Rethinking OS Interfaces for LLM Agents

Yuan Wang[*◊†] , Mingyu Li[*◊] , Haibo Chen[*◊‡]
[*]Key Laboratory of System Software (Chinese Academy of Sciences)
[◊]Institute of Software, Chinese Academy of Sciences
[‡]Shanghai Jiao Tong University
[†]University of Chinese Academy of Sciences

This is a condensed version of “From Imperative to Declarative: Towards LLM-friendly OS Interfaces for Boosted Computer-Use Agents,” to appear in EuroSys 2026.

Computer-Use Agent (CUA)

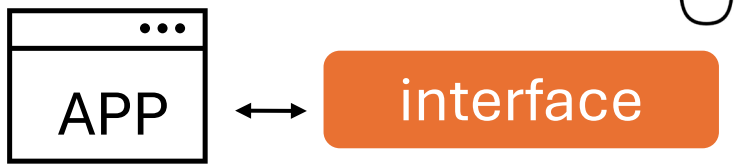
Vision:
complete tasks automatically
free human labor

OpenAI ANTHROP\C UI-TARS manus

OpenClaw

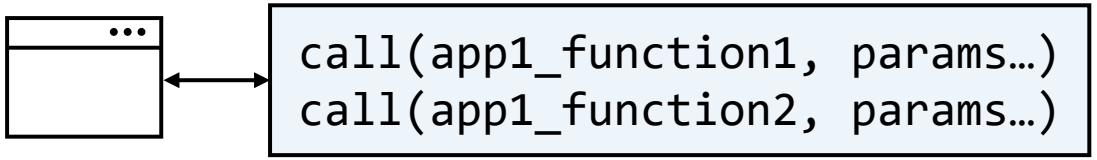
Computer-Use Agent (CUA)

