



INFO-I590: Fundamentals and Applications of LLMs

# Overview and Introduction

Jisun An

## OpenAI says ChatGPT's weekly users have grown to 200 million

AI startup OpenAI said on Thursday its chatbot ChatGPT now has more than 200 million weekly active users, double the number it had in the...

Aug 29, 2024



## ChatGPT added 50 million weekly users in just two months

OpenAI says ChatGPT now has more than 250 million weekly users. That's an increase of 50 million from late August.

Oct 2, 2024

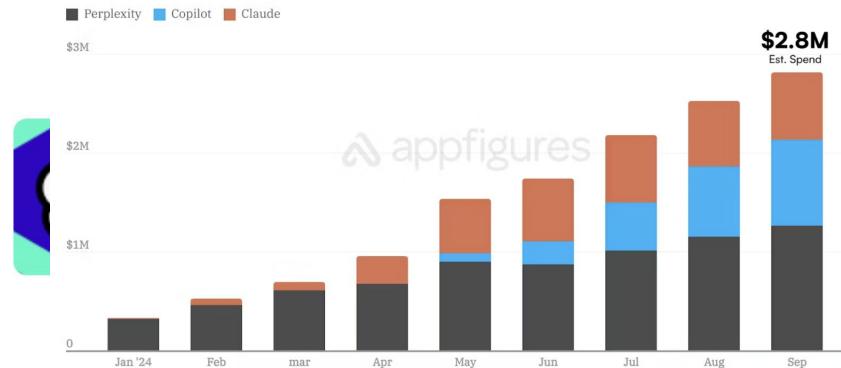
## ChatGPT now has over 300 million weekly users

ChatGPT now has over 300 million people using the AI chatbot each week. OpenAI CEO Sam Altman revealed the milestone during The New York Times' DealBook Summit.

1 month ago



**The "Other" AI Apps Are Growing**  
Est. Consumer Spending on the App Store and Google Play



# What can we do with LLMs?

- Help with writing and editing (e.g., grammar checks, emails, etc)
- Coding!
- Knowledge searching
- Translation
- ...

