# LEARN-BY-INTERACT: A DATA-CENTRIC FRAME-WORK FOR SELF-ADAPTIVE AGENTS IN REALISTIC ENVIRONMENTS

Hongjin Su<sup>12</sup>, Ruoxi Sun<sup>1</sup>, Jinsung Yoon<sup>1</sup>, Pengcheng Yin<sup>1</sup>, Tao Yu<sup>2</sup>, Sercan Ö. Arık<sup>1</sup> <sup>1</sup> Google, <sup>2</sup> The University of Hong Kong

#### ABSTRACT

Autonomous agents powered by large language models (LLMs) have the potential to enhance human capabilities, assisting with digital tasks from sending emails to performing data analysis. The abilities of existing LLMs at such tasks are often hindered by the lack of high-quality agent data from the corresponding environments they interact with. We propose LEARN-BY-INTERACT, a data-centric framework to adapt LLM agents to any given environments without human annotations. LEARN-BY-INTERACT synthesizes trajectories of agent-environment interactions based on documentations, and constructs instructions by summarizing or abstracting the interaction histories, a process called backward construction. We assess the quality of our synthetic data by using them in both training-based scenarios and training-free in-context learning (ICL), where we craft innovative retrieval approaches optimized for agents. Extensive experiments on SWE-bench, WebArena, OSWorld and Spider2-V spanning across realistic coding, web, and desktop environments show the effectiveness of LEARN-BY-INTERACT in various downstream agentic tasks — baseline results are improved by up to 11.1% for ICL with Claude-3.5 and 23.1% for training with Codestral-22B. We further demonstrate the critical role of backward construction, which provides up to 10.6% improvement for training. Our ablation studies demonstrate the efficiency provided by our synthesized data in ICL and the superiority of our retrieval pipeline over alternative approaches like conventional retrieval-augmented generation (RAG). We expect that LEARN-BY-INTERACT will serve as a foundation for agent data synthesis as LLMs are increasingly deployed at real-world environments.

#### **1** INTRODUCTION

Pre-trained large language models (LLMs) offer great potential for assisting humans with various tasks in digital settings, such as editing images, performing data analysis, resolving software engineering issues, and navigating commercial platforms (Xie et al., 2023; 2024; Yao et al., 2022a; Jimenez et al., 2023). By streamlining these, LLM agents can greatly enhance human efficiency and productivity, allowing individuals to shift their focus toward higher-level, creative, and strategic endeavors. To explore this potential, many benchmarks (Jimenez et al., 2023; Zhou et al., 2023b; Xie et al., 2024; Cao et al., 2024; Koh et al., 2024) and agentic frameworks (Yang et al., 2024; Zhan & Zhang, 2023; Yang et al., 2023; Gur et al., 2023; Chen et al., 2024a) have been established based on realistic digital environments, spanning web applications, code development, desktop computing, etc. However, current LLMs often fall short of expected performance in these tasks, consistently displaying a significant gap compared to human capabilities. As a result, they remain less practical and reliable for real-world applications.

Efficient adaptation to new environments can be the key part of the performance improvements. Prior works have explored various prompt-based approaches (Yao et al., 2022b; Yang et al., 2024; Gur et al., 2023; Zhan & Zhang, 2023), that are constrained by the capabilities of underlying foundation models. Other studies on training LLMs with human-labeled examples (Chen et al., 2023; 2024b; Li et al., 2020) on the other hand, come with the fundamental limitation of high annotation costs when new environments are considered. In particular, annotating agentic data can be quite



Figure 1: Overview of the data synthesis and adaptation processes. Given an environment and standard resources, we first leverage self-instruct to create a diverse set of instructions. LLMs are then employed to complete these tasks, resulting in long trajectories of agent-environment interactions. We construct task instructions using LLMs for each sub-trajectory, a process called *backward construction*. The synthesized data are then filtered and used for both training and in-context learning, where we design agentic retrieval to retrieve demonstration examples based on information at each step, using both model-based and observation-based approaches. See Appendix F for the complete data synthesis example and Algorithm 2 for more details on agentic retrieval.

difficult and expensive due to long-trajectory interactions with environments and specific domain expertise required. Few works have explored fully-autonomous data construction pipelines towards self-adaptive agents that can efficiently learn new environments (Gulcehre et al., 2023; Aksitov et al., 2023).

In this paper, we introduce LEARN-BY-INTERACT, a data-centric framework for LLMs to self-adapt to new environments, utilizing agent data synthesis via interactions. Intuitively, the effects of actions executed in environments (e.g., the next webpage after clicking a button) serve as informative demonstrations that help LLMs in future navigation. Inspired by this, we design LEARN-BY-INTERACT that first uses self-instruct (Wang et al., 2022b) to develop a variety of task instructions, referring to standard resources such as documentations and tutorials for a given environment. This covers most important scenarios that human users are interested in and avoids intensive prompt engineering to control the distribution and diversity of the generated data. We then collect diverse trajectories from interactions between LLMs and environments, as illustrated in Fig. 1. However, given the low performance of LLMs in existing agentic benchmarks (Xie et al., 2024; Cao et al., 2024), it is likely that a large percentage of synthesized trajectories do not match with the instructions. To tackle this challenge, we construct new instructions by summarizing or abstracting each sub-trajectory, leveraging the strong summarization capabilities of LLMs (Pu et al., 2023; Liu et al., 2023). We call this process backward construction. After obtaining synthesized instruction-trajectory pairs and filtering low-quality ones, we apply it to both training and ICL, where we craft innovative retrieval pipelines optimized for agents. Concretely, it consists of two parts: (1). model-based approach that leverages LLMs to first write queries based on instructions, interaction histories and current observations, and uses retrieval models to retrieve demonstration examples from synthesized data; (2). observation-based approach that finds examples with the current observation appearing in trajectories (which indicates that the current state has been encountered in the data synthesis process).

Our comprehensive evaluations across four challenging benchmarks: SWE-bench (Jimenez et al., 2023), WebArena (Zhou et al., 2023b), OSWorld (Xie et al., 2024), and Spider2-V (Cao et al., 2024), highlight the efficacy of the data generated by LEARN-BY-INTERACT. With ICL, both Gemini-1.5-pro (Reid et al., 2024) and Claude-3.5-sonnet (Anthropic, 2024) show consistent and remarkable improvements – for OSWorld (Xie et al., 2024), our generated data nearly doubles Claude-3.5-sonnet's baseline performance, increasing it from 11.4% to 22.5%. Furthermore, substantial improvements are observed by training models of varying sizes and architectures with our synthesized data. As an example, Codestral-22B's (Team, 2024b) performance in WebArena significantly increases from

4.7% to 27.8% after training. These results underscore the high quality of our generated agent data and its broad applicability across diverse agent environments.

Our extensive ablation studies reveal that backward construction not only increases the quantity of the synthesized data, but also improves its overall quality (§3.5). With data synthesized by LEARN-BY-INTERACT, we observe significant improvements in both performance and efficiency during LLM inference (§4.1). Our empirical results demonstrate the superiority of the agentic retrieval in ICL (§4.2). We anticipate that this research will spark innovative developments in enhancing agent performance using LLMs and contribute to its wider-spread adoption in real-world application scenarios.

#### 2 LEARN-BY-INTERACT

We introduce the LEARN-BY-INTERACT pipeline to synthesize agent data in an autonomous way by leveraging interactions between LLMs and environments. We first formalize the agent canonical task (§2.1), and introduce the detailed synthesis (§2.2) and filtering (§2.3) procedures. We then describe the application of the synthesized data in adapting LLMs in both training-free and training-based settings (§2.4).

#### 2.1 TASK FORMULATION

Given an environment E and a task instruction I, the objective of an agent A is to achieve the target G through multi-step interactions with E. At each step i, A predicts the next action  $a_i$  based on the instruction I and the previous history  $H = (o_0, a_1, o_1, a_2, ..., o_{i-1})$ , which is then executed in the environment E to get a new observation  $o_i$ . The interactions terminated until A predicts the action stop or the maximum number of steps m is reached.

#### 2.2 AGENTIC DATA SYNTHESIS

The essential idea of LEARN-BY-INTERACT is manifested in synthesizing environmentspecific agent data with zero human effort. In Algorithm 1, we show the overall process with pseudo-code. Given an environment for a downstream application (such as visual studio code), we first leverage commonlyaccessible resources like documentation to generate diverse task instructions using selfinstruct (Wang et al., 2022b) (line 5). These resources are usually created by human experts to address common concerns and provide usage suggestions, e.g., how to navigate a website or operate a software. Intuitively, such references often cover representative usecases of an application. Therefore the task instructions generated conditioned on them could cover most popular scenarios in the domain and avoids potentially unreasonable cases that may be of less value.

For each generated task, LLMs then aim to solve it, which results in a long trajectory  $T = (o_0, a_1, o_1, ..., a_n, o_n)$  (line 9-14 in Algorithm 1). To address the potential misalignment between the instruction *I* and the generated trajectories *T*, we introduce a novel mechanism, backward construction, to construct instructions based on trajectories (line 15-22 in Algorithm 1). Specifically, for each sub-trajectory

#### Algorithm 1 Agent data synthesis

- 1: **Input:** *LLM*: Large Language Model; *E*: environment; *Doc*: standard resources like documentation; *N*: the number of instructions to generate per document; *F*: data filter.
- 2: Initialization: D = []: synthesized data.

```
3: for d in Doc do
```

8:

9:

10:

11:

12:

13:

14:

15:

16:

17:

18:

19:

20:

21.

22:

- 4: // self-instruct to generate N task instructions
- 5: Instructions = LLM(d, N)
- 6: **for** *I* in *Instructions* **do**
- 7: E.reset()
  - $T = [] \quad // \text{ initialize interaction trajectory} \\ \textbf{while not } E.finished() \textbf{ do} \\ o = E.get_observation() \\ a = LLM(I, T, o) \\ T += [o, a] \end{cases}$

```
end while
T.append(E.get_observation())
```

```
// backward construction
```

```
for i in range(0, len(T) - 1, 2) do
```

```
for j in range(i + 2, len(T), 2) do

T' = T[i : j]
```

```
I' = LLM(T')
D.append([I', T'])
```

```
end for
end for
```

```
23: end for
```

```
24: end for
```

```
25: D = F(D) // Filter low-quality data
```

```
26: Return: D
```

 $T' = (o_i, a_{i+1}, o_{i+1}, \dots, a_i, o_i), 0 \le i < j \le n$ , we obtain two types of new instructions: (1). summarizations of trajectory steps; (2). abstractions of the trajectory purpose. In Fig. 1, the subtrajectory (Obs1, Act2, Obs2) is summarized into a new task instruction that requires to replicate the Act2. The abstraction of the full trajectory updates the original task objective, which is no longer aligned with the generated trajectory due to the wrong prediction in the action 3. Overall, the LEARN-BY-INTERACT pipeline offers two notable advantages:

- It corrects the potential misalignment between instructions and predicted trajectories by updating task objectives, which enhances the data quality as verified by the experimental results in §3.5.
- It maximizes the utility of each generated trajectory by crafting new instructions for each subtrajectory. This results in a quadratic increase in the number of synthesized examples with respect to the steps in the sequence per generated trajectory. For a given target dataset size, backward construction substantially decreases the necessary interactions, which is particularly valuable in scenarios where such interactions are challenging and costly to obtain such as Robotics (Keipour, 2022).

#### 2.3 FILTERING

To further enhance the data quality, we design the following criteria to filter inferior synthesized data: (1). Remove duplicate states: We remove duplicate  $(a_i, o_i)$  from T' if  $(a_i, o_i) = (a_{i-1}, o_{i-1})$ , which is potentially introduced by the invalid action or the environment error (inactivity). (2). LLM committee check: We feed the generated instruction-trajectory pair (I', T') into a committee of LLMs, and only classify it of high-quality if all LLMs consider the trajectory coherent, natural, reasonable and aligned with the instruction. The listed criteria are all fully-autonomous and canonically-applicable for filtering data synthesized in general agent scenarios. See Table 35 for our prompts used in LLM committee check.

#### 2.4 Adaptation

After obtaining the synthesized data D, we apply it to both ICL and training. Given the unique characteristics of multi-round interactions with environments in agent settings, we design agentic retrieval (pseudo-code in Algorithm 2) to maximize the effectiveness of the synthesized data. Specifically, we propose two retrieval pipelines: observation-based (line 5-14) and model-based retrieval (line 15-17). In observation-based retrieval, we compare the current observation o to the trajectory of each example e in the synthesized data, where e = $[I', [o_0, a_1, o_1, ..., a_n, o_n]]$ . If o matches one of the observations in e, i.e.,  $o = o_i$ , then we consider e as a helpful example to the current task. For the model-based retrieval, we leverage LLMs to first write queries based on the instruction, the interaction history and the current observation (line 16), and then employ retrieval models to retrieve non-duplicate examples (line 17). LLMs are then augmented with the retrieved examples to predict the next action (line 18). Refer to Table 36 to 39 for prompts to write queries and predict actions.

Apart from using the synthesized data as demonstration examples in ICL, we further uti-

#### Algorithm 2 ICL with agentic retrieval

- 1: Input: LLM: Large Language Model; E: environment; D: synthesized data; RM: retriever; I: task instruction; m1: maximum number of examples from observation-based retrieval; m2: maximum number of examples from model-based retrieval.
- 2: Initialization: H = []: interaction history; R: retrieved examples.
- 3: while not *E*.finished() do
- 4:  $o = E.get_observation()$ 5:
  - // observation-based retrieval
- for i, t in D do 6: 7:
  - // iterate through the trajectory
  - for  $o_1$  in t do

```
if o_1 = o then
```

```
R.append([i, t])
end if
```

```
end for
```

```
13:
        end for
```

8:

9:

10:

11:

12:

```
14:
       R = R[:m1]
```

- // model-based retrieval 15:
- 16: q = LLM(I, H, o)
- R + = RM(q, D, m2, R)17:
- a = LLM(I, H, o, R)18.
- H + = [o, a]19:
- 20: end while

lize them to fine-tune models. For a given generated example, we convert it to the format of action prediction (Table 36), and prepare input-output pairs for supervised fine-tuning. More details on the experimental settings can be found in §3.3.

