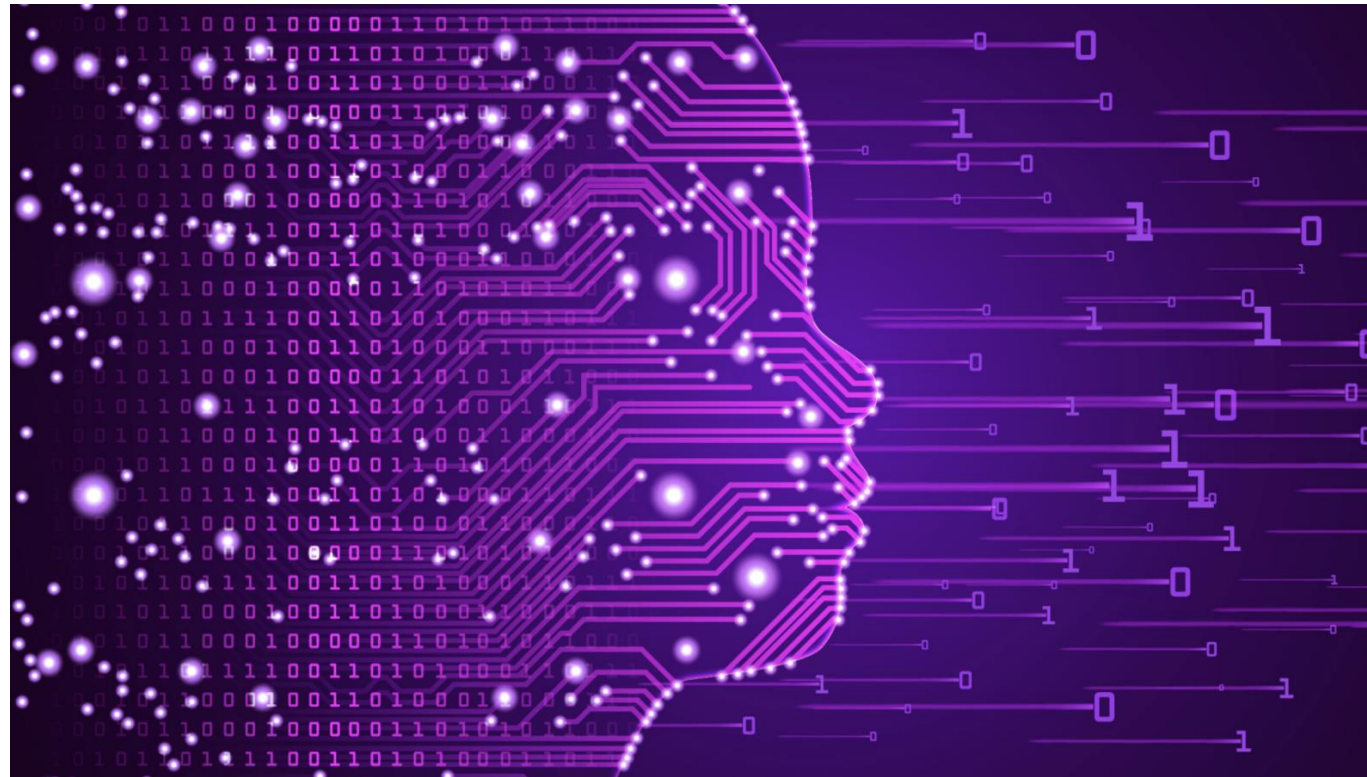


BME 2315: Computational Biomedical Engineering



Using Generative AI (ChatGPT) for Programming

Jeff Saucerman

Outline

- What are AGI, AI and generative AI?
- Uses of generative AI for computer programming
- How to use ChatGPT for programming
- How ChatGPT works

Artificial general intelligence (AGI)

An artificial general intelligence (AGI) is a *hypothetical* type of intelligent agent.[1] If realized, an AGI could learn to accomplish *any intellectual task* that human beings or animals can perform

https://en.wikipedia.org/wiki/Artificial_general_intelligence



Ex Machina (2015), Terminator 2 (1991), Space Odyssey 2001 (1968)

