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(54) **REAL-TIME INTERACTIVE VOICE CONVERSATION STATE MANAGEMENT IN LARGE LANGUAGE MODELS**

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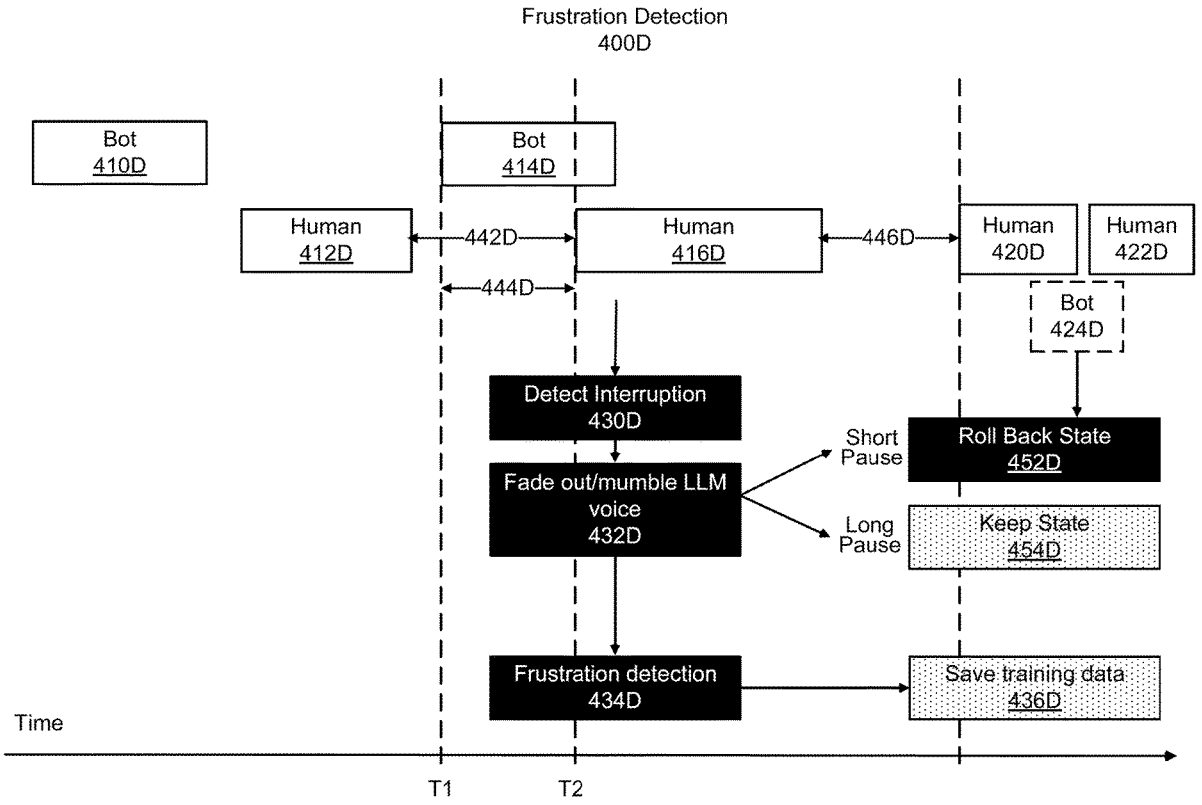
CPC ***G10L 15/22*** (2013.01); ***G10L 13/08*** (2013.01); ***G10L 15/26*** (2013.01)

(57) **ABSTRACT**

A method or system for managing interruptions during oral interactions between users and Large Language Models (LLMs). Initially, a user's spoken input is received and converted to text, which forms a prompt for the LLM. Upon generating a text response by the LLM, the text response is then converted back into speech and played to the user. If the user interrupts while the response is being played, the playback stops, and the interruption is captured as a new spoken input. This interruption is used to generate a new prompt for the LLM. Subsequently, the LLM generates a second text response based on the interruption, which is converted to speech and played back to the user. This process ensures that user interruptions are effectively managed, allowing for a more dynamic and interactive conversation with the LLM and enhancing the user's experience by adapting the conversation flow to real-time inputs.



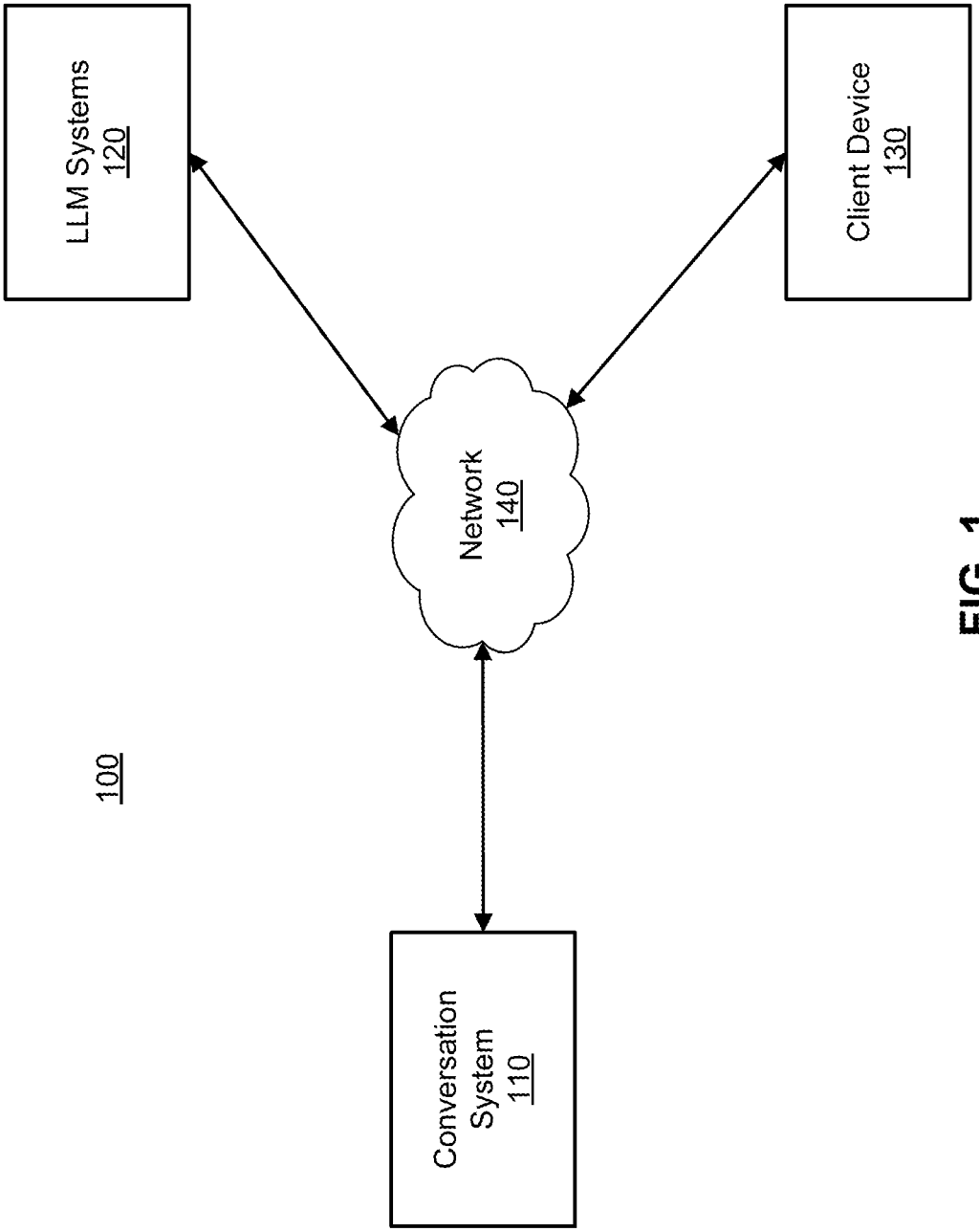

LLM Systems
120
Client Device
130
Network
140
Conversation System
110
100

FIG. 1

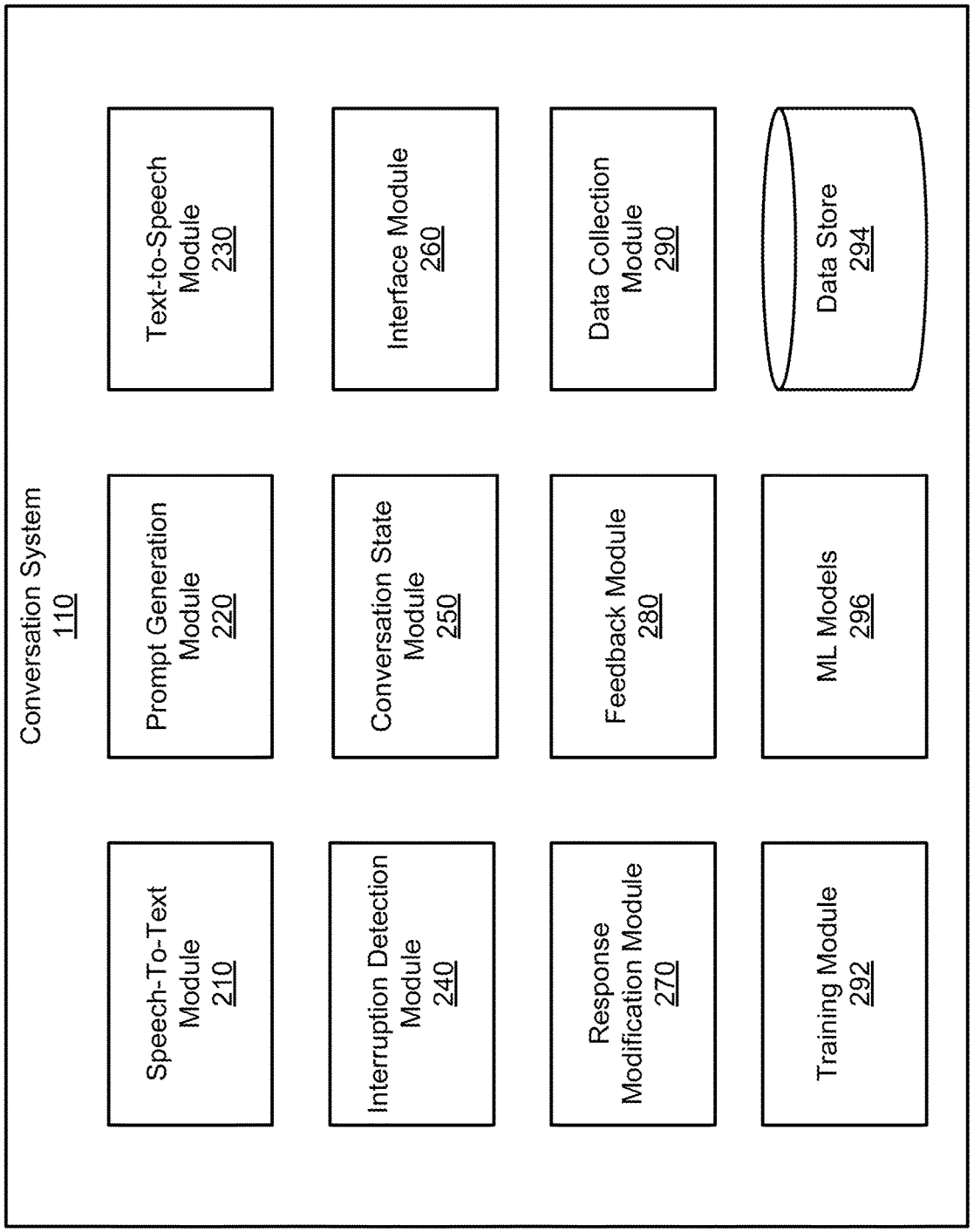

Conversation System
110
Speech-To-Text Module
210
Prompt Generation Module
220
Text-to-Speech Module
230
Interruption Detection Module
240
Conversation State Module
250
Interface Module
260
Response Modification Module
270
Feedback Module
280
Data Collection Module
290
Training Module
292
ML Models
296
Data Store
294

FIG. 2

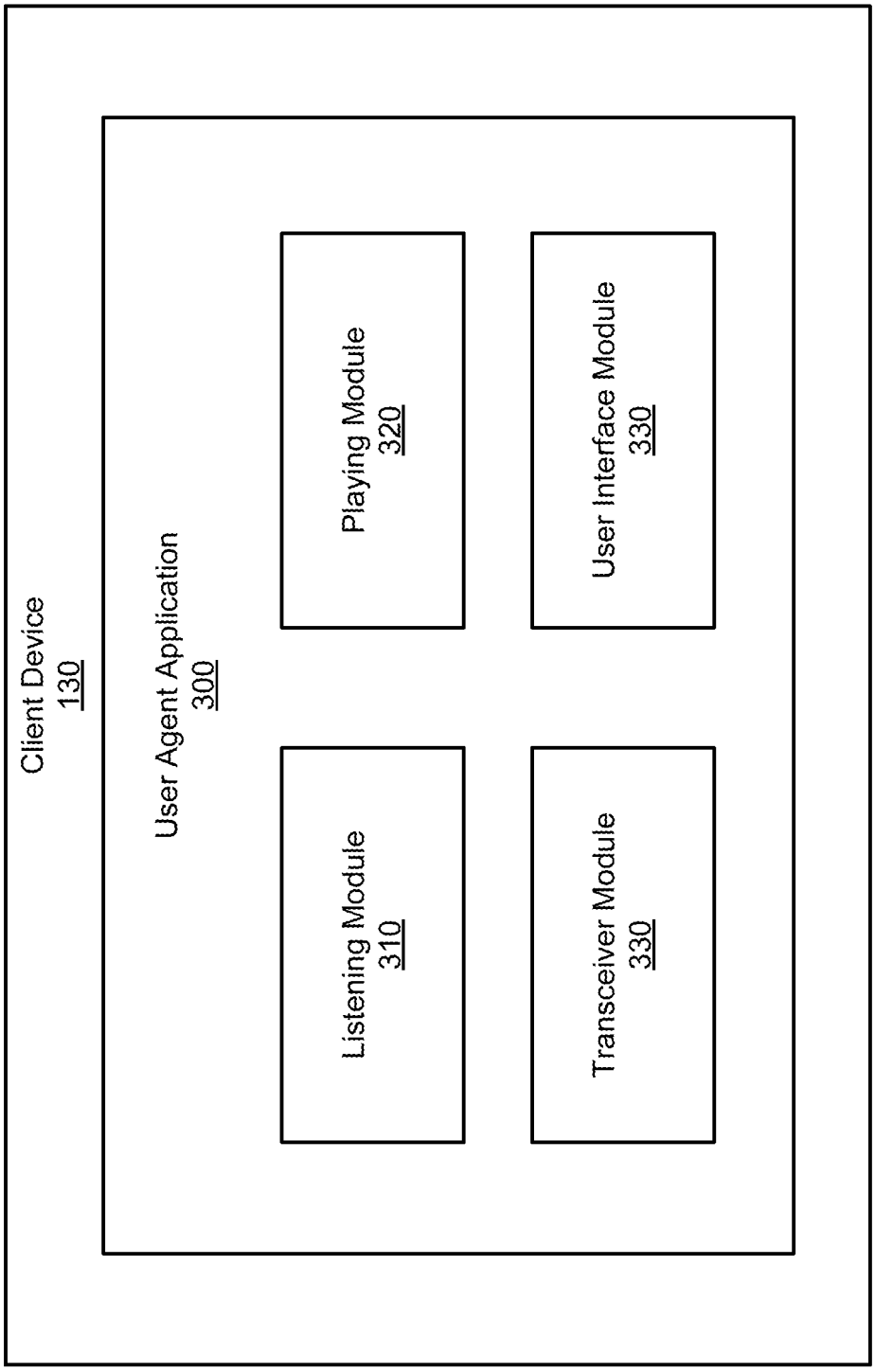

Client Device
130
User Agent Application
300
Playing Module
320
User Interface Module
330
Listening Module
310
Transceiver Module
330

