CMSC 412/612 Neurosymbolic Text Generation

Instructor: Lara J. Martin (she/they)

TA: Arya Honraopatil

https://laramartin.net/neurosymbolic-text-gen/

Who is Lara?

laramartin.net

BS CS & Linguistics @ Rutgers

MS Language Technologies @ CMU

PhD Human-Centered Computing @ GT

CIFellows Postdoc @ UPenn

Assistant Prof @ UMBC

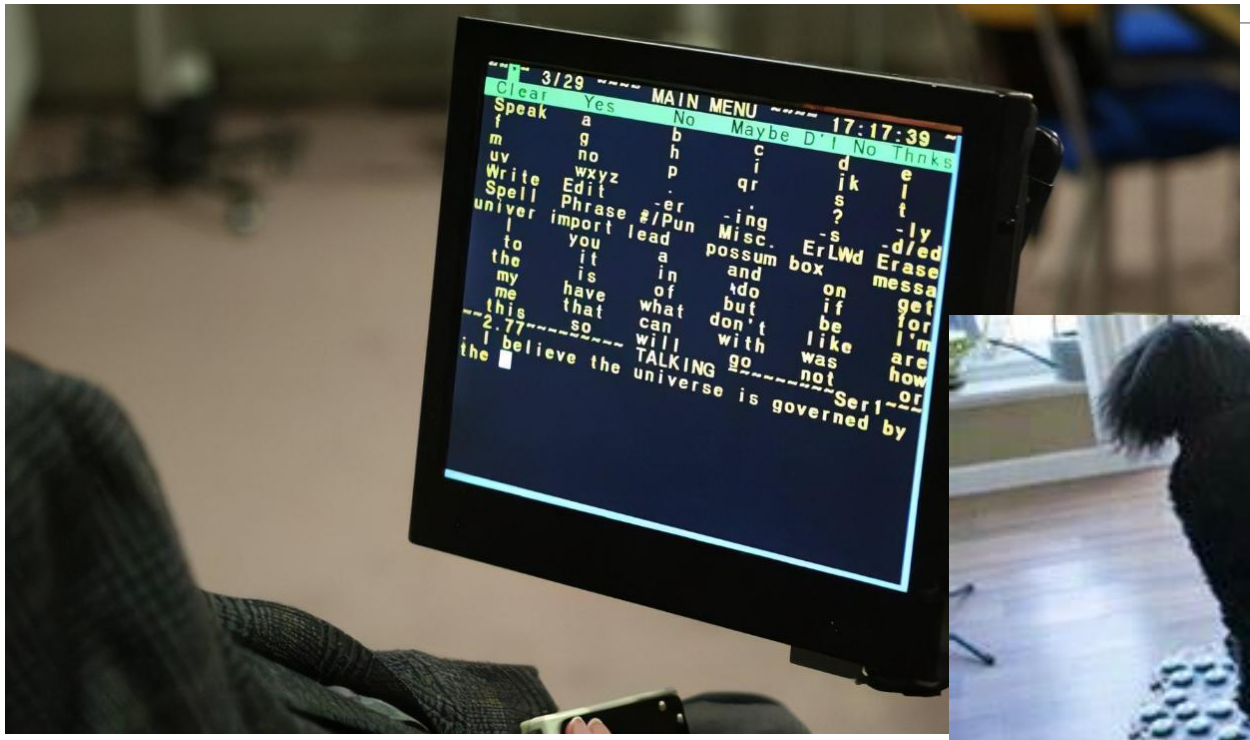
https://upload.wikimedia.org/wikipedia/commons/a/a4/Map_of_USA_with_state_and_territory_names_2.png

What do I work on?