	SWE-bench	WebArena	OSWorld	Spider2-V
Documents	6,464	3,578	7,362	11,231
Raw trajectories	19,392	10,734	22,086	33,693
Examples	180,752	185,635	437,635	652,786
Filtered examples	101,523	109,276	103,526	125,683

Table 1: Statistics for the number of crawled documents, generated raw trajectories, examples (instruction-trajectory pairs) and examples after filtering.

## 3 EXPERIMENTS

#### 3.1 BASELINES

We compare ICL with agentic retrieval to the following prompt-based approaches.

- Baseline: The vanilla prediction pipeline in each benchmark that includes the task instruction, interaction history and the state observation in the prompt. See more implementation details in Appendix A.
- RAG: The conventional RAG pipeline that first retrieves from the resources like documentation based on the instruction, and augments LLMs with the retrieved content.
- Data distill: We follow the same pipeline to synthesize data in Algorithm 1 except backward construction (replace line 15-22 with D.append(I,T)), and follow Algorithm 2 during the evaluation.
- Reflexion (Shinn et al., 2024): A general framework to reinforce language agents through linguistic feedback from both executors and LLMs.
- Language Agent Tree Search (LATS) (Zhou et al., 2023a): It integrates the combinatorial tree search into expanding ReAct (Yao et al., 2022b) and combine agent online reasoning, acting and planning throughout the trajectory.

For the training-based evaluation, we primarily compare to the data distillation, which also constructs data from scratch and requires no human effort to annotate seed or preference data. Additionally, we include the model performance before training as another baseline.

## 3.2 DATASETS

We consider 4 agent datasets that involve multi-round interactions with realistic environments. They span diverse domains of code, web, computer desktop and professional software. Appendix C illustrates details of each dataset with examples.

- SWE-bench (Jimenez et al., 2023) is an evaluation benchmark on realistic software engineering problems from realistic Github issues. We use the Lite version by default throughout the experiments.
- Webarena (Zhou et al., 2023b) evaluates agent capabilities to perform tasks in the web environments such as e-commerce, social forum discussion, and beyond.
- OSWorld (Xie et al., 2024) is an integrated environment for assessing open-ended computer tasks, which involve diverse applications like terminal, chrome, etc.
- Spider2-V (Cao et al., 2024) is a multimodal agent benchmark focusing on professional data science and engineering workflows, which includes BigQuery, Airbyte and more.

## 3.3 SETTINGS

We synthesize one separate set of environment-specific data for each evaluated benchmark. Throughout the data synthesis process, we employ the Claude-3.5-sonnet (Anthropic, 2024) as the generator model and both Gemini-1.5-pro (Reid et al., 2024) and Claude-3.5-sonnet as the LLM committee for filtering low-quality data. For each document, we sample three task instructions from

$Benchmark \rightarrow$	SWE	Web	OS	Spider2-V	SWE	Web	OS	Spider2-V
Approach $\downarrow$		Gem	ini-1.5-j	pro		Claud	e-3.5-soi	nnet
				Existing	approacl	hes		
Baseline	13.3	17.9	4.9	8.3	26.7	31.5	11.4	7.5
RAG	13.7	19.5	5.1	9.1	27.0	31.8	11.7	7.7
Data distill	14.0	19.8	5.7	9.1	28.0	32.1	11.9	8.5
Reflexion	14.3	20.2	5.7	9.3	28.3	32.4	12.2	8.9
LATS	15.3	21.0	6.5	11.3	29.0	34.2	13.6	10.3
	Ours							
Learn-by-interact $\Delta$ over baseline	<b>18.7</b> +5.4	<b>25.6</b> +7.7	<b>10.3</b> +5.4	<b>16.4</b> +8.1	<b>34.7</b> +8.0	<b>39.2</b> +7.7	<b>22.5</b> +11.1	<b>16.3</b> +8.8

Table 2: Comparison of LEARN-BY-INTERACT to other existing training-free approaches. S	SWE
refers to SWE-bench, Web refers to WebArena and OS refers to OSWorld. The best result	s are
highlighted in bold. We include more leaderboard results of SWE-bench and WebArena in Tab	ole 6.

LLMs. The statistics for generated raw trajectories, examples before and after filtering are shown in Table 1. In Appendix E, we list document sources used for each benchmark. During ICL, we retrieve examples until the maximum length of LLMs and set an upper bound of 5 for both modelbased and observation-based retrieval (m1 = 5, m2 = 5 in Algorithm 2). We leverage Gemini-1.5pro (Reid et al., 2024) and Claude-3.5-sonnet (Anthropic, 2024)<sup>1</sup>, Codegemma-7B (Team, 2024a) and Codestral-22B (Team, 2024b) in the ICL evaluation, and tune Codegemma-7B and Codestral-22B with LoRA (Hu et al., 2021) to evaluate the data quality as training sources. By default, we do not include retrieval content in evaluating the trained model to avoid the confusion in understanding the effectiveness of our synthesized data in training. We include more detailed hyperparameter settings (both existing approaches and LEARN-BY-INTERACT) and machine information in Appendix D.

#### 3.4 EVALUATION

We follow the default evaluation metrics designed by the original benchmarks. In SWEbench (Jimenez et al., 2023), we apply the generated patch program to the repository codebase, and measure the agent performance by execution accuracy (pass@1). In WebArena (Zhou et al., 2023b), we employ both LLM-based fuzzy match and string match that checks keywords in predictions. Slightly different from the original work that uses gpt-4-0613 as the LLM judge, we use Claude-3.5-sonnet as a similar replacement. In OSWorld (Xie et al., 2024), we leverage the sample-specific evaluation scripts to assess the functional correctness of the task completion, which processes environment states and checks if agents finish the task as expected. In Spider2-V (Cao et al., 2024), we utilize file-based comparison, information-based validation, execution-based verification to determine whether a task is successfully completed. All performance numbers throughout the paper are shown in the percentage of resolved instances with % omitted for brevity.

## 3.5 RESULTS

## 3.5.1 TRAINING-FREE EVALUATION

We first consider LEARN-BY-INTERACT in the training-free setting, where the proposed methods can be applied to the commercial LLMs even with prediction-only API access.

Results on Table 2 show marginal improvement of RAG compared to the baseline, which suggests limited effectiveness by simply concatenating standard reousrces to LLM prompts. By retrieving examples from distilled data, we observe better performance compared to RAG, but still no more than 2% improvement over the baseline, which indicates that the distilled data tend to be noisy in the setting with multi-round agent-environment interactions. This highlights the critical role of

<sup>&</sup>lt;sup>1</sup>In the subsequent descriptions, Gemini refers to Gemini-1.5-pro, and Claude refers to Claude-3.5-sonnet.

Table 3: Downstream task performance of models trained from data generated by Learning-by-
interact and data distillation. We include the models results before training, where the synthesized
data is used as demonstration examples, and after training, where the synthesized data is used to
train models.

$Benchmark \rightarrow$	Web	OS	Web	OS	Web	OS	Web	OS
$Model \to$	Codege	mma-7E		ral-22B	Codege	mma-7B	Codesti	al-22B
Approach $\downarrow$		Befor	e tuning		After tuning			
		<i>Existing approaches</i>						
Baseline	3.3	0.0	4.7	2.2	-	-	-	-
Data distill	4.2	0.0	5.8	2.7	6.2	1.4	10.2	5.4
	Ours							
Learn-by-interact $\Delta$ over baseline	t 7.6 +4.3	3.5 +3.5	9.9 +5.2	5.4 +3.2	17.9 +14.5	6.5 +6.5	27.8 +23.1	11.7 +9.5

backward construction, which corrects the misalignment between instructions and trajectories by curating new task objectives.

Both Reflexion and LATS consistently improve over the baseline across 4 benchmarks, which demonstrate their general applicability to agent tasks. Using the data synthesized from the LEARN-BY-INTERACT, we can see a significant performance gain compared to all other frameworks in both Gemini and Claude. For example, in OSWorld, augmenting Claude with synthesized environment-specific data almost doubles the result compared to the baseline. This signifies the high quality of the generated data and the effectiveness of the LEARN-BY-INTERACT framework.

#### 3.5.2 TRAINING-BASED EVALUATION

We consider the data synthesized by LEARN-BY-INTERACT in the scenario of LLM tuning, which is applicable to the LLMs with access to weight updates.

The results presented in Table 3 reveal that LEARN-BY-INTERACT substantially surpasses both the baseline and data distillation, suggesting its capacity to generate high-quality training data that enables language models to learn and adapt efficiently. We discover that utilizing our synthesized data for model training yields better results compared to using it as in-context learning (ICL) examples. A notable instance is in WebArena, where Codestral-22B's performance jumps from 4.7% to 27.8% when trained on our synthesized data, while only showing a 5.2% improvement in the ICL scenario. Remarkably, the Codestral-22B model trained with our synthesized data even outperforms Gemini when the latter uses our data as demonstration examples.

## 4 ANALYSIS

#### 4.1 INFERENCE EFFICIENCY

We compare the efficiency of different pipelines at inference. We analyze the trade-off between downstream task performance and the required computational costs. We focus on measuring the number of LLM calls and consumed tokens per example, which are averaged across four evaluated datasets (§3.2) using Claude-3.5-sonnet. As illustrated in Fig. 2, while Reflexion and LATS demonstrate enhanced performance, this comes at the cost of significantly increased computational resources during inference. Specifically, LATS yields a 2.5% improvement on average, but requires nearly four times used tokens per instance relative to the baseline. In contrast, LEARN-BY-INTERACT exhibits superior performance while utilizing fewer LLM calls and slightly more tokens compared to the baseline. Thanks to the rich environment information stored in the examples of synthesized data, LLMs can potentially make better decisions and thus finish the task in fewer steps. This removes the performance-efficiency trade-off during inference at the cost of data synthesis in



Figure 2: Evaluation performance, the number of LLM calls and consumed tokens (per example) of various training-free pipelines during inference, which are all averaged across four benchmarks: SWE-bench, Webarena, OSWorld and Spider2-V.

Table 4: Model performance based on different retrieval paradigms. Observation-based and Modelbased retrieval prove to be particularly effective in agent tasks, whose combination (ours) gives the best results.

$Benchmark \rightarrow$	SWE	Web	OS	Spider2-V	SWE	Web	OS	Spider2-V
Retrieval ↓		Gemi	ni-1.5-j	pro		Claude	e-3.5-so	nnet
No retrieval	13.3	17.9	4.9	8.3	26.7	31.5	11.4	7.5
Instruction-based	14.7	21.6	7.0	10.2	27.7	33.6	15.7	9.1
Observation-based	16.3	23.5	8.7	14.6	32.3	36.3	18.7	13.2
Model-based	17.0	24.3	9.5	15.4	33.7	37.2	20.3	14.5
Ours	18.7	25.6	10.3	16.4	34.7	39.2	22.5	16.3

advance and suggests that LEARN-BY-INTERACT is particularly well-suited for real-world deployment that demonds both low latency and high performance.

#### 4.2 THE IMPACT OF RETRIEVAL

As mentioned in §2.4, we employ both model-based and observation-based retrieval in our evaluation with ICL. We analyze their effectiveness by incorporating only one of them (skip line 5-14 in Algorithm 2 for model-based retrieval only and skip line 15-17 for observation-based retrieval only). In addition, we compare to two baselines: (1). no retrieval: LLMs predict each action in the zero-shot setting; (2). instruction-based: only use instructions to retrieve synthesized data and apply the same demonstration examples in every action prediction throughout the trajectory.

The results presented in Table 4 illustrate how various retrieval methods impact LLMs when using the synthetic data as the retrieval source. Despite having access to the same example pool (except the baseline without using retrieval), there are notable differences in performance across different retrieval strategies, highlighting the crucial role of agentic retrieval in effectively utilizing synthesized data. Traditional Retrieval-Augmented Generation (RAG) methods, which only employs instructions for retrieval, show the least improvement across four benchmarks and two LLMs. In contrast, the observation-based approach proves particularly effective for agent-based tasks, significantly outperforming the instruction-based retrieval, for instance, achieving a 4.4% absolute improvement in Spider-2V when using Gemini. By leveraging task instructions, interaction history and the current observation, model-based retrieval demonstrates even better results compared to using the observation-based version. Ultimately, the most impressive scores are achieved by combining both model-based and observation-based retrieval, which results in our agentic retrieval pipeline. These findings underscore the importance of carefully designing retrieval pipelines to maximize the potential of synthetic data and LLMs in agent scenarios.

#### 4.3 DATA GRANULARITY

$Benchmark \rightarrow$	SWE	Web	OS	Spider2-V	Web	OS
Granularity $\downarrow$		Claude	-3.5-so	nnet	Codest	ral-22B
Baseline	26.7	31.5	11.4	7.7	4.6	2.2
Short	28.7	33.3	14.9	10.3	13.5	4.9
Medium	28.0	32.5	13.8	9.5	12.6	4.0
Long	27.3	31.9	13.0	8.9	10.6	3.4
Short+Medium	30.0	34.4	15.7	10.7	14.6	5.7
Short+Long	29.3	33.9	15.2	10.5	14.4	5.3
Medium+Long	28.7	32.9	14.4	10.1	13.2	4.5
Short+Medium+Long	31.0	34.9	16.3	11.3	15.4	6.3

Table 5: Effectiveness of synthetic data with various granularity. In general, short-trajectory data is more advantageous to both training and ICL, while mixing all of short, medium and long-trajectory data provides the best performance.

As mentioned in §2.2, we synthesize data by taking contiguous sub-trajectories from the full generation paths of LLMs, i.e. T' = T[i : j], which results in trajectories of diverse lengths in the synthesized data. We divide the synthetic data into three groups: (1). trajectory steps < 5 (short); (2).  $5 \leq$  trajectory steps < 10 (medium); (3). trajectory steps  $\geq 10$  (long), and leverage each group and their combinations in both the trainingfree and the training-based process. To ensure a fair comparison, we constraint the data size in each group and combined group to 200M tokens<sup>2</sup>, utilizing Su et al. (2022) for sub-sampling. Table 5 presents the results. In both training-free and training-based evaluation, LLMs derive greater advantages from short-trajectory data, as demonstrated by its consistently superior performance compared to medium and long-trajectory data with Claude-3.5-sonnet and Codestral-22B. This can be at-



Figure 3: Scaling laws of the synthesized data. Compared to in-context learning, tuned models achieves more significant improvements as the data scales up. The performance is averaged across WebArena and OSWorld.

tributed to the versatility of short-trajectory data, which usually serves as a sub-step or a partial workflow in downstream tasks. The combination of any two data groups proves more effective than relying on a single group, showcasing the complementary nature of diverse data sets. For instance, in Webarena with Codestral-22B, incorporating examples with both short and medium-length trajectories shows additional improvement over using either one exclusively (14.6 vs 13.5 and 14.6 vs 12.6). This underscores the value of considering the trajectory length as a unique dimension of agent data synthesis.

