Enhancing AI Systems with Agentic Workflows Patterns in Large Language Model

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Abstract— This paper explores the significant shift towards agentic workflows in the application of Large Language Models (LLMs), moving away from traditional, linear interactions between users and AI. Through a case study analysis, we highlight the effectiveness of agentic workflows, which facilitate a more dynamic and iterative engagement, in improving outcomes in tasks such as question answering, code generation or stock analysis. Central to the agentic workflow are four foundational design patterns: reflection, planning, multi-agent collaboration, and tool utilization. These components are crucial for boosting LLM productivity and enhancing performance. The study demonstrates how agentic workflows, by promoting an iterative and reflective process, can serve as a crucial step towards achieving Artificial General Intelligence (AGI).

Keywords — Agentic Workflows, Agentic Patterns, Large Language Models, LLM Agent, AI Planning, Reflective AI, Multi-agent, Tools, Agent Collaboration.

I. INTRODUCTION

The research community is currently captivated by the capabilities Large Language Models (LLMs) withholds by using a zero-shot manner of prompting, LLM generate outputs that are almost indistinguishable from those produced by human experts, showcasing their remarkable versatility and potential as studied by Singh [1] and in investigations of AI generation models from textual descriptions [2]. This advancement opens up exciting avenues for innovation, though it also encourages ongoing dialogue about responsible development and application.

In the process of experimenting with zero-shot prompting, the journey often starts with users typing their initial query, which kicks off a sequence of iterations that are critically dependent on user feedback for any subsequent improvements. Each round of interaction unfolds in a linear manner, where the quality and direction of the LLM's next response are directly influenced by the user's preceding feedback. This iterative exchange, characterized by a continuous back-and-forth between user and agent, is crucial for refining the content. Importantly, the LLM's capacity to enhance its output in the following query is contingent upon receiving specific feedback from the user. This engagement method, marked by its reliance on ongoing user input, is commonly referred to as a non-agentic workflow.

In an agentic workflow, the process begins with the user initiating the first query. Before delivering the final output, the LLM agent enters a proactive series of questions and explorations on its own. This signifies a departure from simply reacting to user inputs; instead, the agent actively seeks to enhance the outcome through a self-guided cycle of feedback and improvement. Much like a team working collaboratively to refine a project, the agent iteratively revises, tests, and optimizes its responses. This approach not only provides more flexibility but also holds the potential for achieving higher quality outcomes, as the LLM agent takes on a more dynamic role in seeking ways to improve its performance based on the initial prompt from the user.

The agentic workflow operates on four fundamental principles: reflection, tools, planning, and multi-agent collaboration. This paper delves into these four pillars, highlighting the potential of agentic workflows. Specifically, we explore the application of reflection patterns in Q/A scenarios, trip planning through multi-agent collaboration, and the strategic use of tools and planning.
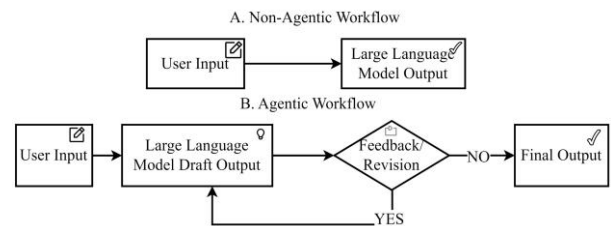

Fig. 1. Non-Agentic vs Agentic Workflow

II. BACKGROUND

Recent advancements in artificial intelligence have emphasized the importance of multi-agent reasoning design patterns, integrating capabilities like reflection, tool use, planning, and multi-agent collaboration. These components are essential for developing systems capable of sophisticated decision-making and problem-solving.