AI

Artificial intelligence (AI) is the ability of machines to perform ***tasks that are typically associated with human intelligence***, such as learning and problem-solving.

https://en.wikipedia.org/wiki/Artificial_intelligence



<https://techvidvan.com/tutorials/artificial-intelligence-applications/>

Public Health

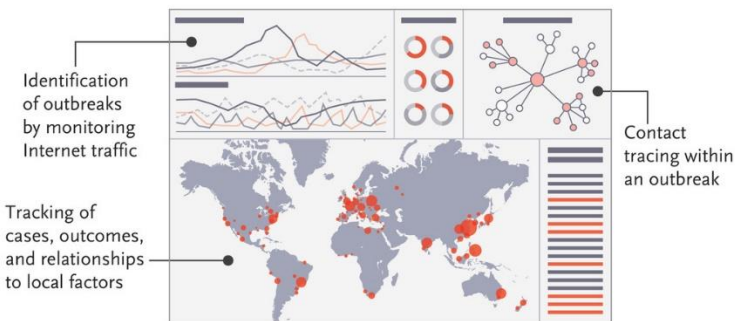
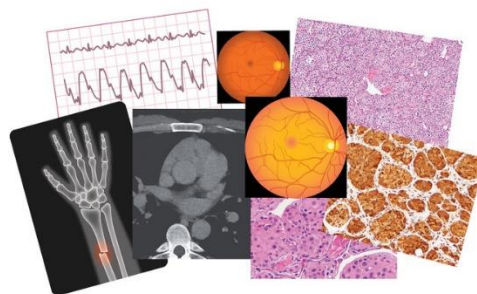


Image Analysis



Clinical-Trial Performance

Decision support in trial design
 Patient identification, recruitment, and retention
 Outcome and side-effect monitoring



Retrieval of Medical Information

Use of multiple information sources about a patient to make a diagnosis
 Internet search engines
 EMR decision support



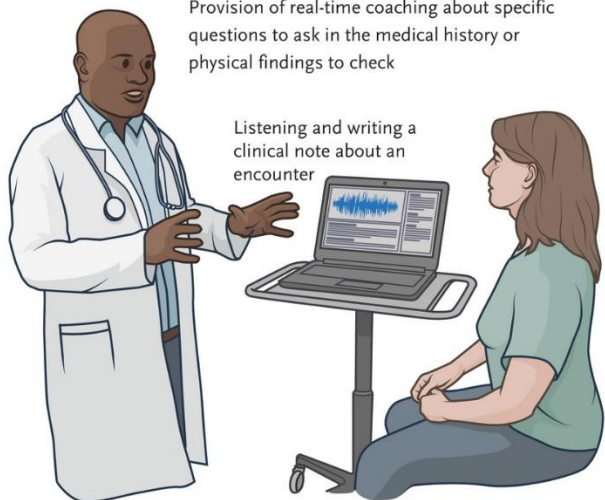
Operational Organization

Operating-room scheduling
 Billing and collections
 Patient follow-up



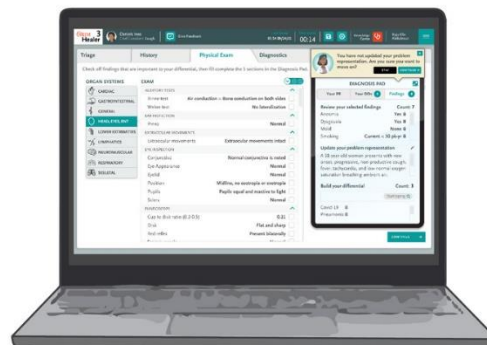
Provision of real-time coaching about specific questions to ask in the medical history or physical findings to check

