Bayesian Neural Networks

Ava, Conor, Taylor

Reed College

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A Brief History

1979 — The patent a 'Method of providing digital signatures' is filed by Ralph C. Merkle [**merkle-patent**].

1999 — The original patent expires.

2009 — Bitcoin uses Merkle Trees for 'block header commitment.' [**friedenb**

2023 — Twenty students taking a cryptography class .

Applications

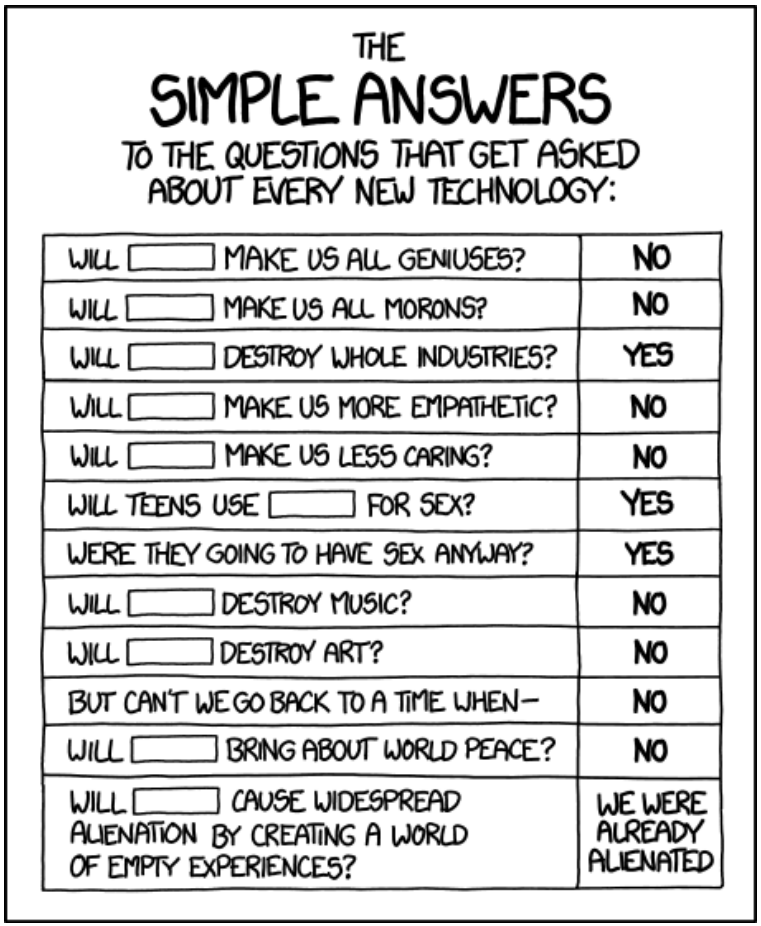


Figure: XKCD: "*Simple Answers*" [7]

What are....

Neural Networks (NN)