require interfaces to interact with applications



API

reliable and efficient



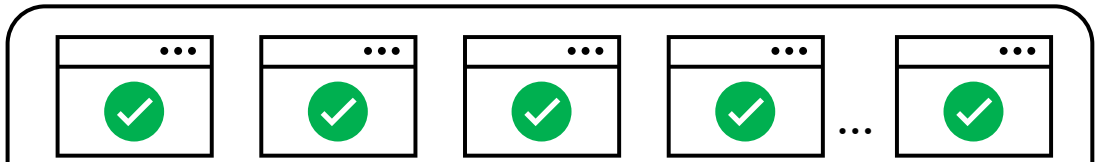
limited generality

We **cannot** use most applications through APIs

most apps w/o public APIs

GUI

dominant and universal



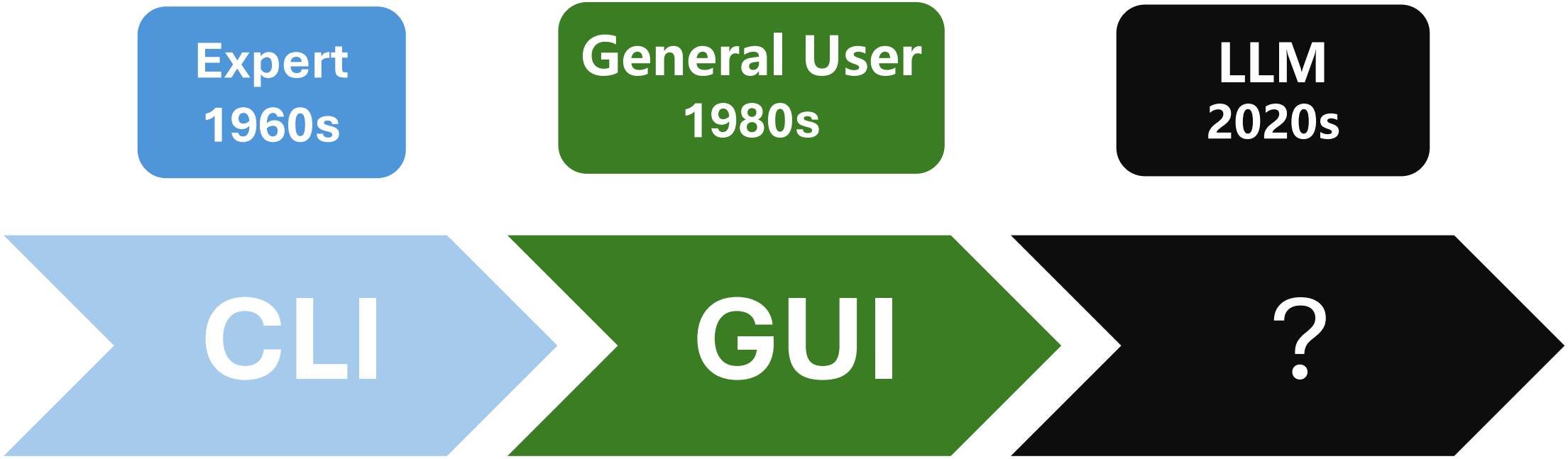
most apps w/ GUIs

long sequence of actions

visual perception

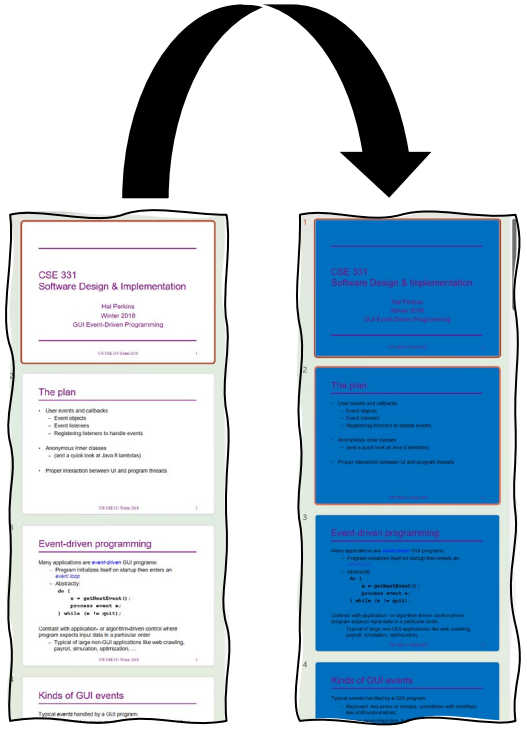
observe and **do action** 1 -> **observe** and **do action** 2 ->
observe and **do action** 3 -> **observe** and **do action** 4 ->
.....

What is a good OS interface for LLMs?