Reflection is a crucial aspect of agentic reasoning, allowing systems to analyze and improve their outputs iteratively. Madaan et al. introduced Self-Refine, a method that enhances LLMs' initial outputs through iterative feedback and refinement without additional training data or reinforcement learning, demonstrating significant performance improvements across diverse tasks [3]. Similarly, Shinn et al. proposed Reflexion, a framework that uses linguistic feedback for language agents to learn from trial-and-error efficiently, achieving notable results in coding and reasoning tasks [4] as illustrated in Fig. 2. Gou et al. developed CRITIC, a framework enabling LLMs to self-correct through interaction with external tools, enhancing their performance in various domains [5]. The reflection process can be described as:

$$p_{i+1} = refine(p_i, feedback(p_i, task_{context})); i = 0,1,2,\dots n \quad (1)$$

It continuously improves an output p_i through iterative refinements using task-specific feedback, until optimal results are achieved.
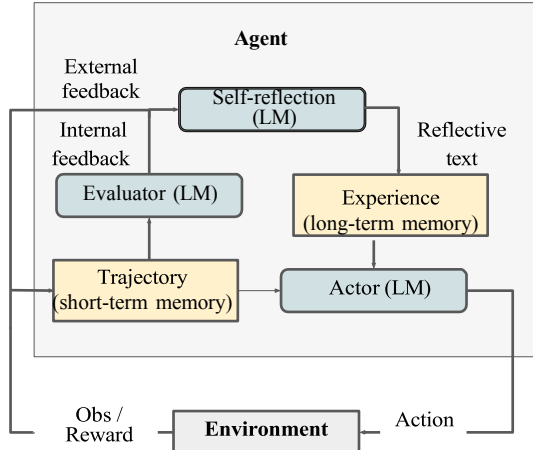
Fig. 2. Schematic of Reflection [2]

Tool use has been explored to extend LLMs' capabilities beyond language processing. Patil et al. released Gorilla, a model that effectively utilizes APIs, addressing the challenges of accurate input generation and hallucination [6]. Yang et al. proposed MM-REACT, integrating ChatGPT with vision experts for advanced visual intelligence tasks, demonstrating the feasibility of multimodal reasoning and action [7]. The tool use process can be defined as:

$$output = integrate(api\_call(input, parameters), model\_context) \quad (2)$$

This illustrates the enhancement of LLM outputs through the integration of external API responses, combining these with the model's context to improve functionality and precision.

Planning involves the strategic formulation of actions to achieve specific goals. Wei et al. highlighted the effectiveness of chain-of-thought prompting in eliciting reasoning in LLMs, significantly improving their performance on complex tasks [8]. Shen et al. introduced HuggingGPT, leveraging LLMs as controllers to manage AI models across different domains, showcasing the potential for solving sophisticated AI tasks [9]. The planning process can be defined as:

$$plan = generate(actions(sequence), evaluate(sequence, goals)); \quad (3)$$

This outlines the strategic planning process where a sequence of actions is generated and evaluated against specific goals, aligning the model's actions with intended outcomes.

Multi-agent collaboration is pivotal for systems to perform in concert towards common objectives. Qian et al. presented ChatDev, a paradigm that employs communicative agents throughout the software development process, demonstrating its efficiency and cost-effectiveness [10]. Wu et al. developed AutoGen, a framework for building LLM applications through conversable agents, enabling diverse applications across several domains [11]. Additionally, Du and Ding provided an extensive overview of multi-agent deep reinforcement learning, underscoring the significance of collaborative efforts in AI research [12].

III. AGENTIC WORKFLOW

Vacation or Trip planning is a complex process that requires considering multiple factors such as destination selection, accommodation, local attractions, and logistics. The Multi-Agent Travel Planning System is an innovative solution developed using Langchain [13] and its LangGraph for multi-agent workflows (as shown in Fig. 3). This advanced system incorporates the agentic workflow patterns of reflection, tool use, planning, and multi-agent collaboration. It adheres to best practices such as self-examination for continuous improvement, leveraging specialized tools for task execution, strategic multi-step planning, and collaborative problem-solving among agents to enhance the vacation planning process.

