Decoding Code Hallucinations in LLMs

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Instructor

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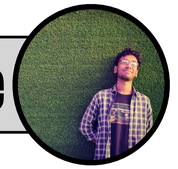

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Decoding Code Hallucinations in LLMs

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Input-Conflicting: Contradicts the prompt

Context-Conflicting: Inconsistent with previous output

Fact-Conflicting: Misaligned with real-world knowledge

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Input-Conflcting: Contradicts the prompt

> ***Prompt:*** *Summarize the following article without mentioning any political figures:"*
>
> ***Article Snippet:*** *"The new healthcare policy aims to expand access to rural clinics. President Smith emphasized the importance of equitable coverage."*
>
> ***LLM Output:*** *"President Smith introduced a groundbreaking healthcare reform to improve rural access."*

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Context-Conflcting: Inconsistent with previous output

User: *“What’s the capital of Italy?”*

LLM: *“The capital of Italy is Rome.”*

User: *“And what about France?”*

LLM: *“The capital of France is Rome.”*

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Fact-Conflcting: Misaligned with real-world knowledge

Prompt: "Tell me about Albert Einstein."

LLM Output: *"Albert Einstein was a 21st-century physicist best known for inventing the telescope."*

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Cool….but what about the code?

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NLP Hallucination.	***Code Hallucination***
Input Conflicting	*Misimplements requirements*
Context Conflicting	*Uses wrong library/API call*
Fact Conflicting	*Incorrect variable reuse/logic*

Decoding Code Hallucinations in LLMs

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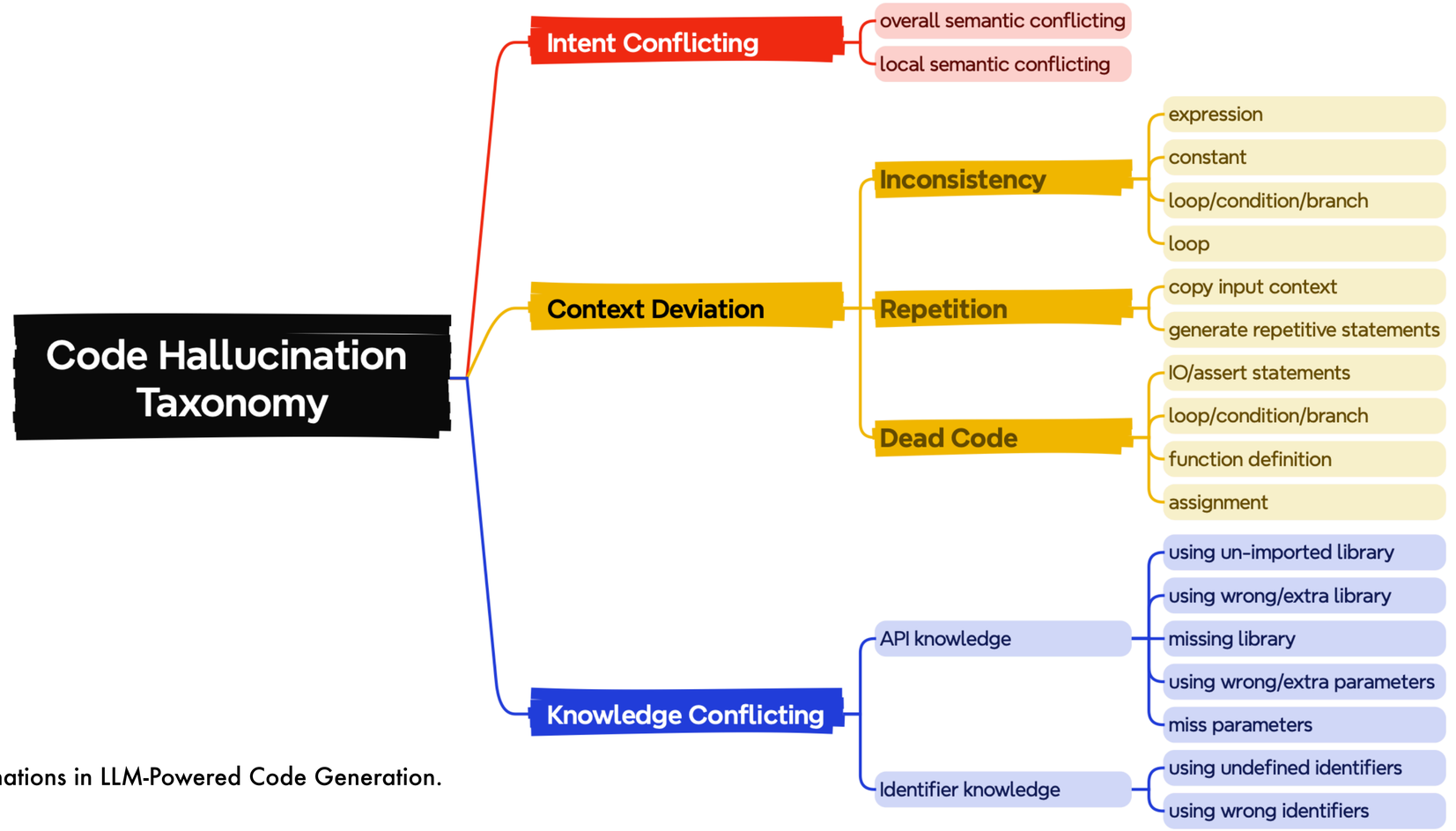
NLP Hallucination.	Code Hallucination
Input Conflicti	*nts*
	e wrong library/API call
Fact Conflicting	*Incorrect variable reuse/logic*