Imperative GUI design： Navigation

To navigate through menus, dropdowns, dialogs to make target control visible



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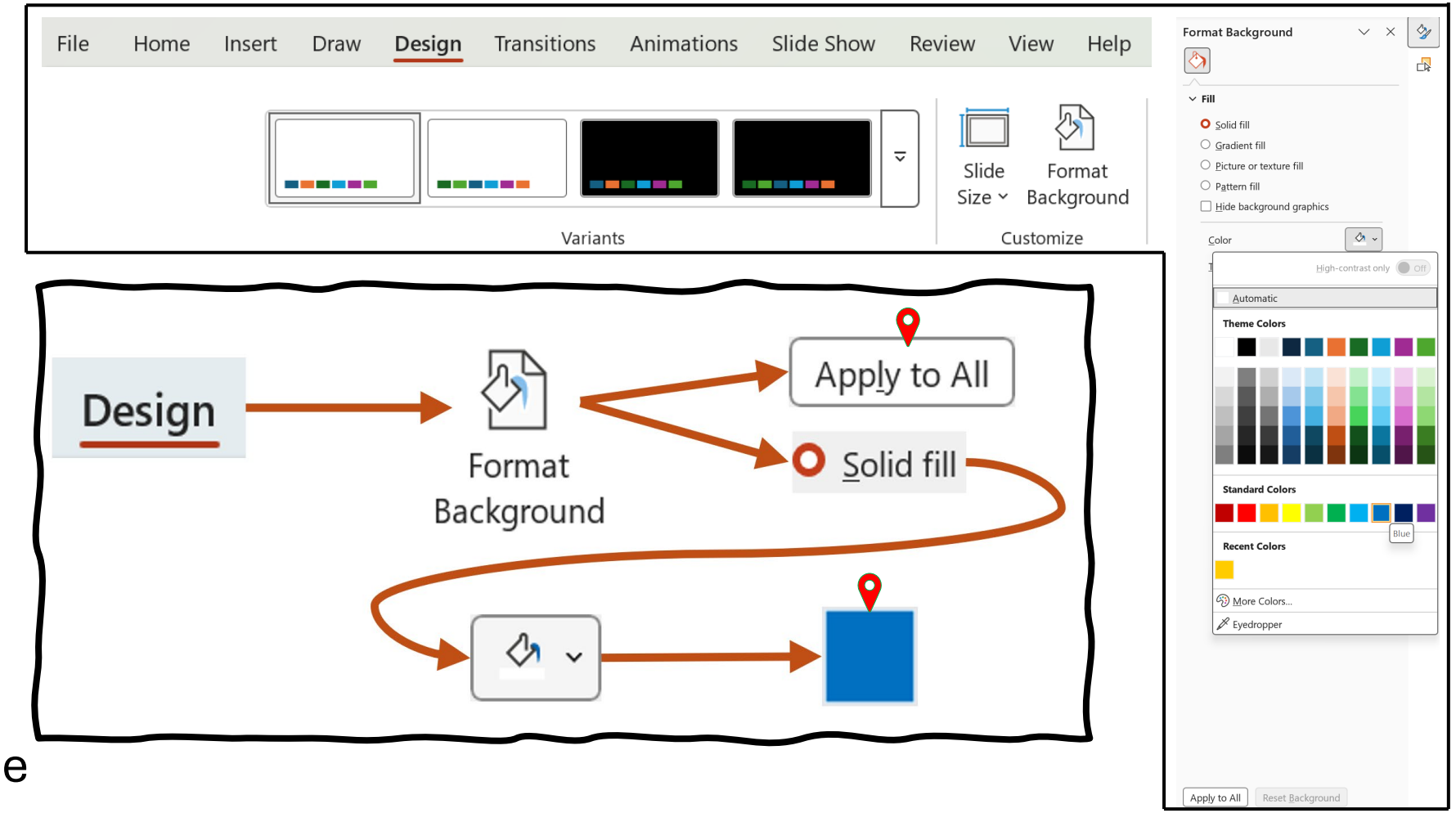
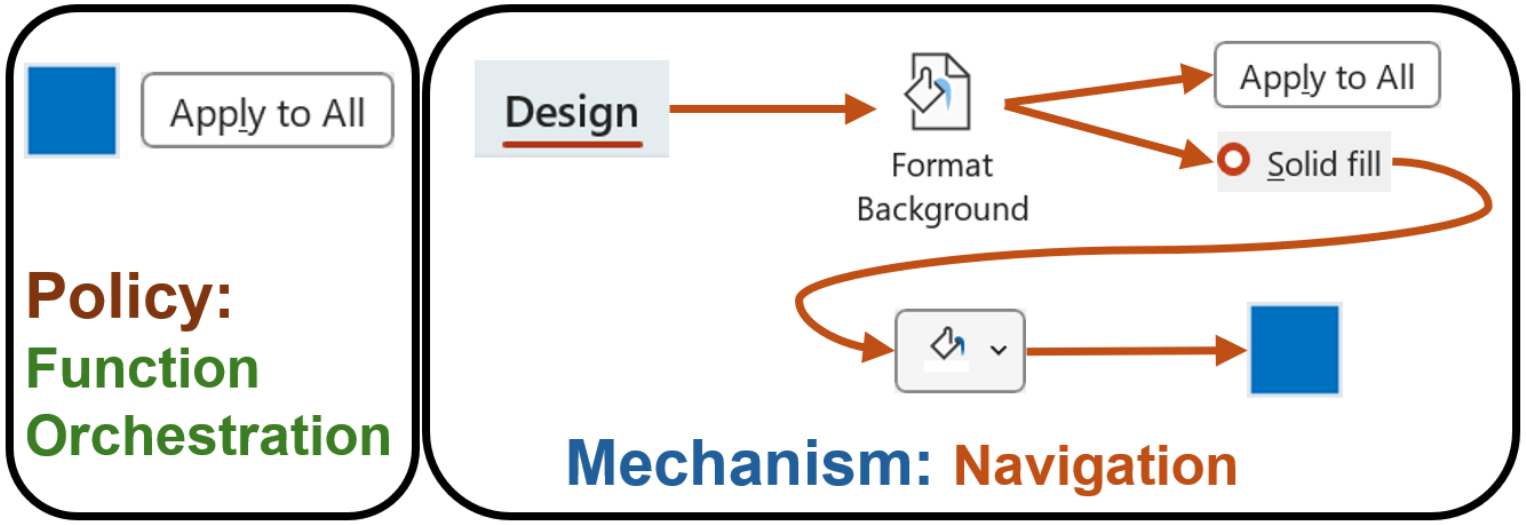


