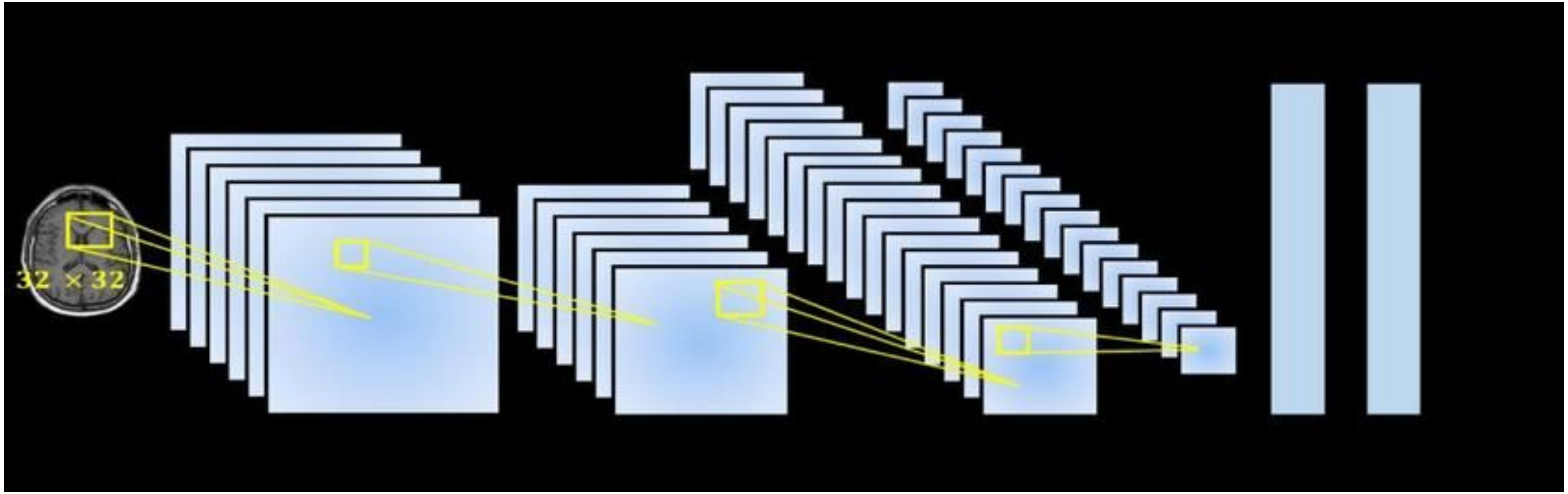
Applications: Image Processing with CNNs



(a) Normal (b) Benign (c) Malignant

Figure 1: Sample MRI Images

S. M. Anwar, M. Majid, A. Qayyum, M. Awais, M. Alnowami, and M. K. Khan, “Medical image analysis using convolutional neural networks: a review,” Journal of Medical Systems, vol. 42, no. 11, p. 226, 2018 Oct 8.

Applications: Natural Language Processing

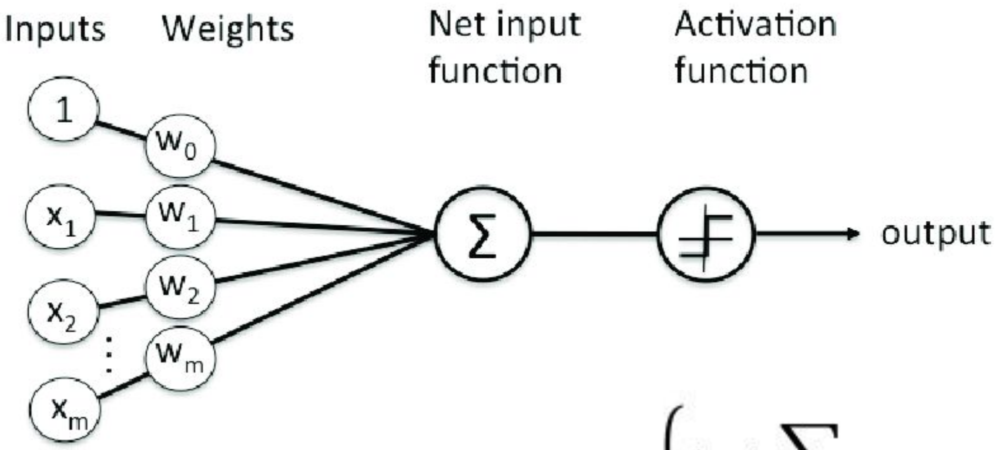
https://devopedia.org/natural-language-processing