#### 4.4 SCALING LAWS

We examine how the model performance improves as the synthetic data size scales up. Figure 3 presents two sets of results, with training-free (where Claude, Gemini, Codegemma and Codestral use retrieval augmentation without training) and with training-based (where fine-tuned Codegemma and Codestral models are evaluated without retrieval). All results are averaged across Webarena and OSworld due to the limit of computational resources. The findings indicate that both learning paradigms benefit from larger data, suggesting the synthetic data is diverse and high-quality. In the training-free evaluation, more substantial improvements are observed for larger models (Claude and Gemini) compared to smaller ones (Codegemma and Codestral), possibly due to the enhanced

<sup>&</sup>lt;sup>2</sup>We use the number of tokens to measure the data size due to the fact that long-trajectory example may contain more information compared to the short version.

in-context learning abilities of larger models. Our analysis also reveals that for a given amount of synthetic data, fine-tuning smaller models is more effective than using the data as demonstration examples during evaluation.

## 5 RELATED WORK

Various agents based on LLMs have been developed (Wang et al., 2024; Zhang et al., 2024; Shinn et al., 2024; Huang et al., 2022; Wang et al., 2023a;b). React (Yao et al., 2022b) proposes to synergize reasoning and acting in LLMs. By integrating Monte Carlo Tree Search (Kocsis & Szepesvári, 2006; Coulom, 2006), Zhou et al. (2023a) leverages LLM-powered value functions and self-reflection (Madaan et al., 2024) to encourage proficient exploration and decision-making. However, it comes with increased computational costs and relies on the premise that the environment allows for state reversals. In contrast, LEARN-BY-INTERACT removes such assumptions and improves both agent efficiency and performance by synthesizing high-quality data in advance.

Another line of research to improve agent models relies on training on human-labeled examples (Zeng et al., 2023; Yin et al., 2023; Deng et al., 2024; Chen et al., 2024b; Wang et al., 2022a) or data distilled from LLMs like GPT-4 (Chen et al., 2023; Zhao et al., 2024). AgentGen (Hu et al., 2024) explores automatic synthesis of both environments and tasks and then leverages FastDownward<sup>3</sup> to generate trajectory data. AgentTuning (Zeng et al., 2023) utilizes both existing datasets and self-instruct (Wang et al., 2022b) to derive instructions and then samples trajectories from GPT-4 (Achiam et al., 2023). In contrast, LEARN-BY-INTERACT focuses on realistic environments and generate tasks and trajectories using backward construction. Some other researchers are also exploring ways to use data more efficiently with reinforcement learning (Ball et al., 2023; Schwarzer et al., 2020; Nachum et al., 2018; Thomas & Brunskill, 2016; Schwarzer et al., 2021). Gulcehre et al. (2023) suggests using data created by an LLM's policy can enhance itself via offline reinforcement learning algorithms. Aksitov et al. (2023) takes this further by combining with ReAct (Yao et al., 2022b) to train agent models iteratively on experience trajectories. These typically require a reward model as the scoring function or LLM/execution-generated feedback to enhance data quality. Our work, however, takes a different approach by employing the backward construction to improve the data quality by aligning instructions and trajectories.

## 6 CONCLUSION

We introduce LEARN-BY-INTERACT, a data-centric framework to adapt LLM agents to any given environments without human annotations. Based on commonly-accessible resources like documentaion, LLMs propose downstream tasks and complete them with multi-round interactions with environments. We address the misalignment between instructions and trajectories by updating objectives with new instructions derived from trajectories. Additionally, we design innovative retrieval pipelines that leverage agent instructions, interaction histories, and current observations to retrieve synthesized examples. Through extensive experiments, we demonstrate that the synthetic data from LEARN-BY-INTERACT significantly enhances model performance in ICL and training. Compared with other leading approaches in agent tasks, LEARN-BY-INTERACT shows much better performance with lower latency and computational costs, which make it particularly suitable for large-scale deployment. Further analysis has also shown the superiority of LEARN-BY-INTERACT over the classical RAG. In future work, we plan to explore multi-modal settings and train general agent models widely applicable in realistic environments. We anticipate that LEARN-BY-INTERACT will inspire future research to push the state-of-the-art in this direction.

# 7 LIMITATIONS

Although LEARN-BY-INTERACT effectively synthesizes high-quality agentic data with trajectories, it requires a lot of LLM calls in generation and filtering. We hope that future works will explore more efficient approaches to complete annotations without sacrificing quality. Additionally, LEARN-BY-INTERACT leverages the environment-related resources to generate instructions. In some scenarios, however, these resources may be incomplete or not available.

<sup>&</sup>lt;sup>3</sup>https://www.fast-downward.org/

#### REFERENCES

- Josh Achiam, Steven Adler, Sandhini Agarwal, Lama Ahmad, Ilge Akkaya, Florencia Leoni Aleman, Diogo Almeida, Janko Altenschmidt, Sam Altman, Shyamal Anadkat, et al. Gpt-4 technical report. arXiv preprint arXiv:2303.08774, 2023.
- Renat Aksitov, Sobhan Miryoosefi, Zonglin Li, Daliang Li, Sheila Babayan, Kavya Kopparapu, Zachary Fisher, Ruiqi Guo, Sushant Prakash, Pranesh Srinivasan, et al. Rest meets react: Selfimprovement for multi-step reasoning llm agent. arXiv preprint arXiv:2312.10003, 2023.
- Anthropic. Introducing claude 3.5 sonnet, 2024. URL https://www.anthropic.com/ news/claude-3-5-sonnet.
- Philip J Ball, Laura Smith, Ilya Kostrikov, and Sergey Levine. Efficient online reinforcement learning with offline data. In *International Conference on Machine Learning*, pp. 1577–1594. PMLR, 2023.
- Ruisheng Cao, Fangyu Lei, Haoyuan Wu, Jixuan Chen, Yeqiao Fu, Hongcheng Gao, Xinzhuang Xiong, Hanchong Zhang, Yuchen Mao, Wenjing Hu, et al. Spider2-v: How far are multimodal agents from automating data science and engineering workflows? arXiv preprint arXiv:2407.10956, 2024.
- Baian Chen, Chang Shu, Ehsan Shareghi, Nigel Collier, Karthik Narasimhan, and Shunyu Yao. Fireact: Toward language agent fine-tuning. *arXiv preprint arXiv:2310.05915*, 2023.
- Dong Chen, Shaoxin Lin, Muhan Zeng, Daoguang Zan, Jian-Gang Wang, Anton Cheshkov, Jun Sun, Hao Yu, Guoliang Dong, Artem Aliev, et al. Coder: Issue resolving with multi-agent and task graphs. *arXiv preprint arXiv:2406.01304*, 2024a.
- Zehui Chen, Kuikun Liu, Qiuchen Wang, Wenwei Zhang, Jiangning Liu, Dahua Lin, Kai Chen, and Feng Zhao. Agent-flan: Designing data and methods of effective agent tuning for large language models. arXiv preprint arXiv:2403.12881, 2024b.
- Rémi Coulom. Efficient selectivity and backup operators in monte-carlo tree search. In *International conference on computers and games*, pp. 72–83. Springer, 2006.
- Xiang Deng, Yu Gu, Boyuan Zheng, Shijie Chen, Sam Stevens, Boshi Wang, Huan Sun, and Yu Su. Mind2web: Towards a generalist agent for the web. *Advances in Neural Information Processing Systems*, 36, 2024.
- Caglar Gulcehre, Tom Le Paine, Srivatsan Srinivasan, Ksenia Konyushkova, Lotte Weerts, Abhishek Sharma, Aditya Siddhant, Alex Ahern, Miaosen Wang, Chenjie Gu, et al. Reinforced self-training (rest) for language modeling. *arXiv preprint arXiv:2308.08998*, 2023.
- Izzeddin Gur, Hiroki Furuta, Austin Huang, Mustafa Safdari, Yutaka Matsuo, Douglas Eck, and Aleksandra Faust. A real-world webagent with planning, long context understanding, and program synthesis. *arXiv preprint arXiv:2307.12856*, 2023.
- Edward J Hu, Yelong Shen, Phillip Wallis, Zeyuan Allen-Zhu, Yuanzhi Li, Shean Wang, Lu Wang, and Weizhu Chen. Lora: Low-rank adaptation of large language models. *arXiv preprint arXiv:2106.09685*, 2021.
- Mengkang Hu, Pu Zhao, Can Xu, Qingfeng Sun, Jianguang Lou, Qingwei Lin, Ping Luo, Saravan Rajmohan, and Dongmei Zhang. Agentgen: Enhancing planning abilities for large language model based agent via environment and task generation. arXiv preprint arXiv:2408.00764, 2024.
- Wenlong Huang, Pieter Abbeel, Deepak Pathak, and Igor Mordatch. Language models as zero-shot planners: Extracting actionable knowledge for embodied agents. In *International conference on machine learning*, pp. 9118–9147. PMLR, 2022.
- Carlos E Jimenez, John Yang, Alexander Wettig, Shunyu Yao, Kexin Pei, Ofir Press, and Karthik Narasimhan. Swe-bench: Can language models resolve real-world github issues? *arXiv preprint arXiv:2310.06770*, 2023.

- Azarakhsh Keipour. Physical interaction and manipulation of the environment using aerial robots. *arXiv preprint arXiv:2207.02856*, 2022.
- Levente Kocsis and Csaba Szepesvári. Bandit based monte-carlo planning. In European conference on machine learning, pp. 282–293. Springer, 2006.
- Jing Yu Koh, Robert Lo, Lawrence Jang, Vikram Duvvur, Ming Chong Lim, Po-Yu Huang, Graham Neubig, Shuyan Zhou, Ruslan Salakhutdinov, and Daniel Fried. Visualwebarena: Evaluating multimodal agents on realistic visual web tasks. arXiv e-prints, pp. arXiv–2401, 2024.
- Yang Li, Jiacong He, Xin Zhou, Yuan Zhang, and Jason Baldridge. Mapping natural language instructions to mobile ui action sequences. *arXiv preprint arXiv:2005.03776*, 2020.
- Yixin Liu, Kejian Shi, Katherine S He, Longtian Ye, Alexander R Fabbri, Pengfei Liu, Dragomir Radev, and Arman Cohan. On learning to summarize with large language models as references. *arXiv preprint arXiv:2305.14239*, 2023.
- Aman Madaan, Niket Tandon, Prakhar Gupta, Skyler Hallinan, Luyu Gao, Sarah Wiegreffe, Uri Alon, Nouha Dziri, Shrimai Prabhumoye, Yiming Yang, et al. Self-refine: Iterative refinement with self-feedback. Advances in Neural Information Processing Systems, 36, 2024.
- Ofir Nachum, Shixiang Shane Gu, Honglak Lee, and Sergey Levine. Data-efficient hierarchical reinforcement learning. *Advances in neural information processing systems*, 31, 2018.
- Xiao Pu, Mingqi Gao, and Xiaojun Wan. Summarization is (almost) dead. arXiv preprint arXiv:2309.09558, 2023.
- Machel Reid, Nikolay Savinov, Denis Teplyashin, Dmitry Lepikhin, Timothy Lillicrap, Jeanbaptiste Alayrac, Radu Soricut, Angeliki Lazaridou, Orhan Firat, Julian Schrittwieser, et al. Gemini 1.5: Unlocking multimodal understanding across millions of tokens of context. *arXiv preprint arXiv:2403.05530*, 2024.
- Max Schwarzer, Ankesh Anand, Rishab Goel, R Devon Hjelm, Aaron Courville, and Philip Bachman. Data-efficient reinforcement learning with self-predictive representations. arXiv preprint arXiv:2007.05929, 2020.
- Max Schwarzer, Nitarshan Rajkumar, Michael Noukhovitch, Ankesh Anand, Laurent Charlin, R Devon Hjelm, Philip Bachman, and Aaron C Courville. Pretraining representations for data-efficient reinforcement learning. Advances in Neural Information Processing Systems, 34:12686–12699, 2021.
- Noah Shinn, Federico Cassano, Ashwin Gopinath, Karthik Narasimhan, and Shunyu Yao. Reflexion: Language agents with verbal reinforcement learning. *Advances in Neural Information Processing Systems*, 36, 2024.
- Paloma Sodhi, SRK Branavan, Yoav Artzi, and Ryan McDonald. Step: Stacked llm policies for web actions. In *First Conference on Language Modeling*, 2024.
- Hongjin Su, Jungo Kasai, Chen Henry Wu, Weijia Shi, Tianlu Wang, Jiayi Xin, Rui Zhang, Mari Ostendorf, Luke Zettlemoyer, Noah A Smith, et al. Selective annotation makes language models better few-shot learners. arXiv preprint arXiv:2209.01975, 2022.
- CodeGemma Team. Codegemma: Open code models based on gemma. *arXiv preprint arXiv:2406.11409*, 2024a.
- The Mistral AI Team. Codestral: Hello, world!, 2024b. URL https://mistral.ai/news/ codestral/.
- Philip Thomas and Emma Brunskill. Data-efficient off-policy policy evaluation for reinforcement learning. In *International Conference on Machine Learning*, pp. 2139–2148. PMLR, 2016.
- Guanzhi Wang, Yuqi Xie, Yunfan Jiang, Ajay Mandlekar, Chaowei Xiao, Yuke Zhu, Linxi Fan, and Anima Anandkumar. Voyager: An open-ended embodied agent with large language models. *arXiv preprint arXiv:2305.16291*, 2023a.

