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Vega: Intelligent Chatbot Platform for Internet of Things and Embedded Systems Development

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This paragraph of the first footnote will contain support information, including sponsor and financial support acknowledgment. For example, "This work was supported in part by the U.S. Department of Commerce under Grant BS123456."

ABSTRACT Large language models (LLMs) have revolutionized natural language processing, yet their potential in Internet of Things (IoT) and embedded systems (ESys) applications remains largely untapped. Traditional IoT interfaces often require specialized knowledge, creating barriers for non-technical users. We present a modular system that leverages LLMs to enable intuitive, natural language control of IoT devices, specifically a Raspberry Pi (RPi) connected to various sensors and devices. Our solution comprises three key components: a physical circuit with input and output devices, an RPi integrating a control server, and a web application integrating LLM logic. Users interact with the system through natural language commands, which the LLM interprets to call appropriate commands for the RPi. The RPi executes these instructions on the connected circuit, with outcomes communicated back to the user via LLM-generated responses. We empirically evaluate our system's performance across a range of task complexities and user scenarios, demonstrating its ability to handle complex, conditional logic without additional RPi-level coding. Our findings reveal that LLM-driven IoT control can effectively bridge the gap between complex device functionality and user-friendly interaction. We discuss the system's scalability, exploring its potential applications in diverse settings such as smart homes, industrial monitoring, and educational environments. By enabling natural language interaction with IoT devices, our approach not only enhances accessibility for non-technical users but also opens new avenues for creative and intelligent IoT applications. This research contributes to the growing body of work on interactive intelligent systems for IoT, offering insights into the design and implementation of LLM-integrated IoT interfaces.

INDEX TERMS Enter key words or phrases in alphabetical order, separated by commas. Autocorrelation, beamforming, communications technology, dictionary learning, feedback, fMRI, mmWave, multipath, system design, multipath, slight fault, underlubrication fault.

I. INTRODUCTION

THE evolution of large language models (LLM's) has led to rapid development in the realm of intelligent systems. However, the application of LLM's hasn't been thoroughly explored in internet of things (IoT) and embedded systems (ESys). Traditionally, the development of IoT systems that seamlessly adapt to the user's need and tasks poses a considerable challenge. Leveraging the capabilities of LLMs presents an opportunity to address this challenge and bridge the gap between technical intricacies and user accessibility.

II. BACKGROUND AND RELATED WORK

A. APPLICATIONS OF CHAT ORIENTED SYSTEMS

B. LLM'S IN INDUSTRIAL APPLICATIONS

C. LLM'S IN IOT AND ESYS

III. METHODOLOGY

A. OVERALL ARCHITECTURE

B. PHYSICAL CIRCUIT DESIGN

C. RASPBERRY PI DESIGN

D. WEB APP DESIGN

IV. EXPERIMENT AND RESULTS

A. COMPLEX COMMANDS

B. AUTOMATED EVALUATION

C. RESULT ANALYSIS

D. REAL LIFE APPLICABILITY

V. CONCLUSION

ACKNOWLEDGMENT

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[1] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp.

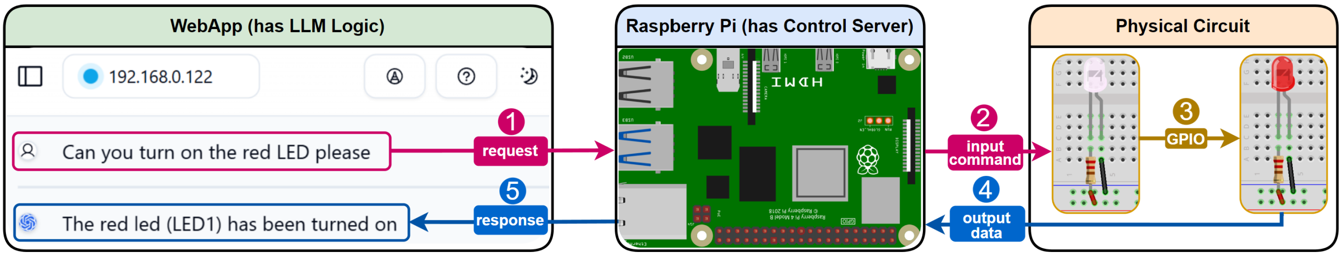

FIGURE 1. Magnetization as a function of applied field. It is good practice to explain the significance of the figure in the caption.

