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RepoAgent: An LLM-Powered Open-Source Framework for Repository-level Code Documentation Generation

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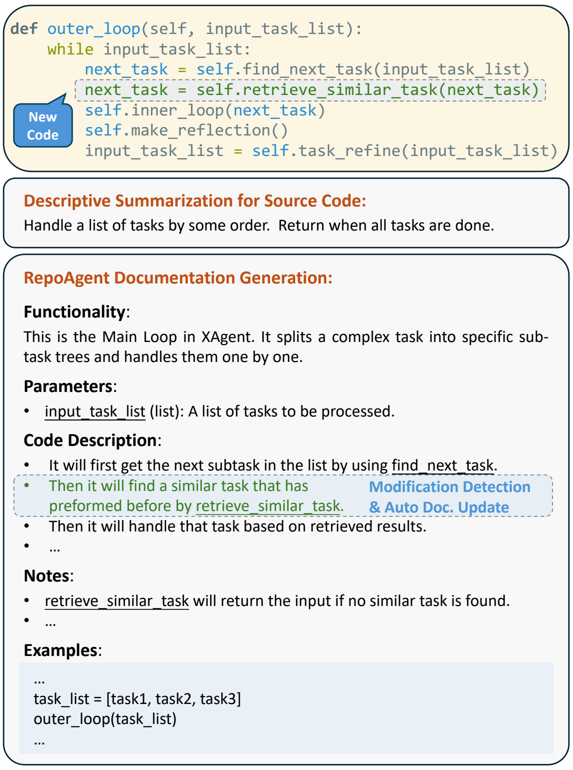
Abstract

Generative models have demonstrated considerable potential in software engineering, particularly in tasks such as code generation and debugging. However, their utilization in the domain of code documentation generation remains underexplored. To this end, we introduce REPOAGENT, a large language model powered open-source framework aimed at proactively generating, maintaining, and updating code documentation. Through both qualitative and quantitative evaluations, we have validated the effectiveness of our approach, showing that REPOAGENT excels in generating high-quality repository-level documentation. The code and results are publicly accessible at `https://github.com/OpenBMB/RepoAgent`.

1 Introduction

Developers typically spend approximately 58% of their time on program comprehension, and high-quality code documentation plays a significant role in reducing this time (Xia et al., 2018; de Souza et al., 2005). However, maintaining code documentation also consumes a considerable amount of time, money, and human labor (Zhi et al., 2015), and not all projects have the resources or enthusiasm to prioritize documentation as their top concern.



```
def outer_loop(self, input_task_list):
    while input_task_list:
        next_task = self.find_next_task(input_task_list)
        next_task = self.retrieve_similar_task(next_task)
        self.inner_loop(next_task)
        self.make_reflection()
        input_task_list = self.task_refine(input_task_list)
```

Descriptive Summarization for Source Code:

Handle a list of tasks by some order. Return when all tasks are done.

RepoAgent Documentation Generation:

Functionality:

This is the Main Loop in XAgent. It splits a complex task into specific sub-task trees and handles them one by one.

Parameters:

- input_task_list (list): A list of tasks to be processed.

Code Description:

- It will first get the next subtask in the list by using find_next_task.
- Then it will find a similar task that has preformed before by retrieve_similar_task.
- Then it will handle that task based on retrieved results.
- …

Notes:

- retrieve_similar_task will return the input if no similar task is found.
- …

Examples:

```
…
task_list = [task1, task2, task3]
outer_loop(task_list)
…
```

Figure 1: The comparison of code documentation generated by the plain summarization method and the proposed REPOAGENT .

To alleviate the burden of maintaining code documentation, early attempts at automatic documentation generation aimed to provide descriptive summaries for source code (Sridhara et al., 2010; Rai et al., 2022; Khan and Uddin, 2022; Zhang et al., 2022), as illustrated in Figure 1. However, they still have significant limitations, particularly in the following aspects: **(1) Poor summarization**. Previous methods primarily focused on summarizing isolated code snippets, overlooking the dependencies of code within the broader repository-level context. The generated code summaries are overly abstract and fragmented, making it difficult to accurately convey the semantics of the code and compile the code summaries into documentation. **(2) Inadequate guidance**. Good documentation not only accurately describes the code's functionality, but also meticulously guides developers on the correct usage of the described code (Khan and Uddin, 2022; Wang et al., 2023). This includes, but is not limited to, clarifying functional boundaries, highlighting potential misuses, and presenting examples of inputs and outputs. Previous methods still fall short of offering such comprehensive guidance. **(3) Passive update**. Lehman's first law of software evolution states that a program in use will continuously evolve to meet new user needs (Lehman, 1980). Consequently, it is crucial for the documentation to be updated in a timely manner to align with code changes, which is the capability that previous methods overlook. Recently, Large Language Models (LLMs) have made significant progress (Ope-

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[*] Indicates equal contribution.

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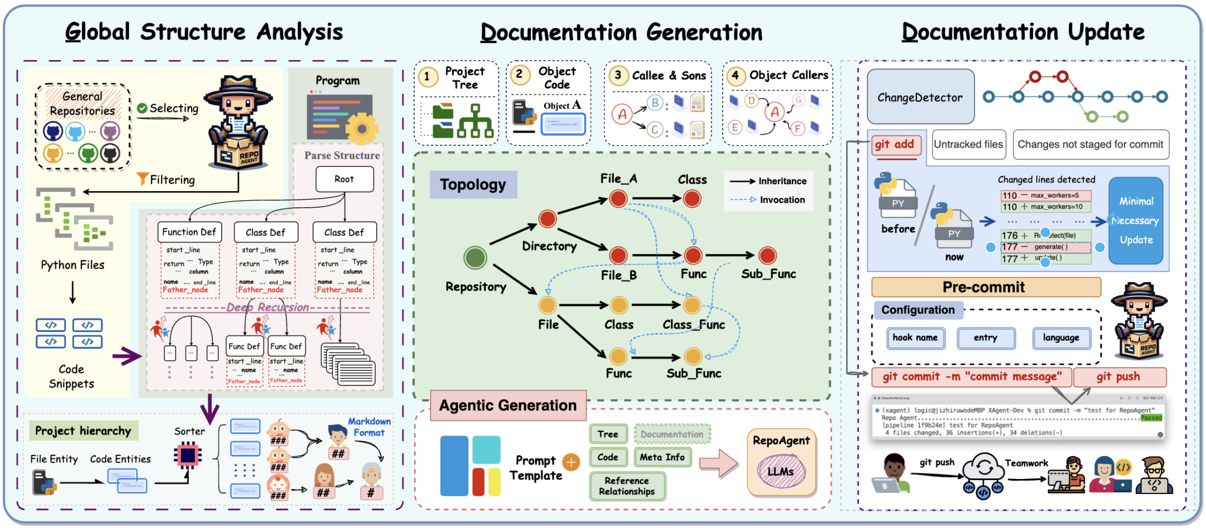


```
(xagent) logic@jizhiruwodeMBP XAgent-Dev % git commit -m "test for RepoAgent"
Repo Agent.........................................................................Passed
[pipeline 1f9b24e] test for RepoAgent
 4 files changed, 36 insertions(+), 34 deletions(-)
```

Figure 2: The RepoAgent method consists of Global Structure Analysis, Documentation Generation, and Documentation Update. Each component can be executed independently or packaged as a hook for tooling purposes. When operating as a whole, RepoAgent ensures the capability to construct and maintain documentation for a repository from scratch, elevating documentation to the same level of importance as code, facilitating synchronization and collaboration among teams.

nAI, 2022, 2023), especially in code understanding and generation (Nijkamp et al., 2023; Li et al., 2023; Chen et al., 2021; Rozière et al., 2023; Xu et al., 2024; Sun et al., 2023; Wang et al., 2023; Khan and Uddin, 2022). Given these advancements, it is natural to ask: **Can LLM be used to generate and maintain repository-level code documentation, addressing the aforementioned limitations?**

In this study, we introduce REPOAGENT, the first framework powered by LLMs, designed to proactively generate and maintain comprehensive documentation for the entire repository. A running example is demonstrated in Figure 1. REPOAGENT offers the following features: **(1) Repository-level documentation:** REPOAGENT leverages the global context to deduce the functional semantics of target code objects within the entire repository, enabling the generation of accurate and semantically coherent structured documentation. **(2) Practical guidance:** REPOAGENT not only describes the functionality of the code but also provides practical guidance, including notes for code usage and examples of input and output, thereby facilitating developers' swift comprehension of the code repository. **(3) Maintenance automation:** REPOAGENT can seamlessly integrate into team software development workflows managed with Git and proactively take over documentation maintenance, ensuring that the code and documentation remain synchronized. This process is automated and does not require human intervention.

We qualitatively showcased the code documentation generated by REPOAGENT for real Python repositories. The results reveal that REPOAGENT is adept at producing documentation of a quality comparable to that created by humans. Quantitatively, in two blind preference tests, the documentation generated by REPOAGENT was favored over human-authored documentation, achieving preference rates of 70% and 91.33% on the Transformers and LlamaIndex repositories, respectively. These evaluation results indicate the practicality of the proposed REPOAGENT in automatic code documentation generation.

2 RepoAgent

REPOAGENT consists of three key stages: **global structure analysis**, **documentation generation**, and **documentation update**. Figure 2 shows the overall design of REPOAGENT. The **global structure analysis** stage involves parsing necessary meta information and global contextual relationships from the source code, laying the foundation for REPOAGENT to infer the functional semantics of the target code. In the **documentation generation** stage, we have designed a sophisticated strategy that leverages the parsed meta information and global contextual relationships to prompt the LLM to generate fine-grained documentation that is of practical guidance. In the **documentation update** stage, REPOAGENT utilizes Git tools to track code changes and update the documentation accordingly, ensuring that the code and documentation remain synchronized throughout the entire project lifecycle.

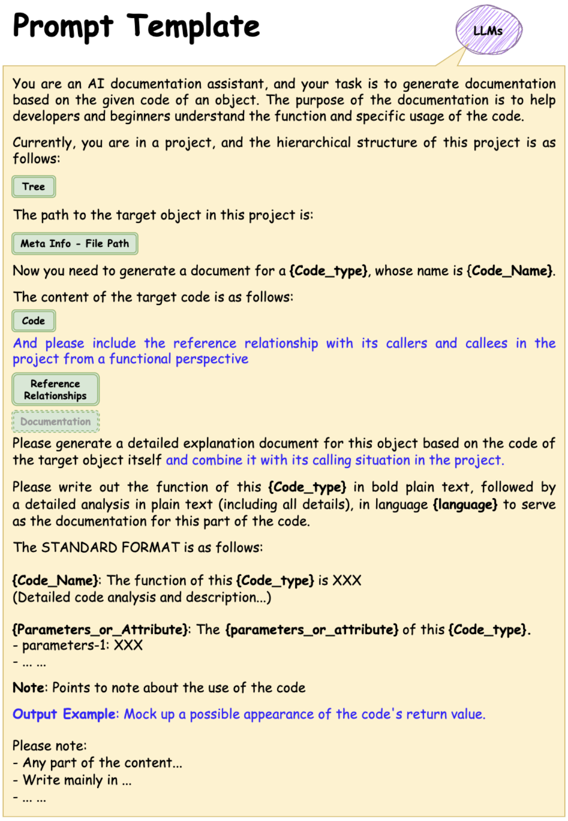
2.1 Global Structure Analysis

An essential prerequisite for generating accurate and fine-grained code documentation is a comprehensive understanding of the code structure. To achieve this goal, we proposed a project tree, a data structure that maintains all code objects in the repository while preserving their semantic hierarchical relationships. Firstly, we filter out all non-Python files within the repository. For each Python file, we apply Abstract Syntax Tree (AST) analysis (Zhang et al., 2019) to recursively parse the meta information of all Classes and Functions within the file, including their type, name, code snippets, etc. These Classes and Functions associated with their meta information are used as the atomic objects for documentation generation. It is worth noting that the file structures of most well-engineered repositories have reflected the functional semantics of code. Therefore, we first utilize it to initialize the project tree, whose root node represents the entire repository, middle nodes and leaf nodes represent directories and Python files, respectively. Then, we add the parsed Classes and Functions as new leaf nodes (or sub-trees) to the corresponding Python file nodes to form the final project tree.

Beyond the code structure, the reference relationships within the code, as a form of important global contextual information, can also assist the LLM in identifying the functional semantics of the code. Also, references to a target function can be considered natural in-context learning examples (Wei et al., 2022) to teach the LLM to use the target function, thereby helping generate documentation that is of practical guidance. We consider two types of reference relationships: `Caller` and `Callee`. We use the Jedi library[1] to extract all bi-directional reference relationships in the repository, and then ground them to the corresponding leaf nodes in the project tree. The project tree augmented with the reference relationships forms a Directed Acyclic Graph[2] (DAG).

2.2 Documentation Generation

REPOAGENT aims to generate fine-grained documentation that is of practical guidance, which includes detailed **Functionality**, **Parameters**, **Code Description**, **Notes**, and **Examples**. A backend LLM leverages the parsed meta information and reference relationships from the previous stage to generate documentation with the required structure using a carefully designed prompt template. An illustrative prompt template is shown in Figure 3, and a complete real-world prompt example is given in Appendix C.1.



You are an AI documentation assistant, and your task is to generate documentation based on the given code of an object. The purpose of the documentation is to help developers and beginners understand the function and specific usage of the code.

Currently, you are in a project, and the hierarchical structure of this project is as follows:

Tree

The path to the target object in this project is:

Meta Info - File Path

Now you need to generate a document for a **{Code_type}**, whose name is **{Code_Name}**.

The content of the target code is as follows:

Code

And please include the reference relationship with its callers and callees in the project from a functional perspective

Reference Relationships

Documentation

Please generate a detailed explanation document for this object based on the code of the target object itself and combine it with its calling situation in the project.

Please write out the function of this **{Code_type}** in bold plain text, followed by a detailed analysis in plain text (including all details), in language **{language}** to serve as the documentation for this part of the code.

The STANDARD FORMAT is as follows:

{Code_Name}: The function of this **{Code_type}** is XXX
(Detailed code analysis and description...)

{Parameters_or_Attribute}: The **{parameters_or_attribute}** of this **{Code_type}**.
- parameters-1: XXX
- ... ...

Note: Points to note about the use of the code

Output Example: Mock up a possible appearance of the code's return value.

Please note:
- Any part of the content...
- Write mainly in ...
- ... ...

Figure 3: Prompt template used for documentation generation, some details are omitted. Variables within the braces are assigned according to different objects. The blue parts are dynamically filled based on the Meta Info of different objects, enriching the documentation content according to the object characteristics. The Documentation within the dashed boxes can be dynamically utilized according to the program settings. If the documentation information is not used, the program may not execute in topological order.

The prompt template mainly requires the following parameters: The **Project Tree** helps REPOAGENT perceive the repository-level context. The **Code Snippet** serves as the main source of information for REPOAGENT to generate the documentation. The **Reference Relationships** provide semantic invocation relationships between code objects and assist REPOAGENT in generating guiding notes and examples. The **Meta Information** indicates the necessary information such as type, name, relative file path of the target object, and is used for post-processing of the documentation. Additionally, we can include the previously generated **Documentation** of a direct child node of an object as auxiliary information to help code understanding. This is optional, as omitting it can save costs significantly.

REPOAGENT follows a bottom-to-top topological order to generate documentation for all code objects in the DAG, ensuring that the child nodes of each node, as well as the nodes it references, have their documentation generated before it. After the documentation is generated, REPOAGENT compiles it into a human-friendly Markdown format. For example, objects of different levels are associated with different Markdown headings (e.g., ##, ###). Finally, REPOAGENT utilizes GitBook[3] to render the Markdown formatted documentation into a convenient web graphical interface, which enables easy navigation and readability for documentation readers.

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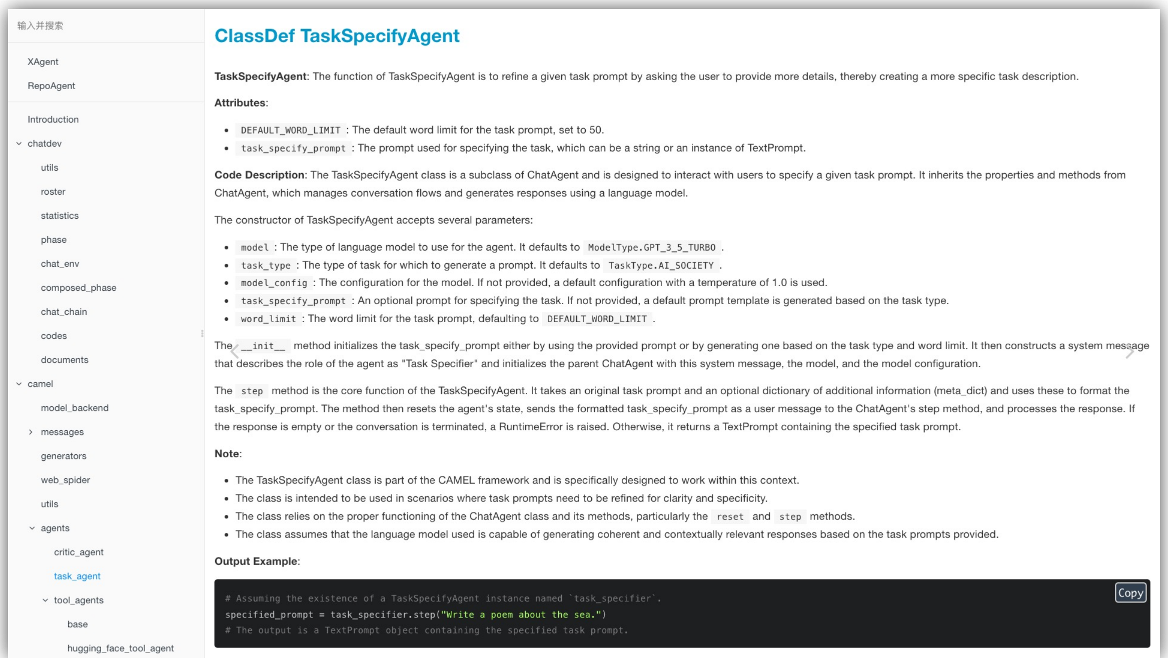
[1] `https://github.com/davidhalter/jedi`
Extensible to programming languages other than Python by replacing code parsing tools.

