Design and Development of a Human-Agent Collaboration Model for Situation Awareness in Cockpit

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1. Background

1

The Challenges of Full Autonomous Driving

Level 5 autonomous driving still faces challenges from technology, legal issues, and ethics[1]. Thus, OEMs are adopting L2 and L3 autonomous features (ADAS).

2

Human-Centered Driving

For the foreseeable future, humans will remain at the core of driving. Human-Centered Driving aims to enhance the driving experience and safety for humans.

3

Human-Agent Collaboration

Designing effective collaboration mechanisms between human drivers and ADASs is crucial for Human-Centered Driving.

1.1 Challenges and Requirements

> Advanced Driver Assistance Systems (ADASs) may intermittently **require human re-engagement** in vehicle operation. Conversely, **drivers may need the support** of ADASs in certain scenarios[1]...Understanding and predicting the **human driver's intentions** is critical to this two-way cooperative process[2].
>
> Establishing an **efficient, transparent communication mechanism** between ADASs and human drivers to ensure rapid and accurate information exchange at critical moments is a significant challenge[3]...
>
> How to process and **integrate information from various sensors and data sources** to achieve accurate **situation awareness** is a key issue in system design[4]...

Excerpt from the Literature Review and Requirements Analysis of this project.

1.2 Motivation

Design and develop a **Human-Agent**[1] **Collaboration** model considering

1. **human driver's intention**
2. **communication mechanism**

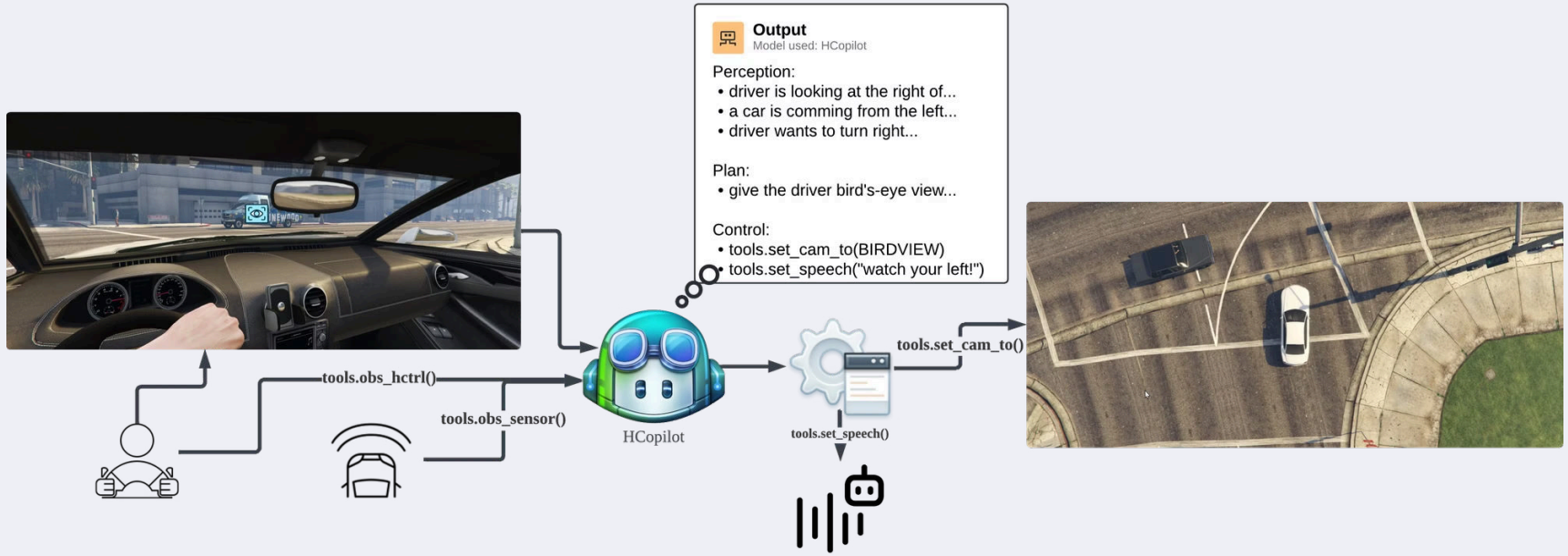
to improve **human-centered driving** in:

User Experience (UX)	Security
Intention-Based Implicit Interaction	Low Attention Alerts
Driver Situation Awareness Enhancement	Potential Threat Alerts
ADAS[2] *Preferences Suggestion*	*Autonomous Emergency Takeover*

Excerpt from the Software Feature List of this project.

