GitHub Copilot Prompt Engineering

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GitHub Copilot

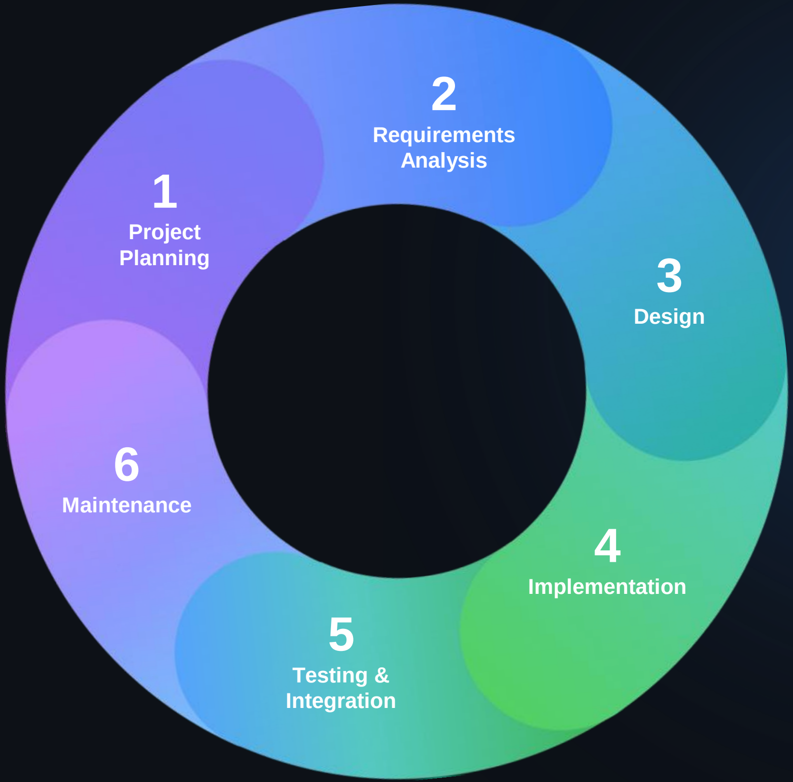
Helpful Resources

- Getting started with GitHub Copilot
- Configuring GitHub Copilot in your environment
- GitHub Copilot Trust Center

Agenda

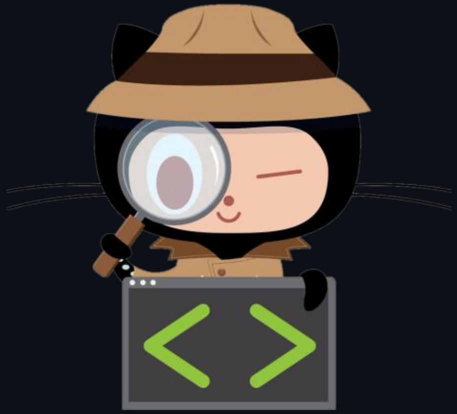
- Introduction
- Best Practices
- Prompting Techniques
- Coding Demos
- Q & A

GitHub Copilot + Chat



Helps developers stay in the flow throughout the entire SDLC

What is Prompt Engineering?



Prompt Engineering is the strategic crafting of user inputs to guide the AI towards producing desired code outputs.

A nuanced understanding of prompt engineering allows developers to optimize their use of Copilot, ensuring they get the most out of this advanced coding assistant.

```
/*
Create a function 'sqrGen' which returns a lamda function
that will square the argument passed to the lambda
Example usage:
auto sqr = sqrGen(); int result = sqr(5); // result will be 25

auto sqrGen() {
    return [](int m)->int {return m * m;};
}
```

Best Practices

> To be understood by the machine, you have to behave like an engineer

- Write Clear Instructions
- Split Complex Tasks into Simpler Subtasks
- Use External Tools
- Provide References
- Give the Model Time to Think
- Test Changes

Source: OpenAI's Prompt Engineering Strategies

Prompt Quality
For better prediction

Vague Prompt

Q: “How do I implement this API?”

A: “You can implement an API by writing the necessary code and setting up your server to handle requests”

- General
- Non-actionable
- Too broad
- Not very helpful

General Prompt, Little Context

Q: “How do I implement an API in Java?”

A: “To implement an API in Java, you need to use a framework like Spring Boot. You will define your endpoints, handle HTTP requests, and set up your server to process these requests.”

- Some context (framework)
- Narrows down response
- Still lacks depth

Specific Prompt, Detailed Context

Q: “How do I implement a RESTful API in Java using Spring Boot? Provide steps to set up a basic API with a sample endpoint that returns a list of users

A: “1) Set up your project …
2) Create your Main application class:

```
package com.example.demo;
import org.springframework.boot.SpringApplication
…
```

- Clear, detailed & comprehensive
- Instructions and code samples
- More accurate

Using Prompt Engineering

You need to create a function named 'job' that simulates a workload by iterating a specified number of times, sleeping for a random time during each iteration.