A. Langchain Tools Utilized by Agents:

- SearchTools: (Google SERPER: https://serper.dev/): Empowers agents with internet search capabilities to source travel data.
- Scrape and summarize website (browserless.io): Enables agents to scrape and summarize web content, yielding concise data outputs.
- CalculatorTools: Assists agents in conducting various mathematical calculations, crucial for financial aspects of travel planning.

B. Agents and Their Roles

- Data Collector Agent: The primary task of Data collector agent is to collects user input regarding travel preferences, including origin, desired destinations, travel dates, and interests. The user input is captured and passed to the Destination Finder agent to initiate the destination selection process.
- Destination Finder Agent (City Selection Expert): The role of Destination finder agent is to selects the best city for the traveler based on weather, seasonality, and prices. It analyzes travel data to compare multiple cities, considering factors like current weather conditions, cultural events, and travel expenses, resulting in a detailed report on the chosen city.
- Local Expert Agent: This agent provides in-depth insights about the selected city, emphasizing local attractions. It compiles comprehensive city guide, including information about key attractions, special events, and recommended daily activities, highlighting the unique characteristics that appeal to the traveler's interests.
- Itinerary Expert Agent: This agent creates detailed travel itineraries with suggestions for accommodations, dining, and activities, including budget and packing recommendations.

C. Data Flow within the System

The Data Collector Agent initiates the flow by gathering initial user data such as the origin, potential cities, travel dates, and interests. The Destination Finder Agent receives this data and engages in a two-fold process: internet searching and content summarization, leading to the selection of the optimal city. The selected city information is then passed on to the Local Destination Expert Agent, who crafts a detailed local guide, enriched with cultural and practical insights. With the local guide as its foundation, the Itinerary Expert Agent develops a complete travel itinerary, providing a day-to-day plan along with budget and packing advice.
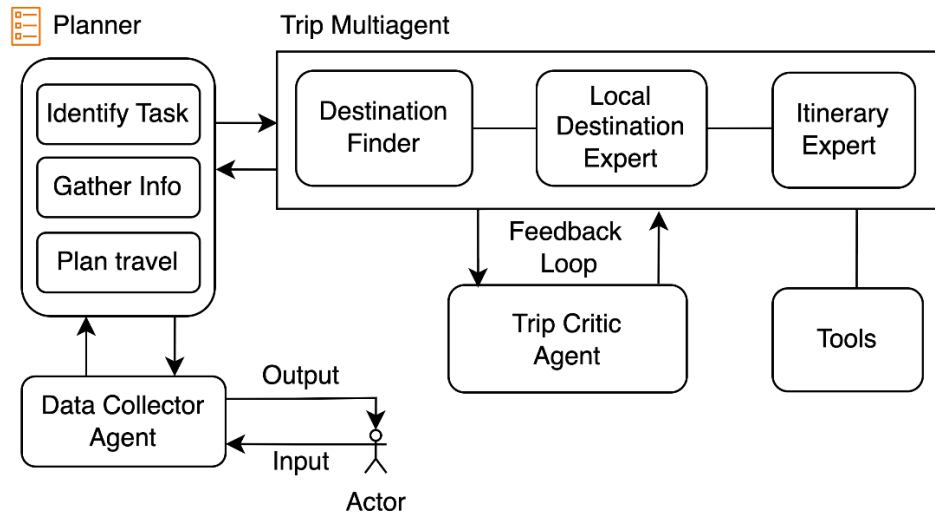
Fig. 3. Overall Architecture

Throughout the process, the Trip Critic Agent monitors the quality of outputs from each agent, offering iterative feedback to refine the recommendations until they meet a satisfactory standard. The agents use Langchain ChatOpenAI with model='gpt-4' underlies the entire system, driving the intelligent interaction and decision-making processes of all the specialized agent's analysis.