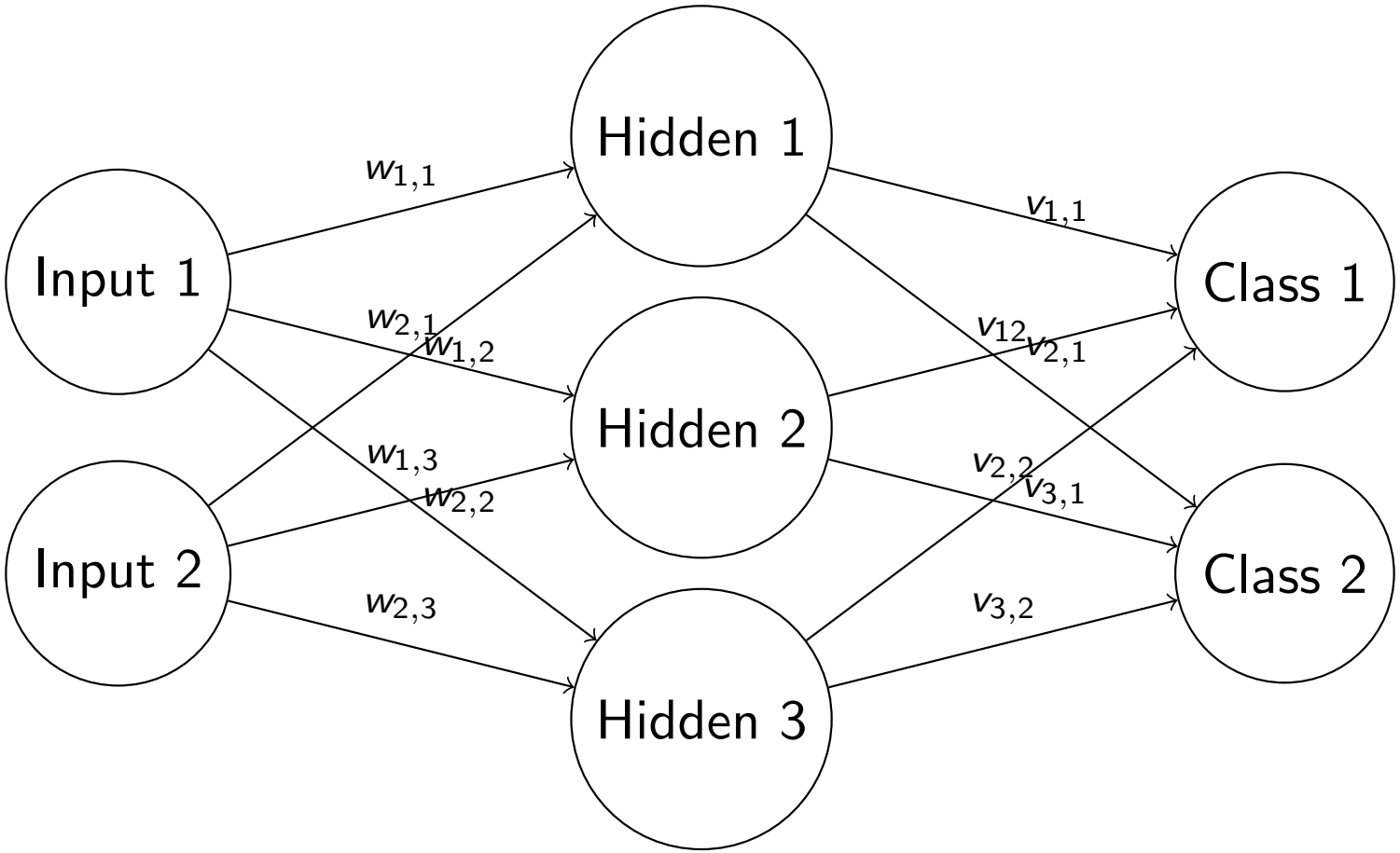


Figure: Example neural network

Issues with Neural Networks

Figure: XKCD: "*Machine Learning*" [5]

- Stir data and pray
-

Convolutional Neural Networks (CNN)

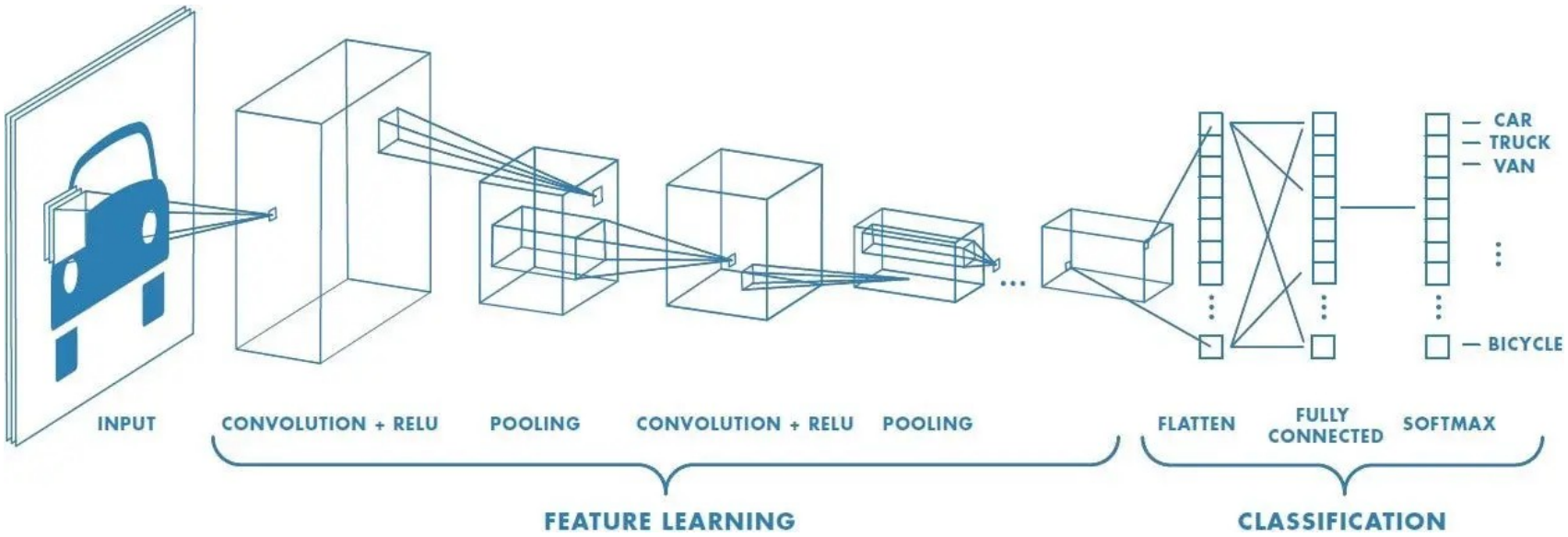
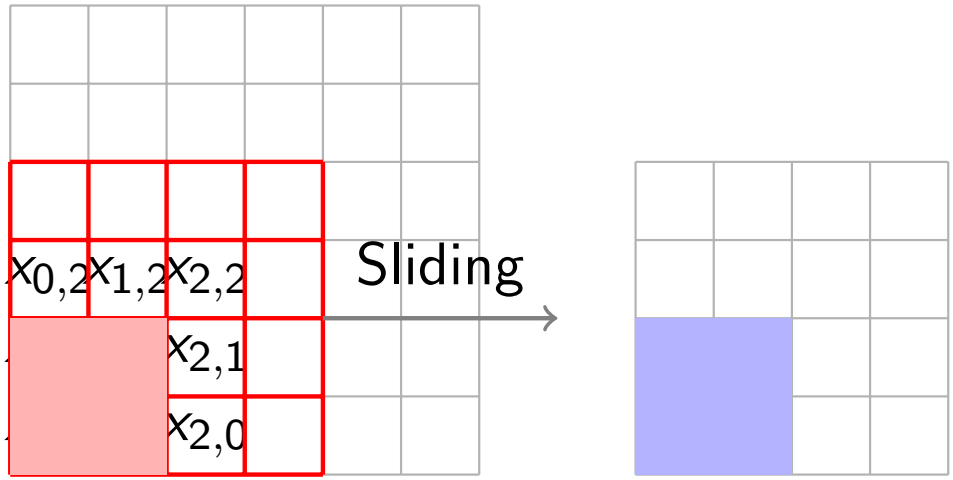