Improving NLP Techniques for Cool Problems

- human-AI communication
  - Story generation / Dungeons & Dragons AI
  - Chatbots
- computer-mediated human-human communication
  - Speech processing
  - Augmentative and alternative communication (AAC)

Augmentative & Alternative Communication



https://www.abc.es/media/ciencia/2018/03/15/20576450-kgXH--620x349@abc.jpg

A		B		C		D		SPACE		END OF MESSAGE	
E		F		G		H		START OVER		I DON'T KNOW	
I		J		K		L		M		N	
O		P		Qu		R		S		T	
U		V		W		X		Y		Z	
1	2	3	4	5	6	7	8	9	Ø	YES	NO

Letter Board - AEIOU format

unl.edu/documents/secd/forms/Letter-Boards.png

https://bdnews24.com/lifestyle/2021/05/30/the-talking-dog-of-tiktok

What do I work on?

Improving NLP Techniques for Cool Problems

- human-AI communication
  - Story generation / Dungeons & Dragons AI
  - Chatbots
- computer-mediated human-human communication
  - Speech processing
  - Augmentative and alternative communication (AAC)

Using **neurosymbolic** methods

Icebreaker

What do you think of when you hear “neurosymbolic”? **What does “neurosymbolic AI” mean to you?**

When poll is active respond at
PollEv.com/laramartin527

Or

Send **laramartin527** and your message to **22333**

Today’s Learning Objectives

Define neurosymbolic AI

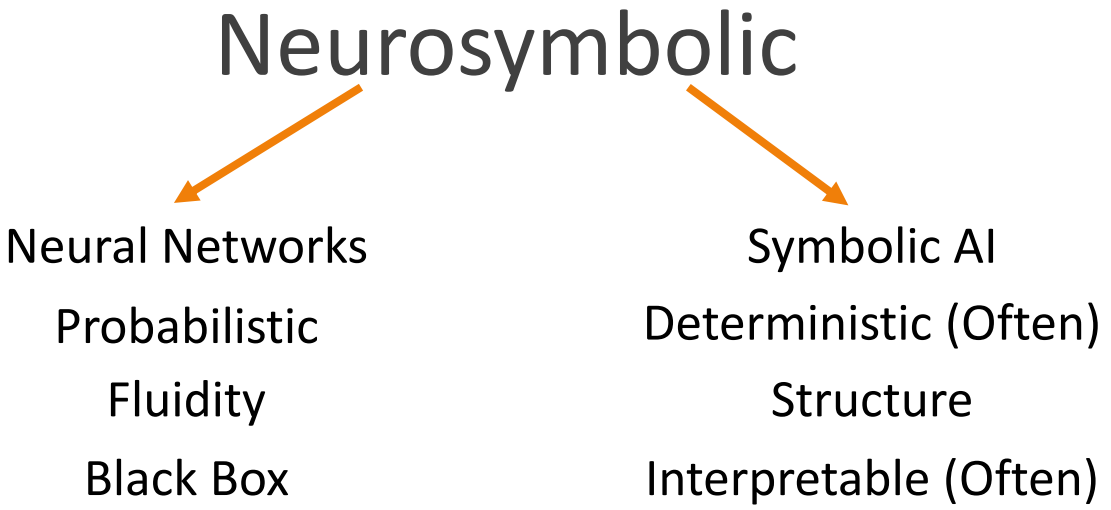
Understand (on a basic level) how neurosymbolic AI is shaping AI

Memorize the class’s logistics

Decide if you still want to take the class

What is *neurosymbolic*?

How many of you are familiar with symbolic AI?



What is neurosymbolic *text generation*?