Origins: Perceptron

Psychological Review
Vol. 65, No. 6, 1958

THE PERCEPTRON: A PROBABILISTIC MODEL FOR INFORMATION STORAGE AND ORGANIZATION IN THE BRAIN[1]

F. ROSENBLATT



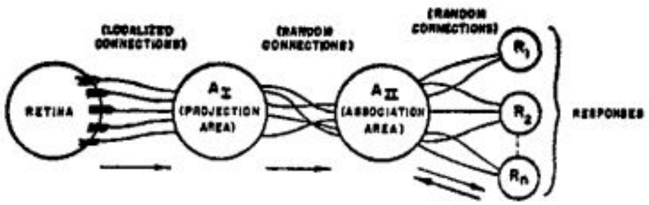


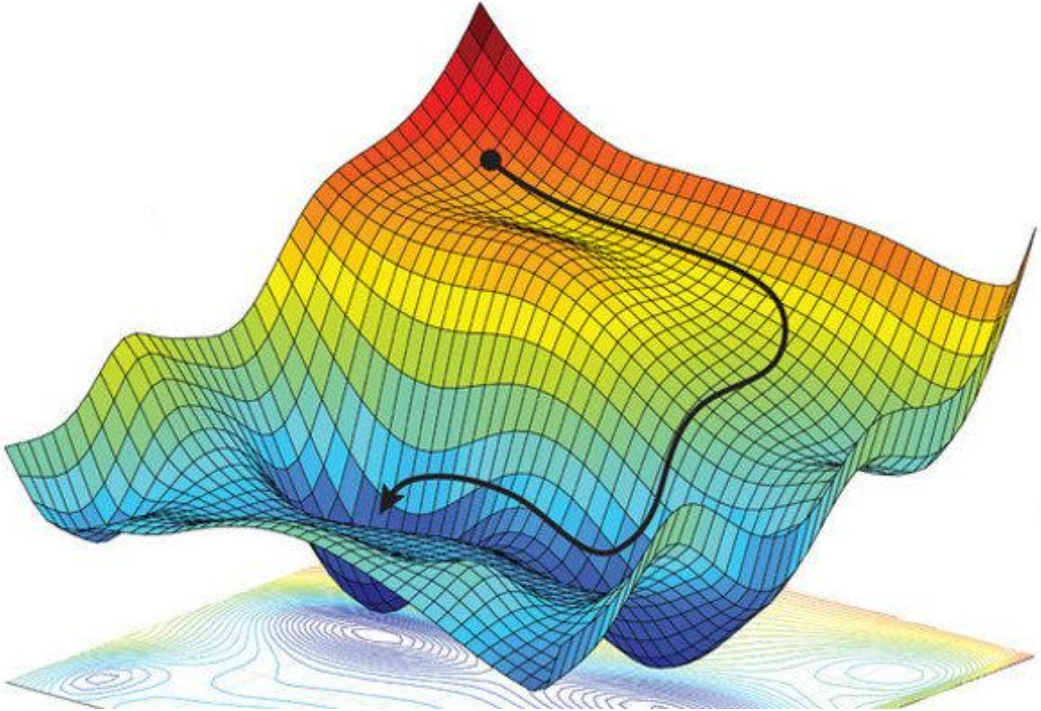
FIG. 1. Organization of a perceptron.

$$salida = \begin{cases} 1 \; si \; \sum_i w_i . x_i \geq umbral \\ 0 \; si \; \sum_i w_i . x_i < umbral \end{cases}$$

Gradient Descent Algorithm

Gradient descent algorithm

$$\text{repeat until convergence } \{$$
$$\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta_0, \theta_1)$$
$$(\text{for } j = 1 \text{ and } j = 0)$$
$$\}$$



A. Amini, A. Soleimany, S. Karaman, and D. Rus, “Spatial Uncertainty Sampling for End-to-End control,” in Neural Information Processing Systems (NIPS); Bayesian Deep Learning Workshop, 2017.