[2] We simply ignored circular dependencies to avoid loops, as most of these situations may have bugs.

[3] `https://www.gitbook.com/`



ClassDef TaskSpecifyAgent

TaskSpecifyAgent: The function of TaskSpecifyAgent is to refine a given task prompt by asking the user to provide more details, thereby creating a more specific task description.

Attributes:

- `DEFAULT_WORD_LIMIT` : The default word limit for the task prompt, set to 50.
- `task_specify_prompt` : The prompt used for specifying the task, which can be a string or an instance of TextPrompt.

Code Description: The TaskSpecifyAgent class is a subclass of ChatAgent and is designed to interact with users to specify a given task prompt. It inherits the properties and methods from ChatAgent, which manages conversation flows and generates responses using a language model.

The constructor of TaskSpecifyAgent accepts several parameters:

- `model` : The type of language model to use for the agent. It defaults to `ModelType.GPT_3_5_TURBO` .
- `task_type` : The type of task for which to generate a prompt. It defaults to `TaskType.AI_SOCIETY` .
- `model_config` : The configuration for the model. If not provided, a default configuration with a temperature of 1.0 is used.
- `task_specify_prompt` : An optional prompt for specifying the task. If not provided, a default prompt template is generated based on the task type.
- `word_limit` : The word limit for the task prompt, defaulting to `DEFAULT_WORD_LIMIT` .

The `__init__` method initializes the task_specify_prompt either by using the provided prompt or by generating one based on the task type and word limit. It then constructs a system message that describes the role of the agent as "Task Specifier" and initializes the parent ChatAgent with this system message, the model, and the model configuration.

The `step` method is the core function of the TaskSpecifyAgent. It takes an original task prompt and an optional dictionary of additional information (meta_dict) and uses these to format the task_specify_prompt. The method then resets the agent's state, sends the formatted task_specify_prompt as a user message to the ChatAgent's step method, and processes the response. If the response is empty or the conversation is terminated, a RuntimeError is raised. Otherwise, it returns a TextPrompt containing the specified task prompt.

Note:

- The TaskSpecifyAgent class is part of the CAMEL framework and is specifically designed to work within this context.
- The class is intended to be used in scenarios where task prompts need to be refined for clarity and specificity.
- The class relies on the proper functioning of the ChatAgent class and its methods, particularly the `reset` and `step` methods.
- The class assumes that the language model used is capable of generating coherent and contextually relevant responses based on the task prompts provided.

Output Example:

```
# Assuming the existence of a TaskSpecifyAgent instance named `task_specifier`.
specified_prompt = task_specifier.step("Write a poem about the sea.")
# The output is a TextPrompt object containing the specified task prompt.
```

Figure 4: Demonstration of code documentation generated by REPOAGENT for the ChatDev repository.

2.3 Documentation Update

REPOAGENT supports automatic tracking and updating of documentation through seamless collaboration with Git. The pre-commit hook of Git is utilized to enable REPOAGENT to detect any code changes and perform documentation updates. After the update, the hook submits both the code and documentation changes, ensuring that the code and documentation remain synchronized. This process is fully automated and does not require human intervention.

Local code changes generally do not affect other code due to the low coupling principle, it is not necessary to regenerate the entire documentation with each minor code update. REPOAGENT only updates the documentation of affected objects. The updates are triggered when (1) an object's source code is modified; (2) an object's referrers no longer reference it; or (3) an object gets new references. It is worth noting that the update is not triggered when an object's reference objects change, because we adhere to the dependency inversion principle (Martin, 1996), which states that high-level modules should not depend on the implementations of low-level modules.

3 Experiments

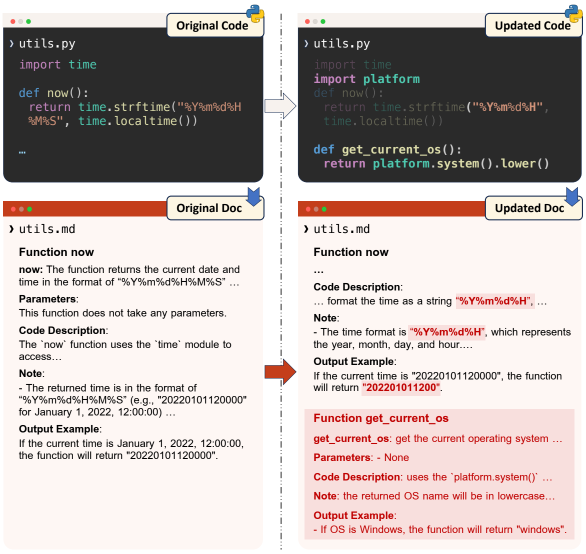
3.1 Experimental Settings

We selected 9 Python repositories of varying scales for documentation generation, ranging from less than 1,000 to over 10,000 lines of code. These repositories are renowned for their classic status or high popularity on GitHub, and are characterized by their high-quality code and considerable project complexity. The detailed statistics of the repositories are provided in Appendix A.1. We adopted the API-based LLMs `gpt-3.5-turbo` (OpenAI, 2022) and `gpt-4-0125` (OpenAI, 2023), along with the open-source LLMs `Llama-2-7b` and `Llama-2-70b` (Touvron et al., 2023) as backend models for REPOAGENT .

3.2 Case Study

We use the ChatDev repository (Qian et al., 2023) and the `gpt-4-0125` backend for a case study. The generated documentation is illustrated in Figure 4. Documentation generated by REPOAGENT is structured into several parts, starting with a clear, concise sentence that articulates the object's functionality. Following this, the parameters section enumerates all relevant parameters along with their descriptions, aiding developers in understanding how to leverage the provided code. Moreover, the code description section comprehensively elaborates on all aspects of the code, implicitly or explicitly demonstrating the object's role and its associations with other code within the global context. In addition, the notes section further enriches these descriptions by covering usage considerations for the object at hand. Notably, it highlights any logical errors or potential optimization within the code, thereby prompting advanced developers to make modifications. Lastly, if the current object yields a return value, the model will generate an examples section, filled with simulated content to clearly demonstrate the expected output. This is highly advantageous for developers, facilitating efficient code reuse and unit test construction.

Once the code is changed, the documentation update



```
› utils.py
  import time

  def now():
    return time.strftime("%Y%m%d%H
    %M%S", time.localtime())

  …
```

```
› utils.py
  import time
  import platform
  def now():
    return time.strftime("%Y%m%d%H",
    time.localtime())

  def get_current_os():
    return platform.system().lower()
```

› utils.md

Function now

now: The function returns the current date and time in the format of "%Y%m%d%H%M%S" …

Parameters:
This function does not take any parameters.

Code Description:
The `now` function uses the `time` module to access…

Note:
- The returned time is in the format of "%Y%m%d%H%M%S" (e.g., "20220101120000" for January 1, 2022, 12:00:00) …

Output Example:
If the current time is January 1, 2022, 12:00:00, the function will return "20220101120000".

› utils.md

Function now

…

Code Description:
… format the time as a string **"%Y%m%d%H"**, …

Note:
- The time format is **"%Y%m%d%H"**, which represents the year, month, day, and hour.…

Output Example:
If the current time is "20220101120000", the function will return **"202201011200"**.

Function get_current_os

get_current_os: get the current operating system …

Parameters: - None

Code Description: uses the `platform.system()` …

Note: the returned OS name will be in lowercase…

Output Example:
- If OS is Windows, the function will return "windows".

Figure 5: Documentation update for functions of ChatDev.

will be triggered, as illustrated in Figure 5. Upon code changes in the staging area, REPOAGENT identifies affected objects and their bidirectional references, updates documentation for the minimally impacted scope, and integrates these updates into a new Markdown file, which includes additions or global removals of objects' documentation. This automation extends to integrating the pre-commit hook of Git to detect code changes and update documentation, thus seamlessly maintaining documentation alongside project development. Specifically, when code updates are staged and committed, REPOAGENT is triggered, automatically refreshing the documentation and staging it for the commit. It confirms the process with a "Passed" indicator, without requiring extra commands or manual intervention, preserving developers' usual workflows.

3.3 Human Evaluation

We adopted human evaluation to assess the quality of generated documentation due to the lack of effective evaluation methods. We conducted a preference test to compare human-authored and model-generated code documentation. We randomly sampled 150 pieces of documentation content, including 100 class objects and 50 function-level objects, from both the Transformers and LlamaIndex repositories respectively. Three evaluators were recruited to assess the quality of both documentation sets, with the detailed evaluation protocol outlined in Appendix A.2.2. The results, presented in Table 1, underscore RepoAgent's notable effectiveness in producing documentation that surpasses human-authored content, achieving win rates of 0.70 and 0.91, respectively.

3.4 Quantitative Analysis

Reference Recall. We evaluated the models' perception of global context by calculating the recall for identifying reference relationships of code objects. We sampled 20 objects from each of 9 repositories and compared 3 documentation generation methods for their recall in global caller and callee identification. The comparison methods included a machine learning based method that uses LSTM for comment generation (Iyer et al., 2016), long context concatenation leveraging LLMs with up to 128k context lengths to process entire project codes for identifying calling relationships, single-object generation method that only provides code snippets to LLMs.

	Total	Human	Model	Win Rate
Transformers	150	45	105	**0.70**
LlamaIndex	150	13	137	**0.91**

Table 1: Results of human preference test on human-authored and model-generated code documentation.

Figure 6 demonstrates the recall for identifying reference relationships. The machine learning based method is unable to identify reference relationships, whereas the Single-object method partially identifies callees but not callers. The Long Context method, despite offering extensive code content, achieves only partial and non-comprehensive recognition of references, with recall declining as context increases. In contrast, our approach utilizes deterministic tools Jedi and bi-directional parsing to accurately convey global reference relationships, effectively overcoming the scope limitations that other methods encounter in generating repository-level code documentation.

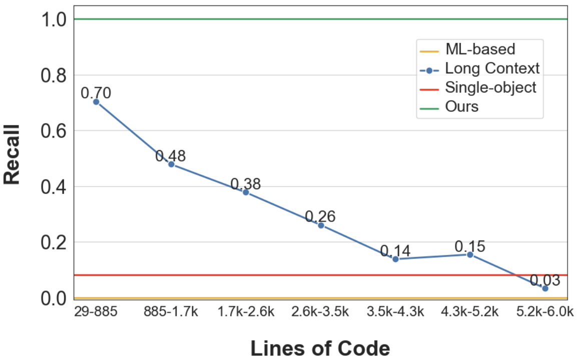


Figure 6: Recall for identifying reference relationships.

Format Alignment. Adherence to the format is critical in documentation generation. The generated documentation should consist of 5 basic parts, where the *Examples* is dynamic, depending on whether the code object has a return value or not. We evaluated the ability of LLMs to adhere to the format using all 9 repositories, the results are shown in Figure 7. Large models like GPT series and `Llama-2-70b` perform very well in format alignment, while the small model `Llama-2-7b` performs poorly, especially in terms of the examples.

Repository	`Llama-2-7b`	`Llama-2-70b`	`gpt-3.5-turbo`	`gpt-4-0125`
unoconv	0.0000	0.5000	**1.0000**	**1.0000**
simdjson	0.4298	0.6336	**1.0000**	0.9644
greenlet	0.5000	0.7482	0.9252	**0.9615**
code2flow	0.5145	0.6171	0.9735	**0.9803**
AutoGen	0.3049	0.5157	0.8633	**0.9545**
AutoGPT	0.4243	0.5611	0.8918	**0.9527**
ChatDev	0.5387	0.6980	0.9164	**0.9695**
MemGPT	0.4582	0.5729	0.9285	**0.9911**
MetaGPT	0.3920	0.5819	0.9066	**0.9708**

Table 2: Accuracy of identifying function parameters with different LLMs as backends.

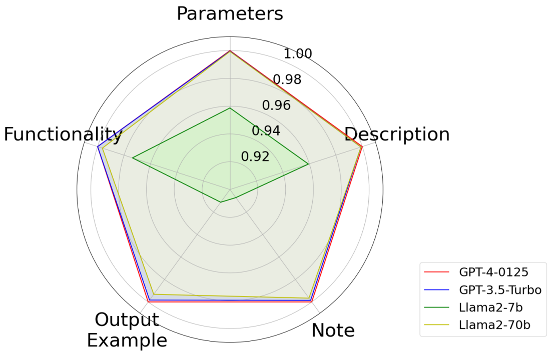


Figure 7: Format alignment accuracy of different LLMs.

Parameter Identification. We further evaluated the models' capability to identify parameters on all 9 repositories, the results are shown in Table 2. It is worth noting that we report the accuracy instead of recall, because models may hallucinate non-existent parameters, which should be taken into account. As seen in the table, the GPT series significantly outperforms the LLaMA series in parameter identification, and `gpt-4-0125` performs the best.

4 Related Work

Code Summarization. The field focuses on generating succinct, human-readable code summaries. Early methods were rule-based or template-driven (Haiduc et al., 2010; Sridhara et al., 2010; Moreno et al., 2013; Rodeghero et al., 2014). With advancements in machine learning, learning-based approaches like CODE-NN, which utilize LSTM units, emerged for summary creation (Iyer et al., 2016). The field further evolved with attention mechanisms and transformer models, significantly enhancing the ability to model long-range dependencies (Allamanis et al., 2016; Vaswani et al., 2017), indicating a shift towards more context-aware and flexible summarization techniques.

LLM Development. The development and application of LLMs have revolutionized both NLP and software engineering fields. Initially, the field was transformed by masked language models like BERT (Devlin et al., 2019), followed by advancements in encoder-decoder models, such as the T5 series (Raffel et al., 2020), and auto-regressive models like the GPT series (Radford et al., 2018). Auto-regressive models, notable for their sequence generation capabilities, have been effectively applied in code generation (Nijkamp et al., 2023; Li et al., 2023; Chen et al., 2021; Rozière et al., 2023; Xu et al., 2024), code summarization (Sun et al., 2023), and documentation generation (Wang et al., 2023; Khan and Uddin, 2022), highlighting their versatility in programming and documentation tasks. Concurrently, LLM-based agents have become ubiquitous (XAgent, 2023; Qin et al., 2024; Lyu et al., 2023; Ye et al., 2023; Qin et al., 2023), especially in software engineering (Chen et al., 2024; Qian et al., 2023; Hong et al., 2024), facilitating development through role-play and the automatic generation of agents (Wu et al., 2023), thereby enhancing repository-level code understanding, generation and even debugging (Tian et al., 2024). With the development of LLM-based agents, repository-level documentation generation become solvable as an agent task.

5 Conclusion and Discussion

In this paper, we introduce REPOAGENT, an open source framework designed to generate fine-grained repository-level code documentation, facilitating improved team collaboration. The experimental results suggest that REPOAGENT is capable of generating and proactively maintaining high-quality documentation for the entire project. REPOAGENT is expected to free developers from this tedious task, thereby improving their productivity and innovation potential.

In future work, we consider how to effectively utilize this tool and explore ways to apply REPOAGENT to a broader range of downstream applications in the future. To this end, we believe that chatting can serve as a natural tool for establishing a communication bridge between code and humans. Currently, by employing our approach with retrieval-augmented generation, which combines code, documentation, and reference relationships, we have achieved preliminary results in what we called "Chat With Repo", which marks the advent of a novel coding paradigm.

Limitations

Programming Language Limitations. RepoAgent currently relies on the Jedi reference recognition tool, limiting its applicability exclusively to Python projects. A more versatile, open-source tool that can adapt to multiple programming languages would enable broader adoption across various codebases, which will be addressed in future iterations.

Requirement for Human Oversight. AI-generated documentation may still require human review and modification to ensure its accuracy and completeness. Technical intricacies, project-specific conventions, and domain-specific terminology may necessitate manual intervention to enhance the quality of generated documentation.

Dependency on Language Model Capabilities. The performance of RepoAgent significantly depends on the backend LLMs and associated technologies. Although current results have shown promising progress with API-based LLMs like GPT series, the long-term stability and sustainability of using open-source models still require further validation and research.

Lack of Standards for Evaluation. It is difficult to establish a unified quantitative evaluation method for the professionalism, accuracy, and standardization of generated documentation. Furthermore, it is worth noting that the academic community currently lacks benchmarks and datasets of exemplary human documentation. Additionally, the subjective nature of documentation further limits current methods in terms of quality assessment.

Broader Impact

Enhancing Productivity and Innovation. RepoAgent automates the generation, update and maintenance of code documentation, which is traditionally a time-consuming task for developers. By freeing developers from this burden, our tool not only enhances productivity but also allows more time for creative and innovative work in software development.