Figure: CNN pipeline [9]

Convolutional Neural Networks (CNN)



Convolutional Kernel

Input Matrix

Output Feature Map

Why we use CNNs

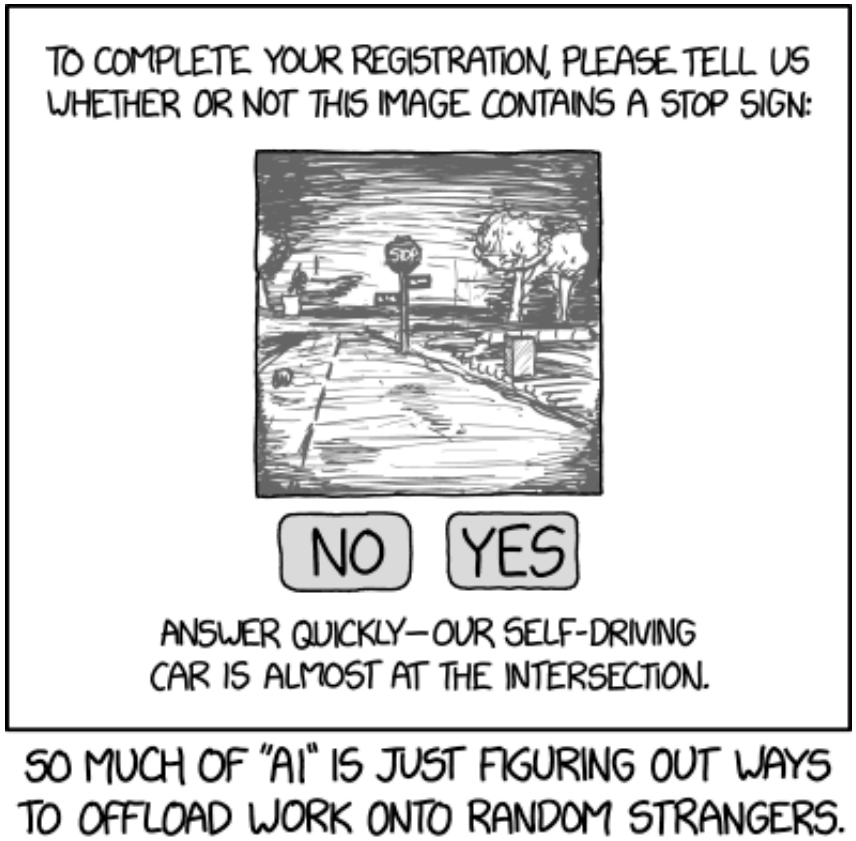


Figure: XKCD: "*Self Driving*" [6]

- They are more efficient for image based tasks
- Channels...