2. My Solution:

HCockpit and HCopilot



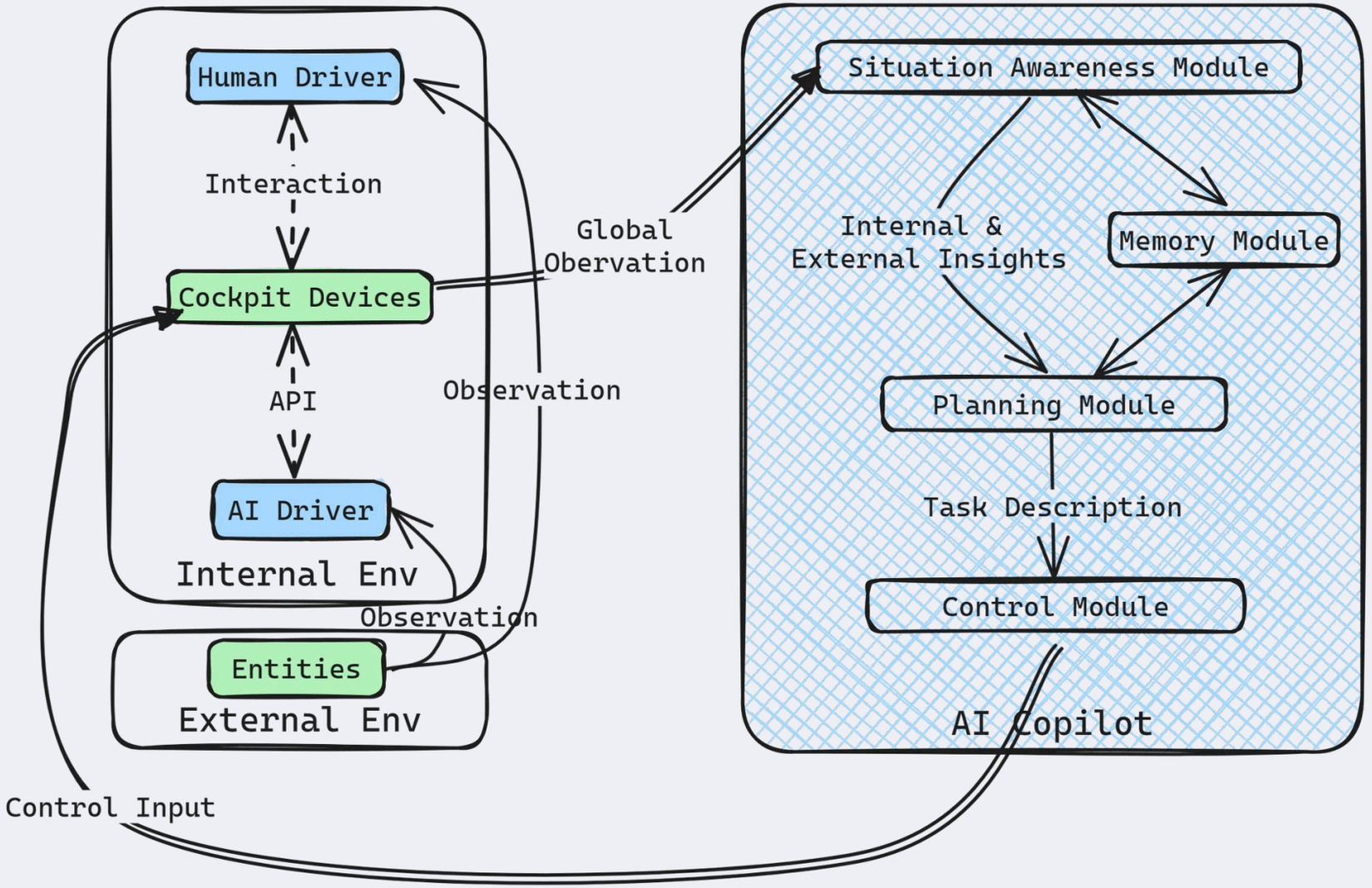
3. Design and Implementation

1 **HCockpit Architecture**

2 **HCopilot Implementation**

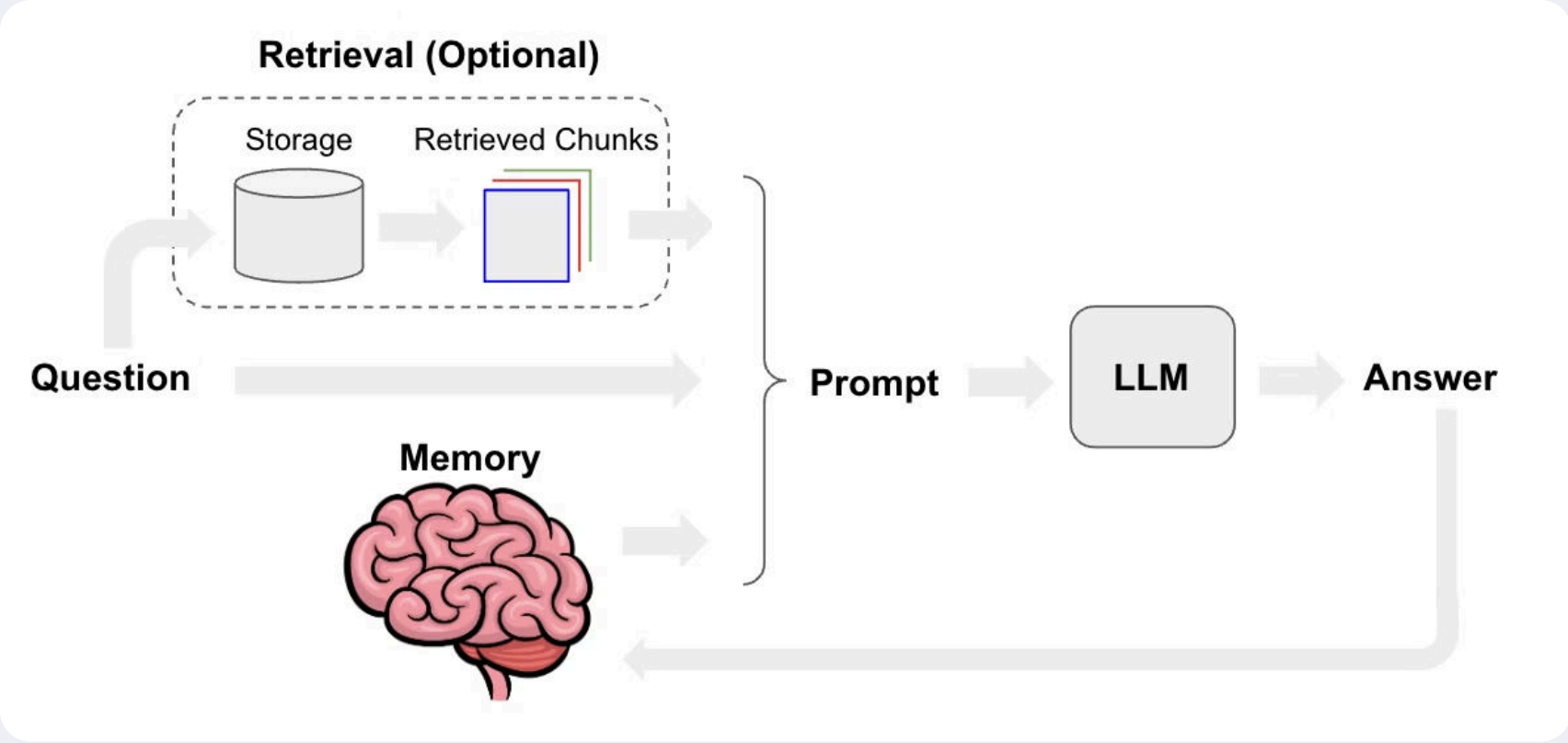
HCopilot is an agent developed following HCockpit architecture.