- Ruoyao Wang, Peter Jansen, Marc-Alexandre Côté, and Prithviraj Ammanabrolu. Scienceworld: Is your agent smarter than a 5th grader? *arXiv e-prints*, pp. arXiv–2203, 2022a.
- Xingyao Wang, Yangyi Chen, Lifan Yuan, Yizhe Zhang, Yunzhu Li, Hao Peng, and Heng Ji. Executable code actions elicit better llm agents. *arXiv preprint arXiv:2402.01030*, 2024.
- Yizhong Wang, Yeganeh Kordi, Swaroop Mishra, Alisa Liu, Noah A Smith, Daniel Khashabi, and Hannaneh Hajishirzi. Self-instruct: Aligning language models with self-generated instructions. arXiv preprint arXiv:2212.10560, 2022b.
- Zihao Wang, Shaofei Cai, Guanzhou Chen, Anji Liu, Xiaojian Ma, and Yitao Liang. Describe, explain, plan and select: Interactive planning with large language models enables open-world multi-task agents. *arXiv preprint arXiv:2302.01560*, 2023b.
- Chunqiu Steven Xia, Yinlin Deng, Soren Dunn, and Lingming Zhang. Agentless: Demystifying llm-based software engineering agents. *arXiv preprint arXiv:2407.01489*, 2024.
- Tianbao Xie, Fan Zhou, Zhoujun Cheng, Peng Shi, Luoxuan Weng, Yitao Liu, Toh Jing Hua, Junning Zhao, Qian Liu, Che Liu, et al. Openagents: An open platform for language agents in the wild. arXiv preprint arXiv:2310.10634, 2023.
- Tianbao Xie, Danyang Zhang, Jixuan Chen, Xiaochuan Li, Siheng Zhao, Ruisheng Cao, Toh Jing Hua, Zhoujun Cheng, Dongchan Shin, Fangyu Lei, et al. Osworld: Benchmarking multimodal agents for open-ended tasks in real computer environments. *arXiv preprint arXiv:2404.07972*, 2024.
- John Yang, Carlos E Jimenez, Alexander Wettig, Kilian Lieret, Shunyu Yao, Karthik Narasimhan, and Ofir Press. Swe-agent: Agent-computer interfaces enable automated software engineering. arXiv preprint arXiv:2405.15793, 2024.
- Zhao Yang, Jiaxuan Liu, Yucheng Han, Xin Chen, Zebiao Huang, Bin Fu, and Gang Yu. Appagent: Multimodal agents as smartphone users. *arXiv preprint arXiv:2312.13771*, 2023.
- Shunyu Yao, Howard Chen, John Yang, and Karthik Narasimhan. Webshop: Towards scalable real-world web interaction with grounded language agents. Advances in Neural Information Processing Systems, 35:20744–20757, 2022a.
- Shunyu Yao, Jeffrey Zhao, Dian Yu, Nan Du, Izhak Shafran, Karthik Narasimhan, and Yuan Cao. React: Synergizing reasoning and acting in language models. *arXiv preprint arXiv:2210.03629*, 2022b.
- Da Yin, Faeze Brahman, Abhilasha Ravichander, Khyathi Chandu, Kai-Wei Chang, Yejin Choi, and Bill Yuchen Lin. Lumos: Learning agents with unified data, modular design, and open-source llms. *arXiv preprint arXiv:2311.05657*, 2023.
- Daoguang Zan, Zhirong Huang, Ailun Yu, Shaoxin Lin, Yifan Shi, Wei Liu, Dong Chen, Zongshuai Qi, Hao Yu, Lei Yu, et al. Swe-bench-java: A github issue resolving benchmark for java. arXiv preprint arXiv:2408.14354, 2024.
- Aohan Zeng, Mingdao Liu, Rui Lu, Bowen Wang, Xiao Liu, Yuxiao Dong, and Jie Tang. Agenttuning: Enabling generalized agent abilities for llms. arXiv preprint arXiv:2310.12823, 2023.
- Zhuosheng Zhan and Aston Zhang. You only look at screens: Multimodal chain-of-action agents. arXiv preprint arXiv:2309.11436, 2023.
- Jiwen Zhang, Yaqi Yu, Minghui Liao, Wentao Li, Jihao Wu, and Zhongyu Wei. Ui-hawk: Unleashing the screen stream understanding for gui agents. *arXiv preprint*, 2024.
- Zhonghan Zhao, Ke Ma, Wenhao Chai, Xuan Wang, Kewei Chen, Dongxu Guo, Yanting Zhang, Hongwei Wang, and Gaoang Wang. Do we really need a complex agent system? distill embodied agent into a single model. *arXiv preprint arXiv:2404.04619*, 2024.
- Andy Zhou, Kai Yan, Michal Shlapentokh-Rothman, Haohan Wang, and Yu-Xiong Wang. Language agent tree search unifies reasoning acting and planning in language models. *arXiv preprint arXiv:2310.04406*, 2023a.

Approach ↓	site	result
CodeStory Aide + Mixed Models	https://www.swebench.com/	43.0
Honeycomb	https://honeycomb.sh/	38.3
AbanteAI MentatBot	https://mentat.ai/blog/mentatbot-sota-coding-agent	38.0
Gru	https://gru.ai/	35.7
Isoform	https://www.isoform.ai/	35.0
SuperCoder2.0	https://superagi.com/supercoder/	34.0
MarsCode	https://www.marscode.com/	34.0
Lingma	https://arxiv.org/abs/2406.01422	33.0
Factory Code Droid	https://www.factory.ai/	31.3
AutoCodeRover	https://autocoderover.dev/	30.7
LEARN-BY-INTERACT (ours)	This paper	34.7

Table 6: Top-10 results of SWE-bench from the leaderboard at https://www.swebench.com/. All the numbers are fetched on 2024-10-01.

Shuyan Zhou, Frank F Xu, Hao Zhu, Xuhui Zhou, Robert Lo, Abishek Sridhar, Xianyi Cheng, Tianyue Ou, Yonatan Bisk, Daniel Fried, et al. Webarena: A realistic web environment for building autonomous agents. arXiv preprint arXiv:2307.13854, 2023b.

# A **BASELINE IMPLEMENTATIONS**

We follow the existing frameworks to set up baselines in each benchmark. In SWE-bench (Jimenez et al., 2023), we follow the prompt styles of the Agentless (Xia et al., 2024) pipeline to first localize suspicious files, then find classes and functions to edit. In WebArena (Zhou et al., 2023b), we follow the implementation of Step (Sodhi et al., 2024), which concatenates task objectives, action space descriptions, general instructions (e.g., output formats) and webpage observations in the prompt, and ask LMs to predict the next action. By default, we use the accessibility tree<sup>4</sup> as the observation space. In OSWorld (Xie et al., 2024) and Spider2-V (Cao et al., 2024), we follow the original prompt style designed by the benchmark, which also concatenates task objectives, action space descriptions, general instructions and computer observations in the prompt. By default, we use the accessibility tree as the observation space for OSWorld, and use the set-of-mark for Spider2-V due to the significant information loss of the accessibility tree in the original benchmark. See an example in Table 22 and 23 for more details.

## B COMPARISON TO TASK-SPECIFIC APPROACHES

In Table 6, we compare LEARN-BY-INTERACT to top-10 task-specific approaches (with open-sourced code) that may not broadly applied in agent scenarios for SWE-bench (Zan et al., 2024) and WebArena (Zhou et al., 2023b). All the information is retrieved on 2024-10-01 from the official leaderboard https://www.swebench.com/ and https://docs.google.com/spreadsheets/d/1M8011EpBbKSNwP-vDBkC\_pF7LdyGUlf\_ufZb\_NWNBZQ/edit?gid=0#gid=0. To the best of our knowledge, we are the first to apply our methods in OSWorld (Xie et al., 2024) and Spider2-V (Cao et al., 2024).

## C DATASET EXAMPLES

From Table 8 to 21, we provide one example for each dataset with full instructions, interaction history with the environment.

## D EXPERIMENTAL SETTINGS

We retrieve documents until the maximum length of LLMs for RAG and set an upper bound number of 50 documents, where the retrieved documents remain unchanged throughout agent interaction trajectory because only instructions are used as the query for retrieval. For Reflexion (Shinn et al.,

<sup>&</sup>lt;sup>4</sup>https://developer.mozilla.org/en-US/docs/Glossary/Accessibility\_tree

Approach $\downarrow$	site	result
Jace.AI	https://www.jace.ai/	57.1
WebPilot	https://www.arxiv.org/pdf/2408.15978	37.2
AWM	https://arxiv.org/pdf/2409.07429	35.5
Step	https://arxiv.org/abs/2310.03720	33.5
BrowserGym	https://github.com/ServiceNow/BrowserGym	23.5
Auto Eval	https://arxiv.org/abs/2404.06474	20.2
Tree Search	https://jykoh.com/search-agents	19.2
AutoWebGLM	https://arxiv.org/abs/2404.03648	18.2
gpt-4-0613	https://arxiv.org/abs/2307.13854	14.9
gpt-4o-2024-05-13	https://arxiv.org/abs/2307.13854	13.1
LEARN-BY-INTERACT (ours)	This paper	39.2

Table 7: Top-10 results of WebArena from the leaderboard at https://docs.google.com/ spreadsheets/d/1M8011EpBbKSNwP-vDBkC\_pF7LdyGU1f\_ufZb\_NWNBZQ/edit? gid=0#gid=0. All the numbers are fetched on 2024-10-01.

2024), we use the maximum trials 3. In LATS (Zhou et al., 2023a), we use the number of generated action 5, depth limit 15, value function weight 0.8, following the original setting in paper with WebShop (Yao et al., 2022a), which is also an agent task based on website. By default, we use https://huggingface.co/dunzhang/stella\_en\_1.5B\_v5 as the retriever for model-based retrieval considering both size and the performance. We use the temperature 0 throughout the experiments to ensure better reproductivity of the experiments. During training, we the batch size 128, learning rate 0.00002, warmup ratio 0.03 and maximum length 8192, and tune the model for 3 epochs. All experiments are conducted in H100 machines with 80GB memeory.

## **E** DOCUMENT SOURCES

We use all the non-repeated python files in SWE-bench-Lite (Jimenez et al., 2023) as the document sources. Although we may not always find abundant documentations and tutorials for each environment, we believe that documentations in the same domain still have a good coverage of frequent operations. For example, one subset of WebArena (Zhou et al., 2023b) focuses on the navigation of the shopping website OneStopMarket, we use the Amazon documentation as a good replacement. Regardless of the shopping websites, the frequent tasks usually include order change, product search, delivery checking, etc. Therefore, we use other documentations in the same domain to sample task instructions when the exact version for the target environment is not available. Concretely, we use the following sources for WebArena:

- https://docs.gitlab.com/ee/tutorials/
- https://support.google.com/maps
- https://www.amazon.com/hz/contact-us/foresight/hubgateway
- https://support.reddithelp.com/hc/en-us/articles

The following sources are used for OSWorld:

- https://support.google.com/chrome/?hl=en
- https://www.gimp.org/tutorials/
- https://books.libreoffice.org/en/CG72/CG72.html
- https://books.libreoffice.org/en/WG73/WG73.html
- https://ubuntu.com/tutorials/command-line-for-beginners
- https://support.mozilla.org/en-US/products/thunderbird
- https://wiki.videolan.org/Documentation:Documentation
- https://code.visualstudio.com/docs
- , The following sources are used for Spider2-V:

- https://docs.getdbt.com/
- https://release-1-7-2.dagster.dagster-docs.io/
- https://docs.astronomer.io/
- https://docs.airbyte.com/
- https://airbyte.com/tutorials/
- https://airbyte-public-api-docs.s3.us-east-2.amazonaws.com/rapidoc-api-docs.html
- https://superset.apache.org/docs/
- https://www.metabase.com/docs/v0.49/
- https://www.metabase.com/learn/
- https://docs.snowflake.com/en/
- https://cloud.google.com/bigquery/docs/
- https://jupyterlab.readthedocs.io/en/4.1.x/

## F SYNTHESIZED DATA EXAMPLES

From Table 24 to 30, we provide a complete example of data synthesis. To begin with, an LLM generates instructions based on standard resources like tutorials, documentations and FAQs: Upload CSV data in Google Drive to BigQuery. (See prompt in Table 33) It then attempts solve the task by predicting actions and collecting feedback from environments (interactions). This produces a long trajectory showing how LLMs try to achieve the goal.

However, it is not guaranteed that the trajectory successfully achieves the target. In our example, the LLM makes a wrong prediction in the action 4. It selects the table source Google Cloud Storage, while the correct action should select "Drive" to align with the instruction that reuiqres to upload CSV data in Google Drive. This results in wrong actions in the subsequent predictions, and the generated trajectory is not aligned with the initial instruction, which leads to noisy data in this case.

Instead of using the original instruction-trajectory pairs for downstream training and in-context learning, we fix the mentioned misalignment by crafting new instructions for each sub-trajectory (backward construction). Concretely, we feed the generated trajectory into LLM prompts, and ask it to summarize the trajectory or propose a new task based on it. For example, the LLM updates the task objective to "Link CSV file in Google Cloud Storage to BigQuery" after observing the trajectory, which makes the task instruction and the trajectory aligned. Additionally, we also generate new instructions for each sub-trajectory, which would increase the utility of a generated full trajectory. For instance, based on the sub-trajectory (observation 0, Action 1, observation 1), the LLM generates a new instruction: When is dataset "demo" created? In Table 31 and 32, we list more generated instructions based on sub-trajectories.

## G CASE STUDY ON FILTERED EXAMPLES

In Table 40-49, we demonstrate the representative synthesized examples that fail to meet our designed criteria. The example in Table 40-45 is filtered because the trajectory shows detour in accomplishing the goal, i.e. Action 1-6 are not necessary. The example in Table 46-49 is filtered because it goes back and forth in states, i.e. repeat the actions of clicking "My Orders" and clicking "View Order". We filter these low-quality examples to avoid their negative influences in the downstream applications.

#### Table 8: SWE-bench example

#### Instruction

Please address the following Github issue.