# What are people using LLMs for?

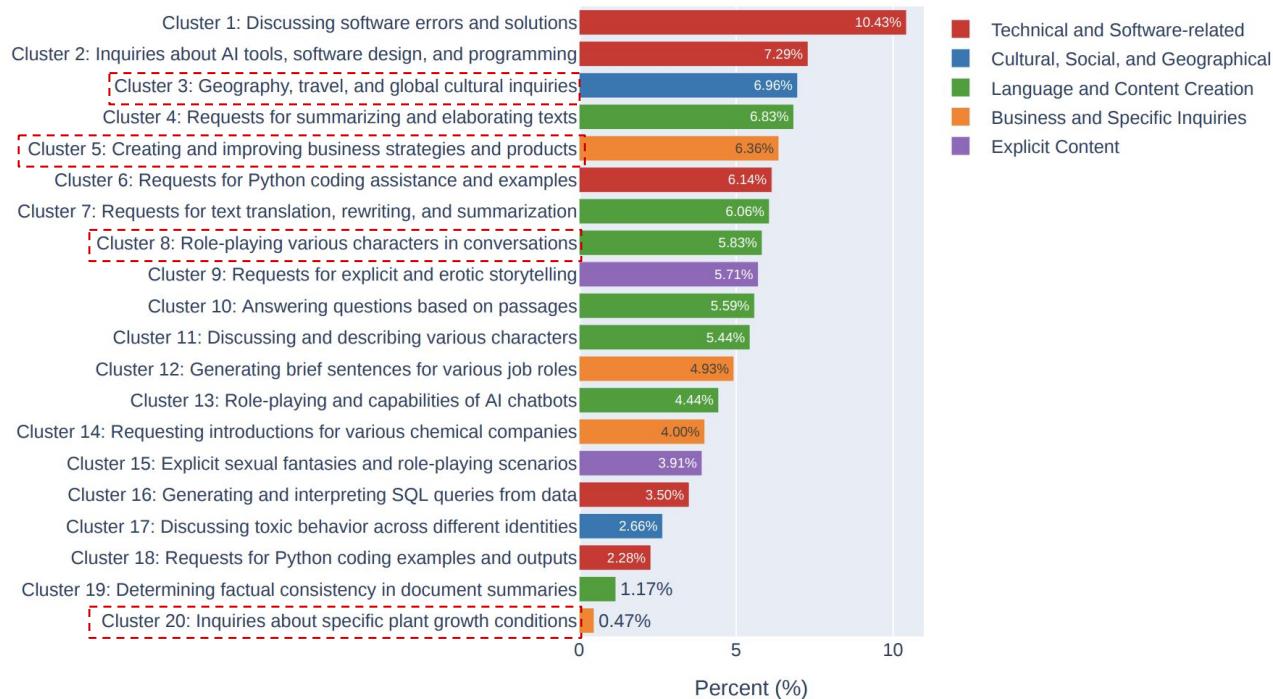


Figure 3: Topic distribution of 100K sampled conversations. Manual inspection of cluster centroids

What's the top news today?



Here are some of today's top news stories:

#### Politics

- **UK Anti-Corruption Minister Under Scrutiny:** Tulip Siddiq, the UK's anti-corruption Treasury minister, is facing calls for her resignation due to her family's connections and an alleged eight-year secret detention by a regime led by her aunt. Despite these issues, she remains in her position. FINANCIAL TIMES

#### Business

- **Stock Market Movements:** The Dow Jones Industrial Average rose by 0.7% on Monday, driven by gains in UnitedHealth, Caterpillar, and Amgen. However, Nvidia's shares declined due to new chip export restrictions imposed by the Biden administration. INVESTOR'S BUSINESS DAILY

#### Technology

- **UK Invests in AI Computing:** The UK government has announced a significant investment in AI computing capacity over the next five years, including the construction of a new supercomputer, aiming to establish a globally competitive artificial intelligence sector. FINANCIAL TIMES

#### Transportation

- **M4 Motorway Closures:** Starting today, the M4 motorway, a major route from London to South Wales, will experience multiple closures due to scheduled roadworks, potentially causing delays of up to 30 minutes over the next two weeks. THE SUN

#### Entertainment

- **'Today' Show Host Change:** Hoda Kotb exited the "Today" show on January 10, with Craig Melvin replacing her as co-anchor on January 13. On Melvin's first day, co-hosts showed support, while Carson Daly humorously noted the sudden absence of Hoda's pictures in the studio. PEOPLE.COM

What's the top news in Korea?



Here are some of the top news stories from Korea today:

#### Political Developments

- **South Korea's Political Turmoil:** South Korea is experiencing significant political unrest following President Yoon Suk Yeol's failed attempt to impose martial law. The National Assembly has impeached President Yoon, and an arrest warrant has been issued against him on charges related to the martial law declaration. This marks the first time a sitting South Korean president has faced such legal action. FINANCIAL TIMES

- **South Korea-Japan Diplomatic Engagement:** Amidst the political crisis, Japanese Foreign Minister Takeshi Iwaya is scheduled to visit Seoul to meet with Acting President Choi Sang-mok. The visit aims to strengthen security cooperation between the two nations and the United States, especially in light of regional security concerns. REUTERS

#### Military Affairs

- **North Korean Troops in Ukraine:** Reports indicate that North Korean soldiers have been captured by Ukrainian forces while fighting alongside Russian troops. South Korea's National Intelligence Service (NIS) has confirmed the capture and noted that the soldiers have not expressed a desire to defect to South Korea. Approximately 300 North Korean troops have reportedly died, and 2,700 have been injured in the conflict. ASSOCIATED PRESS

#### Aviation Incident

- **Jeju Air Crash Investigation:** South Korean authorities are investigating a tragic Jeju Air crash that resulted in 179 fatalities. The incident involved a Boeing 737-800 that overshot the runway at Muan International Airport. The government has announced plans to inspect all Boeing 737-800 aircraft operated in the country and is considering overhauling airport structures to enhance safety. ASSOCIATED PRESS

GPT-4o  
on Jan 13

# When do LLMs fail?

“

Write a sentence that ends with the letter s.



Sure! Here's a sentence:  
"The cat loves chasing butterflies."

“

Write a sentence that contains the letter f exactly three times.



Sure! Here's a sentence:  
"Frank found a fluffy fox."

“

Mike's mum had 4 kids; 3 of them are Luis, Drake and Matilda. What is the name of the 4th kid?