Improving Software Quality and Collaboration. High-quality documentation is crucial for understanding, using, and contributing to software projects, facilitating developers' swift comprehension of projects. RepoAgent 's ability ensures long-term high consistency in code documentation. We posit that integrating RepoAgent closely with the project development process can introduce a new paradigm for standardizing and making repositories more readable. This, in turn, is expected to stimulate active community contributions and rapid development with higher overall quality of software projects.

Educational Benefits. RepoAgent can serve as an educational tool by providing clear and consistent documentation for codebases, making it easier for students and novice programmers to learn software development practices and understand complex codebases.

Bias and Inaccuracy. While RepoAgent aims to generate high-quality documentation, there's a potential risk of generating biased or inaccurate content due to model hallucination.

Security and Privacy Concerns. Currently, RepoAgent mainly relies on remote API-based LLMs, which will have the opportunity to access users' code data. This may raise security and privacy concerns, especially for proprietary software. Ensuring data protection and secure handling of the code is crucial.

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A Appendix: Experimental Details

A.1 Implementation Details

Table 3 presents the detailed statistics of the selected repositories and the token costs associated with the production of initial documentation. These repositories are sourced from both well-established, highly-starred projects and newly emerged, top-performing projects on GitHub. Repositories are characterized by their numbers of lines of code, classes and functions. Including global information like the project's directory structure and bidirectional references results in very long prompts (as detailed in Appendix C). Despite this, the resulting documentation is thorough yet concise, typically ranging between 0.4k and 1k tokens in length.

During the actual generation process, we addressed the issue of varying text lengths across different models. When using models with shorter context lengths (e.g., `gpt-3.5-turbo` and the LLaMA series), REPOAGENT adaptively switches to models with larger context lengths (e.g., `gpt-3.5-16k` or `gpt-4-32k`) based on the current prompt's length, to cope with the token overhead of incorporating global perspectives. In cases where even these models' limits are exceeded, REPOAGENT truncates the content by simplifying the project's directory structure and removing bidirectional reference code before reinitiating the documentation generation task. Such measures are infrequent when employing models with the longest contexts (128k), such as `gpt-4-1106` or `gpt-4-0125`. This dynamic scheduling strategy, combined with variable network conditions, may influence token consumption. Nevertheless, REPOAGENT ensures the integrity of the documentation while striving for cost-effectiveness to the greatest extent.

A.2 Settings

A.2.1 Technical Environment

All experiments were conducted within a Python 3.11.4 environment. The system had CUDA 11.7 installed and was equipped with 8 NVIDIA A100 40GB GPUs.

A.2.2 Human Evaluation Protocol

We recruited three human evaluators to assess the code documentation generated by REPOAGENT, and instructed all human evaluators to give an overall evaluation considering a set of evaluation criteria shown in Table 4. We randomly sampled 150 pieces of documentation from the repository. Subsequently, each human evaluator was assigned 50 pairs of documentation, each containing one human-authored and one model-generated documentation. The human evaluators were required to select the better documentation for each pair.

A.2.3 Reference Recall

The experiment aims to evaluate the model's ability to perceive global context, which is reflected by the recall for identifying reference relationships. The comparison methods are:

1. **ML-based method.** Iyer et al. (2016) utilized traditional machine learning and deep learning methods for generating comments describing the functionality of code objects.

2. **Long context concatenation.** The method directly concatenates the code snippets until the context length reaches 128k to let the model discover reference relationships.

3. **Single-object generation.** Sun et al. (2023) used the GPT-3.5 series to generate documentation by directly feeding code snippets of the target object. We modified the prompt on this basis, adding requirements for outputting the callers and callees.

Notably, among these methods, only the ML-based approach failed to explicitly or implicitly manifest call relationships in the final document. While it is inherently challenging for a code snippet to discern its invocation throughout the entire repository, the code typically elucidates the current object's calls explicitly. To measure the recall of callers and callees, we enhanced the original documentation by adding information about the calling functions (callers) and the called functions (callees). Then we compared the enriched documentation with our bidirectional reference data from MetaInfo.

For long context concatenation, we randomly selected 20 objects from each of the 9 repositories, culminating in a total of 180 objects. Given the intricate nature of defining context construction criteria for repository-level documentation generation tasks, we circumvented direct concatenation of adjacent and file-adjacent context content. Instead, we formulated negative samples by extracting all objects with reference relationships to fulfill the context length. Leveraging the content of objects and negative sample content, we devised context lengths for the 180 objects, spanning from 29 to 6.0k Code Lines. This approach aimed to optimize the distribution of context lengths while maximizing the utilization of the model's context length. In the case of single-object generation method, we utilized the same pool of 180 objects, providing the model with object source code snippets to generate documentation and elucidate reference relationships.

During the evaluation of both the Long Context Concatenation and Single-object Generation methods, we provided the model with tree-structured hierarchical position information for target objects and their related counterparts. This additional information was intended to help the model in better identifying callers and delineating them in a path form. Despite this assistance, the model's misinterpretations exacerbated as the context length increased, and the Single-object Generation method yielded a substantial amount of speculative information, resulting in unstable and inaccurate caller relationship recognition.

A.2.4 Format Alignment

The experiment evaluates whether the model-generated documentation follows the defined format. LLMs generally excel in instruction following, but the complexity of our task requires models to grasp core intents within lengthy prompts, posing a challenge. We use a one-shot approach with strict output examples, enabling evaluation of model answers through format matching algorithms. Specifically, we mandate that section titles be enclosed in bold symbols, ensure clear divisions between sections, and require contents within sections to be extractable and meaningful.

We observed the shortcomings of open-source models (LLaMA series) in their ability to adhere to formatting. In contrast, the GPT-4 series models excellently achieve format integrity and stability. We also observed behavioral differences between `gpt-4-0125` and `gpt-4-1106` models, the former appeared to produce more redundant information.

Format alignment can also be achieved with perfect accuracy using hierarchical or modular generation methods. However, this approach introduces a significant token overhead since each independent module must encompass complete global information and invocation relationships. Current method has demonstrated satisfactory performance on format alignment, meeting human readability standards effectively.

A.2.5 Parameter Identification

Accurately identifying and describing parameters or attributes (depending on whether the current object is a function or a class) in code is crucial as it helps readers quickly understand the design logic and usage. We extracted recognized parameters from the Parameters section using a matching pattern: parameters follow a uniform and fixed format, with the parameter name enclosed in code identifiers followed by the parameter's descriptive text.

We organized the extracted parameters into arrays and calculated accuracy by comparing them with the values in the params field (also an array) of the Repository's MetaInfo. It is important to note that we were calculating accuracy here, not recall. This is because some models may hallucinate many nonexistent parameters based on the code snippets. These errors must be taken into consideration, otherwise they will result in biased evaluations.

Repository	Model	Prompt Tokens	Completion Tokens	Class Numbers	Function Numbers	Code Lines
unoconv	`gpt-4-0125`	4020	2550	0	1	≤1k
	`gpt-3.5-turbo`		2743			
	`Llama-2-7b`	1180	2916			
	`Llama-2-70b`		437			
simdjson	`gpt-4-0125`	45344	35068	6	55	≤ 1k
	`gpt-3.5-turbo`		29736			
	`Llama-2-7b`	49615	27562			
	`Llama-2-70b`		32961			
greenlet	`gpt-4-0125`	86587	79113	59	319	1k ≤ 10k
	`gpt-3.5-turbo`		260464			
	`Llama-2-7b`	33177	31561			
	`Llama-2-70b`		225595			
code2flow	`gpt-4-0125`	185511	134462	51	257	1k ≤ 10k
	`gpt-3.5-turbo`		234101			
	`Llama-2-7b`	354574	431761			
	`Llama-2-70b`		187835			
AutoGen	`gpt-4-0125`	4939388	516975	64	590	1k ≤ 10k
	`gpt-3.5-turbo`		288609			
	`Llama-2-7b`	889050	630139			
	`Llama-2-70b`		410256			
AutoGPT	`gpt-4-0125`	4116296	888223	318	1170	≥ 10k
	`gpt-3.5-turbo`		799380			
	`Llama-2-7b`	1838425	1893041			
	`Llama-2-70b`		927946			
ChatDev	`gpt-4-0125`	2021168	602474	183	729	≥ 10k
	`gpt-3.5-turbo`		519226			
	`Llama-2-7b`	1122400	946131			
	`Llama-2-70b`		531838			
MemGPT	`gpt-4-0125`	628482	345109	74	478	≥ 10k
	`gpt-3.5-turbo`		234101			
	`Llama-2-7b`	742591	740783			
	`Llama-2-70b`		352940			
MetaGPT	`gpt-4-0125`	154364	111159	291	885	≥ 10k
	`gpt-3.5-turbo`		134101			
	`Llama-2-7b`	1904244	2265991			
	`Llama-2-70b`		1009996			

Table 3: Statistics for the selected repositories and the token consumption for documentation generation. Note that token count calculation varies with each model's tokenizer, rendering direct comparisons between different models impractical.

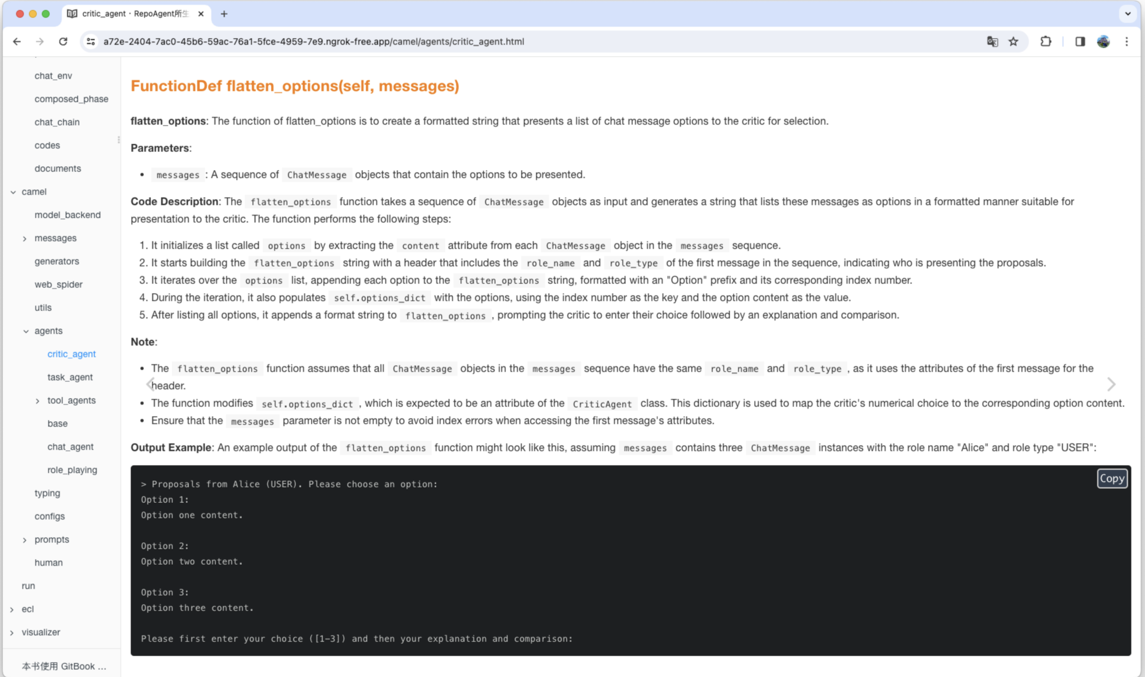
Criteria	Details
Accuracy	**Correctness**: Verify if the documentation accurately describes the code's functionality, algorithms, and expected behavior under various conditions.
	Precision: Assess whether the documentation provides precise and unambiguous information regarding the code's operations, parameters, and expected outcomes.
	Alignment with Codebase: Ensure that the documentation aligns closely with the actual implementation of the code, including any updates or changes made to the codebase.
Completeness	**Coverage**: Evaluate if the documentation comprehensively covers all significant aspects of the code, including inputs, outputs, error handling, edge cases, and any potential exceptions.
	In-depth Explanation: Determine if the documentation delves into detailed explanations of complex functionalities or algorithms, providing insights into the underlying logic.
	Documentation of External Dependencies: Check if the documentation adequately addresses any external libraries, modules, or APIs used within the codebase.
Understandability	**Clarity**: Assess the clarity and readability of the documentation, ensuring that it is easily understandable by developers of varying expertise levels.
	Conciseness: Determine if the documentation conveys information concisely without unnecessary verbosity or technical jargon that might hinder comprehension.
	Structured Organization: Evaluate if the documentation is logically organized, with clear headings, sections, and navigation aids for easy reference and comprehension.
Consistency	**Formatting Consistency**: Ensure consistency in the formatting, styling, and layout of the documentation across all sections and pages.
	Terminology Consistency: Verify that consistent terminology and naming conventions are used throughout the documentation to maintain coherence and clarity.
	Style Guide Adherence: Assess if the documentation adheres to any predefined style guides or conventions established by the project or organization.
Relevance	**Content Relevance**: Determine if the information provided in the documentation is directly relevant to the code's functionality, purpose, and usage scenarios.
	Avoidance of Redundancy: Check for redundancy or repetition within the documentation, eliminating any extraneous or irrelevant details that do not contribute to understanding the code.
Examples and Usage	**Code Samples**: Evaluate if the documentation includes sufficient code samples, snippets, or examples to illustrate the usage and implementation of key functionalities.
	Use Cases: Assess if the documentation provides real-world use cases or scenarios where the code can be applied, demonstrating its practical utility and versatility.
	Step-by-Step Instructions: Determine if the documentation offers clear, step-by-step instructions or tutorials for integrating, configuring, and utilizing the code in different environments or applications.

Table 4: Detailed criteria for human evaluation.

B Appendix: More Cases of Generated Documentation

B.1 Documentation Showcases

In this section, we showcase additional generated documentation to validate the practical application of REPOAGENT . The included images are direct screenshots from the documentation of two open-source projects, ChatDev and AutoGen. Our intent is to provide readers with a detailed and panoramic view of how our method is utilized in real-world scenarios, thereby offering a deeper understanding of its effectiveness and versatility.



FunctionDef flatten_options(self, messages)

flatten_options: The function of flatten_options is to create a formatted string that presents a list of chat message options to the critic for selection.

Parameters:

- `messages` : A sequence of `ChatMessage` objects that contain the options to be presented.

Code Description: The `flatten_options` function takes a sequence of `ChatMessage` objects as input and generates a string that lists these messages as options in a formatted manner suitable for presentation to the critic. The function performs the following steps:

1. It initializes a list called `options` by extracting the `content` attribute from each `ChatMessage` object in the `messages` sequence.
2. It starts building the `flatten_options` string with a header that includes the `role_name` and `role_type` of the first message in the sequence, indicating who is presenting the proposals.
3. It iterates over the `options` list, appending each option to the `flatten_options` string, formatted with an "Option" prefix and its corresponding index number.
4. During the iteration, it also populates `self.options_dict` with the options, using the index number as the key and the option content as the value.
5. After listing all options, it appends a format string to `flatten_options` , prompting the critic to enter their choice followed by an explanation and comparison.

Note:

- The `flatten_options` function assumes that all `ChatMessage` objects in the `messages` sequence have the same `role_name` and `role_type` , as it uses the attributes of the first message for the header.
- The function modifies `self.options_dict` , which is expected to be an attribute of the `CriticAgent` class. This dictionary is used to map the critic's numerical choice to the corresponding option content.
- Ensure that the `messages` parameter is not empty to avoid index errors when accessing the first message's attributes.

Output Example: An example output of the `flatten_options` function might look like this, assuming `messages` contains three `ChatMessage` instances with the role name "Alice" and role type "USER":

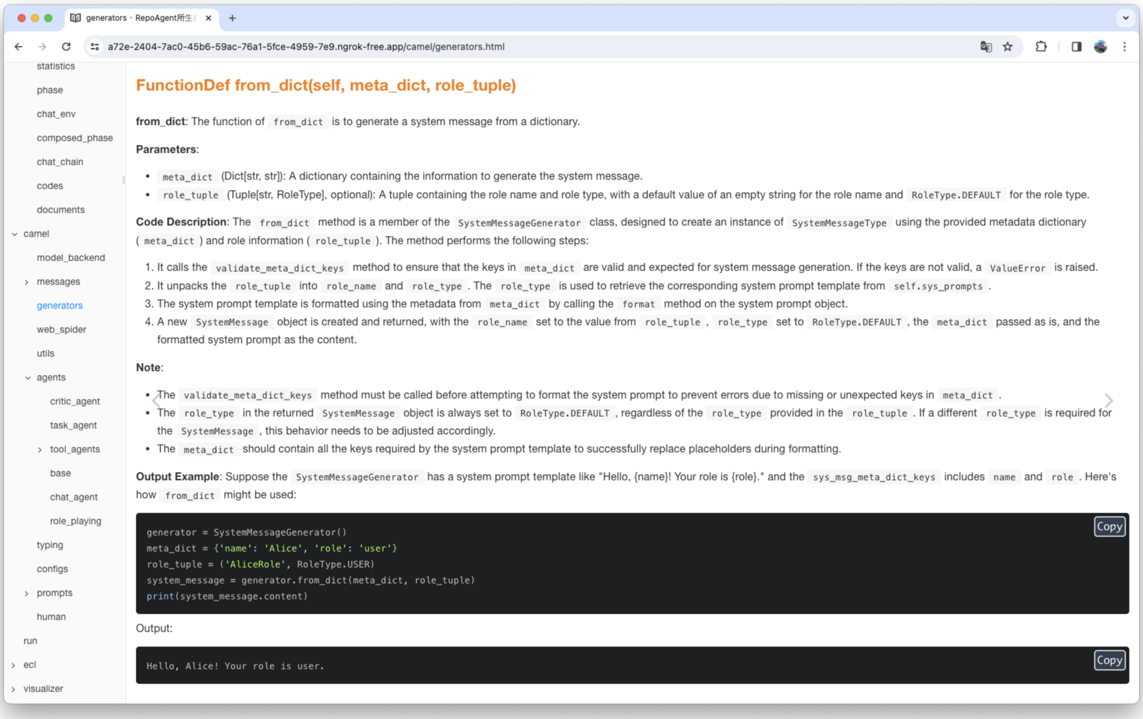
```
> Proposals from Alice (USER). Please choose an option:
Option 1:
Option one content.

Option 2:
Option two content.

Option 3:
Option three content.

Please first enter your choice ([1-3]) and then your explanation and comparison:
```

(a)



FunctionDef from_dict(self, meta_dict, role_tuple)

from_dict: The function of `from_dict` is to generate a system message from a dictionary.