### GitHub Problem Description ### ModelChoiceIteratorValue is not hashable. Description

Recently I migrated from Django 3.0 to Django 3.1. In my code, I add custom data-\* attributes to the select widget options. After the upgrade some of those options broke. Error is TypeErrorunhashable type: 'ModelChoiceIteratorValue'.

```
Example (this one breaks):
def create option(self name valu
```

def create\_option(self, name, value, label, selected, index, subindex=None, attrs=None):
 context = super().create\_option(name, value, label, selected, index, subindex, attrs)
 if not value:
 return context
 if value in self.show\_fields: # This is a dict 1: ['first\_name', 'last\_name']

context['attrs']['data-fields'] = json.dumps(self.show\_fields[value])

However, working with arrays is not an issue:

def create\_option(self, name, value, label, selected, index, subindex=None, attrs=None):
 context = super().create\_option(name, value, label, selected, index, subindex, attrs)
 if not value:

return context

...

if value in allowed\_values: # This is an array [1, 2]

#### **Observation 0 (repository structure)**

django/ setup.py \_\_init\_\_.py \_main\_\_.py shortcuts.py forms/ \_init\_\_.py utils.py fields.py renderers.py forms.py formsets.py widgets.py boundfield.py models.py db/ \_init\_\_.py transaction.py utils.py models/ signals.py constants.py fields/ files.py \_\_init\_\_.py related.py

••

#### Table 9: SWE-bench example cont.

## Action 1 (Find related files to edit)

Based on the problem description and the repository structure, here are the most likely files that would need to be edited to fix the issue:

django/forms/models.py django/forms/fields.py django/forms/widgets.py django/forms/\_\_init\_\_.py django/db/models/fields/\_\_init\_\_.py django/db/models/fields/related.py

### **Observation 1 (File skeleton)**

...

### File: django/forms/models.py def construct\_instance(form, instance, fields=None, exclude=None): ... def model\_to\_dict(instance, fields=None, exclude=None): ••• class ModelChoiceIteratorValue: def \_\_init\_\_(self, value, instance): def \_\_str\_(self): def \_\_\_eq\_\_(self, other): class ModelChoiceField(ChoiceField): def \_get\_choices(self): ### File: django/forms/fields.py class Field: widget = TextInput # Default widget to use when rendering this type of Field. hidden\_widget = HiddenInput # Default widget to use when rendering this as "hidden" def \_\_init\_\_(self, \*, required=True, widget=None, label=None, initial=None): def prepare\_value(self, value): def to\_python(self, value): def validate(self, value): def run\_validators(self, value): ••• class ChoiceField(Field): def validate(self, value): def valid\_value(self, value): ... •••

#### Table 10: SWE-bench example cont.

#### Action 2 (Find related classes, methods to edit)

Here are the identified locations that need inspection or editing to fix the problem:

django/forms/models.py class: ModelChoiceIteratorValue

django/forms/models.py class: ModelChoiceField method: \_get\_choices

django/forms/fields.py class: ChoiceField method: valid\_value

#### •••

## **Observation 2 (Classes and methods content)**

```
### File django/forms/models.py
class ModelChoiceIteratorValue:
  def __init__(self, value, instance):
     self.value = value
     self.instance = instance
  def __str__(self):
     return str(self.value)
  def eq (self, other):
     if isinstance(other, ModelChoiceIteratorValue):
       other = other.value
     return self.value == other
class ModelChoiceField(ChoiceField):
  def _get_choices(self):
     return self.iterator(self)
### django/forms/fields.py
class ChoiceField(Field):
  def valid value(self, value):
     text value = str(value)
     for k, v in self.choices:
       if isinstance(v, (list, tuple)):
          # This is an optgroup, so look inside the group for options
          for k2, v2 in v:
             if value == k2 or text value == str(k2):
               return True
       else:
          if value == k or text_value == str(k):
            return True
     return False
```

```
•••
```

#### Table 11: SWE-bench example cont.

#### Action 3 (Edit code to address the issue)

Based on the issue description and the provided code segment, it appears that the 'Model-ChoiceIteratorValue' class is not hashable, which is causing the TypeError when trying to use it as a dictionary key. To fix this, we need to make the 'ModelChoiceIteratorValue' class hashable by implementing the '\_\_hash\_\_' method. Here's the proposed fix:

```
### django/forms/models.py
### Replace the following code
class ModelChoiceIteratorValue:
    def __init__(self, value, instance):
        self.value = value
        self.instance = instance
```

def \_\_str\_\_(self): return str(self.value)

def \_\_eq\_\_(self, other):
 if isinstance(other, ModelChoiceIteratorValue):
 other = other.value
 return self.value == other

#### ### with

class ModelChoiceIteratorValue: def \_\_init\_\_(self, value, instance): self.value = value self.instance = instance

def \_\_str\_\_(self): return str(self.value)

```
def __eq_(self, other):
    if isinstance(other, ModelChoiceIteratorValue):
        other = other.value
    return self.value == other
```

def \_\_hash\_\_(self): return hash(self.value)

#### **Observation 3 (Generated patch)**

```
diff -git a/django/forms/models.py b/django/forms/models.py
index 5a30801..55b3c81 100644
- - - a/django/forms/models.py
+++ b/django/forms/models.py
@ @ -1171,6 +1171,9 @ @ class ModelChoiceIteratorValue:
        other = other.value
        return self.value == other
+ def __hash__(self):
+ return hash(self.value)
+
class ModelChoiceIterator:
    def __init__(self, field):
```



# Table 13: Webarena example cont.

# **Observation 1**

				Му	Account My Wish	List Sign Out	Welcome, Emma I	
One Stop Market					S	earch entire sto	re here Q	
anuty & Berronal Care Sports & O	utdoors Clothi	ng Shoas & Jaw	Inv . Home & Kitc	han . Office Brodu	Adv	anced Search	at -	
seauty a reisonal care sports a ot		ing, snoes a jewe	ny nome a kite	once Produ	10013 @ 11	one improvement	in.	
Health & Household · Patio, Lawn & O	Sarden Electro	onics - Cell P	hones & Accessories	Video Games	Grocery & Gourm	et Food		
	My Aco	ount						
My Account	iviy Acc	Jound						
My Orders								
My Downloadable Products	Account Inform	nation						
My Wish List	Contact Informa	tion		Newsle	tters			
Address Rook	Emma Lopez			You are	n't subscribed to our	newsletter.		
Access book	emma.lopez@gm	ail.com		Edit				
Account mormation	Edit Change Passi	word						
Stored Payment Methods								
My Product Reviews	Address Book	Manage Addres	ises					
Newsletter Subscriptions	Default Billing A	ddress		Default Shipping Address				
	Emma Lopez			Emma Lopez				
	101 S San Mateo	Dr		101 S Sa	an Mateo Dr			
	San Mateo, Califo	rnia, 94010		San Mat	teo, California, 94010	)		
ompare Products	T: 6505551212			T: 65055	51212			
ou have no items to compare.	Edit Address			Edit Address				
lecently Ordered								
Plus Size Lingerie for Women Sexy for	Recent Orders	View All						
Sex Naughty Eyelash Lace Bodysuit	Order #	Date	Ship To	Order Total	Status	Action		
Bodysuit Outfits	000000170	5/17/23	Emma Lopez	\$365.42	Canceled	View Order	Reorder	
Uttermost Volterra Crackled Taupe-	000000189	5/2/23	Emma Lopez	\$754.99	Pending	View Order	Reorder	
Gray Ceramic Table Lamp	000000188	5/2/22	Emmelaner	42.004.00	Dending	View Order	December	
Shelf with 4 Hooks, Hanging Entryway	00000188	5/2/23	Emma Lopez	\$2,004.99	Pending	view Order	neorder	
Organizer for Mug Coffee Cup, Holding	000000187	5/2/23	Emma Lopez	\$1,004.99	Pending	View Order	Reorder	
Kitchen Living Room, Bathroom and	000000180	3/11/23	Emma Lopez	\$65.32	Complete	View Order	Reorder	
Bedroom								

Stop: The total cost of the latest cancelled order is \$365.42

## Table 14: OSWorld example

## Instruction

Could you assist me in adding a new layer and naming it 'Square'?

**Observation 0 (Interface of the software GIMP)** 



#### Action 1

import pyautogui

pyautogui.hotkey('shift', 'ctrl', 'n') // shortcut to initialize a new layer.

```
Observation 1 (Interface of the software GIMP)
```



## Table 15: OSWorld example cont.

## Action 2

## import pyautogui

pyautogui.typewrite('Square') // change the layer name to Square.

#### **Observation 2 (Interface of the software GIMP)**



### Action 3

import pyautogui

pyautogui.click(1096, 892) // click OK to save the change.

#### **Observation 3 (Interface of the software GIMP)**



#### Table 16: Spider2-V example, cont.

#### Instruction

I have established a connection from Faker to local .csv file. Could you help me change the running schedule? I hope it can be replicated at 18:00 pm every day.

#### **Observation 0 (Interface of the software Airbyte)**



#### Action 1

import pyautogui

pyautogui.click(550,280) // click the connection row with the name "Sample Data (Faker)  $\rightarrow$  Local CSV"

#### **Observation 1 (Interface of the software Airbyte)**

	-	04301			
		Airbyte   C	onnections   Sample Data (Faker) $\rightarrow$ Local CSV - Chromium		- a x
	✓ Q Bing	× 🕼 Airbyte   Connections   💈 × 🕂			
>_	← → ♂ ⊙ local	host:8000/workspaces/1f3dcee5-a48a-4d79-9dd1-e06151174a5e/connectio	ons/bc47a312-7306-4fe3-8560-b07bea5bc917/status		다 소 다 🏝 :
	🔊 Airbyte	Connections / Sample Data (Faker) → Local CSV			
×	Connections	Sample Data (Faker) → Local CSV			Enabled
	⊖ Sources	🍓 Sample Data (Faker) COMMUNITY 🔿 📠 Local CSV (COMMUNITY)			
	Destinations	Status Job History Replication Transformation Setting	ge		
1	Rullder				
	<ul> <li>Settings •</li> </ul>	On time Next sync in a day			Sync now
		Enabled streams		Q Search	
12		Status Stream name	Last record loaded 🕥		
		On time products	a few seconds ago		
$(\underline{A})$		On time purchases	a few seconds ago		
0		<ul> <li>On time users</li> </ul>	a few seconds ago		
	(1) Help				
::::	či Liebt mode				
	m Eight mode				

## Table 17: Spider2-V example, cont.

## Action 2

# import pyautogui

pyautogui.click(500,300) // click the button Replication

## **Observation 2 (Interface of the software Airbyte)**

Activitie	s 💿 Chromium Web Brow	ser Se	o 24 19:45		4 4 U					
		Airbyte   Connections   Sample	Data (Faker) → Local CSV - Chromium		- @ X					
	✓ Q Bing	× Airbyte   Connections   5 × +								
<u>~</u>	← → C O localhost:8000/workspaces/1f3dcee5-a48a-4d79-9dd1+e06151174a5e/connections/bc47a312-7306-4fe3-8560-b07bea5bc917/replication									
$\checkmark$	Airbyte Connections / Sample Data (Faker) -> Local CSV									
$\sim$	1. Connections	Sample Data (Faker) → Local CSV			Enabled 🚺					
	$\ominus$ Sources	🆓 Sample Data (Faker) (COMMUNITY) 🔸 🔚 Local CSV (COMMUNITY)								
	Destinations	Status Job History Replication Transformation Settings								
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	Settings •	Configuration			<b>`</b>					
		Replication frequency: Destination Namespace: Destination Stream Prefix: Every 24 hours Destination default Mirror source name	Detect and propagate schema changes: Detect changes and manually approve							
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		Search stream name								
•(A)		Hide disabled streams								
		C Symc Data destination 🕸 Stream 🕲	Sync mode 🛈		Fields					
0		<destination schema=""> products</destination>	Select a value V	Cursor field updated_at Primary key ld	AL					
		<destination schema=""> purchases</destination>	Select a value 🗸	Cursor field updated_at Primary key ld	AL					
		destination schema> users	Select a value V	Cursor field updated_at Primary key id	AL					
	0.00									
::::	() Help				Cancel Save changes					
	localhost:8000/workspaces/1		5bc917/replication							

#### Action 3

import pyautogui

pyautogui.click(500,450) // click the panel Configuration

#### **Observation 3 (Interface of the software Airbyte)**

Activiti	es 🛛 💿 Chromium Web Bro	wser	Sep 24 19:45		A 🐠 🖱
		Airbyte	Connections   Sample Data (Faker) $\rightarrow$ Local CSV - Chromium		- a ×
$\mathbf{O}$	✓ Q Bing	× 🖉 Airbyte   Connections   S × +			
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	nirbyte	Connections $/$ : Sample Data (Faker) $\rightarrow$ Local CSV			
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	$\bigcirc$ Sources	🍓 Sample Data (Faker) соммиляту 🔸 📘 Local CSV (соммиляту			
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	🛞 Settings 😐	Configuration			ř
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		Replication frequency $\odot$	Every 24 hours	~	
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• <del>(A</del> )		Detect and propagate schema changes $_{\odot}$	Detect changes and manually approve	e ~	
0					
		Activate the streams you want to sync			G Refresh source schema
		Search stream name			
		Hide disabled streams			
		💽 Sync Data destination 🛞 Stream 🕲	Sync mode 👁		Fields
		cdestination schema> products	Select a value 🗸 🗸	Cursor field updated_at Primary key ld	AL
	(*) Help	destination schema> purchases	Select a value 🗸 🗸	Cursor field updated_at Primary key id	AL
	🔅 Light mode	destination schema> users	Select a value 🗸 🗸	Cursor field updated_at Primary key id	Cancel Save Aganges
	I				*