The name of the 4th kid is Mike! It's a riddle, and the answer is in the question itself: "Mike's mum had 4 kids." 😊

“

What is taller, Mount Everest or the Burj Khalifa?



Mount Everest is much taller than the Burj Khalifa.

- Mount Everest: Approximately 8,849 meters (29,032 feet) above sea level.
- Burj Khalifa: The tallest building in the world at 828 meters (2,717 feet).

So, Mount Everest is over 10 times taller than the Burj Khalifa!

“

How tall will the first 7-ft president be?

It's not possible to predict with certainty how tall the first 7-ft president will be, as

the height of an individual is determined by

- The first 7-foot president will be exactly 7 feet tall, which inches or approximately 213.36 centimeters.

This would make them the tallest president in U.S. history Lincoln and Lyndon B. Johnson, who both stood at 6 feet time.

“

How many non-stop flights are there a day between Heathrow and St Pancras International?



There are no non-stop flights between Heathrow Airport and St Pancras International because they are both located in London and only about 15 miles apart. Instead, you can easily travel between the two via public transportation, such as:

- The London Underground (Piccadilly Line) to connect Heathrow to central London.
- The Elizabeth Line or the Heathrow Express to Paddington, and then other lines to St Pancras.

GPT-4o  
on Jan 13

# LLMs may fail significantly...

AI hallucinations caused artificial intelligence to falsely describe these people as criminals

By Anna Kelsey-Sugg and Damien Carrick for Law Report

ABC RN Artificial Intelligence

Sun 3 Nov

DIVE BRIEF

## Legal GenAI tools mislead 17% of time: Stanford study

Specialized legal applications are better than a general purpose tool like ChatGPT but whether they save time, given the oversight they need, is a question, an academic study says.

Published May 24, 2024

TechCrunch

Hacker tricks ChatGPT into giving out detailed instructions for making homemade bombs

The New York Times

## *Can A.I. Be Blamed for a Teen's Suicide?*

The mother of a 14-year-old Florida boy says he became obsessed with a chatbot on Character.AI before his death.

NBC NEWS

## Lawsuit claims Character.AI is responsible for teen's suicide

Megan Garcia says the company's chatbots encouraged her 14-year-old son, Sewell Setzer, to take his own life, according to the lawsuit.

"They were all court cases I wrote about,"

Bernklau says.