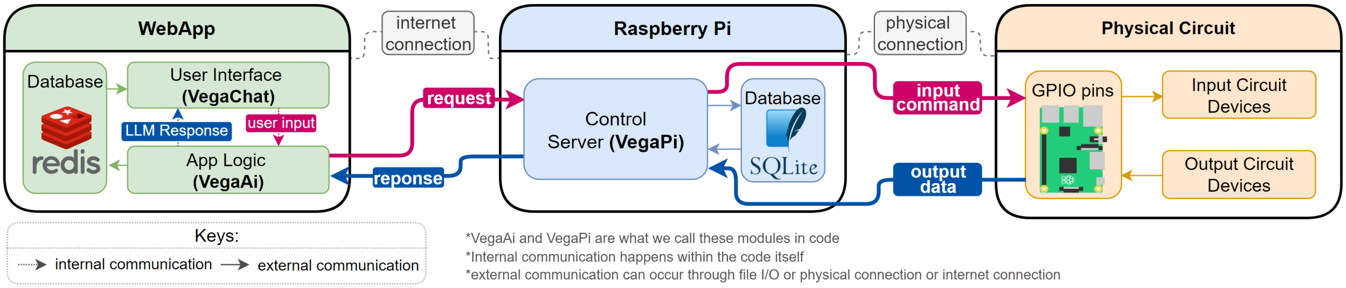

FIGURE 2. The overall arhcitecture of the system.

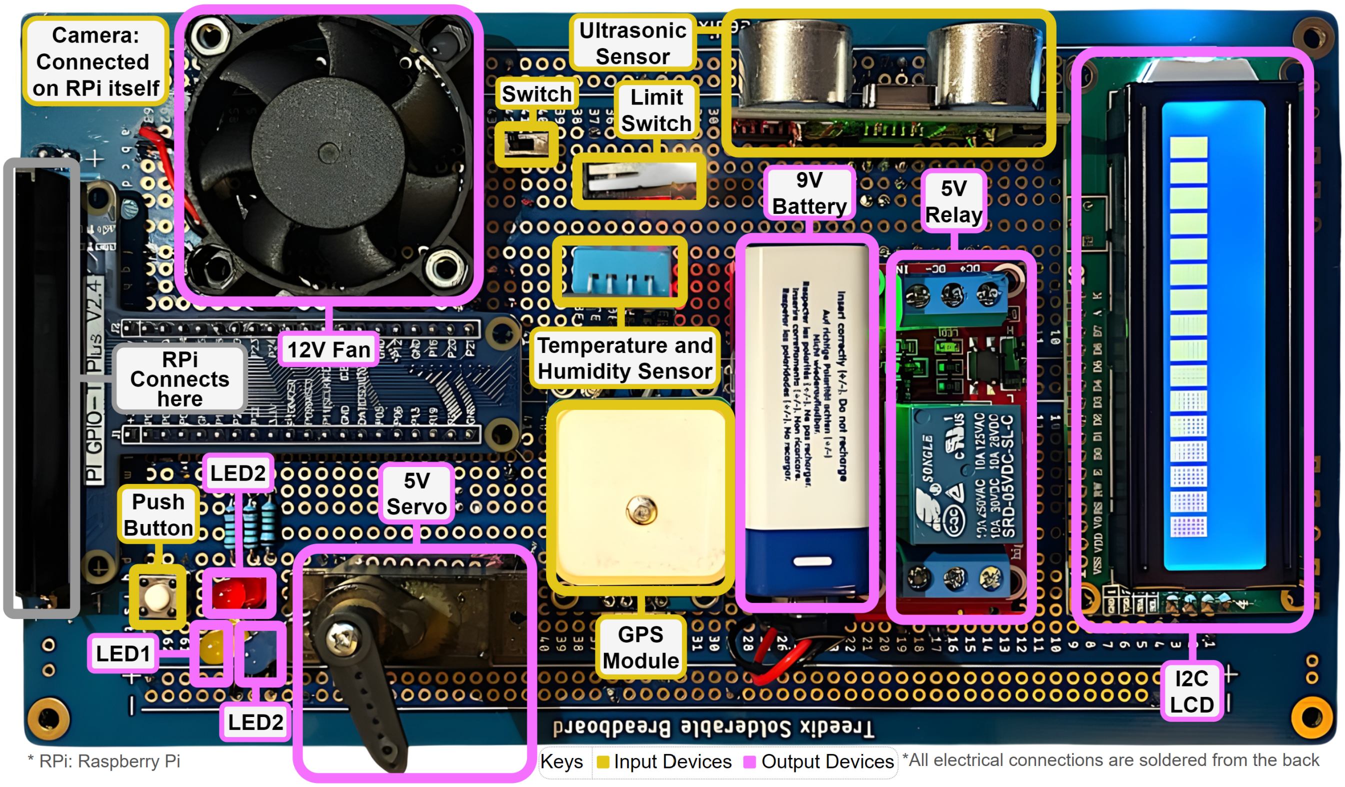

FIGURE 3. Soldered physical circuit connected to the RPi

15–64.