Parameters:

- `meta_dict` (Dict[str, str]): A dictionary containing the information to generate the system message.
- `role_tuple` (Tuple[str, RoleType], optional): A tuple containing the role name and role type, with a default value of an empty string for the role name and `RoleType.DEFAULT` for the role type.

Code Description: The `from_dict` method is a member of the `SystemMessageGenerator` class, designed to create an instance of `SystemMessageType` using the provided metadata dictionary (`meta_dict`) and role information (`role_tuple`). The method performs the following steps:

1. It calls the `validate_meta_dict_keys` method to ensure that the keys in `meta_dict` are valid and expected for system message generation. If the keys are not valid, a `ValueError` is raised.
2. It unpacks the `role_tuple` into `role_name` and `role_type` . The `role_type` is used to retrieve the corresponding system prompt template from `self.sys_prompts` .
3. The system prompt template is formatted using the metadata from `meta_dict` by calling the `format` method on the system prompt object.
4. A new `SystemMessage` object is created and returned, with the `role_name` set to the value from `role_tuple` , `role_type` set to `RoleType.DEFAULT` , the `meta_dict` passed as is, and the formatted system prompt as the content.

Note:

- The `validate_meta_dict_keys` method must be called before attempting to format the system prompt to prevent errors due to missing or unexpected keys in `meta_dict` .
- The `role_type` in the returned `SystemMessage` object is always set to `RoleType.DEFAULT` , regardless of the `role_type` provided in the `role_tuple` . If a different `role_type` is required for the `SystemMessage` , this behavior needs to be adjusted accordingly.
- The `meta_dict` should contain all the keys required by the system prompt template to successfully replace placeholders during formatting.

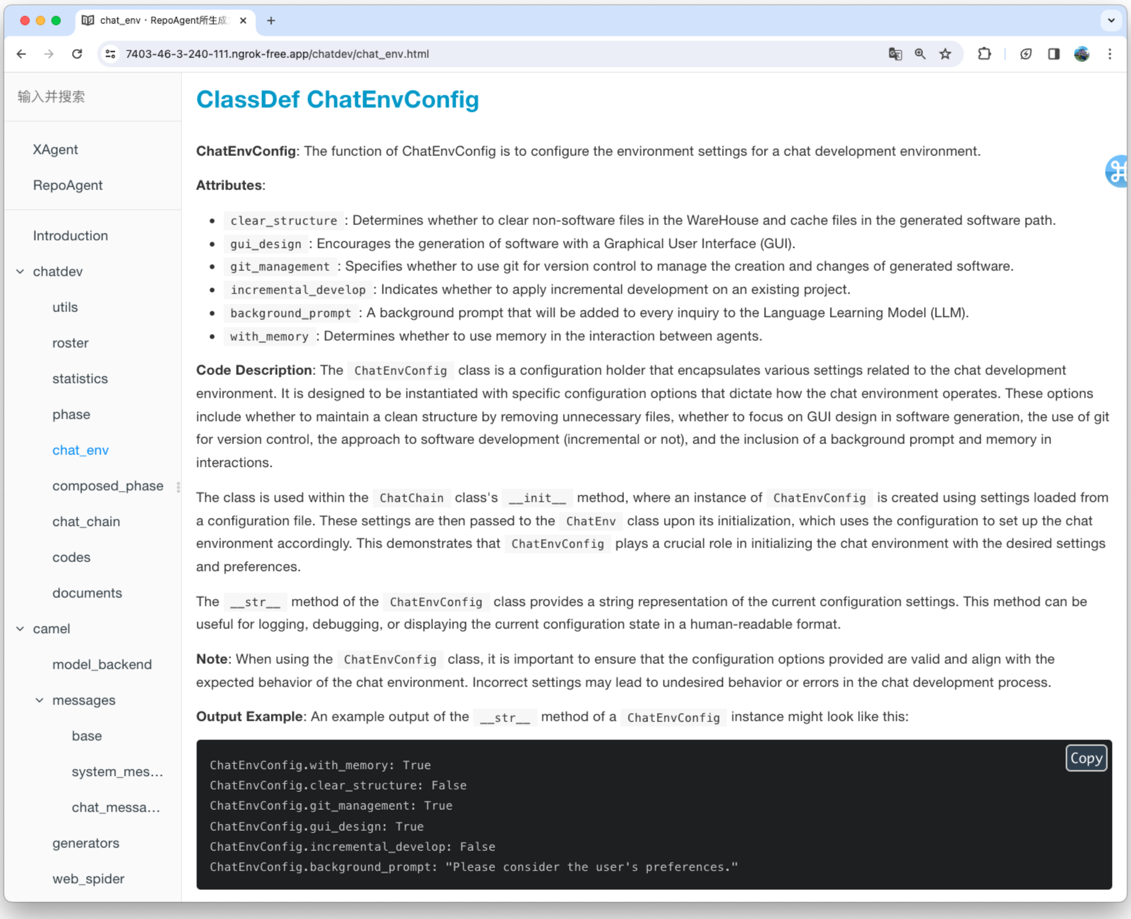
Output Example: Suppose the `SystemMessageGenerator` has a system prompt template like "Hello, {name}! Your role is {role}." and the `sys_msg_meta_dict_keys` includes `name` and `role` . Here's how `from_dict` might be used:

```
generator = SystemMessageGenerator()
meta_dict = {'name': 'Alice', 'role': 'user'}
role_tuple = ('AliceRole', RoleType.USER)
system_message = generator.from_dict(meta_dict, role_tuple)
print(system_message.content)
```

Output:

```
Hello, Alice! Your role is user.
```

(b)



ClassDef ChatEnvConfig

ChatEnvConfig: The function of ChatEnvConfig is to configure the environment settings for a chat development environment.

Attributes:

- `clear_structure` : Determines whether to clear non-software files in the WareHouse and cache files in the generated software path.
- `gui_design` : Encourages the generation of software with a Graphical User Interface (GUI).
- `git_management` : Specifies whether to use git for version control to manage the creation and changes of generated software.
- `incremental_develop` : Indicates whether to apply incremental development on an existing project.
- `background_prompt` : A background prompt that will be added to every inquiry to the Language Learning Model (LLM).
- `with_memory` : Determines whether to use memory in the interaction between agents.

Code Description: The `ChatEnvConfig` class is a configuration holder that encapsulates various settings related to the chat development environment. It is designed to be instantiated with specific configuration options that dictate how the chat environment operates. These options include whether to maintain a clean structure by removing unnecessary files, whether to focus on GUI design in software generation, the use of git for version control, the approach to software development (incremental or not), and the inclusion of a background prompt and memory in interactions.

The class is used within the `ChatChain` class's `__init__` method, where an instance of `ChatEnvConfig` is created using settings loaded from a configuration file. These settings are then passed to the `ChatEnv` class upon its initialization, which uses the configuration to set up the chat environment accordingly. This demonstrates that `ChatEnvConfig` plays a crucial role in initializing the chat environment with the desired settings and preferences.

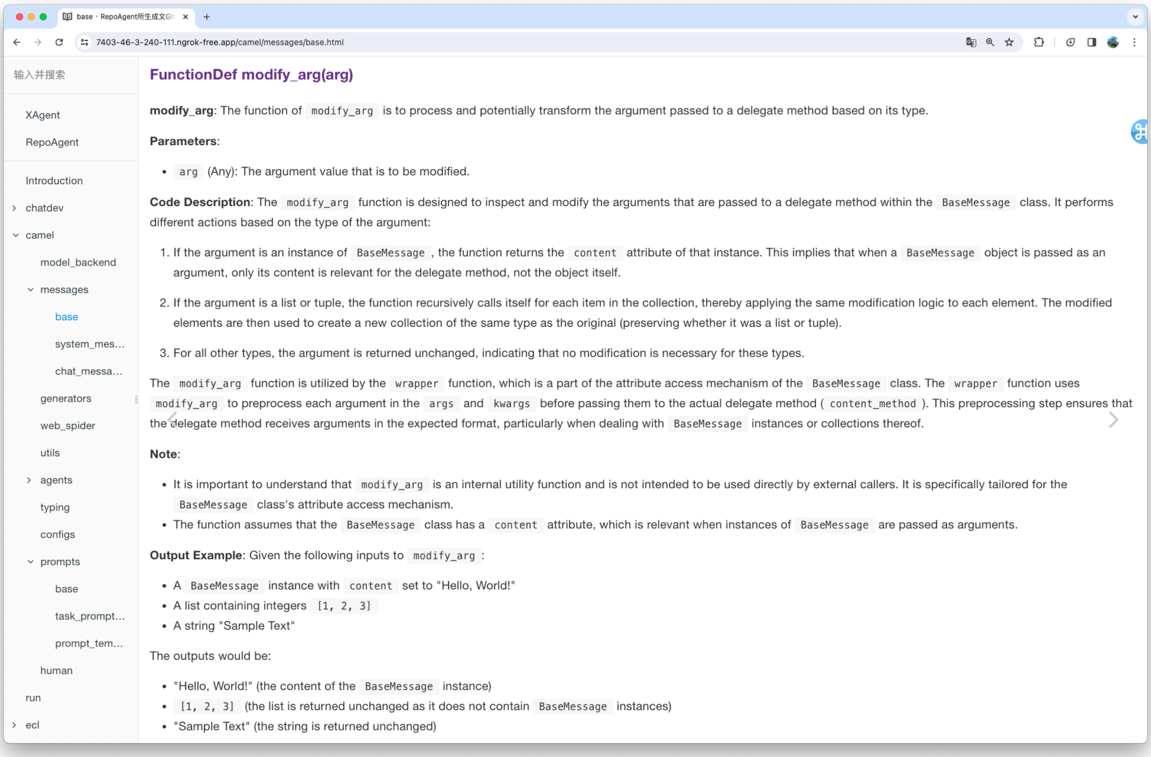
The `__str__` method of the `ChatEnvConfig` class provides a string representation of the current configuration settings. This method can be useful for logging, debugging, or displaying the current configuration state in a human-readable format.

Note: When using the `ChatEnvConfig` class, it is important to ensure that the configuration options provided are valid and align with the expected behavior of the chat environment. Incorrect settings may lead to undesired behavior or errors in the chat development process.

Output Example: An example output of the `__str__` method of a `ChatEnvConfig` instance might look like this:

```
ChatEnvConfig.with_memory: True
ChatEnvConfig.clear_structure: False
ChatEnvConfig.git_management: True
ChatEnvConfig.gui_design: True
ChatEnvConfig.incremental_develop: False
ChatEnvConfig.background_prompt: "Please consider the user's preferences."
```

(c)



FunctionDef modify_arg(arg)

modify_arg: The function of `modify_arg` is to process and potentially transform the argument passed to a delegate method based on its type.

Parameters:

- `arg` (Any): The argument value that is to be modified.

Code Description: The `modify_arg` function is designed to inspect and modify the arguments that are passed to a delegate method within the `BaseMessage` class. It performs different actions based on the type of the argument:

1. If the argument is an instance of `BaseMessage` , the function returns the `content` attribute of that instance. This implies that when a `BaseMessage` object is passed as an argument, only its content is relevant for the delegate method, not the object itself.
2. If the argument is a list or tuple, the function recursively calls itself for each item in the collection, thereby applying the same modification logic to each element. The modified elements are then used to create a new collection of the same type as the original (preserving whether it was a list or tuple).
3. For all other types, the argument is returned unchanged, indicating that no modification is necessary for these types.

The `modify_arg` function is utilized by the `wrapper` function, which is a part of the attribute access mechanism of the `BaseMessage` class. The `wrapper` function uses `modify_arg` to preprocess each argument in the `args` and `kwargs` before passing them to the actual delegate method (`content_method`). This preprocessing step ensures that the delegate method receives arguments in the expected format, particularly when dealing with `BaseMessage` instances or collections thereof.

Note:

- It is important to understand that `modify_arg` is an internal utility function and is not intended to be used directly by external callers. It is specifically tailored for the `BaseMessage` class's attribute access mechanism.
- The function assumes that the `BaseMessage` class has a `content` attribute, which is relevant when instances of `BaseMessage` are passed as arguments.

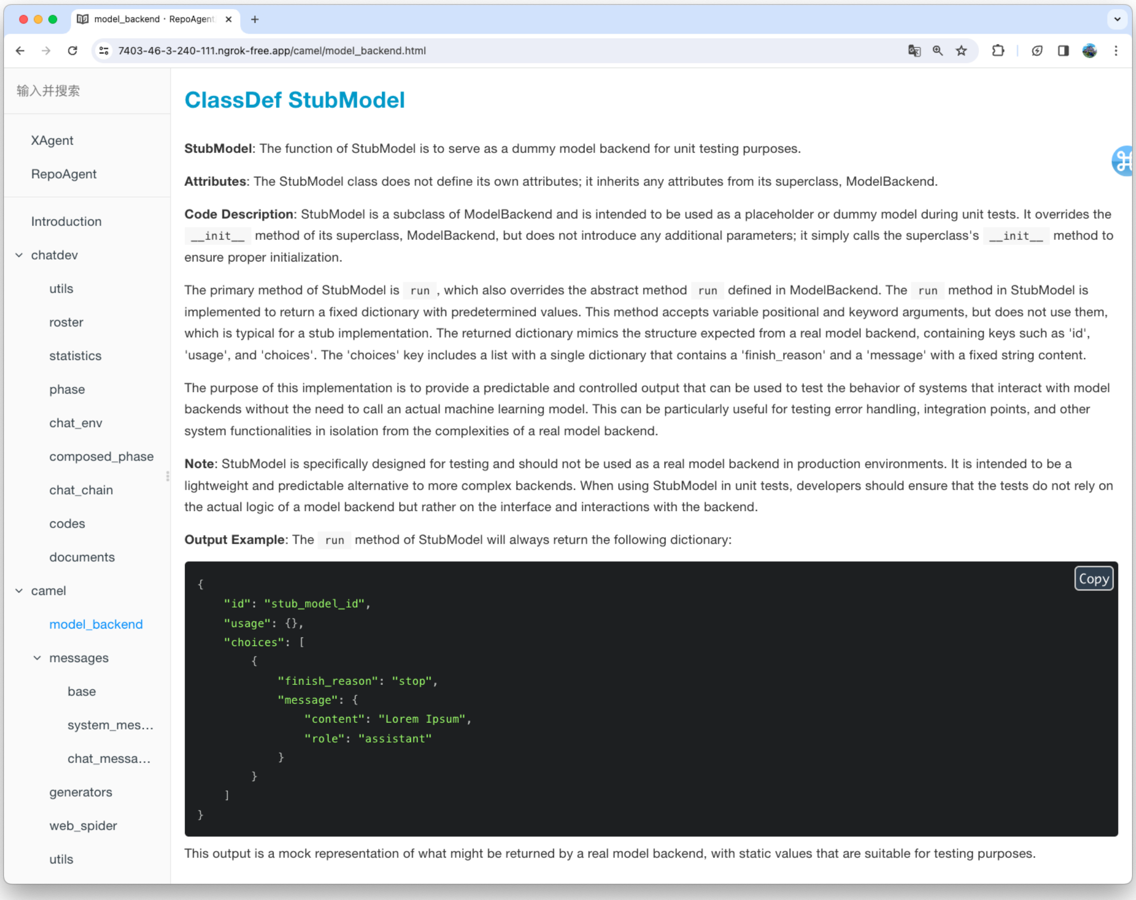
Output Example: Given the following inputs to `modify_arg` :

- A `BaseMessage` instance with `content` set to "Hello, World!"
- A list containing integers `[1, 2, 3]`
- A string "Sample Text"

The outputs would be:

- "Hello, World!" (the content of the `BaseMessage` instance)
- `[1, 2, 3]` (the list is returned unchanged as it does not contain `BaseMessage` instances)
- "Sample Text" (the string is returned unchanged)

(d)



ClassDef StubModel

StubModel: The function of StubModel is to serve as a dummy model backend for unit testing purposes.

Attributes: The StubModel class does not define its own attributes; it inherits any attributes from its superclass, ModelBackend.

Code Description: StubModel is a subclass of ModelBackend and is intended to be used as a placeholder or dummy model during unit tests. It overrides the `__init__` method of its superclass, ModelBackend, but does not introduce any additional parameters; it simply calls the superclass's `__init__` method to ensure proper initialization.

The primary method of StubModel is `run`, which also overrides the abstract method `run` defined in ModelBackend. The `run` method in StubModel is implemented to return a fixed dictionary with predetermined values. This method accepts variable positional and keyword arguments, but does not use them, which is typical for a stub implementation. The returned dictionary mimics the structure expected from a real model backend, containing keys such as 'id', 'usage', and 'choices'. The 'choices' key includes a list with a single dictionary that contains a 'finish_reason' and a 'message' with a fixed string content.

