KNOWACT-GUICLAW: KNOW DEEPLY, ACT PERFECTLY, PERSONAL GUI ASSISTANT WITH SELF-EVOLVING MEMORY AND SKILL

Anonymous authors
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ABSTRACT

OpenClaw has emerged as a leading agent framework for complex task automation, yet its variants face two core bottlenecks: insufficient cross-platform GUI interaction support and no built-in self-evolution mechanism. We propose the "**Know Deeply, Act Perfectly**" paradigm, in which accumulated human–machine interaction and task-running experience improve execution accuracy and efficiency. Based on this paradigm, we introduce **KnowAct-GUIClaw**, a Know–Route–Act–Reflect framework that pairs a host agent for knowledge-grounded, long-horizon task decomposition with a pluggable GUI subagent equipped with experience-attributable memory and a self-evolving skill library. User profiles and feedback guide task decomposition and tool calls, while validated skills enable fast-path execution. Experiments across Android, iOS, HarmonyOS, and Windows examine manipulation efficiency, accuracy, and cross-platform adaptability. On the 117-task MobileWorld GUI-Only benchmark, the Kimi-K2.6 configuration achieves 64.1% pass@1, exceeding the compared systems, including Seed-2.0-Pro and GPT-5.5. Memory and skills support gains of 8.5 percentage points with Kimi-K2.6 and 16.2 points with Qwen3.5-35B-A3B, the latter using Kimi-derived experience.

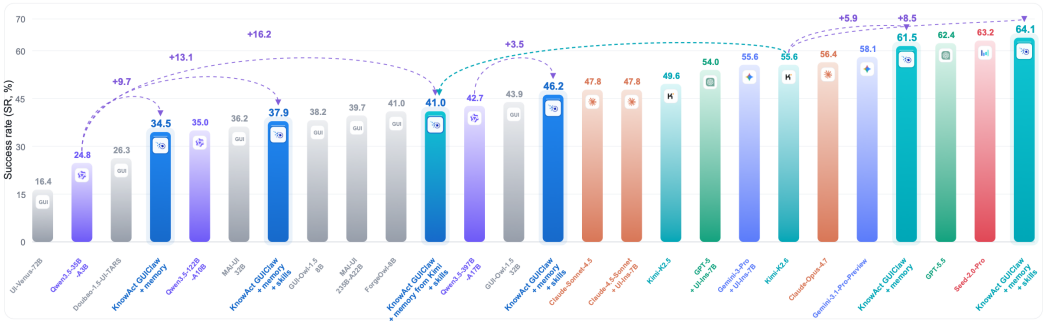

Figure 1: MobileWorld GUI-Only success rates. KnowAct-GUIClaw augments Qwen3.5 and Kimi-K2.6 with host orchestration, memory, and skills; detailed configurations and results appear in Table 1.

1 INTRODUCTION

Large language model (LLM) agents are transitioning from one-off dialogue bots to stateful, long-running personal assistants. They preserve persistent workspace state, invoke external tools, coordinate auxiliary subagents, and resume interrupted workflows. ReAct-based agents unify reasoning and environmental action execution (Yao et al., 2023), while general autonomous agent frameworks modularize planning, memory, tools, and multi-agent dialogue (Zhou et al., 2023). OpenClaw, Nanobot, and Hermes integrate these designs into local-first assistant platforms with channel routing, tool extensions, configurable skills, session persistence, and structured memory (OpenClaw Contributors, 2026; HKUDS, 2026; Nous Research, 2026). As capable autonomous personal assistants, these

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platforms autonomously decompose and fulfil complex user objectives through targeted external tool calls.

However, numerous real-world user tasks demand interaction with graphical user interfaces (GUIs), rather than standardized application programming interfaces (APIs). A personal assistant may need to inspect mobile applications, migrate data across apps, handle permission dialogues, or execute workflows within login-protected environments. Benchmarks spanning web, mobile, and desktop platforms indicate that GUI manipulation demands visual grounding, sequential decision-making, and resilient execution amid shifting interface states (Deng et al., 2023; Zhou et al., 2024; Koh et al., 2024; Xie et al., 2024; Rawles et al., 2025; Li et al., 2026). Dedicated GUI agents have advanced screenshot-grounded action generation (Zhang et al., 2023; Wang et al., 2024; Qin et al., 2025; Xu et al., 2025). Hence, *a natural research question arises: how can we endow OpenClaw-style agents with the ability to efficiently interact with visual graphical environments?*

A straightforward approach is to integrate a standalone GUI agent into the OpenClaw framework. For long-horizon personal assistant tasks, this approach suffers from four drawbacks. *Firstly*, high-level instructions span multiple applications: free-text summaries may lose intermediate values, while rigid app labels for vague tasks can cause app-allocation hallucinations. *Secondly*, GUI observations are incomplete: screenshots, accessibility trees, foreground app IDs, and action histories each reveal only fragments of the device state, requiring historical evidence and host guidance. *Thirdly*, successful and failed trajectories are typically discarded, forcing analogous tasks to repeat navigation and re-learn shortcuts and failure patterns. *Finally*, most GUI workflows do not integrate faster non-visual paths such as web search, Android deeplinks, intents, and predefined action sequences; these cannot become reliable long-term skills without validation against the current interface.

This work presents KNOWACT-GUICLAW, an agent framework augmented with structured knowledge and executable skills, built upon an OpenClaw-style host runtime and GUI-centric execution engine. It comprises an attribution policy-enhanced personalized memory system and a self-evolving skill library. The design follows a simple principle: *Know Deeply, Act Perfectly*. Before acting, the agent retrieves task-relevant app candidates, tools, policies, and GUI hints. During action, it records structured trajectory evidence; after action, it converts useful traces into skills or generalized memory. The host owns conversation, workspace memory, user profiles, external tools, and orchestration, deciding *what* to do; the GUI executor owns perception, action normalization, device backends, skill validation, and trajectory recording, deciding *how* to carry it out. The system invokes GUI control when visual interaction is required and reuses validated skills and fast tools whenever possible.

On this foundation, KNOWACT-GUICLAW contributes four connected mechanisms.

Two-tier host–executor collaboration. A structured, resumable GUI task interface returns completion status, progress, and resumption cues. Partial or blocked runs become checkpoints, while the host directly handles eligible information-gathering subtasks with tools to reduce delegation overhead.

Memory-grounded routing and information transfer. The router distinguishes single-app tasks from cross-app workflows. Each subtask declares its inputs and outputs; a temporary blackboard transfers these structured values, while routing memory supplies candidate apps and context.

Knowledge- and skill-augmented GUI execution. KNOWACT-GUICLAW distills trajectories into parameterized, state-validated skills, letting the executor select a reusable action prefix as one decision. The same abstraction covers click-then-type patterns and Android deeplink and intent shortcuts whose launch behavior and target page satisfy the skill's contract.

Trajectory-derived memory and skill evolution. Reflection summarizes traces, distills success and failure lessons into retrievable memory, and refines skills. This knowledge feeds routing before decomposition and the executor during interaction, closing the loop from past runs to future decisions.

Experiments demonstrate strong MobileWorld performance, cross-platform deployment, and memory and skill transfer.

2 RELATED WORK

Personal Assistant Agent. ReAct, the Agents framework, and OS-Copilot pair language models with action interfaces, memory, and control loops (Yao et al., 2023; Zhou et al., 2023; Wu et al.,

2024a). OpenClaw and Nanobot expose channels, tools, session state, memory, and user-authored skills as declarable components (OpenClaw Contributors, 2026; HKUDS, 2026). Hermes instead foregrounds adaptation through reusable routines distilled from prior interactions (Nous Research, 2026). Both directions treat control logic, memory, tools, and history as managed state around the model.

GUI Agents. GUI and computer-use agents study how language models act through visual interfaces rather than clean APIs. Mind2Web, WebArena, and VisualWebArena expose long-horizon navigation and visually grounded decision-making over realistic sites (Deng et al., 2023; Zhou et al., 2024; Koh et al., 2024). AndroidWorld provides dynamic, programmatically checked tasks, while OSWorld and OmniACT cover broader desktop and web settings (Rawles et al., 2025; Xie et al., 2024; Kapoor et al., 2024). Model-centric systems such as CogAgent, OS-Atlas, ShowUI, UI-TARS, and Aguvis further improve perception, grounding, and visual action generation (Hong et al., 2024; Wu et al., 2024b; Lin et al., 2024; Qin et al., 2025; Xu et al., 2025). These works have substantially improved GUI task execution; their primary focus is often on task completion within benchmarked interaction environments.

Memory and Skill Reuse. Agents improve without weight updates through verbal feedback in Reflexion (Shinn et al., 2023), reflective memory in Generative Agents (Park et al., 2023), and executable skills in Voyager (Wang et al., 2023). ReasoningBank distills success and failure rationales into reusable memory (Ouyang et al., 2026); LearnAct and CUA-Skill explore knowledge and skill reuse for GUI agents (Liu et al., 2025; Chen et al., 2026). A recent survey frames memory as a write–manage–read loop coupled with perception and action (Du, 2026). Memory preserves guidance and context, whereas skills compress procedures into reusable behavior.

3 KnowAct-GUIClaw

Recent mobile-agent systems and benchmarks point to three requirements: hybrid GUI–shortcut action spaces improve efficiency when shortcuts are available (Zhao et al., 2026); perception, memory, and action work as one execution stack (Ren et al., 2026); and a GUI-agent framework should learn from the execution trajectories (Tang et al., 2026). KnowAct-GUIClaw organizes new long-horizon task execution as a four-stage loop: *Know*, *Route*, *Act*, and *Reflect*. Figure 2 summarizes this loop and the persistent stores that feed every stage.

GUI execution should serve as a subagent within the personal user assistant framework, specifically to address scenarios where no standardized API endpoints are available and graphical interfaces are dynamically rendered in real time. Accordingly, the GUI task interface acts as the formal boundary between the host agent and the UI subagent. Each GUI task returns a structured output consisting of three components: its completion status, a concise execution summary, and the final screen state upon task termination. The host agent retains responsibility for user-facing task orchestration and long-horizon context maintenance, while the GUI subagent operates as a self-contained engine dedicated to low-level device control.