FIG. 3

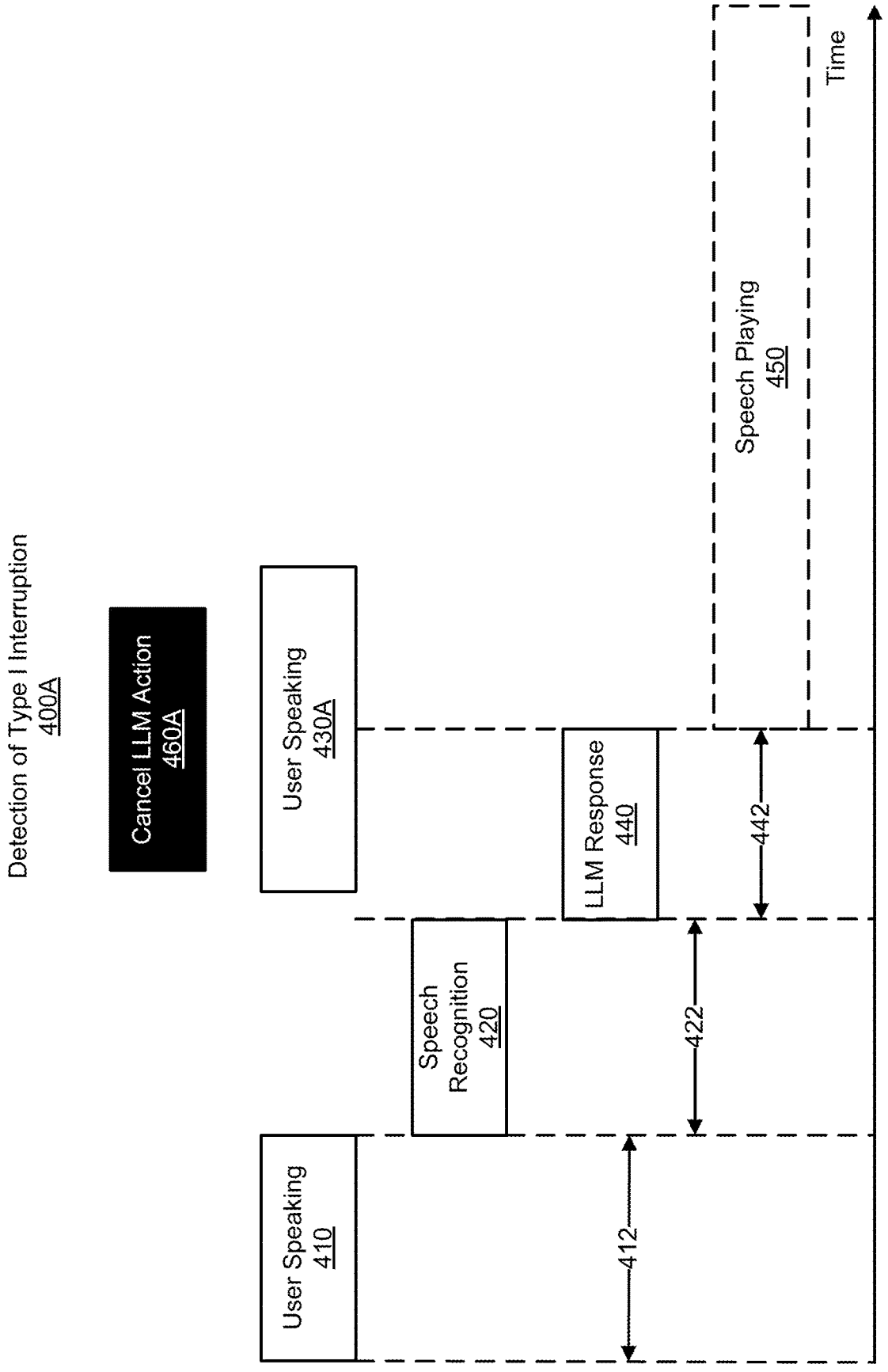

Detection of Type I Interruption
400A
Cancel LLM Action
460A
User Speaking
430A
LLM Response
440
Speech Playing
450
Time
User Speaking
410
Speech Recognition
420
412
422
442

FIG. 4A

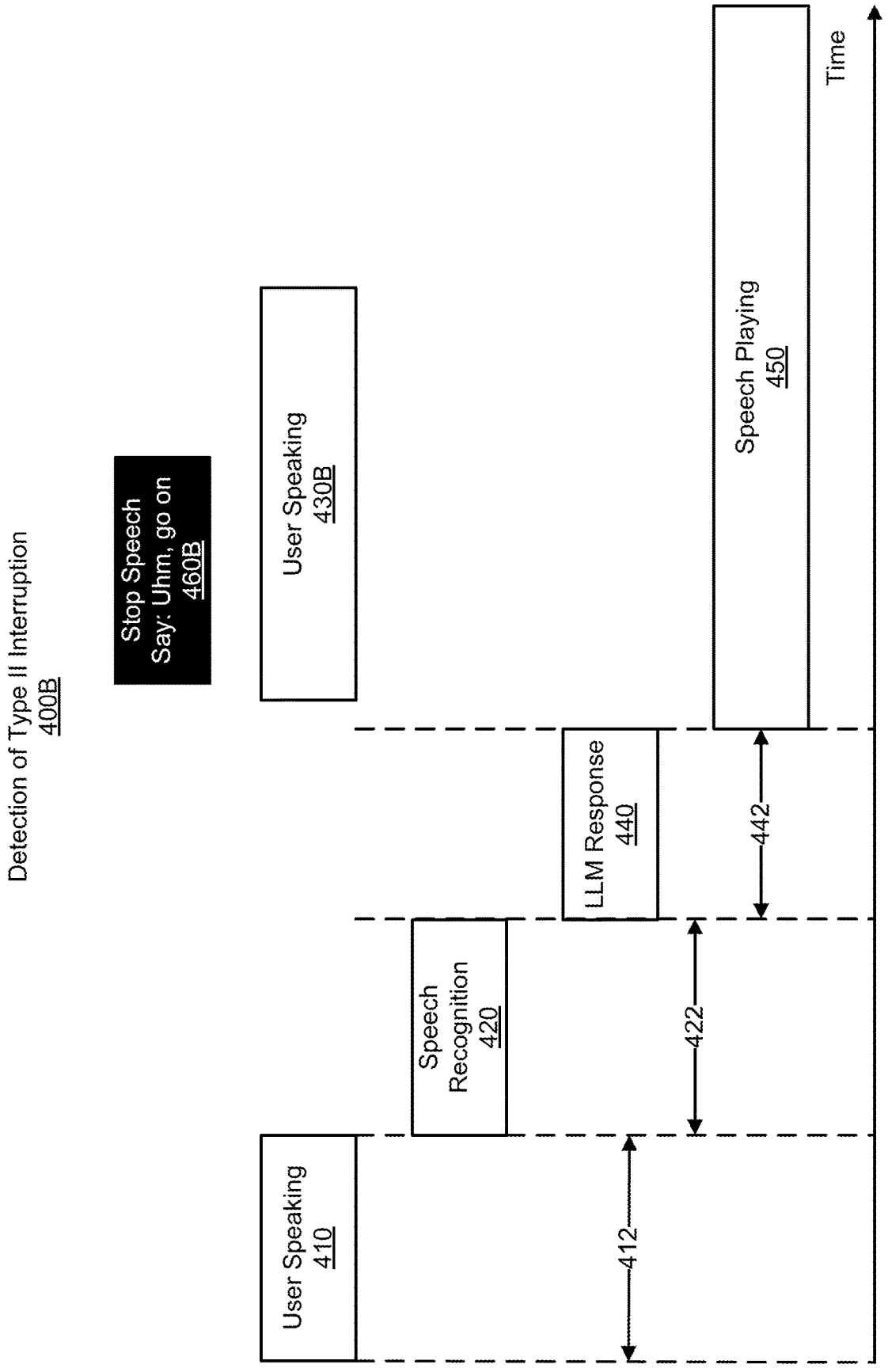

Detection of Type II Interruption
400B
Stop Speech
Say: Uhm, go on
460B
User Speaking
430B
Speech Playing
450
Time
User Speaking
410
Speech
Recognition
420
LLM Response
440
412
422
442

FIG. 4B

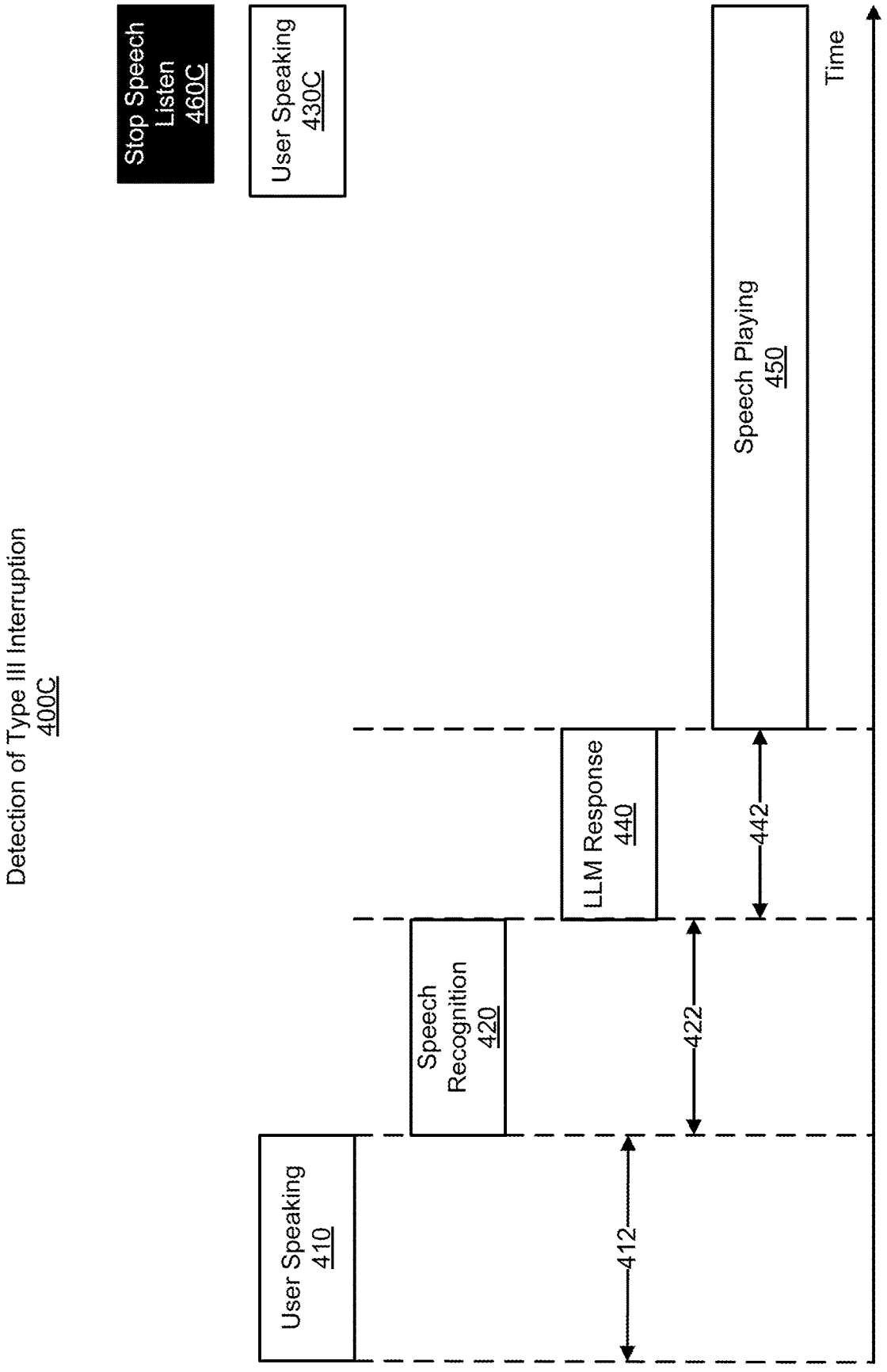

Detection of Type III Interruption
400C
User Speaking
410
Speech
Recognition
420
LLM Response
440
Speech Playing
450
Time
412
422
442
User Speaking
430C
Stop Speech
Listen
460C

FIG. 4C

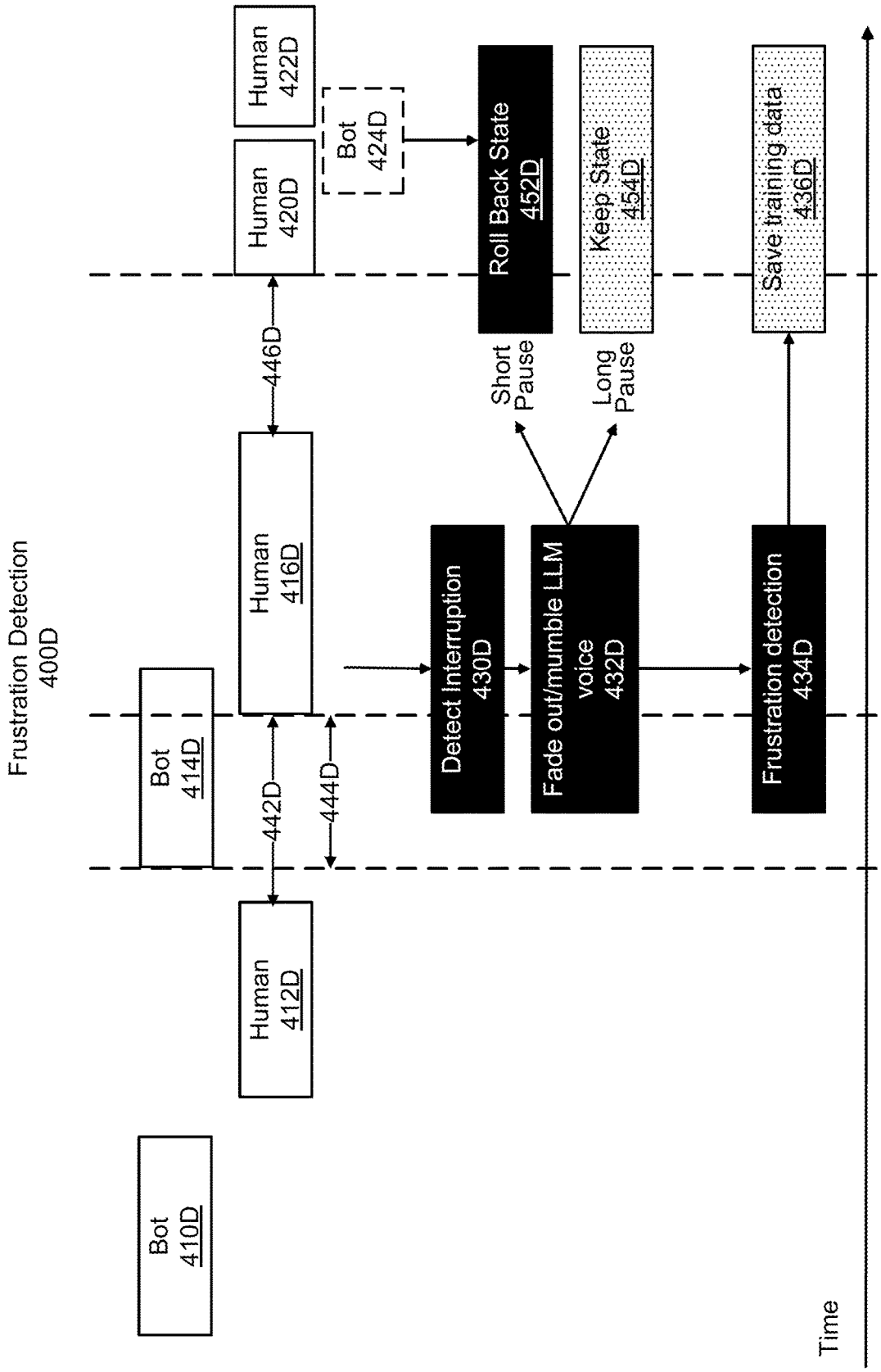

Frustration Detection
400D
Bot
410D
Human
412D
Bot
414D
Human
416D
Human
420D
Human
422D
Bot
424D
442D
444D
446D
Detect Interruption
430D
Fade out/mumble LLM voice
432D
Frustration detection
434D
Roll Back State
452D
Keep State
454D
Save training data
436D
Short Pause
Long Pause
T1
T2
Time