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[3] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959, 10.1109/TED.2016.2628402.

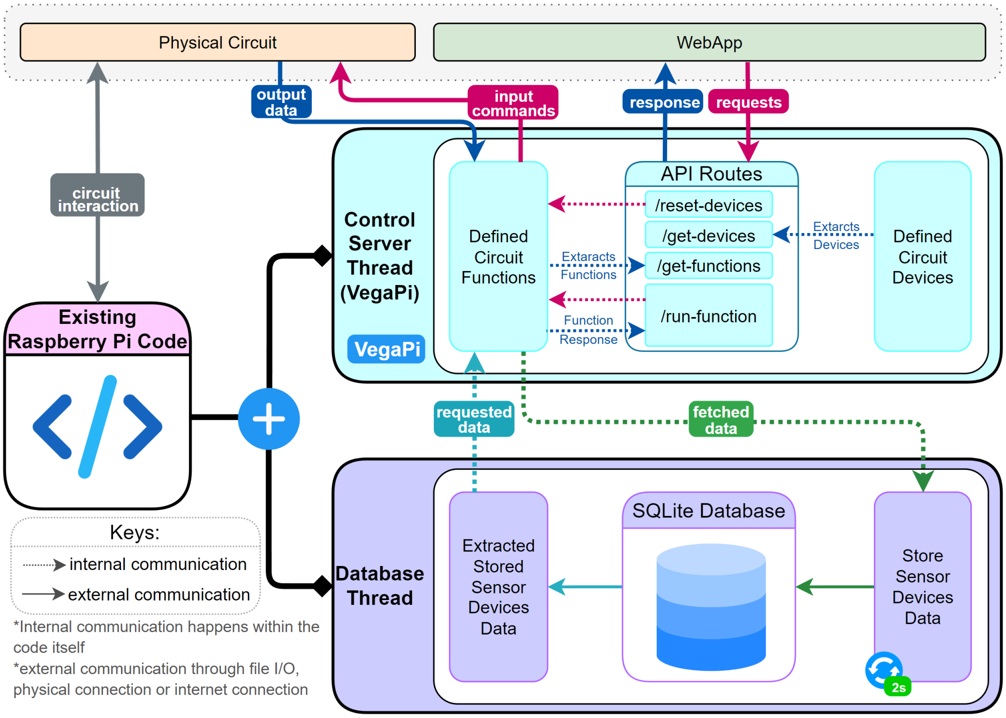

FIGURE 4. Architecture design of the RPi control server

TABLE 1. Physical devices defined on the Control Server, which are then supplied to the LLM

Symbol	Type	Description
ULTS	Input	Ultrasonic Distance Sensor in 'cm'
CAM	Input	Camera device for picture input
GPS	Input	GPS device for longitude and latitude coordinates
TMP	Input	Temperature sensor giving response in degree celcuis
FAN	Output	12V fan controled by a digital GPIO pin through a relay
LCD	Output	I2C LCD for displaying strings
SRV	Output	Servo motor rotates using PWM to a given angles
LED1	Output	Yellow LED light
LED2	Output	Red LED light
LED3	Output	Blue LED light

TABLE 2. Defined functions on the Control Server, called by the LLM based on user input, executes on the RPi and processed on the webapp

Function	Description	Use Case
set_led	Toggles specefic LED	"Turn on yellow LED"
set_fan	Toggles fan on or off	"Turn on the fan"
get_recorded_sensor_data	Gets interval sensor data from database	"Plot me the distance data in last 30 seconds"
get_raspberry_stats	Gets CPU, RAM, Disk of RPi	"What is the current disk usage"
capture_image	Capture and upload image to Imgur	"Capture an image, does it contain a pen?"
get_connected_devices	Fetches the data of connected devices	"What is the current humidity and temperature"
get_location_	Gets the current location from GPS	"From the location are we currently in Leeds?"
set_servo_angles	Turn servo to certain angle	"Turn the servo to 10 then 180 degrees"

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From 2001 to 2004, he was a Research Assistant with the Princeton Plasma Physics Laboratory. Since 2009, he has been an Assistant Professor with the Mechanical Engineering Department, Texas A&M University, College Station. He is the author of three books, more than 150 articles, and more than 70 inventions. His research interests include high-pressure and high-density nonthermal plasma discharge processes and applications, microscale plasma discharges, discharges in liquids, spectroscopic diagnostics, plasma propulsion, and innovation plasma applications. He is an Associate Editor of the journal *Earth, Moon, Planets*, and holds two patents.

Dr. Author was a recipient of the International Association of Geomagnetism and Aeronomy Young Scientist Award for Excellence in 2008, and the IEEE Electromagnetic Compatibility Society Best Symposium Paper Award in 2011.