Using neurosymbolic architectures to generate text

Neural network provides fluency or “creativity”, symbolic system provides control

Results in potentially safer generation

The Neural Component

Any type of neural network

My own work started with LSTM RNNs

Most modern neural networks for text generation are transformers (Module 1)

The Symbolic Component

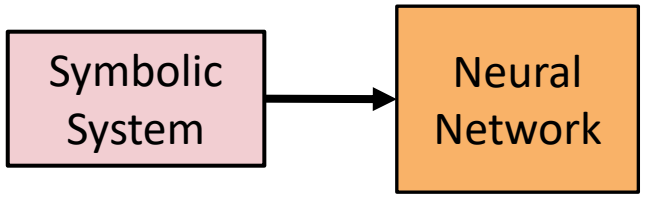
Can be…

- Knowledge graphs ★
- Ontologies ★
- Rules or if/then statements
- Scripts ★
- Planners ★
- Reinforcement Learning (if not fully deep) ★
- Information Retrieval (RAG) ★
- State Tracking ★
- Pipelines ★
- Pattern Matching
- Logic
- Proofs

★ Will be discussed in this course

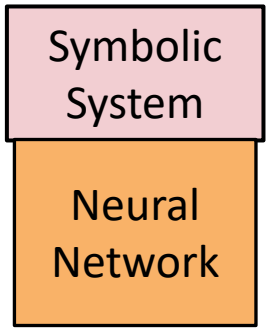
Basic Types Neurosymbolic Architectures

(1) Before / Bootstrapping



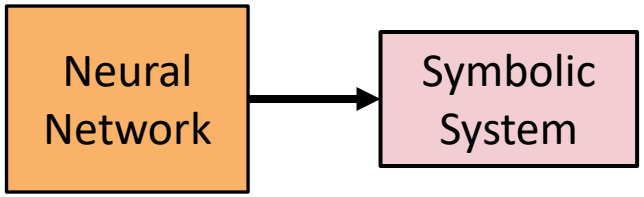
Guided Generation (Module 2)