FIG. 4D

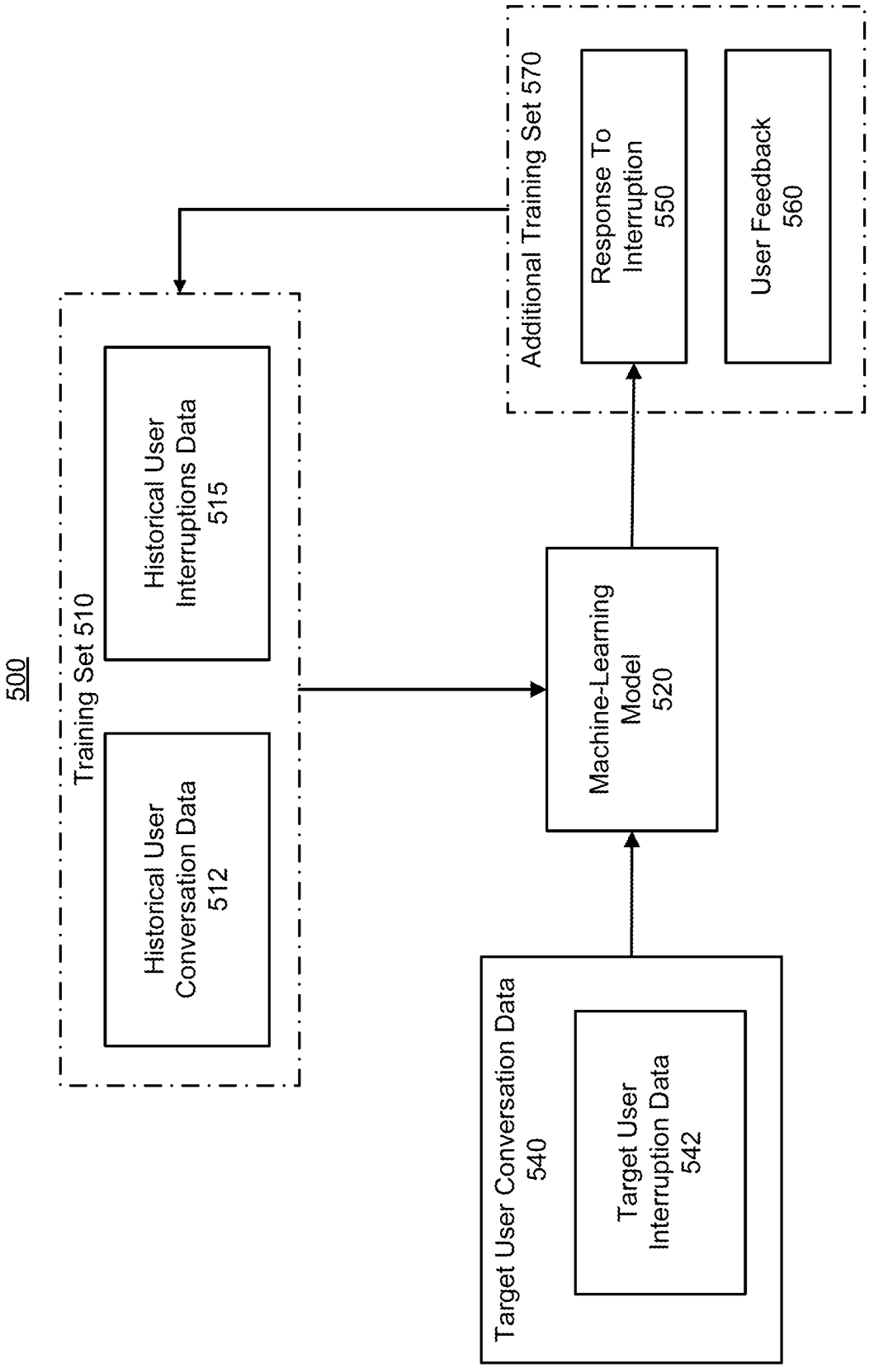

500
Training Set 510
Historical User Conversation Data 512
Historical User Interruptions Data 515
Machine-Learning Model 520
Additional Training Set 570
Response To Interruption 550
User Feedback 560
Target User Conversation Data 540
Target User Interruption Data 542

FIG. 5

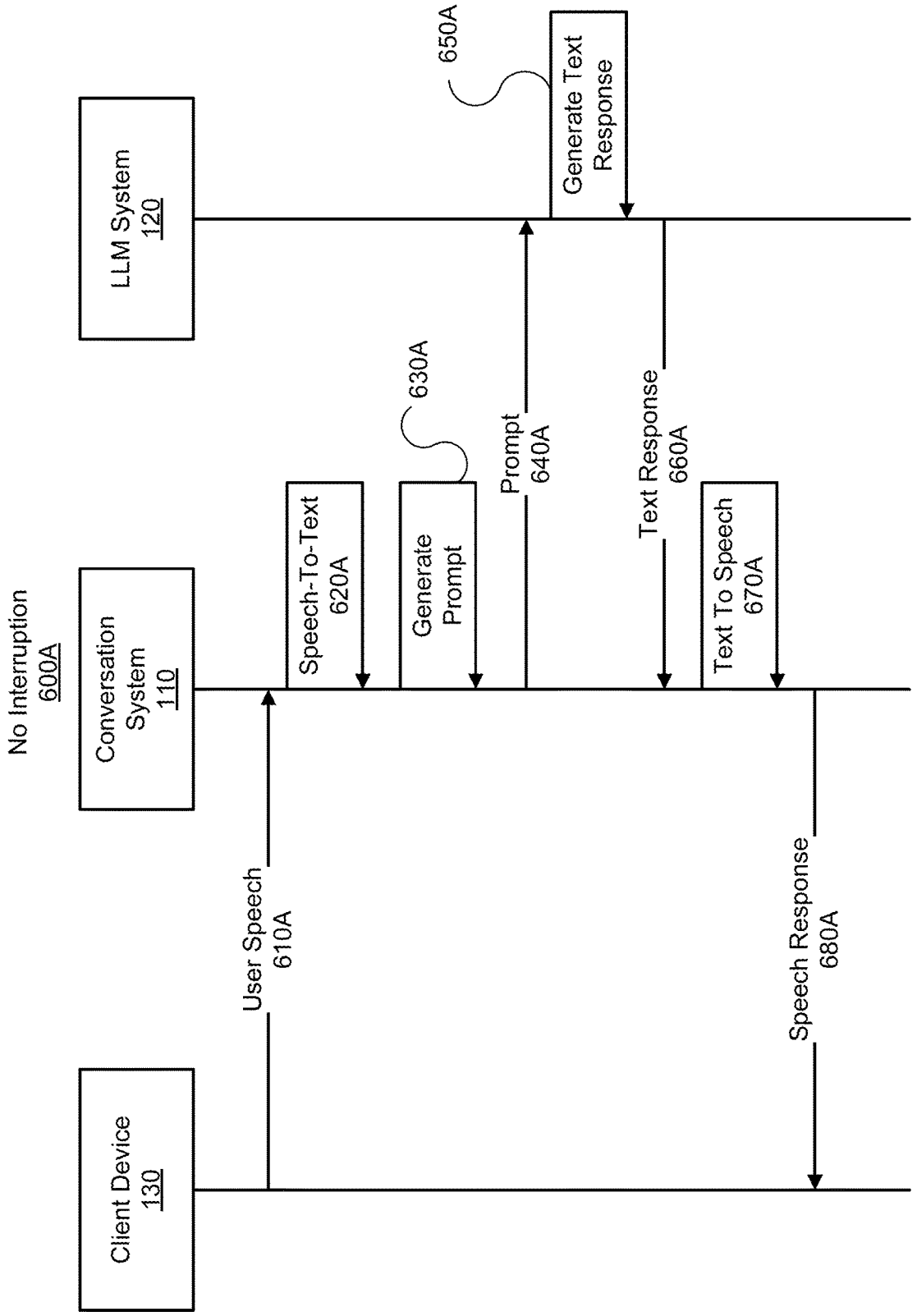

No Interruption
600A
Client Device
130
Conversation System
110
LLM System
120
User Speech
610A
Speech-To-Text
620A
630A
Generate Prompt
Prompt
640A
650A
Generate Text Response
Text Response
660A
Text To Speech
670A
Speech Response
680A

FIG. 6A

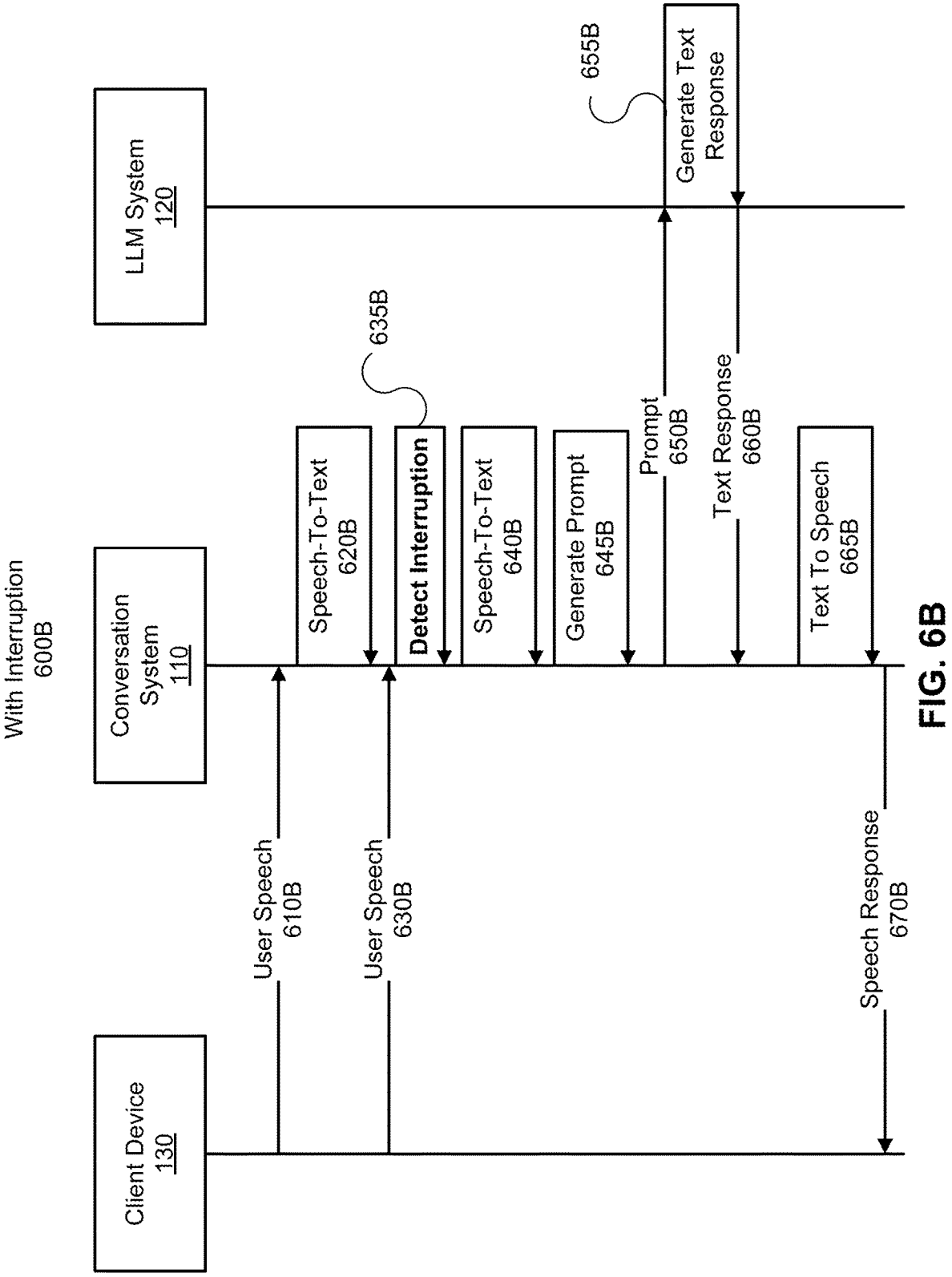

With Interruption
600B
Client Device
130
Conversation System
110
LLM System
120
User Speech
610B
Speech-To-Text
620B
635B
Detect Interruption
User Speech
630B
Speech-To-Text
640B
Generate Prompt
645B
Prompt
650B
655B
Generate Text Response
Text Response
660B
Text To Speech
665B
Speech Response
670B