Common sense is an abstract concept

Decoding Code Hallucinations in LLMs



Exploring and Evaluating Hallucinations in LLM-Powered Code Generation.
Liu et al.

Decoding Code Hallucinations in LLMs

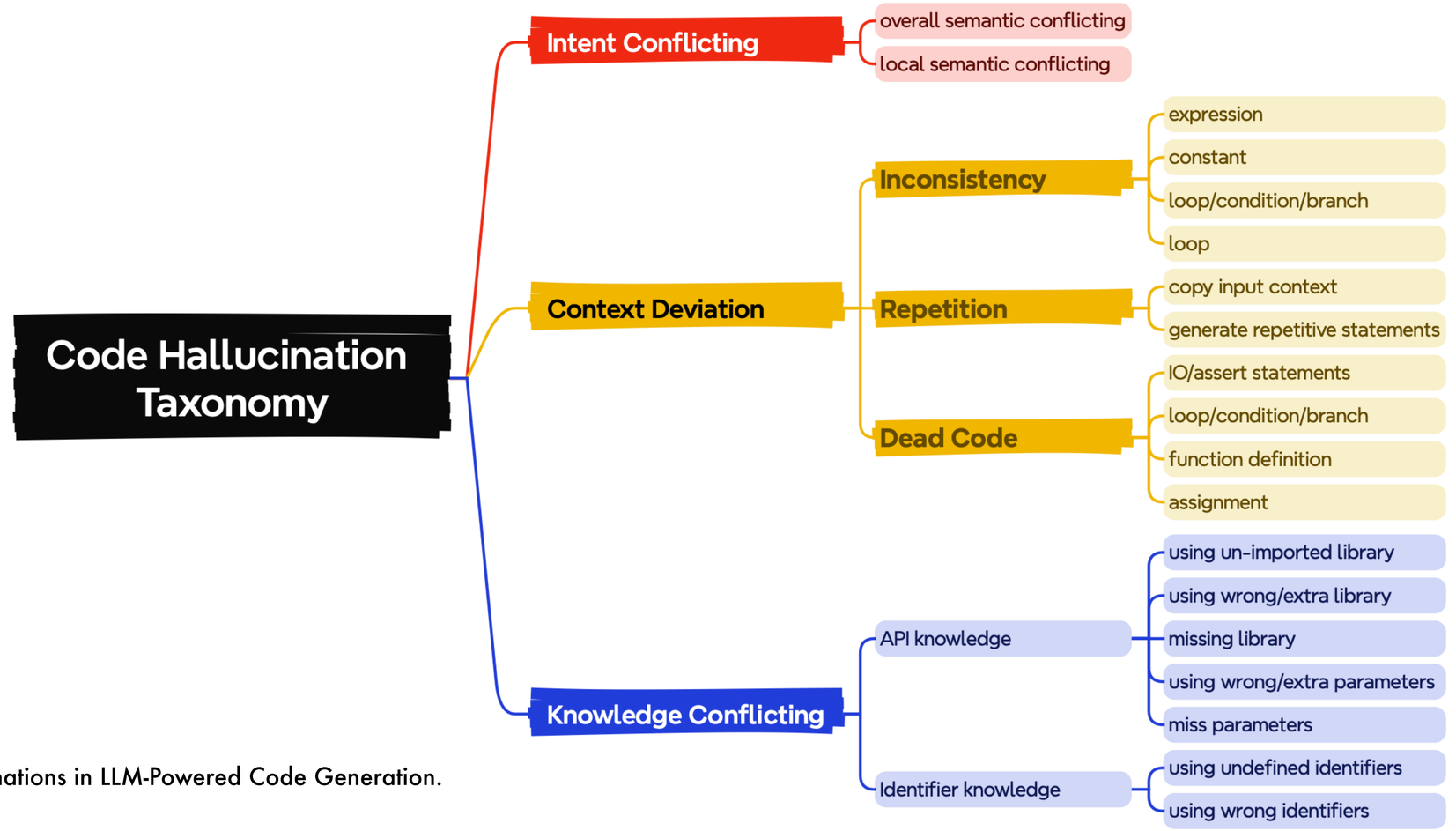
- **Intent Conflicting**
  - overall semantic conflicting
  - local semantic conflicting
- **Inconsistency**

```
def string_xor(a: str, b: str) -> str:
    """ Input are two strings a and b
    consisting only of 1s and 0s.
    Perform binary XOR on these inputs
    and return result also as a string.
    >>> string_xor('010', '110')
    '100'
    """
    # generated by CodeRL
    a, b = a.strip('0'), b.strip('0')
    res = ''
    if a!= b:
     res = '0' + res
    if a:
     res = '1' + res
    if b:
     res = '0' + res
    return res
```

Conflicting

```
    # reference solution
    def xor(i, j):
        if i == j:
            return '0'
        else:
            return '1'
    return ''.join(xor(x, y) for x, y
            in zip(a, b))
```