Imperative GUI design： Interaction

To trigger a function

a simple click, and complex interactions

Imperative GUI problem: Policy-Mechanism Coupling



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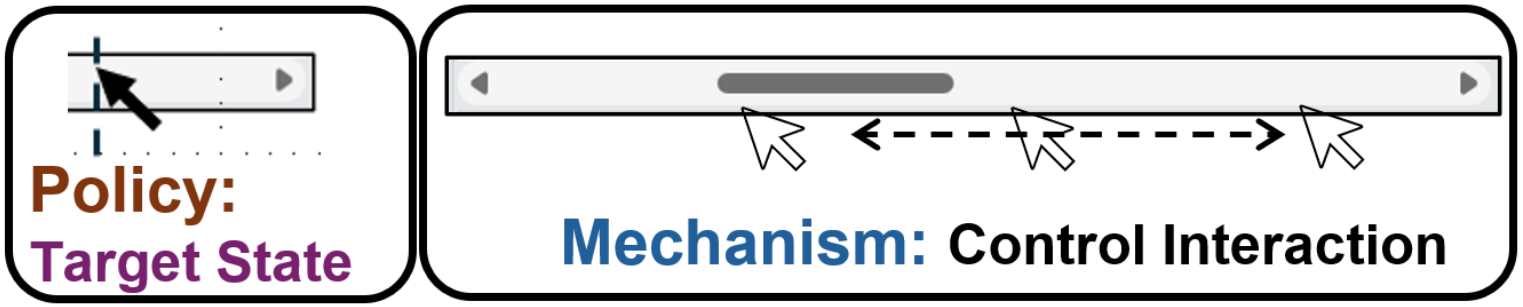
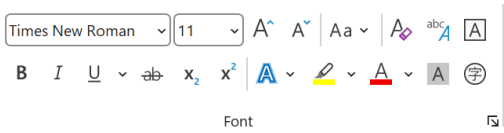
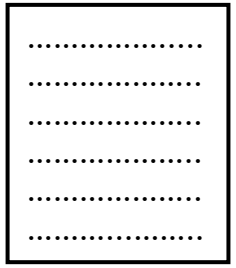
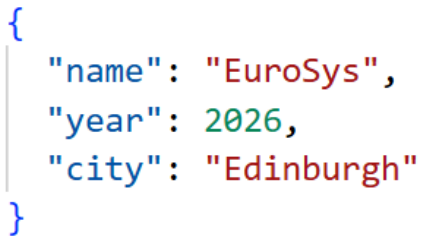
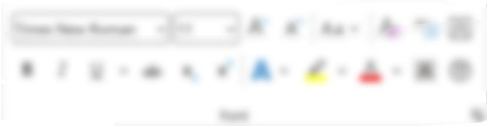


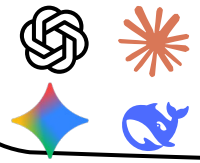
show the area close to the end.

Mismatch #1: Procedural *navigation*

hierarchical **navigation**, **limited** set of choices for each step

Memory Size	Syntax Recall	Visual Recognition
... 5 – 20 options	command names? structured output? programming?	
 1M tokens		