3.1 HCockpit Architecture



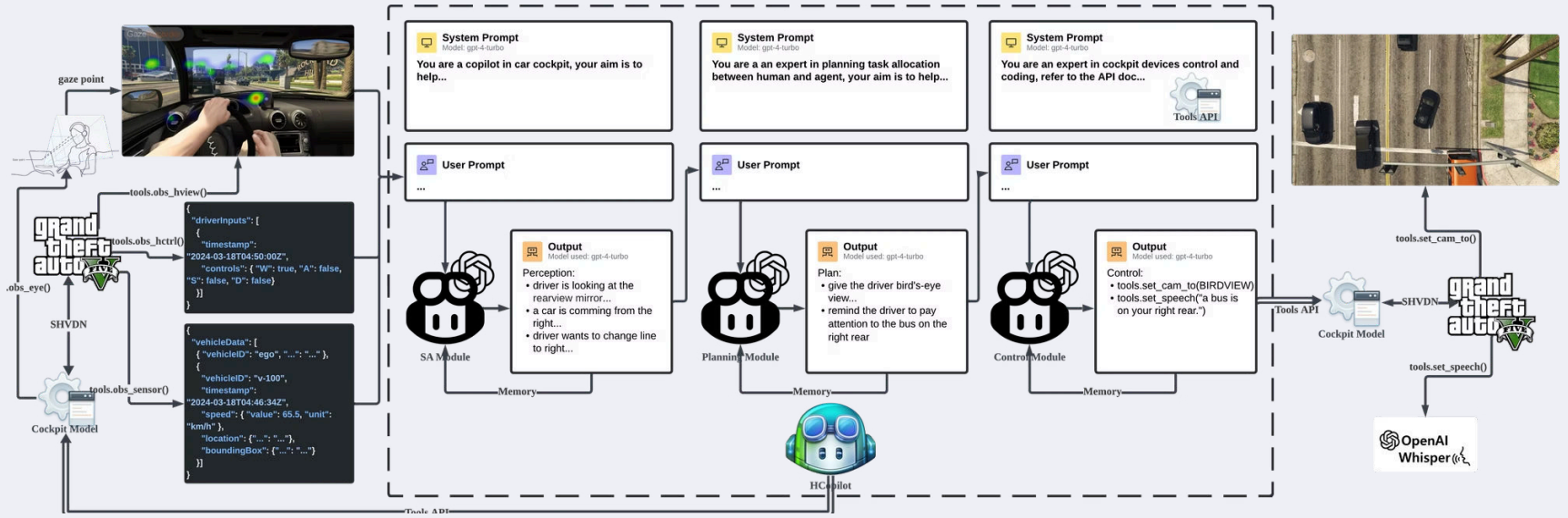
Design Basis: The Rise and Potential of Large Language Model Based Agents: A Survey[1]