Decoding Code Hallucinations in LLMs



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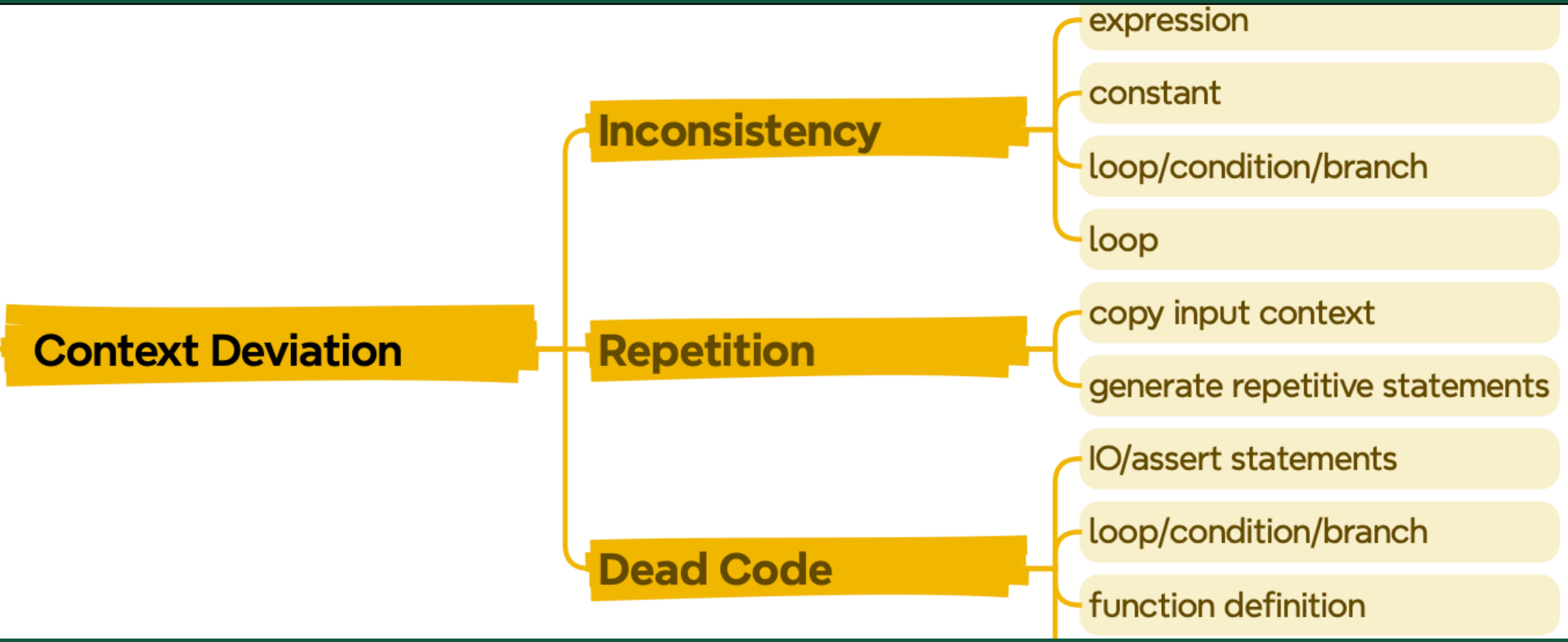