(2) Integrated

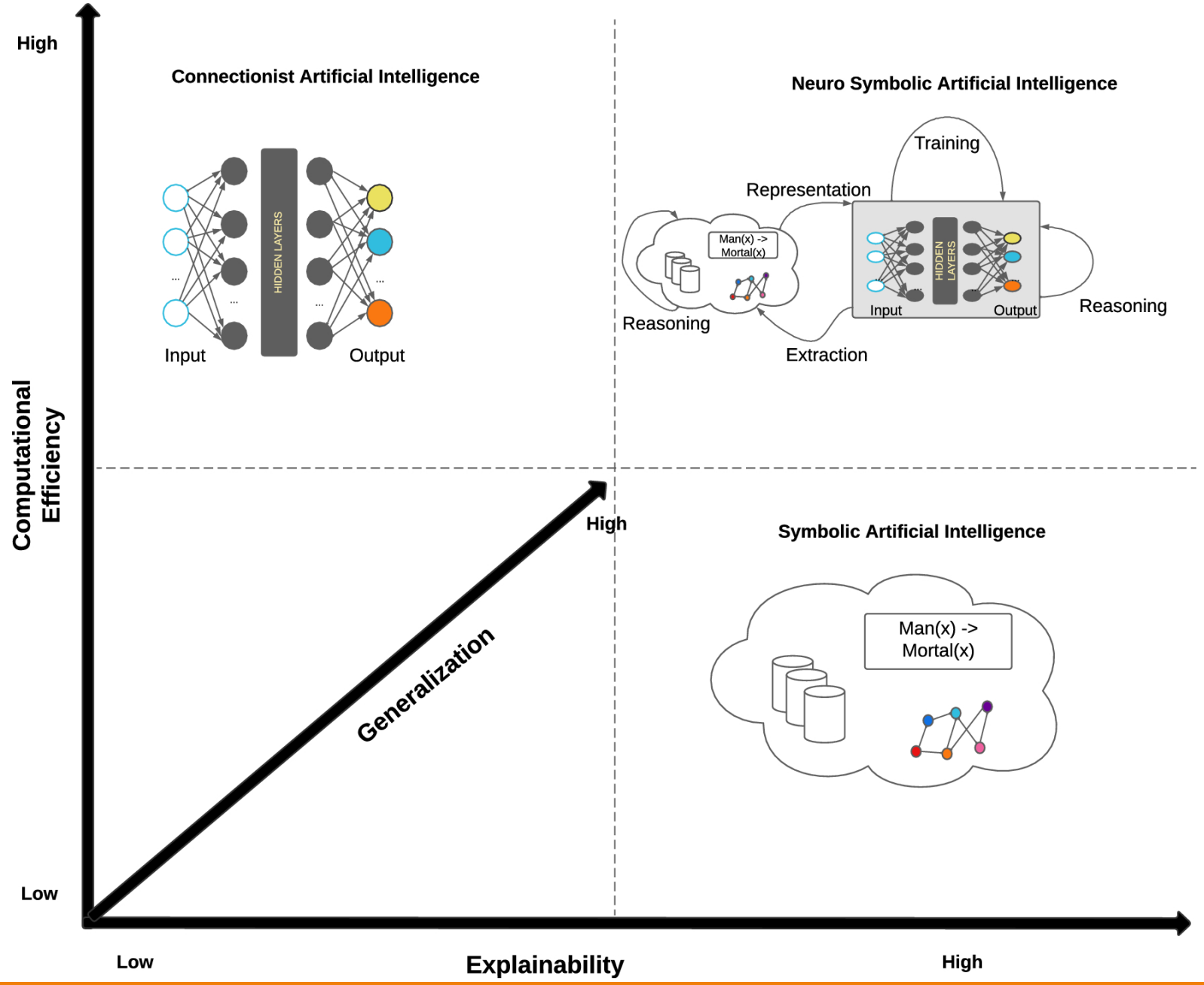


Planning (Module 3)