3.1.1 Context Awareness

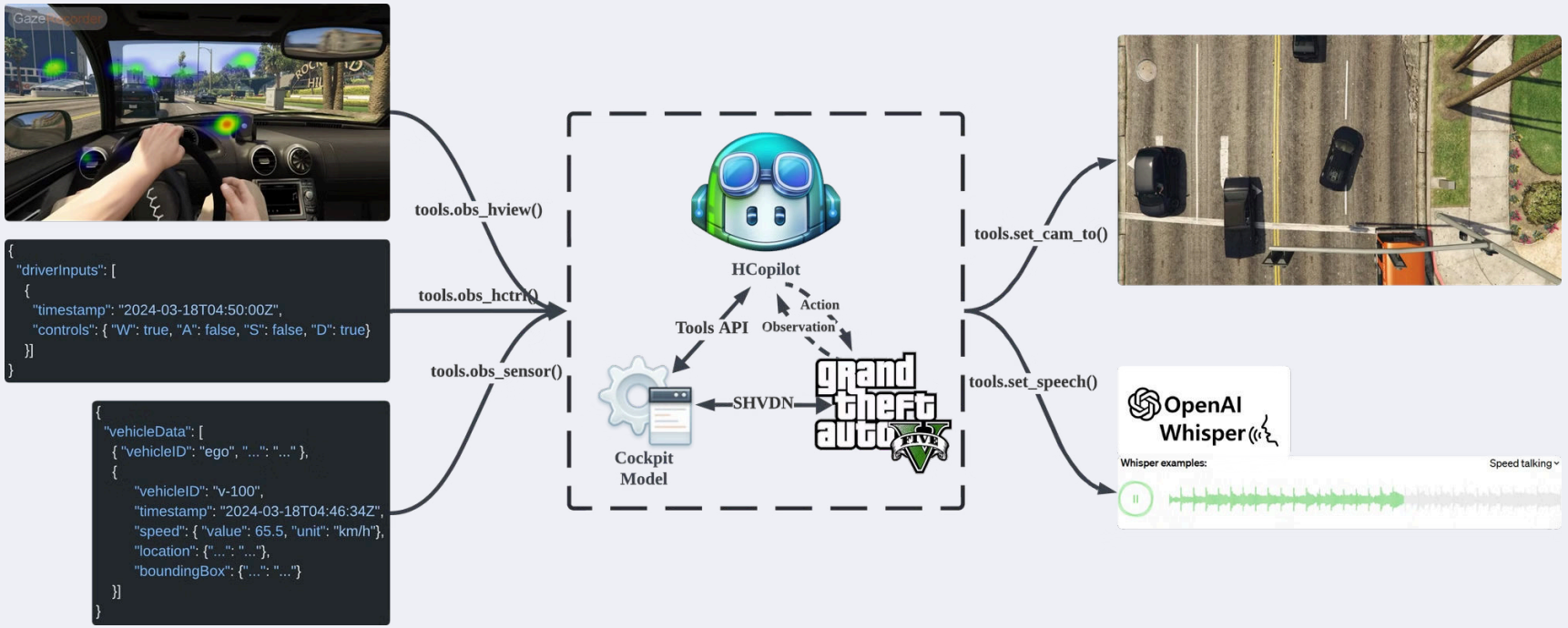


Inspired by ChatGPT[1] architecture.

3.2 HCopilot Implementation

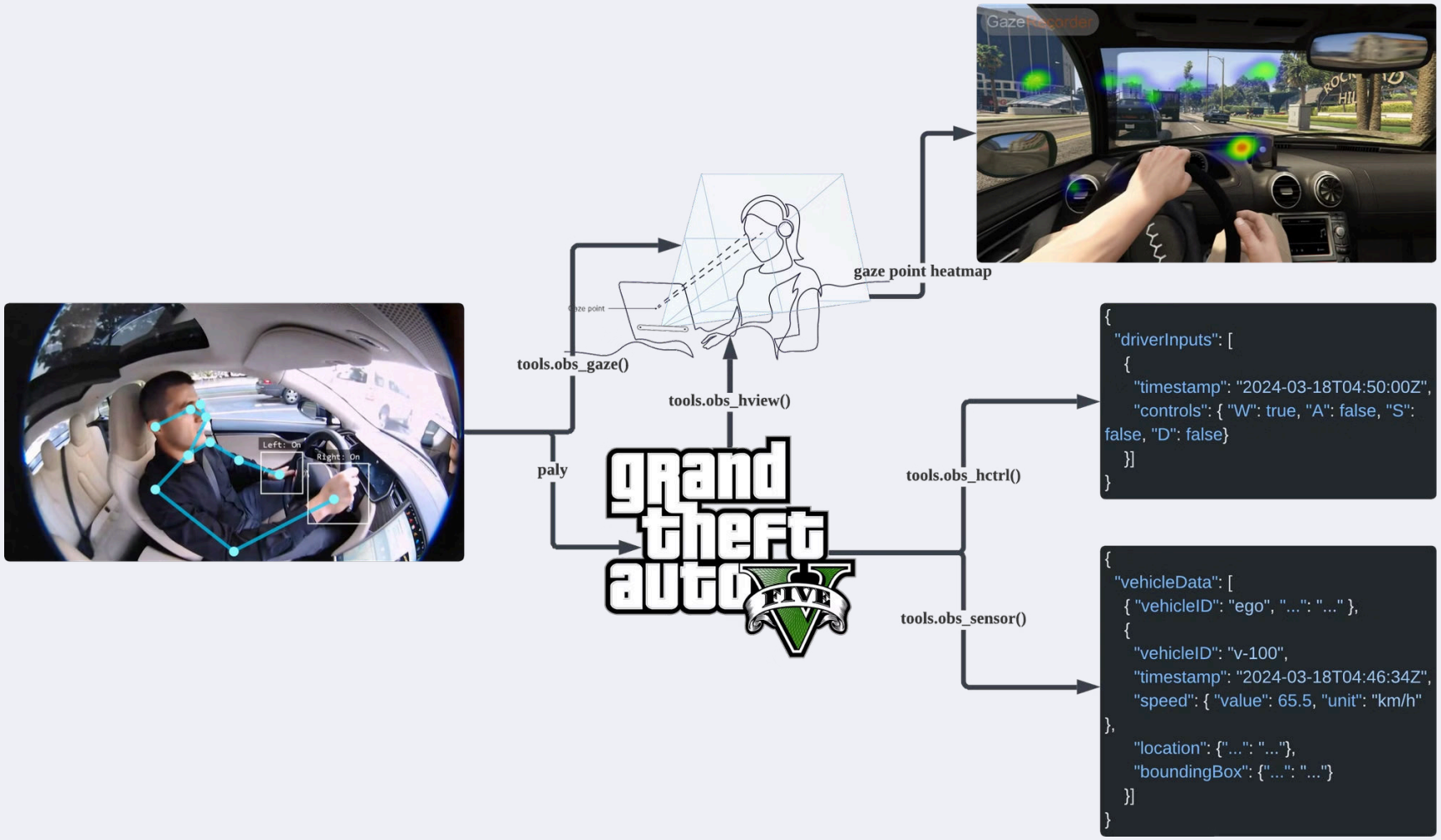


3.2.1 Tools API



References: Script Hook V[1], SHVDN[2], GTAV[3] and Whisper[4].

3.2.2 Data Collection



Tools used: iVCam[1], Beam Eye Tracker[2] and OpenTrack[3].