D. Agentic Workflow Patterns Utilised in Vacation Planner

The agentic workflow patterns have four pillars [14]:

- Reflection: The Trip Critic Agent implements reflective analysis, enhancing the itinerary based on a continuous feedback loop.
- Tool Use: LLMs are equipped with an array of tools that assist in tasks such as data retrieval, processing, and action execution.
- Planning: Each LLM follows a strategic planning approach, methodically working through the steps from user engagement to the delivery of the final product.
- Multi-Agent Collaboration: The system's agents work in concert, sharing tasks and insights to formulate a travel plan that surpasses the capabilities of individual agents

IV. CASE STUDY: AGENTIC WORKFLOWS IN LLMS

Let's take an example of Alex, a traveler planning a weekend in Atlanta from New York utilizes the Multi-Agent Travel Planning System for an optimal journey. The system kicks off with the Data Collector Agent, which meticulously gathers the traveler's preferences as depicted in Fig. 4. This foundational information is crucial in tailoring the journey to the traveler's specific interests.

The Destination Finder Agent then identifies the best travel dates and arrangements, considering weather and events. The Local Destination Expert Agent crafts a personalized guide featuring Atlanta's jazz scenes, culinary hotspots, and historical sites like the Martin Luther King Jr.

National Historical Park. This guide (illustrated in Fig. 5) is transformed into a detailed itinerary by the Itinerary Expert Agent, ensuring a balance of activities tailored to the traveler's interests.

Throughout the planning, the Trip Critic Agent provides feedback to refine the itinerary, ensuring it meets the traveler's expectations for a memorable Atlanta experience. This concise scenario highlights the system's ability to seamlessly tailor a travel plan, demonstrating its efficiency in enhancing the travel planning process from New York to Atlanta as shown in Fig. 6.


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*****Welcome to Vaccation Planner****
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From where will you be traveling from?
New York

What are the cities options you are interested in visiting?
Atlanta

What is the date range you are interested in traveling?
early May

What are some of your high level interests and hobbies?
Music
[DEBUG]: Working Agent: City Selection Expert
[INFO]: Starting Task:
Analyze and select the best city for the trip based
on specific criteria such as weather patterns, seasonal
events, and travel costs. This task involves comparing
multiple cities, considering factors like current weather
conditions, upcoming cultural or seasonal events, and
overall travel expenses.