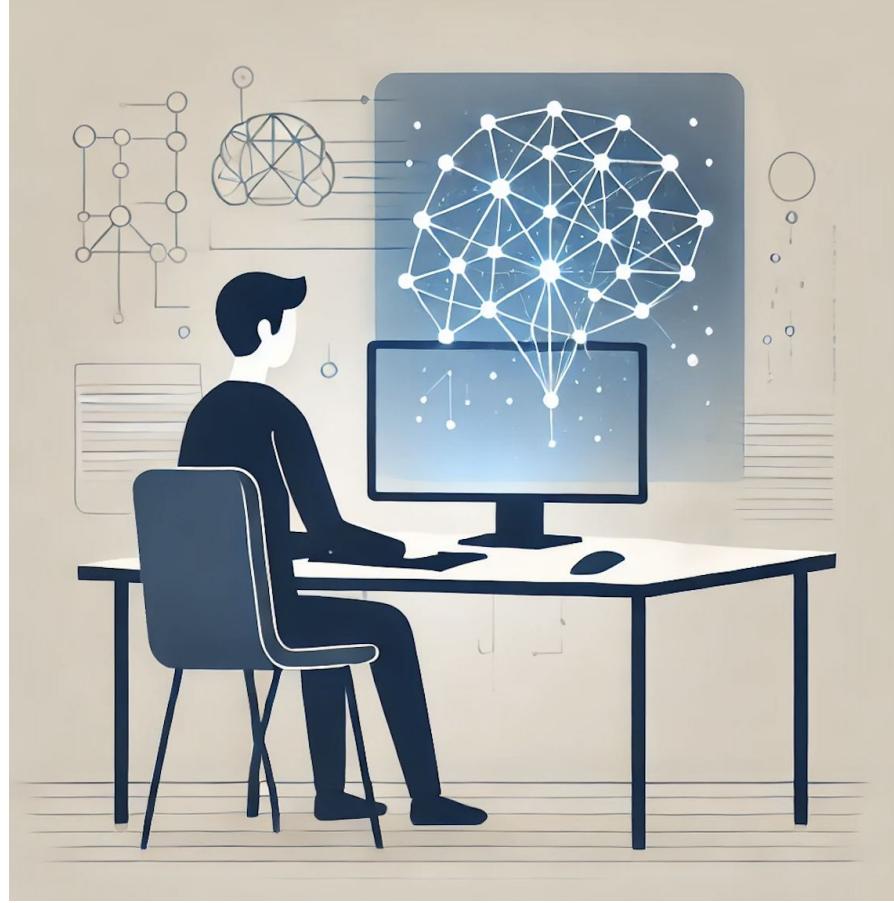
CNBC

AI tools such as ChatGPT are generating a mammoth increase in malicious phishing emails

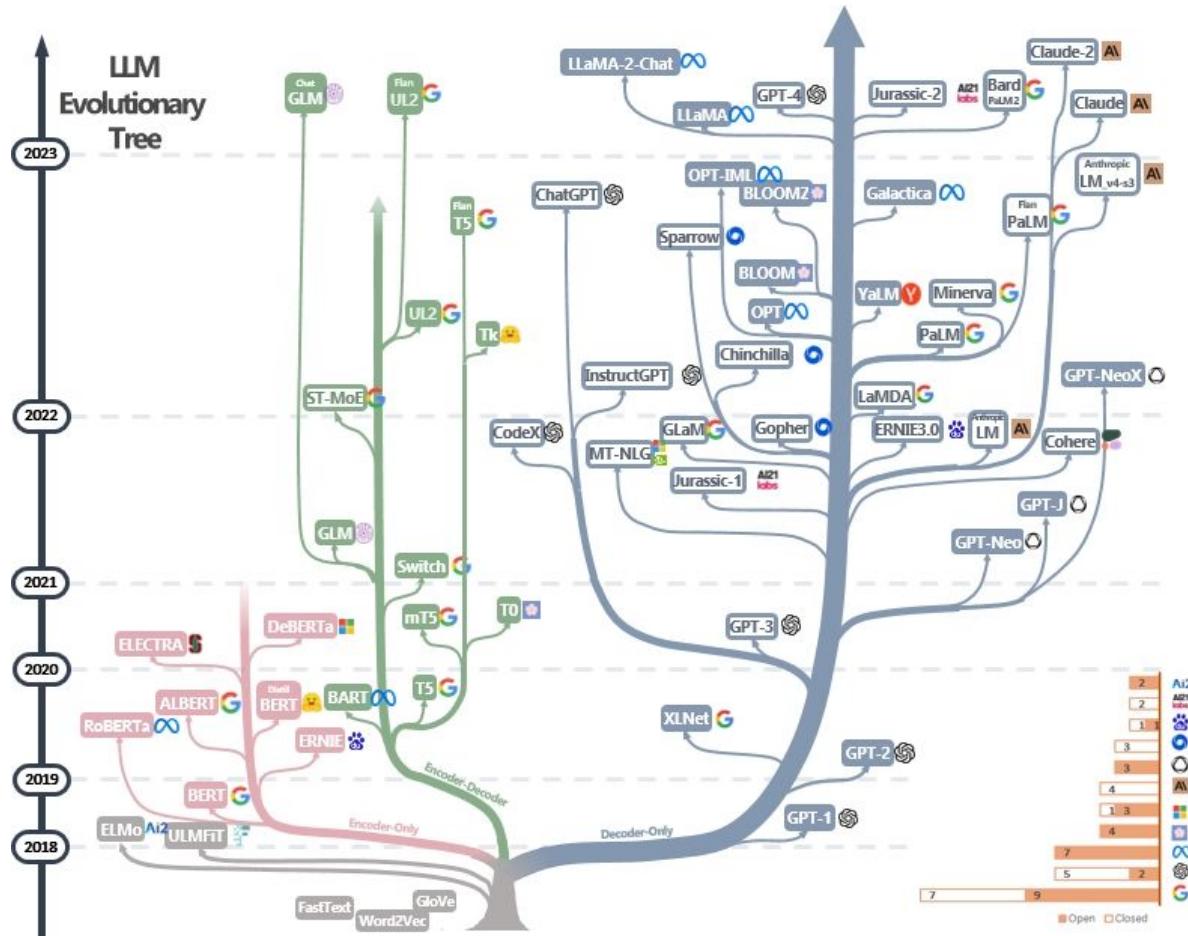
PUBLISHED TUE, NOV 28 2023 10:39 AM EST

Bob Violino

SHARE



Img: created by GPT-4o (feat. DALL·E 3)