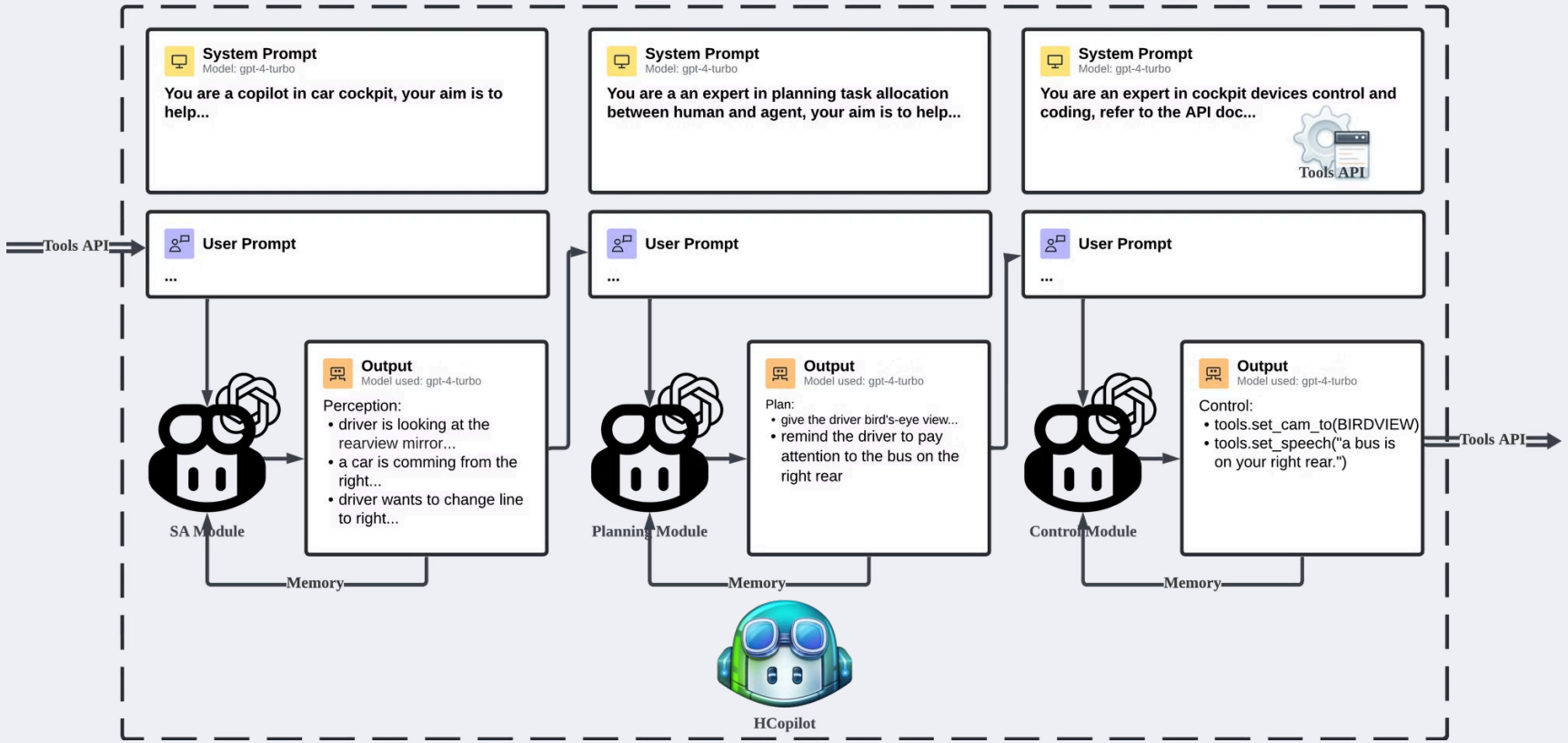
3.2.3 Prompt Engineering

1. Tactics (under the guide[1] from OpenAI)

1. Include detailed information in the query to obtain more relevant answers.
2. Ask the model to adopt a persona.
3. Use delimiters to clearly indicate different parts of the input.
4. Follow the chain-of-thought (CoT) prompting[2], specifying the steps required to complete the task.
5. Provide examples.

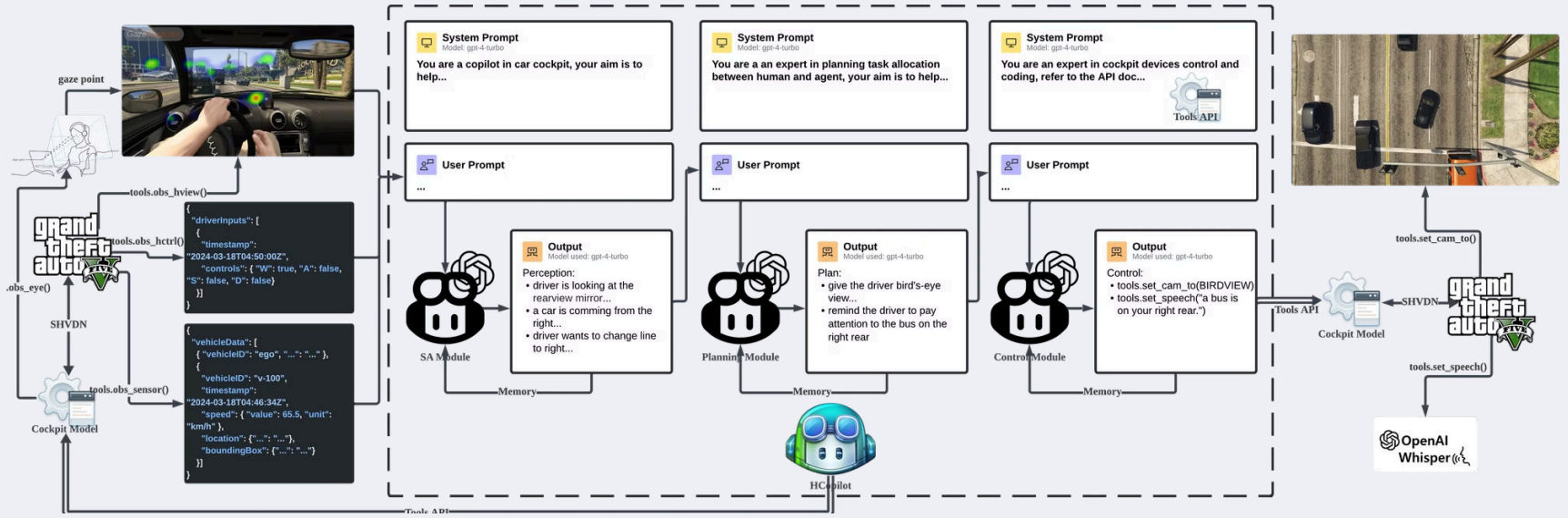
> Prompt, also known as the input to LMM, is the description of the input data and the tasks.