3.1 Know: Context Gathering and Host Control

Active retrieval and policy injection. Before any GUI action, the Know stage gathers most of its context actively: prior GUI memories and candidate skills are retrieved by semantic similarity and kept advisory, never overriding the current instruction, while policy memory is injected directly rather than ranked. Figure 4 illustrates this advisory role on a Mastodon task: the retrieved lesson redirects the task from unsupported mobile-app settings to the web administration panel without replaying an old trajectory.

Host-held context and active recall. The host agent keeps the running session context and forwards only what a GUI task needs when it issues that task, and it recalls its own stored memories, such as session history, agent memory, and the user profile, only when it judges them relevant. When the inputting instruction is fuzzy, it draws on these memories to propose defaults as explicit, overridable assumptions. *This capability is critical for an agentic assistant to achieve continuous capability improvement when deployed across mobile and desktop platforms.*

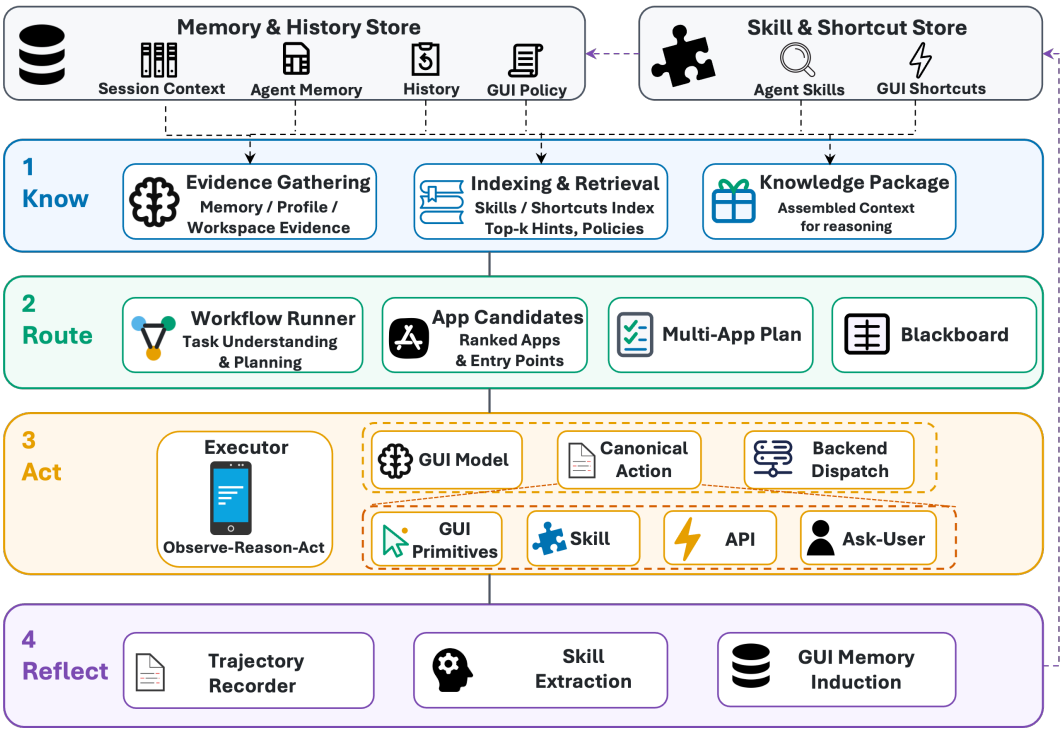

Figure 2: **Overview of the KnowAct-GUIClaw execution loop**. Persistent memory and skill stores inform context gathering (Know), app-scoped decomposition with typed information transfer (Route), grounded hybrid-action execution (Act), and trajectory distillation into reusable lessons and procedures (Reflect).

Host-centric Control. The host agent delegates selectively. It answers a subtask itself when conversation context, recalled memory, or non-GUI tools suffice and no device-local GUI state must be observed or changed, and it issues a GUI task only when the subtask needs a live app session, visual grounding, cross-app manipulation, text entry, or on-device verification. Resolving eligible subtasks directly reduces hand-offs and token-heavy GUI traces.

3.2 Route: Task Decomposition and Information Contracts

Task decomposition. The routing policy emits either a single GUI task or an ordered multi-app workflow. In the multi-app case, each subtask is a goal-level tuple (g_i, h_i, I_i, O_i): g_i is the app-scoped goal, h_i optionally narrows the app, I_i names the inputs it requires, and O_i names the values it should return. The router does not predict screen sequences. Because each subtask has its corresponding app, the relevant memory and skills are retrieved afresh for that subtask rather than inherited from the top-level route.

Information transfer. The blackboard makes cross-app data flow explicit. Let G denote GUIClaw, which executes a subtask over the partially observed device state, let E denote the evidence-to-value mapping, and let B_i denote the blackboard after subtask i. A subtask sees only the declared inputs already on B_{i-1}, and only its declared outputs are written back from the trajectory evidence:

$$G(g_i, h_i, B_{i-1}[I_i]) \to \tau_i, \qquad E(\tau_i, O_i) \to B_i[O_i]. \tag{1}$$

If a required input or a declared output is missing, the workflow fails closed rather than running a subtask on incomplete state or letting a later one infer or fabricate the value. This rule matters for cross-app transfer, comparison, and fact-collection tasks. Figure 3 traces the typed tuple contract, while Figure 5 (Appendix C) shows the same mechanism in a real cross-app trajectory.

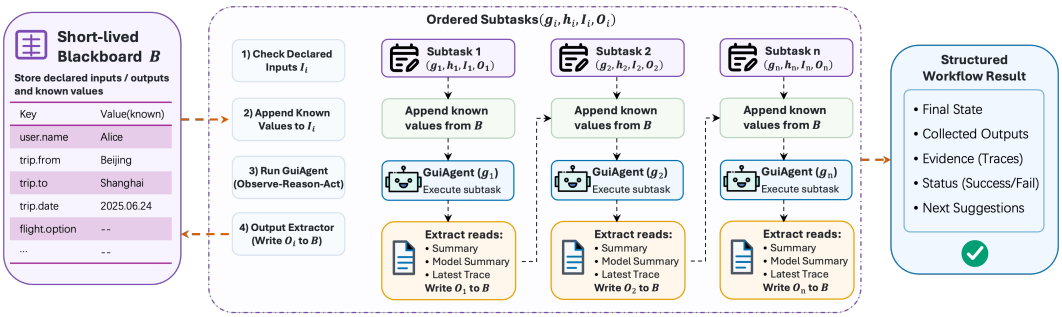

Figure 3: Blackboard-mediated routing. Each app-scoped subtask reads declared inputs I_i, executes GUIClaw, and writes only evidence-backed outputs O_i to the shared blackboard. Missing required inputs or outputs halt the workflow (Eq. 1).

3.3 ACT: HYBRID GUI–FAST PATH EXECUTION

Hybrid action space. GUIClaw executes each routed subtask over a hybrid action space:

$$\mathcal{A} = \mathcal{A}_{\text{gui}} \cup \mathcal{A}_{\text{skill}} \cup \mathcal{A}_{\text{shortcut}} \cup \mathcal{A}_{\text{ask}}. \tag{2}$$

$\mathcal{A}_{\text{gui}}$ contains human-like primitives such as tap, swipe, scroll, text input, navigation, app open/close, and wait; $\mathcal{A}_{\text{skill}}$ contains skills distilled from reusable GUI behavior. $\mathcal{A}_{\text{shortcut}}$ contains Android deeplinks and intents (Android Developers, 2026a;b) which bypass lengthy navigation workflows when verified as valid on the target device. Predefined action sequences with historically calibrated interaction parameters can also be stored in this set to eliminate the visual grounding overhead of the GUI subagent, though such rigid shortcut schemes suffer from limited generalization capability. $\mathcal{A}_{\text{ask}}$ contains intervention actions for cases that require user input or authorization. These types trade efficiency against reliability, so the executor validates skills and shortcuts against the current state before using them. Appendix D gives the unified action space, by platform, that realizes $\mathcal{A}_{\text{gui}} \cup \mathcal{A}_{\text{ask}}$.

Observe–Reason–Act loop. Within this action space, GUIClaw runs a grounded control loop:

$$p_t \rightarrow o_t \rightarrow a_t \rightarrow e_t \rightarrow o_{t+1}, \tag{3}$$

where p_t is the prompt, o_t is the current observation, a_t is the action, and e_t its result on the device. The prompt carries the subtask, task's blackboard, policy memory, interface hints, and available skills, and a normalization step maps each model's output into a common action format. Appendix E gives the prompt contracts used to expose, induce, and validate these skills.

Skills. Skills turn repeated interaction into reusable procedures. Each stored skill contains an identifier, app and platform scope, description, parameters, reliability counters, and an ordered sequence of steps. Stable fields such as app package names, coordinates, components, and intent payloads are fixed in advance, while task-dependent values are represented as placeholders and grounded at run time. Before each subtask, the GUI subagent retrieves app-scoped candidates by lexical and embedding signals, then uses a lightweight applicability prompt to select one useful prefix or reject all candidates. Retrieved skills (Top-5) are advisory: KNOWACT-GUICLAW may apply one or fall back to ordinary actions. Before each step, it checks the expected state through a deterministic state contract when available and through a visual valid-state check otherwise; on a mismatch, it either runs a bounded recovery subgoal, skips an optional obstacle step, or returns control to ordinary GUI execution. Appendix F gives concrete skill records, including a multi-step skill with per-step state validation.

Deeplink and intent shortcuts. $\mathcal{A}_{\text{shortcut}}$ contains page-validated Android deeplinks and intents that bypass long GUI navigation. During execution, GUIClaw treats them as one-step skills with `open_deeplink` or `open_intent`, and uses them only after their target page, required parameters, and app state have been validated. This prevents broad Android constants such as `SEARCH`, `SEND`, or `GET_CONTENT` from being executed merely because a manifest exposes them. Appendix F shows representative skill and shortcut entries.

3.4 REFLECT: TRAJECTORY DISTILLATION AND SKILL EVOLUTION

Post-run summarization. After each GUI task, reflection summarizes where execution ended and what remains, making partial or blocked runs resumable checkpoints. When enabled, the post-run processor evaluates the outcome before learning. Runs with no useful signal, including empty, cancelled, timed out before progress, or entirely skill-reused runs, are excluded from long-term stores.