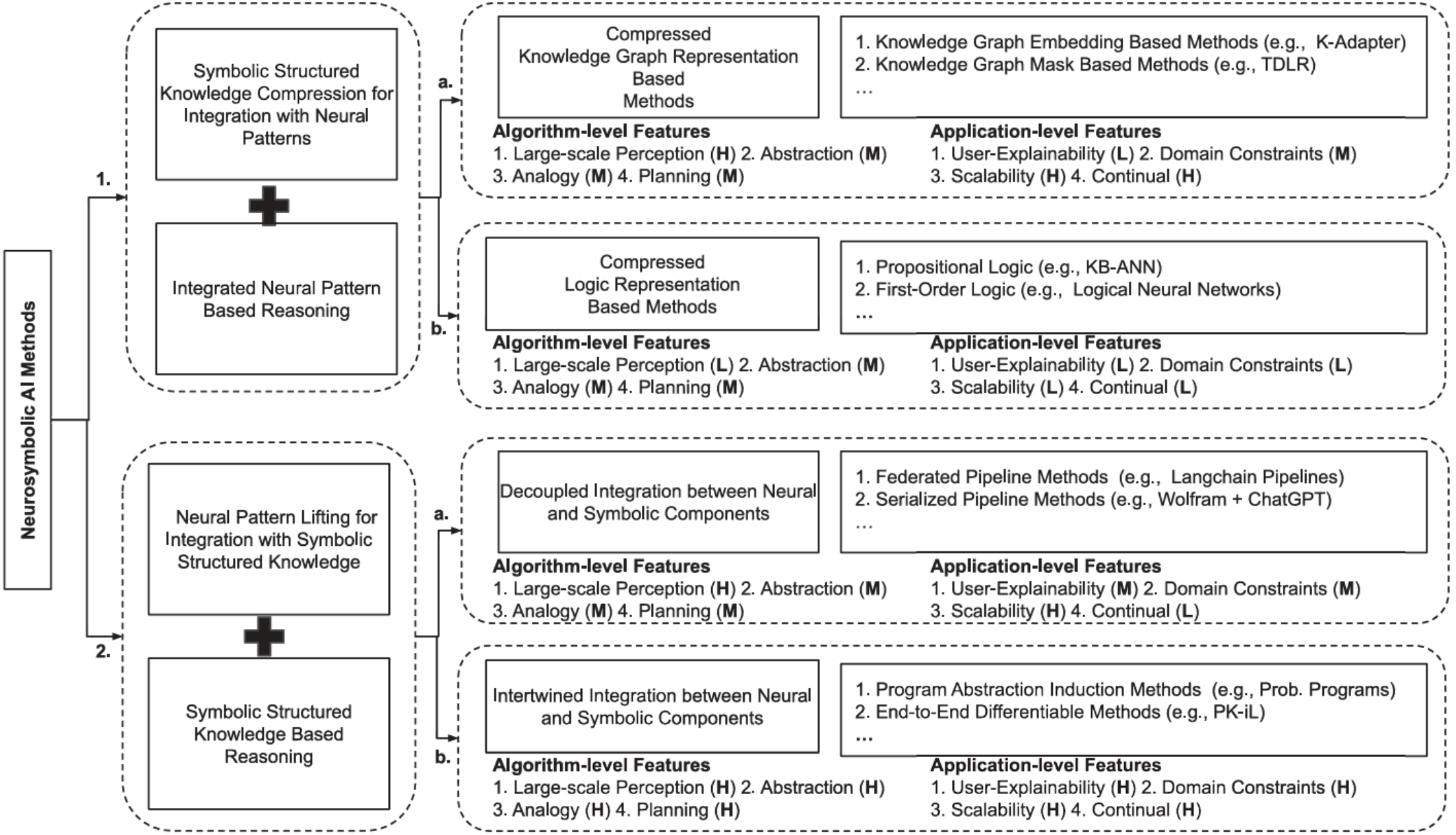
(2) After / Validation



Commonsense Reasoning (Module 4)



Bhuyan, Bikram Pratim, et al. "Neuro-symbolic artificial intelligence: a survey." Neural Computing and Applications 36.21 (2024): 12809-12844.


Neurosymbolic AI Methods
1.
Symbolic Structured Knowledge Compression for Integration with Neural Patterns
Integrated Neural Pattern Based Reasoning
a.
Compressed Knowledge Graph Representation Based Methods
1. Knowledge Graph Embedding Based Methods (e.g., K-Adapter)
2. Knowledge Graph Mask Based Methods (e.g., TDLR)
…
Algorithm-level Features
1. Large-scale Perception (H) 2. Abstraction (M)
3. Analogy (M) 4. Planning (M)
Application-level Features
1. User-Explainability (L) 2. Domain Constraints (M)
3. Scalability (H) 4. Continual (H)
b.
Compressed Logic Representation Based Methods
1. Propositional Logic (e.g., KB-ANN)
2. First-Order Logic (e.g., Logical Neural Networks)
…
Algorithm-level Features
1. Large-scale Perception (L) 2. Abstraction (M)
3. Analogy (M) 4. Planning (M)
Application-level Features
1. User-Explainability (L) 2. Domain Constraints (L)
3. Scalability (L) 4. Continual (L)
2.
Neural Pattern Lifting for Integration with Symbolic Structured Knowledge
Symbolic Structured Knowledge Based Reasoning
a.
Decoupled Integration between Neural and Symbolic Components
1. Federated Pipeline Methods (e.g., Langchain Pipelines)
2. Serialized Pipeline Methods (e.g., Wolfram + ChatGPT)
…
Algorithm-level Features
1. Large-scale Perception (H) 2. Abstraction (M)
3. Analogy (M) 4. Planning (M)
Application-level Features
1. User-Explainability (M) 2. Domain Constraints (M)
3. Scalability (H) 4. Continual (L)
b.
Intertwined Integration between Neural and Symbolic Components
1. Program Abstraction Induction Methods (e.g., Prob. Programs)
2. End-to-End Differentiable Methods (e.g., PK-iL)
…
Algorithm-level Features
1. Large-scale Perception (H) 2. Abstraction (H)
3. Analogy (H) 4. Planning (H)
Application-level Features
1. User-Explainability (H) 2. Domain Constraints (H)
3. Scalability (H) 4. Continual (H)

