Detecting Linguistic Characteristics of Alzheimer's Dementia by Interpreting Neural Models

Sweta Karlekar
Computer Science, UNC Chapel Hill
Graduate Student: Tong Niu
Research Mentor: Dr. Mohit Bansal

Alzheimer's Disease (AD)

- Most common form of Dementia
- Caused by cortical degeneration
- Decline in language comprehension and ability
- Medication can slow or halt progression

Image courtesy of National Institute on Aging, National Institutes of Health, U.S. Department of Health and Human Services

Evaluation Techniques

Mental Status and Mood Testing

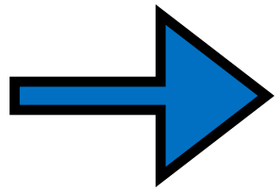
Physical and Neurological Exams

Extensive Medical History

Brain Imaging

The Task

Transcripts of Spoken Languages samples



Binary Classification of AD+ or AD-

But first, let’s look at the methodology.

ML vs. DL

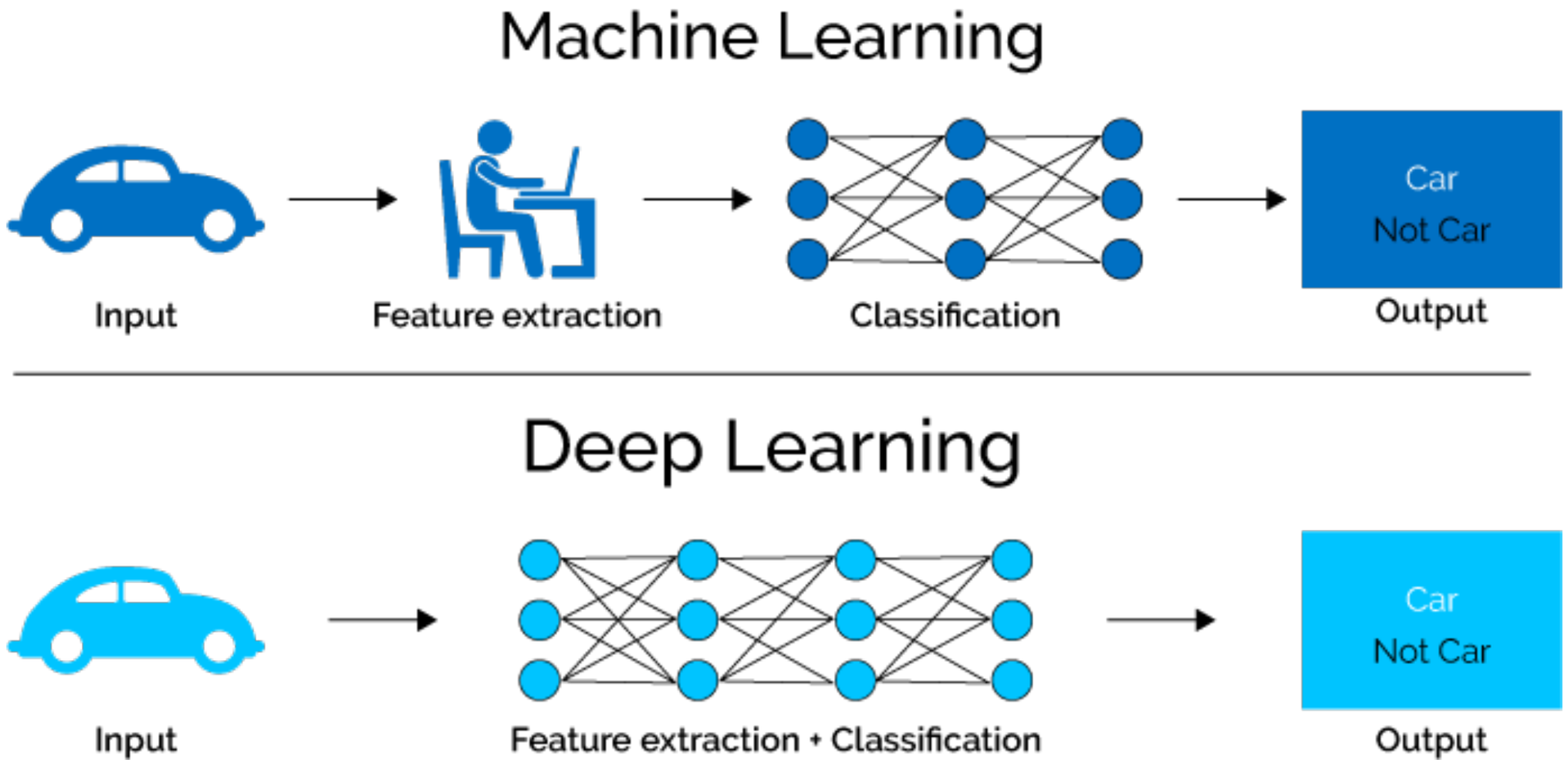
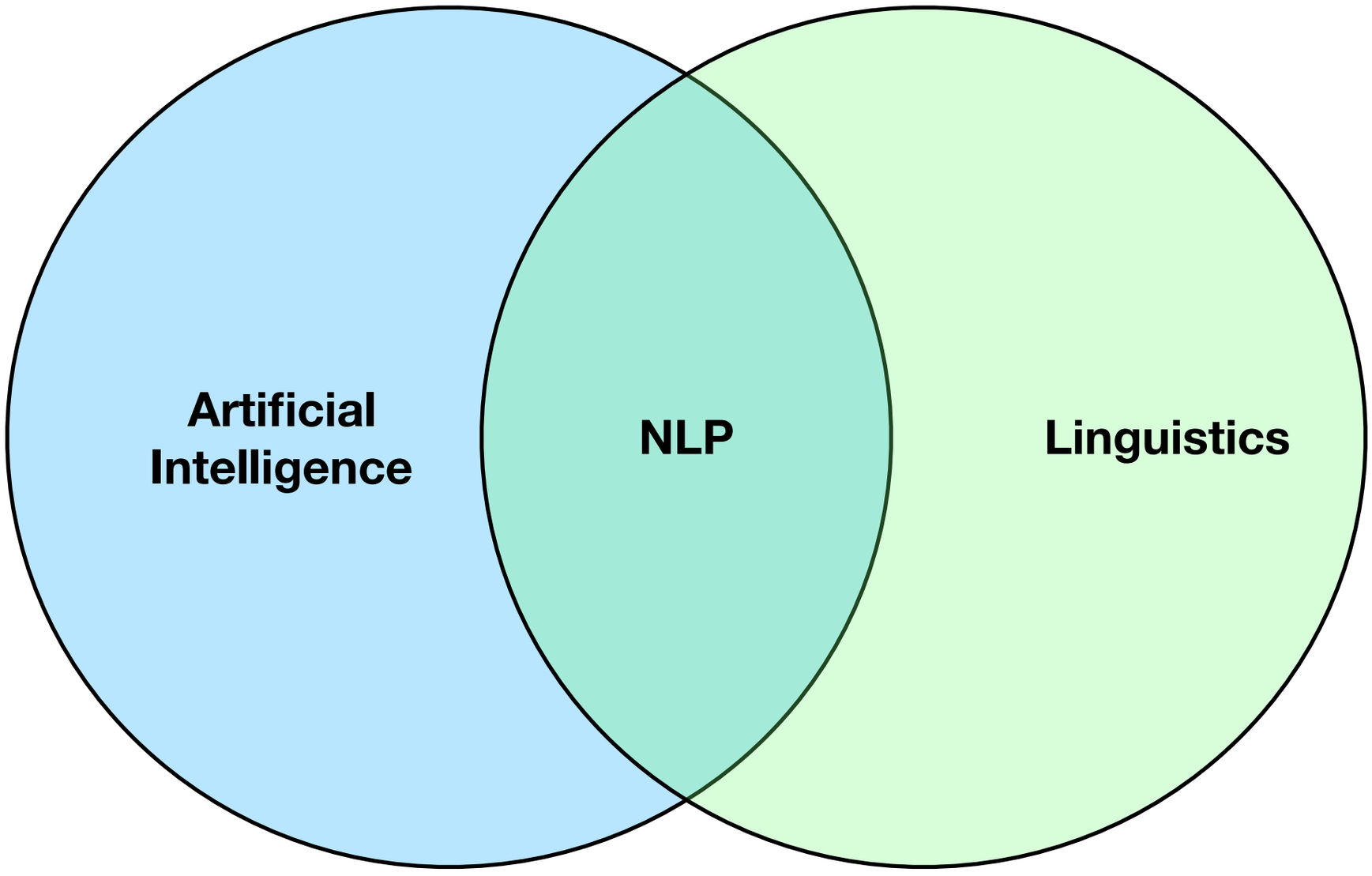


Image from: https://codeutsava.in/blog/40

Natural Language Processing



GOAL: Have computers understand natural language to perform useful tasks.

