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SUGGESTED ALTERATIONS FOR MODIFIABLE CONTENT

Abstract

Implementations are described herein for leveraging generative models such as LLMs to generate and provide recommended alterations to various types of content. In various implementations, a LLM input prompt may be processed using an LLM to generate a first LLM response, which may be operable to cause first content derived from the first LLM response to be rendered. At least a portion of the first LLM response may be assembled with a request to generate recommended alteration(s) to the portion of the first LLM response and processed using the LLM to generate a second LLM response. The second LLM response may be operable to cause selectable element(s) to be rendered. Each of the selectable element(s) may: identify a respective recommended alteration, and be operable to cause corresponding modified content to be rendered. The modified content may include at least some of the first content modified based on the recommended alteration.

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Background/Summary

BACKGROUND

[0001] Generative models such as large language models (LLMs) can be used to process, as LLM input, sequences of input tokens to generate, as LLM responses, sequences of output tokens. These sequences of input/output tokens often take the form of and/or otherwise represent strings of text, although they can take other forms such as embeddings, numbers, etc. Some LLM responses may include a relatively large number of details and/or extensive natural language. For example, a user may request that the LLM be used to generate a multi-paragraph summary of a document, a detailed invitation to a birthday party, a business email, etc.

[0002] If a user is dissatisfied with a rendered LLM output, they can copy the LLM output into a text editor and then modify the text manually. However, this process may be cumbersome enough to discourage use of the LLM in the first place. Alternatively, the user may issue a follow up natural language request to modify the entire LLM output, e.g., to add more detail, change the LLM output's "tone," replace tokens with other tokens (e.g., synonyms), etc. However, it may be the case that the user is satisfied with some parts of the LLM output but not with others. Moreover, the user may lack knowledge or experience to recognize that the LLM output is deficient in some way.

SUMMARY

[0003] Implementations described herein relate to leveraging generative models such as LLMs to generate and provide recommended alterations to various types of content, such as LLM-generated content and/or user-composed content. More particularly, but not exclusively, implementations described herein relate to providing workflows that process LLM-generated or user-composed content (collectively, "modifiable content") to generate selectable element(s) corresponding to recommended alteration(s) of the modifiable content, and presenting those selectable element(s) to users. This enables users to selectively leverage the LLM to improve modifiable content in ways that may or may not have occurred to the users, e.g., due to their lack of experience, knowledge, or expertise.

[0004] In various implementations, modifiable content may be assembled into an LLM input prompt with a separate (e.g., implicit) request to generate recommended (or proposed) alteration(s) to the modifiable content. The request to recommend alteration(s) may take various forms. In some implementations, the request may be a natural language request, such as "what is <modifiable content> missing?" (which may cause the LLM to output data indicative of information that the LLM is trained to typically encounter in similar content but is missing from the modifiable content). In other implementations, the request may be in the form of predesignated token(s) or symbol(s) that the LLM has been pre-trained and/or fine-tuned to recognize as a request to generate recommended alteration(s).

[0005] In some implementations, the modifiable content (e.g., text, images, audio, any combination thereof) may be encoded into input tokens (e.g., words, characters, numeric embeddings, etc.) that are dimensioned appropriately for processing by the LLM, along with additional input token(s) that represent the request to generate recommended alteration(s). The input prompt may then be processed using the LLM to generate an LLM response. The LLM response may include tokens from which various information can be derived (e.g., read or consumed directly, decoded, etc.).

[0006] At least a portion of the LLM response may also be operable, e.g., by a client application operated by the user, to cause selectable element(s) corresponding to the recommended alteration(s) to be presented at the client application. These selectable element(s) may take various forms depending on factors such as the output modality employed by the client application (e.g., audio output versus visual output), the nature of the recommended alteration, and so forth. Operation of one of these selectable elements may cause the corresponding recommended alteration to be affected on the modifiable content and/or presented as output at the client application of the user.

[0007] In some implementations, when a selectable element is operated, the corresponding recommended alteration and the original modifiable content may be assembled into a new input

prompt that is processed using the LLM to generate a new LLM response in which the modifiable content has been updated based on (e.g., incorporates) the recommended alteration. The LLM may have hundreds of billions of parameters or more. Accordingly, waiting to process this new input prompt until the user has affirmatively operated a selectable element avoids expending the considerable computing resources and/or energy associated with applying the LLM to data unless the user explicitly requests it.

[0008] Alternatively, in some implementations, the recommended alteration and modifiable content may be processed automatically and/or proactively, e.g., behind the scenes and/or in parallel to the original modifiable content being presented to the user. The resulting new LLM response may then be cached client side and/or server side. In at least some of these implementations, operation of the selectable element may cause the cached new LLM response (or content derived therefrom) to be presented to the user. Caching the new LLM response (or content derived therefrom) in this manner may reduce or eliminate latency that the user might otherwise experience if the new LLM response is not generated until the selectable element is operated.

[0009] In some implementations, a selectable element may include a textual summary of and/or brief textual statement describing the recommended alteration that would be implemented/surfaced should the user operate the selectable element. For instance, suppose the original modifiable content is a user-composed or LLM-generated project proposal. Suppose further that the project proposal lacks any discussion of risk(s) associated with implementing the project, and that the underlying LLM has been trained using at least some project proposals that do discuss risks (in which case the LLM “expects” to see risk discussion in project proposals). In such a scenario, a selectable element may be generated that includes a recommended alteration such as “Discussion of risk appears to be missing; would you like to add it?”, or “I don't see any discussion of risk. Would you like to see some examples of what your proposal would look like with risk discussion added?” In some implementations, the textual summary may be generated by the LLM based on a longer version of the recommended alteration (e.g., a whole LLM-generated paragraph describing potential risk(s)), e.g., by requesting the LLM summarize the longer version of the recommended alteration.

[0010] The recommended alterations generated using the LLM may vary depending on various factors, such as the nature and/or modalit(ies) of the modifiable content, contextual information that is available for inclusion in the LLM input prompt, data used to pretrain and/or fine-tune the LLM, and so forth. As one non-limiting example, suppose the modifiable content processed using the LLM is a resume that includes some number of positions filled by a user over a span of time (e.g., since graduating college). Suppose further that the timeline formed by the positions is incomplete because the resume fails to account for some intermediate time interval (i.e. there is a gap in the resume).