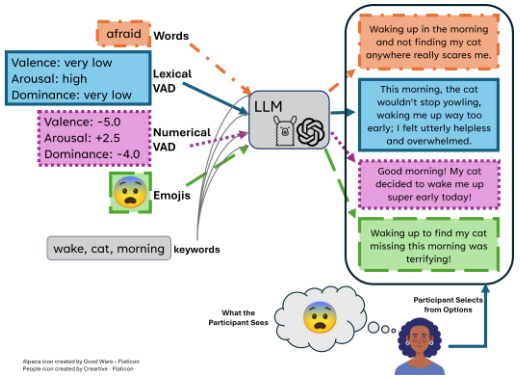
Some of My Past Neurosymbolic Work

Structure-Guided Generation

(subject, verb, direct object, modifier)

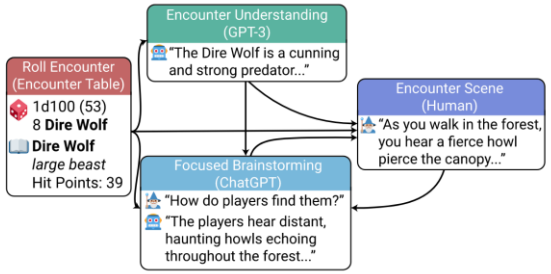
Original sentence: yoda uses the force to take apart the platform
Event: yoda use force Ø
Generalized Event: <PERSON>0 use-105.1 causal_agent.n.01 Ø

L. J. Martin *et al.*, "Event Representations for Automated Story Generation with Deep Neural Nets," *AAAI*, vol. 32, no. 1, pp. 868–875, Apr. 2018, doi: 10.1609/aaai.v32i1.11430.

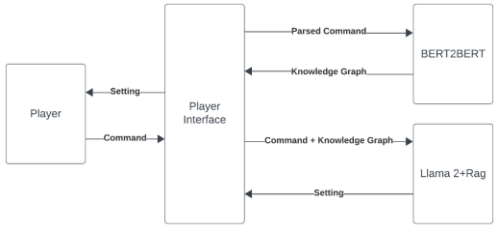


S. H. Choudhury *et al.*, "Evaluating Human-LLM Representation Alignment: A Case Study on Affective Sentence Generation for Augmentative and Alternative Communication," *IJCNLP-AACL Findings*, pp. 1618-1637, Dec. 2025, doi: 10.18653/v1/2025.findings-ijcnlp.100.

Retrieval-Augmented Generation for IF / D&D

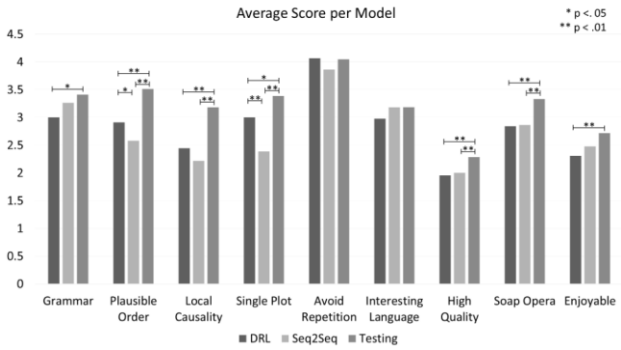


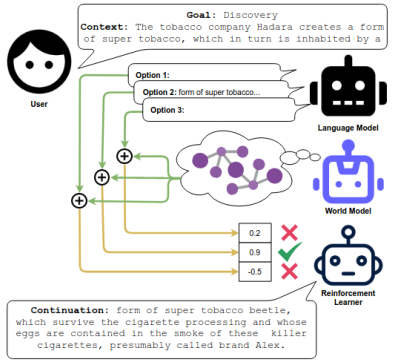
A. Zhu *et al.*, "CALYPSO: LLMs as Dungeon Masters' Assistants," *AIIDE*, vol. 19, no. 1, pp. 380-390, Oct. 2023, doi: 10.1609/aiide.v19i1.27534.