NLP + Deep Learning

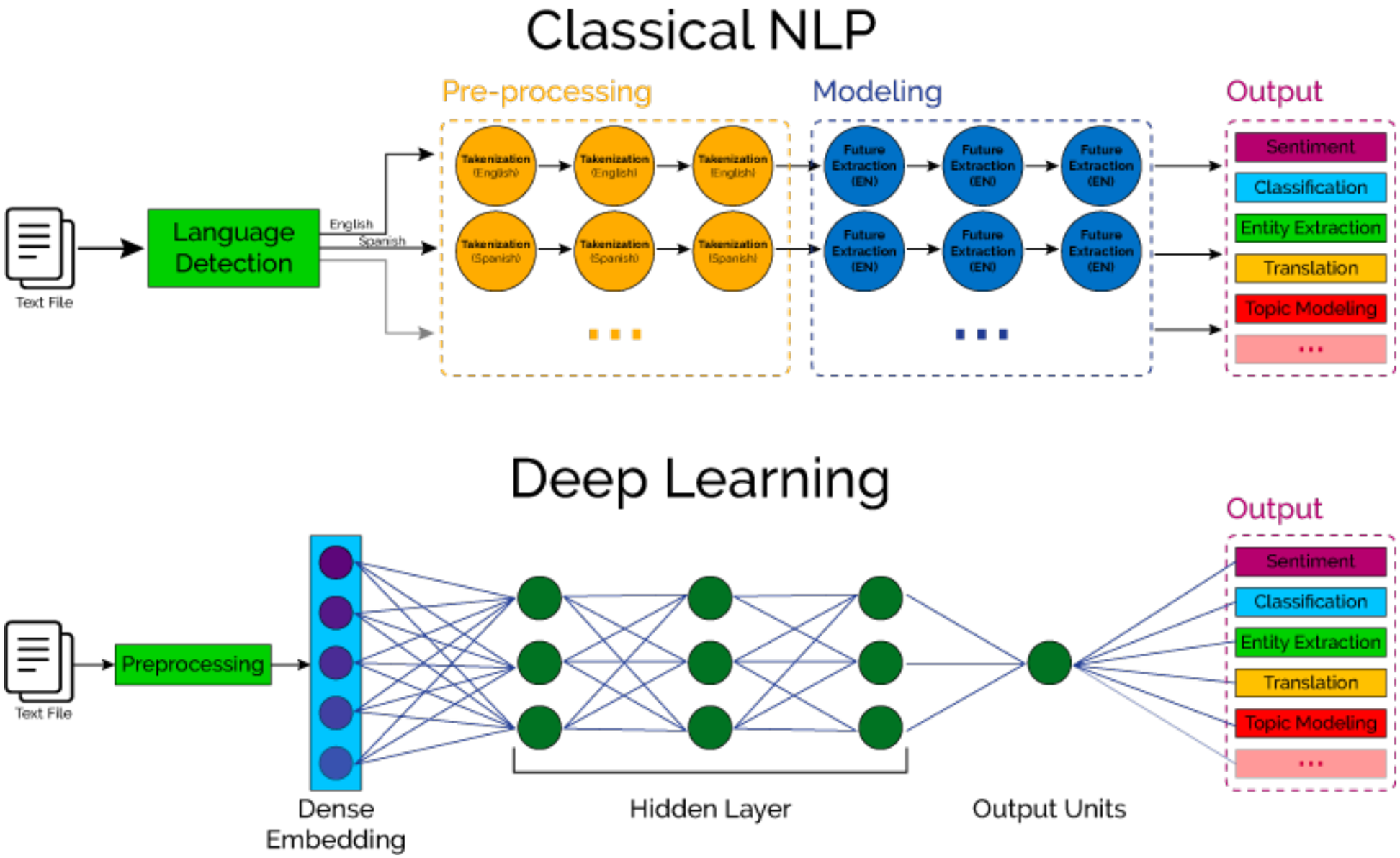


Image from: https://www.xenonstack.com/blog/data-science/overview-of-artificial-intelligence-and-role-of-natural-language-processing-in-big-data

Back to the task...

Dataset

- Dementia Bank dataset
- Transcripts and speech samples
- Non-AD + AD Patients
- Includes POS tags
    - Noun, verb, adjective, adverb, present participle, determiner, etc.