## Table 18: Spider2-V example, cont.

#### Action 4

## import pyautogui

pyautogui.click(1270,430) // reveal the dropdown menu of the schedule type

## **Observation 4 (Interface of the software Airbyte)**

Activitie	es 🛛 💿 Chromium Web Brow	vser		Sep 24 19:46				4	<>> </th
			Airbyte   Connections   Sa	mple Data (Faker)	→ Local CSV - Chromium			-	ø x
	<ul> <li>♥ Q Bing</li> </ul>	× 🖉 Airbyte   Connections   🗄 ×	+						
>_	← → ♂ ④ localho	st:8000/workspaces/1f3dcee5-a48a-4d79-9dd1-e06	151174a5e/connections/bc47a312-73	06-4fe3-8560-b07bea	5bc917/replication		Ե ☆	д 🛛	<b>a</b> :
	nirbyte	Connections / Sample Data (Faker) $\rightarrow$ Local CSV							
~	11 Connections	Sample Data (Faker) → Local CS	v					Enable	nd 🚺
	⊖ Sources	👙 Sample Data (Faker) соммиляту 🔸 📘 L	ocal CSV (DOMMUNITY)						
	Destinations	Status Job History Replication Tran	formation Settings						
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	Settings •	Configuration							ř
		Schedule type		l	Scheduled	<u> </u>			
		Replication frequency			Scheduled				
- 12		Destination Namespace $\odot$			Manual				
		Destination Stream Prefix  Optional			Cron	CAR			
•@		Detect and propagate schema changes $\odot$			Detect changes and manua	illy approve			
6									
-									51
		Activate the streams you want to syr	ic				C Refres	1 source schem	Ia
		Search stream name							
		Hide disabled streams							
		Sync Data destination 🛞 Strea	n ()	Sync mode	e ()			Field	15
		destination schema> produ	icts	Select a v	ralue 🗸	Cursor field update Primary key ld	d_at	AI	
	() Help	destination schema> purch	ases	Select a v	ralue 🗸	Cursor field update Primary key id	d_at	AI	
	🔅 Light mode	destination schema> users		Select a v	value 🗸	Cursor field update Primary key ld	d_at Cance	a Save Al	

#### Action 5

import pyautogui pyautogui.click(1200,565) // select the schedule type Cron

#### **Observation 5 (Interface of the software Airbyte)**

Activiti	es 🛛 🔘 Chromium Web Bro	wser	Sep 24 19:46	0 🚸 🕹
		Airbyte   Connection	as   Sample Data (Faker) → Local CSV - Chromium	- o ×
	<ul> <li>♥ Q Bing</li> </ul>	× 🖉 Airbyte   Connections   💈 × 🕂		
>_	← → ♂ ⊙ localh	ost:8000/workspaces/1f3dcee5-a48a-4d79-9dd1-e06151174a5e/connections/bc47a3	12-7306-4fe3-8560-b07bea5bc917/replication	С 🖈 д 🛛 😩 :
	🔊 Airbyte	Connections / Sample Data (Faker) $\rightarrow$ Local CSV		
~	1. Connections	Sample Data (Faker) → Local CSV		Enabled
	$\bigcirc$ Sources	🍓 Sample Data (Faker) community 🔸 🧧 Local CSV (community)		
	Destinations	Status Job History Replication Transformation Settings		
<b>×</b>	<li>8 Builder</li>			î
	Settings •	Configuration		× I
		Schedule type	Cron ~	
		Cron expression 💿	0 0 12 * * ? UTC ~	
			At 12:00 PM	
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•(A)		Destination Stream Prefix  O Optional	Mirror source name Edit	
		Detect and propagate schema changes	Detect changes and manually approve	
0				
		Activate the streams you want to sync		C Refresh source schema
		Search stream name		
		Hide disabled streams		
		💽 Sync Data destination 🛞 Stream 🕲	Sync mode 💿	Fields
		destination schema> products	Select a value	AL
	Help	<destination schema=""> purchases</destination>	Select a value	AL
:::	🔅 Light mode	cdestination schema> users	Select a value Cursor field updated_at Primary key id	Al •

## Table 19: Spider2-V example, cont.

## Action 6

#### import pyautogui

pyautogui.click(1020,480) // focus on the content of the Cron expression

## **Observation 6 (Interface of the software Airbyte)**

Activitie	es 💿 Chromium Web Brow	wser Sep	24 19:46	A 🔹 🕪 🕛
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	촀 Airbyte	Connections / Sample Data (Faker) → Local CSV		
~	1 Connections	Sample Data (Faker) → Local CSV		Enabled 🦲
	$\ominus$ Sources	👙 Sample Data (Faker) соммиляту 🔸 📑 Local CSV соммиляту		
	Destinations	Status Job History Replication Transformation Settings		
<b>/</b>	N Builder			Î
	Settings •	Configuration		~
		Schedule type	Cron ~	
		Cron expression	0 0 12 ***? UTC ~	
			At 12:00 PM	
		Destination Namespace O	Destination default Edit	
•(A)		Destination Stream Prefix O Optional	Mirror source name Edit	
		Detect and propagate schema changes $\odot$	Detect changes and manually approve $\qquad \lor$	
0				
		Activate the streams you want to sync		C Refresh source schema
		Search stream name		
		Hide disabled streams		
		Sync Data destination 🛞 Stream 🕲	Sync mode 💿	Fields
		cdestination schema> products	Select a value v Curs	or field updated_at AL
	(†) Help	cdestination schema> purchases	Select a value	or field updated_at
	🔅 Light mode	<destination schema=""> users</destination>	Select a value V Curs	or field updated_at

#### Action 7

import pyautogui

pyautogui.hotkey("ctrl", "a") // select all content in the textbox

#### **Observation 7 (Interface of the software Airbyte)**

Activiti	es 🛛 💿 Chromium Web Br	owser	Sep 24 19:47	A 🗣 🖉
		Airbyte   Connection	is   Sample Data (Faker) → Local CSV - Chromium	- o ×
	<ul> <li>♥ Q Bing</li> </ul>	× 🖉 Alrbyte   Connections   5 × +		
>_	← → C O local	nost:8000/workspaces/1f3dcee5-a48a-4d79-9dd1-e06151174a5e/connections/bc47a3	12-7306-4fe3-8560-b07bea5bc917/replication	않☆ 죠 @ ≗ :
	🔊 Airbyte	Connections / Sample Data (Faker) → Local CSV		
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			At 12:00 PM	
		Destination Namespace $\odot$	Destination default Edit	
A		Destination Stream Prefix  Optional	Mirror source name Edit	
		Detect and propagate schema changes	Detect changes and manually approve	
0				
		Activate the streams you want to sync		C Refresh source schema
		Search stream name		
		Hide disabled streams		
		Sync Data destination 🛞 Stream 🕲	Sync mode 💿	Fields
		(destination schema> products	Select a value   Cursor field updated_at Primary key Id	Al
	(*) Help	destination schema> purchases	Select a value	
	🔅 Light mode	C <destination schema=""> users</destination>	Select a value   Cursor field updated_at  Primary key ld	Cancel Save changes

## Table 20: Spider2-V example, cont.

# Action 8 import pyautogui

pyautogui.press("delete") // delete the default content

**Observation 8 (Interface of the software Airbyte)** 

Activitie	is 💿 Chromium Web Brow	vser Sep 24	19:47	A 🕸 U
		Airbyte   Connections   Sample Da	ta (Faker) → Local CSV - Chromium	- • ×
	✓ Q Bing	× 🖉 Airbyte   Connections   💈 × 🛛 +		
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	nirbyte	Connections / Sample Data (Faker) → Local CSV		
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	🛞 Settings 😐	Configuration		Ť
		Schedule type 💿	Cron ~	
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			expression does to make sure your syntax is correct.	
		Destination Namespace $\odot$	Destination default Edit	
•(		Destination Stream Prefix  Optional	Mirror source name Edit	
0		Detect and propagate schema changes	Detect changes and manually approve	
		Activate the streams you want to sync		G Refresh source schema
		Search stream name		
		Hide disabled streams		
		C Sync Data destination 🛞 Stream 🕲	Sync mode 🗇	Fields
	() Help	cdestination schema> products	Select a value   Cursor field updated_at Primary key id	(AI)
	🔅 Light mode	The form is invalids to the set of the set o	Select a value	Cancel Save ganges

### Action 9

import pyautogui

pyautogui.write("0 0 18 \* \* ?") // update the content to align 18:00 pm in the instruction

## **Observation 9 (Interface of the software Airbyte)**

Activitie	es 🛛 💿 Chromium Web Bi	rowser	Sep 24 19:47	🚣 🚸 😃
		Airbyte   Connections   5	Sample Data (Faker) → Local CSV - Chromium	- a ×
0	<ul> <li>♥ Q Bing</li> </ul>	× 🖉 Airbyte   Connections   5 × +		
>_	← → C ① local	host:8000/workspaces/1f3dcee5-a48a-4d79-9dd1-e06151174a5e/connections/bc47a312-7	7306-4fe3-8560-b07bea5bc917/replication	С 🛧 🔲 😩 :
	🔊 Airbyte	Connections / Sample Data (Faker) → Local CSV		
$\sim$	1.Connections	Sample Data (Faker) → Local CSV		Enabled
	$\ominus$ Sources	👙 Sample Data (Faker) (COMMUNITY) 🔸 📑 Local CSV (COMMUNITY)		
	⇒ Destinations	Status Job History Replication Transformation Settings		
<u>×</u>	N Builder	Oraclineartha		
	Settings •			, , , , , , , , , , , , , , , , , , ,
		Schedule type 🕤	Cron ~	
		Cron expression $_{\odot}$	0 0 18 1 * ? UTC ~	
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		Destination Stream Prefix  O Optional	Mirror source name Edit	
(9)		Detect and propagate schema changes	Detect channes and manually approve	
0			beteet energies and manaary approve	
		Activate the streams you want to sync		C Refresh source schema
		Search stream name		
		Hide disabled streams		
		C Sync Data destination 🛞 Stream 🕲	Sync mode O	Fields
		C <destination schema=""> products</destination>	Select a value	Al
	Help	<destination schema=""> purchases</destination>	Select a value  V Cursor field updated_at Primary key Id	A
	🔅 Light mode	c <destination schema=""> users</destination>	Select a value   Cursor field updated, at Primary key Id	Cancel Save changes

# Table 21: Spider2-V example, cont.

## Action 10

import pyautogui

pyautogui.click(1450,900) // click the button save changes

**Observation 10 (Interface of the software Airbyte)** 

Activitie	es 💿 Chromium Web Bro	wser Sep	24. 19:49	A 🐠 U
		Airbyte   Connections   Sample	Data (Faker) → Local CSV - Chromium	- a x
	✓ Q Bing	× M Airbyte   Connections   S × +		
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$\mathbf{A}$	Mirbyte	Connections / Sample Data (Faker) → Local CSV		
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	$\ominus$ Sources	🆓 Sample Data (Faker) соммиляту 🔸 🧧 Local CSV соммиляту		
	Destinations	Status Job History Replication Transformation Settings		
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	🛞 Settings 😐	Configuration		~
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•(A)		Destination Stream Prefix  O Optional	Mirror source name Edit	
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		c <destination schema=""> products</destination>	Select a value   Cursor field updated_at  Primary key Id	AI
	Help	classification schema> purchases	Select a value	AI
	🔆 Light mode	Your changes were saved! C <destination schema=""> users</destination>	Select a value   Cursor field updated_at Primary key Id	Cancel Save changes

Screenshot		
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Table 22: Observation space of Spider2-V.

Set-of-mark



Table 23: Observation space of Spider2-V. The accessibility tree suffers from significant information loss. Compared to the screenshot and set-of-mark shown in Table 22, the presented accessibility tree fails to retrieve webpage information, and only shows the details of the desktop icons in the left panel.

[208, 13] menu Chromium Web Browser "" [1463, 13] menu System "" [35, 65] push-button Chromium Web Browser "" [753, 81] label Please download waiting software updates. "" 135, 109 label Home [35, 133] push-button Terminal "" [35, 201] push-button Visual Studio Code "" [35, 269] push-button Files "" [35, 337] push-button Text Editor "" (953, 370) label Updated software is available for this computer. Do you want to install it now? [35, 405] push-button LibreOffice Calc "" [951, 463] table-cell Security updates [1191, 463] table-cell 638.8 MB [35, 473] push-button LibreOffice Writer "" [963, 486] table-cell LibreOffice 1191, 486 table-cell 23.4 MB [963, 509] table-cell LibreOffice Calc 1191, 509 table-cell 8.7 MB [923, 524] toggle-button Details of updates "" [963, 532] table-cell LibreOffice Draw 1191, 532 table-cell 3.0 MB [35, 541] push-button Document Viewer "" [963, 555] table-cell LibreOffice Impress 1191, 555 table-cell 1.3 MB [963, 578] table-cell LibreOffice Math [1191, 578] table-cell 673 kB [35, 612] push-button Software Updater "" [935, 660] label 1157.8 MB will be downloaded. [35, 680] push-button Trash "" [671, 702] push-button Settings... "" 1054, 702] push-button Cancel "" 1176, 702 push-button Install Now "" [35, 884] toggle-button Show Applications ""

## Table 24: Example of data synthesis - Bigquery

# Instruction

Upload CSV data in Google Drive to BigQuery.

## **Observation 0 (Bigquery Interface)**



#### Action 1

import pyautogui pyautogui.doubleClick(332,447) // double click the dataset demo.

#### **Observation 1 (Bigquery Interface)**

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## Table 25: Example of data synthesis - Bigquery

## Action 2

import pyautogui pyautogui.doubleClick(1002,321) // double click the button CREATE TABLE.

**Observation 2 (Bigquery Interface)** 

Activitie	es 🌘	Chromium We	b Browser Sep 29 17:36			Å	۹۶	Ċ
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	E	location					_	
	Þ	modified	CREATE TABLE CANCEL					

#### Action 3

import pyautogui

pyautogui.click(1458,279) // click the dropdown menu to select table source.

**Observation 3 (Bigquery Interface)** 

Activiti	es 🥝	Chromium Web	Browser Sep 29 17:37			Å (	» U
			Create table – BigQuery – bigquery-project – Google Cloud console - Chromium			- 0	5 ×
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	•	Q Search Big	Google Cloud Storage				
	Œ	Viewing resour	Upload				
	z	SHOW STARR	Drive				
	-	- bigquery-pr	Google Bigtable				5
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		SHOW	Azure Blob storage				5
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	Đ	location					
	IN	Last modified	CREATE TABLE CANCEL				
		Description					

## Table 26: Example of data synthesis - Bigquery

#### Action 4

## import pyautogui

// wrong prediction: click the table source Google Cloud Storage. // The correct prediction should select Drive to align with the instruction. pyautogui.click(1302,331)

#### **Observation 4 (Bigquery Interface)**

Activitie	es @	Chromium Web	Browser Sep 29 17:39			۰.	Ċ
			Create table – BigQuery – bigquery-project – Google Cloud console - Chromium		-	0	×
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	Ĩ	Free trial status: \$3	Create table				×
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	<b>m</b>	demo bigquery-project	Schema				
	0	Data	Source file defines the schema.				
	E	Last					
	D	modified Description	CREATE TABLE CANCEL				

### Action 5

import pyautogui

pyautogui.click(1389,340) // click BROWSE to find file.