[0011] In various implementations, when the resume (which may be user-composed or LLM-generated) is processed using the LLM along with the request to generate recommended alteration(s), the LLM response may be operable to cause a selectable element to be rendered to the user that recommends “filling the gap in the resume's timeline.” If the user operates the selectable element, the user's resume may be generated once again, except a placeholder may be incorporated into the resume by the LLM, e.g., in a position that corresponds to the gap in the user's employment timeline. The user may then have the option of manually editing the placeholder to add a job description. Alternatively, if contextual data of the user is available for processing using the LLM, then this contextual data may be mined, e.g., to determine what the user's position was during the timeline gap and automatically generate and incorporate a description of that position into the modified resume.

[0012] In some implementations, a method may be implemented using one or more processors and may include: processing a large language model (LLM) prompt using an LLM to generate a first LLM response; providing the LLM response to a client application, wherein the first LLM response

is operable by the client application to cause first content derived from the first LLM response to be rendered at one or more output devices; assembling, as a second LLM prompt, at least a portion of the first LLM response with data indicative of a request to generate one or more recommended alterations to the portion of the first LLM response; processing the second LLM prompt using the LLM to generate a second LLM response; and providing at least a portion of the second LLM response to the client application, wherein the portion of the second LLM response is operable by the client application to cause one or more selectable elements to be rendered at one or more of the output devices, wherein each of the one or more selectable elements: identifies a respective one of the recommended alterations, and is operable to cause corresponding modified content to be rendered at one or more of the output devices, wherein the modified content includes at least some of the first content modified based on the respective one of the recommended alterations.

[0013] In various implementations, the method may include: receiving, from the client application, an indication that one or more of the selectable elements was operated; and in response to the receiving, providing a remainder of the second LLM response to the client application, wherein the modified content corresponding to the operated selectable element is derived from the remainder of the second LLM response.

[0014] In various implementations, the method may include: receiving, from the client application, an indication that one or more of the selectable elements was operated; and in response to the receiving: assembling, as a third LLM prompt, at least a portion of the first LLM response and data indicative of the recommended alteration identified by the given selectable element, processing the third LLM prompt using the LLM to generate a third LLM response, and providing at least a portion of the third LLM response to the client application, wherein the portion of the third LLM response is operable by the client application to cause the modified content to be rendered at one or more of the output devices.

[0015] In various implementations, the method may include: receiving, from the client application, an indication of a subportion of the first content that has been selected using one or more input devices; and extracting, as the portion of the first LLM response that is assembled into the second LLM prompt, a subportion of the first LLM response that corresponds to the selected subportion of the first content.

[0016] In various implementations, the portion of the second LLM response provided to the client application may include the entire second LLM response. In various implementations, at least the portion of the second LLM response may be operable by the client application to locally cache one or more instances of modified content corresponding to one or more of the selectable elements.

[0017] In various implementations, a given selectable element of the one or more selectable elements may include a textual summary of the modified content that is rendered in response to operation of the given selectable element. In various implementations, the first LLM response may include one or more time descriptions forming an incomplete timeline, and one or more of the recommended alterations includes an additional time description to fill a gap in the incomplete timeline.

[0018] In various implementations, the method may include: formulating a search query based on one or more details of the first LLM response; and retrieving, from a search engine, one or more documents that are responsive to the search query; wherein a given selectable element of the one or more selectable elements is operable to cause additional content from the one or more documents that are responsive to the search query to be included in the second LLM prompt.

[0019] In another aspect, a method may be implemented using one or more processors and may include: receiving, from a user via a client application, a user-composed content; assembling, as a first large language model (LLM) prompt, data indicative of the user-composed content and data indicative of a request to generate one or more recommended alterations to the user-composed content; processing the first LLM prompt using an LLM to generate a first LLM response; and providing at least a portion of the first LLM response to the client application, wherein the portion

of the first LLM response is operable by the client application to cause one or more selectable elements to be rendered at one or more output devices, wherein each of the one or more selectable elements: identifies a respective one of the recommended alterations, and is operable to cause corresponding modified content to be rendered at one or more of the output devices, wherein the modified content includes at least some of the user-composed content modified based on the respective one of the recommended alterations.

[0020] In addition, some implementations include one or more processors of one or more computing devices, where the one or more processors are operable to execute instructions stored in associated memory, and where the instructions are configured to cause performance of any of the aforementioned methods. Some implementations also include one or more non-transitory computer readable storage media storing computer instructions executable by one or more processors to perform any of the aforementioned methods. It should be appreciated that all combinations of the foregoing concepts and additional concepts described in greater detail herein are contemplated as being part of the subject matter disclosed herein. For example, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the subject matter disclosed herein.

Description

DESCRIPTION OF THE DRAWINGS

[0021] FIG. 1 schematically depicts an example environment in which selected aspects of the present disclosure may be implemented.

[0022] FIG. 2A and FIG. 2B schematically depict an example of how various components of FIG. 1 may cooperate to carry out selected aspects of the present disclosure.

[0023] FIG. 3A and FIG. 3B depict an example scenario in which selected aspects of the present disclosure are implemented.

[0024] FIG. 4A and FIG. 4B depict another example scenario in which selected aspects of the present disclosure are implemented.

[0025] FIG. 5 depicts an example method for carrying out selected aspects of the present disclosure.

[0026] FIG. 6 schematically depicts an example computer architecture that can be configured to carry out selected aspects of the present disclosure.

DETAILED DESCRIPTION

[0027] Turning now to FIG. 1, a block diagram of an example environment **100** that demonstrates various aspects of the present disclosure, and in which implementations disclosed herein can be implemented is depicted. The example environment **100** includes a client device **110**, a natural language (NL) based response system **120**, and search system(s) **140**. Although illustrated separately, in some implementations all or aspects of NL based response system **120** and all or aspects of search system(s) **140** can be implemented as part of a cohesive system.

[0028] In some implementations, all or aspects of the NL based response system **120** can be implemented locally at the client device **110**. In additional or alternative implementations, all or aspects of the NL based response system **120** can be implemented remotely from the client device **110** as depicted in FIG. 1 (e.g., at remote server(s)). In those implementations, the client device **110** and the NL based response system **120** can be communicatively coupled with each other via one or more networks **199**, such as one or more wired or wireless local area networks (“LANs,” including Wi-Fi LANs, mesh networks, Bluetooth, near-field communication, etc.) or wide area networks (“WANs,” including the Internet).