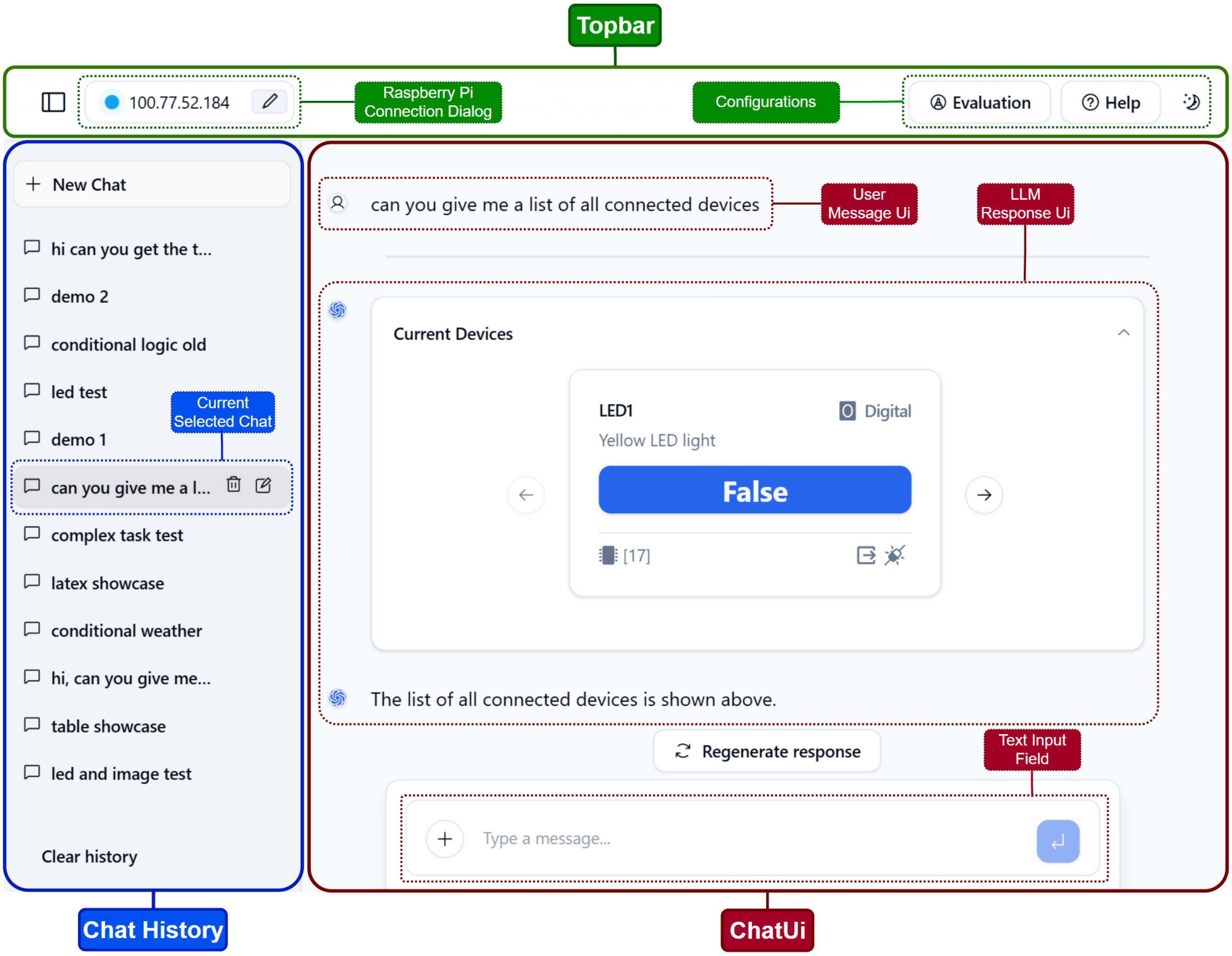

FIGURE 5. **Webapp user interface implementation**

SECOND B. AUTHOR (M'76–SM'81–F'87) and all authors may include biographies. Biographies are often not included in conference-related papers. This author became a Member (M) of IEEE in 1976, a Senior Member (SM) in 1981, and a Fellow (F) in 1987. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state, and country, and year the degree was earned. The author's major field of study should be lower-cased.

The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (publisher name, year) similar to a reference. Current and previous research interests end the paragraph.

The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies other than the IEEE. Finally, list any awards and work for IEEE committees and publications. If a photograph is provided, it should be of good quality, and professional-looking. Following are two examples of an author's biography.