Bayesian Neural Network

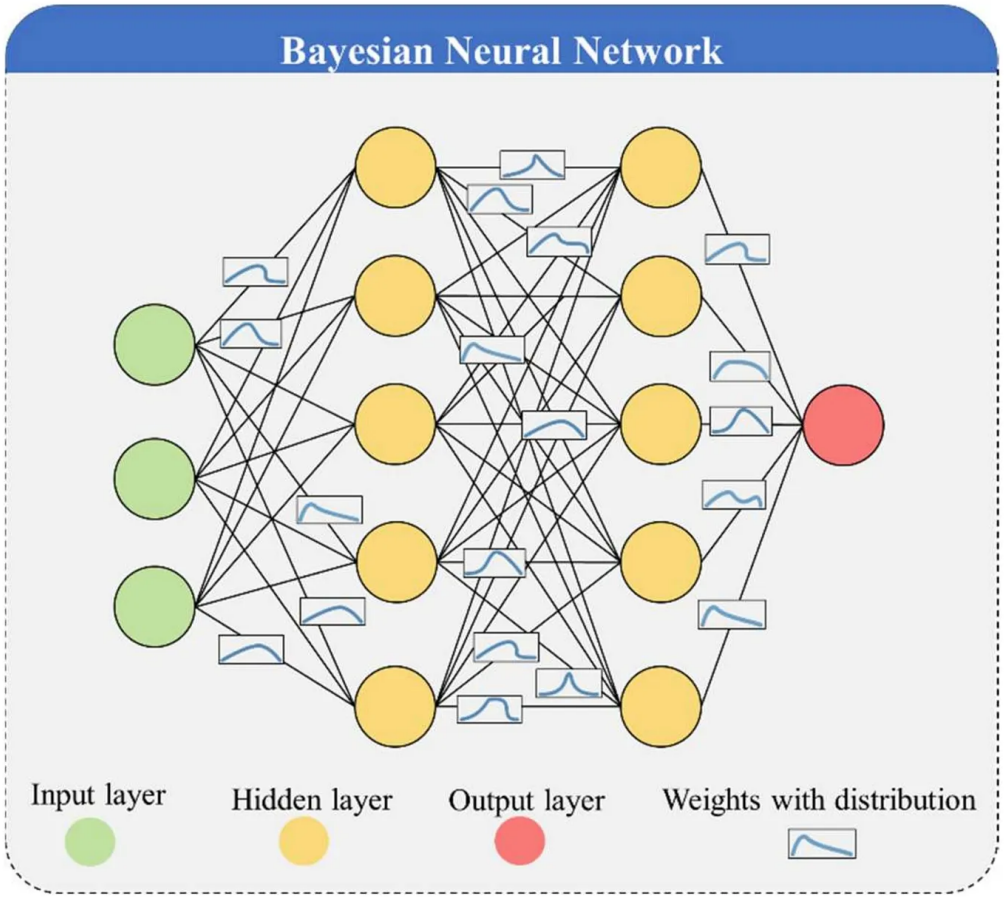


Figure: Example BNN [1]

BNN Neuron

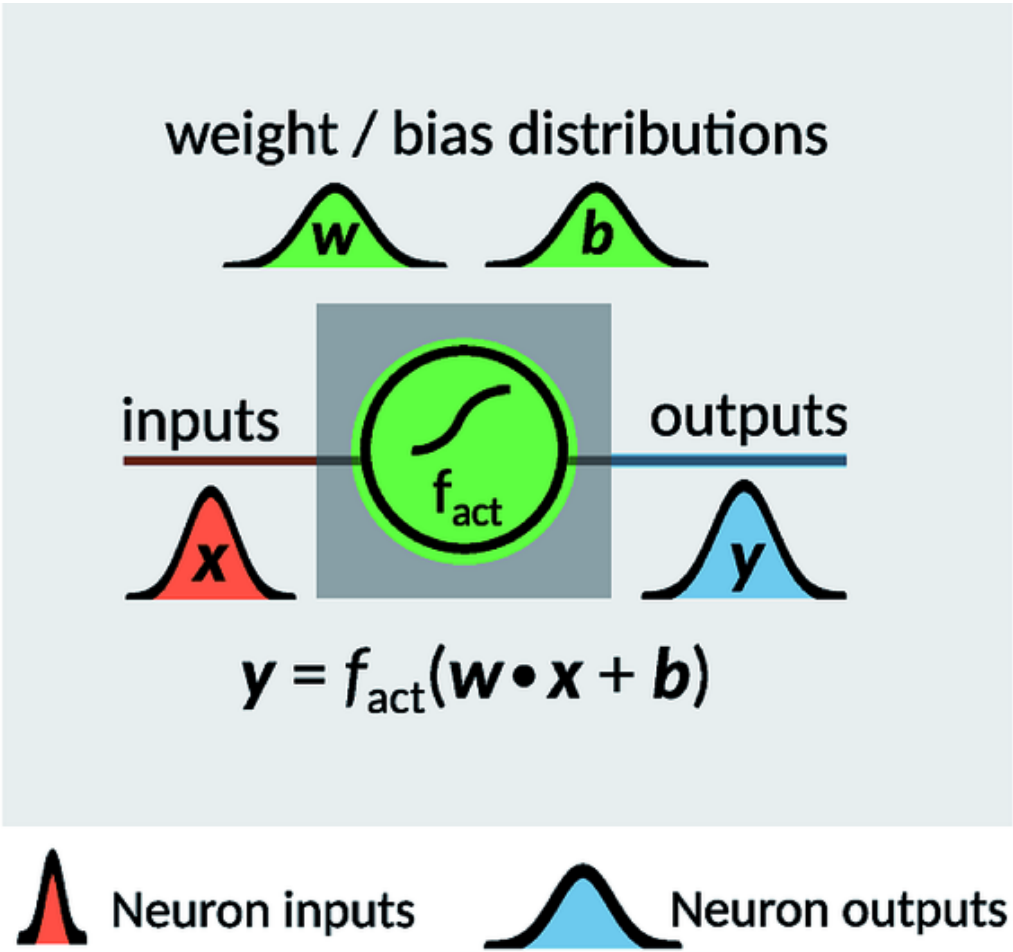


Figure: Example BNN Neuron [2]