LLM



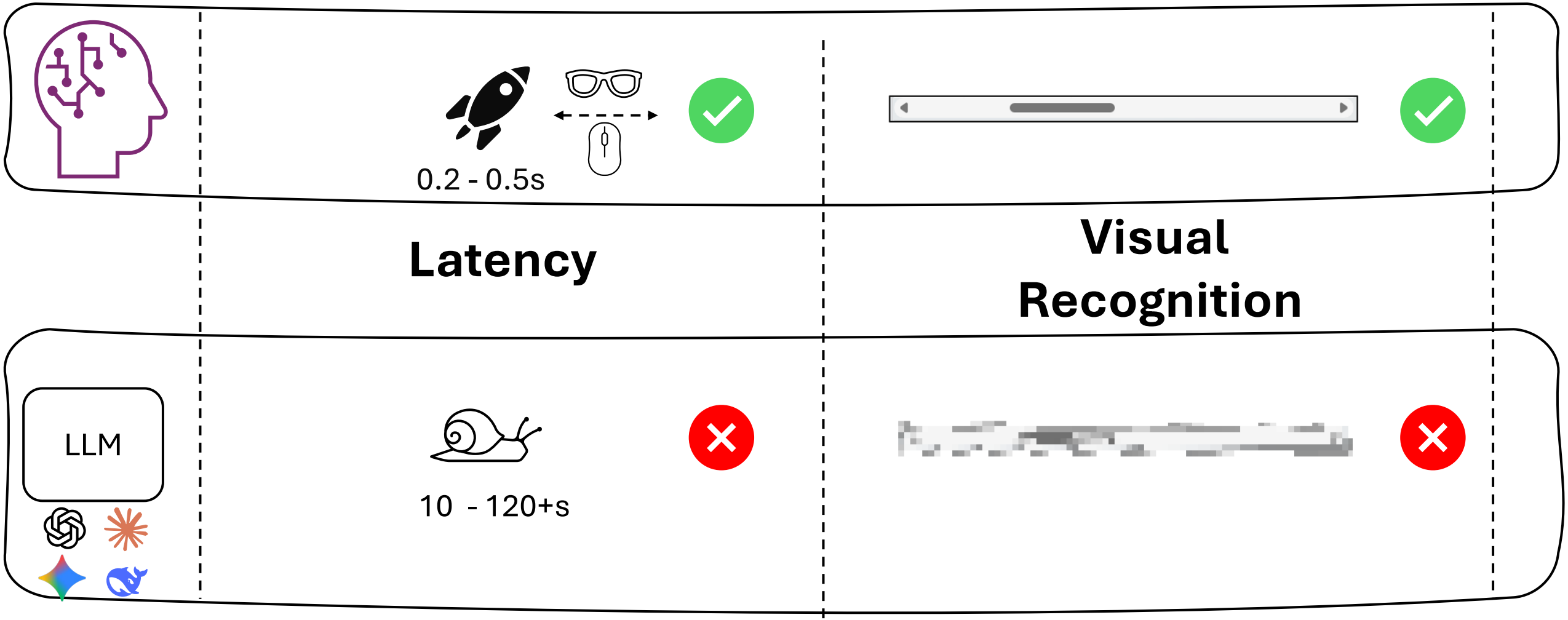
Mismatch #1: Procedural *navigation*

LLM's view:

GUI navigation requires long, fine-grained sequence of actions.
Success Rate: 0.7 x 0.7 x 0.7 x 0.7 x 0.7 x 0.7 x … 😭

Mismatch #2: Iterative *interaction*

“observe-act” loop to interact with UI controls



Mismatch #2: Iterative *interaction*

LLM's view:

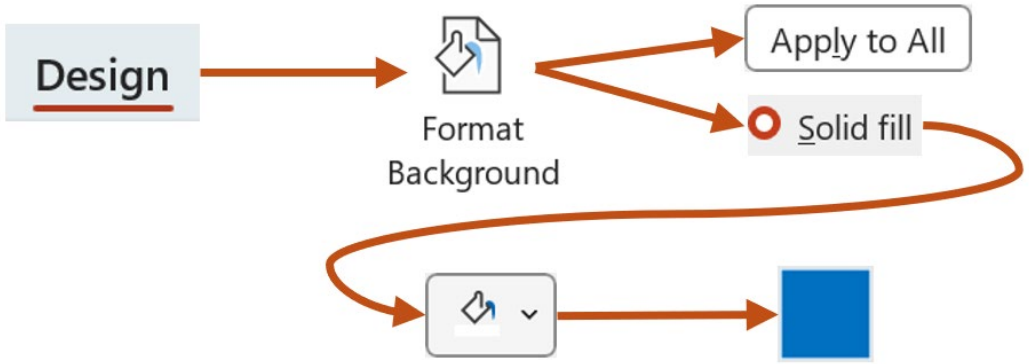
GUI interaction incurs substantial latency/token cost overhead & low success rate. 😭

How should OSes evolve interfaces for LLM agents?

Insight

much of the mechanism (navigation & interaction) is deterministic and can be resolved algorithmically without LLM involvement