[0029] The client device **110** can be, for example, one or more of: a desktop computer, a laptop computer, a tablet, a mobile phone, a computing device of a vehicle (e.g., an in-vehicle

communications system, an in-vehicle entertainment system, an in-vehicle navigation system), a standalone interactive speaker (optionally having a display), a smart appliance such as a smart television, and/or a wearable apparatus of the user that includes a computing device (e.g., a watch of the user having a computing device, glasses of the user having a computing device, a virtual or augmented reality computing device). Additional and/or alternative client devices may be provided. [0030] The client device **110** can execute one or more applications, such as application **115**, via which queries can be submitted and/or NL based summaries and/or other response(s) to the query can be rendered (e.g., audibly and/or visually). The application **115** can be an application that is separate from an operating system of the client device **110** (e.g., one installed “on top” of the operating system)—or can alternatively be implemented directly by the operating system of the client device **110**. For example, the application **115** can be a web browser installed on top of the operating system, or can be an application that is integrated as part of the operating system functionality. The application **115** can interact with the NL based response system **120**.

[0031] In various implementations, the client device **110** can include a user input engine **111** that is configured to detect user input provided by a user of the client device **110** using one or more user interface input devices. For example, the client device **110** can be equipped with one or more microphones that capture audio data, such as audio data corresponding to spoken utterances of the user or other sounds in an environment of the client device **110**. Additionally, or alternatively, the client device **110** can be equipped with one or more vision components that are configured to capture vision data corresponding to images and/or movements (e.g., gestures) detected in a field of view of one or more of the vision components. Additionally, or alternatively, the client device **110** can be equipped with one or more touch sensitive components (e.g., a keyboard and mouse, a stylus, a touch screen, a touch panel, one or more hardware buttons, etc.) that are configured to capture signal(s) corresponding to touch input directed to the client device **110**. Some instances of a query or request described herein can be a query or request that is formulated based on user input provided by a user of the client device **110** and detected via user input engine **111**. For example, the query or request can be a typed query or request that is typed via a physical or virtual keyboard, a suggested query or request that is selected via a touch screen or a mouse, a spoken voice query or request that is detected via microphone(s) of the client device, or an image query or request that is based on an image captured by a vision component of the client device.

[0032] In various implementations, the client device **110** can include a rendering engine **112** that is configured to provide content (e.g., an NL based summary, creative LLM output, chat output, etc.) for audible and/or visual presentation to a user of the client device **110** using one or more user interface output devices. For example, the client device **110** can be equipped with one or more speakers that enable content to be provided for audible presentation to the user via the client device **110**. Additionally, or alternatively, the client device **110** can be equipped with a display or projector that enables content to be provided for visual presentation to the user via the client device **110**. In some implementations, the display may be part of a head-mounted display (HMD).

[0033] In some implementations, rendering engine **112** may be configured to generate rendered content based on raw LLM responses. For example, an LLM response may include a sequence of tokens that is operable by rendering engine **112** to render audible and/or visual output. In some implementations, this sequence of tokens may include a sequence of raw text. Some parts of the sequence of raw text may include meaningful content that is responsive to a user's query or request. Other parts of the sequence of text may include metadata instructions (e.g., symbols) that are usable, e.g., by rendering engine **112** (or by UX engine **136**, described below), to cause the meaningful content to be rendered in a particular way (e.g., with selected fonts, line breaks, images, formatting, etc.). In some implementations, rendering engine **112** may also be configured to create a mapping between raw LLM responses and the downstream rendered content that is generated based on the raw LLM responses. For instance, when incorporating raw LLM content into hypertext markup language (HTML) or extensible markup language (XML) DOM nodes, rendering

engine **112** may add attributes (e.g., character offsets) to HTML tags that identify where in the underlying raw LLM response the content that is going to be displayed using the DOM node is located.

[0034] In various implementations, the client device **110** can include a context engine **113** that is configured to determine a context (e.g., current or recent context) of the client device **110** and/or of a user of the client device **110**. In a multi-turn dialog session between the user and an automated assistant (alternatively, “virtual assistant”, “chatbot”, etc.), the context of the client device and/or user may be maintained over multiple turns as a “user state.”

[0035] In some implementations, the context engine **113** can determine a context and/or update the user's state utilizing current or recent interaction(s) via the client device **110**, a location of the client device **110**, profile data of a profile of a user of the client device **110** (e.g., an active user when multiple profiles are associated with the client device **110**), and/or other data accessible to the context engine **113**. For example, the context engine **113** can determine a current context based on a one or more recent queries of the search session, profile data, and/or a current location of the client device **110**. For instance, the context engine **113** can determine a current context of “looking for a healthy lunch restaurant in Louisville, Kentucky” based on a recently issued query or request, profile data, and a location of the client device **110**.

[0036] As another example, the context engine **113** can determine a current context based on which application is active in the foreground of the client device **110**, a current or recent state of the active application, and/or content currently or recently rendered by the active application. A context determined by the context engine **113** can be utilized, for example, in supplementing or rewriting a query or request that is formulated based on user input, in generating an implied query or request (e.g., a query or request formulated independent of user input), and/or in determining to submit an implied query/request and/or to render result(s) for an implied query/request. And the user's context across multiple turns of a search session can be used as a user state to enrich output rendered, e.g., by a search chatbot companion, at each turn of a multi-turn human-to-computer dialog session.

[0037] In various implementations, client device **110** can include a selection mapping engine **114** that is configured to map user-selected subportion(s) of rendered LLM output provided by rendering engine **112** to corresponding subportion(s) of raw LLM responses that were used to generate the rendered LLM output. In some implementations, selection mapping engine **114** may utilize the HTML attributes (e.g., character offsets) mentioned previously to map user-selected subportion(s) of rendered LLM output provided by rendering engine **112** to corresponding subportion(s) of raw LLM responses.

[0038] In various implementations, selection mapping engine **114** may provide data indicative of this mapping, such as starting and ending characters indexes in the raw LLM response, to other components to extract the corresponding portion of the raw LLM response. In some cases, selection mapping engine **114** may provide data indicative of the mapping to a component of NL based response system **120**, such as selection extraction engine **130**, and selection extraction engine **130** may extract the corresponding portion of the raw LLM response. In other cases, selection mapping engine **114** may use the mapping data directly to extract the corresponding portion of the raw LLM response, and provide that extracted portion to a component of NL based response system **120**, such as LLM input engine **126** (discussed in more detail below).

[0039] Further, the client device **110**, the NL based response system **120**, and/or the search system **140** can include one or more memories for storage of data and/or software applications, one or more processors for accessing data and executing the software applications, and/or other components that facilitate communication over one or more of the networks **199**. In some implementations, one or more of the software applications can be installed locally at the client device **110**, whereas in other implementations one or more of the software applications can be hosted remotely (e.g., by one or more servers) and can be accessible by the client device **110** over one or more of the networks **199**.