Skill extraction. Reflection converts selected trajectories into reusable procedures. Structured evidence includes the task, platform, observed apps, actions and parameters, screenshots, target-control hints, and inferred state contracts. A vision LLM receives this evidence under a prompt restricted to declarative action sequences. Candidates are normalized and checked for supported actions, declared parameters, executable fixed fields, reusable app scope, and valid-state coverage. Accepted steps inherit trajectory-derived state contracts for validation during execution. Offline extraction uses the same agent, filters short or abnormal traces, retains bounded successful prefixes, clusters structurally identical skills, and records success counts for retrieval priority.

Skill evolution. Repair takes precedence over new extraction. When a reused skill fails, reflection records the failed step, screen evidence, error, original skill, and prior feedback. An evolution prompt updates that skill in place: it may narrow its description, add guarded optional obstacle handling, or refresh stale targets and state contracts, but cannot introduce an unrelated workflow or destructive terminal actions. New skills are extracted only when no failed reused skill is present.

Shortcut validation. App manifests supply candidates, not trusted actions. Validation launches candidate variants, records the foreground app, ADB output, UI tree, and screenshot, and asks a verifier for usability, page status, payload preservation, parameters, and a capability description. Only page-validated records become one-step skills; merely launchable records remain candidates unless explicitly allowed by the validation configuration. Appendix E gives the validation prompt.

Experience memory. Inspired by ReasoningBank (Ouyang et al., 2026), KNOWACT-GUICLAW converts action-and-UI summaries into a few actionable textual policies using separate success and failure prompts. The inducer skips short or abnormal traces, resolves outcome and app per trace, caps items per task, and removes near-duplicates within each app. Unlike executable skills, these lessons guide routing through app selection and decomposition, and GUI execution through layout, shortcut-reliability, and recovery hints. Appendix E provides the induction prompts and filtering rules.

4 EXPERIMENTS

4.1 BENCHMARKS AND METRICS

We evaluate KNOWACT-GUICLAW on two mobile GUI benchmarks that include diverse real-user tasks. *MobileWorld* (Kong et al., 2025) is our primary benchmark: it emphasizes long-horizon mobile tasks, many of which span multiple applications. From its 201 tasks over 20 applications, we use the 117-task GUI-Only subset, scored by the benchmark's native deterministic evaluators. *AndroidDaily* (Yan et al., 2025) is a complementary end-to-end benchmark that groups tasks by type, complexity, and ambiguity; many of its tasks require returning an explicit answer rather than only manipulating the UI. Lacking a native evaluator, we score its GUI-only tasks with `qwen3.5-flash` as an LLM judge and its answer-returning tasks with two human experts, with correct tasks scoring 1.0 and partial tasks 0.5.

Setup. Unless noted, KNOWACT-GUICLAW pairs a Qwen3.5-397B-A17B host with a Qwen3.5-35B-A3B GUI executor. In the Kimi-K2.6 configurations of Table 1, Kimi-K2.6 serves as both the host and GUI executor. The Kimi-to-Qwen transfer configuration retains the default Qwen host–executor pairing and instead uses a joint set of experience memory and skills distilled from trajectories generated by the Kimi-K2.6 host–executor configuration. All MobileWorld configurations use the same 117-task GUI-Only subset, native deterministic evaluators, and 50-step cap. Following the public leaderboard, our primary MobileWorld metric is the single-run success rate (SR), i.e. pass@1; we report pass@3 only as a repeated-attempt upper bound, in a separate table (Table 6). For AndroidDaily we report a *resolved* setting over the 194 available tasks and an *all* setting that scores the 41 unavailable entries as 0 across all 235 tasks. The AndroidDaily evaluation uses iOS devices.

Table 1: MobileWorld GUI-Only success rate (pass@1). External rows are grouped by the public MobileWorld leaderboard categories (Kong et al., 2025). All KNOWACT-GUICLAW rows are our own runs; the Kimi-to-Qwen transfer row equips the 35B executor with experience memory and skills distilled from Kimi-K2.6 trajectories. Rows matching configurations B, C, and F are analyzed in Table 2, and Table 6 reports the repeated-attempt upper bound.

Model	SR (pass@1, %)
General models	
Seed-2.0-Pro (Bytedance Seed, 2026)	63.2
GPT-5.5 (OpenAI, 2026)	62.4
Gemini-3.1-Pro-Preview (Google DeepMind, 2026)	58.1
Claude-Opus-4.7 (Anthropic, 2026)	56.4
Kimi-K2.6 (Moonshot AI, 2026)	55.6
Kimi-K2.5 (Kimi Team, 2026)	49.6
Claude-Sonnet-4.5 (Anthropic, 2025)	47.8
Qwen3.5-397B-A17B (Qwen Team, 2026)	42.7
Qwen3.5-122B-A10B (Qwen Team, 2026)	35.0
Qwen3.5-35B-A3B (Qwen Team, 2026)	24.8
Qwen3-VL-235B-A22B (Bai et al., 2025)	12.8
Agentic systems	
Gemini-3-Pro + UI-Ins-7B (Google DeepMind, 2026; Chen et al., 2025)	55.6
GPT-5 + UI-Ins-7B (Singh et al., 2026; Chen et al., 2025)	54.0
Claude-4.5-Sonnet + UI-Ins-7B (Anthropic, 2025; Chen et al., 2025)	47.8
Specialized GUI models	
GUI-Owl-1.5-32B (Xu et al., 2026)	43.9
ForgeOwl-8B (Liu et al., 2026)	41.0
MAI-UI-235B-A22B (Zhou et al., 2025)	39.7
GUI-Owl-1.5-8B (Xu et al., 2026)	38.2
MAI-UI-32B (Zhou et al., 2025)	36.2
Doubao-1.5-UI-TARS (Qin et al., 2025)	26.3
UI-Venus-72B (Gu et al., 2025)	16.4
GUI-Owl-7B (Ye et al., 2025)	7.7
Ours (Open-source Qwen3.5)	
35B + host & memory	**34.5**
35B + host, memory & skills	**37.9**
35B + host, Kimi-derived memory & skills	**41.0**
397B host acts directly	**46.2**
Ours (Open-source Kimi-K2.6)	
+ host & memory	**61.5**
+ host, memory & skills	**64.1**

Efficiency metrics. We report SR together with execution cost: GUI steps, the number of GUI task invocations, executed GUI-trace tokens, and host tokens. The *total* column measures the executed GUI traces and is comparable across systems; *host total* measures the additional generation that the host spends to route, coordinate, call external tools such as web search, and resolve eligible subtasks.

4.2 MAIN RESULTS OF MOBILEWORLD

Table 1 compares KNOWACT-GUICLAW with the public leaderboard. Host and memory raise the 35B executor's SR from 24.8 to 34.5, and skills further raise it to 37.9. Kimi-K2.6 reaches 61.5 with host and memory and 64.1 with skills, the highest SR listed. The directly acting 397B Qwen host reaches 46.2 versus its public plain-GUI score of 42.7.

4.3 ABLATION AND EFFICIENCY ANALYSIS

Table 2 reports a system-level ablation along two executor scales.

Table 2: MobileWorld ablation and efficiency. A–C use the Qwen3.5-35B-A3B executor; D–F use Qwen3.5-397B-A17B. "Host & mem" adds orchestration, routing, and memory; "skills" enables reuse. E–F allow direct host participation. D is our plain-GUI run, distinct from the public 42.7 score. Total and Host Total report GUI-trace and additional host tokens per task, respectively.

Config	Setting	SR (%)	GUI steps	GUI tasks	Total	Host Total
GUI executor: Qwen3.5-35B-A3B						
A	exec. only	24.8	26.7	1.0	281,266	–
B	+ host & mem	34.5	26.8	2.3	279,211	65,224
C	+ skills	37.9	25.1	2.5	278,289	63,792
GUI executor: Qwen3.5-397B-A17B						
D	exec. only	40.7	26.1	1.0	254,459	–
E	+ host & mem	43.3	26.8	1.4	273,352	10,096
F	+ skills	**46.2**	**23.7**	1.7	**260,516**	10,982

Table 3: Skill-reuse effect on the MobileWorld tasks that invoke at least one skill (83 with the 35B executor, 87 with the 397B host), each compared against the same tasks run without skills. SR and pass@3 deltas are in percentage points.

	Qwen3.5-35B-A3B executor			Qwen3.5-397B-A17B executor		
Metric (skill-using tasks)	+ skills	no skills	Δ	+ skills	no skills	Δ
GUI steps / task	25.7	29.0	−3.3	22.3	25.6	−3.3
total tokens / task	284,279	303,014	−6.2%	242,930	258,084	−5.9%
single-run SR (%)	40.6	35.7	+4.9	50.2	48.3	+1.9
pass@3 (%)	54.2	53.0	+1.2	63.2	63.2	+0.0

Host and memory raise accuracy. Adding orchestration and memory raises SR at both scales (A→B, 24.8 → 34.5; D→E, 40.7 → 43.3). GUI-trace tokens stay near 280k for 35B and rise about 7% for 397B. Additional host cost is 65,224 and 10,096 tokens per task, respectively.

Skills cut steps and total tokens (B→C, E→F). Enabling skills on top of the host–memory setting lowers GUI steps and total tokens—modestly for the 35B executor, and more clearly for the 397B host, where steps fall from 26.8 to 23.7 and total tokens by about 5%—while SR rises rather than falls. The saving comes from shorter trajectories and fewer screenshot-heavy observations. Table 3 isolates this effect on the tasks that actually invoke a skill.

Experience memory and skills transfer across base models. Equipping the Qwen3.5-35B-A3B executor with experience memory and skills distilled from Kimi-K2.6 trajectories raises SR to 41.0, compared with 37.9 for the standard host–memory–skills configuration and 24.8 for the base executor. Textual experience rationales and state-validated executable behaviors can thus carry task knowledge across model families in the tested Kimi-to-Qwen direction.

Direct host participation (F). Resolving eligible queries directly yields the highest Qwen SR (46.2). Relative to C, GUI invocations fall from 2.5 to 1.7, GUI-trace tokens from 278,289 to 260,516, and host tokens from 63,792 to 10,982, reducing delegation overhead.