1. Deterministic navigation

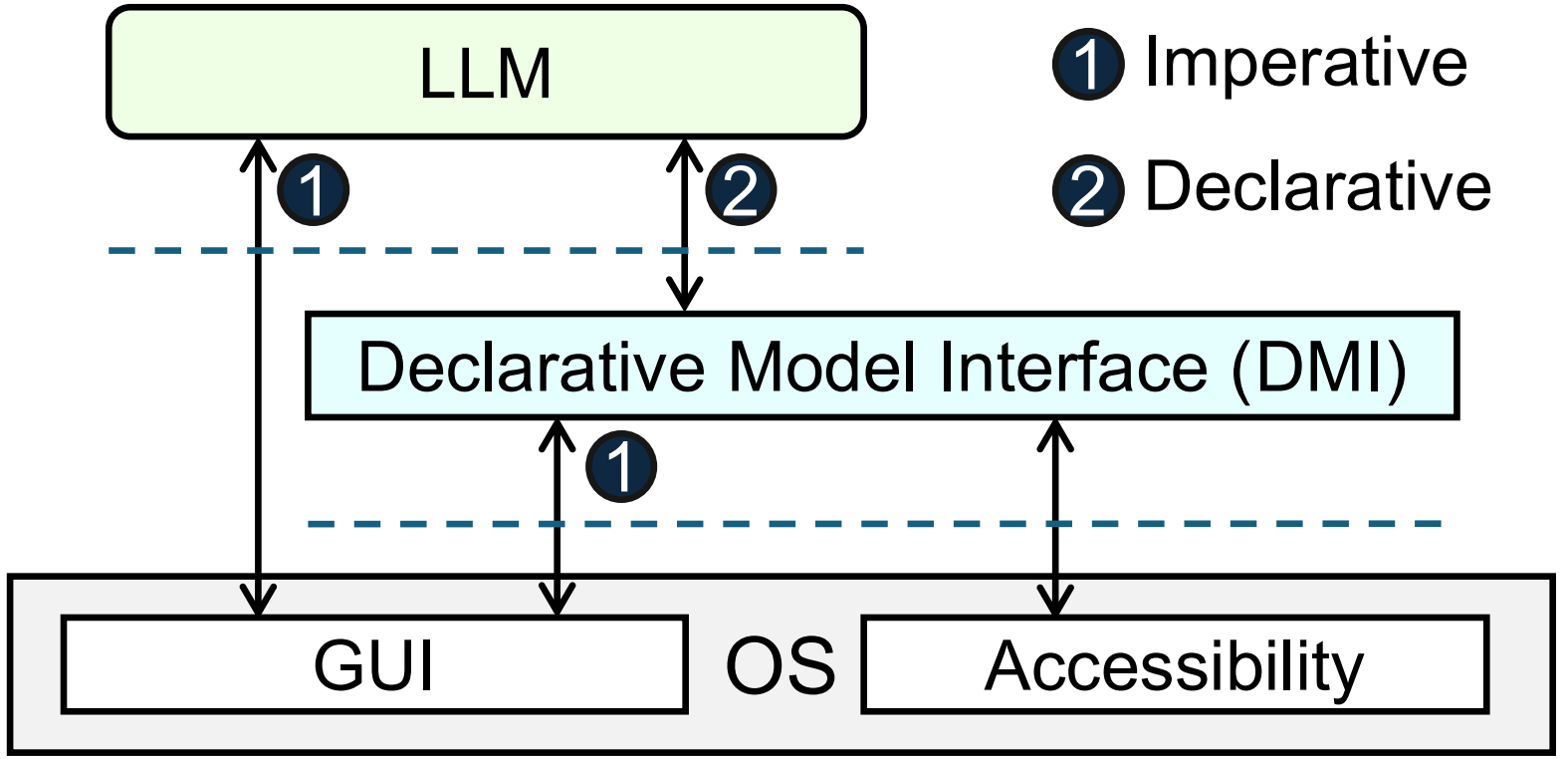


2. Finite interaction operations (UI Automation)

- 41 control types (e.g., Button, ListItem, Edit)
- 34 control patterns (e.g., TextPattern, ScrollPattern, SelectionPattern)

Solution : abstraction

Policy-Mechanism decoupling



Instead of forcing the LLM to operate the GUI imperatively, we introduce a higher-level abstraction that separates **policy** from **mechanism**.

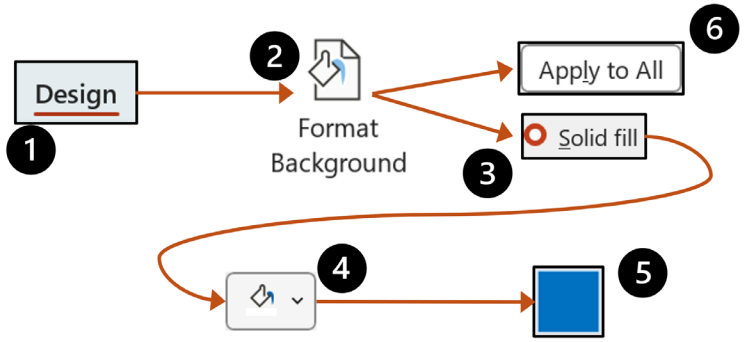
Primitive: Access

abstract away **navigation**

access | *visit(["leaf_node_id1",...)] ...*

make the background blue on all slides.

Task	GUI	DMI
1	click("Design") → click("Format Background") → click("Solid fill") → click("Fill Color") → click("Blue") → click("Apply to All")	visit(["Blue", "Apply to All"])



Just declare what to do:

Use "Blue", "Apply to All"