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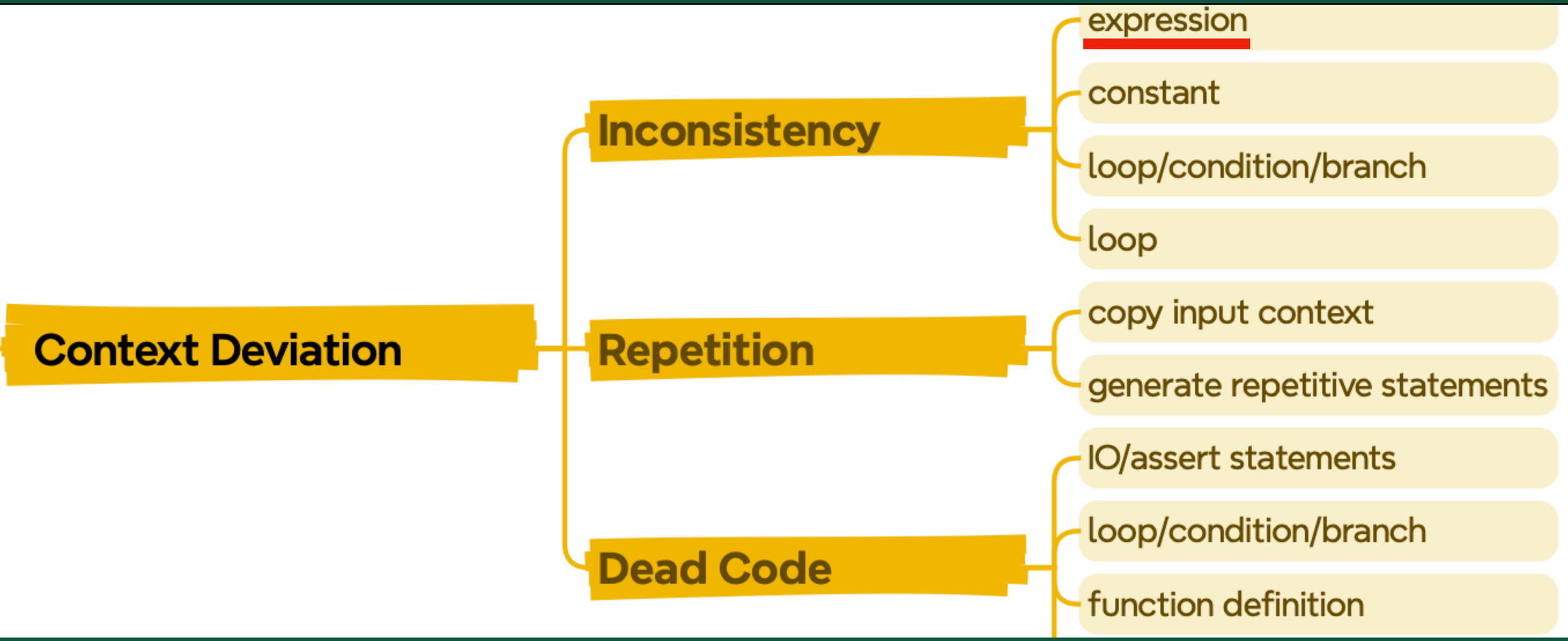