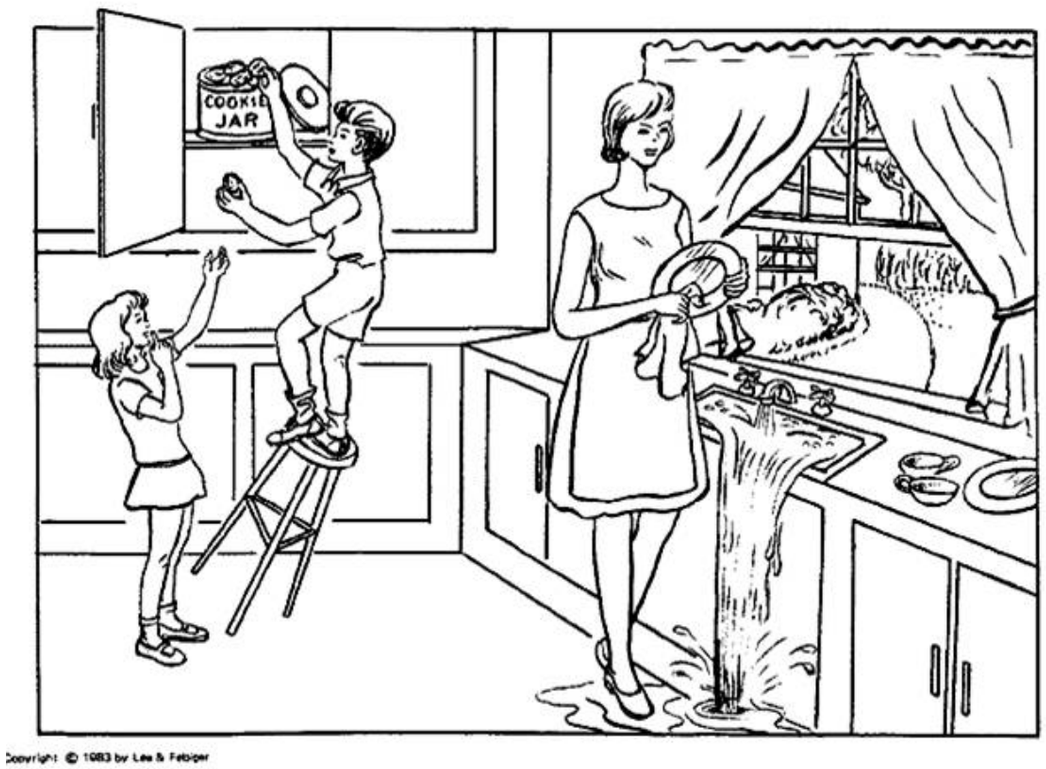


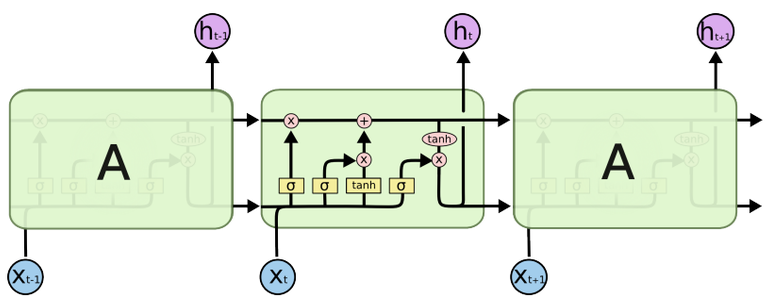
Image from: https://www.researchgate.net/figure/The-Cookie-theft-picture_fig1_317095410

Previous Works

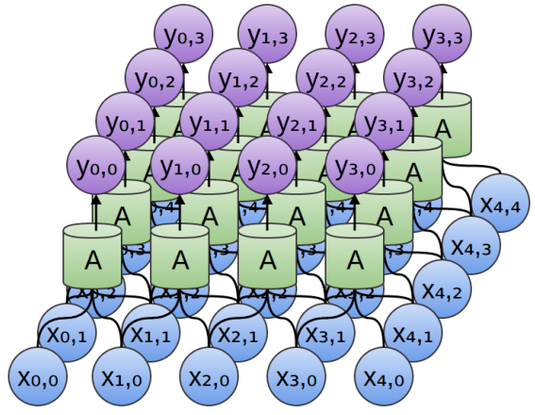
Author	ML vs. DL	Description	Accuracy
Rudzicz et al.	Machine Learning	Extracted over 200+ lexical features	67.0%
Orimaye et al.	Machine Learning	Used syntactic, lexical, and n-gram features	86.1%
Konig et al.	Machine Learning	Analyzed speech audio	87.0%
Orimaye et al.	Deep Learning	Deep Neural + Language Model	87.5%