[0040] Although aspects of FIG. 1 are illustrated or described with respect to a single client device having a single user, it should be understood that is for the sake of example and is not meant to be limiting. For example, one or more additional client devices of a user and/or of additional user(s) can also implement the techniques described herein. For instance, the client device **110**, the one or more additional client devices, and/or any other computing devices of a user can form a coordinated ecosystem of devices that can employ techniques described herein. These additional client devices and/or computing devices may be in communication with the client device **110** (e.g., over the network(s) **199**). As another example, a given client device can be utilized by multiple users in a shared setting (e.g., a group of users, a household).

[0041] NL based response system **120** is illustrated as including a search result document (SRD) selection engine **122**, an LLM selection engine **124**, an LLM input engine **126**, an LLM response generation engine **128**, a selection extraction engine **130**, and a user interface (UX) engine **136**. Some of the engines can be omitted and/or combined in various implementations.

[0042] The SRD selection engine **122** may be configured to generate, using an LLM and search result documents that are responsive to a query, information that may not be readily generated using the LLM alone, such as an NL based summary response to a query, or information derived from documents that are more recent than the last instance in which the LLM was trained or fine-tuned. SRD selection engine **122** may also cause the NL based summary to be rendered in response to the query.

[0043] The LLM selection engine **124** can, for example, select zero or more generative models from multiple candidate LLMs. For example, in some iterations the system will determine to not utilize any of the candidate generative models, in some iterations the system will determine to utilize only one of the candidate generative models, and in some iterations the system will determine to utilize multiple of the candidate generative models. LLM selection engine **124** can optionally utilize one or more rules and/or one or more classifiers **125** that are trained to generate output identifying which LLMs are best suited to generate a response to a current query or request, given a current user state/context.

[0044] The LLM input engine **126** may be configured to assemble LLM input prompts based on data such as a current query, current user state/context, past queries, past LLM responses (which may be included in the current user state/context), portions of past rendered LLM outputs that are selected by users for modification, search result documents, etc. LLM input prompts may, in some implementations, include a sequence of tokens, which may be words, phrases, numbers, and/or embeddings generated from data such as text, images, audio, etc.

[0045] The LLM response generation engine **128** may be configured to apply one or more LLMs stored in an LLM database **129** to LLM input prompts generated by LLM input engine **126** to generate an LLM response. An LLM response may take various forms, such as a sequence of tokens that correspond to, represent, or directly convey words, phrases, embeddings, etc. LLMs (or more generally, generative models) stored in LLM database **129** may take a variety of forms, such as PaLM, BERT, LaMDA, Meena, Genesis and/or any other LLM, such as any other LLM that is encoder-only based, decoder-only based, sequence-to-sequence based and that optionally includes an attention mechanism or other memory. Visual language models (VLMs) capable of processing images and text may be included as well.

[0046] In various implementations, LLM input engine **126** may be configured to assemble an LLM input prompt with a separate (e.g., implicit) request to generate recommended (or proposed) alteration(s) to the modifiable content. Also, the original modifiable content may be assembled by LLM input engine **126** into a new input prompt that is processed using the LLM to generate a new LLM response in which the modifiable content has been updated based on (e.g., incorporates) the recommended alteration.

[0047] Selection extraction engine **130** may be configured to extract subportions of raw LLM responses that correspond with selected subportions of rendered LLM output provided at client

device **110** by rendering engine **112** based on the raw LLM responses. As noted previously, in some implementations, selection extraction engine **130** may extract these portions of raw LLM responses based on mapping data received from selection mapping engine **114**. For example, selection mapping engine **114** may provide starting and/or ending character positions, and selection extraction engine **130** may extract the subportion of the raw LLM response that begins at the starting character position and ends at the ending character position.

[0048] In some implementations, LLM input engine **126** and/or LLM response generation engine **128** may cooperate to provide recommended alterations to various types of content, such as LLM-generated content and/or user-composed content. In various implementations, modifiable content may be assembled, e.g., by LLM input engine **126**, into an LLM input prompt with a separate (e.g., implicit) request to generate recommended (or proposed) alteration(s) to the modifiable content. The request to recommend alteration(s) may take various forms. In some implementations, the request may be a natural language request, such as “what is <modifiable content> missing?” (which may cause the LLM to output data indicative of information that the LLM is trained to typically encounter in similar content but is missing from the modifiable content). In other implementations, the request may be in the form of predesignated token(s) or symbol(s) that the LLM has been pre-trained and/or fine-tuned to recognize as a request to generate recommended alteration(s).

[0049] LLM response generation engine **128** may be configured to process this LLM input prompt (which includes the separate request) using one or more LLMs **129** to generate LLM output. The LLM output may include, among other things, data that is operable, e.g., by client device **110**, to render one or more selectable elements. Each selectable element may identify a different recommended alteration and may be operable to cause corresponding modified content to be rendered at one or more of the output devices. The modified content may include at least some of the original modifiable content (e.g., LLM rendered output or user-composed output) modified based on the recommended alteration corresponding to the actuated selectable element.

[0050] In some implementations, UX engine **136** may be configured to provide client device **110** with raw LLM responses (e.g., sequences of tokens intermixed with metadata instructions), which may be operable by rendering engine **112** to provide rendered LLM output. Additionally or alternatively, in some implementations, UX engine **136** may generate content that can be rendered more directly, such as HTML code that includes the raw LLM response and that can be rendered by rendering engine **112** or application **115**, e.g., as a webpage.

[0051] Search system **140** is illustrated as including an SRD engine **142** and a results engine **144**. Some of the engines can be omitted or combined with each other in various implementations. The SRD engine **142** can, for example, utilize indices **143** and/or other resources in identifying search result documents that are responsive to queries or requests as described herein. For example, SRD engine **142** can use queries or requests formulated by component(s) of NL based response system **120** to identify search result documents or other content that can be used for recommending alterations to rendered LLM output. For example, a user may be presented with a selectable element that suggests incorporating the most recent data pertaining to a particular topic—which may not yet be trained or fine-tuned into the LLM—into the LLM response. The results engine **144** can provide non-LLM generated search results that can be harvested for update-to-date content that may be assembled by LLM input engine **126** into a new LLM input prompt. LLM response generation engine **128** may then process this new LLM input prompt using an LLM **129** to generate modified LLM responses that are conditioned on content that has been generated more recently than the LLM was last trained or fine-tuned.

[0052] In some implementations, when a user issues a request for information about a particular topic, one or more components of NL based response system **120** and/or search system **140** may formulate a search query based on the topic. Search system **140** may then retrieve one or more documents that are responsive to the search query, and that contain data that post-dates the latest LLM training or fine-tuning. Data from the one or more documents that are responsive to the

search query may be incorporated, e.g., by LLM input engine **126**, into a subsequent LLM input prompt that is used to generate a modified version of the previously rendered LLM output.