Create a Plan

Define the Objective

- Clearly state the goal: To create a function that simulates a workload with random delays

Break Down the Task

- Identify the key components:
  function definition, loop structure, etc

Create Prompts for Each Component

- Write specific prompts to generate code for each component.

Combine the Generated Code

- Integrate the code generated from each prompt into a complete function.

Example Prompt steps

Function Definition:
- Write a Python function named job that takes an integer parameter workload.

Loop Structure:
- Add a for loop inside the job function that iterates from workload down to 1.

Random Number Generation:
- Inside the loop, generate a random float between 0.5 and 1.5 using the random module.

Sleep for Random Duration:
- Use the time.sleep function to pause the execution for the generated random duration.

Console Output:
- Print the current step number to the console inside the loop.

Example solution

```
Create a lambda function named 'job' that simulates a workload.
Arguments:
- 'workload': an integer representing the number of steps in the workload
Returns: void
Details:
- Use a 'for loop' to to simulate a workload by iterating from the given workload value down
to 1.
- For each iteration, it performs the following steps:
    1) Generates a random sleep time between 0.5 and 1.5 seconds.
    2) Pauses the execution for the generated sleep time.
    3) Prints a message indicating the completion of the current step.
Errors:
- If the workload is less than or equal to 0, the function should throw an invalid_argument
exception with the message "Invalid workload value".
Example:
job(10);
```

Use Pseudocode for Granular Prompting

1. **Function Definition**:
   - Define a function `binary_gcd` that takes two unsigned integers `numerator` and `denominator`.
2. **Base Cases**:
   - If `numerator` is 0, return `denominator`.
   - If `denominator` is 0, return `numerator`.
3. **Both Numbers Even**:
   - If both `numerator` and `denominator` are even:
     - Return 2 times the result of `binary_gcd(numerator / 2, denominator / 2)`.
4. **One Number Even, One Odd**:
   - If `numerator` is even and `denominator` is odd:
     - Return the result of `binary_gcd(numerator / 2, denominator)`.
   - If `numerator` is odd and `denominator` is even:
     - Return the result of `binary_gcd(numerator, denominator / 2)`.
5. **Both Numbers Odd**:
   - If both `numerator` and `denominator` are odd:
     - If `numerator` is greater than `denominator`:
       - Return the result of `binary_gcd((numerator - denominator) / 2, denominator)`.
     - Else:
       - Return the result of `binary_gcd((denominator - numerator) / 2, numerator)`.

At a Lower Level…

Given the following:

Mask: 0b1010

Array 1: [0b1010, 0b1100, …, 0b1111]
Array 2: [0b0110, 0b0011, …, 0b0000]

How would you use prompt engineering to generate a transformation procedure that produces the following result?

Array 1: [0b0010, 0b0110, …, 0b0101]
Array 2: [0b1110, 0b1001, …, 0b1010]

The solution should be a function that takes the mask, arrays, and size as arguments.

Detailed Prompt

Generate a function 'conditionalBitSwap' that takes in 4 arguments:
- 'arr1': an array of char
- 'arr2': an array of char
- ‘mask': a char that represents a char bit mask.
- 'arrLen': a size_t that represents the length of the array.

Implementation details:
- the conditionalBitSwap function swaps the bits in the same positions of the elements of two arrays, but only if the corresponding bit in the mask is set and the bits to be swapped are different.
- the conditionalBitSwap function should not return anything.

Example:

arr1 = [0b1010, 0b1100]
arr2 = [0b0110, 0b0011]
mask = 0b1010

After calling conditionalBitSwap(arr1, arr2, mask, 2), arr1 and arr2 should be:
arr1 = [0b0010, 0b0110]
arr2 = [0b1110, 0b1001]

Q & A

Thank you

GPT Models

Copilot is always evolving and much of this evolution is powered by the evolving models behind it

Past (Codex)

- AI Hallucination problem
- Outdated/Deprecated code
- Lack of contextual understanding
- Failing to suggest best practices
- But it worked!

Present (GPT-3.5 GPT-4)

- Faster
- More efficient in regards to GPU usage
- Larger context window
- More recent training data

Future (Specific Models)*

- Code-specific models
- Enhanced experience and quality through fine-tuning
- Customization of models

* GPT keeps evolving and the latest can be found in github.com/blog

How does a LLM work?

> A LLM combines deep learning techniques with extensive training data to understand and generate human-like text based on the input it receives

Training
The model is trained on large amounts of text data, with parameters to learn patterns, grammar and facts

Architecture
Most use a neural network called Transformer, effective at handling sequential data

Prediction
Find the most likely output for next token based on patterns learned during training

Tokenization
Input is broken down into smaller units (words, subwords, characters)

Contextual Understanding
Surrounding tokens are used to understand meaning and predict next token

Fine-Tuning
Apply a specific dataset for a particular task after training (e.g. code, java, legal documents)

Inference
The input is tokenized, and processed through the different transformer layers to capture context and relationship.

The model generates predictions for the next token and repeats until a complete response is generated.

This response can be controlled or guided through **prompt engineering** to achieve desired outcomes