Listening and writing a clinical note about an encounter



Serving as a teacher and an assessor in medical education

Creating realistic "flight simulators" for simple and complex patient encounters



Artificial Intelligence and Machine Learning in Clinical Medicine, 2023

N Engl J Med 2023; 388:1201-1208

EDITORIAL APRIL 26, 2022

The Basics of Machine Learning

M. Fralick

AI and Medical Education

A. Cooper and A. Rodman

INSIGHTS REPORT MARCH 16, 2022

Growing Use and Confidence in Artificial Intelligence for Care Delivery

W. Gordon

REVIEW ARTICLE

Artificial Intelligence in Molecular Medicine

B. Gomes and E.A. Ashley

Generative AI

Generative artificial intelligence (AI) is artificial intelligence capable of generating text, images, or other media, using generative models.

https://en.wikipedia.org/wiki/Generative_artificial_intelligence



Text (2022, word prediction)

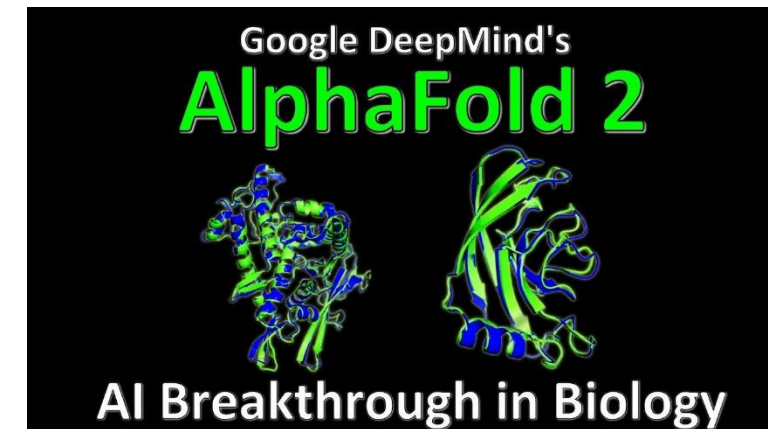
<https://openai.com/chatgpt>



Images (2022)

Midjourney DALL-E2

<https://midjourney.com>



Protein structure

AlphaFold2 (2021)

Jumper+ Nature 2021

Uses of generative AI for programming

- Writing code
- Commenting, explaining, and improving code
- Translating code between languages
- Writing unit tests



WARNING: AI tools hallucinate, don't trust them blindly!



Hallucination: the generation of images, sounds, or other types of data that **do not exist in the real world or in the training data** used to create the AI model.

Causes:

- 1) Insufficient or biased training data
- 2) Improper optimization
- 3) Lack of diversity in training data
- 4) Input data outside scope of training data

Effects:

- 1) Reduced accuracy, reliability
- 2) Legal and ethical concerns of incorrect predictions

This class will introduce you to the key concepts of why models hallucinate and how to avoid, illustrated using simpler computational methods.

Writing code: addTwoNumbers

Prompt:

write a python function called addTwoNumbers that adds two numbers together and returns the sum.

BingChat 7/28

Sure! Here's a Python function called `addTwoNumbers` that adds two numbers together and returns the sum:

```
def addTwoNumbers(x, y):  
    return x + y
```

You can call this function by passing in two numbers as arguments. For example, if you want to add 2 and 3 together, you can call the function like this:

```
result = addTwoNumbers(2, 3)  
print(result)
```

This will output `5`, which is the sum of 2 and 3.

I hope this helps! Let me know if you have any other questions.

Writing code: total_legs

Prompt:

Write a python function called animals that returns the total number of legs of all the animals. Input arguments are the number of chickens, cows, and pigs.
BingChat 7/28

Sure! Here's a Python function called animals that returns the total number of legs of all the animals given the number of chickens, cows, and pigs:

```
def animals(chickens, cows, pigs):  
    return chickens * 2 +  
        cows * 4 + pigs * 4
```

For example, if you have 2 chickens, 3 cows, and 4 pigs, you can call the function like this:

```
animals(2, 3, 4)
```

This will return the total number of legs of all the animals which is 26.

Writing code: factorial

Prompt:

Create a python function called factorial that takes an integer and returns the factorial of that integer.
BingChat 7/28

Note: this is an interesting different solution that is different than how I would do it!