[0053] FIG. **2** schematically depicts an example of how various components depicted in FIG. **1** may cooperate to carry out selected aspects of the present disclosure. As indicated at top, in some implementations, the components on the left side of the vertical dashed line may be part of NL based response system **120**. Components on the right side of the vertical dashed line may be part of client device **110**. In other implementations, various components may be implemented elsewhere. [0054] Starting at top right, a first request **250A** may be received at user input engine **111**, which in turn provides data indicative of the first request **250A** (e.g., the request itself, embedding(s) generated therefrom, etc.) to LLM input engine **126** of NL based response system **120**. First request **250A** may be typed, may be transcribed using automatic speech recognition (ASR) on a spoken utterance, or may even be an implied query. Whichever the case, data indicative of first request **250A** may be assembled by LLM input engine **126** into an LLM prompt (not depicted) that is then processed by LLM response generation engine **128** using one or more LLMs from database **129** to generate a first raw LLM response **252A**.

[0055] As noted previously, first raw LLM response **252A** may include a sequence of tokens, such as a sequence of raw text that includes both content responsive to the request and metadata instructions interspersed therein. First raw LLM response **252A** may be provided by UX engine **136** to rendering engine of client device **110**. Rendering engine **112** may provide, e.g., a display and/or speakers, first rendered LLM output **254A** (alternative referred to as “first content”), which may include various modalities of output, such as audible, images, text, etc.

[0056] Once rendered at client device **110**, in some cases, the user may select, e.g., via user input engine **111**, a portion **256A** of the first rendered LLM output **254A**. In various implementations, the selected portion **256A** may be provided to selection mapping engine **114**, which may in turn provide, to selection extraction engine **130** of NL based response system **120**, data indicative of a mapping (e.g., starting and ending character positions) between the selected subportion **256A** of the first rendered LLM output **254A** and a corresponding subportion of first raw LLM response **252A**. Selection extraction engine **130** may then use the mapping to extract a corresponding selected subportion **258** of the raw LLM response **252A**. e.g. In other implementations, rather than a user selecting just a portion **256A** of the first rendered LLM output **254A**, the entire first rendered LLM output **254A**/first LLM response **252A** may be processed as described below.

[0057] In various implementations, the selected subportion **258** of the raw LLM response **252A** (or the entire first LLM response **252A** if the user did not select a subportion) may be assembled by LLM input engine **126** into a new input prompt, along with an (implicit) request to generate recommended (or proposed) alteration(s) to the first rendered LLM output **254A** or selected portion **256A** thereof. As shown in FIG. **2A**, in some implementations, this new input prompt may be assembled in response to a user explicitly opting to generate suggestions. For example, the user may select a button that says, “Click to generate suggestions,” or something to that effect. In other implementations, the new input prompt may be generated automatically, without explicit user input.

[0058] LLM input engine **126** may then provide the new LLM input prompt to LLM response generation engine **128**. LLM response generation engine **128** may process this new input prompt using LLM(s) **129** to generate a second LLM response **252B**. In various implementations, second LLM response **252B** may include data **261** that is indicative of one or more selectable elements. For example, data **261** may include one or more uniform resource locators (URLs) or other markup language content that, when rendered at client device **110**, is operable by a user to trigger incorporation of suggested alteration(s) of the original rendered LLM output **254A**.

[0059] Second LLM response **252B** may be provided by UX engine **136** to rendering engine **112** of client device **110**. Rendering engine **112** may then present second rendered LLM output **254B** that includes, at reference number **263**, the previously mentioned one or more selectable elements. In

some implementations, textual snippet(s) summarizing the respective suggested alterations may be rendered so that the user can discern how the original LLM response will be updated if the user chooses to operate one or more of the selectable elements. Suppose the original LLM response was an auto-generated resume (or curriculum vitae, “CV”) for the user (generated using context data of the user, such as their profile data, previous resumes stored on the cloud, etc.). One selectable element may include a textual snippet that says, “Add a position for February 2021 to June 2023” (assuming there was a gap detected in the resume). Another selectable element might be “Add a description of your hobbies, such as paragliding or fly fishing,” assuming those hobbies are derivable from the user's profile or other contextual data.

[0060] Referring now to FIG. 2B, in some implementations, when user input engine **111** detects that a selectable element has been operated by the user, the recommended alteration **265** that corresponds to the operated selectable element, and the original modifiable content (**258** in FIGS. 2A-B, but could be any of **254A**, **256A**) may be assembled by LLM input engine **126** into a new input prompt. The new input prompt may be processed by LLM response generation engine **128** using the LLM **129** to generate a third LLM response **252C**. In the third LLM response **252C**, the modifiable content **258** (or **254A** for instance) has been updated based on (e.g., incorporates) the recommended alteration **265**. As before, third LLM response **252C** may then be passed by UX engine **136** back to rendering engine **112**. Rendering engine **112** may then provide third rendered LLM output **254C** that includes the original modifiable content, modified based on the user's selection of the suggested alteration.

[0061] In FIGS. 2A-B, the user selected a subportion **256A** of the first rendered LLM output **254A** to generate suggested alterations. However, as noted above, this is not required. Suggested alterations can be generated for the entire first rendered LLM output **254A** as well. In addition, various operations may be performed slightly differently than depicted in FIGS. 2A-B without departing from the present disclosure. For instance, in some implementations, rather than the user explicitly opting to generate suggestions, the selectable elements may be generated automatically, e.g., while the user has an opportunity to read or otherwise consumes the first rendered LLM output **254A**. Once ready, those selectable elements may be presented as all or part of second rendered LLM output **254B** (e.g., at the reference number **263**).

[0062] In some implementations, the system may not wait until the user selects a selectable element in order to generate possible third LLM outputs (e.g., **252C**). In various implementations, the system may automatically generate these LLM outputs that include modified versions of the original LLM output, e.g., in the background while the user reads or otherwise consumes the first rendered LLM output **254A**. As a result, these modified versions can, in some implementations, be cached at system **120** and/or at client device **110**. If the user operates a selectable element corresponding to one of these cached modified versions, the cached modified version may be surfaced to the user more-or-less immediately, without requiring the user to wait for the LLM to be applied to the data (which, given the hundreds of billions of parameters or more that are common in LLMs, may take multiple seconds to process).