## **Observation 5 (Bigquery Interface)**

Activitie	es 🧯	Chromium Web	Browser Sep 29 17:40			<b>Å ●</b> ∪
			Create table – BigQuery – bigquery-project – Google Cloud o	console - Chromium		- a ×
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		Explorer	Create table from Google Cloud Storage	🖨 test-1616	>	
		O. Soorah Bia				
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	38		Table *			
	3		Maximum name size is 1,024 UTF-8 bytes. Unicode letters, marks, numbers, connectors, dashes and spaces are allowed.			
		SUMMA	Native table			
	<b>M</b>	demo	Schema			
	0	bigquery-projec	• • • • • • • •	Filename		
	Ē	location	<ul> <li>Source me demes me schema.</li> </ul>			
	D	Last modified Description	CREATE TABLE CANCEL	SELECT CANCEL		

## Table 27: Example of data synthesis - Bigquery

# Action 6 import pyautogui pyautogui.click(1341,282) // click to find files under directory. Observation 6 (Bigquery Interface)

Activitie	es G	Chromium We	b Browser Sep 29 17:42		A 🗣 🛈
			Create table – BigQuery – bigquery-project – Google Cloud o	console - Chromium	- ø ×
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	ĨĨ	Free trial status: \$3	Create table	Choose a file	
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	(I)	Explorer	Create table from Google Cloud Storage	test.csv	la la
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	2	CUMMAN	Table type Native table		
	•	demo			
	<b>M</b>	bigquery-projec	Schema	Filename	
		Data	Source file defines the schema.		
	D	Last modified Description	CREATE TABLE CANCEL	SELECT CANCEL	

### Action 7

import pyautogui pyautogui.doubleClick(1203,284) // select the CSV file.

## **Observation 7 (Bigquery Interface)**

Activiti	es 🧯	Chromium Web	o Browser Sep 29 17:42		A 🔹 U
0	~ 0	Bing	Create table – BigQuery – bigquery-project – Google Cloud o	console - Chromium	(_ (Ø) (X
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	ĩ	Free trial status: \$:	Create table	Choose a file	
×	=	Google Clos	Source	test.1616	
		Explorer	Create table fromGoogle Cloud Storage	test.csv	
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	• 61	demo	Schema	- Filename	
	•	Data	Source file defines the schema.	test.csv	
	Ē	Last	CREATE TABLE CANCEL	SELECT CANCEL	
	N N	Description	UNCATE FADLE VARIABLE	UNIVOEL	

## Table 28: Example of data synthesis - Bigquery

## Action 8

import pyautogui

pyautogui.click(1000,915) // click to select file.

**Observation 8 (Bigquery Interface)** 

Activitie	es 🧯	Chromium We	b Browser Sep 29 17:43			Å		U
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	×		blgguery-project-436417		В	ROWS	E	
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	•							
0	38		Table * Maximum name size is 1,024 UTF-8 bytes. Unicode letters, marks, numbers, connectors, dashes and spaces are allowed.					
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	<b>M</b>	demo bigguery-project	Schema					
	0	Data	Auto-detect					
	Ē	location	Difference Edit as text					
	D	modified	CREATE TABLE CANCEL					

#### Action 9

import pyautogui pyautogui.click(1000,668) // click to focus on the text box Table.

**Observation 9 (Bigquery Interface)** 

Activiti	es 🌘	Chromium We	eb Browser Sep 29 17:44			÷	ه.	ው
			Create table – BigQuery – bigquery-project – Google Cloud console - Chromium				ø	×
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	îî	Free trial status: \$	Create table					×
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	¢	Explorer	Create table from Google Cloud Storage				•	
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	•		Table *					
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	4		Table type				_	
		SUMMA	Native table			•	0	
	ŝ	demo bigquery-proje	Schema					
	0	Data	Auto-detect					
	e	location	G Edit as text					
	Þ	modified Description	CREATE TABLE CANCEL					

#### Table 29: Example of data synthesis - Bigquery

Action 10

import pyautogui

pyautogui.write("test") // name the file "test".

**Observation 10 (Bigquery Interface)** 



#### Action 11

import pyautogui pyautogui.click(1425,726) // click to reveal dropdown menu of the table type.

**Observation 11 (Bigquery Interface)** 

Activitie	es @	Chromium Web	Browser Sep 29 17:52			Å	۵	Ċ
			Create table – BigQuery – bigquery-project – Google Cloud console - Chromium			-	ø	×
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	Ĩ	Free trial status: \$3	Create table				>	×
$\sim$	≡	Google Clos	Source					
	¢	Explorer	Create table from Google Cloud Storage				•	
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	0	Data	Auto-detect					
	e	location	D Edit as text					
	D	Last modified Description	CREATE TABLE CANCEL					

#### Table 30: Example of data synthesis - Bigquery

### Action 12

import pyautogui

pyautogui.click(1297,801) // select the table source external table.

**Observation 12 (Bigquery Interface)** 



#### Action 13

import pyautogui pyautogui.click(303,914) // click CREATE TABLE.

**Observation 13 (Bigquery Interface)** 

Activitie	es @	Chromium Web Browser	Sep 29 17:54	🚣 🌒 (U)
			BigQuery – bigquery-project – Google Cloud console - Chromium	- o ×
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>_	€ -3	C : console.cloud.google.com/	query?project=bigquery-project-436417&ws=!1m4!1m3!3m2!1sbigquery-project-436417!2sdemo	☆ 죠 ◘ ≗ :
	11	Free trial status: \$300.00 credit and 91 days rema	g. Activate your full account to get unlimited access to all of Google Cloud – use any remaining credits, then pay only for what you use.	DISMISS ACTIVATE
$\sim$	≡	Google Cloud S* bigquery-pr	ct 🔻 Search (/) for resources, docs, products and more	★ ≥ 2 ? : H
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			Description	
	^		Default collation	
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C'			Case insensitive false	
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	٩	_	Dataset replica info PREVIEW	VIEW REPLICAS
		SUMMARY	Primary location US	
		demo		
	m	bigquery-project-436417		
	0	Data US		
	E	location		
:::		Last 29 Sept 2024, 17:32:00	test created. GO TO TABLE 🗙	
•••	D	modified UTC-7	Job history	CREFRESH A
		Description		

sub-trajectory	type	instruction
Observation 0 $\downarrow$ Action 1 $\downarrow$ Observation 1)	New task	When is dataset "demo" created?
Observation 1 $\downarrow$ Action 2 $\downarrow$ Observation 2	Replicate trajectory	Replicate the following: We are currently at the Google Cloud Console interface, specifically focused on a BigQuery project. The browser window displays details of a dataset named "demo" within a BigQuery project. The interface provides information about the dataset, including its creation date, last modified time, data location (US), and other properties like default table expiry and rounding mode. On the left side of the screen, there's a navigation panel showing the Explorer view with the "demo" dataset selected. The top of the screen shows the Google Cloud header with project selection and search functionality. The overall layout is characteristic of a cloud-based data management platform, with options to create tables, share data, and manage dataset properties. After taking the action to click the CREATE TABLE button, we go to the user interface for creating a table. The screen displays a form titled "Create table" with various fields and options. The source section allows selecting a table to create from, while the destination section includes fields for project, dataset, and table name. There's also a schema section and partition and cluster settings. The interface is part of the Google Cloud Console, as evident from the sidebar on the left showing different Cloud services and project navigation.
Observation 4 $\downarrow$ Action 5 $\downarrow$ Observation 5 $\downarrow$ Action 6 $\downarrow$ Observation 6 $\downarrow$ Action 7 $\downarrow$ Observation 7 $\downarrow$ Action 8 $\downarrow$ Observation 8	New task	Select test.csv in the bucket test-1616 in Google Cloud Storage as the table source.

Table 31: Instructions generated from trajectory from Table 24 to 30

sub-trajectory	type	instruction
Observation 8 $\downarrow$ Action 9 $\downarrow$ Observation 9 $\downarrow$ Action 10 $\downarrow$ Observation 10	Replicate trajectory	Replicate the following: We are in the the interface for creating a table in Google Cloud's BigQuery service. The page is divided into several sections. At the top, it indicates the user is creating a table from a Google Cloud Storage source, with a CSV file selected. The destination section shows the project ID and allows input for the dataset and table name. The destination table is empty. The table type is set to "Native table". At the bottom, there's an option for schema detection, with buttons to create the table or cancel the operation. The left side of the screen displays a navigation menu for the Google Cloud Console, including options like Explorer and various project-related items. The overall layout suggests this is part of a larger cloud data management and analysis platform. After we click on the text box Table, we select and focus on the text box. We then type "test" into the box, which gives the table a name. Except the textbox we are working on, the other parts of the webpage has not changed after clicking and typing.
Observation 0 $\downarrow$ Action 1 $\downarrow$ Observation 1 $\downarrow$ Action 2 $\downarrow$  $\downarrow$ Observation 13	New task	Link CSV file in Google Cloud Storage to BigQuery

Table 32: Instructions generated from trajectory from Table 24 to 30

Table 33: self-instruct prompts to propose instructions based on tutorials, documentations and FAQs.

{Documentation}

Based on the tutorial, examplify 3 tasks that users frequently perform. User the following format to output:

...

Table 34: Prompts to summarize (sub-)trajectories or propose new tasks based on the (sub-)trajectories.

Prompt 1
Below is a trajectory to complete a task.
Observation:
$\{Observation_i\}$
Action:
{Action <sub><math>i+1</math></sub> }
Observation:
$\{Observation_{i+1}\}$
Action:
{Action <sub><math>i+2</math></sub> }
 Action:
{Action <sub><math>i-1</math></sub> }
Observation:
$\{Observation_j\}$
•

Please write a reasonable task instruction that is completed by the trajectory. Wrap the instruction with ```.

## Prompt 2

Below is a trajectory to complete a task. Observation: {Observation; Action: {Action: {Action: {Observation: {Observation: {Observation: {Action: {Action:

Please summarize the trajectory about each observation and changes after each action. Wrap the summarization with

Task instruction:
{instruction}
Below is the trajectory to complete the task.
Observation:
{Observation <sub>i</sub> }
Action:
{Action <sub><math>i+1</math></sub> }
Observation:
$\{Observation_{i+1}\}$
Action:
$\{Action_{i+2}\}$
Action:
{Action <sub><math>j-1</math></sub> }
Observation:
$\{Observation_i\}$

Table 35: LLM prompts to filter low-quality data

Here are the criteria to indicate a good pair of the instruction and the trajectory:

1. The instruction and the trajectory are aligned, which means the trajectory successfully accomplishes the goal in the instruction.

2. The trajectory is coherent, indicating that each action is logical based on its previous observation and the actions do not contradict with each other based on the task instruction.

3. The trajectory is natural, meaning that the trajectory closely mimics real-world interactions and a human user would possibly perform it when engaging in the environment.

4. The trajectory is reasonable, indicating that the trajectory finishes the task instruction using a reasonable solution, e.g., not using an over-complicated method, not over-simply the problem, not going back and forth in states, etc.

Please answer yes if the task instruction and the trajectory satisfies all the criteria, otherwise, answer with no.

Table 36: Model inference prompts without external knowledge

SYSTEM MESSAGE: {system message} OBJECTIVE: {task instruction} INTERACTION HISTORY: {interaction history} OBSERVATIONS: {observations}

Your REASONING and ACTION in the format: REASON: Your reason to choose a specific action. ACTION: Your action

#### Table 37: Model inference prompts with external knowledge

SYSTEM MESSAGE: {system message} ADDITIONAL INFORMATION FOR REFERENCE: {external knowledge} OBJECTIVE: {task instruction} INTERACTION HISTORY: {interaction history} OBSERVATIONS: {observations}

Your REASONING and ACTION in the format: REASON: Your reason to choose a specific action. ACTION: Your action

Table 38: Expected model outputs

# REASON:

ACTION:

...

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Table 39: Model prompts to write query for retrieval

SYSTEM MESSAGE: {system message} Here is the final goal we want to achieve: {task instruction} To achieve the goal, we have done the following: {interaction history} Now, we have observed: {observations}

To better finish the task, write a query to ask for useful information, e.g., what kind of examples or interaction history will be helpful to predict the next action.

## Table 40: OSWorld example (filtered)

Instruction

Sum numbers in the first column.

**Observation 0 (Interface of the software LibreOffice Calc)** 

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Action 1

import pyautogui pyautogui.click(543,126) // click Tools.

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#### Table 41: OSWorld example (filtered) cont.

Action 2

import pyautogui pyautogui.click(543,580) // click Solver.

**Observation 2** 

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Action 3

import pyautogui pyautogui.click(772,892) // click Close.

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## Table 42: OSWorld example (filtered) cont.

# Action 4

import pyautogui pyautogui.click(520,126) // click Data.

# **Observation 4**

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# Action 5

import pyautogui pyautogui.moveTo(520,562) // move to Calculate.

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## Table 43: OSWorld example (filtered) cont.

## Action 6

import pyautogui pyautogui.click(498,126) // click Sheet.

# **Observation 6**

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# Action 7

import pyautogui pyautogui.click(152,591) // click cell A4.

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## Table 44: OSWorld example (filtered) cont.

## Action 8

import pyautogui

pyautogui.click(480,302) // click the formula box.

## **Observation 8**

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Action 9

import pyautogui
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# Table 45: OSWorld example (filtered) cont.