Exercise: try variations on the prompt to see how that affects the output. Try different AI engines like ChatGPT-3.5, GPT-4, Bard

Sure! Here's a Python function called factorial that takes an integer and returns the factorial of that integer:

```
def factorial(n):  
    if n == 0:  
        return 1  
    else:  
        return n *  
        factorial(n-1)
```

For example, if you want to find the factorial of 5, you can call the function like this:

```
factorial(5)
```

This will return the factorial of 5 which is 120.

I hope this helps! Let me know if you have any other questions.

Debugging code: python_basics_buggy_orig.py

Prompt:

Find the bugs in this code:

<inserted code>

BingChat 7/28

I see. Here are some bugs I found in the code:

- In line 4, the string should end with a double quote instead of a single quote.
- In line 13, the print statement should say "Counter = 2" instead of "Counter = 3".
- In line 16, the print statement should say "Counter = (0, 0)" instead of "Counter = (0, 1)".
- In line 22, the variable c should be assigned to a + b instead of a + b + 1.

I hope this helps! Let me know if you have any other questions.

Translating code

Prompt: translate this code to XXX:

Python

```
def addTwoNumbers(a,b):  
    c = a + b  
    return c
```

MATLAB

```
function c = addTwoNumbers(a,b)  
    c = a + b;  
end
```

JAVA

```
public int addTwoNumbers(int a, int b) {  
    int c = a + b;  
    return c;  
}
```

C++

```
int addTwoNumbers(int a, int b) {  
    int c = a + b;  
    return c;  
}
```

Unit tests

Our original unit tests

```
# test_addTwoNumbers

from addTwoNumbers import addTwoNumbers

def test1():
    computed = addTwoNumbers(3,4)
    expected = 7
    assert computed == expected
    print("Test 1 completed.")

def test2():
    computed = addTwoNumbers(5,8)
    expected = 13
    assert computed == expected
    print("Test 2 completed.")

test1()
test2()
```

Prompt: write a unit test for this code:

```
def addTwoNumbers(a,b): c = a + b return c
```

```
import unittest

def addTwoNumbers(a,b):
    c = a + b
    return c

class TestAddTwoNumbers(unittest.TestCase):
    def test_addTwoNumbers(self):
        self.assertEqual(addTwoNumbers(2,3), 5)
        self.assertEqual(addTwoNumbers(0,0), 0)
        self.assertEqual(addTwoNumbers(-1,-1), -2)

if __name__ == '__main__':
    unittest.main()
```

Explaining, commenting, improving code

Explain how this code works: <addTwoNumbers.py>

This is a simple Python function that takes two arguments a and b. It adds them together and stores the result in a variable called c. Finally, it returns the value of c.

So if you call this function with two numbers, it will return their sum. For example, if you call `addTwoNumbers(2, 3)`, it will return 5.

I hope this helps! Let me know if you have any other questions.

Add comments to this code: <addTwoNumbers.py>

```
def addTwoNumbers(a, b):  
    # Add the two numbers together and  
    store the result in a variable called c  
    c = a + b  
  
    # Return the value of c  
    return c
```

Improve this code: <addTwoNumbers.py>

This code is already pretty good! It's a simple function that does exactly what it's supposed to do.

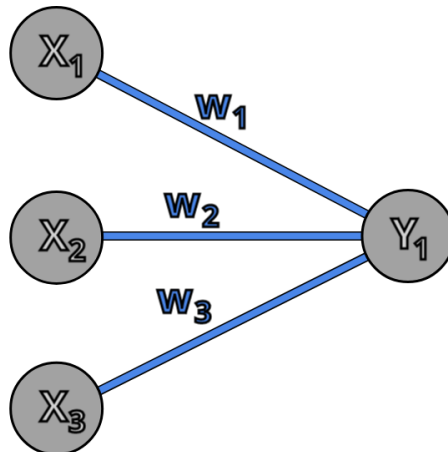
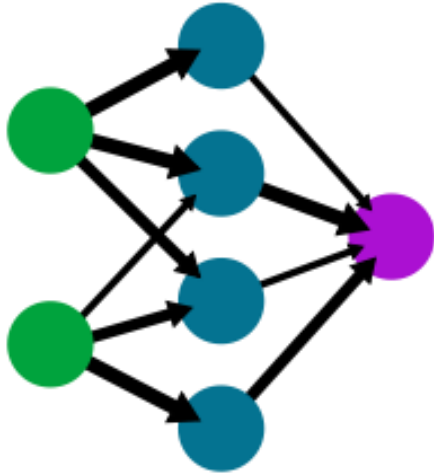
However, if you want to make it more readable, you could add some comments to explain what the code does. Here's an example:

So how does ChatGPT/AI work?

Neural networks

A simple neural network

input layer hidden layer output layer



$$Y_1 = \text{Activation}(W_1 \times X_1 + W_2 \times X_2 + W_3 \times X_3)$$

Computer models that were meant to mimic how biological neural networks behave and learn

- 1) Define model inputs, outputs, and allowed connections.
- 2) Training of the model using known input/output data by adjusting the connection weight **parameters** until you minimize difference between predicted outputs and measured outputs. **Optimization to minimize error.** This is also called **supervised learning** because you provide the known answers on which to learn.
- 3) Use the trained model to **generate predictions** for new situations.

Deep learning uses neural networks with many hidden layers, so it requires much more data to train.

https://en.wikipedia.org/wiki/Neural_network

https://en.wikipedia.org/wiki/Artificial_neural_network

So how does ChatGPT work?

Large language models

Probabilistic model of language (predict next word) constructed with an **artificial neural network** containing with up to billions of connection weight parameters.

parameters: GPT3 175B, GPT4 1.5T, Google Bard 1.6T

GPT-3 trained with self-supervised and then semi-supervised training. GPT-4 training computing cost \$100M.

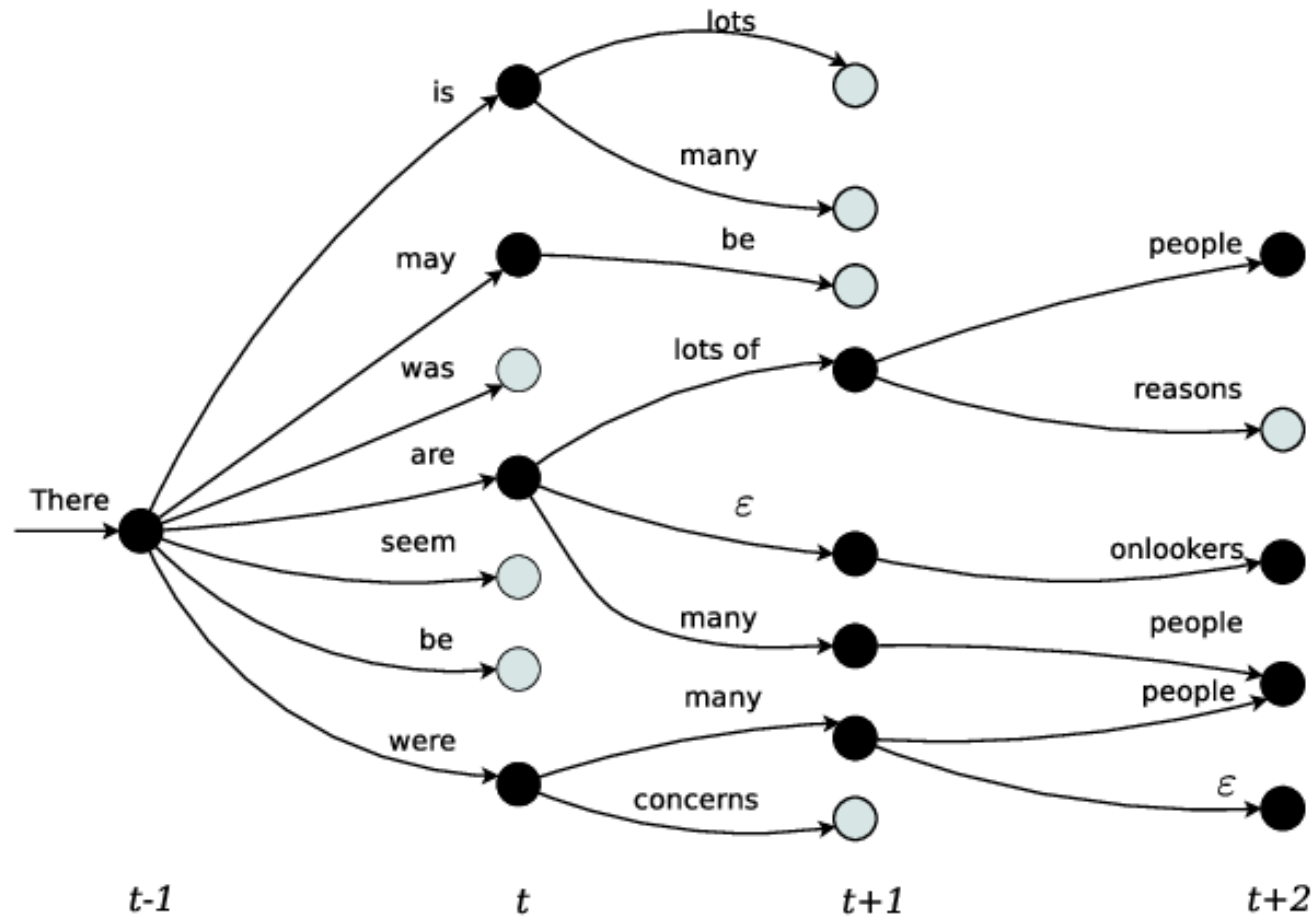
- 45 TB text database, 160K human dialogue database
- Many other conversation databases
- Unstructured data on web, books
- Human pre-training (data labelers <\$2/hour in Kenya)