Primitive: State & Observation

abstract away **interaction**: **stateful representation**

`state` *set_scrollbar_pos(); select_controls(); select_lines(); …*

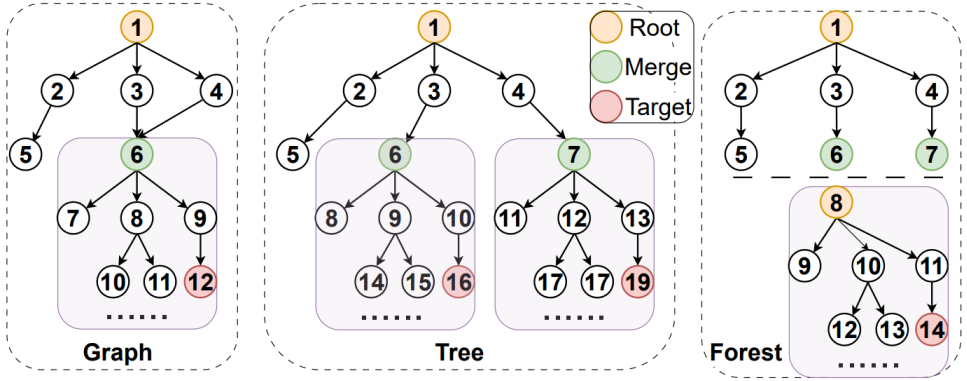
`observation` *get_texts(); …*

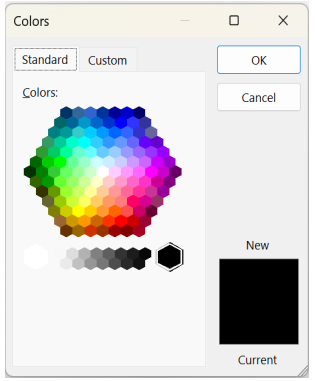
state declaration and observation declaration interfaces. UIA defines **34 control patterns** in total. These interfaces are extensible. For example, set_texts builds on TextPattern, set_toggle_state builds on TogglePattern, and set_expanded/set_collapsed builds on ExpandCollapsePattern.

Interface	Control Pattern	Description
set_scrollbar_pos	Scroll	Set scrollbar position to x%
select_lines	Text	Select one or contiguous lines
select_paragraphs	Text	Select one paragraph or a contiguous paragraph range
select_controls	Select	Support single or multiple selection
get_texts	Text & Value	Retrieve a control's text

Challenge

- navigation path ambiguity
- Limited LLM context windows
- Inaccurate long-horizon planning





Solution

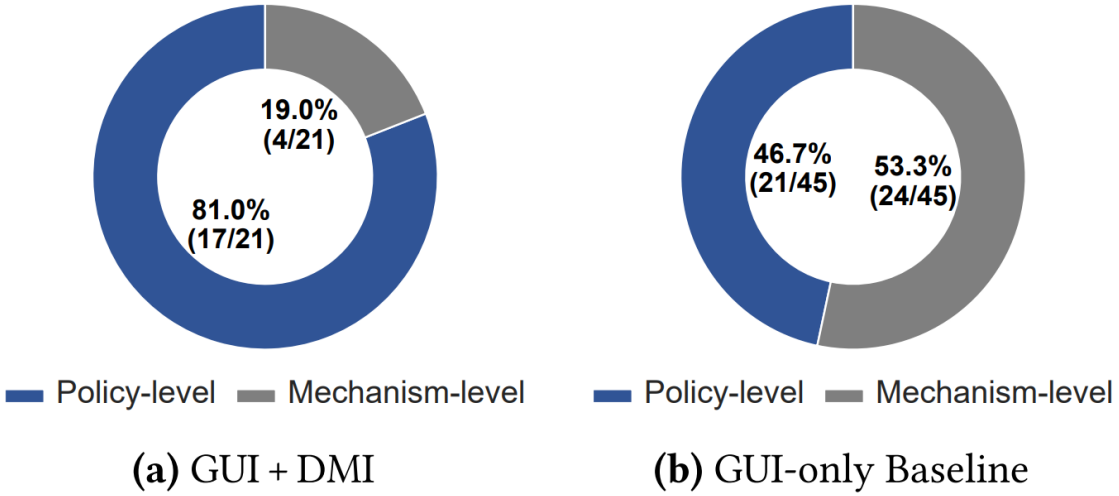
- path-unambiguous topology
- forest (a main tree and subtrees)
- query on-demand
- filtering, fuzzy match, fast-path/slow-path

Evaluation

Improvements over several model settings and tasks.