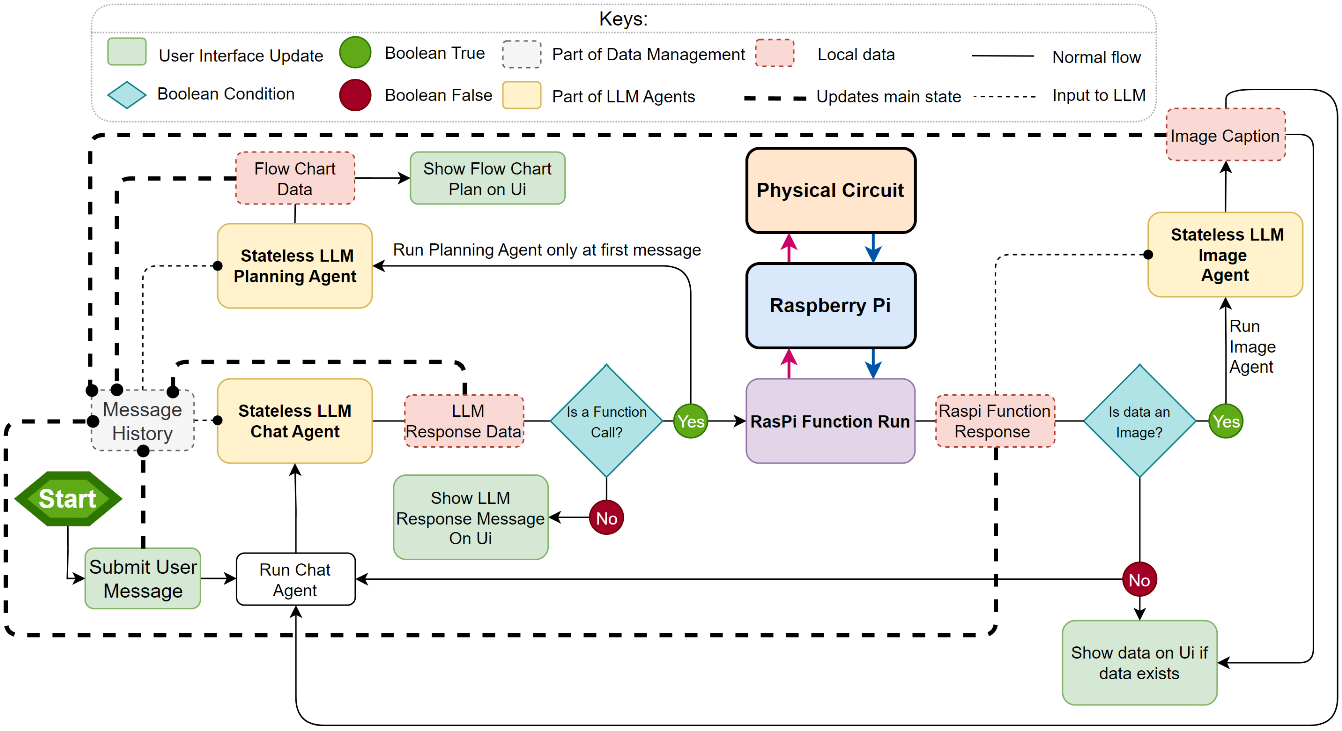

FIGURE 6. Webapp logic design

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Mr. Author's awards and honors include the Frew Fellowship (Australian Academy of Science), the I. I. Rabi Prize (APS), the European Frequency and Time Forum Award, the Carl Zeiss Research Award, the William F. Meggers Award and the Adolph Lomb Medal (OSA).