FIG. 6B

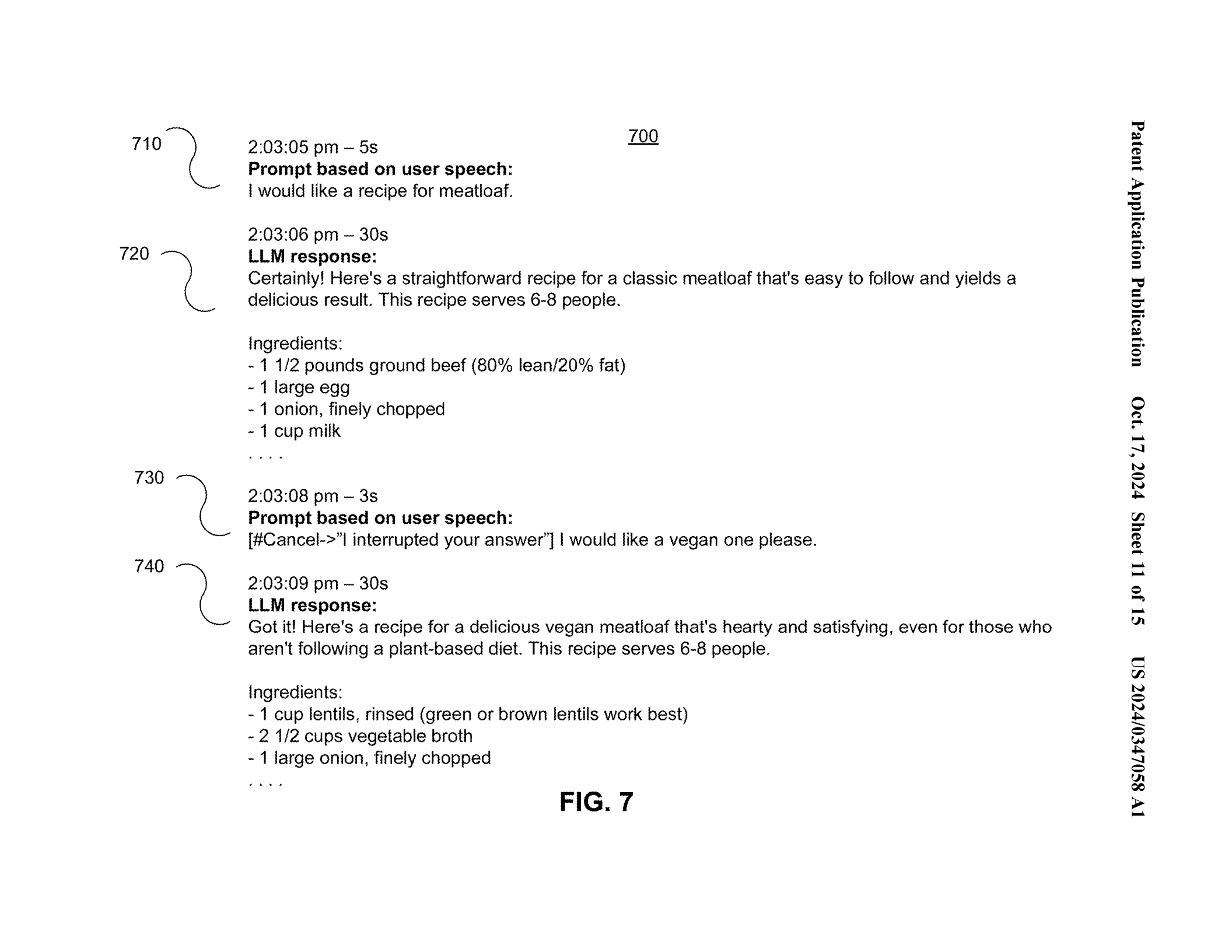

700
710
2:03:05 pm – 5s
Prompt based on user speech:
I would like a recipe for meatloaf.
2:03:06 pm – 30s
720
LLM response:
Certainly! Here's a straightforward recipe for a classic meatloaf that's easy to follow and yields a delicious result. This recipe serves 6-8 people.
Ingredients:
- 1 1/2 pounds ground beef (80% lean/20% fat)
- 1 large egg
- 1 onion, finely chopped
- 1 cup milk
. . . .
730
2:03:08 pm – 3s
Prompt based on user speech:
[#Cancel->"I interrupted your answer"] I would like a vegan one please.
740
2:03:09 pm – 30s
LLM response:
Got it! Here's a recipe for a delicious vegan meatloaf that's hearty and satisfying, even for those who aren't following a plant-based diet. This recipe serves 6-8 people.
Ingredients:
- 1 cup lentils, rinsed (green or brown lentils work best)
- 2 1/2 cups vegetable broth
- 1 large onion, finely chopped
. . . .

FIG. 7

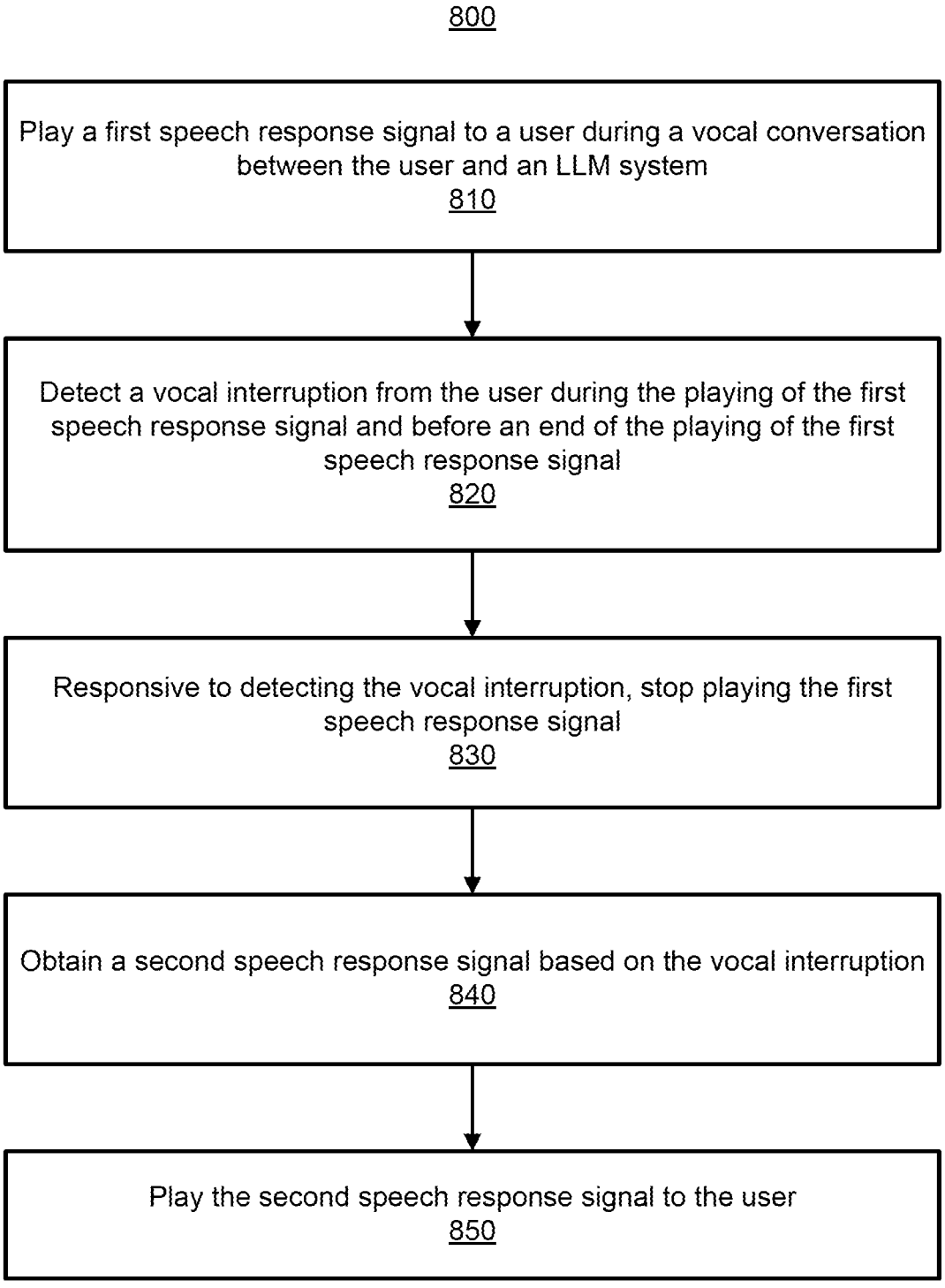

800
Play a first speech response signal to a user during a vocal conversation between the user and an LLM system
810
Detect a vocal interruption from the user during the playing of the first speech response signal and before an end of the playing of the first speech response signal
820
Responsive to detecting the vocal interruption, stop playing the first speech response signal
830
Obtain a second speech response signal based on the vocal interruption
840
Play the second speech response signal to the user
850

FIG. 8

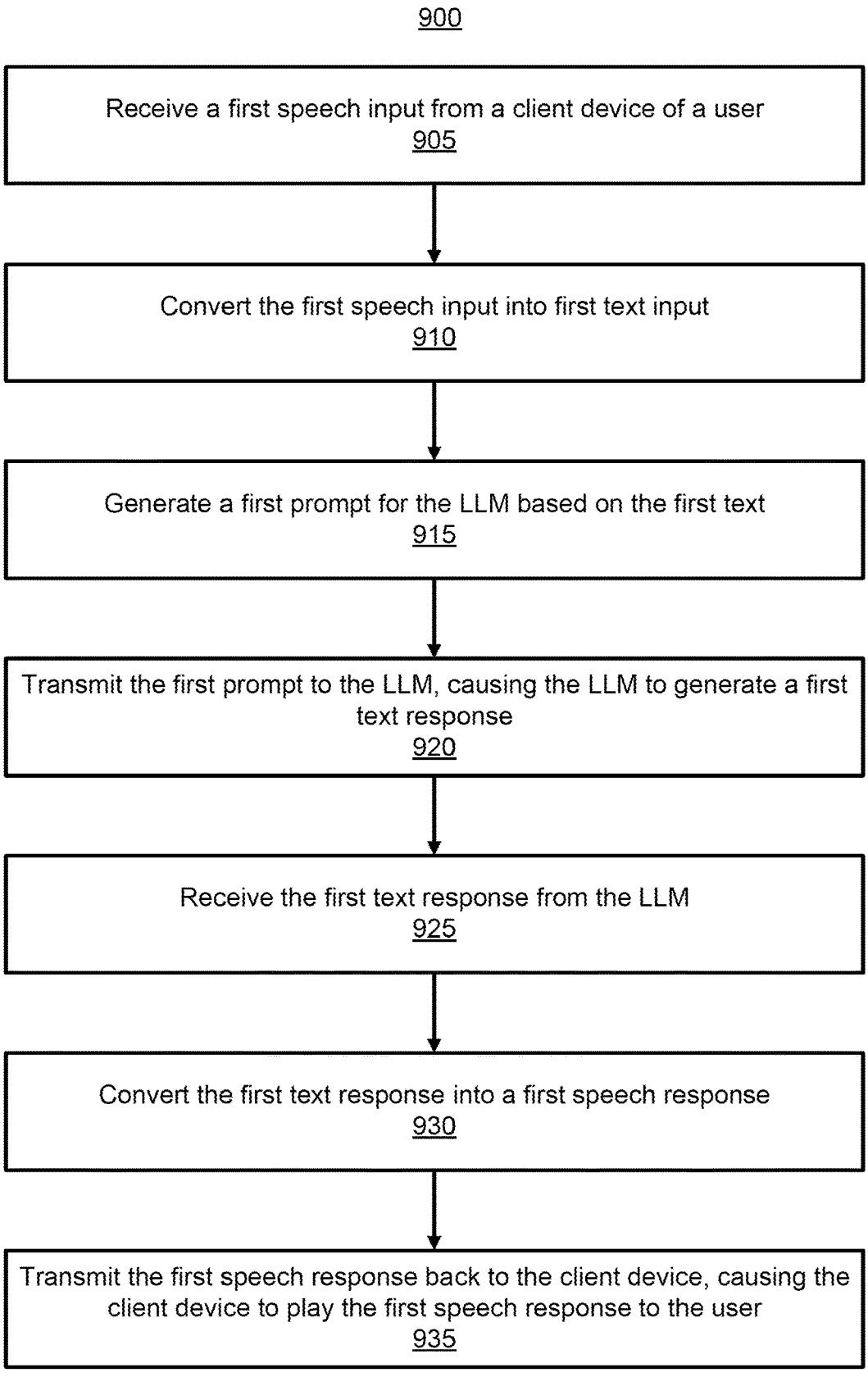

900
Receive a first speech input from a client device of a user
905
Convert the first speech input into first text input
910
Generate a first prompt for the LLM based on the first text
915
Transmit the first prompt to the LLM, causing the LLM to generate a first text response
920
Receive the first text response from the LLM
925
Convert the first text response into a first speech response
930
Transmit the first speech response back to the client device, causing the client device to play the first speech response to the user
935

FIG. 9A

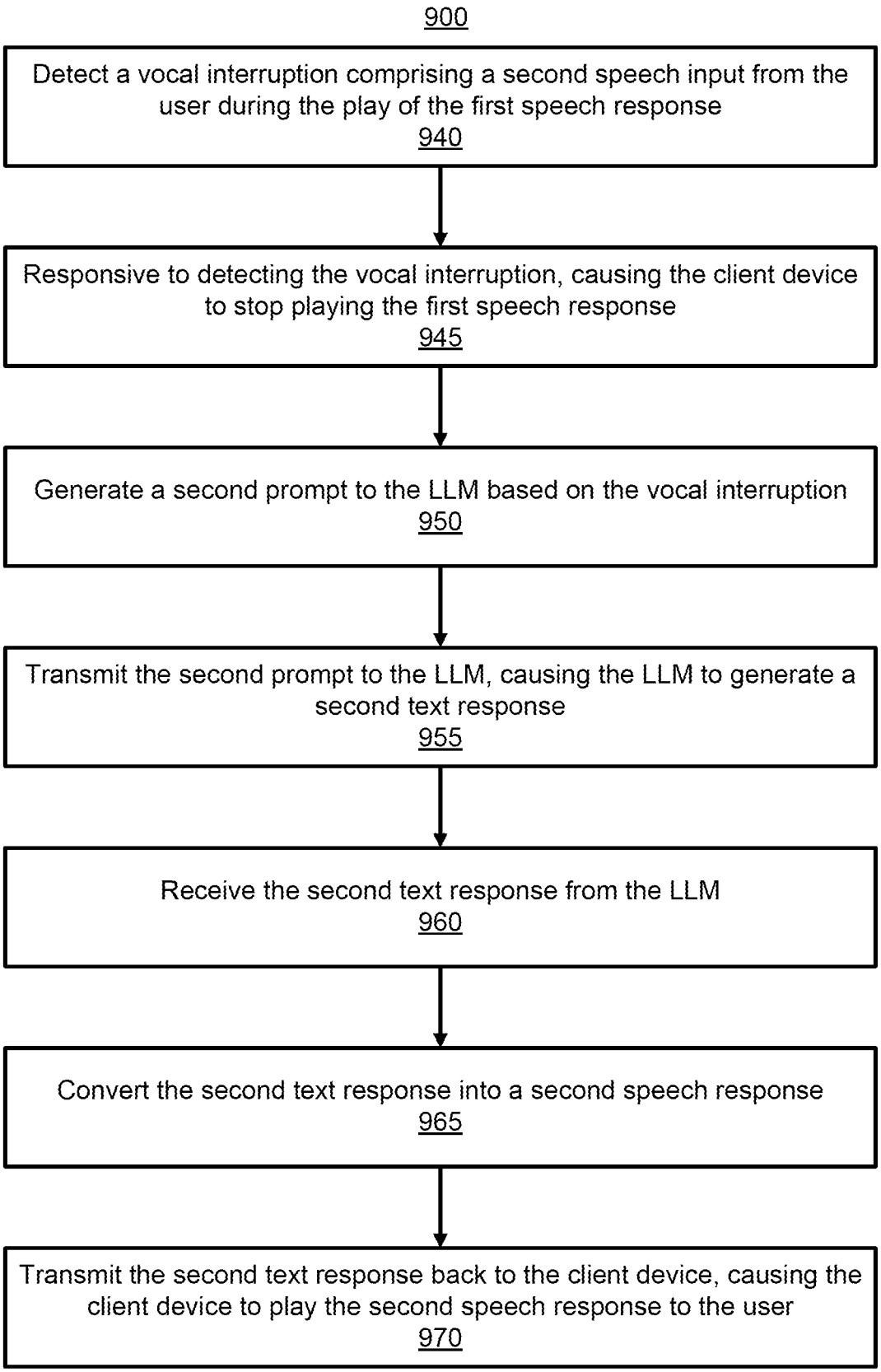

900
Detect a vocal interruption comprising a second speech input from the user during the play of the first speech response
940
Responsive to detecting the vocal interruption, causing the client device to stop playing the first speech response
945
Generate a second prompt to the LLM based on the vocal interruption
950
Transmit the second prompt to the LLM, causing the LLM to generate a second text response
955
Receive the second text response from the LLM
960
Convert the second text response into a second speech response
965
Transmit the second text response back to the client device, causing the client device to play the second speech response to the user
970