Backpropagation

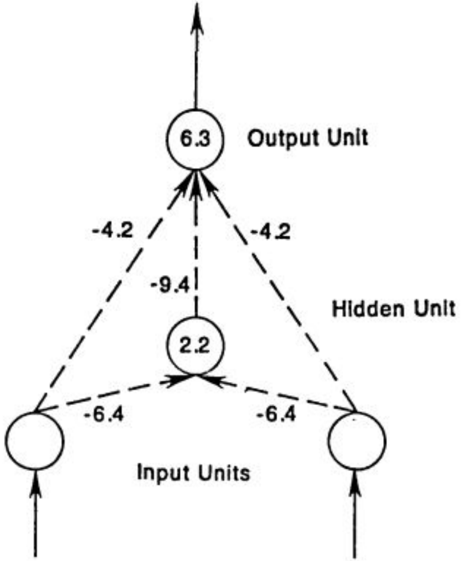


FIGURE 3. Observed XOR network. The connection weights are written on the arrows and the biases are written in the circles. Note a positive bias means that the unit is on unless turned off.

LEARNING INTERNAL REPRESENTATIONS BY ERROR PROPAGATION

David E. Rumelhart, Geoffrey E. Hinton, and Ronald J. Williams

September 1985

Not surprisingly, the contribution of unit u_j to the error is simply proportional to δ_{pj}. Moreover, since we have linear units,

$$o_{pj} = \sum_i w_{ji} i_{pi}, \tag{5}$$

from which we conclude that

$$\frac{\partial o_{pj}}{\partial w_{ji}} = i_{pi}.$$

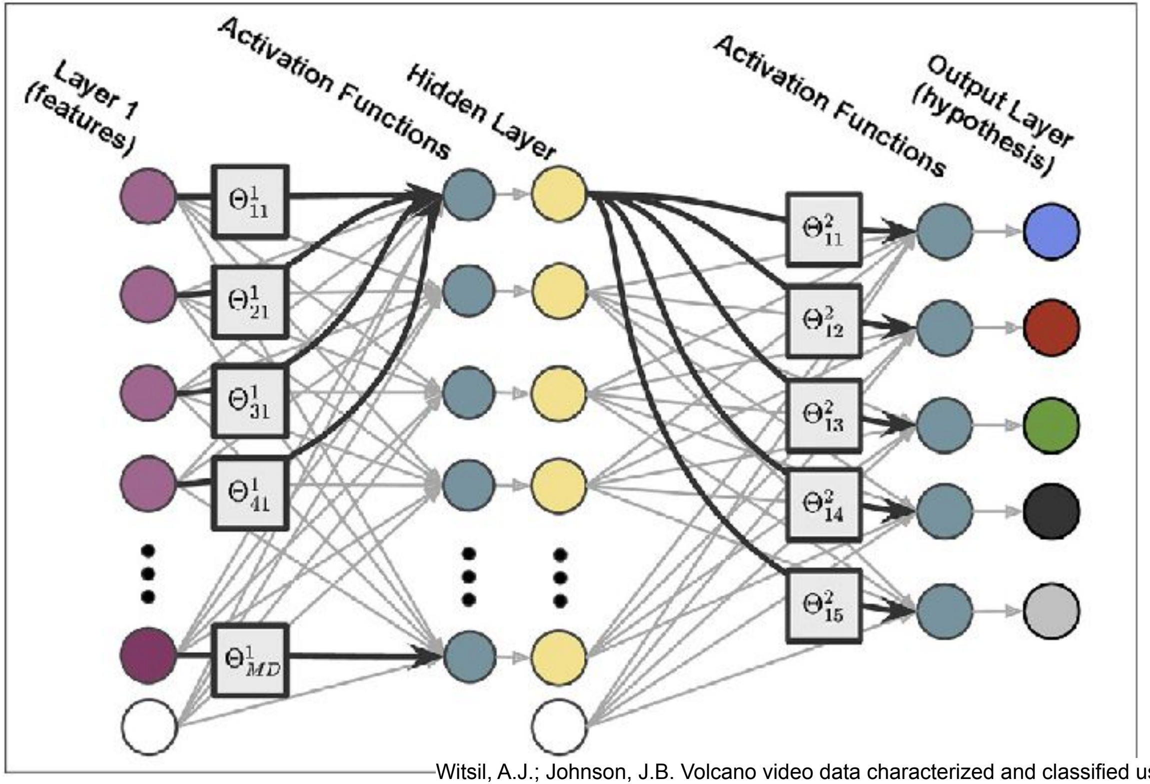
Thus, substituting back into Equation 3, we see that