Why we use BNN

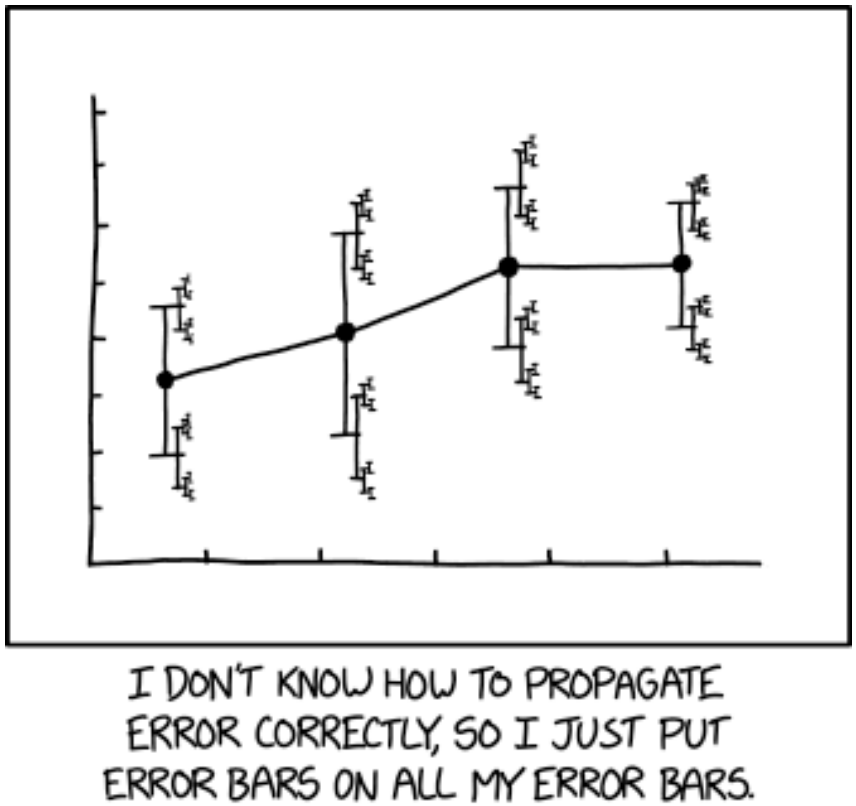


Figure: XKCD: "*Error Bars*" [6]

- We can put uncertainty on our weights
- ....