FIG. 9B

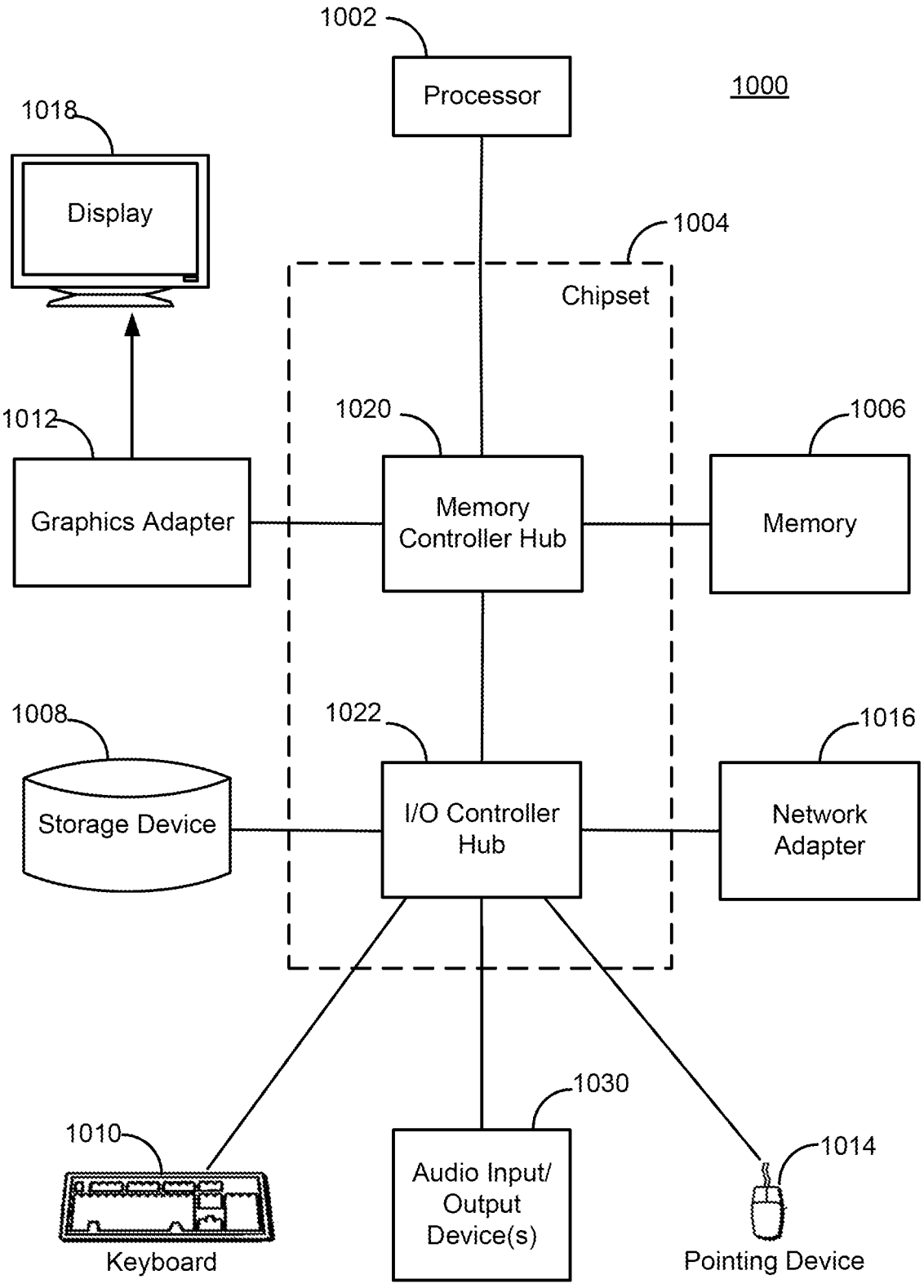

1002
Processor
1000
1018
Display
1004
Chipset
1012
1020
1006
Graphics Adapter
Memory Controller Hub
Memory
1008
1022
1016
Storage Device
I/O Controller Hub
Network Adapter
1030
1010
1014
Audio Input/ Output Device(s)
Keyboard
Pointing Device

FIG. 10

REAL-TIME INTERACTIVE VOICE CONVERSATION STATE MANAGEMENT IN LARGE LANGUAGE MODELS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/495,961, filed Apr. 13, 2023, which is incorporated by reference in its entirety.

BACKGROUND

[0002] This disclosure relates generally to real-time voice conversations with large language models (LLMs) and, more specifically, to managing interruptions and maintaining the flow of real-time conversations between users and LLMs.

[0003] A large language model (LLM) like GPT (Generative Pre-trained Transformer) is an advanced artificial intelligence system designed to understand and generate human-like text based on the input it receives. These models are trained on vast amounts of text data, enabling them to comprehend context, answer questions, compose text, and even engage in conversation in a manner that closely resembles human interaction.

[0004] For example, LLMs can generate articles, reports, stories, language tutoring lessons, and even poetry. They can assist writers by suggesting content improvements, generating ideas, or overcoming writer's block. LLM can also be integrated into chatbots and virtual assistants; businesses can automate customer service, providing quick and accurate responses to inquiries, which enhances customer experience and operational efficiency. LLMs are also capable of understanding and translating languages, making them valuable tools for global communication and content localization, reducing language barriers between individuals and businesses. LLMs can also be used to create personalized learning materials, provide tutoring, generate quiz questions, and offer explanations on topics, thereby enhancing the learning experience. LLMs, especially those trained in coding languages, can also assist developers by generating code snippets, debugging, or even explaining code, thus improving productivity and learning in software development.

SUMMARY

[0005] Embodiments described herein include a method or a system for managing interruptions during verbal conversations between users and large language models (LLMs). The system receives a first speech input from a client device of a user, and converts the first speech input into first text. The system then generates a first prompt for the LLM based on the first text, and transmits the first prompt to the LLM, causing the LLM to generate a first text response. Upon receiving the first text response from the LLM, the system converts the first text response into a first speech response and transmits the first speech response back to the client device, causing the client device to play the first speech response to the user.

[0006] At the same time, the system also causes the client device to monitor a surrounding environment for detecting vocal interruptions from the user. A vocal interruption comprises a second speech input from the user. Upon detecting the vocal interruption during the play of the first speech response, the system causes the client device to stop playing the first speech response. The system converts the second speech input into a second text input, and generates a second prompt to the LLM based on the vocal interruption. For example, in some embodiments, the prompt may be annotated with metadata associated with vocal interruption, such as the timing of the interruption, and the state of the conversation when the vocal interruption is detected. The system transmits the second prompt to the LLM, causing the LLM to generate a second text response. Upon receiving the second text response from the LLM, the system converts the second text response into a second speech response, and transmits the second speech response back to the client device, causing the client device to play the second speech response.

[0007] In some embodiments, the embodiments include a method or a device for managing interruptions during verbal conversations between users and LLMs. The device plays a first speech response signal on a client device of a user during a vocal conversation between the user and an LLM system. The device detects a vocal interruption from the user during the playing of the first speech response signal and before an end of the playing of the first speech response signal. Upon detecting the vocal interruption, the device stops playing the first speech response signal and generates a second speech response signal based on the vocal interruption, and plays the second speech response signal on the client device of the user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a block diagram of a system environment in which an online system, such as a conversation system, operates in accordance with one or more embodiments.

[0009] FIG. **2** illustrates an example architecture of the conversation system in accordance with one or more embodiments.

[0010] FIG. **3** illustrates an example architecture of a client device in accordance with one or more embodiments.

[0011] FIG. **4**A illustrates an example process of detecting a first type of interruption in a conversation in accordance with one or more embodiments.

[0012] FIG. **4**B illustrates an example process of detecting a second type of interruption in a conversation in accordance with one or more embodiments.

[0013] FIG. **4**C illustrates an example process of detecting a third type of interruption in a conversation in accordance with one or more embodiments.

[0014] FIG. **4**D illustrates an example process of detecting user frustration in a conversation in accordance with one or more embodiments.

[0015] FIG. **5** illustrates an example process of training or retraining a machine learning model **520** in accordance with one or more embodiments.

[0016] FIG. **6**A illustrates an example communication pattern of a conversation, in which no interruption is detected in accordance with one or more embodiments.

[0017] FIG. **6**B illustrates an example communication pattern of a conversation, in which an interruption is detected in accordance with one or more embodiments.

[0018] FIG. **7** illustrates an example text record of a conversation in accordance with one or more embodiments.

[0019] FIG. **8** is a flowchart of a method for managing interruptions during a verbal conversation between users and LLMs in accordance with one or more embodiments.

[0020] FIGS. **9**A-**9**B is a flowchart of a method for managing interruptions during a verbal conversation between users and LLMs in accordance with one or more embodiments.

[0021] FIG. **10** is a block diagram of an example computer suitable for use in the networked computing environment of FIG. **1**.

[0022] The figures depict embodiments of the present disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles or benefits touted by the disclosure described herein.

DETAILED DESCRIPTION

[0023] The integration of large language models (LLMs) into real-time voice or video conversation platforms opens up a plethora of innovative applications, including (but not limited to) customer support, language learning, healthcare advice, personal assistance, language tutoring, and interview simulations. Despite the promising applications, several challenges must be addressed to fully realize the potential of real-time voice or video conversations with LLMs.

[0024] In particular, real-time interaction with LLMs during voice or video calls demands not just low latency but also dynamic conversation flow management. Users engaging with these models seek prompt responses, often wanting the flexibility to interrupt or steer the conversation without waiting for lengthy replies to conclude. This necessitates a system where the user's need to interject-a result of impatience, a change in query, or a misunderstanding-is seamlessly integrated into the conversation flow, enhancing the interaction experience.

[0025] Embodiments described herein relate to a system or a method for improved management of interactive voice conversations with LLMs by handling the interruptions effectively. Whether due to the user's intent to fast-forward the dialogue, correct a perceived error, or modify their query, the system is able to adapt to the user's intent. This involves fading out the LLM's response upon interruption, signaling attentiveness through auditory cues like a gentle beep or a verbal prompt, and, if necessary, recalibrating the LLM's response strategy based on the nature and timing of the interruption.

[0026] In some embodiments, the system employs state management, incorporating metadata such as response timing, voice tone, and even visual cues in video chats, to maintain a coherent and responsive dialogue. This metadata may be integrated directly into the LLM's prompt or managed by a response modification module, which can modify responses to acknowledge interruptions or adapt the conversation tone based on detected frustration or misunderstanding.

[0027] In some embodiments, post-interruption, the system can either revert to address the user's initial request anew, taking into account the latest input, or proceed by incorporating the interruption into the dialogue context, enhancing the LLM's response relevance. In some embodiments, LLMs are trained or fine-tuned on this augmented state space. In some embodiments, the system includes a response modification module configured to refine responses, ensuring the conversation remains fluid and user-centric.

[0028] In some embodiments, proactive strategies are implemented to minimize interruptions caused by premature LLM responses. By employing probabilistic methods to assess whether a user has finished speaking or is merely pausing, the system can better decide when to initiate a response, thereby reducing unnecessary interjections. Adjusting response timings based on cues like hesitation phrases allows the system to demonstrate patience and attentiveness, fostering a more natural and respectful dialogue.

[0029] In some embodiments, in cases where the conversation involves complex reasoning or when a user seeks specific information mid-discourse, the system causes the LLM to succinctly redirect the conversation or summarize previous reasoning steps, ensuring clarity and continuity despite interruptions.

[0030] The embodiments described herein facilitate verbal conversations with LLMs that mimic human interaction, characterized by flexibility, understanding, and adaptability. Through state management and responsive design, the system offers beyond mere responses to user requests; it creates a perception of genuine engagement, thereby narrowing the gap between human expectations and technological capabilities.

System Architecture

[0031] FIG. **1** is a block diagram of a system environment **100** in which an online system, such as a conversation system **110** as further described below in conjunction with FIGS. **2** and **7**, operates. The system environment **100** shown by FIG. **1** comprises one or more client devices **130**, a network **140**, one or more LLM systems **120**, and the conversation system **110**. In alternative configurations, different and/or additional components may be included in the system environment **100**.

[0032] The conversation system **110** is configured to communicate with the client device(s) **130** and LLM system(s) **120** via the network **140**. The client device **130** may include one or more microphones, one or more cameras, and one or more speakers. The client device **130** is configured to listen to speech input from a user and sends the received speech input to the conversation system **110**. Upon receiving the speech input, the conversation system **110** is configured to convert the speech input into a text input. The conversation system **110** then generates a text prompt for the LLM system **120** based on the text input and sends the text prompt to the LLM system **120**. Upon receiving the text prompt from the conversation system **110**, the LLM system **120** generates a text response based on the text prompt and sends the text response to the conversation system **110**. The conversation system **110** then converts the text response into a speech response and sends the speech response to the client device **130**, causing the client device **130** to play the speech response to the user.

[0033] Further, the conversation system **110** causes the client device **130** to monitor a surrounding environment for detecting vocal interruptions that comprise a new speech input by the user. Upon detecting a vocal interruption during the play of the previous speech response, the conversation system **110** causes the client device to stop playing the previous speech response. The conversation system **110** converts the new speech input into a new text input and generates a new text prompt based on the vocal interruption. Note that this updated text prompt doesn't just include the

new textual input; it also integrates metadata related to the vocal interruption. This may include (but is not limited to) speaker identity, tone information, the conversation's state at the moment of interruption and a signal indicating that the user has interrupted the previous response. The conversation system **110** then transmits the new text prompt to the LLM system **120**, causing the LLM system **120** to generate a new text response. Upon receiving the new text response from the LLM system **120**, the conversation system **110** converts the new text response into a new speech response and transmits the new speech response back to the client device, causing the client device to play the new speech response.

[0034] Notably, the client device **130** may be caused to constantly monitor the surrounding environment to detect vocal interruptions at any time during a conversation, including before or during a speech response is generated or played. The conversation system **110** determines a response action based on the timing when the interruption is received. This process repeats as long as the user continues the conversation. As such, the conversation system **110** can engage users beyond merely responding to requests. The conversation system **110** creates a perception of genuine engagement, thereby narrowing the gap between human-to-human interactions and technological capabilities.