Skill reuse, measured where it applies. Restricting to the tasks that invoke a skill concentrates the same effect (Table 3): reuse removes about three GUI steps per task (−3.3), cuts total and prompt tokens by roughly 6%, and improves SR (+4.9 and +1.9 points).

4.4 AndroidDaily Results

AndroidDaily includes long-horizon tasks requiring cross-app analysis and explicit answers. The largest gains occur on *Analyze* and *complex* tasks (Table 4), where decomposition, blackboard transfer, and memory reduce repeated trajectory solving. The resolved/all gap reflects unavailable apps and environment mismatch.

Table 4: AndroidDaily (end-to-end) performance by task type, complexity, and ambiguity. Our AndroidDaily evaluation is conducted on iOS devices. For KNOWACT-GUICLAW, *resolved* excludes the 41 unavailable entries and rates the remaining 194 tasks, while *all* scores those entries as 0 over all 235 tasks.

	Task Type			Complexity			Ambiguity			
Model / Setting	Filter	Query	Analyze	Atomic	Comp.	Cond.	Low	Mid	High	Total
UI-TARS-1.5	57.64	65.97	36.71	61.41	13.64	60.38	57.05	54.90	57.89	56.64
Step-GUI-4B	44.77	64.29	33.72	54.03	19.61	42.86	51.21	38.32	59.52	49.06
Step-GUI-8B	52.50	63.82	32.95	59.09	14.00	42.86	54.08	44.55	61.54	52.50
Ours (Resolved)	80.56	76.88	77.08	81.25	62.50	75.00	78.89	77.50	78.95	**78.61**
Ours (All)	68.40	66.13	51.39	70.98	41.67	53.23	64.94	65.96	62.50	64.89

4.5 CASE STUDY

Experience-memory correction. In the Mastodon invite-link task (Figure 4, Appendix C), GUIClaw without memory follows a nonproductive mobile-settings path. Retrieved experience redirects it to the web administration panel, where advanced invite links are supported. The lesson corrects app and route selection while live screen evidence still grounds each action.

Skills and cross-app information transfer. In the price-comparison task (Figure 5), the host supplies the product model from the user profile and routes two GUI tasks. A validated JD shortcut reaches search results directly, whereas Taobao requires five ordinary GUI steps. The blackboard carries both observed prices into the host's recommendation, illustrating navigation compression and explicit information transfer.

Host recovery and direct participation. In the conference-location task (Figure 8), Email returns only "Harvard Square Hotel." The host resolves its full address through web search before delegating Messages and Maps tasks; Maps reports a 13-minute walk. This combines partial GUI evidence with external tools while preserving typed subtask boundaries. Appendix C provides the screenshots and further recovery cases.

4.6 CROSS-PLATFORM CHECKS

The same interface solves $48/63$ HarmonyOS tasks (76.2%) and $21/30$ Windows tasks (70.0%). HarmonyOS uses MobileWorld-derived tasks, manual initialization where needed, and `qwen3.5-flash` judging; Windows uses manually designed desktop workflows. These usability checks follow different protocols. Appendix B provides task examples and analyzes failures in inertial pickers, payment-page semantics, icon grounding, notifications, and geometric control.

5 CONCLUSION

This work proposes KnowAct-GUIClaw, a cross-platform GUI agent framework built on the "Know Deeply, Act Perfectly" paradigm to address two core limitations of mainstream OpenClaw-style agent systems: insufficient cross-device GUI interaction capacity and the absence of native self-evolution mechanisms. The framework instantiates a four-stage Know–Route–Act–Reflect closed-loop pipeline that decouples high-level task orchestration (host agent) from low-level visual device manipulation (GUI subagent). It introduces two core reusable storage modules: attribution-aware persistent experience memory and state-validated self-evolving skill libraries, alongside a typed blackboard information transfer protocol to standardize cross-application data flow and eliminate fuzzy free-text context loss. Future work targets tighter native integration of the Knowledge module, external general-purpose tools, and the GUI subagent to eliminate rigid sequential pipeline handoffs. We will design a unified joint planner to concurrently weigh knowledge retrieval, non-visual tool calls and GUI actions within one decision cycle and cut host-subagent communication overhead.

AI USE STATEMENT

Generative AI tools were used to assist with writing polishing, and formatting checks. The framework itself uses language models for GUI execution, host orchestration, trajectory reflection, memory and skill induction, and selected evaluation judgments, as described in the methods and evaluation protocol.

REPRODUCIBILITY STATEMENT

Section 4 specifies the models, task sets, evaluation rules, and execution cap. Appendix B describes the cross-platform protocols, and Appendices D–F provide the action interface, prompt contracts, and skill records. GUI-executor traces and host calls are accounted for separately in Table 2.

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A Additional Method Details

A.1 GUI Automation as a POMDP

GUI automation is naturally modeled as a partially observable Markov decision process (POMDP) (Kaelbling et al., 1998):

$$\mathcal{M} = (\mathcal{S}, \mathcal{A}, \mathcal{O}, T, \Omega, R, \gamma), \tag{4}$$

where $\mathcal{S}$ is the hidden device state, $\mathcal{A}$ the action space, $\mathcal{O}$ the observation space, T and Ω the transition and observation functions, R the task reward, and γ the discount factor. The defining property of GUI control is partial observability: the agent never observes $\mathcal{S}$ directly but only an observation o_t—typically a screenshot with optional screen metadata, the foreground app, and a bounded action history—that exposes a projection of hidden state such as navigation stacks, login and permission status, asynchronous loading, and off-screen form values. A GUI agent must therefore act and recover from errors under this uncertainty rather than assume a fully known interface.

A.2 Host-Centric Multi-Agent Systems

Multi-agent systems distribute problem solving across agents with distinct roles, capabilities, and local information, coordinating through communication and shared environments rather than a single monolithic policy (Wooldridge, 2009). Recent LLM agent frameworks adopt this view, pairing a central orchestrator that maintains conversation state, memory, and tool access with specialized environment- or tool-facing agents to which it delegates subtasks (Zhou et al., 2023). For GUI automation, this host-orchestration pattern motivates separating long-horizon task management from low-level interaction with a partially observed device; Section 3 instantiates this as a concrete execution stack for mobile GUI tasks.

B Cross-Platform Protocols and Failure Analysis

We further test whether the same KnowAct-GUIClaw interface remains usable outside the Android evaluation stack. On HarmonyOS, we run MobileWorld-derived tasks that are not tied, or only weakly tied, to Android-specific mirrored app states; weakly tied cases are manually initialized before evaluation, and outcomes are judged with `qwen3.5-flash`. On Windows, we use a manually designed desktop set to check basic usability across browser, file, office, terminal, and system-control workflows. Under this protocol, KnowAct-GUIClaw solves $48/63$ HarmonyOS tasks (76.2%) and $21/30$ Windows tasks (70.0%). Table 5 reports ten source-matched cases from each platform.

Table 5: Representative cross-platform usability cases. HarmonyOS instructions are translated into English when necessary while preserving their source requirements. Windows instructions name one concrete application wherever the source offered alternatives or referred to a generic application.

Instruction	Success
HarmonyOS mobile checks	
Next Saturday from 10:00 a.m. to 12:30 p.m., I will travel to Shanghai Hongqiao Railway Station. Add a Calendar event named "Business Trip." Find attractions within 10 km of the station that I can visit before work on Monday, and place them in the event description as "attraction name: address," separated by commas.	Yes
Check my calendar and send a WeChat message to Su with the dates of my arrival in Shanghai. The message must contain only the two dates in `MM/DD/YYYY` format, separated by a comma.	Yes
I received a coffee invitation for 3:00 p.m. tomorrow. Check my calendar; if I am available, reply "OK" to Ping An Xi Le in QQ and create the corresponding calendar event. Otherwise, reply "Not available in this time slot."	Yes
Plan exactly one shortest taxi route in Chengdu from Chengdu Shuangliu International Airport Terminal 2 to my hotel at No. 8, South Section of Chunxi Road, Jinjiang District, visiting exactly Kuanzhai Alley and Jinli Ancient Street in either order. Send Ping An Xi Le in QQ the names and coordinates of all four locations as "name: longitude, latitude," the shortest visit order, the three driving distances in meters, and the total driving distance in meters; separate each ordered list with commas.	Yes

Continued on next page

Table 5 continued

Instruction	Success
An error message on my phone contains the keyword `TurnOffWifi`. Search the `google-research/android_world` GitHub repository for related issues. If similar issues exist, send every issue link, separated by commas, to Ping An Xi Le in QQ; otherwise send "no turnoffwifi issues."	Yes
Find the resume file downloaded most recently within the past month in Downloads, and send it to my HR colleague with the subject `candiaditaes_cv`.	Yes
Take a selfie and share it with Jimmy via email.	Yes
Increase the font size and icons on my phone to the maximum setting.	Yes
Set a weekend alarm for 8:25 a.m. with the ringtone "beebeep" and vibration off.	No
Halloween is approaching. Use TaoBao to place an order for a set of temporary tattoos, and hand control back to me when the payment page appears.	No
Windows desktop checks	
Open the Ctrip website and search for a one-way flight from Beijing to Tokyo on the Friday after next. Filter for nonstop flights, sort by price in ascending order, and select the cheapest option.	Yes
Open Baidu Maps in Google Chrome and search for "Starbucks near Tiananmen Square." Select the highest-rated result from the left-hand list, open its details, copy its building or street address, and save the address to `address.txt` on the desktop using Notepad.	Yes
Open `loop.py` in Visual Studio Code, add a breakpoint on line 3, open Run and Debug, and start debugging.	Yes
Use Google Chrome to find the current Apple (AAPL) share price, calculate the value of 100 shares, and save the total to `stock.txt` on the desktop using Notepad.	Yes
Open Windows Settings, retrieve the detailed operating-system version, and save it in a new draft email in Microsoft Outlook.	Yes
Open the PDF report in Documents with Microsoft Edge, translate the first paragraph of Chapter 1 into English using Google Translate, and save the translation as a plain-text file on the desktop using Notepad.	Yes
Open GitHub in Google Chrome, search for the `nanobot` project, copy its latest commit hash, and save it to `commit_record.txt` on the desktop using Notepad.	Yes
Open Microsoft PowerPoint, create a blank slide, insert a local image, and apply a "Fly In" animation to the image.	Yes
I will send a test message in Slack within the next minute. Keep the desktop idle; when the Slack notification appears, click it immediately, open the conversation, and reply "Received."	No
Open the locally installed WeChat, open File Transfer Assistant, send the text "Test emoji," and then use the built-in emoji panel to send a "laughing" emoji.	No

HarmonyOS failure modes. The failed HarmonyOS cases expose both low-level control difficulties and state-semantic mismatches. In the weekend-alarm case, the minute field uses an inertial wheel picker. GUIClaw repeatedly swipes within a nearby range but cannot settle on 25 minutes, so it exhausts the step budget without setting 8:25 a.m. In the temporary-tattoo case, the agent stops on the order-confirmation screen before submitting the order, rather than handing control back after reaching the subsequent payment page. This premature termination reflects application-level UI diversity: after a payment method is selected, TaoBao presents a "Pay Now" button, which the model misinterprets as evidence that the current screen is already the payment page; in fact, the payment page appears only after that button is pressed. The full set also shows system-UI mismatches: several quick-setting tasks repeatedly open the left notification pane even though the relevant HarmonyOS controls require a swipe from the right.