R. Chambers *et al.*, "BERALL: Generating Retrieval-augmented State-based Interactive Fiction Games," *Wordplay Workshop*, Aug. 2024, url: https://wordplay-workshop.github.io/wordplay2024/pdfs/21.pdf

Reinforcement Learning for Story Generation





P. Tambwekar *et al.*, "Controllable Neural Story Plot Generation via Reward Shaping," *IJCAI*, pp. 5982-5988, Oct. 2019, doi: 10.24963/ijcai.2019/829.

A. Alabdulkarim *et al.*, "Goal-Directed Story Generation: Augmenting Generative Language Models with Reinforcement Learning," *arXiv preprint*, Dec. 2021, doi: 10.48550/arXiv.2112.08593.

Think-Pair-Share

If neurosymbolic methods result in safer, controllable text generation, why aren’t more AI systems neurosymbolic?

Course Logistics

Important Note

If you have taken my 491/691 on Interactive Fiction and Text Generation, I *highly discourage* you to take this course.

Materials

Mostly on course website: https://laramartin.net/neurosymbolic-text-gen/

Submissions and grades are on Blackboard

No textbook!

You will probably need to purchase credit for OpenAI API. Let me know if you need financial help with this.

Schedule

https://laramartin.net/neurosymbolic-text-gen/lectures.html

The lecture schedule will be updated as the term progresses. You can find more details under the Modules tab.

Date	Lecture Topic	Knowledge Check	Academic Papers	Supplemental Media	Homework Due
Tue, Aug 25, 2026	Intro to the Class & Neurosymbolic AI (Module 0) [slides]				
Thu, Aug 27, 2026	Neural Language Models + Attention (Module 1)		• Ilya Sutskever, Oriol Vinyals, Quoc V. Le, Sequence to Sequence Learning with Neural Networks • Alex Graves, Generating Sequences With Recurrent Neural Networks	• Elle Hunt (The Guardian), Tay, Microsoft's AI chatbot, gets a crash course in racism from Twitter • Tom Simonite (Wired), The AI Text Generator That's Too Dangerous to Make Public	
	aitlist Deadline				
Mon, Aug 31, 2026	Waitlists Deactivated				
Tue, Sep 1, 2026	Transformers (Module 1)		• Emily M. Bender, Timnit Gebru, Angelina McMillan-Major, Margaret Mitchell, On the Dangers of Stochastic Parrots: Can	• Jay Alammar, The Illustrated Transformer	

Slides, Posted before class

Topics

What is Neurosymbolic AI? (Module 0) – Just this lesson

Language Modeling (Module 1)

Guided Generation (Module 2)

Search and Planning (Module 3)

Commonsense Reasoning and Schemas (Module 4)

Dialog and Agents (Module 5)

Academic Integrity

If you feel the need to cheat on the assignment to do well on it, please talk to me or the TA first. We can work it out ahead of time, but once you cheat it's hard to do anything.

If you cheat or plagiarize, you…

- aren't learning anything
- wasting money paying for tuition
- will get an F on the assignment (at the very least)

More details on course website

If you want to use LLMs for assignments

- If it's explicitly part of the assignment, follow the assignment instructions
- Otherwise, make sure you're saying that you used it
- Always:
  - Provide your prompt and the original generation (along with how you edited it)
  - Make sure that you're not avoiding the learning objectives by using it
- If you **do not** say you're using it and I notice, that is an academic integrity violation
- It's not allowed for the grad presentation
- It's okay to use grammar tools (e.g., spell check or Grammarly) or small-scale prediction (e.g., next word prediction, tab completion), provided that they don't change the **substance** of your work

Course-Long Learning Objectives

1. Understand the strengths and weaknesses of neural language models (LMs) by themselves.
2. Implement and appraise the value of
   - conditioned generation,
   - planning, and
   - schemata

   in text generation.
3. Discuss complex neurosymbolic systems and argue for the appropriate components of a working neurosymbolic text generation system.
4. Create your own neurosymbolic text generation system.