$$-\frac{\partial E_p}{\partial w_{ji}} = \delta_{pj} i_i \tag{6}$$

as desired. Now, combining this with the observation that

$$\frac{\partial E}{\partial w_{ji}} = \sum_p \frac{\partial E_p}{\partial w_{ji}}$$

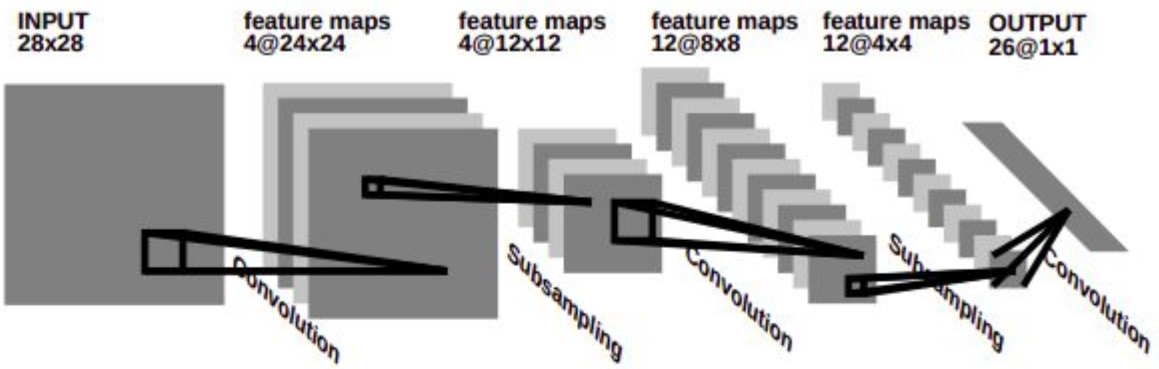
Multilayer Perceptrons and Dense NNs.



Witsil, A.J.; Johnson, J.B. Volcano video data characterized and classified using computer vision and machine learning algorithms. Geosci. Front. 2020,11, 1789–1803

Convolutional NNs

Convolutional Networks for Images, Speech, and Time-Series



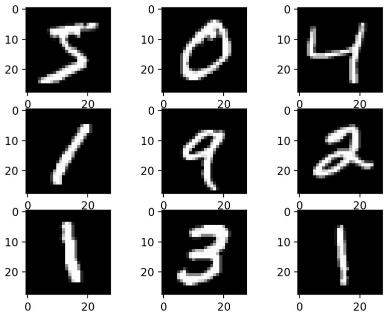
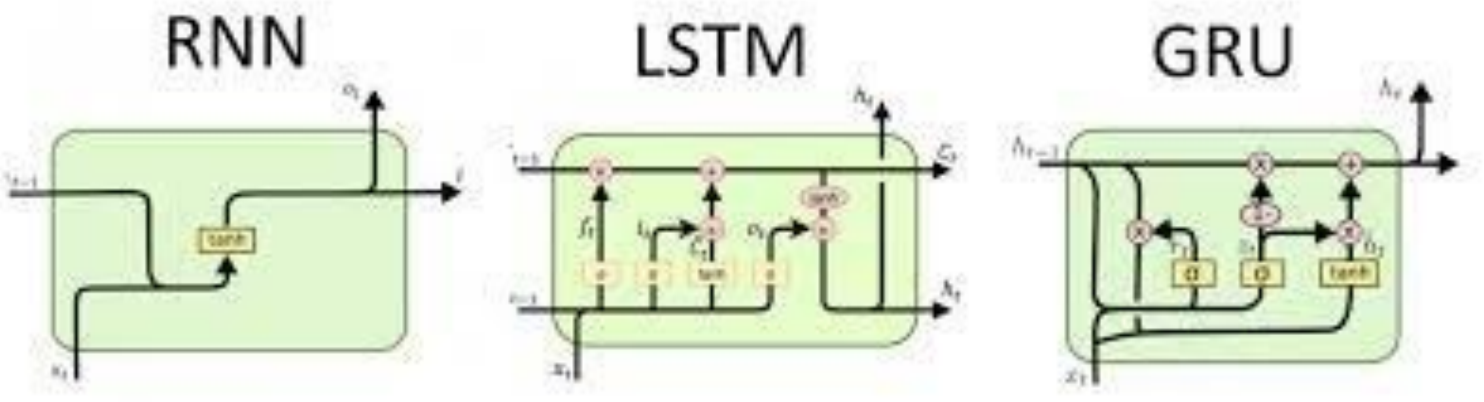