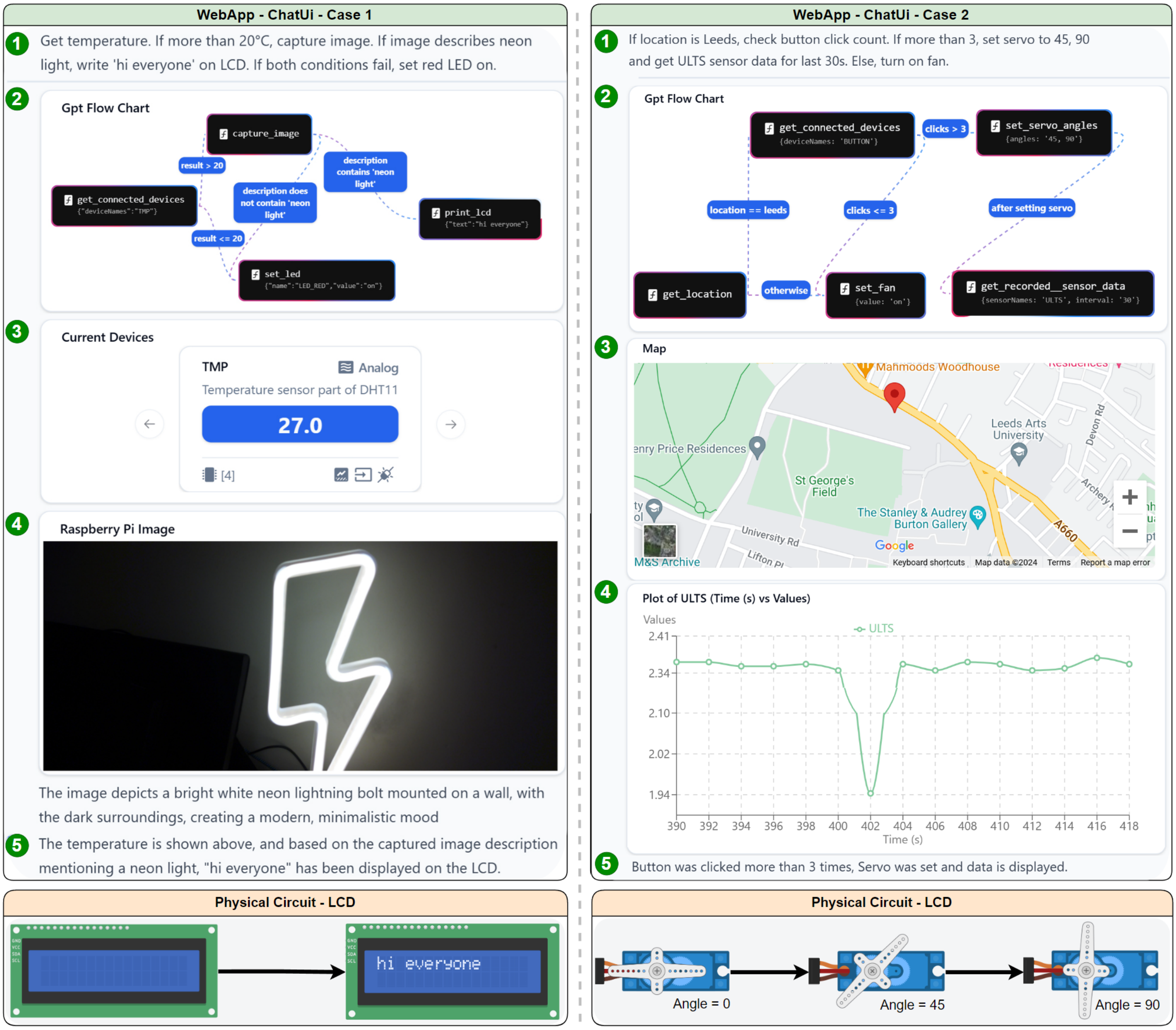

FIGURE 7. System case studies

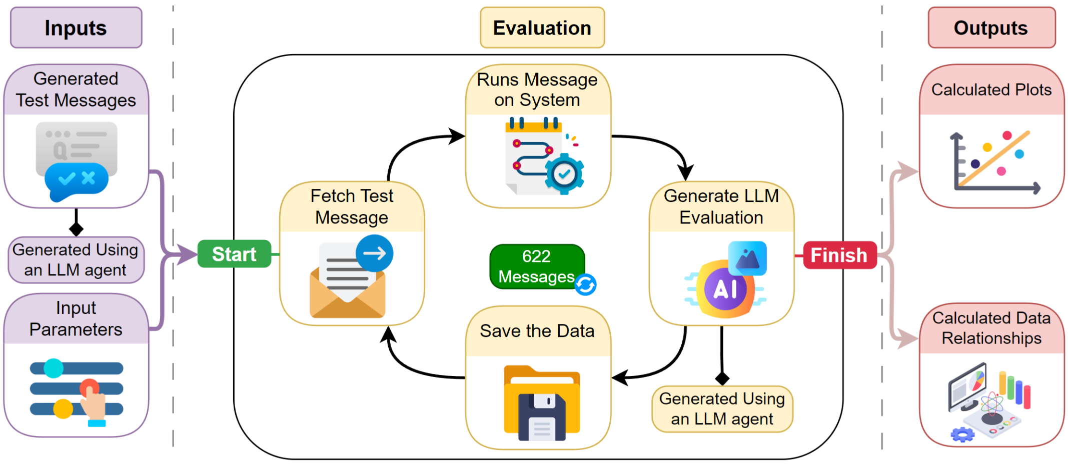

FIGURE 8. **Magnetization as a function of applied field. It is good practice to explain the significance of the figure in the caption.**