Welcome to INFO-I590:  
**Fundamentals** and **Applications** of  
Large Language Models (LLMs)

# What is a Large Language Model?

# What is NLP (Natural Language Processing)?

- NLP is a form of artificial intelligence (AI) that aims to enable **computers to understand, interpret, and interact with human languages**, whether it be written, spoken, or even scribbled.

# Applications of NLP

- Text Analysis and Understanding (e.g. sentiment analysis, topic modeling)
- Language Generation (e.g. chatbots, content creation)
- Code Generation
- Machine Translation
- Speech Recognition and Processing (e.g. speech-to-text)
- Information Retrieval (e.g. search engines)
- Named Entity Recognition (NER)
- Question Answering
- Text Classification

# Techniques Used in NLP

- Rule-based Approaches
  - Using predefined linguistic rules to process language
- Statistical Methods
  - Leveraging probabilistic models to analyze language patterns (e.g.,n-grams)
- Machine Learning and Deep Learning
  - Training models like Support Vector Machines (SVM) or neural networks
  - Popular deep learning models include:
    - RNNs (Recurrent Neural Networks) and LSTMs for sequence data
    - **Transformers** (e.g., BERT, GPT) for large-scale language understanding and generation

# Large Language Model (LLM)

- LLM is an **advanced type of NLP models** designed to understand, generate, and manipulate human language **by leveraging deep learning techniques**. LLMs are pre-trained on massive datasets from diverse text sources and are built on *transformer architectures*.
- Applications of LLMs?
  - LLMs can handle, and often excel in, most applications of NLP without requiring separate, specialized algorithms for each application.
  - Instead of creating individual models for specific NLP tasks, a single LLM can perform a wide range of tasks effectively.

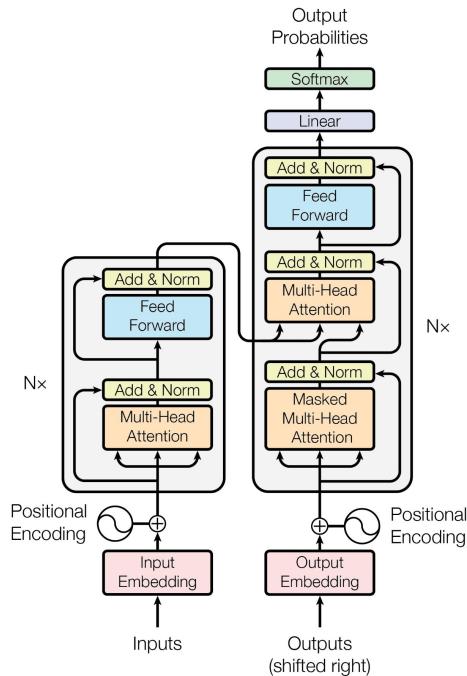
# In this class, we will:

- Learn the principles, architectures, and training methods of large language models;
- Gain hands-on experience fine-tuning and applying LLMs across various domains;
- Critically assess the ethical, social, and practical implications of LLMs.

# Roadmap

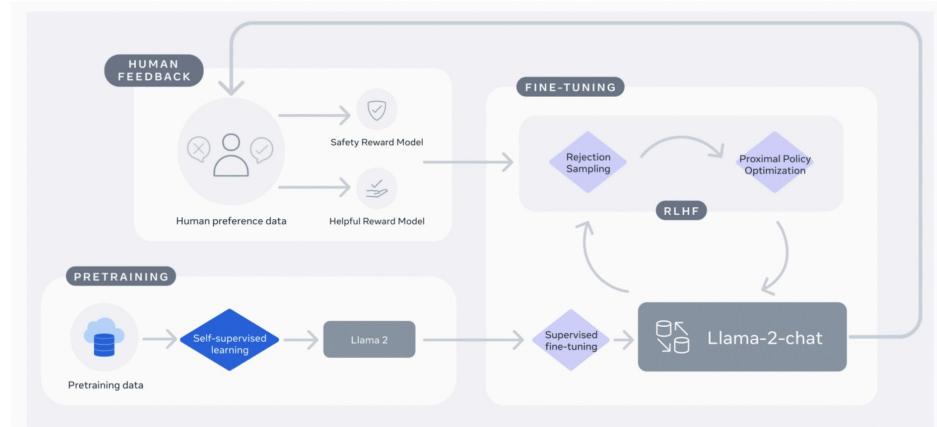
# Topic 1: Language Modeling Fundamentals