The purpose of this implementation is to provide a predictable and controlled output that can be used to test the behavior of systems that interact with model backends without the need to call an actual machine learning model. This can be particularly useful for testing error handling, integration points, and other system functionalities in isolation from the complexities of a real model backend.

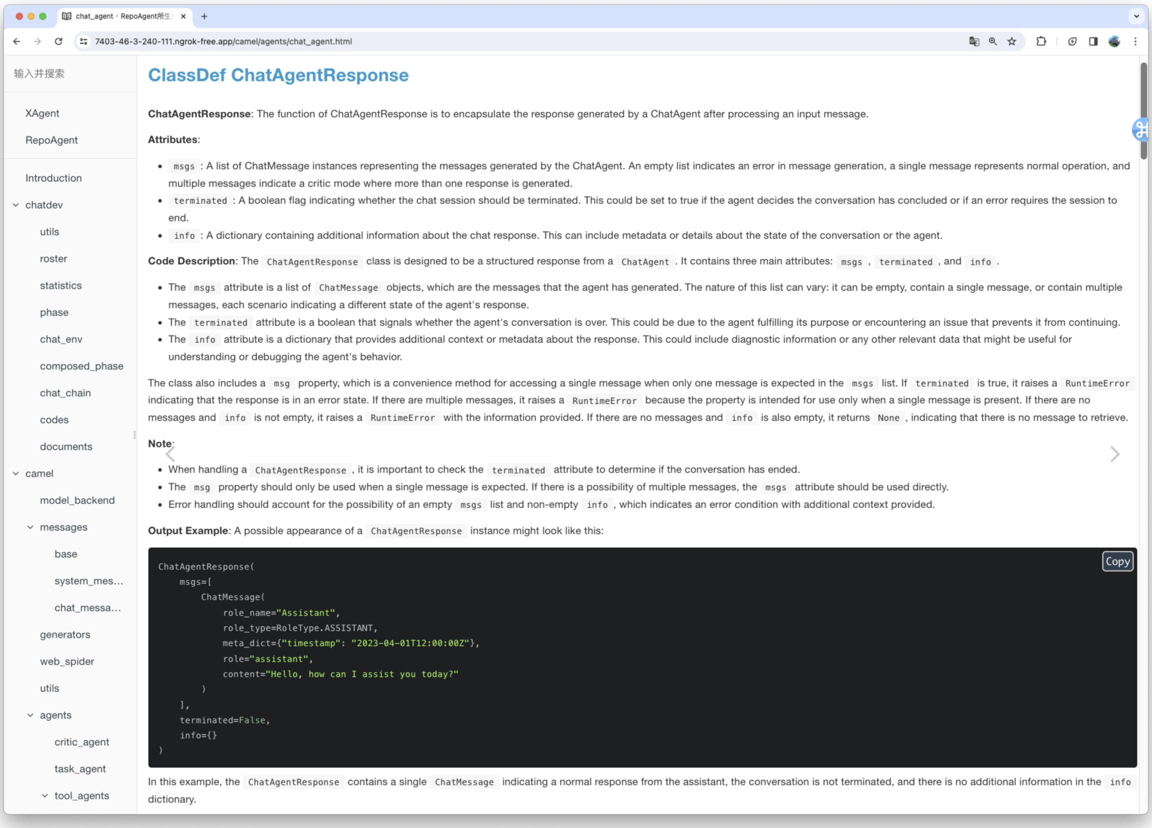
Note: StubModel is specifically designed for testing and should not be used as a real model backend in production environments. It is intended to be a lightweight and predictable alternative to more complex backends. When using StubModel in unit tests, developers should ensure that the tests do not rely on the actual logic of a model backend but rather on the interface and interactions with the backend.

Output Example: The `run` method of StubModel will always return the following dictionary:

```
{
    "id": "stub_model_id",
    "usage": {},
    "choices": [
        {
            "finish_reason": "stop",
            "message": {
                "content": "Lorem Ipsum",
                "role": "assistant"
            }
        }
    ]
}
```

This output is a mock representation of what might be returned by a real model backend, with static values that are suitable for testing purposes.

(e)



ClassDef ChatAgentResponse

ChatAgentResponse: The function of ChatAgentResponse is to encapsulate the response generated by a ChatAgent after processing an input message.

Attributes:

- `msgs` : A list of ChatMessage instances representing the messages generated by the ChatAgent. An empty list indicates an error in message generation, a single message represents normal operation, and multiple messages indicate a critic mode where more than one response is generated.
- `terminated` : A boolean flag indicating whether the chat session should be terminated. This could be set to true if the agent decides the conversation has concluded or if an error requires the session to end.
- `info` : A dictionary containing additional information about the chat response. This can include metadata or details about the state of the conversation or the agent.

Code Description: The `ChatAgentResponse` class is designed to be a structured response from a `ChatAgent` . It contains three main attributes: `msgs` , `terminated` , and `info` .

- The `msgs` attribute is a list of `ChatMessage` objects, which are the messages that the agent has generated. The nature of this list can vary: it can be empty, contain a single message, or contain multiple messages, each scenario indicating a different state of the agent's response.
- The `terminated` attribute is a boolean that signals whether the agent's conversation is over. This could be due to the agent fulfilling its purpose or encountering an issue that prevents it from continuing.
- The `info` attribute is a dictionary that provides additional context or metadata about the response. This could include diagnostic information or any other relevant data that might be useful for understanding or debugging the agent's behavior.

The class also includes a `msg` property, which is a convenience method for accessing a single message when only one message is expected in the `msgs` list. If `terminated` is true, it raises a `RuntimeError` indicating that the response is in an error state. If there are multiple messages, it raises a `RuntimeError` because the property is intended for use only when a single message is present. If there are no messages and `info` is not empty, it raises a `RuntimeError` with the information provided. If there are no messages and `info` is also empty, it returns `None` , indicating that there is no message to retrieve.

Note:

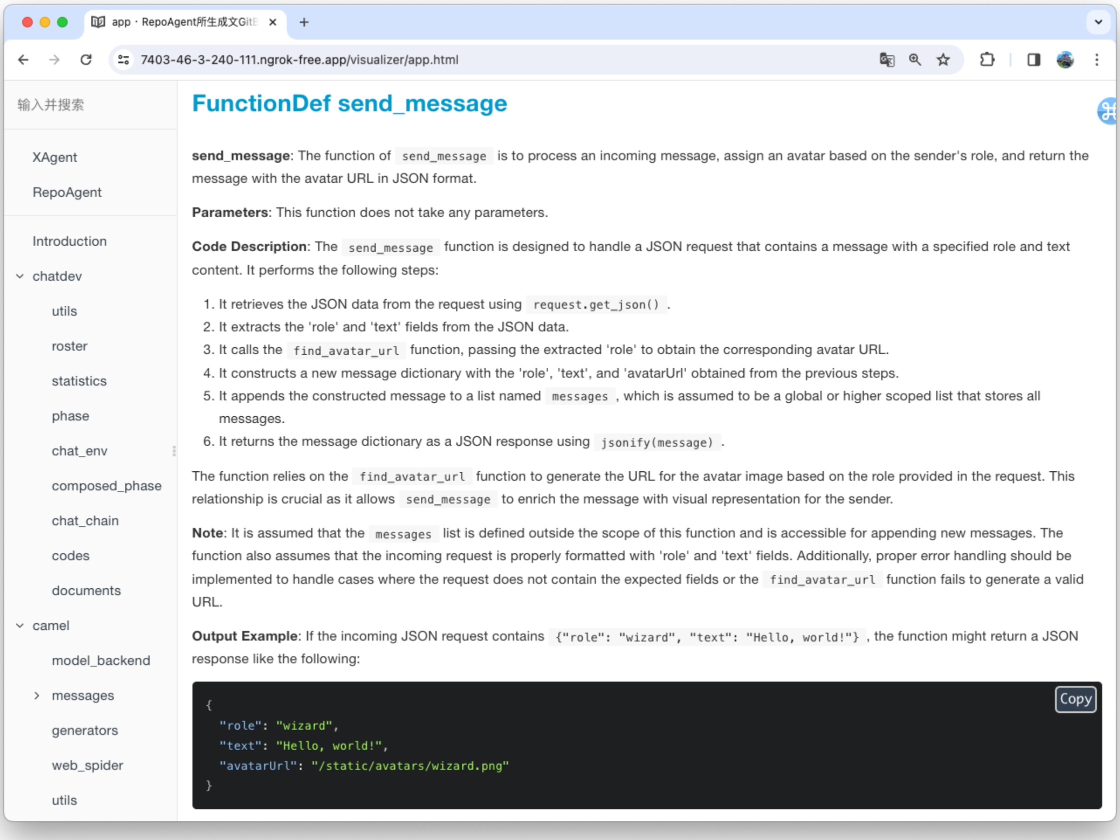
- When handling a `ChatAgentResponse` , it is important to check the `terminated` attribute to determine if the conversation has ended.
- The `msg` property should only be used when a single message is expected. If there is a possibility of multiple messages, the `msgs` attribute should be used directly.
- Error handling should account for the possibility of an empty `msgs` list and non-empty `info` , which indicates an error condition with additional context provided.

Output Example: A possible appearance of a `ChatAgentResponse` instance might look like this:

```
ChatAgentResponse(
    msgs=[
        ChatMessage(
            role_name="Assistant",
            role_type=RoleType.ASSISTANT,
            meta_dict={"timestamp": "2023-04-01T12:00:00Z"},
            role="assistant",
            content="Hello, how can I assist you today?"
        )
    ],
    terminated=False,
    info={}
)
```

In this example, the `ChatAgentResponse` contains a single `ChatMessage` indicating a normal response from the assistant, the conversation is not terminated, and there is no additional information in the `info` dictionary.

(f)



FunctionDef send_message

send_message: The function of `send_message` is to process an incoming message, assign an avatar based on the sender's role, and return the message with the avatar URL in JSON format.

Parameters: This function does not take any parameters.

Code Description: The `send_message` function is designed to handle a JSON request that contains a message with a specified role and text content. It performs the following steps:

1. It retrieves the JSON data from the request using `request.get_json()`.
2. It extracts the 'role' and 'text' fields from the JSON data.
3. It calls the `find_avatar_url` function, passing the extracted 'role' to obtain the corresponding avatar URL.
4. It constructs a new message dictionary with the 'role', 'text', and 'avatarUrl' obtained from the previous steps.
5. It appends the constructed message to a list named `messages`, which is assumed to be a global or higher scoped list that stores all messages.
6. It returns the message dictionary as a JSON response using `jsonify(message)`.

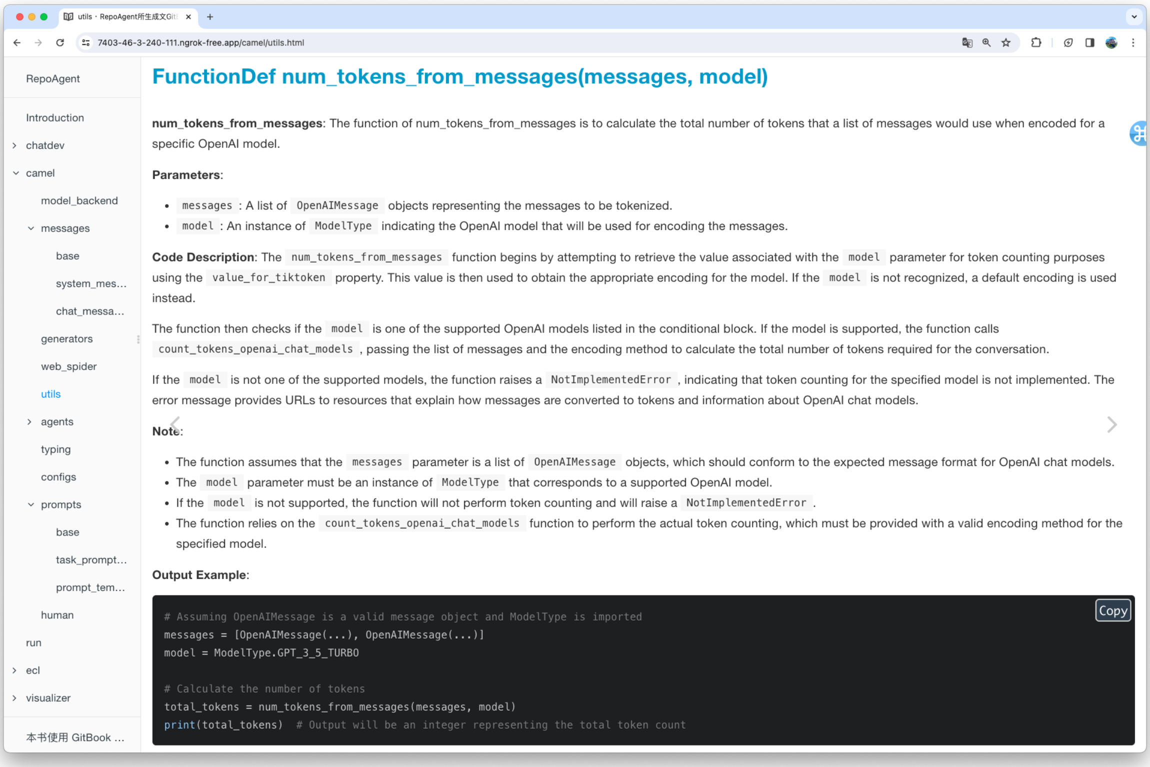
The function relies on the `find_avatar_url` function to generate the URL for the avatar image based on the role provided in the request. This relationship is crucial as it allows `send_message` to enrich the message with visual representation for the sender.

Note: It is assumed that the `messages` list is defined outside the scope of this function and is accessible for appending new messages. The function also assumes that the incoming request is properly formatted with 'role' and 'text' fields. Additionally, proper error handling should be implemented to handle cases where the request does not contain the expected fields or the `find_avatar_url` function fails to generate a valid URL.

Output Example: If the incoming JSON request contains `{"role": "wizard", "text": "Hello, world!"}`, the function might return a JSON response like the following:

```
{
  "role": "wizard",
  "text": "Hello, world!",
  "avatarUrl": "/static/avatars/wizard.png"
}
```

(g)



FunctionDef num_tokens_from_messages(messages, model)

num_tokens_from_messages: The function of num_tokens_from_messages is to calculate the total number of tokens that a list of messages would use when encoded for a specific OpenAI model.

Parameters:

- `messages` : A list of `OpenAIMessage` objects representing the messages to be tokenized.
- `model` : An instance of `ModelType` indicating the OpenAI model that will be used for encoding the messages.

Code Description: The `num_tokens_from_messages` function begins by attempting to retrieve the value associated with the `model` parameter for token counting purposes using the `value_for_tiktoken` property. This value is then used to obtain the appropriate encoding for the model. If the `model` is not recognized, a default encoding is used instead.

The function then checks if the `model` is one of the supported OpenAI models listed in the conditional block. If the model is supported, the function calls `count_tokens_openai_chat_models`, passing the list of messages and the encoding method to calculate the total number of tokens required for the conversation.

If the `model` is not one of the supported models, the function raises a `NotImplementedError`, indicating that token counting for the specified model is not implemented. The error message provides URLs to resources that explain how messages are converted to tokens and information about OpenAI chat models.

Note:

- The function assumes that the `messages` parameter is a list of `OpenAIMessage` objects, which should conform to the expected message format for OpenAI chat models.
- The `model` parameter must be an instance of `ModelType` that corresponds to a supported OpenAI model.
- If the `model` is not supported, the function will not perform token counting and will raise a `NotImplementedError`.
- The function relies on the `count_tokens_openai_chat_models` function to perform the actual token counting, which must be provided with a valid encoding method for the specified model.