2. LMMs Chain



Implemented using LangChain[1], an open-source framework to dev apps powered by LMMs.

3.2.4 Overall Workflow



4. Demonstration

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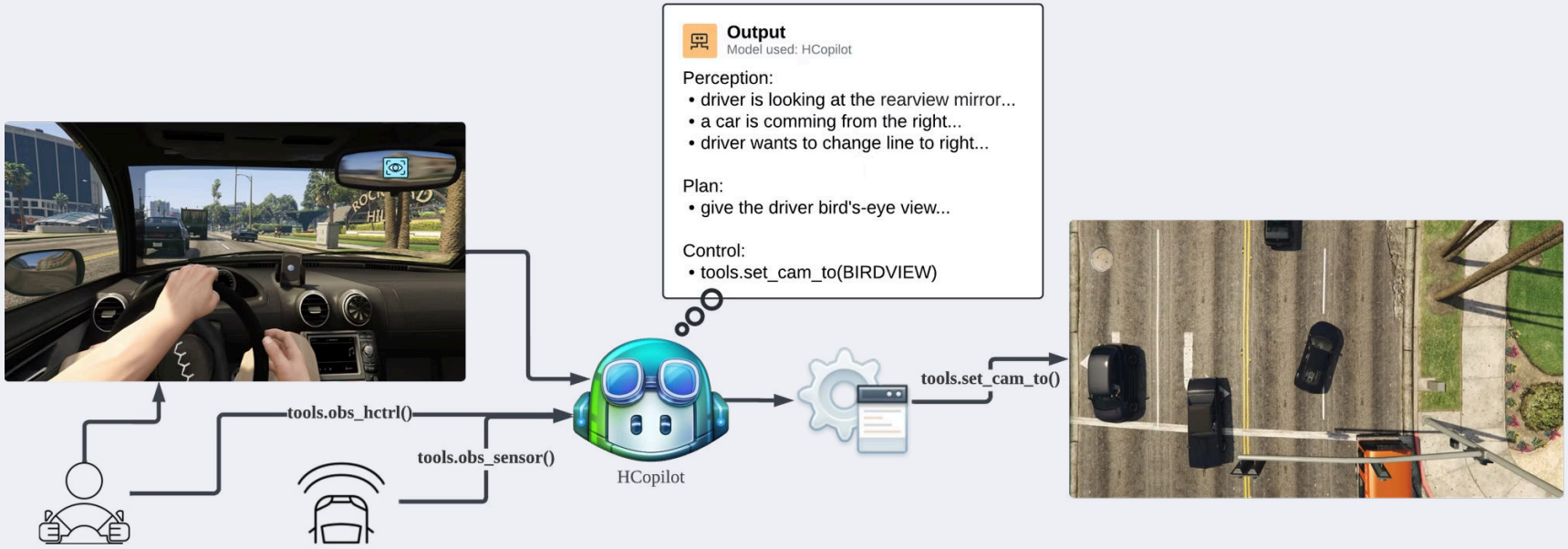
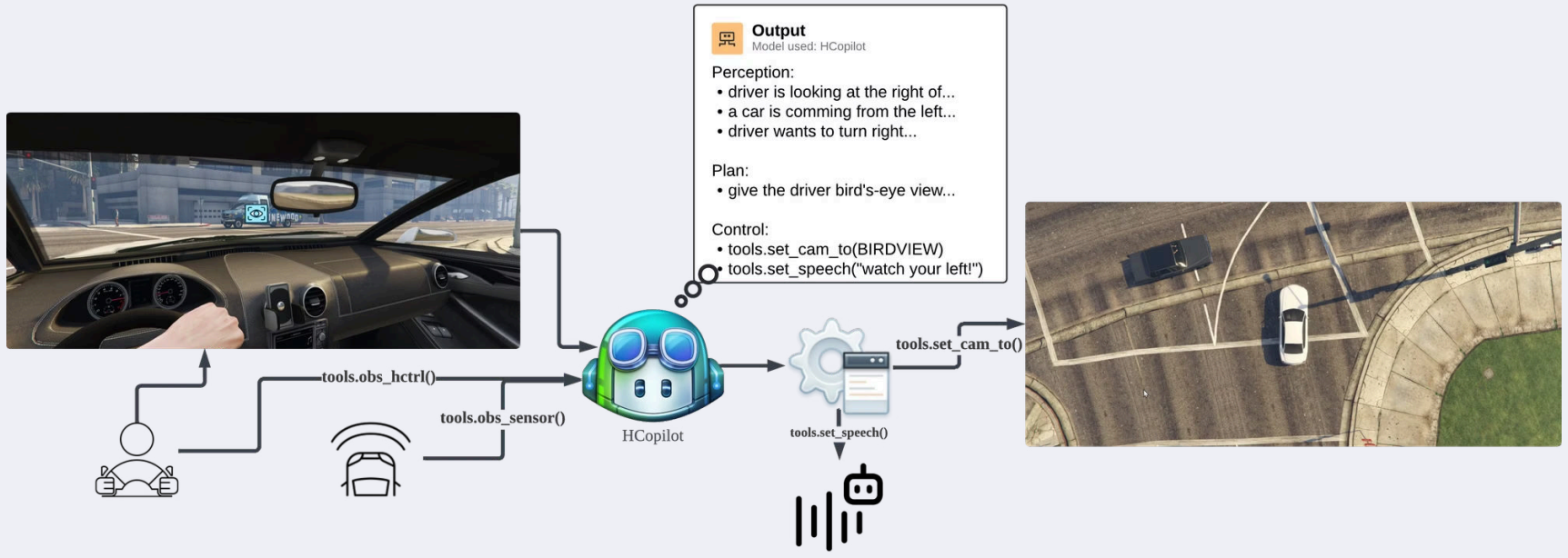
Scenario 1: Lane Change