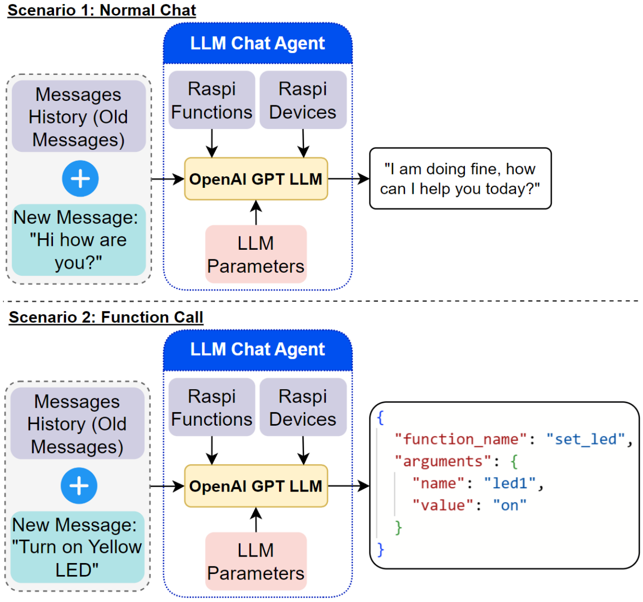

FIGURE 9. **Evaluation metrics for the functions defined earlier in .**

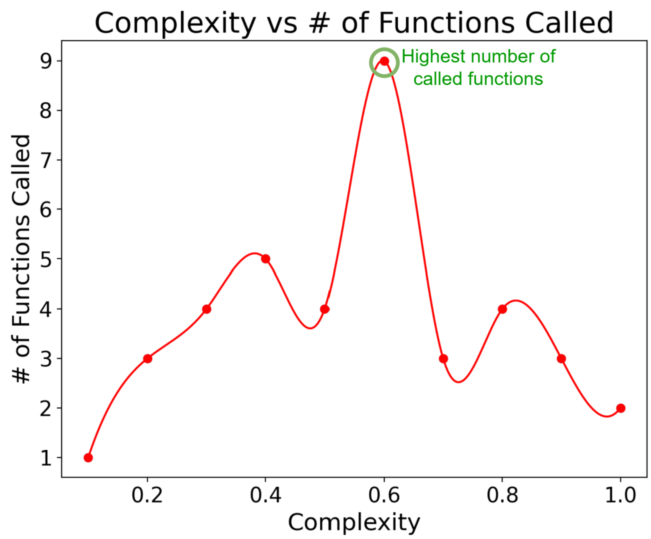

FIGURE 11. **Message complexity against the number of functions called per message.**

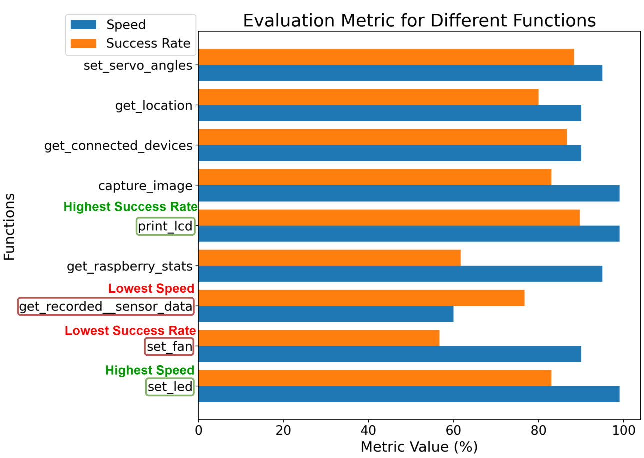

FIGURE 10. **Evaluation metrics for the functions defined earlier in .**

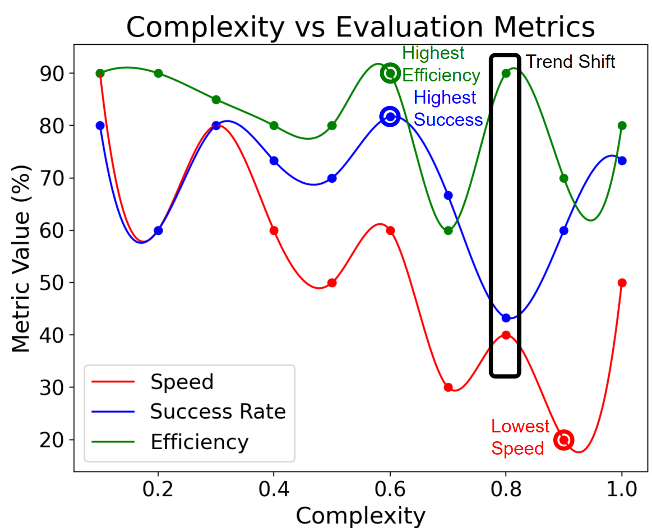

FIGURE 12. **Message complexity against all evaluation metrics and most importantly the success rate.**