Figure 1: Convolutional Neural Network for image processing, e.g., handwriting recognition

LeCun, Y. and Bengio, Y., 1995. Convolutional networks for images, speech, and time series. The handbook of brain theory and neural networks, 3361(10), p.1995.

Recurrent Neural Networks for text Processing



https://medium.com/analytics-vidhya/recurrent-neural-network-and-its-variants-de75f9ee063

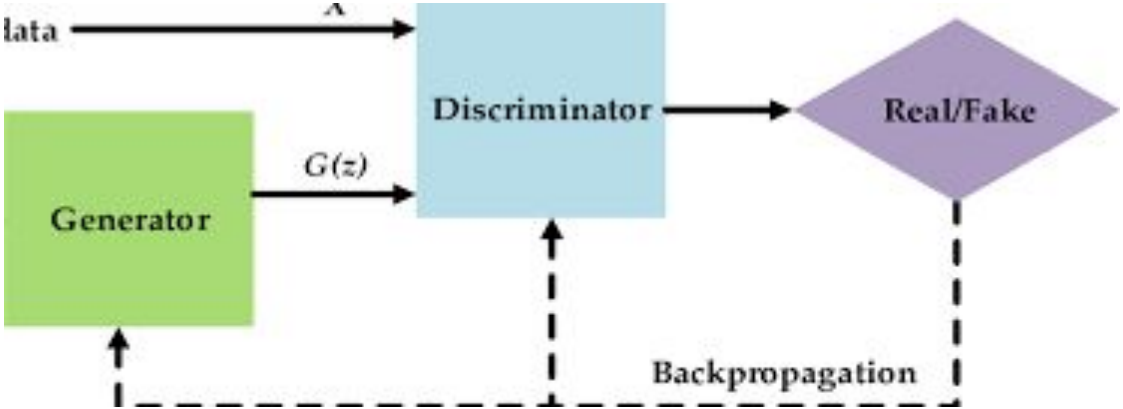
More Recent Deep Learning Proposals

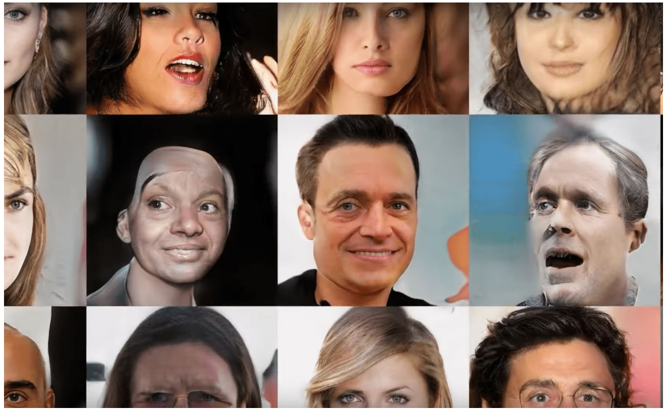
Generative Adversarial Networks (GANs)

Generative Adversarial Nets

Ian J. Goodfellow, Jean Pouget-Abadie*, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair†, Aaron Courville, Yoshua Bengio‡

https://www.youtube.com/watch?v=YOgGaMMwf0E&ab_channel=PopcornEntertainment





Goodfellow, I.; Pouget-Abadie, J.; Mirza, M.; Xu, B.; Warde-Farley, D.; Ozair, S.; Courville, A.C.; Bengio, Y. Generative adversarial networks. Commun. ACM 2020,63, 139–144.