Difference between BNNs and BCNNs

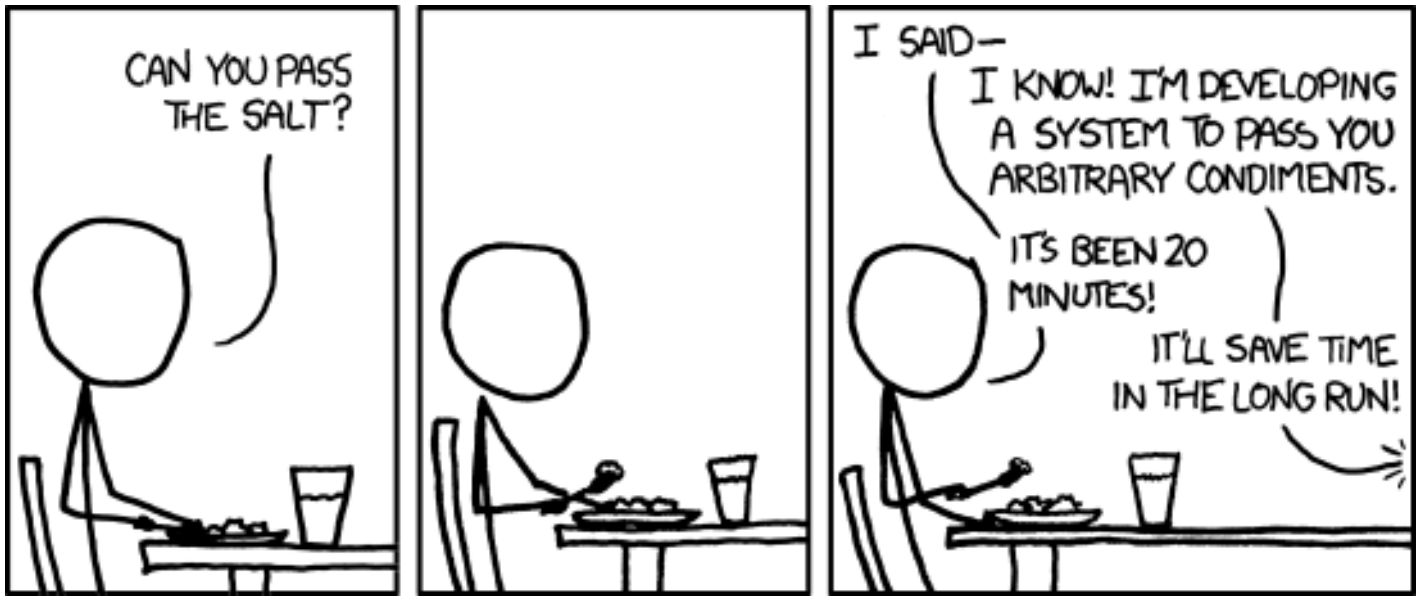


Figure: XKCD: "*The General Problem*" [8]

The relationship between BNNs and BCNNs is the same as NNs and CNNs.

CIFAR-10

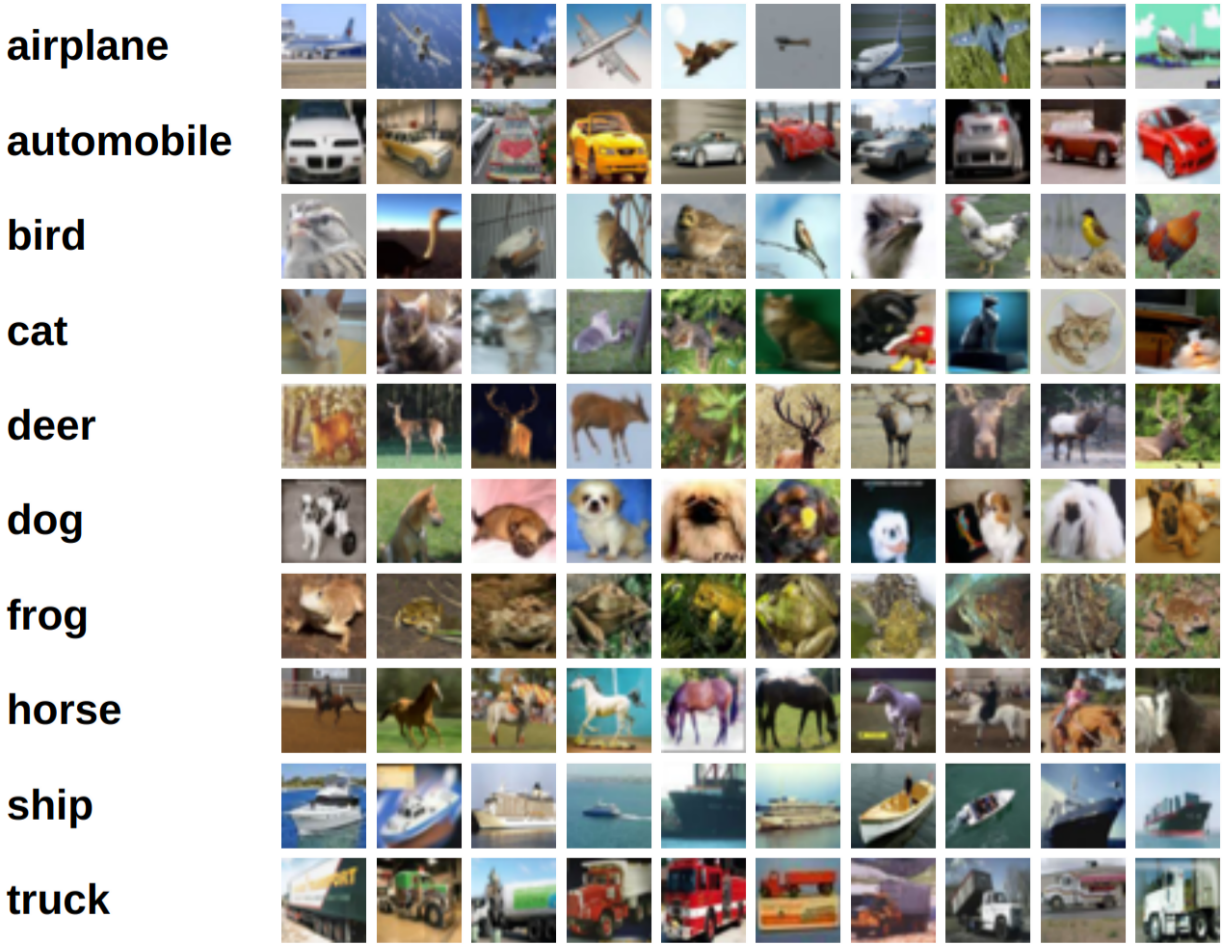


Figure: Example CIFAR-10 images [3]