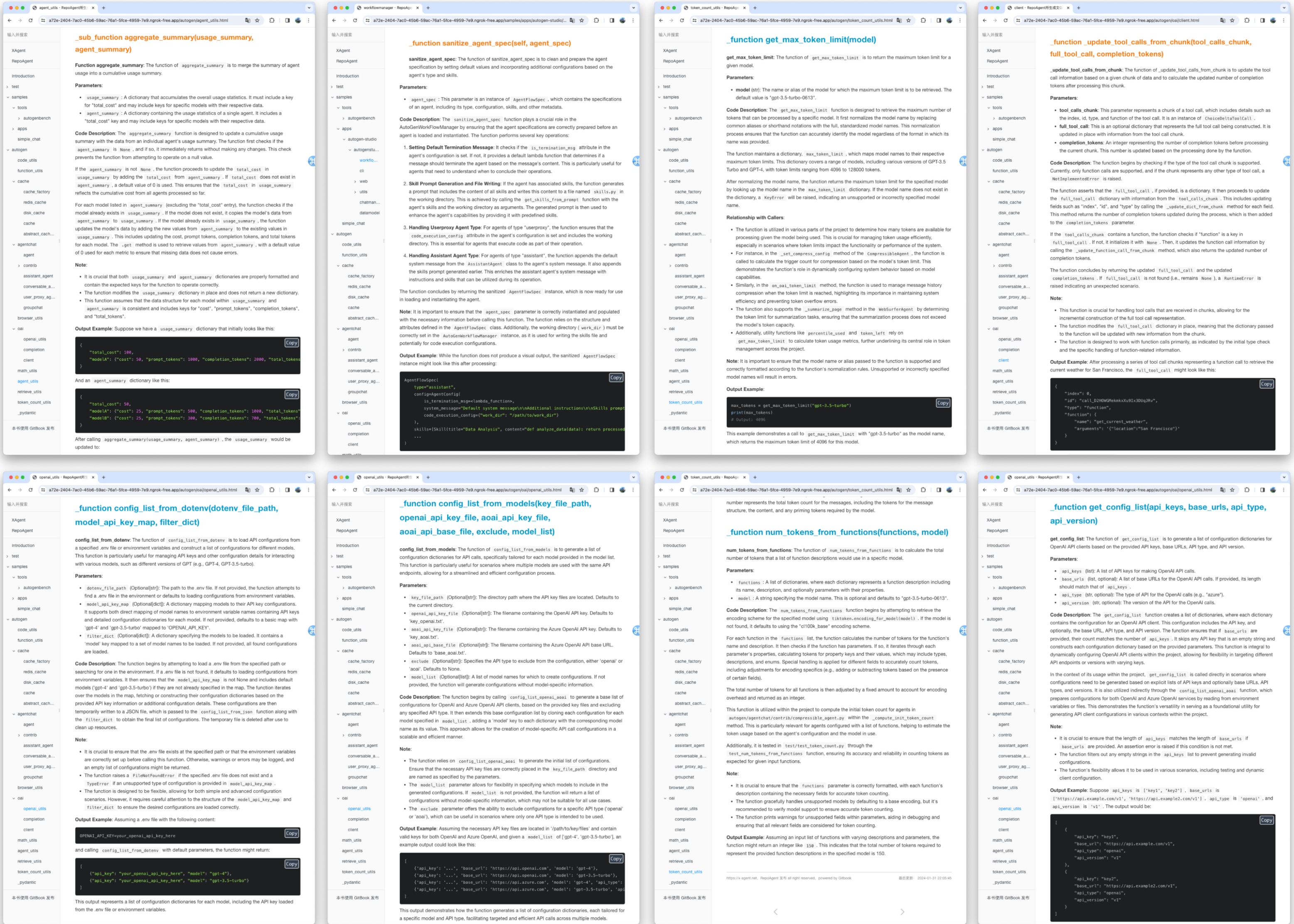
Output Example:

```
# Assuming OpenAIMessage is a valid message object and ModelType is imported
messages = [OpenAIMessage(...), OpenAIMessage(...)]
model = ModelType.GPT_3_5_TURBO

# Calculate the number of tokens
total_tokens = num_tokens_from_messages(messages, model)
print(total_tokens)  # Output will be an integer representing the total token count
```

(h)

Figure 8: Samples of code documentation generated by REPOAGENT for the ChatDev repository.



_sub_function aggregate_summary(usage_summary, agent_summary)

Function aggregate_summary: The function of `aggregate_summary` is to merge the summary of agent usage into a cumulative usage summary.

Parameters:

- `usage_summary` : A dictionary that accumulates the overall usage statistics. It must include a key for "total_cost" and may include keys for specific models with their respective data.
- `agent_summary` : A dictionary containing the usage statistics of a single agent. It includes a "total_cost" key and may include keys for specific models with their respective data.

Code Description: The `aggregate_summary` function is designed to update a cumulative usage summary with the data from an individual agent's usage summary. The function first checks if the `agent_summary` is `None` , and if so, it immediately returns without making any changes. This check prevents the function from attempting to operate on a null value.

If the `agent_summary` is not `None` , the function proceeds to update the `total_cost` in `usage_summary` by adding the `total_cost` from `agent_summary` . If `total_cost` does not exist in `agent_summary` , a default value of 0 is used. This ensures that the `total_cost` in `usage_summary` reflects the cumulative cost from all agents processed so far.

For each model listed in `agent_summary` (excluding the "total_cost" entry), the function checks if the model already exists in `usage_summary` . If the model does not exist, it copies the model's data from `agent_summary` to `usage_summary` . If the model already exists in `usage_summary` , the function updates the model's data by adding the new values from `agent_summary` to the existing values in `usage_summary` . This includes updating the cost, prompt tokens, completion tokens, and total tokens for each model. The `.get` method is used to retrieve values from `agent_summary` , with a default value of 0 used for each metric to ensure that missing data does not cause errors.

Note:

- It is crucial that both `usage_summary` and `agent_summary` dictionaries are properly formatted and contain the expected keys for the function to operate correctly.
- The function modifies the `usage_summary` dictionary in place and does not return a new dictionary.
- This function assumes that the data structure for each model within `usage_summary` and `agent_summary` is consistent and includes keys for "cost", "prompt_tokens", "completion_tokens", and "total_tokens".

Output Example: Suppose we have a `usage_summary` dictionary that initially looks like this:

```
{
    "total_cost": 100,
    "modelA": {"cost": 50, "prompt_tokens": 1000, "completion_tokens": 2000, "total_tokens
}
```

And an `agent_summary` dictionary like this:

```
{
    "total_cost": 50,
    "modelA": {"cost": 25, "prompt_tokens": 500, "completion_tokens": 1000, "total_tokens"
    "modelB": {"cost": 25, "prompt_tokens": 300, "completion_tokens": 700, "total_tokens":
}
```

After calling `aggregate_summary(usage_summary, agent_summary)` , the `usage_summary` would be updated to:

_function sanitize_agent_spec(self, agent_spec)

sanitize_agent_spec: The function of sanitize_agent_spec is to clean and prepare the agent specification by setting default values and incorporating additional configurations based on the agent's type and skills.

Parameters:

- `agent_spec` : This parameter is an instance of `AgentFlowSpec` , which contains the specifications of an agent, including its type, configuration, skills, and other metadata.

Code Description: The `sanitize_agent_spec` function plays a crucial role in the AutoGenWorkFlowManager by ensuring that the agent specifications are correctly prepared before an agent is loaded and instantiated. The function performs several key operations:

1. **Setting Default Termination Message**: It checks if the `is_termination_msg` attribute in the agent's configuration is set. If not, it provides a default lambda function that determines if a message should terminate the agent based on the message's content. This is particularly useful for agents that need to understand when to conclude their operations.
2. **Skill Prompt Generation and File Writing**: If the agent has associated skills, the function generates a prompt that includes the content of all skills and writes this content to a file named `skills.py` in the working directory. This is achieved by calling the `get_skills_from_prompt` function with the agent's skills and the working directory as arguments. The generated prompt is then used to enhance the agent's capabilities by providing it with predefined skills.
3. **Handling Userproxy Agent Type**: For agents of type "userproxy", the function ensures that the `code_execution_config` attribute in the agent's configuration is set and includes the working directory. This is essential for agents that execute code as part of their operation.
4. **Handling Assistant Agent Type**: For agents of type "assistant", the function appends the default system message from the `AssistantAgent` class to the agent's system message. It also appends the skills prompt generated earlier. This enriches the assistant agent's system message with instructions and skills that can be utilized during its operation.

The function concludes by returning the sanitized `AgentFlowSpec` instance, which is now ready for use in loading and instantiating the agent.

Note: It is important to ensure that the `agent_spec` parameter is correctly instantiated and populated with the necessary information before calling this function. The function relies on the structure and attributes defined in the `AgentFlowSpec` class. Additionally, the working directory (`work_dir`) must be correctly set in the `AutoGenWorkFlowManager` instance, as it is used for writing the skills file and potentially for code execution configurations.

Output Example: While the function does not produce a visual output, the sanitized `AgentFlowSpec` instance might look like this after processing:

```
AgentFlowSpec(
    type="assistant",
    config=AgentConfig(
        is_termination_msg=<lambda_function>,
        system_message="Default system message\n\nAdditional instructions\n\nSkills prompt
        code_execution_config={"work_dir": "/path/to/work_dir"}
    ),
    skills=[Skill(title="Data Analysis", content="def analyze_data(data): return processed
    ...
)
```

_function get_max_token_limit(model)

get_max_token_limit: The function of `get_max_token_limit` is to return the maximum token limit for a given model.

Parameters:

- **model** (str): The name or alias of the model for which the maximum token limit is to be retrieved. The default value is "gpt-3.5-turbo-0613".

Code Description: The `get_max_token_limit` function is designed to retrieve the maximum number of tokens that can be processed by a specific model. It first normalizes the model name by replacing common aliases or shorthand notations with the full, standardized model names. This normalization process ensures that the function can accurately identify the model regardless of the format in which its name was provided.

The function maintains a dictionary, `max_token_limit` , which maps model names to their respective maximum token limits. This dictionary covers a range of models, including various versions of GPT-3.5 Turbo and GPT-4, with token limits ranging from 4096 to 128000 tokens.

After normalizing the model name, the function returns the maximum token limit for the specified model by looking up the model name in the `max_token_limit` dictionary. If the model name does not exist in the dictionary, a `KeyError` will be raised, indicating an unsupported or incorrectly specified model name.

Relationship with Callers:

- The function is utilized in various parts of the project to determine how many tokens are available for processing given the model being used. This is crucial for managing token usage efficiently, especially in scenarios where token limits impact the functionality or performance of the system.
- For instance, in the `_set_compress_config` method of the `CompressibleAgent` , the function is called to calculate the trigger count for compression based on the model's token limit. This demonstrates the function's role in dynamically configuring system behavior based on model capabilities.
- Similarly, in the `on_oai_token_limit` method, the function is used to manage message history compression when the token limit is reached, highlighting its importance in maintaining system efficiency and preventing token overflow errors.
- The function also supports the `_summarize_page` method in the `WebSurferAgent` by determining the token limit for summarization tasks, ensuring that the summarization process does not exceed the model's token capacity.
- Additionally, utility functions like `percentile_used` and `token_left` rely on `get_max_token_limit` to calculate token usage metrics, further underlining its central role in token management across the project.

Note: It is important to ensure that the model name or alias passed to the function is supported and correctly formatted according to the function's normalization rules. Unsupported or incorrectly specified model names will result in errors.

Output Example:

```
max_tokens = get_max_token_limit("gpt-3.5-turbo")
print(max_tokens)
# Output: 4096
```

This example demonstrates a call to `get_max_token_limit` with "gpt-3.5-turbo" as the model name, which returns the maximum token limit of 4096 for this model.

_function _update_tool_calls_from_chunk(tool_calls_chunk, full_tool_call, completion_tokens)

_update_tool_calls_from_chunk: The function of _update_tool_calls_from_chunk is to update the tool call information based on a given chunk of data and to calculate the updated number of completion tokens after processing this chunk.

Parameters:

- **tool_calls_chunk**: This parameter represents a chunk of a tool call, which includes details such as the index, id, type, and function of the tool call. It is an instance of `ChoiceDeltaToolCall` .
- **full_tool_call**: This is an optional dictionary that represents the full tool call being constructed. It is updated in place with information from the tool call chunk.
- **completion_tokens**: An integer representing the number of completion tokens before processing the current chunk. This number is updated based on the processing done by the function.

Code Description: The function begins by checking if the type of the tool call chunk is supported. Currently, only function calls are supported, and if the chunk represents any other type of tool call, a `NotImplementedError` is raised.

The function asserts that the `full_tool_call` , if provided, is a dictionary. It then proceeds to update the `full_tool_call` dictionary with information from the `tool_calls_chunk` . This includes updating fields such as "index", "id", and "type" by calling the `_update_dict_from_chunk` method for each field. This method returns the number of completion tokens updated during the process, which is then added to the `completion_tokens` parameter.

If the `tool_calls_chunk` contains a function, the function checks if "function" is a key in `full_tool_call` . If not, it initializes it with `None` . Then, it updates the function call information by calling the `_update_function_call_from_chunk` method, which also returns the updated number of completion tokens.

The function concludes by returning the updated `full_tool_call` and the updated `completion_tokens` . If `full_tool_call` is not found (i.e., remains `None`), a `RuntimeError` is raised indicating an unexpected scenario.

Note:

- This function is crucial for handling tool calls that are received in chunks, allowing for the incremental construction of the full tool call representation.
- The function modifies the `full_tool_call` dictionary in place, meaning that the dictionary passed to the function will be updated with new information from the chunk.
- The function is designed to work with function calls primarily, as indicated by the initial type check and the specific handling of function-related information.

Output Example: After processing a series of tool call chunks representing a function call to retrieve the current weather for San Francisco, the `full_tool_call` might look like this:

```
{
    "index": 0,
    "id": "call_D2HOWGMekmkxXu9Ix3DUqJRv",
    "type": "function",
    "function": {
        "name": "get_current_weather",
        "arguments": '{"location":"San Francisco"}'
    }
}
```

_function config_list_from_dotenv(dotenv_file_path, model_api_key_map, filter_dict)

config_list_from_dotenv: The function of `config_list_from_dotenv` is to load API configurations from a specified .env file or environment variables and construct a list of configurations for different models. This function is particularly useful for managing API keys and other configuration details for interacting with various models, such as different versions of GPT (e.g., GPT-4, GPT-3.5-turbo).

Parameters:

- `dotenv_file_path` (Optional[str]): The path to the .env file. If not provided, the function attempts to find a .env file in the environment or defaults to loading configurations from environment variables.
- `model_api_key_map` (Optional[dict]): A dictionary mapping models to their API key configurations. It supports both direct mapping of model names to environment variable names containing API keys and detailed configuration dictionaries for each model. If not provided, defaults to a basic map with 'gpt-4' and 'gpt-3.5-turbo' mapped to 'OPENAI_API_KEY'.
- `filter_dict` (Optional[dict]): A dictionary specifying the models to be loaded. It contains a 'model' key mapped to a set of model names to be loaded. If not provided, all found configurations are loaded.

Code Description: The function begins by attempting to load a .env file from the specified path or searching for one in the environment. If a .env file is not found, it defaults to loading configurations from environment variables. It then ensures that the `model_api_key_map` is not None and includes default models ('gpt-4' and 'gpt-3.5-turbo') if they are not already specified in the map. The function iterates over the models in the map, fetching or constructing their configuration dictionaries based on the provided API key information or additional configuration details. These configurations are then temporarily written to a JSON file, which is passed to the `config_list_from_json` function along with the `filter_dict` to obtain the final list of configurations. The temporary file is deleted after use to clean up resources.

Note:

- It is crucial to ensure that the .env file exists at the specified path or that the environment variables are correctly set up before calling this function. Otherwise, warnings or errors may be logged, and an empty list of configurations might be returned.
- The function raises a `FileNotFoundError` if the specified .env file does not exist and a `TypeError` if an unsupported type of configuration is provided in `model_api_key_map` .
- The function is designed to be flexible, allowing for both simple and advanced configuration scenarios. However, it requires careful attention to the structure of the `model_api_key_map` and `filter_dict` to ensure the desired configurations are loaded correctly.

Output Example: Assuming a .env file with the following content:

```
OPENAI_API_KEY=your_openai_api_key_here
```

and calling `config_list_from_dotenv` with default parameters, the function might return:

```
[
    {"api_key": "your_openai_api_key_here", "model": "gpt-4"},
    {"api_key": "your_openai_api_key_here", "model": "gpt-3.5-turbo"}
]
```

This output represents a list of configuration dictionaries for each model, including the API key loaded from the .env file or environment variables.

_function config_list_from_models(key_file_path, openai_api_key_file, aoai_api_key_file, aoai_api_base_file, exclude, model_list)

config_list_from_models: The function of `config_list_from_models` is to generate a list of configuration dictionaries for API calls, specifically tailored for each model provided in the model list. This function is particularly useful for scenarios where multiple models are used with the same API endpoints, allowing for a streamlined and efficient configuration process.

Parameters:

- `key_file_path` (Optional[str]): The directory path where the API key files are located. Defaults to the current directory.
- `openai_api_key_file` (Optional[str]): The filename containing the OpenAI API key. Defaults to 'key_openai.txt'.
- `aoai_api_key_file` (Optional[str]): The filename containing the Azure OpenAI API key. Defaults to 'key_aoai.txt'.
- `aoai_api_base_file` (Optional[str]): The filename containing the Azure OpenAI API base URL. Defaults to 'base_aoai.txt'.
- `exclude` (Optional[str]): Specifies the API type to exclude from the configuration, either 'openai' or 'aoai'. Defaults to None.
- `model_list` (Optional[list]): A list of model names for which to create configurations. If not provided, the function will generate configurations without model-specific information.

Code Description: The function begins by calling `config_list_openai_aoai` to generate a base list of configurations for OpenAI and Azure OpenAI API clients, based on the provided key files and excluding any specified API type. It then extends this base configuration list by cloning each configuration for each model specified in `model_list` , adding a 'model' key to each dictionary with the corresponding model name as its value. This approach allows for the creation of model-specific API call configurations in a scalable and efficient manner.

Note:

- The function relies on `config_list_openai_aoai` to generate the initial list of configurations. Ensure that the necessary API key files are correctly placed in the `key_file_path` directory and are named as specified by the parameters.
- The `model_list` parameter allows for flexibility in specifying which models to include in the generated configurations. If `model_list` is not provided, the function will return a list of configurations without model-specific information, which may not be suitable for all use cases.
- The `exclude` parameter offers the ability to exclude configurations for a specific API type ('openai' or 'aoai'), which can be useful in scenarios where only one API type is intended to be used.

Output Example: Assuming the necessary API key files are located in '/path/to/key/files' and contain valid keys for both OpenAI and Azure OpenAI, and given a `model_list` of ['gpt-4', 'gpt-3.5-turbo'], an example output could look like this:

```
[
    {'api_key': '...', 'base_url': 'https://api.openai.com', 'model': 'gpt-4'},
    {'api_key': '...', 'base_url': 'https://api.openai.com', 'model': 'gpt-3.5-turbo'},
    {'api_key': '...', 'base_url': 'https://api.azure.com', 'model': 'gpt-4', 'api_type':
    {'api_key': '...', 'base_url': 'https://api.azure.com', 'model': 'gpt-3.5-turbo', 'api
]
```

This output demonstrates how the function generates a list of configuration dictionaries, each tailored for a specific model and API type, facilitating targeted and efficient API calls across multiple models.

number represents the total token count for the messages, including the tokens for the message structure, the content, and any priming tokens required by the model.