Windows failure modes. Windows failures expose three distinct grounding bottlenecks. First, the WeChat case reaches File Transfer Assistant and sends the text correctly, but selects a different face from the built-in panel instead of the requested laughing emoji. This error reveals a limitation in mapping a natural-language affect label to the corresponding visually similar, unlabeled icon. Second, the notification case requires sustained observation followed by an immediate click on a short-lived toast, exposing weak temporal grounding. The remaining failures primarily involve continuous geometric control, deep application-specific controls, and targets outside the current viewport, as seen in free-form canvas manipulation, window arrangement, and bottom-of-page actions. Thus, desktop reliability depends not only on pointer precision and timing, but also on semantic grounding between language and graphical symbols.

C CASE STUDIES AND REPEATED ATTEMPTS

This case study uses representative workflows to illustrate four characteristics of KNOWACT-GUICLAW: routing and information transfer, experience-memory correction, navigation compression through skills and shortcuts, and host recovery and direct participation. The screenshots come from actual executions; host cards, step labels, per-step thoughts, and blackboard pills are overlays added for readability.

C.1 EXPERIENCE-MEMORY CORRECTION

Experience memory supplies prior failure lessons as advisory task context before low-level control begins. Figure 4 contrasts an invite-link task with and without retrieved memory. Without memory, GUIClaw remains in Mastodon's mobile settings and follows a nonproductive path; with memory, it recalls that advanced invite links require the web administration panel and switches to the productive interface. The retrieved lesson corrects app and route selection without replacing live screen evidence.

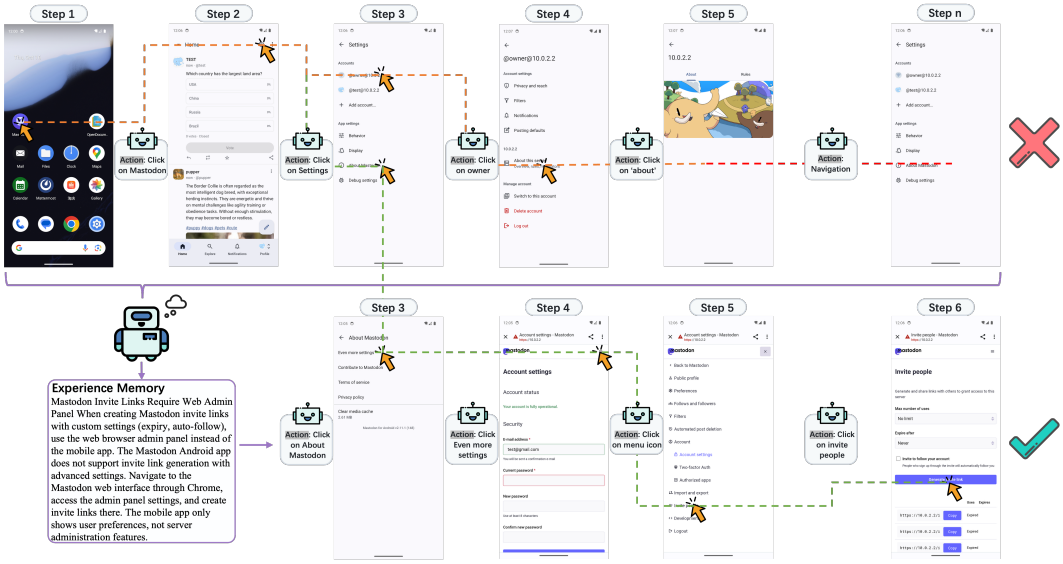

Figure 4: **Experience memory improves a GUI task by changing the task context before low-level control begins**. Without the retrieved memory (Top), GUIClaw continues through Mastodon's mobile settings and reaches a nonproductive path for invite-link creation. With the retrieved memory (bottom), the Know stage supplies an advisory lesson that invite links with advanced settings require the web administration panel; GUIClaw then opens the web interface, navigates to account settings, and reaches the invite-people page. The example shows that experience memory guides app choice, decomposition, and recovery while live screen observations still ground each action.

C.2 CROSS-APP ROUTING AND SKILL REUSE

Routing and information transfer. Long-horizon, cross-app tasks amplify memory decay and goal drift when one GUI trajectory must retain every intermediate summary. KNOWACT-GUICLAW instead decomposes the request into app-scoped GUI tasks and passes only declared outputs through the blackboard. Figure 7(a) isolates this handoff in an Email-to-Clock workflow, while Figure 8 shows a longer Email-to-Messages-to-Maps workflow in which the resolved address becomes an explicit input to both downstream GUI tasks. The cart-to-SMS case similarly transfers product names, an order number, and a recipient phone number from shopping to messaging (Figure 6). These bounded handoffs reduce the history each GUI task must preserve and keep later goals tied to explicit inputs.

Navigation compression through skills and shortcuts. Skills compress repeated procedures, while validated shortcuts eliminate navigation when they can reach a task-relevant page directly. In Figure 5,

one validated JD search shortcut lands on the product-results page, whereas the corresponding Taobao branch requires five ordinary GUI steps. In Figure 6, a validated messaging shortcut opens the SMS compose view with the recipient phone number and message body already populated, leaving GUIClaw to verify and send the message. These cases visualize the navigation savings measured more broadly on skill-using tasks in Table 3.

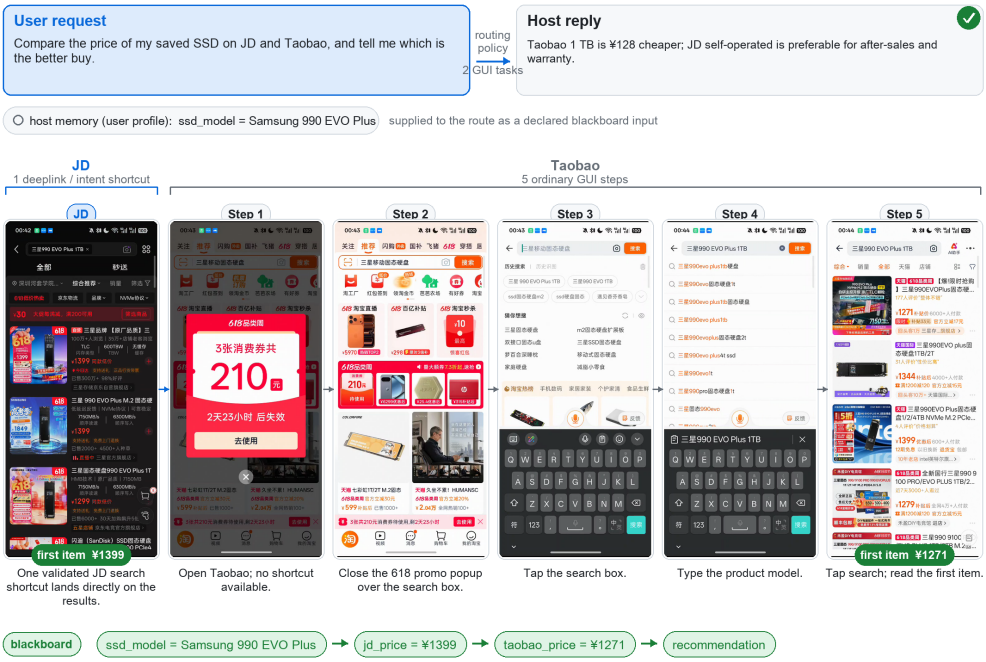

Figure 5: **KnowAct-GUIClaw execution of a cross-app price comparison**. The host supplies the product model from the user profile and routes two GUI tasks. A validated JD search shortcut lands directly on the results page, whereas Taobao requires five ordinary GUI steps. The blackboard carries both observed prices into the host's recommendation, illustrating the step and token savings in Table 3.

The first GUI task extracts the product names, order number, and recipient phone number from TaoDian as explicit outputs. A validated messaging shortcut then opens the SMS compose view with the recipient and message body populated, leaving GUIClaw to verify and send the message.

C.3 Host Recovery and Tool Participation

The host intervenes when GUI execution fails or returns a value that does not satisfy a downstream contract. Figure 7(b) shows failure-driven re-planning: after a message-by-name attempt fails because the contact is absent, the host records the failed lookup, recovers the phone number from a resume, and delegates a new Messages GUI task. Figure 8 shows direct tool participation after the Email GUI task returns only the ambiguous hotel name "Harvard Square Hotel." The host resolves the full street address through web search before delegating the SMS and Maps GUI tasks, avoiding a longer GUI-only address lookup; the final Maps task reports a 13-minute walk. The two trajectories distinguish host-side re-planning from tool-assisted information resolution while preserving typed subtask boundaries.

Figure 9 provides an annotated Chinese companion for the host-mediated recovery case in Figure 8. It shows the same control flow in which an underspecified GUI output is routed back to the host, grounded through web search, and then consumed by downstream Messages and Maps GUI tasks.