Neural Models

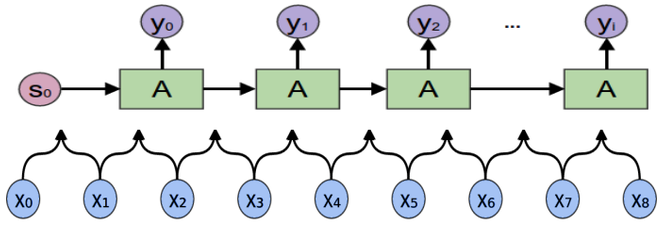
Recurrent Neural Network (RNN)



Convolutional Neural Network (CNN)



Convolutional/Recurrent Neural Network (CNN-RNN)



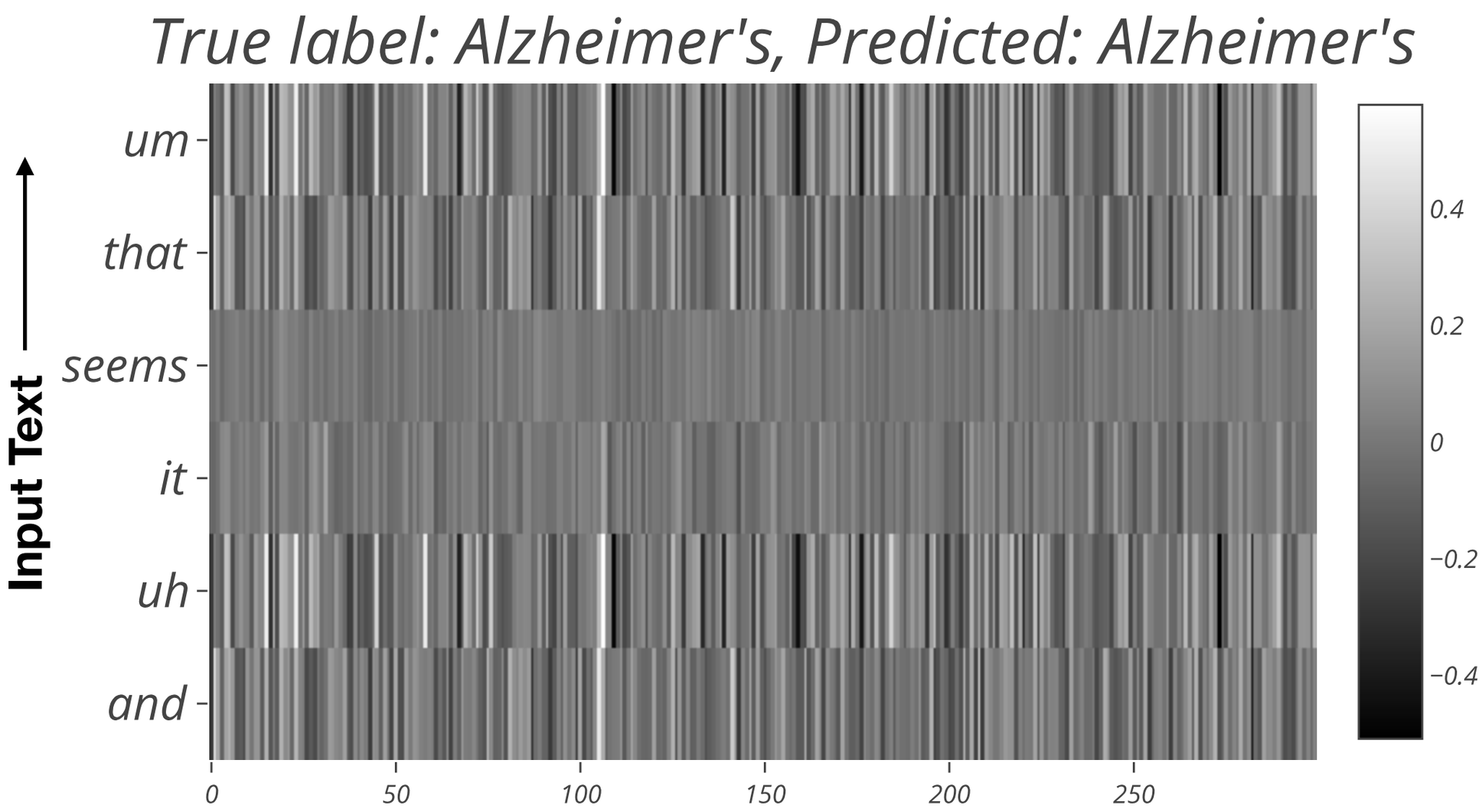
Images from: http://colah.github.io

Results

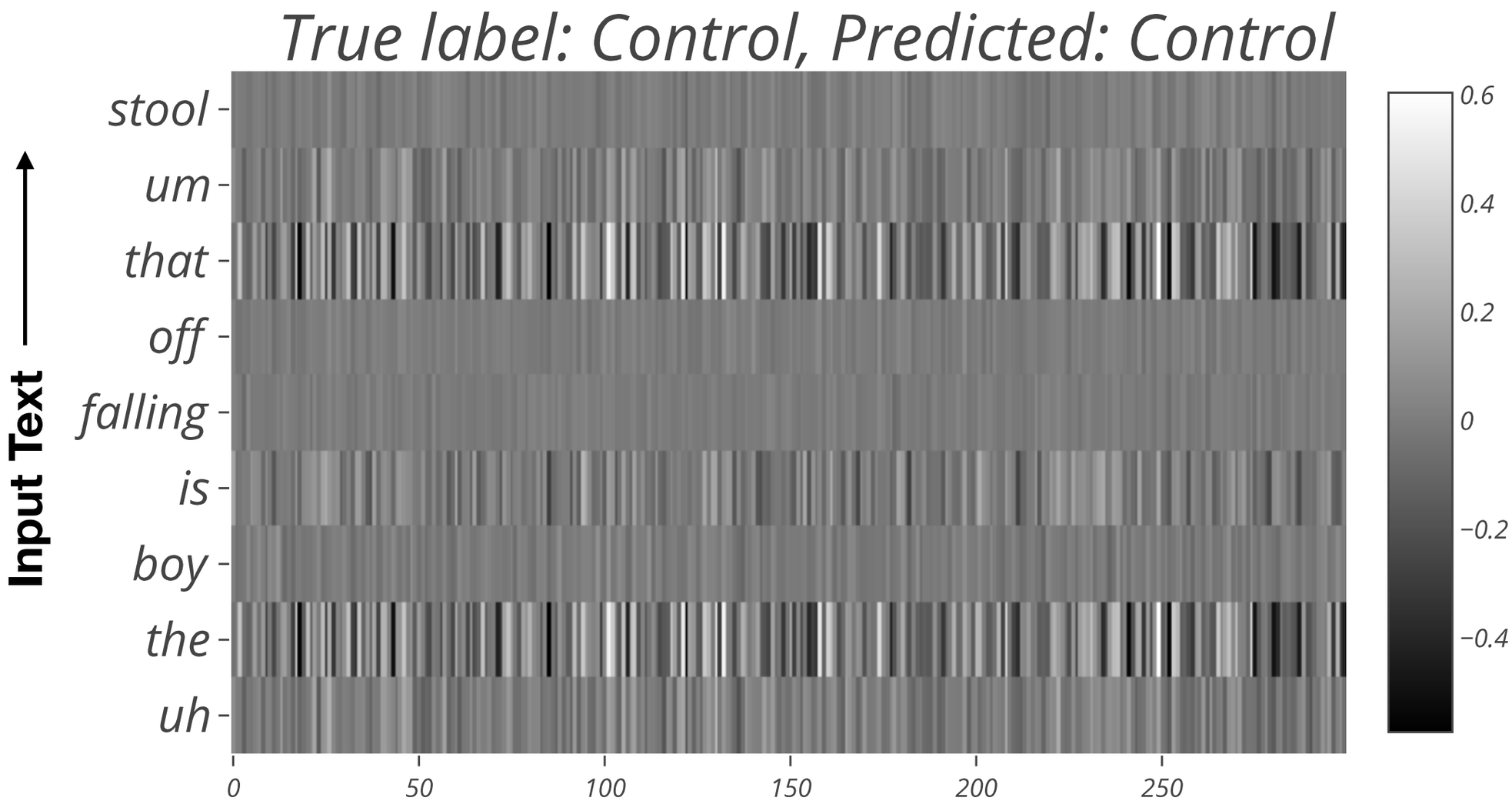
Author	Model	Description	Accuracy
Rudzicz et al.	Machine Learning	200+ lexical features	67.0%
Orimaye et al.	Machine Learning	Syntactic, lexical, and n-gram features	86.1%
Konig et al.	Machine Learning	Speech audio	87.0%
Orimaye et al.	Deep Language Model	Transcripts	87.5%
-	CNN	Transcripts	82.8%
-	RNN	Transcripts	83.7%
-	CNN-RNN	Transcripts	84.9%
-	**CNN-RNN**	**Transcripts + POS**	**91.1%**

But what did the neural model look at?