_function num_tokens_from_functions(functions, model)

num_tokens_from_functions: The function of `num_tokens_from_functions` is to calculate the total number of tokens that a list of function descriptions would use in a specific model.

Parameters:

- `functions` : A list of dictionaries, where each dictionary represents a function description including its name, description, and optionally parameters with their properties.
- `model` : A string specifying the model name. This is optional and defaults to "gpt-3.5-turbo-0613".

Code Description: The `num_tokens_from_functions` function begins by attempting to retrieve the encoding scheme for the specified model using `tiktoken.encoding_for_model(model)` . If the model is not found, it defaults to using the "cl100k_base" encoding scheme.

For each function in the `functions` list, the function calculates the number of tokens for the function's name and description. It then checks if the function has parameters. If so, it iterates through each parameter's properties, calculating tokens for property keys and their values, which may include types, descriptions, and enums. Special handling is applied for different fields to accurately count tokens, including adjustments for encoding specifics (e.g., adding or subtracting tokens based on the presence of certain fields).

The total number of tokens for all functions is then adjusted by a fixed amount to account for encoding overhead and returned as an integer.

This function is utilized within the project to compute the initial token count for agents in `autogen/agentchat/contrib/compressible_agent.py` within the `_compute_init_token_count` method. This is particularly relevant for agents configured with a list of functions, helping to estimate the token usage based on the agent's configuration and the model in use.

Additionally, it is tested in `test/test_token_count.py` through the `test_num_tokens_from_functions` function, ensuring its accuracy and reliability in counting tokens as expected for given input functions.

Note:

- It is crucial to ensure that the `functions` parameter is correctly formatted, with each function's description containing the necessary fields for accurate token counting.
- The function gracefully handles unsupported models by defaulting to a base encoding, but it's recommended to verify model support to ensure accurate token counting.
- The function prints warnings for unsupported fields within parameters, aiding in debugging and ensuring that all relevant fields are considered for token counting.

Output Example: Assuming an input list of functions with varying descriptions and parameters, the function might return an integer like `150` . This indicates that the total number of tokens required to represent the provided function descriptions in the specified model is 150.

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_function get_config_list(api_keys, base_urls, api_type, api_version)

get_config_list: The function of `get_config_list` is to generate a list of configuration dictionaries for OpenAI API clients based on the provided API keys, base URLs, API type, and API version.

Parameters:

- `api_keys` (list): A list of API keys for making OpenAI API calls.
- `base_urls` (list, optional): A list of base URLs for the OpenAI API calls. If provided, its length should match that of `api_keys` .
- `api_type` (str, optional): The type of API for the OpenAI calls (e.g., "azure").
- `api_version` (str, optional): The version of the API for the OpenAI calls.

Code Description: The `get_config_list` function creates a list of dictionaries, where each dictionary contains the configuration for an OpenAI API client. This configuration includes the API key, and optionally, the base URL, API type, and API version. The function ensures that if `base_urls` are provided, their count matches the number of `api_keys` . It skips any API key that is an empty string and constructs each configuration dictionary based on the provided parameters. This function is integral to dynamically configuring OpenAI API clients within the project, allowing for flexibility in targeting different API endpoints or versions with varying keys.

In the context of its usage within the project, `get_config_list` is called directly in scenarios where configurations need to be generated based on explicit lists of API keys and optionally base URLs, API types, and versions. It is also utilized indirectly through the `config_list_openai_aoai` function, which prepares configurations for both OpenAI and Azure OpenAI services by reading from environment variables or files. This demonstrates the function's versatility in serving as a foundational utility for generating API client configurations in various contexts within the project.

Note:

- It is crucial to ensure that the length of `api_keys` matches the length of `base_urls` if `base_urls` are provided. An assertion error is raised if this condition is not met.
- The function filters out any empty strings in the `api_keys` list to prevent generating invalid configurations.
- The function's flexibility allows it to be used in various scenarios, including testing and dynamic client configuration.

Output Example: Suppose `api_keys` is `['key1', 'key2']` , `base_urls` is `['https://api.example.com/v1', 'https://api.example2.com/v1']` , `api_type` is `'openai'` , and `api_version` is `'v1'` . The output would be:

```
[
    {
        "api_key": "key1",
        "base_url": "https://api.example.com/v1",
        "api_type": "openai",
        "api_version": "v1"
    },
    {
        "api_key": "key2",
        "base_url": "https://api.example2.com/v1",
        "api_type": "openai",
        "api_version": "v1"
    }
]
```

Figure 9: Samples of code documentation generated by REPOAGENT for the AutoGen repository.

C Appendix: Full Prompts

C.1 A full prompt of ask_user method in AutoGPT

```
You are an AI documentation assistant, and your task is to generate documentation
based on the given code of an object. The purpose of the documentation is to help
developers and beginners understand the function and specific usage of the code.

Currently, you are in a project, and the related hierarchical structure of this
project is as follows (The current object is marked with an *):
autogpts
   autogpt
      autogpt
         commands
            user_interaction.py
               ask_user
                  *ask_user


The path of the document you need to generate in this project is:
autogpts/autogpt/autogpt/commands/user_interaction.py/ask_user.

Now you need to generate a document for a Function, whose name is "ask_user".

The content of the code is as follows:

async def ask_user(question: str, agent: Agent) -> str:
   print(f"\nQ: {question}")
   resp = await clean_input(agent.legacy_config, "A:")
   return f"The user’s answer: ’{resp}’"


As you can see, the code calls the following objects, their code and docs are as
following:

OBJ_NAME: clean_input
OBJ_PATH: autogpts/autogpt/autogpt/app/utils.py/clean_input

Document:
**Function Name**: clean_input

**Parameters**:
- `config`: An instance of the `Config` class, which holds the configuration
settings for the application.
- `prompt`: A string that represents the prompt to be displayed to the user. It
defaults to an empty string if not provided.

**Code Description**:
The `clean_input` function is an asynchronous function designed to process user
input in a chat-enabled application environment. It performs several key operations
based on the application’s configuration and the plugins that are enabled.

1. **Plugin Handling**: If chat messages are enabled in the application
configuration (`config.chat_messages_enabled`), the function iterates through each
plugin configured in the application. For each plugin, it checks if the plugin can
handle user input (`can_handle_user_input`). If so, it invokes the plugin’s
`user_input` method with the user’s prompt. Depending on the plugin’s response, the
function may return specific keys (`config.authorise_key` or `config.exit_key`) or
the plugin’s response directly.

2. **User Input Collection**: If the application is not handling the input through
plugins or if chat messages are not enabled, the function logs a debug message
indicating that it is waiting for user input via the keyboard. It then
asynchronously waits for the user’s input, ensuring that the application’s signal
handler for interrupt signals (`SIGINT`) is not overridden. This is crucial for
allowing the application to handle interrupt signals as configured elsewhere in the
application, particularly in `autogpt/main.py`.

3. **Interrupt Handling**: The function is equipped to handle a `KeyboardInterrupt`
exception, which occurs when the user attempts to interrupt the application
```

(typically by pressing Ctrl+C). In such cases, it logs a message indicating that the user has interrupted AutoGPT and that the application is quitting, and then exits the application with a status code of 0.

Note:
- The function’s ability to handle plugins dynamically allows for a flexible and extensible architecture where different plugins can be developed and integrated to process user input in various ways.
- The use of asynchronous I/O (‘await session.prompt_async‘) for collecting user input makes the function suitable for asynchronous applications, ensuring that the application remains responsive.
- Proper handling of ‘KeyboardInterrupt‘ ensures a graceful shutdown of the application when the user decides to interrupt the execution.

Output Example:
- If a plugin processes the input and responds with "yes", the function might return the value of ‘config.authorise_key‘.
- If the user inputs "Hello" and no plugins are handling the input, the function returns "Hello".
- If the user interrupts the application, no output is returned as the application exits.

[Code begin of clean_input]

~~~
```
async def clean_input(config: Config, prompt: str = ""):
   try:
      if config.chat_messages_enabled:
         for plugin in config.plugins:
            if not hasattr(plugin, "can_handle_user_input"):
               continue
            if not plugin.can_handle_user_input(user_input=prompt):
               continue
            plugin_response = plugin.user_input(user_input=prompt)
            if not plugin_response:
               continue
            if plugin_response.lower() in [
               "yes",
               "yeah",
               "y",
               "ok",
               "okay",
               "sure",
               "alright",
            ]:
               return config.authorise_key
            elif plugin_response.lower() in [
               "no",
               "nope",
               "n",
               "negative",
            ]:
               return config.exit_key
            return plugin_response

      # ask for input, default when just pressing Enter is y
      logger.debug("Asking user via keyboard...")

      # handle_sigint must be set to False, so the signal handler in the
      # autogpt/main.py could be employed properly. This referes to
      # https://github.com/Significant-Gravitas/AutoGPT/pull/4799/files/
      3966cdfd694c2a80c0333823c3bc3da090f85ed3#r1264278776
      answer = await session.prompt_async(ANSI(prompt + " "), handle_sigint=False)
      return answer
   except KeyboardInterrupt:
      logger.info("You interrupted AutoGPT")
      logger.info("Quitting...")
      exit(0)

```==========
~~~

[Code end of clean_input]

Also, the code has been called by the following objects, their code and docs are as following:

OBJ_NAME: execute_step
OBJ_PATH: autogpts/autogpt/autogpt/app/agent_protocol_server.py/
AgentProtocolServer/execute_step
Document:
None
[Code begin of execute_step]

```
   async def execute_step(self, task_id: str, step_request: StepRequestBody) ->
   Step:
      """Create a step for the task."""
      logger.debug(f"Creating a step for task with ID: {task_id}...")

      # Restore Agent instance
      task = await self.get_task(task_id)
      agent = configure_agent_with_state(
         state=self.agent_manager.retrieve_state(task_agent_id(task_id)),
         app_config=self.app_config,
         llm_provider=self._get_task_llm_provider(task),
      )

      # According to the Agent Protocol spec, the first execute_step request
      contains
      #  the same task input as the parent create_task request.
      # To prevent this from interfering with the agent’s process, we ignore the
      input
      #  of this first step request, and just generate the first step proposal.
      is_init_step = not bool(agent.event_history)
      execute_command, execute_command_args, execute_result = None, None, None
      execute_approved = False

      # HACK: only for compatibility with AGBenchmark
      if step_request.input == "y":
         step_request.input = ""

      user_input = step_request.input if not is_init_step else ""

      if (
         not is_init_step
         and agent.event_history.current_episode
         and not agent.event_history.current_episode.result
      ):
         execute_command = agent.event_history.current_episode.action.name
         execute_command_args = agent.event_history.current_episode.action.args
         execute_approved = not user_input

         logger.debug(
            f"Agent proposed command"
            f" {execute_command}({fmt_kwargs(execute_command_args)})."
            f" User input/feedback: {repr(user_input)}"
         )

      # Save step request
      step = await self.db.create_step(
         task_id=task_id,
         input=step_request,
         is_last=execute_command == finish.__name__ and execute_approved,
      )
      agent.llm_provider = self._get_task_llm_provider(task, step.step_id)

      # Execute previously proposed action
      if execute_command:
         assert execute_command_args is not None
         agent.workspace.on_write_file = lambda path: self._on_agent_write_file(
            task=task, step=step, relative_path=path
         )
         if step.is_last and execute_command == finish.__name__:
            assert execute_command_args
            step = await self.db.update_step(
               task_id=task_id,
               step_id=step.step_id,
               output=execute_command_args["reason"],
            )
            logger.info(
               f"Total LLM cost for task {task_id}: "
               f"${round(agent.llm_provider.get_incurred_cost(), 2)}"
            )
            return step

         if execute_command == ask_user.__name__: # HACK
            execute_result = ActionSuccessResult(outputs=user_input)
            agent.event_history.register_result(execute_result)
         elif not execute_command:
            execute_result = None
         elif execute_approved:
            step = await self.db.update_step(
               task_id=task_id,
               step_id=step.step_id,
               status="running",
            )
            # Execute previously proposed action
            execute_result = await agent.execute(
               command_name=execute_command,
               command_args=execute_command_args,
            )
         else:
            assert user_input
            execute_result = await agent.execute(
               command_name="human_feedback", # HACK
               command_args={},
               user_input=user_input,
            )

      # Propose next action
      try:
         next_command, next_command_args, raw_output = await agent.propose_action()
         logger.debug(f"AI output: {raw_output}")
      except Exception as e:
         step = await self.db.update_step(
            task_id=task_id,
            step_id=step.step_id,
            status="completed",
            output=f"An error occurred while proposing the next action: {e}",
         )
         return step

      # Format step output
      output = (
         (
            f"`{execute_command}({fmt_kwargs(execute_command_args)})` returned:"
            + ("\n\n" if "\n" in str(execute_result) else " ")
            + f"{execute_result}\n\n"
         )
         if execute_command_args and execute_command != ask_user.__name__
         else ""
      )
      output += f"{raw_output[’thoughts’][’speak’]}\n\n"
      output += (
         f"Next Command: {next_command}({fmt_kwargs(next_command_args)})"
         if next_command != ask_user.__name__
         else next_command_args["question"]
      )

      additional_output = {
         **(
            {
```

~~~
               "last_action": {
                  "name": execute_command,
                  "args": execute_command_args,
                  "result": (
                     orjson.loads(execute_result.json())
                     if not isinstance(execute_result, ActionErrorResult)
                     else {
                        "error": str(execute_result.error),
                        "reason": execute_result.reason,
                     }
                  ),
               },
            }
            if not is_init_step
            else {}
         ),
         **raw_output,
      }

      step = await self.db.update_step(
         task_id=task_id,
         step_id=step.step_id,
         status="completed",
         output=output,
         additional_output=additional_output,
      )

      logger.debug(
         f"Running total LLM cost for task {task_id}: "
         f"${round(agent.llm_provider.get_incurred_cost(), 3)}"
      )
      agent.state.save_to_json_file(agent.file_manager.state_file_path)
      return step

```==========
~~~

[Code end of execute_step]

Please generate a detailed explanation document for this object based on the code of the target object itself and combine it with its calling situation in the project.

Please write out the function of this Function in bold plain text, followed by a detailed analysis in plain text (including all details), in language English to serve as the documentation for this part of the code.

The standard format is as follows:

ask_user: The function of ask_user is XXX
parameters: The parameters of this Function.
- parameter1: XXX
- parameter2: XXX
- ...
Code Description: The description of this Function.
(Detailed and CERTAIN code analysis and description...None)
Note: Points to note about the use of the code
Output Example: Mock up a possible appearance of the code's return value.

Please note:
- Any part of the content you generate SHOULD NOT CONTAIN Markdown hierarchical heading and divider syntax.
- Write mainly in the desired language. If necessary, you can write with some English words in the analysis and description to enhance the document's readability because you do not need to translate the function name or variable name into the target language.

Keep in mind that your audience is document readers, so use a deterministic tone to generate precise content and don't let them know you're provided with code snippet and documents. AVOID ANY SPECULATION and inaccurate descriptions! Now, provide the documentation for the target object in English in a professional way.

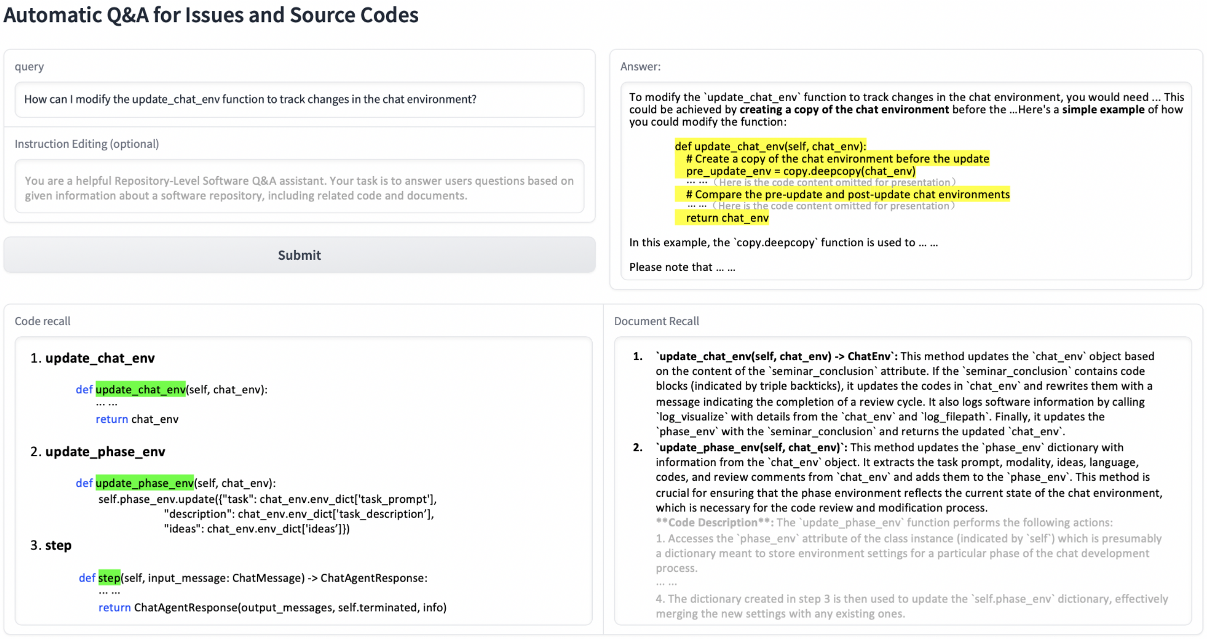
D Appendix: Chat With Repo

Moving beyond documentation generation, we are actively exploring how best to use RepoAgent and examining its potential for a broader range of downstream applications in the future. We categorize these applications as:

- README.md Generation
- Automatic Q&A for Issues and Source Codes
- Unit Test Generation
- Automated Development of New Features
- Repo Level Debugging
- Generation of Public Tutorial Documentation

We conceptualize "**Chat With Repo**" as a unified gateway for these downstream applications, acting as a connector that links RepoAgent to human users and other AI agents. Our future research will focus on adapting the interface to various downstream applications and customizing it to meet their unique characteristics and implementation requirements.

Here we demonstrate a preliminary prototype of **Automatic Q&A for Issues and Code Explanation**. A running example is shown in Figure 10. The program begins by pre-vectorizing code documentation and storing it in a vector database. When a query request is received, it is transformed into an embedding vector for fetching relevant documentation information from the database. This is followed by using the documentation's MetaInfo to locate the pertinent source code, effectively retrieving relevant sections of both documentation text and source code. Moreover, beyond embedding search, a multi-way recall mechanism has been developed, incorporating entity recognition with keyword search. This involves extracting code entities from the user's question using a LLM, and conducting searches across documentation and code repositories to match the top K returned documentation and code blocks. A weighting module has been developed for recalling the most relevant information. Additionally, we input directory tree information to help the model better understand the entire repository. The final step is to concatenate documentation and code blocks retrieved through both mechanisms, along with the target object's parent code, referencing code, and directory tree information, into a prompt for the LLM to generate answers. This sophisticated RAG-based retrieval system bridges human natural language with code language, enabling precise recall at the repository level and paving the way for downstream applications.



Automatic Q&A for Issues and Source Codes

How can I modify the update_chat_env function to track changes in the chat environment?

You are a helpful Repository-Level Software Q&A assistant. Your task is to answer users questions based on given information about a software repository, including related code and documents.

To modify the `update_chat_env` function to track changes in the chat environment, you would need ... This could be achieved by **creating a copy of the chat environment** before the ...Here's a **simple example** of how you could modify the function:

```
def update_chat_env(self, chat_env):
   # Create a copy of the chat environment before the update
   pre_update_env = copy.deepcopy(chat_env)
   ··· ··· （Here is the code content omitted for presentation）
   # Compare the pre-update and post-update chat environments
   ··· ··· （Here is the code content omitted for presentation）
   return chat_env
```

In this example, the `copy.deepcopy` function is used to ... ...

Please note that ... ...

1. **update_chat_env**

```
def update_chat_env(self, chat_env):
    ··· ···
    return chat_env
```

2. **update_phase_env**

```
def update_phase_env(self, chat_env):
    self.phase_env.update({"task": chat_env.env_dict['task_prompt'],
                           "description": chat_env.env_dict['task_description'],
                           "ideas": chat_env.env_dict['ideas']})
```

3. **step**

```
def step(self, input_message: ChatMessage) -> ChatAgentResponse:
    ··· ···
    return ChatAgentResponse(output_messages, self.terminated, info)
```

1. **`update_chat_env(self, chat_env) -> ChatEnv`:** This method updates the `chat_env` object based on the content of the `seminar_conclusion` attribute. If the `seminar_conclusion` contains code blocks (indicated by triple backticks), it updates the codes in `chat_env` and rewrites them with a message indicating the completion of a review cycle. It also logs software information by calling `log_visualize` with details from the `chat_env` and `log_filepath`. Finally, it updates the `phase_env` with the `seminar_conclusion` and returns the updated `chat_env`.
2. **`update_phase_env(self, chat_env)`:** This method updates the `phase_env` dictionary with information from the `chat_env` object. It extracts the task prompt, modality, ideas, language, codes, and review comments from `chat_env` and adds them to the `phase_env`. This method is crucial for ensuring that the phase environment reflects the current state of the chat environment, which is necessary for the code review and modification process.
   Code Description: The `update_phase_env` function performs the following actions:
   1. Accesses the `phase_env` attribute of the class instance (indicated by `self`) which is presumably a dictionary meant to store environment settings for a particular phase of the chat development process.
   ... ...
   4. The dictionary created in step 3 is then used to update the `self.phase_env` dictionary, effectively merging the new settings with any existing ones.

Figure 10: Demonstration of Automatic Q&A for Issues and Code Explanation by the "Chat With Repo" interface.

A real world “Chat With Repo” example with input and output is shown as follows.

Query

````
How would you modify the update\_chat\_env function to track changes in the chat
environment?
````

Answer

~~~
To modify the `update_chat_env` function to track changes in the chat environment,
you would need to add a mechanism to store the state of the chat environment before
and after the update. This could be achieved by creating a copy of the chat
environment before the update and comparing it with the state of the chat
environment after the update. Here’s a simple example of how you could modify the
function:

```python
def update_chat_env(self, chat_env):
   # Create a copy of the chat environment before the update
   pre_update_env = copy.deepcopy(chat_env)

   # Update the chat environment as per your requirements
   # This is where you would add your update logic

   # Compare the pre-update and post-update chat environments
   if pre_update_env != chat_env:
      print("Chat environment has been updated.")
   else:
      print("Chat environment has not been changed.")

   return chat_env
```

In this example, the `copy.deepcopy` function is used to create a deep copy of the
`chat_env` object. This ensures that changes to the `chat_env` object after the
copy do not affect the `pre_update_env` object. After the update, the
`pre_update_env` and `chat_env` objects are compared. If they are not equal, this
means that the chat environment has been updated.

Please note that this is a simple example and the actual implementation may vary
depending on the specific requirements of your project. For instance, you might
want to log the changes in a file instead of printing them, or you might want to
use a more sophisticated method for comparing the chat environments.
~~~

Embedding Recall

````
1.
**Function Name**: `update_phase_env`

**Function of update_phase_env**: The function `update_phase_env` is designed to
update the environment settings of a particular phase in a chat development context
by incorporating various elements from a given chat environment object.

**Parameters**: The parameters of this function include:
- `self`: Represents the instance of the class where the `update_phase_env`
function resides. It allows the function to access the attributes and methods of
the class instance.
- `chat_env`: An object that contains the environment settings for the chat. It is
expected to have an attribute `env_dict` which is a dictionary containing keys such
as ’task_prompt’, ’modality’, ’ideas’, and ’language’. Additionally, `chat_env`
should have methods `get_codes` and `get_requirements` that return specific
information related to codes and requirements.

**Code Description**: The `update_phase_env` function performs the following
actions:
````

1. Accesses the ‘phase_env‘ attribute of the class instance (indicated by ‘self‘) which is presumably a dictionary meant to store environment settings for a particular phase of the chat development process.
2. Calls the ‘update‘ method on ‘self.phase_env‘ to modify its contents.
3. Constructs a new dictionary with the following keys and values:
   - ‘"task"‘: Set to the value associated with the ‘’task_prompt’‘ key in the ‘chat_env.env_dict‘ dictionary.
   - ‘"modality"‘: Set to the value associated with the ‘’modality’‘ key in the ‘chat_env.env_dict‘ dictionary.
   - ‘"ideas"‘: Set to the value associated with the ‘’ideas’‘ key in the ‘chat_env.env_dict‘ dictionary.
   - ‘"language"‘: Set to the value associated with the ‘’language’‘ key in the ‘chat_env.env_dict‘ dictionary.
   - ‘"codes"‘: Obtained by calling the ‘get_codes‘ method on the ‘chat_env‘ object.
   - ‘"requirements"‘: Obtained by calling the ‘get_requirements‘ method on the ‘chat_env‘ object.
4. The dictionary created in step 3 is then used to update the ‘self.phase_env‘ dictionary, effectively merging the new settings with any existing ones.

Note: When using the ‘update_phase_env‘ function, it is important to ensure that the ‘chat_env‘ object passed as a parameter is properly initialized and contains all the necessary attributes and methods. The ‘env_dict‘ attribute must include the keys ’task_prompt’, ’modality’, ’ideas’, and ’language’, and the object must have the ‘get_codes‘ and ‘get_requirements‘ methods implemented. Failure to meet these conditions may result in a ‘KeyError‘ or ‘AttributeError‘. Additionally, this function mutates the state of the ‘self.phase_env‘ dictionary, so any changes made will persist in the instance of the class where this function is called.
2.
CodeReviewModification: The function of the ‘CodeReviewModification‘ class is to manage the phase of code review modifications within a chat development environment. It inherits from a base ‘Phase‘ class and is designed to update the environment with information relevant to the code review and modification process.

Attributes: The attributes of this Class are inherited from the ‘Phase‘ class and any that are added or modified within this class.
- ‘phase_env‘: A dictionary attribute inherited from ‘Phase‘ that stores environment variables relevant to the current phase.
- ‘seminar_conclusion‘: Although not explicitly defined in the provided code, it is implied that this attribute is used to store the conclusion of a seminar or review session.

Code Description: The ‘CodeReviewModification‘ class contains two main methods:

1. ‘update_phase_env(self, chat_env)‘: This method updates the ‘phase_env‘ dictionary with information from the ‘chat_env‘ object. It extracts the task prompt, modality, ideas, language, codes, and review comments from ‘chat_env‘ and adds them to the ‘phase_env‘. This method is crucial for ensuring that the phase environment reflects the current state of the chat environment, which is necessary for the code review and modification process.

2. ‘update_chat_env(self, chat_env) -> ChatEnv‘: This method updates the ‘chat_env‘ object based on the content of the ‘seminar_conclusion‘ attribute. If the ‘seminar_conclusion‘ contains code blocks (indicated by triple backticks), it updates the codes in ‘chat_env‘ and rewrites them with a message indicating the completion of a review cycle. It also logs software information by calling ‘log_visualize‘ with details from the ‘chat_env‘ and ‘log_filepath‘. Finally, it updates the ‘phase_env‘ with the ‘seminar_conclusion‘ and returns the updated ‘chat_env‘.

Note: Points to note about the use of the code:
- The ‘chat_env‘ parameter is expected to be an object that contains an ‘env_dict‘ with keys such as ’task_prompt’, ’modality’, ’ideas’, ’language’, and ’review_comments’, as well as methods like ‘get_codes()‘ and ‘update_codes()‘.
- The ‘seminar_conclusion‘ attribute must be set before calling ‘update_chat_env‘ as it uses this attribute to update the ‘chat_env‘.
- The ‘log_visualize‘ function and ‘get_info‘ function are not defined within the provided code snippet, so they should be implemented elsewhere in the project or imported from a module.
- The ‘ChatEnv‘ return type suggests that there is a ‘ChatEnv‘ class defined elsewhere in the project, which should be used in conjunction with this class.

Output Example: Since the methods do not produce a direct output but rather update the state of objects, there is no typical output example. However, after executing the methods, one could expect the ‘phase_env‘ and ‘chat_env‘ objects to have updated information reflecting the current state of the code review and modification phase.
3.
chatting: The function of ‘chatting‘ is to conduct a simulated chat session between two roles within a software development environment, with the goal of reaching a conclusion on a specific phase of the project.

Parameters:
- ‘chat_env‘: The global chat environment which contains configurations and context for the chat session.
- ‘task_prompt‘: A string representing the user’s query or task that needs to be addressed during the chat.
- ‘assistant_role_name‘: The name of the role assumed by the assistant in the chat.
- ‘user_role_name‘: The name of the role assumed by the user initiating the chat.
- ‘phase_prompt‘: A string containing the prompt for the current phase of the chat.
- ‘phase_name‘: The name of the current phase of the chat.
- ‘assistant_role_prompt‘: The prompt associated with the assistant’s role.
- ‘user_role_prompt‘: The prompt associated with the user’s role.
- ‘task_type‘: An enumeration value representing the type of task being simulated in the chat.
- ‘need_reflect‘: A boolean indicating whether the chat session requires reflection to generate a conclusion.
- ‘with_task_specify‘: A boolean indicating whether the task needs to be specified within the chat.
- ‘model_type‘: An enumeration value indicating the type of language model to be used for generating responses.
- ‘placeholders‘: A dictionary containing placeholders that can be used to fill in the phase environment for generating the phase prompt.
- ‘chat_turn_limit‘: An integer representing the maximum number of turns the chat session can have.

Code Description:
The ‘chatting‘ function starts by ensuring that the ‘placeholders‘ argument is not ‘None‘ and that the ‘chat_turn_limit‘ is within an acceptable range (1 to 100). It then checks if the roles specified by ‘assistant_role_name‘ and ‘user_role_name‘ exist within the ‘chat_env‘.

A ‘RolePlaying‘ session is initialized with the provided role names, prompts, task type, and model type. The function then begins the chat session by initializing the first user message using the ‘init_chat‘ method of the ‘RolePlaying‘ session.

The chat session proceeds in turns, where each turn consists of the user sending a message to the assistant and the assistant responding. The messages and responses are generated by interacting with a language model (LLM). The conversation is logged using a ‘log_visualize‘ function, which is not defined within the provided code snippet.

During the chat, the function looks for a special ‘<INFO>‘ marker in the conversation, which indicates a significant conclusion has been reached. If such a conclusion is found, or if the chat is terminated, the loop ends.

If the ‘need_reflect‘ flag is set, the function may call ‘self_reflection‘ to generate a conclusion if one has not been reached during the chat session. The reflection is based on the entire conversation history and the context of the phase.

Finally, the function logs the seminar conclusion, extracts the relevant part after the ‘<INFO>‘ marker, and returns it as the result of the chat session.

Note:
- The function assumes that the ‘chat_env‘ has methods ‘exist_employee‘ to check for the existence of roles.
- The ‘RolePlaying‘ class is used to simulate the chat session and is expected to have methods like ‘init_chat‘ and ‘step‘.
- The ‘log_visualize‘ function is used for logging purposes but is not defined within the provided code snippet.

- The function raises a `ValueError` if the specified roles are not found within the `chat_env`.
- The `self_reflection` method is used for generating reflections and is assumed to be a member of the same class.

Output Example:
If the chat session concludes with a marked conclusion, the function might return something like:
```
"PowerPoint is the best choice for our presentation needs."
```
If the chat session does not reach a marked conclusion but requires reflection, the `self_reflection` method might return:
```
"Yes"
```
In cases where the chat is terminated without a marked conclusion and no reflection is needed, the last message from the assistant might be returned as is.
4.
Function Name: execute

Purpose: The function `execute` is designed to handle a phase of a chat development environment by updating the environment, checking for module not found errors, resolving them if present, and conducting a chat session if no such errors are found.

Parameters:
- `chat_env`: An instance of `ChatEnv`, which represents the current chat environment.
- `chat_turn_limit`: An integer indicating the maximum number of turns allowed in the chat session.
- `need_reflect`: A boolean indicating whether reflection is needed in the chat session.

Code Description:
The `execute` function begins by updating the phase environment with the current `chat_env`. It then checks if there is a "ModuleNotFoundError" in the `test_reports` of the `phase_env`. If such an error is present, it attempts to fix the error by calling `chat_env.fix_module_not_found_error` and logs the error for visualization.

The function then uses a regular expression to find all instances of the error message indicating a missing module and constructs a string `pip_install_content` that contains the commands to install the missing modules using `pip`. This string is also logged for visualization.

If no "ModuleNotFoundError" is found, the function proceeds to conduct a chat session by calling the `chatting` method with various parameters such as `chat_env`, `task_prompt`, `need_reflect`, role names, prompts, `chat_turn_limit`, and placeholders. The result of this chat session is stored in `self.seminar_conclusion`.

After handling the error or conducting the chat session, the function updates the chat environment with the potentially modified `chat_env` and returns it.

Note:
- The function assumes that the `chat_env` object has the methods `fix_module_not_found_error` and `update_chat_env` implemented.
- The `chatting` method is also assumed to be implemented and is responsible for conducting the chat session.
- The function uses regular expressions to parse error messages, so it is important that the error messages follow the expected format for the regular expressions to work correctly.
- The function logs actions for visualization, which implies that a logging mechanism should be in place for the output to be meaningful.

Output Example:
A possible appearance of the code's return value could be an updated `ChatEnv` object with modifications based on the error handling and chat session conducted within the `execute` function. The object would reflect the new state of the chat

```
environment after the execution of this function.
```

Key Words Recall

````
Key words:
modify, update_chat_env, track

Code:
[’\n```python\n def update_chat_env(self, chat_env):\n return chat_env\n\n```’]
````

Code Recall

```
def update_chat_env(self, chat_env) -> ChatEnv:
   chat_env._update_requirements(self.seminar_conclusion)
   chat_env.rewrite_requirements()
   log_visualize(
      "**[Software Info]**:\n\n {}".format(get_info(chat_env.env_dict[’directory’],
      self.log_filepath)))
   return chat_env

def update_chat_env(self, chat_env) -> ChatEnv:
   chat_env.update_codes(self.seminar_conclusion)
   if len(chat_env.codes.codebooks.keys()) == 0:
      raise ValueError("No Valid Codes.")
   chat_env.rewrite_codes("Code Complete #" + str(self.phase_env["cycle_index"]) +
   " Finished")
   log_visualize(
      "**[Software Info]**:\n\n {}".format(get_info(chat_env.env_dict[’directory’],
      self.log_filepath)))
   return chat_env
```