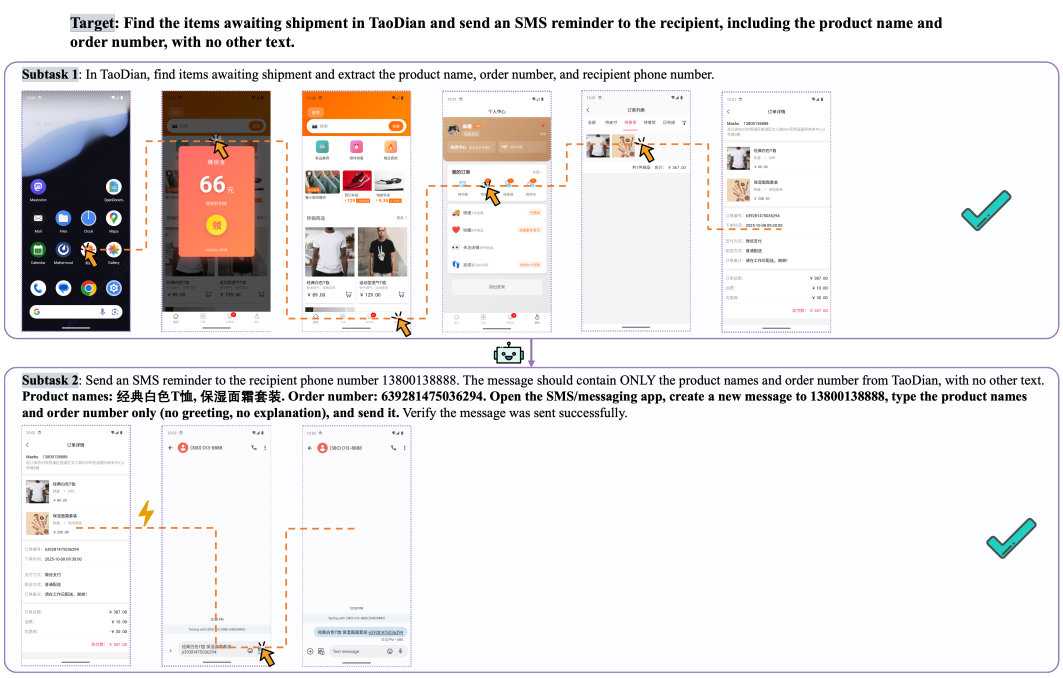

Figure 6: Cart-to-SMS cross-app execution. The TaoDian GUI task extracts the product names, order number, and recipient phone number and transfers them to the downstream messaging task. A validated messaging shortcut opens the SMS compose view with the recipient and message body already populated, illustrating both blackboard information transfer and navigation compression.

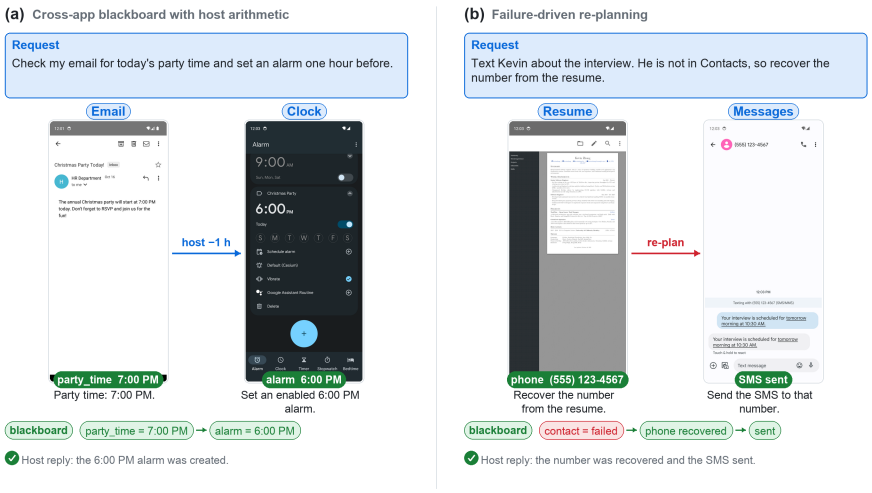

Figure 7: Cases of our workflow with attribution experience. **(a)** Email-to-alarm transfers the observed party time through the blackboard; the host subtracts one hour before the GUI subagent sets the alarm. **(b)** Failure-driven re-planning records a failed contact lookup, recovers the phone number from a resume, and delegates the final Messages GUI task.

C.4 Repeated Attempts and Scope

Table 6 complements the qualitative cases with repeated-run coverage and consistency for configurations A–F. The any-of-three criterion measures whether at least one attempt succeeds, while the all-three criterion requires success in every attempt.

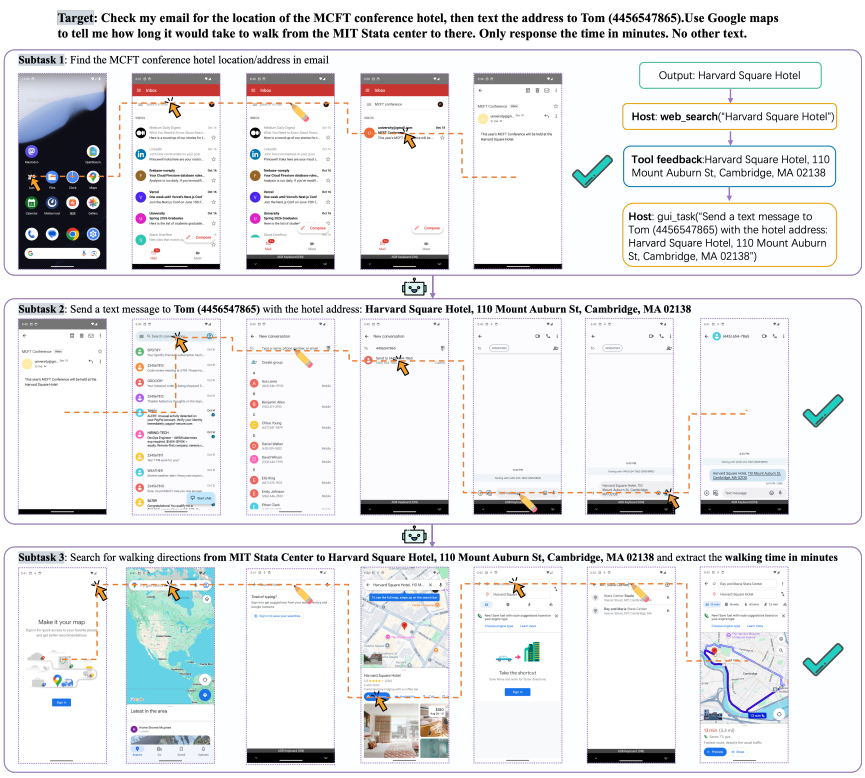

Figure 8: Host-mediated recovery in a conference-location task. The Email GUI task returns only the hotel name, so the host resolves the full address through web search before delegating the Messages and Maps GUI tasks. Maps reports a 13-minute walk. The workflow combines partial GUI evidence with external tools while preserving typed subtask boundaries.

Table 6: MobileWorld repeated-attempt upper bound for the A–F configurations of Table 2. "Any of 3" counts a task solved if at least one of three runs succeeds; "all 3" requires all three. SR (pass@1) is repeated for reference. The two repeated-run criteria characterize coverage and consistency separately.

Metric	A	B	C	D	E	F
single-run SR (%)	24.8	34.5	37.9	40.7	43.3	46.2
pass@3, any of 3 (%)	34.2	47.9	51.3	51.3	59.0	59.8
pass@3, all 3 (%)	15.4	18.8	26.5	30.8	29.1	32.5

Scope of the evidence. The ablations add host orchestration and memory jointly, so their individual effects are not isolated. Transfer is tested in the Kimi-to-Qwen direction with memory and skills transferred together. Skill-reuse statistics condition on tasks that invoke a skill, and AndroidDaily and cross-platform checks use different environments and judging procedures. These results support the reported configurations and protocols; they do not establish universal transfer or equivalent reliability across platforms.

D Action Space

Table 7 gives the unified action space GUIClaw exposes to the GUI executor, realizing $\mathcal{A}_{\text{gui}} \cup \mathcal{A}_{\text{ask}}$ from Section 3.3. The two platforms share a common core of pointer, text, navigation, and task-control actions; desktop adds key combinations, an explicit pointer swipe, and application launch and close, while mobile adds a dedicated enter key. This largely shared action surface is what lets a single host drive both platforms through the same GUI task interface.



Figure 9: Chinese annotated companion for the host-mediated recovery case in Figure 8. The panel highlights the same control flow in which an underspecified GUI output is routed back to the host, grounded through web search, and then consumed by downstream Messages and Maps GUI tasks.

E SKILL EXTRACTION AND PROMPT CONTRACTS

KNOWACT-GUICLAW uses prompt contracts at both execution time and reflection time. The execution prompt below is the runtime MobileWorld-style template used for prompt-side skill selection (Kong et al., 2025): GUIClaw retrieves top-k relevant skills, formats them as the `Compact skills` catalog, and lets the GUI executor choose a listed skill or continue with ordinary actions. Reflection then turns GUI experience into reusable knowledge through additional contracts rather than unrestricted trace replay. First, trajectory evidence is normalized into a task, an app scope, ordered actions, screenshots, target hints, and state contracts. Second, a skill-extraction agent compresses this evidence into one reusable, parameterized procedure and rejects outputs that are not executable or not state guarded. Third, a separate evolution agent repairs a previously reused skill only when a failure trace identifies that skill as the failure source. Finally, a memory-induction agent writes textual success and failure lessons that guide future routing and execution without becoming executable

Table 7: Unified action space of GUIClaw across platforms. **Shared** actions are available on both mobile and desktop; **Desktop** and **Mobile** list the platform-specific additions. Together they realize $\mathcal{A}_{\text{gui}} \cup \mathcal{A}_{\text{ask}}$ (Section 3.3); skills ($\mathcal{A}_{\text{skill}}$), Android deeplink/intent shortcuts ($\mathcal{A}_{\text{shortcut}}$), and external Model Context Protocol (MCP) tool calls extend this set through the runtime.