Course Learning Objectives Align with Assignments

5 Homework Assignments (11% of final grade each), one for each Module – Objectives 1,2

Group Project (30% of final grade) – Objectives 3,4

Knowledge Checks (15% for undergrads, 5% for grads) – Objectives 1,2,3

Paper Presentation (grad only; 10%) – Objectives 2,3

Knowledge Checks

Quick in-class activities or polls to test your understanding

- I try to give feedback on them (sometimes in bulk, sometimes individually)

Not graded for accuracy (1 = you did it, 0 = you didn’t)

You can make it up anytime, no need to let us know. Just submit it on Blackboard.

Lowest 2 grades dropped (i.e., you’re allowed to miss two without making it up)

Active Learning

My classes are interactive by nature

Interactive learning can feel like you're not learning as much (because you're less bored probably), but you're actually learning more than you would with just a lecture [1,2]

If this is not your style, now's the time to drop the class

[1] T. Blyznyuk and T. Kachak, "Benefits of Interactive Learning for Students' Critical Thinking Skills Improvement", *jpnu*, vol. 11, no. 1, pp. 94–102, Mar. 2024. https://journals.pnu.edu.ua/index.php/jpnu/article/view/7840
[2] S. Freeman, S.L. Eddy, M. McDonough, M.K. Smith, N. Okoroafor, H. Jordt, & M.P. Wenderoth, Active learning increases student performance in science, engineering, and mathematics, Proc. Natl. Acad. Sci. U.S.A. 111 (23) 8410-8415, https://doi.org/10.1073/pnas.1319030111 (2014).

Class Project

Create either a demo or research a problem relevant to class

You come up with the topic, I scope the project

Groups of 3-5 people

There will be 4 deadlines throughout the semester

Each deadline builds on the previous

Grad Student Presentations

Prepare an 8-minute presentation on a paper from the reading list or another paper relevant to the module you are assigned

Your presentation should summarize the work and analyze

Module ranking is due 9/4

Assignment Policies

Everyone has 5 free late days (3 max per homework)

- No excuse needed/no need to tell me you're using them

You can collaborate on homeworks (1-2 people) and the project (3-5 people), **not** the knowledge checks or grad presentation

Disclaimer about POTS

I have a disability called Postural Orthostatic Tachycardia Syndrome (POTS)

- It means that my blood doesn't always go where I need it to go (such as my head)
- It's a *dynamic disability*, meaning that it's worse some days than others

How does it affect this class?

- I will be lecturing sitting down
- I might get brain fog and have trouble thinking or recalling words

How to Contact Us

Email us with specific questions

- Instructor: laramar@umbc.edu
- TA: ahonrao1@umbc.edu

Office Hours

Tuesdays 3:15-5PM EST in ITE 342A

Or by appointment: https://calendly.com/laramar/schedule

^ I will start at 3:30PM today though

CMSC 412/612 - Neurosymbolic Text Generation | Schedule | Modules | Assignments

Automatically write descriptions for text adventure games

This assignment is due on Thursday, September 10, 2026 before 11:59PM.

You can download the materials for this assignment here:

- hw1.ipynb

Homework 1: Prompting and Fine-tuning

In this homework, we're going to use OpenAI's API to generate text adventure game components automatically. Starting with the prompting ideas from class and the prompting activity, we'll show how to finetune models to perform specific tasks. In particular, you will generate room descriptions and item properties for text adventure games.

Learning Objectives

For this assignment, we will check your ability to:

- Call APIs for few-shot prompting LLMs
- Call APIs for finetuning LLMs
- Setup data for finetuning
- Compare finetuned output to few-shot output of the same base model

https://laramartin.net/neurosymbolic-text-gen/homeworks/generating-descriptions/light.html