- Representing words
- Language modeling
- Sequence encoding
- Transformers



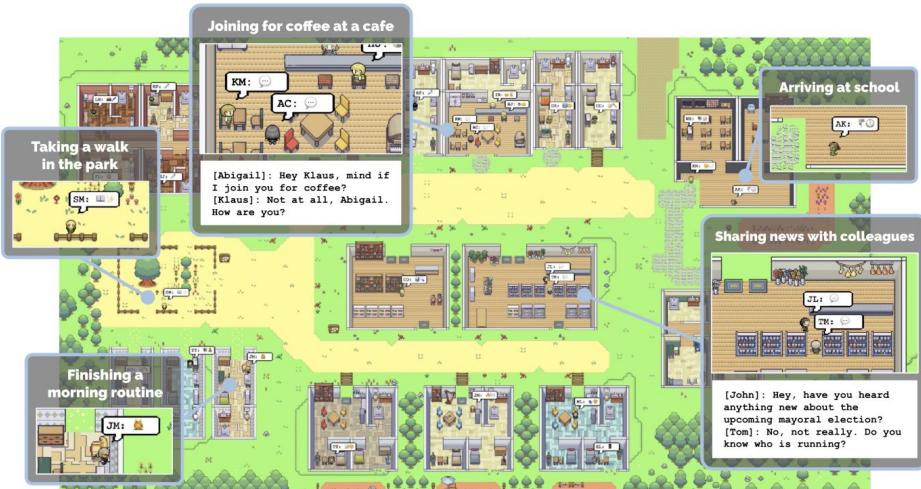
# Topic 2: Training and Inference Methods

- Pre-training
- Fine-tuning
- Instruction Tuning
- Prompting
- Reinforcement Learning



# Topic 3: LLM Applications

- Complex reasoning tasks
- Retrieval Augmented Generation
- Language agents



# Topic 4: LLM in various domains

- Education
- Finance
- Business
- Law
- Health care
- Social science



# Class Format/Structure

# Teaching Team

- Instructor: Jisun An
  - Office hours: Tuesday 9:30 ~ 10:30 AM
  - Zoom: <https://iu.zoom.us/my/jisunan>
- TA: Fan Huang
  - Office hours: Friday 3 ~ 4 PM
  - Zoom: <https://iu.zoom.us/my/fanhuang>

# Prerequisites

To succeed in this course, you are expected to:

- Be proficient in Python, which is required for project work;
- Have a basic understanding of linear algebra, probability, and statistics;
- Be familiar with basic concepts in NLP, such as train/dev/test splits, model fitting, features, and supervised learning. Please note that these topics will not be covered in this course.

# Overview of Class Activities

- Group Project: 40%
  - Proposal presentation: 10%
  - Final Presentation: 10%
  - Final Submission: 20%
- Theoretical Assignments: 15%
- Practical Assignment: 15%
- Exam: 20%
- Participation: 10%

# Group Projects (40%)

- Scope
  - Applying LLMs to real-world problems for social good
  - Proposing new methods tailored to LLM challenges
  - Case studies of human factors in existing LLM systems
  - Case studies of LLM systems
- 5 students per group
- Group Project
  - Proposal presentation (10%): 8 minutes
  - Final presentation (10%): 10 minutes
  - Final report (20%): 8 pages long (in ACL format)



# LLM Hackathon App Gallery

See Instructions

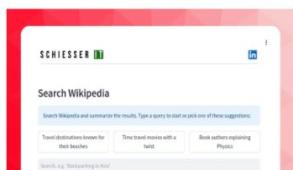


Select a Partner tech used in the app

LangChain ✕ LlamaIndex ✕ AssemblyAI ✕ Weaviate ✕ Clarifai ✕



## Winning Entries



### Wiki-Search

 marcuschiesser

[View source →](#)

