## Bayesian Neural Networks

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Reed College

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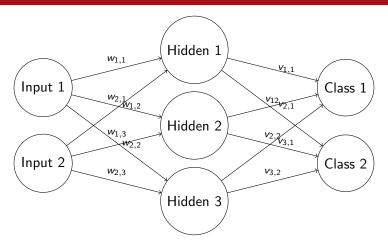


Figure: Example neural network



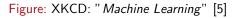
#### Issues with Neural Networks

Neural Networks



Stir data and pray

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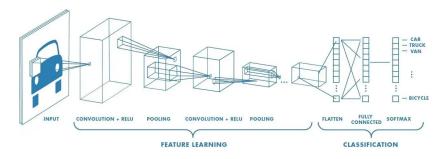
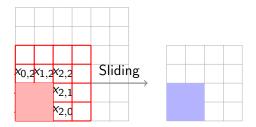


Figure: CNN pipeline [9]



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## Convolutional Neural Networks (CNN)



Convolutional Kernel Input Matrix

Output Feature Map



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Neural Networks

#### TO COMPLETE YOUR REGISTRATION, PLEASE TELL US UNETHER OR NOT THIS MAGE CONTAINS A STOP SIGN:





ANSWER QUICKLY—OUR SELF-DRIVING CAR IS ALMOST AT THE INTERSECTION.

50 MUCH OF "AI" IS JUST FIGURING OUT WAYS TO OFFLOAD WORK ONTO RANDOM STRANGERS.

Figure: XKCD: "Self Driving" [6]

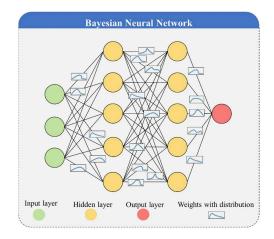
- They are more efficient for image based tasks
- Channels



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## Bayesian Neural Network

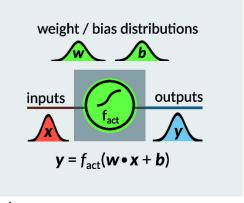






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#### **BNN Neuron**





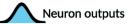


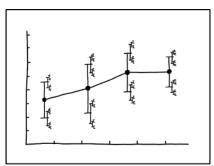
Figure: Example BNN Neuron [2]



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## Why we use BNN



I DON'T KNOW HOW TO PROPAGATE ERROR CORRECTLY, SO I JUST PUT ERROR BARS ON ALL MY ERROR BARS.

Figure: XKCD: "Error Bars" [6]

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



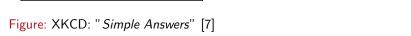
## **Applications**

# SIMPLE ANSWERS

TO THE QUESTIONS THAT GET ASKED ABOUT EVERY NEW TECHNOLOGY:

WILL MAKE US ALL GENIUSES?	NO
WILL MAKE US ALL MORONS?	No
WILL DESTROY WHOLE INDUSTRIES?	YES
WILL MAKE US MORE EMPATHETIC?	No
WILL MAKE US LESS CARING?	NO
WILL TEENS USE FOR SEX?	YES
WERE THEY GOING TO HAVE SEX ANYWAY?	YES
WILL DESTROY MUSIC?	NO
WILL DESTROY ART?	NO
BUT CAN'T WE GO BACK TO A TIME WHEN-	NO
WILL BRING ABOUT WORLD PEACE?	NO
WILL CAUSE WIDESPREAD AUENATION BY CREATING A WORLD OF EMPTY EXPERIENCES?	WE WERE ALREADY ALIENATE

What are....





#### Difference between BNNs and BCNNs

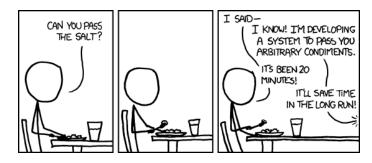


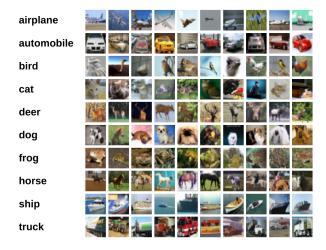
Figure: XKCD: "The General Problem" [8]

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



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#### CIFAR-10







## Hyperparameters

Hyperparameter	CNN	BCNN
Epochs	100	100
Learning Rate	0.001	0.003
Regularization Rate	0.001	0.001
Optimizer	Adamw	Adamw



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### Results

Metric	CNN	BCNN
Train Accuracy	81.609%	70.664%
Validation Accuracy	64.499%	61.399%
Time to Train	17 min 6.1 sec	Adamw



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## Confusion Matrix (CNN)







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## Confusion Matrix (BCNN)







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#### Live Demo

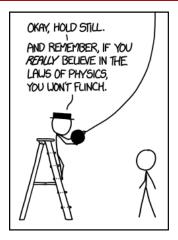


Figure: XKCD: "Laws of Physics" [4]



## Questions

#### THE SIMPLE ANSWERS

TO THE QUESTIONS THAT GET ASKED ABOUT EVERY NEW TECHNOLOGY:

WILL MAKE US ALL GENIUSES?	No
WILL MAKE US ALL MORONS?	No
WILL DESTROY WHOLE INDUSTRIES?	YES
WILL MAKE US MORE EMPATHETIC?	NO
WILL MAKE US LESS CARING?	NO
WILL TEENS USE FOR SEX?	YES
WERE THEY GOING TO HAVE SEX ANYWAY?	YES
WILL DESTROY MUSIC?	NO
WILL DESTROY ART?	NO
BUT CAN'T WE GO BACK TO A TIME WHEN-	NO
WILL BRING ABOUT WORLD PEACE?	NO
WILL. CAUSE WIDESPREAD ALIENATION BY CREATING A WORLD OF EMPTY EXPERIENCES?	WE WERE AUREADY ALIENATED

Figure: XKCD: "Simple Answers" [7]



- [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.



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#### 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).