Decoding Code Hallucinations in LLMs

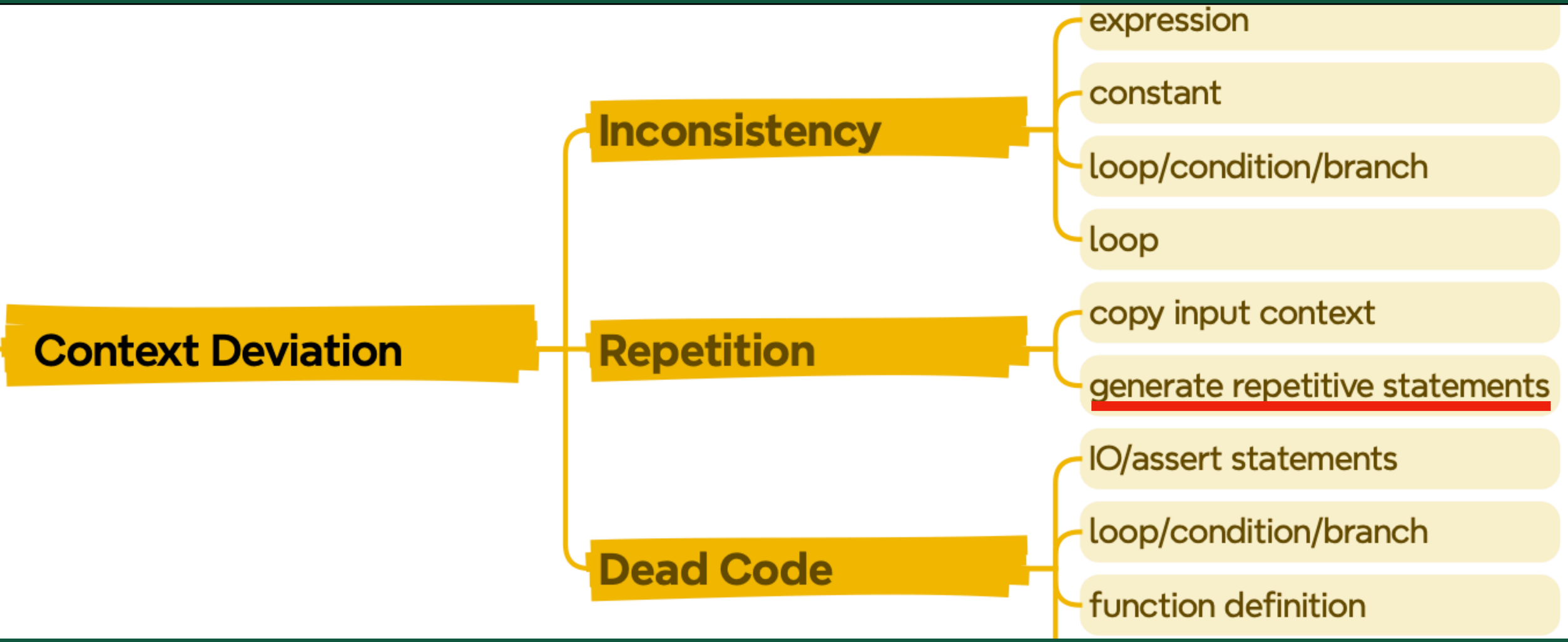
- expression
- constant
- loop/condition/branch
- loop
- copy input context
- generate repetitive statements
- IO/assert statements
- loop/condition/branch

```
def filter_by_substring(strings: List[str], substring: str)
-> List[str]:
    """ Filter an input list of strings only for
        ones that contain given substring
    >>> filter_by_substring([], 'a')
    []
    >>> filter_by_substring(['abc', 'bacd', 'cde',
        'array'], 'a')
    ['abc', 'bacd', 'array']
    """
    # generated by CodeRL
    return [string for string in strings if
            string.startswith(substring)]

    # reference solution
    return [x for x in strings if substring in x]
```