Transformers

Attention Is All You Need

Ashish Vaswani* Google Brain avaswani@google.com

Noam Shazeer* Google Brain noam@google.com

Niki Parmar* Google Research nikip@google.com

Jakob Uszkoreit* Google Research usz@google.com

Llion Jones* Google Research llion@google.com

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Łukasz Kaiser* Google Brain lukaszkaiser@google.com

Illia Polosukhin* ‡ illia.polosukhin@gmail.com

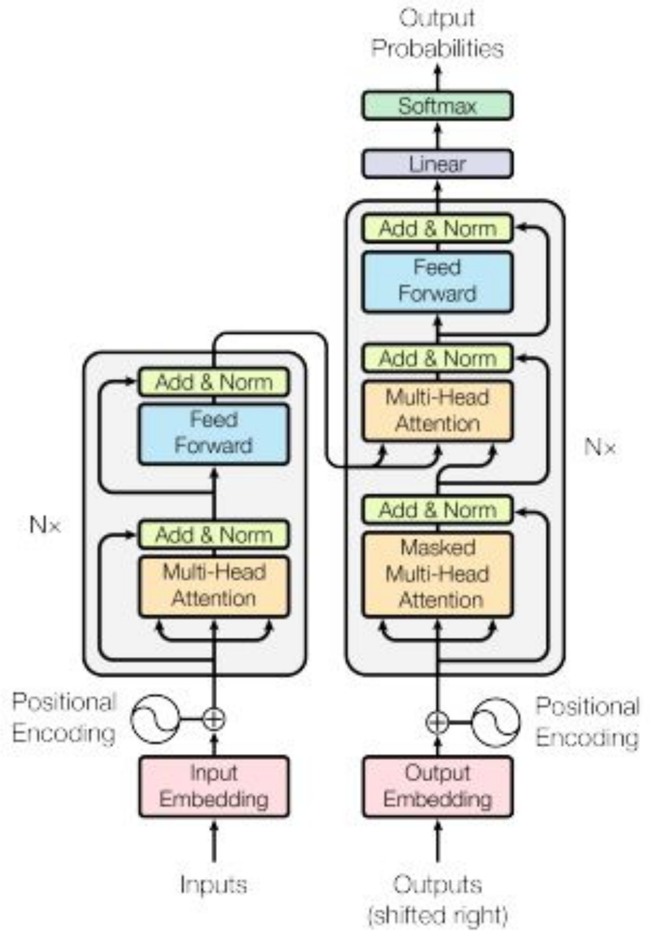
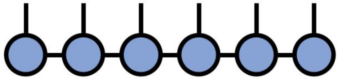


Figure 1: The Transformer - model architecture.

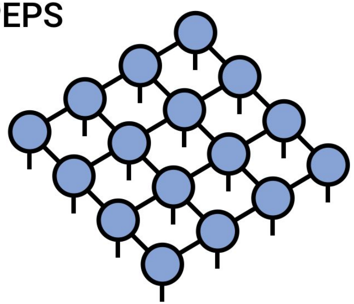
Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Łukasz Kaiser, and Illia Polosukhin. Attention is all you need. In Advances in Neural Information Processing Systems, pages 5998–6008, 2017.