Traveling from: New York
City Options: Atlanta
Trip Date: early May
Traveler Interests: Music
```

Fig. 4. Interaction between user and multi-agent system

Thought: Do I need to use a tool? Yes
Action: Search the internet
Action Input: I need to search for the weather forecast in Atlanta in early May, the current flight costs from New York to Atlanta in early May, and any music events happening in Atlanta during that time.

Title: Find cheap flights from New York to Atlanta from ... - Kayak
Link: https://www.kayak.com/flight-routes/New-York-NYC/Atlanta-Hartsfield-Jackson-ATL
Snippet: Find flights to Atlanta from $29. Fly from New York on Spirit Airlines, Frontier and more. Search for Atlanta flights on KAYAK now to find the best deal.

Title: $27 Cheap flights from New York (NYC) to Atlanta (ATL) - Expedia
Link: https://www.expedia.com/lp/flights/nyc/atl/new-york-to-atlanta
Snippet: Book one-way or return flights from New York to Atlanta with no change fee on selected flights. Earn your airline miles on top of our rewards!

Title: 10-Day Weather Forecast for Atlanta, GA
Link: https://weather.com/weather/tenday/l/Atlanta+GA?canonicalCityId=508c6a2d4ca8386de1772c431
6073b1448fb270ee2d264d01c7b2a4b33073688
Snippet: Be prepared with the most accurate 10-day forecast for Atlanta, GA with highs, lows, chance of precipitation from The Weather Channel and Weather.com.

Title: Find cheap flights from Atlanta to New York from ... - Kayak
Link: https://www.kayak.com/flight-routes/Atlanta-Hartsfield-Jackson-ATL/New-York-NYC
Snippet: Find flights to New York from $28. Fly from Atlanta on Frontier, Spirit Airlines and more. Search for New York flights on KAYAK now to find the best deal.

Action Input: I need to scrape the content from the website https://weather.com/weather/tenday/
l/Atlanta+GA?canonicalCityId=508c6a2d4ca8386de1772c4316073b1448fb270ee2d264d01c7b2a4b33073688 to find out about the 10-day weather forecast for Atlanta, GA.

The content indicates a navigation timeout error, where a process or request exceeded the maximum allowed time of 30000 milliseconds (30 seconds).

Do I need to use a tool? Yes
Action: Search the internet
Action Input: I need to search for a different website that provides the 10-day weather forecast for Atlanta, GA in early May.

Title: 10-Day Weather Forecast for Atlanta, GA
Link: https://weather.com/weather/tenday/l/Atlanta+GA?canonicalCityId=508c6a2d4ca8386de1772c431
6073b1448fb270ee2d264d01c7b2a4b33073688
Snippet: Tue 09 | Day. 72°. 51%. SE 9 mph. Rain showers early with overcast skies later in the day. High 72F. Winds SE at 5 to 10 mph. Chance of rain 50%. Humidity70 ...

Title: Atlanta, GA Monthly Weather - AccuWeather
Link: https://www.accuweather.com/en/us/atlanta/30303/may-weather/348181
Snippet: May · January · February · March · April · May · June · July · August ...

Title: Atlanta, GA 10-Day Weather Forecast
Link: https://www.wunderground.com/forecast/us/ga/atlanta
Snippet: Atlanta, GA 10-Day Weather Forecaststar_ratehome ; Sun. Rise. Set ; Actual Time. 7:18 AM. 8:02 PM ; Civil Twilight. 6:53 AM. 8:28 PM ; Nautical Twilight. 6:23 AM. 8 ...

Title: 10-Day Weather Forecast for Atlanta, GA
Link: https://weather.com/weather/tenday/l/Atlanta+GA+30345
Snippet: A few storms may be severe. Low 56F. Winds SW at 10 to 20 mph. Chance of rain 100%. 1 to 2 inches of rain expected.

Thought: Do I need to use a tool? Yes
Action: Search the internet
Action Input: Music events in Atlanta in early May

Title: Atlanta Concerts, Festivals, Tickets & Tour Dates 2024 & 2025
Link: https://www.songkick.com/metro-areas/4120-us-atlanta
Snippet: Find live music near you. Buy tickets for every upcoming concert, festival, gig and tour date taking place in Atlanta in 2024 & 2025.

Title: Atlanta Concert Tickets - Upcoming event tickets in ATL - Ticketmaster
Link: https://www.ticketmaster.com/discover/concerts/atlanta
Snippet: Buy Atlanta concert tickets on Ticketmaster. Find your favorite Music event tickets, schedules and seating charts in the Atlanta area.

Title: Atlanta Spring Festivals - Things to Do in March, April & May
Link: https://discoveratlanta.com/events/festivals/spring/
Snippet: Explore Atlanta spring festivals taking place in March, April and May such as the Dogwood Festival, Sweet Auburn Festival, Jazz Festival and more.

Title: Shaky Knees | Atlanta, GA | May 3-5, 2024
Link: https://www.shakykneesfestival.com/
Snippet: Shaky Knees is more than just a music festival. With on-site activations like fun photo booths, official festival merch and artist merch of your favorite bands, ...

Do I need to use a tool? Yes
Action: Scrape website content
Action Input: https://www.shakykneesfestival.com/

The Shaky Knees music festival, which has been held annually since 2013, is offering tickets for sale. The festival is known for its diverse lineup of more than 60 bands each year and offers a variety of experiences beyond the music, including food trucks with a wide range of offerings, from southern BBQ to vegetarian friendly corn dogs. In addition to music and food, the festival features on-site activations like photo booths, official festival merch, artist merch, cell phone charging stations, and water refilling stations. The festival also provides information about bookings at exclusive spots and rates in Atlanta.

