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Reed College

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### Neural Networks (NN)

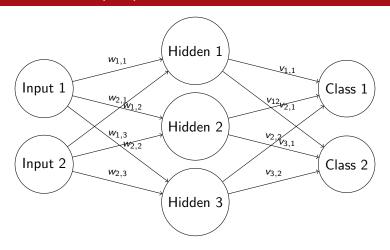


Figure: Example neural network



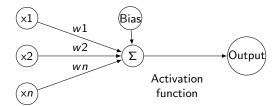


Figure: Example neural network neuron



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#### Issues with Neural Networks

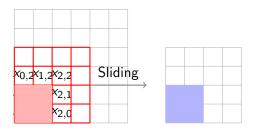


- Figure: XKCD: "Machine Learning"
- [xkcd-ml]

- Stir data and pray
- Interpretability problems
- Lots of data required
- Risk of overfitting
- Unpredictable failures to generalize
- No uncertainty quantification
- Computationally expensive



### Convolutional Neural Networks (CNN)



Convolutional Kernel Input Matrix

Output Feature Map



### Convolutional Neural Networks (CNN)

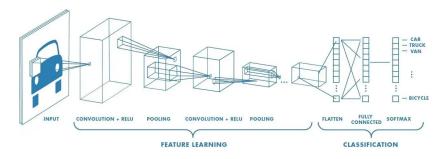


Figure: CNN pipeline [eli5CNN]



Neural Networks

Bayesian Neural Networks Simulation

#### Why we use CNNs

Neural Networks

TO COMPLETE YOUR REGISTRATION, PLEASE TELL US WHETHER OR NOT THIS IMAGE 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.

TO OFFLOAD WORK ONTO RANDOM STRANGER

• Encodo contial

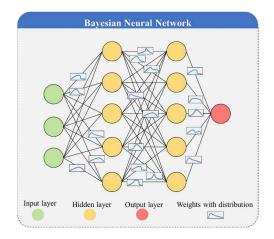
Fewer parameters

- Encode spatial patterns
- More efficient for image tasks



Figure: XKCD: "Self Driving" [xkcd-self-driving]

Neural Networks







Bayesian Neural Networks Simula

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Simula

#### **BNN Neuron**

Neural Networks

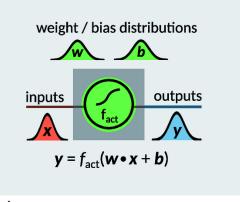




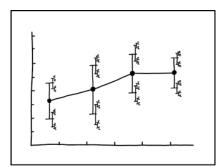


Figure: Example BNN Neuron [hase2019machine]



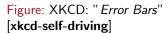
Ava, Conor, Taylor (Reed College)

#### Why we use BNN



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

- Well-calibrated uncertainty
- Handles sparse data while minimizing overfitting
- More predictable failures
- Formalizes prior knowledge and assumptions
- Inherent sequentiality





#### Applications

Neural Networks

#### 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 WEGO 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

- Uncertainty quantification
  - Engineering, Medicine, Finance. ...
- Sparse data
  - Anywhere data is expensive
  - Medical diagnosis
  - Molecular biology
- Warnings before failing to generalize
  - Autonomous driving
  - Engineering
- Sequentiality



Figure: XKCD: "Simple Answers"

#### Difference between BNNs and BCNNs

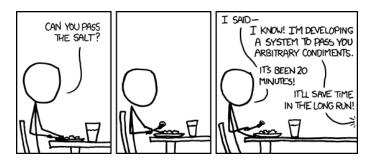


Figure: XKCD: "The General Problem" [xkcd-general-problem]

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



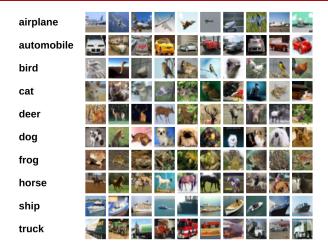


Figure: Example CIFAR-10 images [cifar10]



### Hyperparameters

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



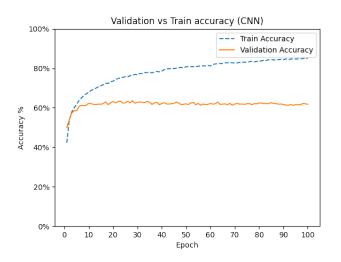
#### Results

Metric	CNN	BCNN
Train Accuracy	84.96%	81.27%
Validation Accuracy	61.76%	59.21%
Time to Train	16 min 11 sec	22 min 11 sec



ural Networks Bayesian Neural Network

### Accuracy over time (CNN)

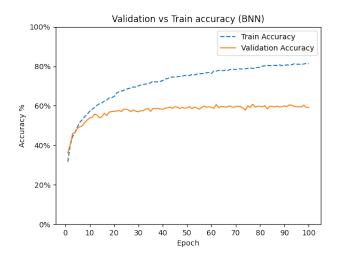






Simulation 00000000

### Accuracy over time (BNN)







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### Confusion Matrix (CNN)







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## Confusion Matrix (BCNN)







#### Live Demo

Neural Networks

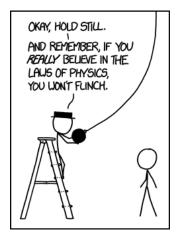


Figure: XKCD: "Laws of Physics" [xkcd-laws-of-physics]



#### Questions

# SIMPLE ANSWERS

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Figure: XKCD: "Simple Answers" [xkcd-simple-answers]



#### References I