Hyperparameters

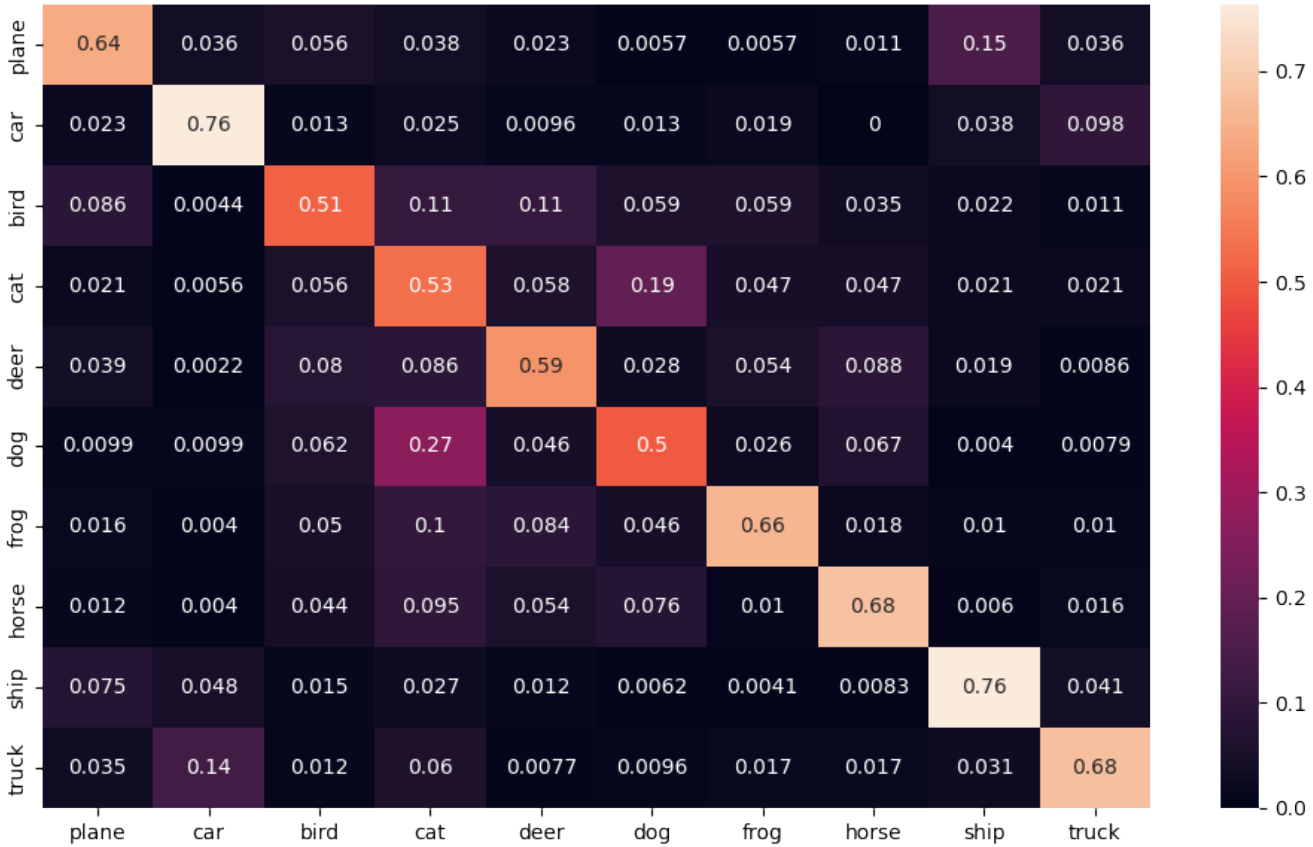
Hyperparameter	**CNN**	**BCNN**
Epochs	50	50
Learning Rate	0.0004	0.0004
Regularization Rate	0.0001	0.0001
Optimizer	Adamw	Adamw

Results

Hyperparameter	**CNN**	**BCNN**
Train Accuracy	81.609%	70.664%
Validation Accuracy	64.499%	61.399%
Optimizer	Adamw	Adamw

Confusion Matrix (CNN)

Confusion Matrix (BCNN)