[0063] In some implementations, the fully modified versions of the first rendered LLM output **254A** may be generated automatically first, before selectable elements are generated. Instead of being generated beforehand, the selectable elements may be formulated based on the fully modified versions. For instance, if the first rendered LLM output **254A** is a project proposal that fails to address risk, then a fully modified version of that project proposal that discusses risk may be generated in the background, e.g., without the user requesting it. Once generated, the fully modified version of the project proposal may be processed, e.g., by LLM response generation engine **128** using one or more LLM **129**, to generate a brief summary of the modifications that were made. This brief summary may be incorporated into a selectable element that is presented to the user, to inform the user what changes would be made. As a result, when the user operates the selectable element, the fully modified version may be presented, e.g., by rendering engine **112**, more-or-less

instantaneously because it was already generated.

[0064] Due to LLMs often having hundreds of billions of parameters or more, generating fully modified versions of first rendered LLM output **254A** (or of portion **256A**) may be expensive in terms of computational resources, time, and/or energy expenditure. It may be beneficial to only proceed with generating fully modified versions of first rendered LLM output **254A** when circumstances warrant. Accordingly, in some implementations, fully modified versions of first rendered LLM output **254A** may or may not be selectively or conditionally generated based on factors such as current computational load of system **120**, network traffic, context length of the LLM selected by LLM selection engine **124**, user preferences, etc. As one example, if the current computational load of system **120** falls below some threshold(s), and/or if energy prices fall below some other threshold, modified versions of first rendered LLM response **254A** may be generated and/or cached automatically. However, if the current computational load of system **120** and/or energy costs exceed these thresholds, then modified versions of first rendered LLM output **254A** may not be generated until a user explicitly requests them.

[0065] FIG. **3A** depicts an example client device **310** in the form of a tablet computer that is being used to engage with NL based response system **120**. Client device **310** includes a display **370** on which a query input field **372** is rendered. A user (not depicted) has entered, into query input field **372** (by typing or having a spoken utterance speech recognized), the request, “List the best investment options for 2024.” A rendered LLM output **354A** (or “first content”) that may share various characteristics with rendered LLM output **254A** in FIG. **2** is generated and rendered on display **370**, e.g., by rendering engine **112**, based on a raw LLM response (not depicted, e.g., **252A** in FIG. **2**) that was generated by LLM response generation engine **128**. Also rendered on display **370** are a thumbs up and down that are operable by the user to provide positive or negative feedback, respectively, about rendered LLM output **354A**.

[0066] Further, a selectable element **376** is rendered to be operable to generate recommended alterations to the rendered LLM output **354A**. In some implementations, operating this selectable element **376** may be similar to FIG. **2A** where the user opted to generate suggestion(s). In other implementations, operation of element **376** may not be necessary (e.g., suggested alterations may be generated in the background regardless of whether the user opts in) and selectable element **376** itself may be omitted.

[0067] The operation of selectable element **376** may cause a pop-up **378** to be rendered on display **370**. Pop-up **378** may include, as second rendered LLM output **354B** (sharing characteristics with **254B**), one or more selectable elements, each selectable element corresponding to a different suggested alteration. The user may operate one of the selectable elements of second rendered LLM output **354B**, e.g., “Give more information about the investment options,” to modify LLM output **354A**. When this particular selectable element is operated, in some implementations, the corresponding recommended alteration and rendered LLM output **354A** may be assembled into a second input prompt that is processed using the LLM to generate a new LLM response in which first rendered LLM output **354A** has been updated based on (e.g., incorporates) the recommended alteration. In other implementations, this second input prompt may have already been generated and used in the background to generate a modified version of the first rendered LLM output **354A**.

[0068] FIG. **3B** depicts a result of when the user operates the selectable element of FIG. **3A**. The first rendered LLM output **354A** is still present, but has been modified to incorporate (shown in bolded lettering for illustrative purposes) the suggested alteration corresponding to the operated selectable element of second rendered LLM output **354B** to yield third rendered LLM output **354C**, which may share various characteristics with **254C** in FIG. **2B**. It can be seen in FIG. **3B** that the first rendered LLM output **354A** has been modified into third rendered LLM output **354C** in which additional details are provided for each of the investment options.

[0069] FIG. **4A** shows another example in which the user has entered, into query input field **372** (by typing or having a spoken utterance speech recognized), the request, “Summarize the ongoing

NBA season.” A first rendered LLM output **454A** that may share various characteristics with first rendered LLM output **254A** in FIG. 2 is generated and rendered on display **370**, e.g., by rendering engine **112**, based on a raw LLM response (not depicted, e.g., **252A** in FIG. 2) that was generated by LLM response generation engine **128**. First rendered LLM output **454A** may include a succinct summary of the current National Basketball Association (NBA) season. However, as explained herein, LLMs (and more generally, large generative models) may only be trained and/or fine-tuned periodically, e.g., at night or during downtime. Consequently, these models may not necessarily have the latest information about current events. Accordingly, FIGS. 4A-B demonstrate how search system **140** may be leveraged to condition LLM output based on recent data that post-dates the most recent training or fine-tuning of the LLM.

[0070] Once again, first rendered LLM output **454A** may be processed by LLM response generation engine **128** using LLM(s) **129** to generate pop up **478** that contains second rendered LLM output **454B**. Second rendered LLM output **454B** may include one or more selectable elements. In this example, the selectable elements give the user the options of (i) adding a description of the top three players in the league, (ii) updating the description to include last week's games, and (iii) update the description to mention the lowest performing teams in the league.

[0071] FIG. 4B depicts the result of the user operating the selectable element that updates the description to include last week's games. In this example, search system **140** may retrieve documents and/or information that describe events of the last week in the NBA season. LLM input engine **126** may incorporate this data (e.g., token embeddings, article summaries, etc.) into an input prompt that is processed by LLM response generation engine **128** using LLM(s) to generate third rendered LLM output **454C**. Third rendered LLM output **454C** includes first rendered LLM output **456A**, modified based on (e.g., to incorporate) the recommended alteration. For example, the third rendered LLM output **454C** mentions the “young stars” winning an “in-season” tournament—information that may be more recent than the most recent instance in which the LLM was fine-tuned.

[0072] Turning now to FIG. 5, a flowchart is depicted that illustrates an example method **500** of implementing selected aspects of the present disclosure. For convenience, the operations of the method **500** are described with reference to a system that performs the operations. This system of the method **500** includes one or more processors, memory, and/or other component(s) of computing device(s). Moreover, while operations of the method **500** are shown in a particular order, this is not meant to be limiting. One or more operations may be reordered, omitted, and/or added.

[0073] At block **502**, the system may receive a query or request. For example, a user may speak or type a natural language request that is processed by user input engine **111** and provided to UX engine **136** and/or LLM input engine **126**. At block **504**, the system, e.g., by way of LLM input engine **126**, may assemble a first LLM prompt based on the query.