Inconsistent

Decoding Code Hallucinations in LLMs



Decoding Code Hallucinations in LLMs

- **Inconsistency**
  - expression
  - constant
  - loop/condition/branch
  - loop
- **Repetition**
  - copy input context
  - generate repetitive statements
- **Dead Code**
  - IO/assert statements
  - loop/condition/branch
  - function definition

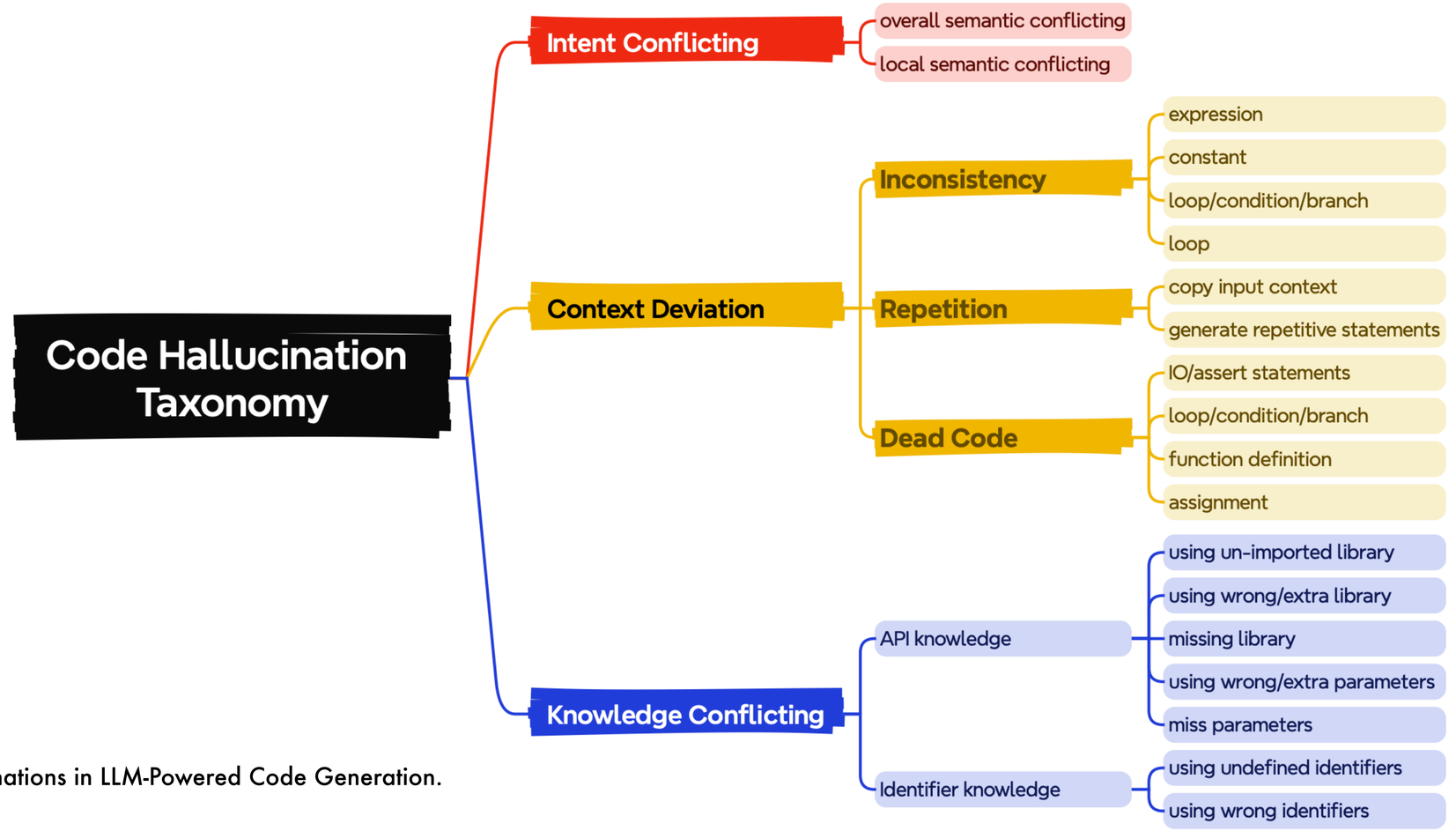
```python
def largest_prime_factor(n: int):
    """Return the largest prime factor of n.
       Assume n > 1 and is not a prime.
    >>> largest_prime_factor(13195)
    29
    >>> largest_prime_factor(2048)
    2
    """
```

```python
# reference solution
def is_prime(k):
    if k < 2:
        return False
    for i in range(2, k - 1):
        if k % i == 0:
            return False
    return True
largest = 1
for j in range(2, n + 1):
    if n % j == 0 and is_prime(j):
        largest = max(largest, j)
return largest
```

```python
# generated by CodeGen
def largest_prime_factor(n: int):
    if n < 2:
        return 1
    if n % 2 == 0:
        return 2
    if n % 3 == 0:
        return 3
    if n % 5 == 0:
        return 5
```