Do I need to use a tool? Yes
Action: Search the internet
Action Input: Best local spots in Atlanta

Title: 10 Places Where Locals Love to Eat in Atlanta - Hotels.com
Link: https://www.hotels.com/go/usa/us-places-locals-love-to-eat-atlanta
Snippet: Where To Go for a Great Meal in Atlanta · Fat Matt's Rib Shack · Krog Street Market · West Egg Café · Atlanta Food Truck Park and Market · Busy Bee Café · 8ARM.

Title: 38 Essential Restaurants Around Atlanta, Winter 2024 - Eater Atlanta
Link: https://atlanta.eater.com/maps/38-best-restaurants-in-atlanta
Snippet: From Peruvian food and an underground steakhouse with sought-after martinis to Southern restaurants and Korean feasts at a Buford Highway ...

Title: 25 Must-try Restaurants in Atlanta
Link: https://discoveratlanta.com/dining/famous-restaurants/
Snippet: Famous, Tried-and-true dining experiences · CASUAL · Mary Mac's Tea Room · The Colonnade · The Busy Bee Cafe · Paschal's · Pittypat's Porch · Eats.

Title: Eat Like a Local in Atlanta - Edible Communities
Link: https://www.ediblecommunities.com/atlanta/local-resources/eat-like-a-local-in-atlanta/
Snippet: Where to eat: Casual spots that are local favorites for lunch and brunch are Ann's Snack Bar (Ghetto Burger), Home Grown and Ria's Bluebird, which is located ...

Do I need to use a tool? Yes
Action: Scrape website content
Action Input: https://www.hotels.com/go/usa/us-places-locals-love-to-eat-atlanta

I'm sorry, but I'm unable to complete the task as I don't have access to any tools.

Do I need to use a tool? Yes
Action: Search the internet
Action Input: Reviews for Fat Matt's Rib Shack in Atlanta

Title: Would not go again - Review of Fat Matt's Rib Shack, Atlanta, GA
Link: https://www.tripadvisor.com/ShowUserReviews-g60898-d466198-r153681268-Fat_Matt_s_Rib_Shack-Atlanta_Georgia.html
Snippet: Fat Matt's Rib Shack: Would not go again - See 1253 traveler reviews, 281 candid photos, and great deals for Atlanta, GA, at Tripadvisor.

Fig. 5. Intermediate Interaction of agent with tools for internet search and web scraping

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[DEBUG]: [Amazing Travel Concierge] Task output: Here is your 7-day itinerary for your trip to
Atlanta in early May:

Day 1: Arrival and Rest
- Flight from NY to Atlanta: $29
- Stay at the Hyatt Regency Atlanta with the average price of $150 per night (reason: it's one
of the top-rated hotels with a restaurant)
- Dinner at the hotel restaurant: estimated $30 per person

Day 2: City Exploration
- Breakfast at the hotel: included in the stay
- Visit the High Museum of Art: $14.50 per person (reason: it's one of the top-rated attraction
s in Atlanta)
- Lunch at the Busy Bee Cafe: estimated $15 per person (reason: it's a beloved, decades-old res
taurant for great soul food)
- Afternoon at the Georgia Aquarium: $35.95 per person (reason: it's one of the largest aquariu
ms in the world)
- Dinner at Bone's Restaurant: estimated $50 per person (reason: it's one of the best American
Steakhouses in Atlanta)

Day 3: Music Festival
- Breakfast at the hotel: included in the stay
- Shaky Knees music festival: $390 per person (reason: it's a key music event in Atlanta and of
fers a diverse lineup of bands, food trucks, and on-site activations)
- Lunch and Dinner at the festival: estimated $30 per person

Day 4: City Exploration
- Breakfast at the hotel: included in the stay
- Visit the Martin Luther King Jr. National Historic Site: free admission (reason: it's a meani
ngful and educational experience)
- Lunch at Atlanta Breakfast Club: estimated $15 per person (reason: it's one of the top-rated
breakfast spots in Atlanta)
- Afternoon at the Atlanta Botanical Garden: $21.95 per person (reason: it's a beautiful garden
 with a variety of plants and flowers)
- Dinner at the South City Kitchen Midtown: estimated $30 per person (reason: it's a popular re
staurant offering Southern cuisine)

Day 5: Relax and Shop
- Breakfast at the hotel: included in the stay
- Morning at Piedmont Park: free admission (reason: it's a beautiful and peaceful park in the c
ity)
- Lunch at the Krog Street Market: estimated $15 per person (reason: it's a vibrant food hall w
ith a variety of food options)
- Afternoon shopping at the Lenox Square: variable (reason: it's a premier shopping destination
 in Atlanta)
Day 6: Music Festival
- Breakfast at the hotel: included in the stay
- Shaky Knees music festival: included in the 3-day pass
- Lunch and Dinner at the festival: estimated $30 per person

Day 7: Departure
- Breakfast at the hotel: included in the stay
- Flight from Atlanta to NY: $29

Packing Suggestions: Pack lightly with summer clothes, but do bring a light jacket for cooler n
ights. Also pack an umbrella as there's a 33% chance of rain in May. Don't forget your festival
 outfits and comfortable shoes for walking.

Budget Breakdown:
- Flights: $58
- Hotel: $900 (6 nights)
- Food: $405
- Music Festival: $390
- Attractions: $71.45
- Shopping: variable
- Total: $1824.45 (excluding shopping)

Enjoy your trip to Atlanta!
```