[0035] In some embodiments, the conversation system **110** may divide a conversation cycle into a plurality of states, including a listening state, a speech-to-text state, a prompt generation state, a text response generation state, a text-to-speech state, a response generation state, and a speech-playing state. For example, in the listening state, the conversation system **110** is awaiting input from the user. Once the conversation system **110** receives speech, it enters the speech-to-text state. In the speech-to-text state, the spoken input from the user is converted into a textual format. The prompt generation state refers to a state where the conversation system **110** processes the text input, determines context of the text input, and formulates a text prompt that will guide the LLM system **120** in its search for information or formation of a response. The text response generation state refers to a state where the LLM system **120** processes the text prompt. Alternatively, or in addition, the conversation system **110** determines the state further based on a time interval between the start of the speech response and the beginning of the new speech input, e.g., within 1 second, within 2 seconds, within 5 seconds, etc.

[0036] In some embodiments, the states may be divided differently. For example, when the LLM is a multimodal LLM, the listening state, speech-to-text state, among others may be combined into a single state at the LLM.

[0037] Upon determining a state when the vocal interruption is received, the conversation system **110** determines a response based on the state of the conversation. In some embodiments, a machine learning model may be trained to generate or modify responses based on a current state when a vocal interruption is received. In some embodiments, the response is a continuer response (e.g., "Uhm, go on.") generated by the conversation system **110**. Alternatively in addition, the response may be generated by the LLM and modified by the conversation system **110**.

[0038] In some embodiments, the conversation system **110** causes a user agent application to be installed on the client device **130**. In some embodiments, the functions of the conversation system **110** and the client device **130** may be divided differently. For example, in some embodiments, the user agent application on the client device **130** may be able to perform speech-to-text or text-to-speech conversions. In some embodiments, users can provide feedback during or after conversations through the user agent application. Simple feedback might be binary, for example, selecting a thumbs up or thumbs down. More complex feedback could include additional options, such as feedback about clarity of response, relevance of information, completeness of the answer, speed of response, voice interaction quality, emotional tone, improvement suggestions, willingness to use the system again, and specific features utilized, among others. The user feedback combined with voice metadata may later be used to retrain or fine-tune the LLM or the state model.

[0039] The LLM system(s) **120** may include a closed-source LLM system, such as OpenAI's GPT-3, GPT-4, HyperCLOVA, Gopher, Chinchilla, BloombergGPT, etc. The LLM system(s) **120** may also include an open-source LLM system, such as LLAMA2, BLOOM, Grover, OpenChatKit, BERT, Falcon 40B and 180B, OPT-175B, XGen-7B, GPT-NeoX, GPT-J, Vicuna 13-B, mistral, Animato-L1, etc. Open-source LLMs have their source code and underlying architecture publicly accessible. The conversation system **110** may retrain an open-source LLM with state data collected during conversations and/or user feedback to cause the LLM to generate a response based on the current state when a vocal interruption is received. Closed-source LLMs have proprietary source code and model weights, which are not publicly accessible, limiting customization and adaptation possibilities. Although some closed-source LLM may not be easily modified, some closed-source LLM still can be fine-tuned or able to learn from context in prompts. For example, the conversation system **110** can include metadata (such as a current state when a vocal interruption is received) as context in text prompts to enable the LLM to learn from the context in generating responses.

[0040] In some embodiments, the LLM system **120** includes a multimodal LLM configured to take audio input directly and understand, process, and generate responses based on the received audio input, among other modalities. The LLM system **120** can interpret and analyze spoken language, convert it into textual format for internal processing, and then perform a range of tasks, such as answering questions, generating text, and/or creating audio responses.

[0041] The conversation system **110** may be a server, server group or cluster (including remote servers), or other suitable computing device or system of devices. The conversation system **110** may include applications configured to communicate with other devices, including those associated with the LLM systems **120** and client devices **130**, over the network **140**. Examples of client devices **130** include conventional computer systems (such as a desktop or a laptop computer, a server, a cloud computing device, and the like), mobile computing devices (such as smartphones, tablet computers, mobile devices, and the like), or any other device having computer functionality. The client device **130** and the conversation system **110** are configured to communicate via the network **140**, for example, using a native application executed by the devices or through an application programming interface (API) running on a native operating system of the devices, such as IOS® or ANDROID™. In another example, the client devices **130**, and the conversation system **110** communicate via applications or APIs running on the

conversation system **110**. Additional details about the conversation system **110** are further described below with respect to FIGS. **2-7**.

[0042] The network **140** may comprise any combination of local area and/or wide area networks, using wired and/or wireless communication systems. In one embodiment, the network **140** uses standard communications technologies and/or protocols. For example, the network **140** includes communication links using technologies such as Ethernet, 802.11, worldwide interoperability for microwave access (WiMAX), 3G, 4G, code division multiple access (CDMA), digital subscriber line (DSL), etc. Examples of networking protocols used for communicating via the network **140** include multiprotocol label switching (MPLS), transmission control protocol/Internet protocol (TCP/IP), hypertext transport protocol (HTTP), simple mail transfer protocol (SMTP), and file transfer protocol (FTP). Data exchanged over the network **140** may be represented using any suitable format, such as hypertext markup language (HTML) or extensible markup language (XML). In some embodiments, all or some of the communication links of the network **140** may be encrypted using any suitable technique or techniques.

Example Conversation System

[0043] FIG. **2** illustrates an example architecture of the conversation system **110** in accordance with one or more embodiments. The conversation system **110** includes a text-to-speech module **210**, a prompt generation module **220**, a text-to-speech module **230**, an interruption detection module **240**, a conversation state module **250**, an interface module **260**, a response modification module **270**, a feedback module **280**, a data collection module **290**, a training module **292**, a data store **294**, and one or more machine-learning models **296**. In alternative configurations, different and/or additional components may be included in the system environment **100**.

[0044] The speech-to-text (STT) module **210** is configured to perform voice or speech recognition, i.e., converting spoken language into text. In some embodiments, the STT module **210** uses deep neural networks (DNNs), such as (but not limited to) convolutional neural networks (CNNs), recurrent neural networks (RNNs), and/or long short-term memory (LSTM) networks, to process audio signals and identify their correlation with linguistic units like phonemes. In some embodiments, the STT module **210** is configured to determine a likelihood of a sequence of words to ensure output text makes linguistic sense. In some embodiments, the STT module **210** uses statistical models to understand context, grammar, and the structure of the language. In some embodiments, the STT module **210** is configured to analyze the audio signal to identify distinct features like pitch, tone, and speed. These features are used to help distinguish between different sounds and understand speech patterns. In some embodiments, the STT module **210** may be part of the LLM system **120**.

[0045] The prompt generation module **220** is configured to generate a text prompt to an LLM system **120** based on the text generated by the STT module **210**. In some embodiments, the prompt generation module **220** is configured to clean the original text generated by the TTS module **210**, such as removing any irrelevant words from the text. In some embodiments, the prompt generation module **220** is configured to add context or additional instructions that help the LLM system understand the prompt's intent, such as metadata associated with a current state of a conversation or a vocal interruption. In some embodiments, the prompt generation module **220** is further configured to structure the prompt in a format that is optimized (or at least better) for the LLM's input requirements.

[0046] Once the LLM system **120** receives the prompt generated by the prompt generation module **220**, the LLM system **120** generates a text response based on the prompt. The text-to-speech (TTS) module **230** is configured to convert the text response into a speech response. In some embodiments, the TTS module **230** analyzes the text response generated by the LLM system **120**, including parsing the text response to understand its structure, such as sentences, phrases, and words. In some embodiments, the TTS module **230** converts the raw text into a standardized format, including abbreviations (e.g., "Dr." to "Doctor"), numbers (e.g., "123" to "one hundred twenty-three"), and special characters into their spoken equivalents. In some embodiments, the TTS module **230** may also perform part-of-speech tagging to understand the role of each word in a sentence, which helps in determining the pronunciation of words that can vary based on context (e.g., "read" in past tense vs. present tense). In some embodiments, the processed text is then converted into phonemes, which are the smallest units of sound in a language. This step may include the use of phonetic dictionaries or preset rules that determine how words are pronounced. Alongside phonetic transcription, the TTS module **210** may also generate prosody information, which includes the rhythm, stress, and intonation patterns of the speech to make the speech sound natural and convey the correct meaning, especially for languages with tonal variation.

[0047] In some embodiments, the TTS module **210** may use a large database of pre-recorded speech segments, selecting and concatenating these segments to form complete utterances. The segments can range from phonemes to words or sentences. The naturalness of the speech depends on the variety and quality of the recorded samples. In some embodiments, parametric synthesis (also known as formant or articulatory synthesis) may be used to generate speech. The parametric synthesis method uses models to generate speech to simulate the physical processes of sound production and the properties of human vocal tracts. In some embodiments, neural network synthesis may be used to generate deep learning models to generate speech. The deep learning models can produce highly natural and expressive speech by learning from vast amounts of recorded speech data.

[0048] The interruption detection module **240** is configured to detect interruption. An interruption occurs if the user begins speaking either before a speech response starts or while it is still playing. Interruptions can result from the user's impatience or desire to steer the conversation differently. They may also happen if the user, believing they have understood the essence of the system's message, wishes to correct, challenge, or expand on that understanding, perhaps due to a perceived mistake or misunderstanding. Additionally, a user might interrupt if they reconsider their query or the conversation's direction. Finally, interruptions can be triggered by the user's need to clarify a point or to share urgent information.

[0049] The conversation state module **250** is configured to determine and track states of each conversation. For

example, potential conversation states may include (but are not limited to) a listening state, a speech-to-text state, a prompt generation state, a text response generation state, a text-to-speech state, a response generation state, and a speech-playing state. In some embodiments, the conversation state module **250** is configured to reset a state of the conversation based on timing of an interruption or a type of an interruption.

[0050] In some embodiments, the conversation state module **250** collaborates with the interruption detection module **240** to determine a type of an interruption. For example, if an interruption is detected either before a speech response begins, the interruption detection module **240** may determine the interruption is a first type, and the conversation state module **250** reverts a state of the conversation (e.g., prompt generation state, text-to-speech state, a response generation state, or a speech-playing state) to a prior state (e.g., listening state). As another example, if an interruption is detected when the speech response just starts, the conversation state module **250** may determine the interruption is a second type and cause the response modification module **270** to generate a new response, overriding or modifying the original response generated by the LLM system **120**. Additional details about the response modification module **270** are further described below. As another example, if an interruption is detected after the speech response has been playing for a threshold time period, the interruption detection module may determine the interruption is a third type, and the conversation state module **250** updates a state of the conversation to a different state.

[0051] The conversation state module **250** may also log metadata related to conversation states or interruptions, and cause the prompt generation module **220** to incorporate the metadata into prompts. The metadata may include (but is not limited to) a special token, a keyword, and/or a description. For example, responsive to detecting that an interruption occurred during a text-to-speech state, the prompt may include [#cancel] followed by a combination of the user's initial input and a new input in the interruption.

[0052] The interface module **260** is configured to transmit text prompt generated by the prompt generation module **220** to the LLM system **120** and receive text response generated by the LLM system **120**. In some embodiments, the interface module **260** performs these communications via an API provided by the LLM system **120**. The API provides a standardized way for the interface module **260** to access the capabilities of the LLM system **120**. The LLM system **120** receives a prompt from the interface module **260** via the API, generates a response based on the received prompt, and sends the response back to the interface module **260** via the API.

[0053] The response modification module **270** is configured to generate a response or modify the received response from the LLM system **120** based on a state of conversation when an interruption is detected or a type of interruption. For example, if an interruption is detected shortly after a speech response starts to play, the response modification module **270** may be configured to generate a continuer response, such as "Uhm, go on." In some embodiments, the response is generated from a small, instant language model that is coupled to the conversation system **110**. if the vocal interruption occurs beyond a second threshold time In some embodiments, the response modification module **270** may also be configured to shorten a response based on a type of interruption.

[0054] The feedback module **280** is configured to receive user feedback during or after conversations. In some embodiments, the feedback module **280** may allow users to input a simple binary feedback, for example, selecting a thumbs up or thumbs down. In some embodiments, the feedback module **280** provides additional feedback options, such as feedback about clarity of response, relevance of information, completeness of the answer, speed of response, voice interaction quality, emotional tone, improvement suggestions, willingness to use the system again, and specific features utilized, among others.

[0055] The data collection module **290** is configured to collect data associated with conversations and states of conversations, including (but not limited to) user inputs, LLM responses, timestamps (e.g., time and date of each interaction), user session data (e.g., session/conversation duration and any unique session/conversation identifiers), user identifiers, interaction flow (e.g., a sequence of questions and answers in a conversation, which helps in understanding how users navigate through conversations and where they might encounter issues), feedback and ratings, technical information (e.g., information about the user's device, browser, or app version), among others. The collected data is stored in the data store **294**.

[0056] The training module **292** is configured to train one or more machine-learning models **296** using the collected data. The machine-learning model may be trained to generate responses based on a conversation state when an interruption is detected. The training dataset may include examples of interruptions and their corresponding metadata about their states and timing. In some embodiments, the examples are also labeled with reasons for the corresponding interruptions, such as misunderstanding, impatience, and any change in the user's tone. In some embodiments, additional features are also extracted, such as audio features like speech rate, volume, and pitch, in addition to textual features extracted through speech-to-text processes. For video conversations, visual features such as facial expressions, gestures, and mouth movements may also be considered.

[0057] In some embodiments, the training module **292** is configured to use sequence modeling to handle the temporal nature of conversations. The machine learning model **296** may be trained to understand the flow of a conversation, recognize when an interruption occurs, and determine the state of the conversation at that moment. In some embodiments, the training module **292** incorporates state management data in the machine-learning model **296**'s architecture to maintain a dynamic representation of the conversation's context, such as tracking the focus of the conversation, a user's intent, and any pending topics that need to be addressed after an interruption. In some embodiments, the machine-learning model **296** is trained to dynamically adjust the conversation state based on a determined type of interruption and generate a response appropriate to the type of interruption and the new state of the conversation. In some embodiments, the machine-learning model **296** is configured to generate empathetic responses, seek clarification, or adjust the response strategy based on the user's behavior and the conversation's context.

[0058] In some embodiments, the training module **292** further uses user feedback received by the feedback module **280** to retrain or fine-tune the machine learning model **296**. In some embodiments, the training module **292** employs continuous learning techniques to refine the machine-learning model **296** as it encounters more diverse conversation patterns and interruption types. The training module **292** regularly updates the machine learning model **296** with new data and feedback to improve its accuracy and responsiveness.

[0059] In some embodiments, the conversation system **110** is also configured to generate video accompanying the speech response. In some embodiments, the video may be generated by another generative model hosted on a remote server. Alternatively, the video may be generated by a machine learning model **296** trained or fine-tuned by the conversation system **110**.

[0060] FIG. **3** illustrates an example architecture of a client device **130** in accordance with one or more embodiments. The client device **130** may include (but is not limited to) a smartphone, a tablet, a laptop, a desktop, a smartwatch, an e-reader, a gaming console, a smart home device, a wearable fitness tracker, a virtual reality (VR) and/or augmented reality (AR) headset, a digital camera, a portable media player, a drone, among others. The client device **130** may have a user agent application **300** installed thereon. The user agent application **300** includes a listening module **310**, a playing module **320**, a transceiver module **330**, and a user interface module **330**.