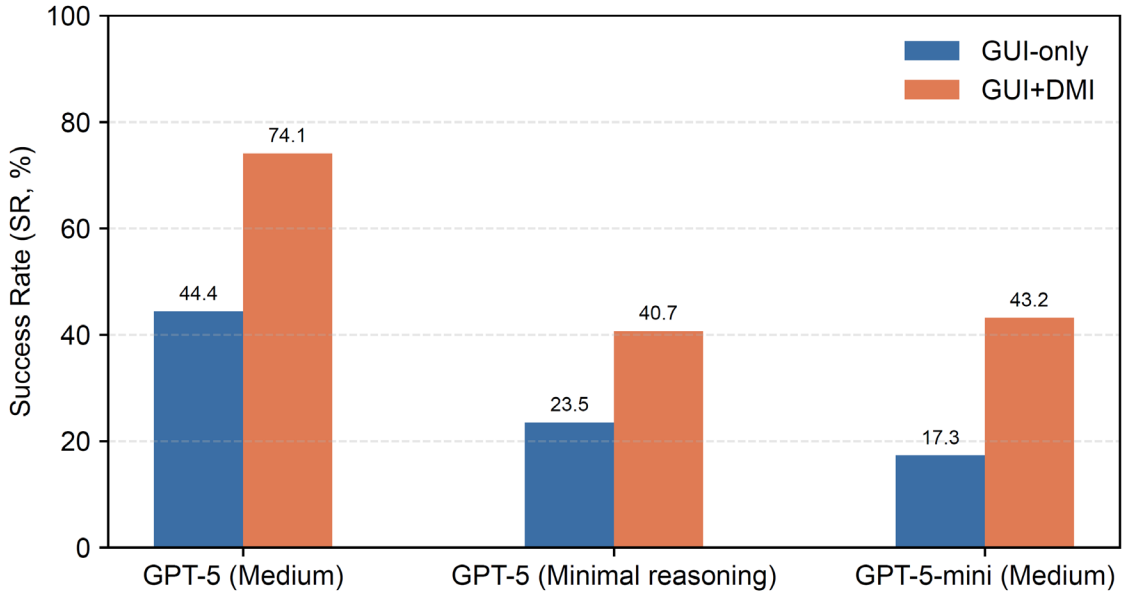
1. success rate: 44.4% to 74.1%.

2. 61% successful cases: only **one** LLM call.

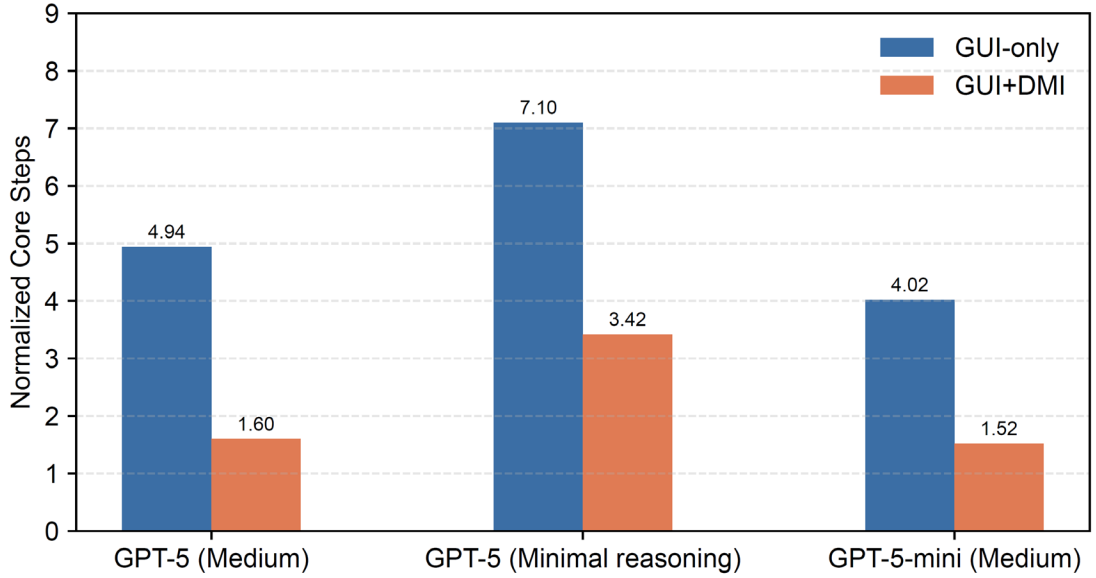


(a) GUI + DMI **(b)** GUI-only Baseline

DMI cuts out mechanism-related errors (navigation and composite interaction) and re-centers policy



(a) Success Rate



(b) Normalized Core steps

Benchmark: OSWorld-W(windows), Word, Excel, PowerPoint

Summary

We introduce DMI, an abstraction that decouples policy from mechanism by reducing complex GUI operations to declarative primitives.

DMI does **not** require modifying or accessing the application source code or relying on application programming interfaces (APIs).

DMI enables API-like declarative interactions for GUI applications.

Thanks!