Fig. 6. Final Vacation Plan Output by Multiagent system

The system consists of four major components: Planner, Multiagent, Critic Agent, and Tools. The user provides information about their trip preferences, including their origin, destination city options, travel dates, and interests via interactive conversation with the data collector agent. Based on these inputs, the planner creates a series of tasks like gathering information and creating the travel plan. The multiagent utilizes its tools to gather data from various sources, such as internet searches, website scraping, and calculations, to fulfill the task requirements. Each agent in this multiagent ecosystem has specialized roles and responsibilities guiding their behaviors and interactions within the system. The system incorporates a feedback loop where it scrutinizes the response from the multiagent and based on the confidence score, a task can be re-executed for that agent multiple times until the critic score reaches a satisfactory threshold. Once a satisfactory score is reached,

the output for the tasks is sent to the user. Overall, our system effectively employs agentic design patterns to facilitate intelligent interaction between users and agents, enabling personalized and comprehensive trip planning assistance.

There is always a risk of mislabeling or misidentification of text that are comprehensively edited by humans. This is because modifications made by humans can change the features that the detector looks for, making it harder to detect machine-generated text. As AI models become more advanced and produce text that is more similar to human writing, it will become increasingly difficult for detectors to distinguish between machine-generated and human-generated text.

Therefore, it's important for users to be aware of these limitations and to use these tools in combination with other methods of verification, such as manual inspections, to

ensure accuracy. These tools have different use cases depending up on the specific purpose and requirement in various industries. For instance, these have application in language translation, social media posts, customer reviews, educational institutions, legal contexts, text reuse, content creation or marketing or advertising and detecting plagiarism.

V. CONCLUSION

The shift towards agentic workflows marks a significant paradigm change in the deployment of Large Language Models (LLMs). Our research indicates that these workflows yield superior results and endow LLMs with a closer approximation to human-like problem-solving capabilities.

We conclude that the adoption of agentic workflows is crucial for unlocking the full potential of LLMs, facilitating the development of AI systems that are not only more robust and adaptable but also significantly more intelligent. As the quest for Artificial General Intelligence (AGI) continues, it becomes clear that agentic workflows may provide the essential, incremental steps needed to achieve this ambitious goal. The future significance of LLMs lies not just in their text generation capabilities but in their ability to engage in self-dialogue, pushing the boundaries of AI towards unprecedented levels of sophistication and utility. By embracing this methodology, we pave the way for a future where LLMs can address complex challenges in artificial intelligence, heralding a major leap forward for the field.

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