Scenario 2: Turn Right at Intersection 1



Scenario 2: Turn Right at Intersection 2

Output
Model used: HCopilot

Perception:
- driver is looking at the comming car...
- a car is comming from the left...
- driver wants to turn right...

Plan:
- do nothing

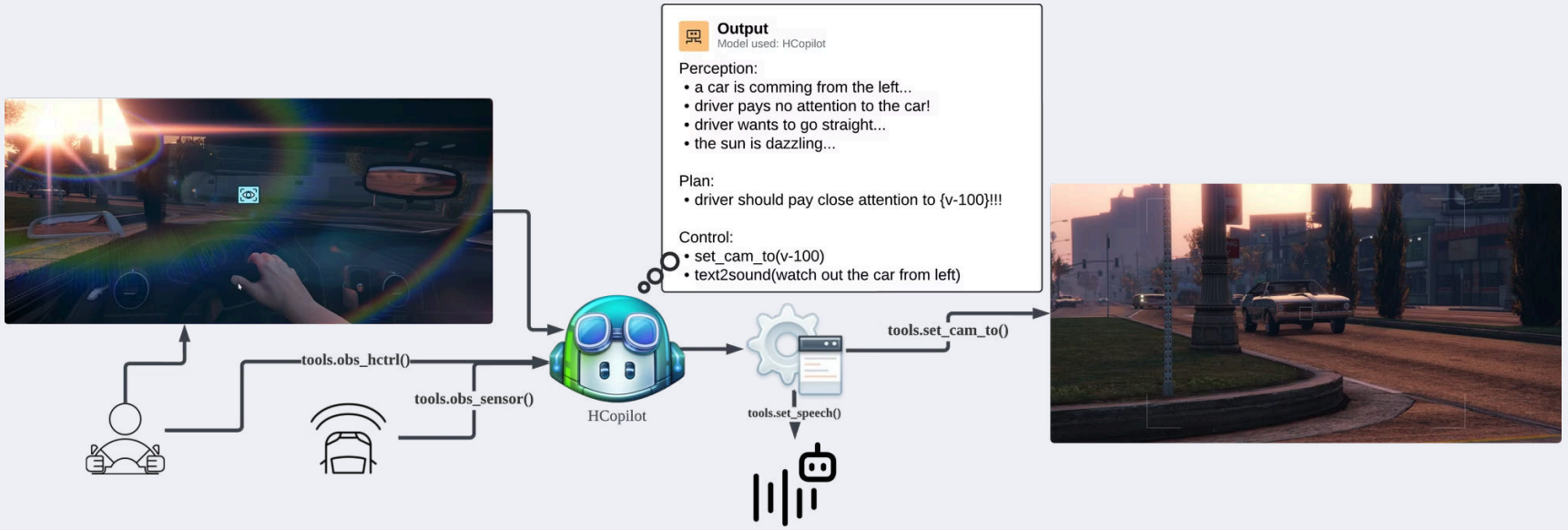
Control:
- tools.do_nothing()

tools.obs_hctrl()

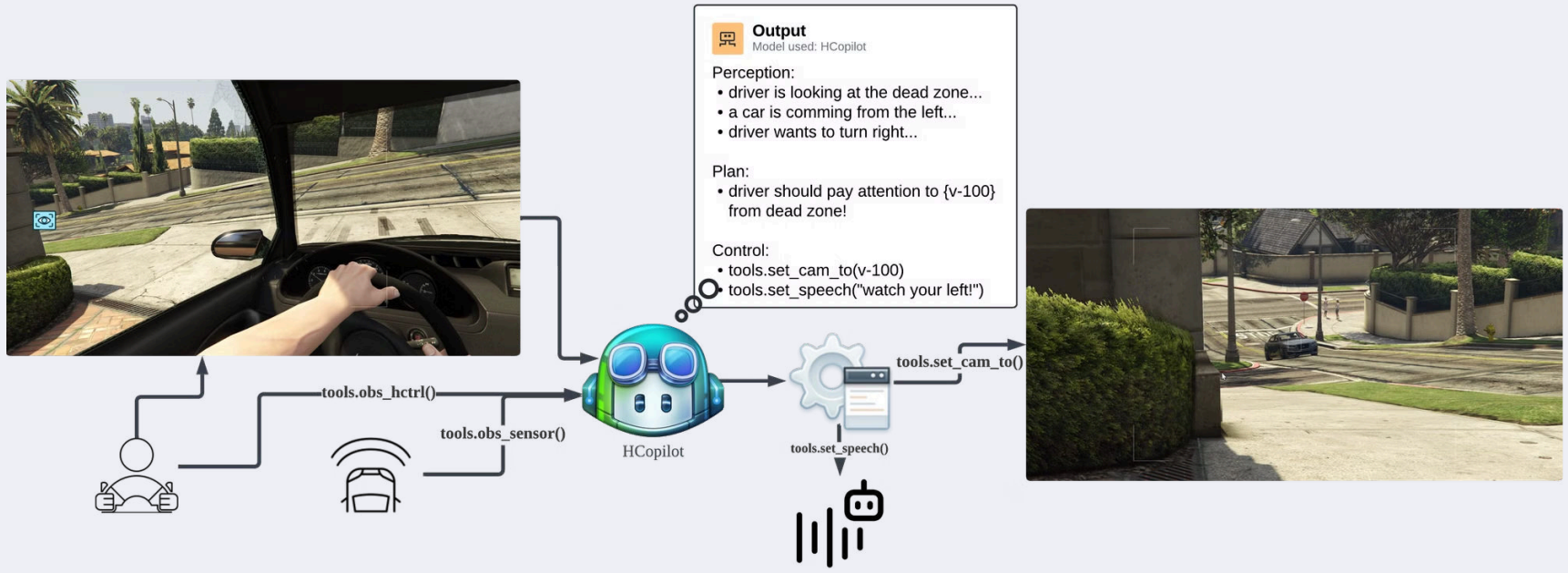
tools.obs_sensor()