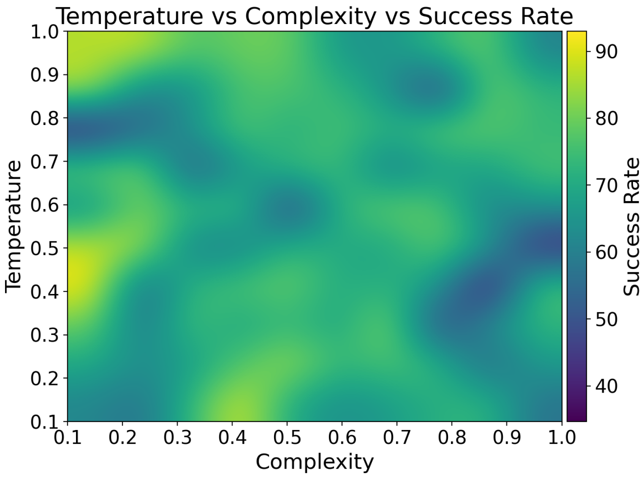

FIGURE 13. Success rate against message complexity and temperature of the LLM.

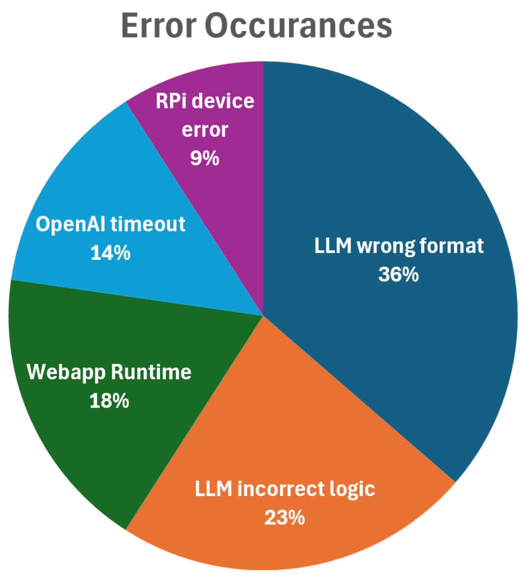

FIGURE 15. What types of errors occured throughout testing.

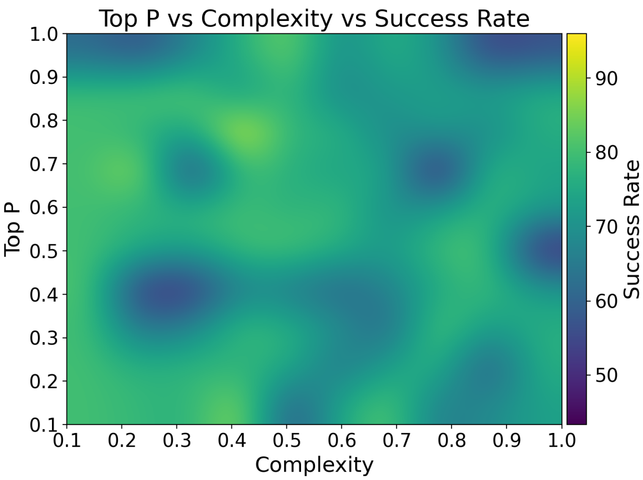

FIGURE 14. Success rate against message complexity and Top P of the LLM.

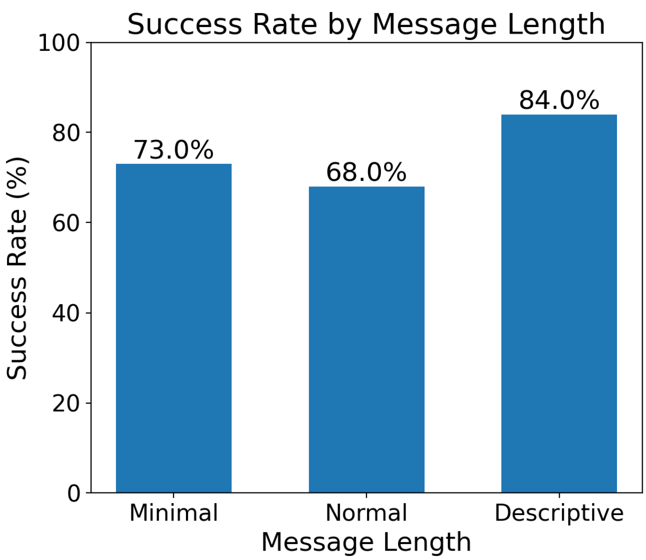

FIGURE 16. Success rate of different tones of the same message.