Environment	Action	Definition
Shared	Click(x, y)	Clicks or taps at coordinates (x, y).
	DoubleTap(x, y)	Double-clicks or double-taps at (x, y).
	LongPress(x, y)	Long-presses at (x, y).
	Drag(x_1, y_1, x_2, y_2)	Drags from (x_1, y_1) to (x_2, y_2).
	Scroll(x, y, direction)	Scrolls at (x, y) in the given direction.
	Type(content)	Types the specified content.
	Back()	Returns to the previous screen.
	Home()	Returns to the home screen.
	Wait()	Pauses for a brief moment.
	Finished()	Returns the final answer or marks the task complete or infeasible.
	CallUser()	Requests user intervention.
Desktop	Hotkey(key)	Presses the specified key combination.
	Swipe(x_1, y_1, x_2, y_2)	Swipes the pointer from (x_1, y_1) to (x_2, y_2).
	OpenApp(name)	Launches the specified application.
	CloseApp(name)	Closes the specified application.
Mobile	PressEnter()	Presses the "enter" key.

actions. The boxes below reproduce the runtime source prompts with blank lines compacted; braces denote runtime placeholders and structured inputs supplied by the caller.

(a) Execution Prompt

```
# Role: Android Phone Operator AI
You are an AI that controls an Android phone to complete user requests. Your
     responsibilities:
- Answer questions by retrieving information from the phone.
- Perform tasks by executing precise actions.
# Action Framework
Respond with EXACT JSON format for one of these actions:
| Action          | Description                              | JSON Format Example
                                                      |
|-----------------|-----------------------------------------
     |-----------------------------------------------------------------------------|
| `click`         | Tap visible element (describe clearly)   | `{"action_type": "click", "
     coordinate": [x, y]}`   |
| `double_tap`    | Double-tap visible element (describe clearly)   | `{"action_type": "
     double_tap", "coordinate": [x, y]}`   |
| `long_press`    | Long-press visible element (describe clearly) | `{"action_type": "
     long_press", "coordinate": [x, y]}`            |
| `drag`          | Drag from visible element to another visible element (describe both
     clearly) | `{"action_type": "drag", "start_coordinate": [x1, y1], "end_coordinate": [
     x2, y2]}`            |
| `input_text`    | Type into field | `{"action_type":"input_text", "text":"Hello"}|
| `answer`        | Respond to user                          | `{"action_type":"answer", "
     text":"It's 25 degrees today."}`                |
| `navigate_home` | Return to home screen                    | `{"action_type": "
     navigate_home"}`                                       |
| `navigate_back` | Navigate back                            | `{"action_type": "
     navigate_back"}`                                       |
| `scroll`        | Scroll direction (up/down/left/right)    | `{"action_type":"scroll", "
     direction":"down"}`                             |
| `status`        | Mark task as `complete` or `infeasible`  | `{"action_type":"status", "
     goal_status":"complete"}`                       |
| `wait`          | Wait for screen to update                | `{"action_type":"wait"}`
                                                     |
| `ask_user`      | Ask user for information                 | `{"action_type":"ask_user",
     "text":"what is the exact requirements do you need?"}`        |
| `keyboard_enter`   | Press enter key         | `{"action_type":"keyboard_enter"}`
            |
```

```
| `use_skill`     | Run a listed compact GUI skill prefix when it clearly matches the task
     | `{"action_type":"use_skill","skill_id":"listed_skill_id","arguments":{}}` |
| `click_then_type` | Preferred one-step action for visible text fields: tap a coordinate
     and type text. Use auto_enter true only for search submission. | `{"action_type":"
     click_then_type","coordinate":[x,y],"text":"Hello","auto_enter":false}` |
| `click_multi` | Tap multiple visible coordinates in sequence | `{"action_type":"
     click_multi","coordinates":[[x1,y1],[x2,y2]]}` |
Note:
- The coordinate is the center of the element to be clicked/long-pressed/dragged.
- x, y are coordinates in the screen, the origin is the top-left corner of the screen.
- x, y are numbers, the range is normalized to [0, 1000].
# Execution Principles
1. Communication Rule:
   - ALWAYS use 'answer' action to reply to users - never assume on-screen text is
     sufficient
   - Please follow the user instruction strictly to answer the question, e.g., only return
     a single number, only return True/False, only return items separated by comma.
   - NEVER use 'answer' action to indicate waiting or loading - use 'wait' action instead
   - Note that `answer` will terminate the task immediately.
2. Efficiency First:
   - Choose simplest path to complete tasks
   - If action fails twice, try alternatives (e.g., long_press instead of click)
3. Smart Navigation:
   - Gather information when needed (e.g., open Calendar to check schedule)
   - For scrolling:
     * Scroll direction is INVERSE to swipe (scroll down to see lower content)
     * If scroll fails, try opposite direction
4. Text Operations:
   - You MUST first click the input box to activate it before typing the text.
   - When a text field is visible, prefer `click_then_type` (one action) over separate `
     click`+`input_text` to activate and type known text.
   - For text manipulation:
     1. Long-press to select
     2. Use selection bar options (Copy/Paste/Select All)
     3. Delete by selecting then cutting
5. Ask User:
    - If you think you have no enough information to complete the task, you should use `
     ask_user` action to ask the user to get more information.
# Decision Process
0. Before a manual GUI action, check the compact skill list; if one clearly matches the
     requested app/workflow, choose `use_skill` (it may open the target app internally, so
     do not open it manually first).
0a. Use listed composite actions only when they exactly match the next local operation.
     Prefer `click_multi` when several targets on screen need the same tap and none opens a
      confirmation dialog. Prefer `click_then_type` over separate `click`+`input_text` when
      tapping a visible text field to enter known text -- unless the field is already
     focused, existing text must be cleared, tapping opens a picker to observe first, or
     the text depends on the tap result.
1. Analyze goal, history, and current screen
2. Determine if task is already complete (use `status` if true)
3. If not, choose the most appropriate action to complete the task.
4. Output in exact format below, and ensure the Action is a valid JSON string:
5. The action output format is different for GUI actions and MCP tool actions. Note only
     one tool call is allowed in one action.
# Optional Compact GUI Skills
Optionally pick ONE listed compact skill as a single action when it clearly matches
the task. If none clearly matches, keep using the normal GUI actions above.
Skill action format:
`{"action_type":"use_skill","skill_id":"listed_skill_id","arguments":{"param":"value"}}`
Rules:
- Prefer `use_skill` over manual navigation when a listed skill clearly matches the
  requested app/workflow; copy its `skill_id` exactly.
- A skill may open/navigate the target app internally, so the target app need not
  already be on screen.
- Fill `arguments` only with values the task makes obvious; otherwise use `{}`.
Compact skills:
- skill_id={skill_id}; skill_name={skill_name}; description={description}; app={app};
     parameters={comma_separated_parameters}
# Expected Output Format (`Thought: ` and `Action: ` are required):
Thought: [Analysis including reference to key steps/points when applicable]
Action: [Single JSON action]
# Output Format Example
## for GUI actions:
Thought: I need to ... to complete the task.
Action: {"action_type": "type", "text": "What is weather like in San Francisco today?"}
```

(b) Skill extraction prompt

```
Extract a reusable GUI skill as Python code from this trajectory.
Target format:
from opengui.skills.flat import C, R, action, skill, tag
@skill(app="{app}", platform="{platform}", name="short_name", description="One sentence
    summary")
async def skill_name(device, param1, param2):
    await action("open_app", target="{app}", fixed=True, fixed_values={"text": "{app}"},
                 valid_state="No need to verify")
    await action("tap", target="search button", fixed=True,
                 fixed_values={"x": 540, "y": 960},
                 valid_state="target is visible and clickable",
                 state_contract=C(app="...[app_package]...", required=[R(resource_id="
    target_id", visible=True)]))
    await action("input_text", target="{{param1}}",
                 valid_state="input field is focused")
Rules:
- Extract ONE cohesive skill that covers the core action sequence. Do NOT split into
    multiple tiny @skill functions.
- fixed=true + fixed_values: static UI (nav bars, toolbar, system actions, open_app). Copy
    exact x/y/text from the trajectory step params shown after "|".
- Use only these action types: tap, long_press, double_tap, drag, swipe, scroll, input_text
    , hotkey, screenshot, wait, open_app, open_deeplink, open_intent, close_app, back,
    home, enter, app_switch, done, request_intervention. Do not invent actions such as
    read_text, press_key, navigate_back, or navigate_to_folder.
- The skill function body must contain only await action(...) statements. Do not add if/for
    /while/try blocks, assignments, calculations, helper calls, return values, or non-
    action awaits.
- Do not use f-strings, string concatenation, arithmetic expressions, comparisons,
    comprehensions, dict/list expressions with computed values, or nested function calls
    in action arguments. Use literal strings or {{param}} placeholders only.
- fixed_values may contain only executable action fields such as x, y, x2, y2, text, key,
    pixels, direction, duration_ms, component, package, intent_action, mime_type,
    categories, extras, relative, status, auto_enter. Never put selectors such as
    resource_id, content_desc, class, or class_name in fixed_values.
- fixed=false: dynamic content (search results, variable input). Use {{param}} placeholders
    , omit fixed_values.
- target: Every required interactive step must have a natural-language target and
    valid_state. Use a concise natural-language grounding hint, e.g. "search button", "
    search input field", "matching video result", "skip ad button". Do not use raw class/
    resource_id as target unless it is also visible user-facing text.
- Collapse all app-launch steps into ONE open_app as the first step. For open_app, prefer
    the trajectory app package for both target and fixed_values.text when available, and
    always use valid_state="No need to verify".
- valid_state: Every required interactive step must have a specific present-tense
    valid_state, e.g. "search field is visible and enabled". For input_text, use "input
    field is focused" if no better state is available. If a required step has no
    verifiable state, remove or regenerate that step instead of leaving valid_state empty.
- state_contract: do not invent selectors. Copy only the exact contract provided by
    trajectory/codegen for the matched step; omit if no contract is provided. The
    extractor postprocess will align contracts from codegen.
- R(...) supports resource_id, text, content_desc, class_, xpath, visible, clickable,
    enabled, focused, and scrollable only. Do not use class_name.
- Drop duplicate/redundant clicks, exploratory taps, and pointless scrolls.
- Transient popups (ads, permissions, consent): keep as optional=True step. Executor skips
    them when absent.
- Keep transient blockers and benign app confirmations such as skip/close/save/done as
    guarded optional=True steps when they appear. Omit destructive or externally visible
    confirmations such as pay, delete, send, submit order, publish, or irreversible
    consent unless the original user task explicitly requires them.
- description: MUST be generic and reusable. Mention app name, capability, and broad
    feature-level route only. Use parameter roles like query, media item, contact, or item.
     NEVER include literal values/entities, exact titles/names, or narrow qualifiers such
    as specific, official, first result, or top result. Avoid tap-by-tap UI actions.
For failure trajectories, insert:
FAILURE trajectory: keep the reusable succeeded prefix. If the failure screen clearly shows
     one safe corrective next action, append at most one non-fixed corrective step with
    natural-language target and valid_state. Do not invent coordinates or state_contract
    for that corrective step. Use optional=True only for transient blockers/popups, and
    never add pay/delete/send/submit/publish/irreversible confirmation actions.
## Trajectory
{code_text}
Output ONLY the Python code. No markdown fences, no JSON object, no explanation.
```