[0061] The listening module **310** is configured to listen to a user's speech input. In some embodiments, the listening module **310** continuously monitors ambient audio and is ready to record a user's speech. In some embodiments, the listening module **310** is in a low-power "listening" mode, where they continuously monitor ambient audio for a specific wake word or phrase. When the listening module **310** detects the wake word, it switches to an active listening mode, ready to record a next spoken speech. The recording may be an audio file of the user's speech.

[0062] In some embodiments, the listening module **310** employs echo cancellation to allow the client device **130** to filter out a sound that is currently playing (e.g., a speech response) from the speech input it captures through its microphones. The listening module **310** identifies a sound pattern of the client device's own output and subtracts it from the ambient noise and audio it captures, isolating the user's speech input. In some embodiments, the listening module **310** is configured to determine a direction from which a user's speech input is coming to dynamically adjust which microphone is prioritized in an array of microphones, focusing on picking up sound from the direction of the user.

[0063] The transceiver module **330** is configured to transmit the recorded audio file to the conversation system **110**, which in turn performs voice recognition, obtains a text response from the LLM system **120**, and generates a speech response based on the text response. The speech response is then sent back to the transceiver module **330** of the client device **130**, which causes the playing module **320** to play the speech response to the user. In some embodiments, playing module **320** includes an audio player configured to play the speech response. Alternatively, or in addition, the playing module **320** may also include a video player configured to play a video accompanying the speech response. The video may also be received from the conversation system **110**.

[0064] In some embodiments, the user interface module **330** may be a graphical user interface enabling users to manually initiate, interrupt, or end a conversation using interactive elements. Additionally, the user interface module **330** may also allow for user feedback and display a text transcript of the conversation. In some embodiments, the client device **130** may also have the capability to store either the text or audio record of the conversation on the client device **130** and the user can review the text record or replay the audio record via the user interface module **330**.

[0065] FIG. **4**A illustrates an example process **400**A of detecting a first type of interruption in a conversation in accordance with one or more embodiments. The horizontal axis represents time. During a first time period **412**, a user is speaking **410**. This period **412** corresponds to a listening state of the conversation. During a second time period **422**, the conversation system **110** performs speech recognition (i.e., speech-to-text operation). This time period **422** corresponds to a speech-to-text state of the conversation. During a third time period, **442**, the LLM system **120** receives the text prompt and generates **440**, a text response based on the text prompt. This period **442** corresponds to a response generation state. After the response generation state, the conversation system **110** will generate a speech response and cause the speech response to be played **450** at the client device **130**, which corresponds to a speech-playing state.

[0066] However, before the LLM system **120** finishes the generation of the response **440**, the user speaks **430***a* again. Due to the timing of the user's second speech **430**A detected before the speech playing **450**, the conversation system **110** determines that the interruption is a first type of interruption, and causes the LLM system **120** to cancel **460**A its action of generating the response. The cancellation can be initiated by a prompt that indicates the cancellation of the previous action and/or discarding the previously generated response. The prompt may also indicate regenerating a response that integrates the new user input with the previous input. For example, the prompt may be: "Please disregard the previous response; consider this additional context: [insert new user input here]. Based on this, generate a new response."

[0067] FIG. **4**B illustrates an example process **400**B of detecting a second type of interruption in a conversation in accordance with one or more embodiments. The first three states of the conversation in FIG. **4**B are the same as those in FIG. **4**A. The user speaks **410** first, the conversation system **110** performs speech recognition **420**, and the LLM system **120** generates a response **440**. After that, the conversation system **110** performs speech generation and causes the speech to be played **450** to the user at the client device **130**. At the very beginning of this speech-playing state, the user starts to speak **430**B again.

[0068] Due to the timing of the user's second speech **430**B detected before a first threshold time of the speech playing **450**, the conversation system **110** determines that the interruption is a second type of interruption, and causes the speech playing **450** to stop and generate **460**B a continuer voice response, e.g., "Uhm, go on." This response signals to the user that the conversation system **110** is still actively listening and interested in what they have to say, encouraging them to continue their train of thought or query. This response also recognizes that the user has made an interruption, which might be due to various reasons such as

seeking to add more information, needing clarification, or correcting a mistake in the previous query, creating a natural and fluid conversation flue.

[0069] FIG. **4**C illustrates an example process **400**C of detecting a third type of interruption in a conversation in accordance with one or more embodiments. Again, four states of the conversation in FIG. **4**C are the same as those in FIG. **4**B. However, the user's interruption comes in later during the speech playing state. This interruption indicates that the response is probably relevant, but too long. The user may want to steer the conversation in another direction. Due to the timing of the user's second speech **430**C detected after a second threshold time of the speech playing **450**, the conversation system **110** determines that the interruption is a third type of interruption, and causes the speech playing **450** to stop speech playing, and revert **460**C the state of the conversation back to the listening state.

[0070] In some embodiments, the conversation system **110** is further configured to detect user frustration during conversations. FIG. **4**D illustrates an example process **400**D of detecting user frustration in a conversation in accordance with one or more embodiments. The boxes **410**D, **414**D, and **424**D labeled as "bot" represent periods during which an audio response generated by the conversation system **110** is being played. The boxes labeled as "human" **412**D, **416**D, **420**D, and **422**D represent periods during which a user is speaking.

[0071] Prior to time T**1**, a conversation between the user and the conversation system **110** proceeds uninterrupted. Subsequently, at time T**2**, the user begins to speak during period **416**D before a previous audio response **414**D concludes. Based on the timing of the user's speech **416**D, the conversation system **110** detects **430**D an interruption at time T**2**, causing the audio response **414**D to fade out **432**D. Furthermore, during the user's speech **416**D, the conversation system **110** also evaluates a tone of the user and identifies **434**D whether the user is frustrated based on the determined tone of the user. In some embodiments, the conversation system **110** applies a machine learning model **296** to data associated with the user speech **416**D to determine the tone of the user. In some embodiments, the data related to the detected frustration may be saved **436**D for training or retraining a machine learning model **296**.

[0072] In addition, the conversation system **110** also determines whether to roll back the conversation state based in part on a pause **442**D between user's two speeches **412**D and **416**D, a pause **444**D between the starting of the audio response **414**D and the start of the user speech **416**D, and/or a pause **446**D between user's two speeches **416**D and **420**D. For example, if the pause **444**D is less than a threshold time, the conversation system **110** determines that the pause is a short pause, causing a roll back **452**D of the conversation state to a previous state; otherwise, the conversation system **110** maintains **454**D the current state.

[0073] FIG. **5** illustrates an example process **500** of training or retraining a machine learning model **520** in accordance with one or more embodiments. In some embodiments, the machine-learning model may be a language model configured to generate a continuer response (e.g., "Uhm, go on.") upon detecting a particular type of interruption. In some embodiments, the machine-learning model is a large language model used by the LLM system **120**. The machine learning model **520** is trained over a training set **510**. The training set **510** includes historical user conversation data **512**, and historical user interruptions data **515**. The historical user conversations data **512** may include (but is not limited to) records of interactions between users and LLMs, along with relevant metadata like timestamps marking user inputs and LLM replies. The historical user interruption data **515** contains information related to disruptions in the conversations between users and LLMs, such as the conversation's state at the moment an interruption occurs and a time interval from the start of a speech response to a detection of an interruption.

[0074] In some embodiments, the historical user interruption data **515** may be labeled or annotated with additional metadata, such as reasons for the interruption, and states of the conversations when the interruptions occurred. Reasons for the interruption may include (but are not limited to) impatience, misunderstanding, correction to previous user input, etc. In some embodiments, the historical user interruption data **515** may be labeled or annotated with additional metadata, such as continuer responses generated in response to the interruptions, and resetting the state of the conversation. The continuer responses may include (but are not limited to) acknowledgment responses, empathetic responses, and clarification requests.

[0075] In some embodiments, the machine-learning model **520** is trained to receive target user conversation data **540** as input and detect when an interruption is likely to occur based on the context of the conversation and the user's previous behavior. In some embodiments, the machine-learning model is trained to determine a speech completion score indicating a likelihood of whether the user has finished speaking. Responsive to the speech completion score greater than a threshold, the conversation system **110** generates a prompt for the LLM system **120** and causes a speech response to be played at the client device **130**. On the other hand, responsive to the speech competition score lower than the threshold, the conversation system **110** refrains from generating a prompt or playing the speech.

[0076] In some embodiments, the machine-learning model **250** is trained to determine a complexity score indicating a level of complexity of the conversation. Responsive to the complexity score greater than a threshold, the conversation system **110** generates a prompt for the LLM system **120**, causing the LLM system **120** to summarize the conversation, thereby verifying with the user that the conversation has been correctly understood.

[0077] In some embodiments, the machine-learning model **250** is trained to receive target user interruption data **542** as input and identify the type of interruption and/or its cause. In some embodiments, the machine-learning model **250** is further trained to generate a response **550** that addresses the cause of the interruption, including (but not limited to) an empathetic response, seeking clarification, and/or correcting a misunderstanding.

[0078] In some embodiments, users can provide feedback **560** after receiving the response **550** or after the conversation is over. In some embodiments, additional training set **570** is generated based on the responses **550** and user feedback **560**. The conversation system **110** employs continuous learning to refine the machine-learning model **520** as more diverse conversations and interruption patterns are received and handled by the machine-learning model **520**.

[0079] FIG. **6**A illustrates an example communication pattern **600**A of a conversation, in which no interruption is detected in accordance with one or more embodiments. The

conversation starts with a user speech **610**A received at the client device **130** and transmitted from the client device **130** to the conversation system **110**. Upon receiving the user speech **610**A, the conversation system **110** performs speech-to-text operation **620**A, converting the user speech in audio form into text. The conversation system **110** then generates **630**A a prompt based on the text, and transmits the prompt **640**A to the LLM system **120**. Upon receiving the prompt **640**A, the LLM system **120** generates **650**A a text response, and transmits the text response **660**A back to the conversation system **110**. The conversation system **110** in turn performs the text-to-speech operation **670**A to convert the text response to a speech response, and transmits the speech response **680**A back to the client device **130**, causing the client device **130** to play the speech response **680**A to a user.

[0080] FIG. **6**B illustrates an example communication pattern **600**B of a conversation, in which an interruption is detected in accordance with one or more embodiments. Similar to the communication pattern **600**A in FIG. **6**A, the conversation starts with a user speech **610**B received at the client device **130** and transmitted from the client device **130** to the conversation system **110**. Upon receiving the user speech **610**B, the conversation system **110** performs speech-to-text operation **620**B. Before the conversation system **110** generates a prompt, a second user speech **630**B is received at the client device **130** and transmitted to the conversation system **110**. Based on the timing of the second user speech **630**B, the conversation system **110** detects **635**B that an interruption has occurred. The conversation system **110** then performs speech-to-text operation **640**B on the second user speech **630**B. After that, the conversation system **110** generates **645**B a prompt based on both the received first user speech **610**B and second user speech **630**B, and transmits **650**B the prompt to the LLM system **120**. Upon receiving the prompt, the LLM system **120** generates **655**B a text response and sends **660**B the text response back to the conversation system **110**. The conversation system **110** performs text-to-speech operation **655**B on the received text response to generate **665**B a speech response and sends **670**B the speech response back to the client device **130**, causing the client device **130** to play the speech response to the user.

[0081] Notably, in conversation pattern **600**B, the interruption is detected after the speech-to-text operation is performed and before a prompt is generated. In other conversation patterns, the interruption may be detected before, during, or after any state of the conversation, including a speech-to-text state, a prompt generation state, a response generation state, a text-to-speech state, and speech playing state, etc. Depending on the state of the conversation or timing of the state when an interruption is detected, the conversation system **110** may react to the interruption differently.

[0082] FIG. **7** illustrates an example text record **700** of a conversation in accordance with one or more embodiments. The text record **700** includes text of a user's speech requests **710**, **730**, and text responses **720**, **740** generated by the LLM system **120**. The text record **700** also includes metadata associated with the user's speech and responses, including the timing and duration of each speech request or speech response. For example, the conversation starts with a prompt generated based on user request **710** "I would like a recipe for meatloaf." Upon receiving the user request **710**, the LLM generates a response **720** including a meatloaf recipe. Before the recipe was finished playing to the user, the user interrupted the response and uttered a second request, **730**, "I would like a vegan one, please." The conversation system **110** then generates **730** a new prompt based on the second request. As illustrated, the conversation system **110** annotated the prompt with metadata related to the interruption, "[#Cancel->" I interrupted your answer"]". The LLM system **120** then generates a new response **740** based on the updated prompt.

[0083] Text record **700** is merely an example text record of a conversation between a user and an LLM. The interruption is detected following the generation of the first response **720** by the LLM, while this response is being played back to the user. In different communication scenarios, interruptions might be spotted either earlier or later, possibly during the initial stages of the response playback or even before it begins. The timing of the interruption's detection influences how a new prompt is annotated, incorporating varied metadata that reflects the interruption's context, timing, and the predicted intent or sentiment of the user.

Example Methods for Managing Interruptions During Verbal Conversations Between Users and LLMs

[0084] FIG. **8** is a flowchart of a method **800** for managing interruptions during a verbal conversation between users and LLMs in accordance with one or more embodiments. In various embodiments, the method includes different or additional steps than those described in conjunction with FIG. **8**. Further, in some embodiments, the steps of the method may be performed in different orders than the order described in conjunction with FIG. **8**. The method described in conjunction with FIG. **8** may be carried out by the client device **130**, the conversation system **110**, or a combination thereof.

[0085] The client device **130** plays **810** a first speech response signal to a user during a vocal conversation between the user and an LLM system **120**. This speech response signal may be received from the conversation system **110** and generated based on a user's speech. The client device **130** detects **820** a vocal interruption from the user during the playing of the first speech response signal and before the end of the playing of the first speech response signal. The vocal interruption includes a user speech input. The client device **130** may include a listening module configured to constantly listen to a user's speech input before, during, and/or after a speech response signal is being played. In some embodiments, the client device **130** is configured to identify a sound pattern of the first speech response signal and substrates the identified sound pattern from ambient noise and captured audio to isolate the user speech input.

[0086] Responsive to detecting the vocal interruption, the client device **130** stops **830** playing the first speech response signal, and obtains **840** a second speech response signal based on the vocal interruption. In some embodiments, the client device **130** records the user speech input and transmits the recorded user speech input to the conversation system **110**. Upon receiving the user speech input, the conversation system **110** generates a prompt and sends the prompt to the LLM system **120**, causing the LLM system **120** to generate a text response based on the prompt. The conversation system **110** then converts the text response into the second speech response and transmits the second speech response

back to the client device **130**. Upon receiving the speech response, the client device **130** plays **850** the second speech response signal to the user.

[0087] FIGS. **9**A-**9**B is a flowchart of a method **900** for managing interruptions during a verbal conversation between users and LLMs in accordance with one or more embodiments. In various embodiments, the method includes different or additional steps than those described in conjunction with FIGS. **9**A-**9**B. Further, in some embodiments, the steps of the method may be performed in different orders than the order described in conjunction with FIGS. **9**A-**9**B. The method described in conjunction with FIGS. **9**A-**9**B may be carried out by the conversation system **110**.