Live Demo

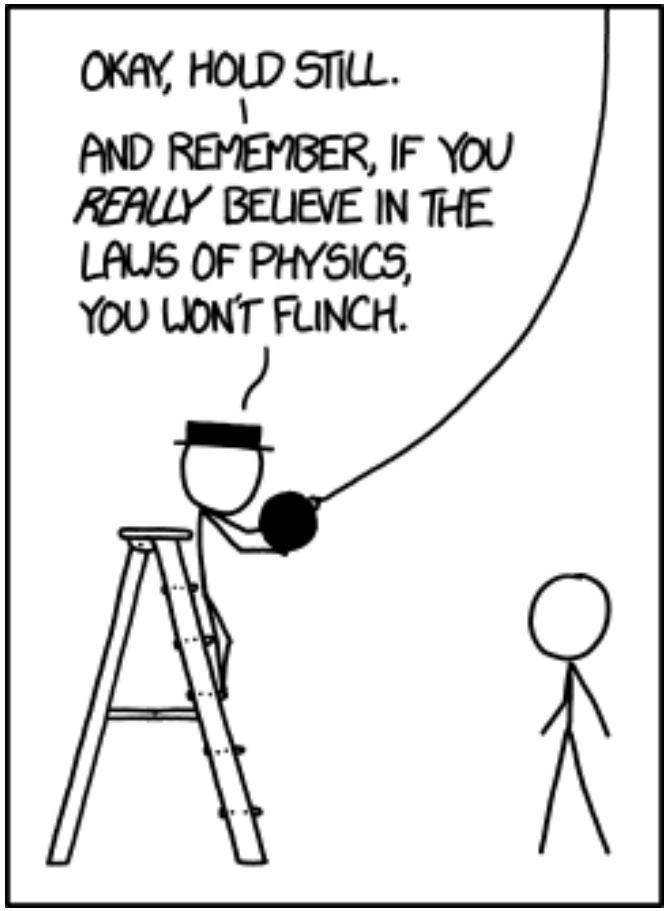


Figure: XKCD: "*Laws of Physics*" [4]

Questions

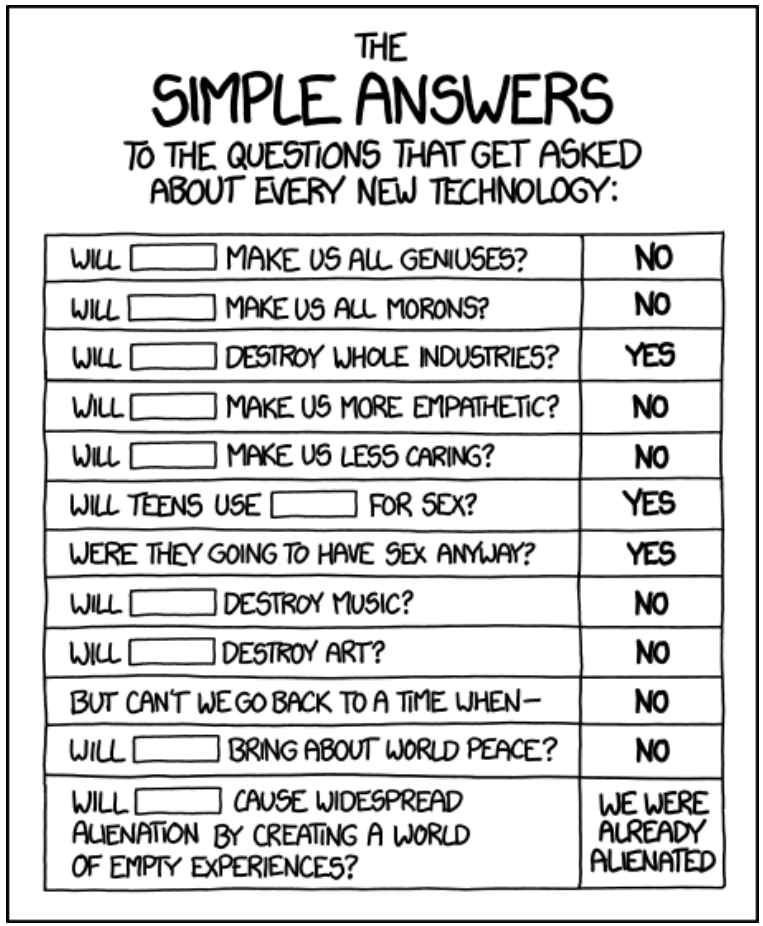


Figure: XKCD: "*Simple Answers*" [7]

References I

[1] Jacek Fleszar. "Bayesian Neural Networks - Capturing The Uncertainty Of The Real World !!" In: (Sept. 2023).

[2] Florian Häse et al. "How machine learning can assist the interpretation of ab initio molecular dynamics simulations and conceptual understanding of chemistry". In: *Chemical science* 10.8 (2019), pp. 2298–2307.

[3] Alex Krizhevsky, Vinod Nair, and Geoffrey Hinton. "CIFAR-10 (Canadian Institute for Advanced Research)". In: (). URL: http://www.cs.toronto.edu/~kriz/cifar.html.

[4] Randall Monroe. *XKCD: Laws of Physics*. Apr. 2016.

[5] Randall Monroe. *XKCD: Machine Learning*. May 2017.

[6] Randall Monroe. *XKCD: Self Driving*. Oct. 2017.

References II

[7] Randall Monroe. *XKCD: Simple Answers*. Nov. 2013.

[8] Randall Monroe. *XKCD: The General Problem*. Nov. 2011.

[9] Sumit Saha. "A Guide to Convolutional Neural Networks — the ELI5 way". In: (Dec. 2018).