Repeated within the generation

Decoding Code Hallucinations in LLMs



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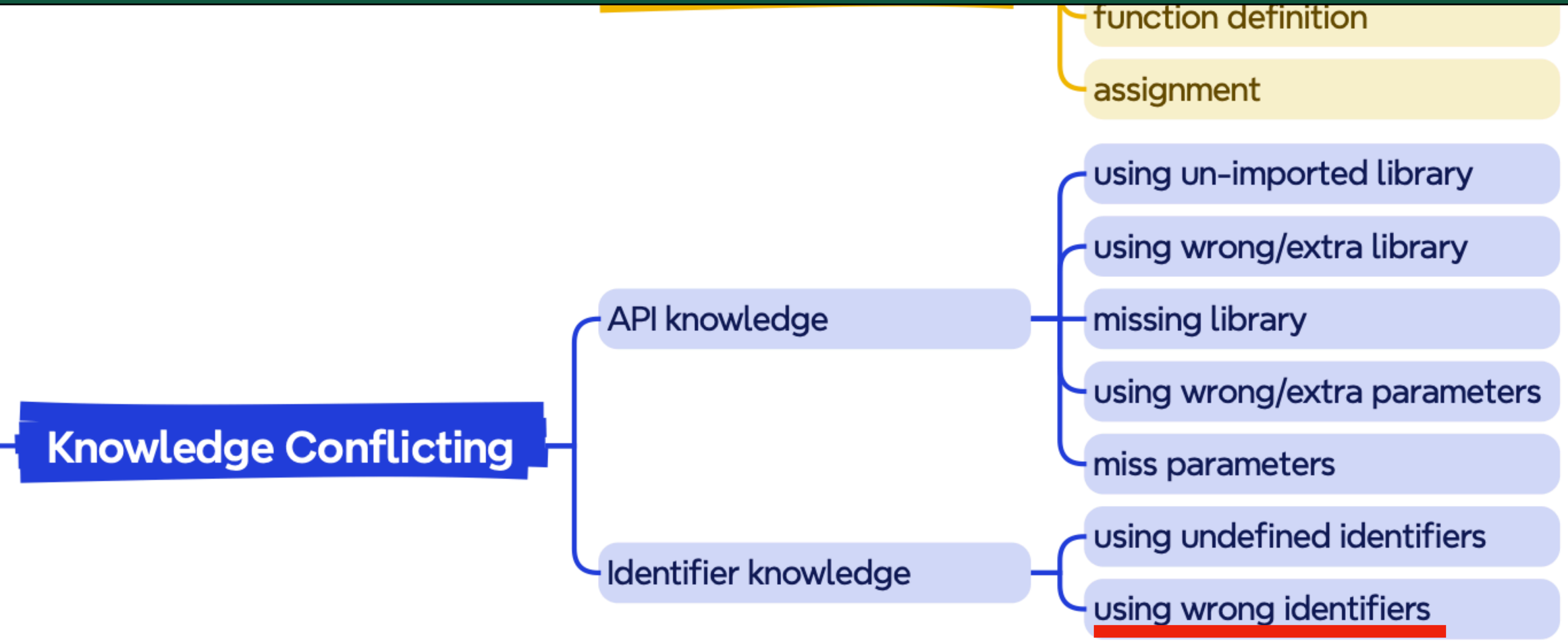

Decoding Code Hallucinations in LLMs

- function definition
- assignment
- using un-imported library
- using wrong/extra library
- missing library
- using wrong/extra parameters
- miss parameters
- using undefined identifiers
- using wrong identifiers

```
def longest(strings: List[str]) -> Optional[str]:
    """ Out of list of strings, return the longest
        one.Return the first one in case of multiple
        strings of the same length. Return None in case
        the input list is empty.
    >>> longest([])

    >>> longest(['a', 'b', 'c'])
    'a'
    >>> longest(['a', 'bb', 'ccc'])
    'ccc'
    """
    if not strings:
        return None
# generated by CodeRL
max_len_idx = 0
max_len_str = None
for idx, curr_str in enumerate(strings):
    if len(curr_str) > max_len_len_str:
        max_len_str = curr_str
        max_len_idx = idx
# reference solution
maxlen = max(len(x) for x in strings)
    for s in strings:
        if len(s) == maxlen:
            return s
```

Decoding Code Hallucinations in LLMs

Mitigation Approaches

1. ***Precision is Key:*** Craft Precise and constraint-aware prompts!
   "Only select from the bag of tasks provided as input"
2. ***Add Context:*** Simply ensure you make use of In-Context Learning whenever possible
3. ***Log probs:*** Extract the likelihood of the predicted word(s)
We can frame this value(s) in terms of confidence that measures how "confident" is the model when predicting Y, given X
4. ***LLMs as Judge:*** Simply ask e.g., Gemini to evaluate ChatGPT's prediction

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```
{
  "model": "gpt-4o-mini",
  "messages": [...],
  "logprobs": true,
  "top_logprobs": 5
}
```

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