(c) Skill evolution prompt

```
You are improving one existing GUI automation skill after it failed during reuse.
Task:
{task}
Original skill JSON:
{skill_json}
Failure case:
{failure_case_json}
Prior feedback for this skill:
{feedback_json}
Full trajectory:
{trajectory_json}
Return ONLY a JSON object for the improved skill, using the same schema as the original
    skill.
Rules:
- Improve the original skill in place. Do not create a different skill or unrelated
    workflow.
- Keep the same high-level intent unless the failure shows the description caused a wrong
    match; then narrow the description/preconditions.
- If a popup or optional obstacle appeared, add a guarded optional step before the blocked
    step:
  {"action_type": "tap", "target": "Close", "parameters": {"optional": true}, "valid_state
    ": "popup close button is visible"}
  Optional steps are skipped when their valid_state is not present.
- If an action target, parameter, valid_state, or state_contract is stale for the new UI,
    update that step.
- Preserve reusable parameters as {param_name} placeholders.
- Do not include final destructive actions such as pay, delete, send, submit, or
    irreversible confirmation unless the original skill already required them.
- Omit skill_id; the caller will preserve the original skill_id.
```

(d) Shortcut validation prompt

```
Verifier system prompt:
You validate Android deeplink/intent probe results. Return only one JSON object with fields
    : usable (boolean), status ('page_validated' or 'launchable' or 'failed'), name (short
     English function name, e.g. 'bili_search', 'taobao_cart'; required when usable=true),
     description (short natural-language capability, e.g. 'Bili video search'), parameters
     (array of strings), payload_preserved (boolean), reason (short string),
    next_variant_hint (string or null). Set usable=true only if the screenshot/UI
    indicates the intended app page opened and the payload, such as query text, was
    preserved when relevant. When usable=true for the intended page, set status='
    page_validated'; use status='launchable' only for target-package launches whose page
    purpose is unclear. The 'name' field must be a concise English identifier (snake_case,
     max 30 chars) derived from the app and page function, e.g. 'bili_scan', '
    taobao_search'. Do not treat a query visible only in search history or suggestions as
    payload_preserved; payload_preserved means the current input/result page reflects that
     payload. Use a concise natural-language description such as 'Bili video search'. Do
    not mention adb, URI, component, or implementation details in description or name.
Verifier user payload:
{
  "task": "{task}",
  "candidate": "{candidate_to_dict(candidate)}",
  "variant": "{variant_to_dict(variant)}",
  "foreground": "{foreground_app}",
  "adb_output": "{summarized_adb_output}",
  "ui_sample": ["..."],
  "ui_tree_excerpt": "{summarized_ui_tree}"
}
If available, the screenshot is attached as an image_url message part.
Metadata refinement system prompt:
You refine shortcut skill names/descriptions. Return only JSON.
Metadata refinement user prompt:
{
  "task": "Refine Android shortcut skill metadata after validation. Return JSON only: {\"
    records\":[{\"index\":0,\"name\":\"...\",\"description\":\"...\"}]}. Do not change
    payload fields, packages, status, parameters, valid_state, or indices. All promoted
    shortcut records must keep valid_state='No need to verify'. Prefer concise distinct
    names and descriptions that help an agent choose the right shortcut.",
  "records": "{compact_records}"
}
```

(e) Experience-memory induction prompt

```
Success system prompt:
You are an expert in Android GUI automation. You will be given a user task query
and the corresponding trajectory that represents **how an agent successfully
accomplished the task**.
## Guidelines
You need to extract and summarize useful insights in the format of memory items
based on the agent's successful trajectory.  The goal of summarized memory items
is to be helpful and generalizable for future similar tasks.
## Important notes
- You must first think why the trajectory is successful, and then summarize
  the insights.
- You can extract *at most 3* memory items from the trajectory.
- You must not repeat similar or overlapping items.
- Prefer concrete, actionable procedures over abstract principles.  Do not
  embed specific product names, queries, or literal string contents from the
  task.
- For Android GUI tasks, focus on: app navigation patterns, form-filling
  strategies, common UI pitfalls that were avoided, and efficient action
  sequences.
- When UI snippets are present in the trajectory, ground lessons in the actual
  visible/clickable controls rather than only repeating the agent's own
  reasoning.
## Output Format
Your output must strictly follow the Markdown format shown below:
```
Memory Item i
Title <the title of the memory item>
Description <one sentence summary describing when to use the memory item>
Content <1-3 sentences describing the insights learned to successfully
  accomplish similar tasks in the future>
```
Failure system prompt:
You are an expert in Android GUI automation. You will be given a user task query
and the corresponding trajectory that represents **how an agent attempted to
resolve the task but failed**.
## Guidelines
You need to extract and summarize useful insights in the format of memory items
based on the agent's failed trajectory.  The goal of summarized memory items is
to be helpful and generalizable for future similar tasks.
## Important notes
- You must first reflect and think why the trajectory failed, and then
  summarize what lessons you have learned or strategies to prevent the failure
  in the future.
- You can extract *at most 3* memory items from the trajectory.
- You must not repeat similar or overlapping items.
- Prefer concrete, actionable recovery procedures over abstract principles.
  Do not embed specific product names, queries, or literal string contents
  from the task.
- For Android GUI tasks, focus on: navigation mistakes, form-filling errors,
  premature task completion, app state assumptions that were wrong, and
  specific UI patterns that caused trouble.
- When UI snippets are present in the trajectory, ground lessons in the actual
  visible/clickable controls rather than only repeating the failed agent's own
  reasoning.
## Output Format
Your output must strictly follow the Markdown format shown below:
```
Memory Item i
Title <the title of the memory item>
Description <one sentence summary describing when NOT to use this approach>
Content <1-3 sentences describing the insights learned to avoid such
  failures in the future>
```
User prompt:
{trajectory_text}
```

F SKILL AND SHORTCUT EXAMPLES

The three boxes below show excerpts from KNOWACT-GUICLAW's Android skill and shortcut store, abbreviated for readability: timestamps and some keyword arguments are dropped, 64-character state-contract hashes and long component names are truncated, and one Chinese accessibility label is glossed in ASCII. They illustrate the three forms covered by the single *skill* abstraction (Section 3.3): (a) a parameterized click-then-type pattern in $\mathcal{A}_{\text{skill}}$; (b) a multi-step skill whose steps

carry an expected state and, where available, a structural state contract checked before each step; and (c) validated deeplink and intent shortcuts in $\mathcal{A}_{\text{shortcut}}$. Stable values, such as package names, button coordinates, and intent components, are fixed in advance, while request-dependent values, such as the query string, are supplied at run time. The `validated` tag marks shortcut candidates that passed on-device validation rather than static manifest discovery alone.

(a) Parameterized pattern: click-then-type

```
@skill(name='click_then_type', platform='android', tags=['compact_action'],
       skill_id='compact:action:click_then_type',
       description='Tap a [0,999] coordinate, then type text.')
async def click_then_type(device, coordinate, text):
    await action('click_then_type', target=coordinate, text=text,
                 auto_enter=False, valid_state='No need to verify')
```

(b) Multi-step skill with per-step state validation (Pinduoduo)

```
@skill(name='search_product', app='com.xunmeng.pinduoduo', platform='android',
       skill_id='flat:search_product',
       description='Search for a product in Pinduoduo.')
async def search_product(device, query):
    await action('open_app', target='com.xunmeng.pinduoduo',
                 valid_state='No need to verify')
    await action('tap', target='search bar', fixed_values={'x': 242, 'y': 88},
                 valid_state='search bar is visible and clickable',
                 state_contract=C.from_dict({
                     'anchor': {'app_package': 'com.xunmeng.pinduoduo'},
                     'signature': {'required': [{
                         'selector': {'content_desc': 'search'},  # ASCII gloss
                         'state': ['visible', 'enabled']}]},
                     'fingerprint': '60c6a0fb...c950947b'}))  # sha256, truncated
    await action('input_text', target=query,
                 valid_state='input field is focused',
                 state_contract=C.from_dict({
                     'anchor': {'app_package': 'com.xunmeng.pinduoduo'},
                     'signature': {'required': [{
                         'selector': {'class': 'android.widget.EditText',
                                      'resource_id': 'com.xunmeng.pinduoduo:id/pdd'},
                         'state': ['visible', 'enabled', 'focused']}]},
                     'fingerprint': 'cbd6ef8c...4e7e2861'}))  # sha256, truncated
    await action('tap', target='search button', fixed_values={'x': 446, 'y': 96},
                 valid_state='search button is visible and clickable')
```

(c) Validated deeplink and intent shortcuts (JD)

```
@skill(name='jd_splash', app='com.jingdong.app.mall', platform='android',
       tags=['shortcut', 'deeplink', 'validated'], success_count=1)
async def jd_splash(device):
    await action('open_deeplink', target='JDAnalytics:',
                 package='com.jingdong.app.mall', valid_state='No need to verify')

@skill(name='jd_search', app='com.jingdong.app.mall', platform='android',
       tags=['shortcut', 'intent', 'validated'], success_count=1)
async def jd_search(device, query):
    await action('open_intent', intent_action='android.intent.action.SEND',
                 package='com.jingdong.app.mall',
                 component='com.jingdong.app.mall/...SearchBridgeActivity',
                 mime_type='text/plain',
                 extras=[['android.intent.extra.TEXT', '{{query}}']],
                 valid_state='No need to verify')
```