[0074] At block **506**, the system, e.g., by way of LLM response generation engine **128**, may process the first LLM prompt using an LLM (e.g., **129**) to generate a first (raw) LLM response (e.g., **252A** in FIG. 2). As noted elsewhere herein, first LLM response (and other “raw” LLM responses described herein) may include a sequence of tokens, such as a sequence of raw text intermixed with metadata instructions in some cases. Metadata instructions may include formatting instructions (e.g., identified fonts, line breaks, indents, spacing, etc.), as well as instructions for rendering other modalities of data, such as images, videos, audio, graphics, etc.

[0075] At block **508**, the system, e.g., by way of UX engine **136**, may provide the first LLM response to a client application, such as application **115**, rendering engine **112**, etc. In various implementations, the first LLM response may be operable by the client application to cause first content derived (e.g., **254A** in FIG. 2) from the first LLM response to be rendered at one or more output devices. For instance, rendering engine **112** may be configured to process the first LLM response to generate a HTML document object model (DOM) hierarchy that causes the relevant content contained in the first LLM response to be rendered or “surfaced”, e.g., by application **115**,

in a useful way.

[0076] At block **510**, the system, e.g., by way of LLM input engine **126**, may assemble at least a portion of first LLM response **252A** with data indicative of a (implicit) request to generate one or more recommended alterations to the portion of first LLM response, as a second LLM prompt. Note that in other implementations, a user may use techniques described herein to make suggested alterations to content they compose, in addition to or instead of LLM-composed content. In such implementations, blocks **502-508** may be omitted, and method **500** may begin at block **510**. Instead of assembling the second LLM input prompt with at least a portion of the first LLM response, LLM input engine **126** may assemble a first LLM input prompt that includes the user-composed content, plus the (implicit) request to generate one or more recommended alterations to the user-composed content (or selected portion thereof).

[0077] At block **512**, the system, e.g., by way of LLM response generation engine **128**, may process the second LLM prompt using the same LLM (e.g., **129**) or a different LLM to generate a second LLM response (e.g., **252B** in FIG. 2). At block **514**, the system, e.g., by way of UX engine **136**, may provide the second LLM response (e.g., **252B**) to the client application **115**. In various implementations, the second LLM response may be operable by the client application to cause selectable elements to be rendered, e.g., as part of second rendered LLM output **254B/354B/454B**, that may include at least a part of the first rendered LLM output (e.g., **254A/354A/454A**) and the modified version (e.g., **256B**) of the first rendered LLM output (e.g., **254A**) with the recommended alterations.

[0078] At block **516**, the system, e.g., by way of UX engine **136**, may receive an indication that a given selectable element has been operated by the user. At block **518**, a third LLM prompt is assembled from at least a portion of first LLM response **252A** with data indicative of the recommended alteration corresponding to the operated selectable element. At block **520**, the system, e.g., by way of LLM response generation engine **128**, may process the third LLM prompt using the same LLM (e.g., **129**) or a different LLM to generate a third LLM response (e.g., **252C**). At block **522**, the system, e.g., by way of UX engine **136**, may provide the third LLM response (e.g., **252C**) to the client application **115**. In various implementations, the third LLM response may be operable by the client application **115** to provide modified content (e.g., **254C/354C/454C**) that may include at least a part of the first content (e.g., **254A**) modified based on the recommended alteration corresponding to the operated selectable element.

[0079] FIG. 6 is a block diagram of an example computer system **610**. Computer system **610** typically includes at least one processor **614** which communicates with a number of peripheral devices via bus subsystem **612**. These peripheral devices may include a storage subsystem **624**, including, for example, a memory subsystem **625** and a file storage subsystem **626**, user interface output devices **620**, user interface input devices **622**, and a network interface subsystem **616**. The input and output devices allow user interaction with computer system **610**. Network interface subsystem **616** provides an interface to outside networks and is coupled to corresponding interface devices in other computer systems.

[0080] User interface input devices **622** may include a keyboard, pointing devices such as a mouse, trackball, touchpad, or graphics tablet, a scanner, a touch screen incorporated into the display, audio input devices such as voice recognition systems, microphones, and/or other types of input devices. In general, use of the term “input device” is intended to include all possible types of devices and ways to input information into computer system **610** or onto a communication network.

[0081] User interface output devices **620** may include a display subsystem, a printer, a fax machine, or non-visual displays such as audio output devices. The display subsystem may include a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), a projection device, or some other mechanism for creating a visible image. The display subsystem may also provide non-visual display such as via audio output devices. In general, use of the term “output device” is intended to include all possible types of devices and ways to output information from

computer system **610** to the user or to another machine or computer system.

[0082] Storage subsystem **624** stores programming and data constructs that provide the functionality of some or all of the modules described herein. For example, the storage subsystem **624** may include the logic to perform selected aspects of method **500**, and/or to implement one or more aspects of systems **120** and/or **140**. Memory **625** used in the storage subsystem **624** can include a number of memories including a main random-access memory (RAM) **630** for storage of instructions and data during program execution and a read only memory (ROM) **632** in which fixed instructions are stored. A file storage subsystem **626** can provide persistent storage for program and data files, and may include a hard disk drive, a CD-ROM drive, an optical drive, or removable media cartridges. Modules implementing the functionality of certain implementations may be stored by file storage subsystem **626** in the storage subsystem **624**, or in other machines accessible by the processor(s) **614**.

[0083] Bus subsystem **612** provides a mechanism for letting the various components and subsystems of computer system **610** communicate with each other as intended. Although bus subsystem **612** is shown schematically as a single bus, alternative implementations of the bus subsystem may use multiple buses.

[0084] Computer system **610** can be of varying types including a workstation, server, computing cluster, blade server, server farm, smart phone, smart watch, smart glasses, set top box, tablet computer, laptop, or any other data processing system or computing device. Due to the ever-changing nature of computers and networks, the description of computer system **610** depicted in FIG. **6** is intended only as a specific example for purposes of illustrating some implementations. Many other configurations of computer system **610** are possible having more or fewer components than the computer system depicted in FIG. **6**.

[0085] While several implementations have been described and illustrated herein, a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein may be utilized, and each of such variations and/or modifications is deemed to be within the scope of the implementations described herein. More generally, all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific implementations described herein. It is, therefore, to be understood that the foregoing implementations are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, implementations may be practiced otherwise than as specifically described and claimed. Implementations of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the scope of the present disclosure.