Tensor Networks

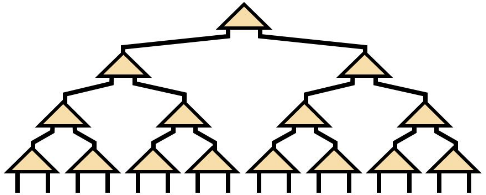
Matrix Product State /
Tensor Train



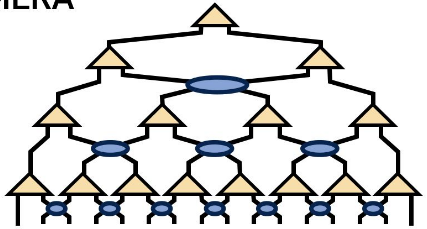
PEPS

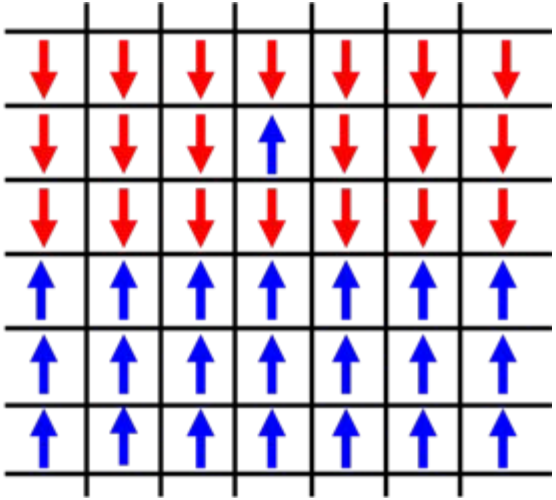


Tree Tensor Network /
Hierarchical Tucker



MERA





Ising Model

Stoudenmire E, and Schwab DJ. Supervised Learning with Tensor Networks. Advances in Neural Information Processing Systems (2016). CurranAssociates, Inc. 4799–807

https://tensornetwork.org/

http://www.bdhammel.com/ising-model/

Quantum Neural Networks

Circuit-centric quantum classifiers

Maria Schuld,[1,2,3] Alex Bocharov,[3] Krysta Svore,[3] and Nathan Wiebe[3]

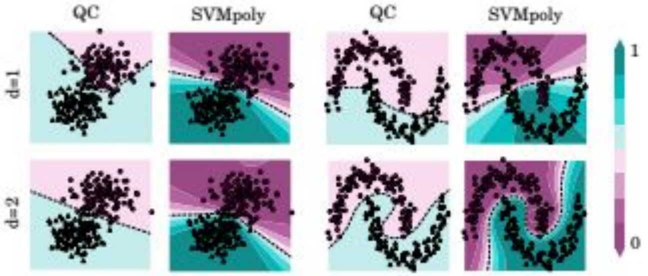
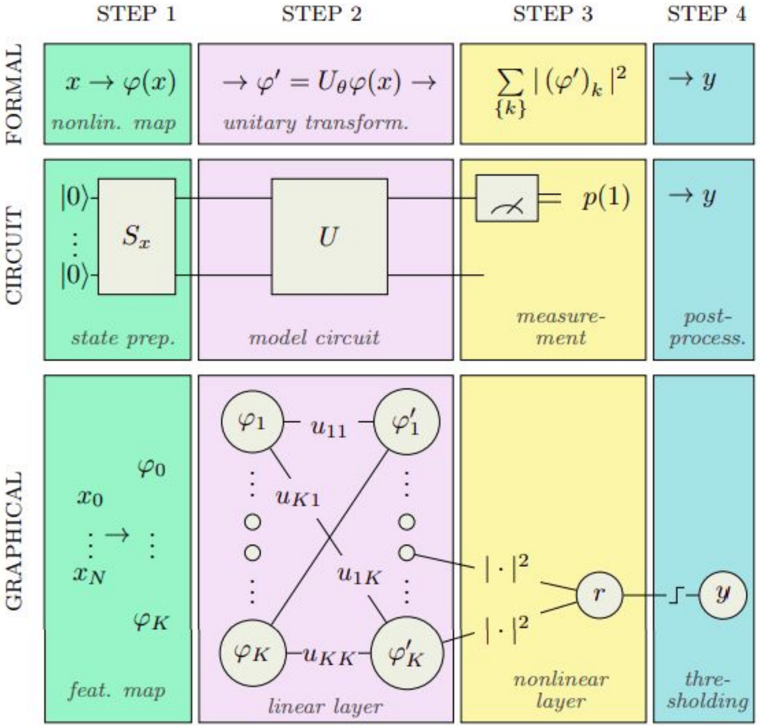


FIG. 9. Comparison of the decision boundary for the circuit-centric quantum classifier (QC) and a support vector machine with polynomial kernel (SVMpoly). The 2-dimensional data



Maria Schuld, Alex Bocharov, Krysta M. Svore, and Nathan Wiebe. Circuit-centric quantumclassifiers. Phys. Rev. A, 101:032308, Mar 2020

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Goodfellow, I.; Pouget-Abadie, J.; Mirza, M.; Xu, B.; Warde-Farley, D.; Ozair, S.; Courville, A.C.; Bengio, Y. Generative adversarial networks. Commun. ACM 2020,63, 139–144.

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https://devopedia.org/natural-language-processing