So how does ChatGPT work?

Large language models

Text is broken down into **tokens**- parts of words. 500B tokens in GPT-3 that came from massive analysis of human writings.

Later training was supervised interactively by humans through **reinforcement learning**.



So how does ChatGPT work?

Large language models

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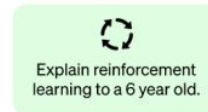
Later training was supervised interactively by humans through **reinforcement learning**.

https://en.wikipedia.org/wiki/Large_language_model,
<https://zapier.com/blog/how-does-chatgpt-work/>

Step 1

Collect demonstration data and train a supervised policy.

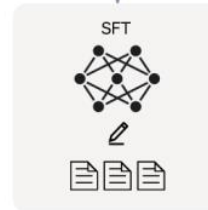
A prompt is sampled from our prompt dataset.



A labeler demonstrates the desired output behavior.



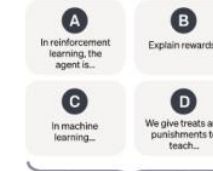
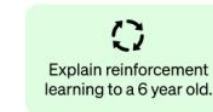
This data is used to fine-tune GPT-3.5 with supervised learning.



Step 2

Collect comparison data and train a reward model.

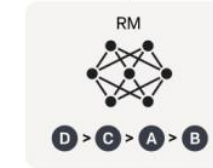
A prompt and several model outputs are sampled.



A labeler ranks the outputs from best to worst.



This data is used to train our reward model.



Step 3

Optimize a policy against the reward model using the PPO reinforcement learning algorithm.

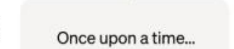
A new prompt is sampled from the dataset.



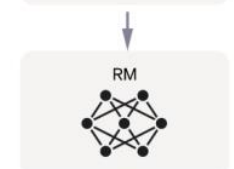
The PPO model is initialized from the supervised policy.



The policy generates an output.



The reward model calculates a reward for the output.



The reward is used to update the policy using PPO.



Problem Set 2 due 9/5

- 1) Using ChatGPT to do computer programming. Practice using ChatGPT to write, explain, improve, comment, and test code.
- 2) Programming the Fibonacci sequence (ChatGPT optional)
- 3) Plotting and analyzing electrocardiogram (ECG) data