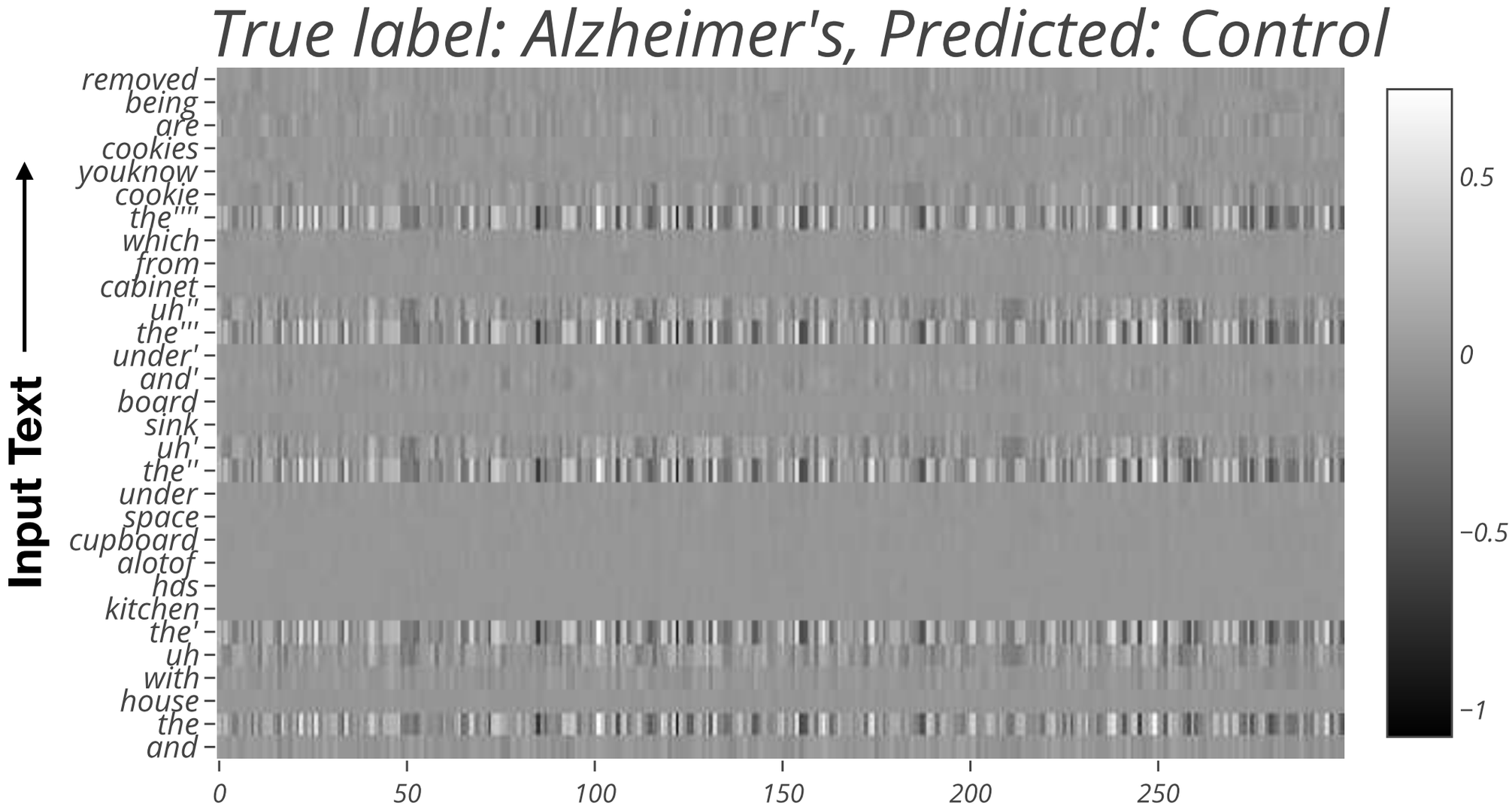
Saliency Heat Maps



Saliency Heat Maps



Saliency Heat Maps



Activation Clustering

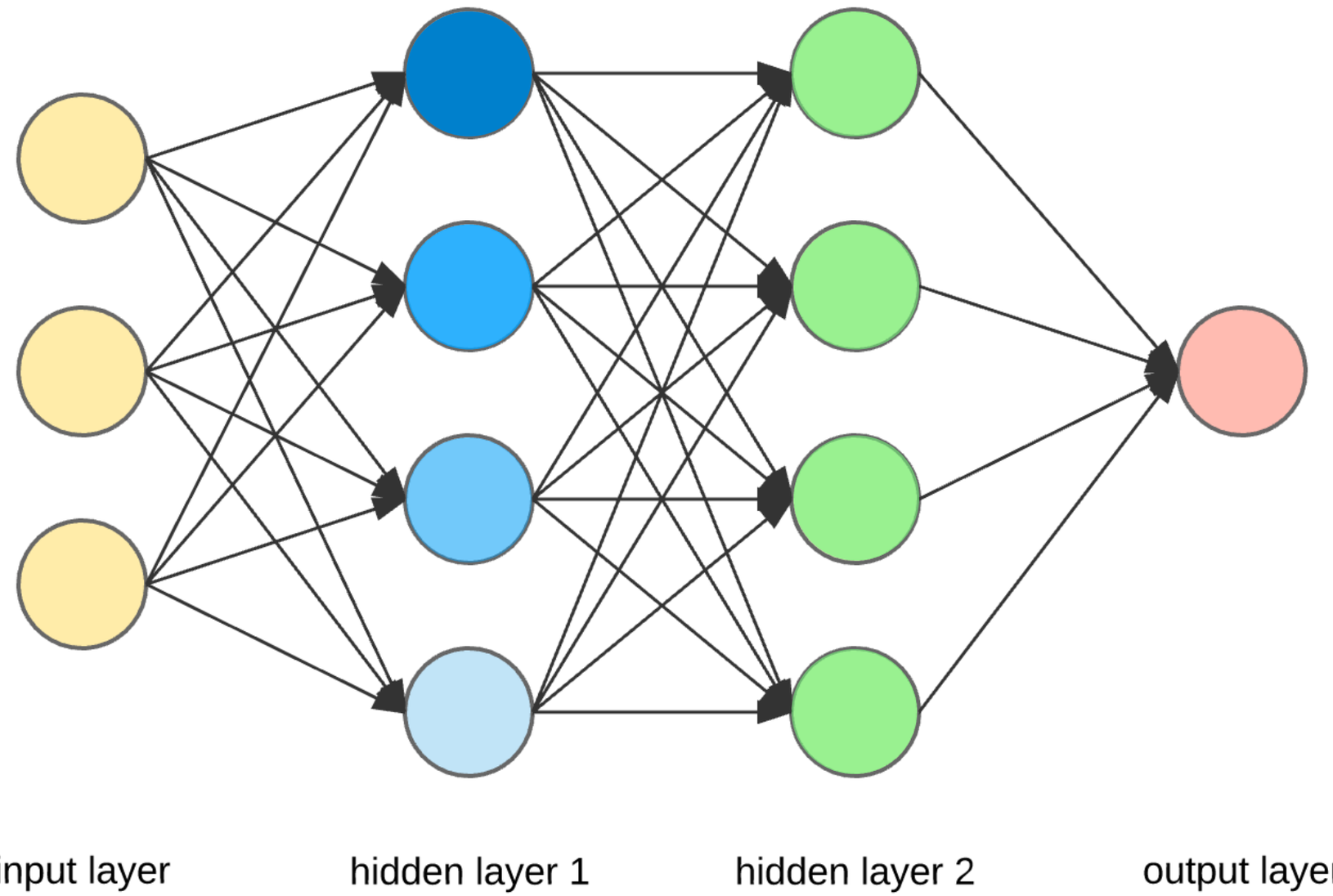


Image from: https://towardsdatascience.com/applied-deep-learning-part-1-artificial-neural-networks-d7834f67a4f6

Activation Clustering

- **Short answers and bursts of speech**
  - *“Okay”, “yes”, “oh!”, “yes”, “fine”*
- **Repeated requests for clarification**
  - *“Did I say facts?”, “Did I get any?”, “Did I say elephant?”*
- **Starting with interjections**
  - *“Well I gotta see it”, “Oh I just a lot of uh…”, “So all the words that you can”*

Activation Clustering

AD		Non-AD	
POS	Frequency	POS	Frequency
n	0.20	*n*	0.15
det	0.14	*det*	0.13
adj	0.05	*presp*	0.07
adv	0.04	*part*	0.05

Conclusion

- Applied 3 different neural models to AD classification
- Achieved a new benchmark accuracy
- Utilized two visualization techniques

Future Work

- Multi-class classification to differentiate among stages
- Apply to other neurological diseases:
    - Huntington’s
    - Diffuse Lewy Body
- How early can we catch AD in language?
    - Agatha Christie and Iris Murdoch novels

Questions?