HCopilot

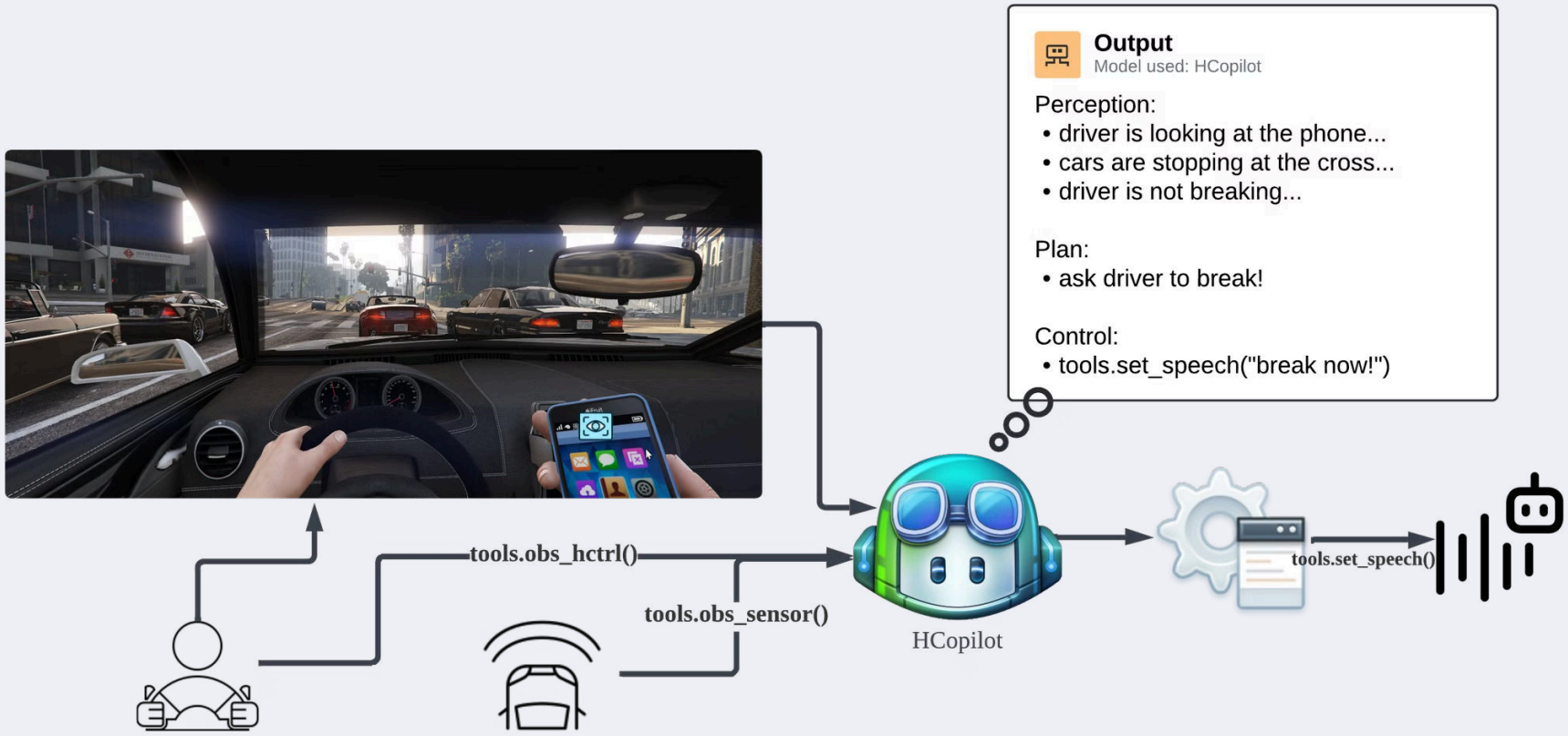
Scenario 3: Too Bright to See



Scenario 4: Blind Area



Scenario 5: Low Attention



Conclusion and Future Work

Conclusion

1. Proposed a novel HAC model (HCockpit) considering both human intention and explanable communication
2. Implemented an copilot agent (HCopilot) powered by the SOTA LMM GPT-4 Turbo, with the following abilities:
    a. Effective Enhancement of Situation Awareness
    b. Timely Threat Perception and Warning
    c. Adaptive and Intelligent Assistance

Future Work

1. Local Real-Time Operation of LMMs
2. Entity Alignment Optimization
3. Local Real-Time Operation of LMMs
4. Unified and Standardized Cockpit Device Control Interface
5. Conduct further validation across a broader demographic

Thank You!