[0088] The conversation system **110** receives **905** a first speech input from a client device **130** of a user. Upon receiving the first speech input, the conversation system **110** converts **910** the first speech input into first text input. In some embodiments, the conversation system **110** includes a speech-to-text (STT) module **210** configured to perform STT, converting the first speech input into the first text input. In some embodiments, the STT module **210** implements various machine learning models, such as CNNs, RNNs, and LSTM networks, to process audio signals and determine a likelihood of a sequence of words in a speech input.

[0089] The conversation system **110** generates **915** a first prompt for an LLM (e.g., LLM system **120**) based on the first text. In some embodiments, the conversation system **110** determines a state of the conversation and incorporates the state of the conversation into the prompt to provide context to the LLM. The conversation system **110** transmits **920** the first prompt to the LLM. Upon receiving the first prompt, the LLM generates a first text response based on the first prompt, and sends the first text response back to the conversation system **110**.

[0090] The conversation system **110** receives **925** the first text response from the LLM and converts **930** the first text response into a first speech response. In some embodiments, the conversation system **110** includes a text-to-speech (TTS) module **230** configured to convert text responses into speech responses. In some embodiments, the TTS module **230** parses the first text response to understand its structure, converts raw text into a standardized format (including converting abbreviations or special characters into their spoken equivalents), determines pronunciation of each word based on context, such as past tense vs. present tense, and generates a sequence of phonemes. The conversation system **110** transmits **935** the first speech response back to the client device, causing the client device to play the first speech response to the user.

[0091] At the same time, the conversation system **110** causes the client device **130** to monitor ambient audio and detect vocal interruptions during the conversation. In some embodiments, the conversation system **110** detects **940** a vocal interruption comprising a second speech input from the user during the play of the first speech response. Responsive to detecting the vocal interruption, the conversation system **110** causes **945** the client device to stop playing the first speech response. The client device **130** captures and sends the second speech input to the conversation system **110**. Upon receiving the second speech input, the conversation system **110** generates **950** a second prompt to the LLM based on the vocal interruption, including the second speech input. Note that this second text prompt doesn't just include the second text input; it also integrates metadata related to the vocal interruption. This includes the conversation's state at the moment of interruption, a signal indicating that the user has interrupted the previous response, and/or a time interval between the start of playing the first speech response and the detection of the vocal interruption.

[0092] For example, if the vocal interruption occurs within a first threshold time after the start of the first speech response, the timing might suggest that the user has not finished speaking. In such cases, the conversation system **110** could generate a prompt, stating, "Please ignore the previous response; consider not only the original input but also this additional information: [insert new user input here]. Based on this information, generate a fresh response."

[0093] As another example, if the vocal interruption occurs beyond a second threshold time since the first speech response began, this timing might suggest that the user has gathered sufficient information from the response and seeks to steer the conversation toward a new topic. Consequently, the conversation system **110** might produce a prompt stating, "I wish to switch topics," causing the LLM to restart a new conversation. In some embodiments, the conversation system **110** may produce a prompt further based on the content or other metadata like vocal tone related to the user speech.

[0094] The conversation system **110** transmits **955** the second prompt to the LLM. Again, upon receiving the second prompt, the LLM generates and sends a second text response to the conversation system **110**. The conversation system **110** receives **960** the second text response from the LLM and converts **965** the second text response into a second speech response. The conversation system **110** transmits **970** the second text response back to the client device **130**, causing the client device **130** to play the second speech response to the user.

[0095] In some embodiments, the conversation system **110** applies one or more machine-learning models to data associated with the conversation or data associated with the vocal interruption. One or more machine-learning models are trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during those conversations. In some embodiments, a machine-learning model may be applied to data associated with the conversation to determine a speech completion score indicating a likelihood of whether the user has finished speaking. Responsive to the speech completion score greater than a threshold, the conversation system generates the first prompt for the LLM.

[0096] Notably, in some cases, the vocal interruption may be detected at any point during the conversation. In some embodiments, a machine-learning model may be applied to data associated with the vocal interruption to determine a type of vocal interruption, e.g., type I, II, or III of vocal interruption described above with respect to FIGS. **4**A-**4**C. The conversation system **110** generates the second prompt based on the determined type of vocal interruption.

[0097] The vocal interruption may also be analyzed to determine the user's tone and/or sentiment. In some embodiments, the conversation system **110** may be a video conversation system, and the vocal interruption may also be accompanied by visual data. The visual data associated with the interruption may also be analyzed to determine the user's sentiment. The conversation system **110** may also incorporate such data, e.g., the user's tone and/or sentiment, into a prompt. In some embodiments, the conversation system **110** may also generate a continuer response (e.g., "Uhm, go on.")

and cause the continuer response to be played prior to generating or delivering the next response from the LLM.

[0098] The above-described process may continue as long as the user interacts with the conversation system **110**, enabling verbal conversations between users and LLMs that resemble human communication.

Example Computing System

[0099] FIG. **10** is a block diagram of an example computer **1000** suitable for use in the networked computing environment **100** of FIG. **1**. The computer **1000** is a computer system and is configured to perform specific functions as described herein. For example, the specific functions corresponding to the conversation system **110** or the LLM system **120** may be configured through the computer **1000**.

[0100] The example computer **1000** includes a processor system having one or more processors **1002** coupled to a chipset **1004**. The chipset **1004** includes a memory controller hub **1020** and an input/output (I/O) controller hub **1022**. A memory system having one or more memories **1006** and a graphics adapter **1012** are coupled to the memory controller hub **1020**, and a display **1018** is coupled to the graphics adapter **1012**. A storage device **1008**, keyboard **1010**, pointing device **1014**, and network adapter **1016** are coupled to the I/O controller hub **1022**. Other embodiments of the computer **1000** have different architectures.

[0101] In some embodiments, the computer **1000** may also include audio input/output devices **1030**, such as one or more microphones, one or more speakers, one or more earphones. The audio input/output devices **1030** are configured to capture speech input from users and deliver audio responses back to the users. In some embodiments, audio input/output devices **1030** may be connected over a phone line. In some embodiments, the computer **1000** may also include visual input/output devices configured to receive video input from users and project video responses back to the users.

[0102] In the embodiment shown in FIG. **10**, the storage device **1008** is a non-transitory computer-readable storage medium such as a hard drive, compact disk read-only memory (CD-ROM), DVD, or a solid-state memory device. The memory **1006** holds instructions and data used by the processor **1002**. The pointing device **1014** is a mouse, track ball, touchscreen, or other types of a pointing device and may be used in combination with the keyboard **1010** (which may be an on-screen keyboard) to input data into the computer **1000**. The graphics adapter **1012** displays images and other information on the display **1018**. The network adapter **1016** couples the computer **1000** to one or more computer networks, such as network **140**.

[0103] The types of computers used by the conversation system **110**, the LLM system **120**, and the client device **130** of FIGS. **1** through **4** can vary depending upon the embodiment and the processing power required by the conversation system **110**, the LLM system **120**, and the client device **130**. For example, the conversation system **110** might include multiple blade servers working together to provide the functionality described. Furthermore, the computers can lack some of the components described above, such as keyboards **1010**, graphics adapters **1012**, and displays **1018**.

Additional Considerations

[0104] The foregoing description of the embodiments has been presented for the purpose of illustration; it is not intended to be exhaustive or to limit the patent rights to the precise forms disclosed. Persons skilled in the relevant art can appreciate that many modifications and variations are possible in light of the above disclosure.

[0105] Some portions of this description describe the embodiments in terms of algorithms and symbolic representations of operations on information. These algorithmic descriptions and representations are commonly used by those skilled in the data processing arts to convey the substance of their work effectively to others skilled in the art. These operations, while described functionally, computationally, or logically, are understood to be implemented by computer programs or equivalent electrical circuits, microcode, or the like. Furthermore, it has also proven convenient at times, to refer to these arrangements of operations as modules, without loss of generality. The described operations and their associated modules may be embodied in software, firmware, hardware, or any combinations thereof.

[0106] Any of the steps, operations, or processes described herein may be performed or implemented with one or more hardware or software modules, alone or in combination with other devices. In one embodiment, a software module is implemented with a computer program product comprising a computer-readable medium containing computer program code, which can be executed by a computer processor for performing any or all of the steps, operations, or processes described.

[0107] Embodiments may also relate to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, and/or it may comprise a general-purpose computing device selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a non-transitory, tangible computer readable storage medium, or any type of media suitable for storing electronic instructions, which may be coupled to a computer system bus. Furthermore, any computing systems referred to in the specification may include a single processor or may be architectures employing multiple processor designs for increased computing capability.

[0108] Embodiments may also relate to a product that is produced by a computing process described herein. Such a product may comprise information resulting from a computing process, where the information is stored on a non-transitory, tangible computer readable storage medium and may include any embodiment of a computer program product or other data combination described herein.

[0109] Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the patent rights. It is therefore intended that the scope of the patent rights be limited not by this detailed description, but rather by any claims that issue on an application based hereon. Accordingly, the disclosure of the embodiments is intended to be illustrative, but not limiting, of the scope of the patent rights, which is set forth in the following claims.

What is claimed is:

1. A method for managing interruptions during verbal conversations between users and Large Language Models (LLMs), comprising:

receiving a first speech input from a client device of a user;

converting the first speech input into first text;

generating a first prompt for an LLM based on the first text;

transmitting the first prompt to the LLM, causing the LLM to generate a first text response;

receiving the first text response from the LLM;

converting the first text response into a first speech response;

transmitting the first speech response back to the client device, causing the client to play the first speech response to the user;

detecting a vocal interruption comprising a second speech input from the user during the play of the first speech response;

responsive to detecting the vocal interruption, causing the client device to stop playing the first speech response;

generating a second prompt to the LLM based on the vocal interruption;

transmitting the second prompt to the LLM, causing the LLM to generate a second text response;

receiving the second text response from the LLM;

converting the second text response into a second speech response; and

transmitting the second speech response back to the client device, causing the client device to play the second speech response to the user.

2. The method of claim **1**, further comprising:

determining a timing of the vocal interruption;

generating the second prompt based on the timing of the vocal interruption.

3. The method of claim **2**, wherein determining the timing of the vocal interruption comprises:

determining whether the vocal interruption is received within a first threshold time period after the first speech response starts;

responsive to determining that the vocal interruption is received within the first threshold time period after the first speech response starts, generating a continuer response to signal the user to continue speaking.

4. The method of claim **2**, wherein determining the timing of the vocal interruption comprises:

determining whether the vocal interruption is received after a second threshold time period after the first speech response starts;

responsive to determining that the vocal interruption is received after the second threshold time period after the first speech response starts,

canceling a previous conversation; and

restarting a new conversation.

5. The method of claim **1**, further comprising:

determining a state of the conversation when the vocal interruption is received; and

generating the second prompt to the LLM based on the determined state of the conversation.

6. The method of claim **1**, further comprising:

applying a machine-learning model to data associated with the conversation to determine a speech completion score indicating a likelihood of whether the user has finished speaking, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations;

responsive to the speech completion score greater than a threshold, generating the first prompt for the LLM.

7. The method of claim **1**, further comprising:

applying a machine-learning model to data associated with the conversation to determine a complexity score indicating a level of complexity of the conversation, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations; and

responsive to the complexity score greater than a threshold, generating the first prompt for the LLM, causing the LLM to summarize the conversation, thereby verifying with the user that the conversation has been correctly understood.

8. The method of claim **1**, further comprising:

applying a machine-learning model to data associated with the vocal interruption to determine a type of the vocal interruption, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations; and

generating the second prompt based on the determined type of the vocal interruption.

9. The method of claim **1**, further comprising:

collecting data associated with the conversation and vocal interruption; and

retraining or fine-tuning the LLM based on the collected data.

10. The method of claim **1**, further comprising:

collecting user feedback on how the vocal interruption was handled; and

retraining or fine-tuning the LLM based on the collected user feedback.

11. A computer program product comprising a non-transitory computer readable storage medium having instructions encoded thereon that, when executed by a processor, cause the processor to:

receive a first speech input from a client device of a user;

convert the first speech input into first text;

generate a first prompt for an LLM based on the first text;

transmit the first prompt to the LLM, causing the LLM to generate a first text response;

receive the first text response from the LLM;

convert the first text response into a first speech response;

transmit the first speech response back to the client device, causing the client to play the first speech response to the user;

detect a vocal interruption comprising a second speech input from the user during the play of the first speech response;

responsive to detecting the vocal interruption, cause the client device to stop playing the first speech response;

generate a second prompt to the LLM based on the vocal interruption;

transmit the second prompt to the LLM, causing the LLM to generate a second text response;

receive the second text response from the LLM;

convert the second text response into a second speech response; and

transmit the second speech response back to the client device, causing the client device to play the second speech response to the user.

12. The computer program product of claim **11**, further comprising:

determining a timing of the vocal interruption;

generating the second prompt based on the timing of the vocal interruption.

13. The computer program product of claim **12**, wherein determining the timing of the vocal interruption comprises:

determining whether the vocal interruption is received within a first threshold time period after the first speech response starts;

responsive to determining that the vocal interruption is received within the first threshold time period after the first speech response starts, generating a continuer response to signal the user to continue speaking.

14. The computer program product of claim **12**, wherein determining the timing of the vocal interruption comprises:

determining whether the vocal interruption is received after a second threshold time period after the first speech response starts;

responsive to determining that the vocal interruption is received after the second threshold time period after the first speech response starts,

canceling a previous conversation; and

restarting a new conversation.

15. The computer program product of claim **11**, further comprising:

determining a state of a current conversation between the user and the LLM when the vocal interruption is received; and

generating the second prompt to the LLM based on the determined state of the conversation.

16. The computer program product of claim **11**, further comprising:

applying a machine-learning model to data associated with a current conversation between the user and the LLM to determine a speech completion score indicating a likelihood of whether the user has finished speaking, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations;

responsive to the speech completion score greater than a threshold, generating the first prompt for the LLM.

17. The computer program product of claim **11**, further comprising:

applying a machine-learning model to data associated with a current conversation between the user and the LLM to determine a complexity score indicating a level of complexity of the conversation, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations; and

responsive to the complexity score greater than a threshold, generating the first prompt for the LLM, causing the LLM to summarize the conversation, thereby verifying with the user that the conversation has been correctly understood.

18. The computer program product of claim **11**, further comprising:

applying a machine-learning model to data associated with the vocal interruption to determine a type of the vocal interruption, wherein the machine-learning model is trained over historical conversation data comprising features associated with historical conversations between users and LLMs and interruptions during the conversations; and

generating the second prompt based on the determined type of the vocal interruption.

19. The computer program product of claim **11**, further comprising:

collecting data associated with a current conversation between the user and the LLM and vocal interruption;

collecting user feedback on how the vocal interruption was handled; and

retraining or fine-tuning the LLM based on the collected data or collected user feedback.

20. A method for managing interruptions during verbal conversations between users and Large Language Models (LLMs), comprising:

playing a first speech response signal on a client device of a user during a vocal conversation between the user and an LLM system;

detecting a vocal interruption from the user during the playing of the first speech response signal and before an end of the playing of the first speech response signal;

responsive to detecting the vocal interruption, stopping playing the first speech response signal; and

generating, by the LLM system, a second speech response signal based on the vocal interruption; and

playing the second speech response signal on the client device of the user.

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