Weaviate



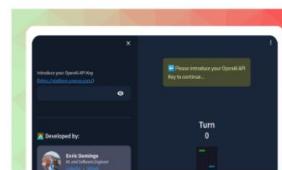
### AI Research Buddy

 bp-high

[View source →](#)

Clarifai LangChain

LlamaIndex



### The LLMs Arena

 enricd

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LangChain

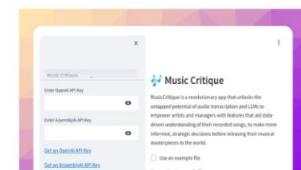


### Persona Simulator

 msull

[View source →](#)

Clarifai



### MusicCritique

 rexsimiloluwah

[View source →](#)

AssemblyAI LangChain

## Theoretical Assignments (15%)

- There will be two individual assignments (T1 and T2, 7.5% each).
- Each assignment will require students to answer multiple-choice questions about the course content.

# Practical Assignment (15%)

- One individual programming assignment using LLMs
- Details will be announced soon!

# Exam (20%)

- Multiple-choice questions about the course content
- In-person, closed-book exam

# Attendance (10%)

- We will take attendance. We will drop the four lowest grades for attendance.

Canvas -> Assignments

-> Attendance -> Thur Jan 16

password:

llm

# Schedule

Week	Topic	Remarks/Assessment
1	Jan 14 Tue - no class	
	Jan 16 Thu - Overview and introduction	
2	Jan 21 Tue - Word representations	
	Jan 23 Thu - Language modeling	
3	Jan 28 Tue - Lab: Language modeling	
	Jan 30 Thu - Attention and transformers	Assignment T1 released
4	Feb 4 Tue - Pre-training and fine-tuning	Assignment P1 released
	Feb 6 Thu - Prompting and reasoning	
5	Feb 11 Tue - Lab - fine-tuning LLMs	
	Feb 13 Thu - Lab - prompting	Feb 16 S-Submit T1
6	Feb 18 Tue - Reinforcement Learning from Human Feedback	
	Feb 20 Thu - AI alignment and safety	

# Schedule

7	Feb 25 Tue - Retrieval augmented generation	Assignment T2 released
	Feb 27 Thu - Lab: RAG	
8	Mar 4 Tue - LLM agents	
	Mar 6 Thu - Lab: LLM agents	
9	Mar 11 Tue - Project proposal presentation	
	Mar 13 Thu - Project proposal presentation	Mar 16 S-Submit T2
10	Mar 18 Spring break	
	Mar 20 Spring break	
11	Mar 25 Tue - LLMs in law, finance, healthcare	
	Mar 27 Thu - Work session	Mar 30 S- Submit P1
12	Apr 1 Tue - LLMs in education, business, and humanity	
	Apr 3 Thu - Exam	
13	Apr 8 Tue - Multimodal LLMs	
	Apr 10 Thu - Lab: Multimodal LLMs	

# Schedule

14	Apr 15 Tue - Project hack week	
	Apr 17 Thu - Project hack week	Apr 20 S- Submit presentation slides
15	Apr 22 Tue - Project presentation	
	Apr 24 Thu - Project presentation	
16	Apr 29 Tue - Final report week (online, optional)	
	May 1 Thu - Final report week (online, optional)	S- Submit final report

# Key Dates

- No class: Jan 14
- Theoretical assignment 1 due: Feb 16 (Sun)
- Theoretical assignment 2 due: Mar 16 (Sun)
- Project proposal presentation: Mar 11 & 13 in class
- Practical assignment 1 due: Mar 30 (Sun)
- Exam: Apr 3 in class
- Spring break: Mar 18 & 20 (No class)
- Project hack week: Apr 15 & 17
- Final presentation slide due: Apr 20, 11:59 PM (Sun)
- Final report submission: May 4, 11:59 PM (Sun)

# AI policy for Assignments / Projects

- AI tools are permitted in the work process, but the idea of your project should be your own.
- Transparency is crucial:
  - Declare which AI tools were used
  - Explain how they were employed
  - Specify tasks/sections and extent of AI use
- Include AI declaration in your report and be honest and specific about AI usage