Claims

1. A method implemented using one or more processors, comprising: processing a large language model (LLM) prompt using an LLM to generate a first LLM response; providing the first LLM response to a client application, wherein the first LLM response is operable by the client application to cause first content derived from the first LLM response to be rendered at one or more output devices; assembling, as a second LLM prompt, at least a portion of the first LLM response with data indicative of a request to generate one or more recommended alterations to the portion of the first LLM response; processing the second LLM prompt using the LLM to generate a second LLM response; and providing at least a portion of the second LLM response to the client

application, wherein the portion of the second LLM response is operable by the client application to cause one or more selectable elements to be rendered at one or more of the output devices, wherein each of the one or more selectable elements: identifies a respective one of the recommended alterations, and is operable to cause corresponding modified content to be rendered at one or more of the output devices, wherein the modified content includes at least some of the first content modified based on the respective one of the recommended alterations.

2. The method of claim 1, further comprising: receiving, from the client application, an indication that one or more of the selectable elements was operated; and in response to the receiving, providing a remainder of the second LLM response to the client application, wherein the modified content corresponding to the operated selectable element is derived from the remainder of the second LLM response.

3. The method of claim 1, further comprising: receiving, from the client application, an indication that one or more of the selectable elements was operated; in response to the receiving: assembling, as a third LLM prompt, at least a portion of the first LLM response and data indicative of the recommended alteration identified by the operated selectable element, processing the third LLM prompt using the LLM to generate a third LLM response, and providing at least a portion of the third LLM response to the client application, wherein the portion of the third LLM response is operable by the client application to cause the modified content to be rendered at one or more of the output devices.

4. The method of claim 1, further comprising: receiving, from the client application, an indication of a subportion of the first content that has been selected using one or more input devices; and extracting, as the portion of the first LLM response that is assembled into the second LLM prompt, a subportion of the first LLM response that corresponds to the selected subportion of the first content.

5. The method of claim 1, wherein the portion of the second LLM response provided to the client application includes the entire second LLM response.

6. The method of claim 1, wherein at least the portion of the second LLM response is operable by the client application to locally cache one or more instances of modified content corresponding to one or more of the selectable elements.

7. The method of claim 1, wherein a given selectable element of the one or more selectable elements comprises a textual summary of the modified content that is rendered in response to operation of the given selectable element.

8. The method of claim 1, wherein the first LLM response comprises one or more time descriptions forming an incomplete timeline, and one or more of the recommended alterations includes an additional time description to fill a gap in the incomplete timeline.

9. The method of claim 1, further comprising: formulating a search query based on one or more details of the first LLM response; and retrieving, from a search engine, one or more documents that are responsive to the search query; wherein a given selectable element of the one or more selectable elements is operable to cause additional content from the one or more documents that are responsive to the search query to be included in the second LLM prompt.

10. A method implemented using one or more processors, comprising: receiving, from a user via a client application, a user-composed content; assembling, as a first large language model (LLM) prompt, data indicative of the user-composed content and data indicative of a request to generate one or more recommended alterations to the user-composed content; processing the first LLM prompt using an LLM to generate a first LLM response; and providing at least a portion of the first LLM response to the client application, wherein the portion of the first LLM response is operable by the client application to cause one or more selectable elements to be rendered at one or more output devices, wherein each of the one or more selectable elements: identifies a respective one of the recommended alterations, and is operable to cause corresponding modified content to be rendered at one or more of the output devices, wherein the modified content includes at least some

of the user-composed content modified based on the respective one of the recommended alterations.

11. The method of claim 10, further comprising: receiving, from the client application, an indication that one or more of the selectable elements was operated; and in response to the receiving, providing a remainder of the first LLM response to the client application, wherein the modified content corresponding to the operated selectable element is derived from the remainder of the first LLM response.

12. The method of claim 10, further comprising: receiving, from the client application, an indication that one or more of the selectable elements was operated; in response to the receiving: assembling, as a second LLM prompt, at least a portion of the user-composed content and data indicative of the recommended alteration identified by the operated selectable element, processing the second LLM prompt using the LLM to generate a second LLM response, and providing at least a portion of the second LLM response to the client application, wherein the portion of the second LLM response is operable by the client application to cause the modified content to be rendered at one or more of the output devices.

13. A system comprising one or more processors and memory storing instructions that, in response to execution by the one or more processors, cause the one or more processors to: process a large language model (LLM) prompt using an LLM to generate a first LLM response; provide the LLM response to a client application, wherein the first LLM response is operable by the client application to cause first content derived from the first LLM response to be rendered at one or more output devices; assemble, as a second LLM prompt, at least a portion of the first LLM response with data indicative of a request to generate one or more recommended alterations to the portion of the first LLM response; process the second LLM prompt using the LLM to generate a second LLM response; and provide at least a portion of the second LLM response to the client application, wherein the portion of the second LLM response is operable by the client application to cause one or more selectable elements to be rendered at one or more of the output devices, wherein each of the one or more selectable elements: identifies a respective one of the recommended alterations, and is operable to cause corresponding modified content to be rendered at one or more of the output devices, wherein the modified content includes at least some of the first content modified based on the respective one of the recommended alterations.

14. The system of claim 13, further comprising instructions to: receive, from the client application, an indication that one or more of the selectable elements was operated; and in response to the received indication, provide a remainder of the second LLM response to the client application, wherein the modified content corresponding to the operated selectable element is derived from the remainder of the second LLM response.

15. The system of claim 13, further comprising instructions to: receiving, from the client application, an indication that one or more of the selectable elements was operated; in response to the receiving: assembling, as a third LLM prompt, at least a portion of the first LLM response and data indicative of the recommended alteration identified by the operated selectable element, processing the third LLM prompt using the LLM to generate a third LLM response, and providing at least a portion of the third LLM response to the client application, wherein the portion of the third LLM response is operable by the client application to cause the modified content to be rendered at one or more of the output devices.

16. The system of claim 13, further comprising instructions to: receive, from the client application, an indication of a subportion of the first content that has been selected using one or more input devices; and extract, as the portion of the first LLM response that is assembled into the second LLM prompt, a subportion of the first LLM response that corresponds to the selected subportion of the first content.

17. The system of claim 13, wherein the portion of the second LLM response provided to the client application includes the entire second LLM response.

- 18.** The system of claim 13, wherein at least the portion of the second LLM response is operable by the client application to locally cache one or more instances of modified content corresponding to one or more of the selectable elements.
- 19.** The system of claim 13, wherein a given selectable element of the one or more selectable elements comprises a textual summary of the modified content that is rendered in response to operation of the given selectable element.
- 20.** The system of claim 13, wherein the first LLM response comprises one or more time descriptions forming an incomplete timeline, and one or more of the recommended alterations includes an additional time description to fill a gap in the incomplete timeline.
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