## Action 10

import pyautogui pyautogui.press("enter")

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Table 46:	WebArena	example	(filtered)

What are item	s ordered in the	latest can	celled or	ler?		
Observation (	)					
					My Account My Wish List	Sign Out Welcome, Emma Lopezi
	One Stop Market				Search en Advanced Se	stire store here Q. 🦕 3
	Beauty & Personal Care - Sports & Health & Household - Patio, Lawn	Outdoors Clothing, Sho & Garden Electronics	es & Jewelry · Home &	& Kitchen Offic	e Products · Tools & Home	Improvement -
	One Stop Mark	et				
	Product Showcases					
						Coostal P
	Pre-baked Gingerbread House Kit V8 Value Pack, 17 oz., Pack of 2, Total St 34 oz. Bi	+Energy, Healthy Energy Drink eady Energy from Black and een Tea, Pomegranate ueberry, 8 Ounce Can .Pack of :	<li>Elmwood Inn Fine Tea Vanilla Caffeine-free I 16-Ounce Pouch 24</li>	as, Orange Bel Fruit Infusion, Mio Cal	e Of The Ball Princess Sprinkle   Wedding Colorful Sprinkles   e Cupcake Cookle Sprinkles   cream Candy Sprinkles   Yellow	So Delicious Dairy Free CocoWhip Light, Vegan, Non-GMO Project Verified, 9 oz. Tub
	★★★★★ 1 Review \$19.99	★★★★ 12 Reviews	★★★★★ 4 Revie \$19.36	WS Gol Flor	d Red Royal Red Rose Icing vers Decorating Sprinkles, 80Z	★★★★ 12 Reviews \$15.62
	Add to Cart 🗢 🏨	4.47	Add to Cart 🛇	nl. \$23	★★★ 12 Reviews	Add to Cart 🗢 💼
click [4918] // <b>Observation</b> 1	click the button	"Му Асс	ount"			
click [4918] // Observation	click the button	"My Acc	ount"		My Account My Wish List	Sign Out Welcome, Emma Loped
click [4918] // Observation 1	click the button I	"My Acc	ount"		My Account My Wish List Search en	Sign Out Wetcome, Emma Loped thre store hereQ_ \vert
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click [4918] // Observation	One Stop Market Beauty & Personal Care Sports & Health & Household Patio, Lawn A	Untdoors - Clothing Sho	ount" es & Jewelry - Home & Cell Phones & Accesso	k Kitchen - Offic ries - Video Gan	My Account My Wish List Search en Advanced Se Products - Tools & Home es - Grocery & Gournet Fo	Sign Out Welcome, Emma Loped the store here. Q >>> 0 arch Improvement -
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elick [4918] // Observation	Click the button	"My Acc Dutdeers - Clething she A Garden Electronics My Account Information Contact Information Contact Information Emma Logie emma Logiez@gmail.com Gift Charge Passac.com	ount" es & Jewelry - Home & Cell Phones & Accesso Int	a Xitchen - Offici	My Account My Wish List Search en Advanced Se Products - Tools & Home hes - Grocery & Gourmet Fo Newsletters You aren't subscribed to our new Edd	Sign Out Welcome, Emma Loped thre store here. Q > > 0 arch Improvement - ood -
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click [4918] // Observation	Cone Stop Market  One Stop Market  Beauty & Personal Care Sports & Health & Household Products My Orders My Orders My Orders My Wish Lit Address Book Account Information Stored Payment Methods My Mush Lit Compare Products Newsletter Subscriptions Compare Products You have no items to compare. Recently Ordered GRUMPH Aleks. Neuroper Products	"My Accc Dutideers - Clerking She & Garden - Electronics - My Account Information Emma Lope2 emmaJope2@pmil.com Edit Change Passeord Address Book Mana Edit Change Passeord Address Book Mana Electronics - State Sam Marco Or Sam Or	ount" es & jewelry - Home & Cell Phones & Accesso Int ge Addresses	k Kitchen - Offic	My Account My Wish List Search en Advanced Se e Products Tools & Home er of Grocery & Gourmet Po Newsletters Newsletters Default Shipping Address Emina Saine, California, 54010 United Sates En Go0551212 Git Address	Sign Out Wetcome, Emma Loped the store here Q
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## Table 47: WebArena example (filtered) cont.

## Action 2

click [4922] // click the button "My Orders".

# **Observation 2**

				My Account	My Wish List Sign Out Welcome, Emm	a Lopez!
One Stop Market					Search entire store here Q.	
Beauty & Personal Care - Sports & Ou	atdoors - Clothing	, Shoes & Jewelry	Home & Kitchen	Office Products	Tools & Home Improvement	
Health & Household 🕤 🛛 Patio, Lawn & 🕯	Garden Electron	ics Cell Phone	& Accessories	Video Games - Grocery	& Gourmet Food	
My Account My Orders	My Ord	ers				
My Downloadable Products	Order #	Date	Order Total	Status	Action	
My Wish List	000000170	5/17/23	\$365.42	Canceled	View Order Reorder	
Address Book	000000189	5/2/23	\$754.99	Pending	View Order Reorder	
Account Information	000000188	5/2/23	\$2,004.99	Pending	View Order Reorder	
Stored Payment Methods	000000187	5/2/23	\$1,004.99	Pending	View Order Reorder	
My Droduct Devicear	000000180	3/11/23	\$65.32	Complete	View Order Reorder	
Newsletter Subscriptions	000000166	3/10/23	\$17.99	Complete	View Order Reorder	
	000000161	2/27/23	\$762.18	Complete	View Order Reorder	
	000000156	2/24/23	\$231.54	Canceled	View Order Reorder	
	000000158	2/11/23	\$174.99	Canceled	View Order Reorder	
Compare Products	000000157	2/9/23	\$185.32	Complete	View Order Reorder	
You have no items to compare.	h				cham 40 m	
Recently Ordered	items i to io oi s7 t	otal		1234 7	show 10 • p	er bage
NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom						
Uttermost Volterra Crackled Taupe- Gray Ceramic Table Lamp						
Plus Size Lingerie for Women Sexy for						

# Action 3

click [6357] // click the button "View Order".

	My Acc	ount My Wish Li	st Sign Out	Welcome,	Emma Lopezi		
One Stop Market		Search entire store here Q y 🗃 🚺					
Beauty & Personal Care - Sports & O	Outdoors - Clothing, Shoes & Jewelry - Home & Kitchen - Office Products	Tools & Hor	ne Improver	nent -			
Health & Household 🚽 🛛 Patio, Lawn 8	k Garden - Electronics - Cell Phones & Accessories - Video Games - G	rocery & Gourme	t Food				
My Account My Orders My Downloadable Products My Block Let	Order # 000000170						
Address Book	Reorder Items Ordered				Print Order		
Account Information Stored Payment Methods	Items Ordered						
My Product Reviews	Product Name	SKU	Price	Qty	Subtotal		
Newsletter Subscriptions	NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cut, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom	B08JLHHCM6	\$40.99	Ordered: 1	\$40.99		
Compare Products	Plus Size Lingerie for Women Sexy for Sex Naughty Eyelash Lace Bodysuit Naughty Mesh One Piece Teddy Bodysuit Outfits	B09LQTV3RX	\$58.63	Ordered: 1	\$58.63		
You have no items to compare.	Color Blue						
Recently Ordered	Size						
NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup. Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom	un ge		Shippin	Subtotal g & Handling	\$350.42 \$15.00		
Uttermost Volterra Crackled Taupe- Gray Ceramic Table Lamp				Grand Total	\$365.42		
Plus Size Lingerie for Women Sexy for							

## Table 48: WebArena example (filtered) cont.

## Action 4

click [4922] // click the button "My Orders".

## **Observation 4**

				My Account	My Wish List Sign Out Welcome,	Emma Lopezi	
One Stop Market					Search entire store here Q Advanced Search	) 🚃	
Beauty & Personal Care - Sports & Ou	atdoors - Clothing,	Shoes & Jewelry	Home & Kitchen	Office Products	Tools & Home Improvement		
Health & Household Patio, Lawn &	Garden Electronic	Cell Phone:	& Accessories	Video Games Grocery	& Gourmet Food		
My Account My Orders	My Orde	ers					
My Downloadable Products	Order #	Date	Order Total	Status	Action		
My Wish List	000000170	5/17/23	\$365.42	Canceled	View Order Reorder		
Address Book	000000189	5/2/23	\$754.99	Pending	View Order Reorder		
Account Information	00000188	5/2/23	\$2,004.99	Pending	View Order Reorder		
Stored Payment Methods	000000187	5/2/23	\$1,004.99	Pending	View Order Reorder		
My Droduct Devicear	000000180	3/11/23	\$65.32	Complete	View Order Reorder		
Newsletter Subscriptions	000000166	3/10/23	\$17.99	Complete	View Order Reorder		
	000000161	2/27/23	\$762.18	Complete	View Order Reorder		
	000000156	2/24/23	\$231.54	Canceled	View Order Reorder		
	000000158	2/11/23	\$174.99	Canceled	View Order Reorder		
Compare Products	000000157	2/9/23	\$185.32	Complete	View Order Reorder		
You have no items to compare.							
Recently Ordered	Items 1 to 10 of 37 to	tal		1 2 3 4 >	Show 10	<ul> <li>per page</li> </ul>	
NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom							
Uttermost Volterra Crackled Taupe- Gray Ceramic Table Lamp							
Plus Size Lingerie for Women Sexy for							

# Action 5

click [6357] // click the button "View Order".

		,	-		
One Stop Market				e here Q	`₩ 3
Description Descriptions of Country of	And an all the first fronter three for the second	Advanced	d Search		
Beauty & Personal Care - Sports e	Outdoors - Clotning, snoes & Jeweiry - Home & Altonen - Office Products	100IS & HOI	me improve	nent -	
Health & Household 🕤 Patio, Lawr	& Garden - Electronics - Cell Phones & Accessories - Video Games - Gr	rocery & Gourme	t Food		
My Account	Order # 000000170				
My Downloadable Products My Wish List	Canceled Order Date: May 17, 2023				
Address Book	Reorder				Print Order
Account Information	Items Ordered				
Stored Payment Methods	Items Ordered				
My Product Reviews	Product Name	SKU	Price	Qty	Subtotal
Newsletter Subscriptions	Uttermost Volterra Crackled Taupe-Gray Ceramic Table Lamp	B087QSCXGT	\$250.80	Ordered: 1	\$250.80
	NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom	B08JLHHCM6	\$40.99	Ordered: 1	\$40.99
Compare Products	Plus Size Lingerie for Women Sexy for Sex Naughty Eyelash Lace Bodysuit Naughty Mach One Direct Teddy Rodewill Outfile	B09LQTV3RX	\$58.63	Ordered: 1	\$58.63
You have no items to compare.	Color Blue				
Recently Ordered	Size				
NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holdir Solid Wooden Shelf with 2 Baskets fo Kitchen Living Room, Bathroom and			Shipoir	Subtotal	\$350.42
Bedroom <ul> <li>Uttermost Volterra Crackled Taupe-</li> </ul>			Subbu	Grand Total	\$365.42
Gray Ceramic Table Lamp					

## Table 49: WebArena example (filtered) cont.

## Action 6

click [4922] // click the button "My Orders".

## **Observation 6**

One Stop Market					Search entire store here Q 🎽 🙀	I.
					Advanced Search	
8eauty & Personal Care - Sports & O	utdoors Clothing,	Shoes & Jewelry	Home & Kitchen	Office Products	Tools & Home Improvement	
Health & Housebold Patio Lawn &	Garden Electronic	Cell Phone	& Accessories Vide	o Games - Grocero	& Gourmet Food	
,				,		
Mu Account	My Orde	ars				
My Account	ivity or at					
My Downloadable Products	Order #	Date	Order Total	Status	Action	
My Wish List	000000170	5/17/23	\$365.42	Canceled	View Order Reorder	
Address Deels	000000189	5/2/23	\$754.99	Pending	View Order Reorder	
Address Book	000000188	5/2/23	\$2.004.99	Pending	View Order Reorder	
Stored Payment Methods	000000187	5/2/23	\$1.004.99	Pending	View Order Reorder	
	000000180	3/11/23	\$65.32	Complete	View Order Reorder	
My Product Reviews	000000166	3/10/23	\$17.99	Complete	View Order Reorder	
Newsletter Subscriptions	000000161	2/27/23	\$762.18	Complete	View Order Reorder	
	000000156	2/24/23	\$231.54	Canceled	View Order Reorder	
	000000158	2/11/23	\$174.99	Canceled	View Order Reorder	
Compare Products	000000157	2/9/23	\$185.32	Complete	View Order Reorder	
'ou have no items to compare.						
Recently Ordered	Items 1 to 10 of 37 to	tai	12	34 >	show 10 v per pag	3
NOZE ustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom						
Uttermost Volterra Crackled Taupe-						

# Action 7

click [6357] // click the button "View Order".

		My Acc	count My Wish Li	st Sign Out	Welcome,	Emma Lopez!			
	One Stop Market		Search entire store here Q 🦉 📜						
	Beauty & Personal Care - Sports & Ou	tdoors - Clothing, Shoes & Jewelry - Home & Kitchen - Office Products	s · Tools & Hor	ne Improver	nent -				
	Health & Household Patio, Lawn & G	arden - Electronics - Cell Phones & Accessories - Video Games - G	Frocery & Gourme	t Food					
	My Account My Orders My Downloadable Products My Wish List	Order # 000000170	Print Order	Print Printer					
	Address Book	Items Ordered							
Account Information Stored Payment Methods	Account Information Stored Payment Methods	Items Ordered							
	My Product Reviews	Product Name	SKU	Price	Qty	Subtotal			
	Newsletter Subscriptions	Uttermost Volterra Crackled Taupe-Gray Ceramic Table Lamp	B087QSCXGT	\$250.80	Ordered: 1	\$250.80			
		NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom	B08JLHHCM6	\$40.99	Ordered: 1	\$40.99			
	Compare Products	Plus Size Lingerie for Women Sexy for Sex Naughty Eyelash Lace Bodysuit Naughty Mesh One Piece Teddy Bodysuit Outfits	B09LQTV3RX	\$58.63	Ordered: 1	\$58.63			
	You have no items to compare.	Color Blue							
	Recently Ordered	Size							
	NOZE Rustic Coat Rack Wall Mounted Shelf with 4 Hooks, Hanging Entryway Organizer for Mug Coffee Cup, Holding Solid Wooden Shelf with 2 Baskets for Kitchen Living Room, Bathroom and Bedroom			Shippin	Subtotal g & Handling Grand Total	\$350.42 \$15.00 \$365.42			
	Gray Ceramic Table Lamp  Plus Size Lingerie for Women Sexy for								