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(54) SUGGESTING AND REFINING USER INPUT BASED ON ORIGINAL USER INPUT

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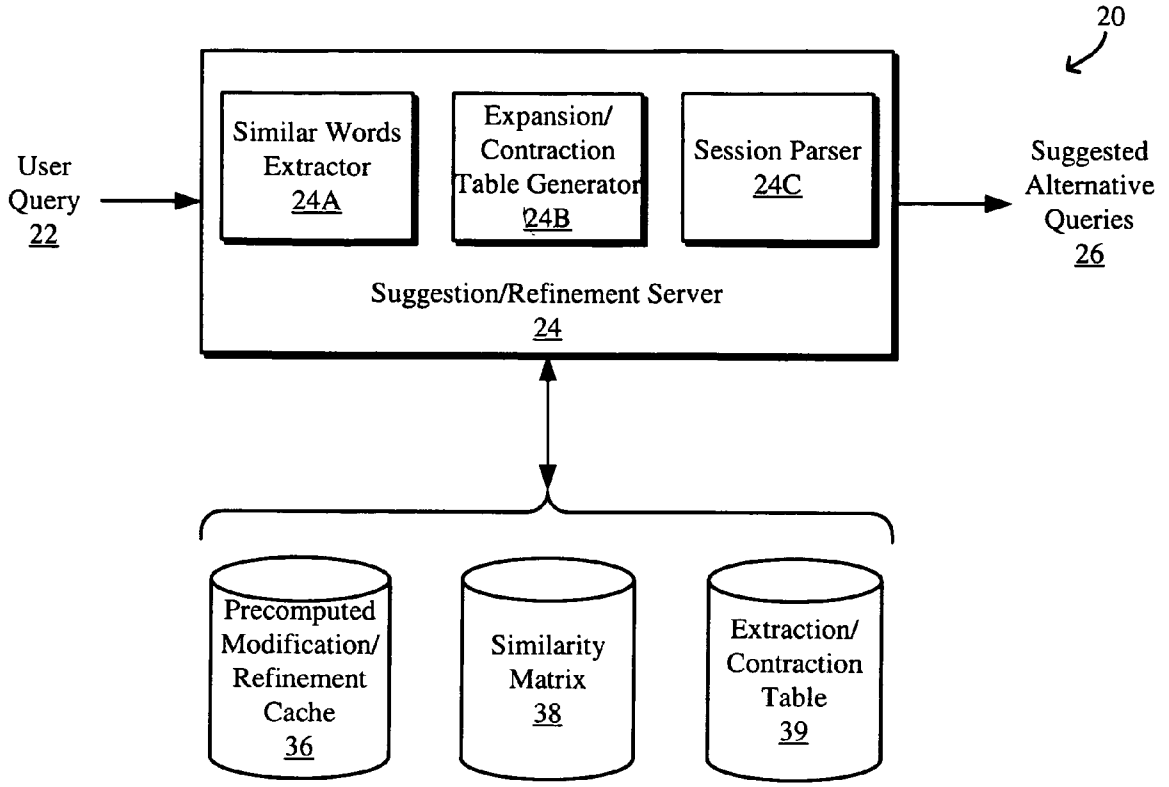
(57) **ABSTRACT**

Systems and methods to generate modified/refined user inputs based on the original user input, such as a search query, are disclosed. The method may be implemented for Roman-based and/or non-Roman based language such as Chinese. The method may generally include receiving an original user input and identifying core terms therein, determining potential alternative inputs by replacing core term(s) in the original input with another term according to a similarity matrix and/or substituting a word sequence in the original input with another word sequence according to an expansion/contraction table where one word sequence is a substring of the other, computing likelihood of each potential alternative input, and selecting most likely alternative inputs according to a predetermined criteria, e.g., likelihood of the alternative input being at least that of the original input. A cache containing pre-computed original user inputs and corresponding alternative inputs may be provided.



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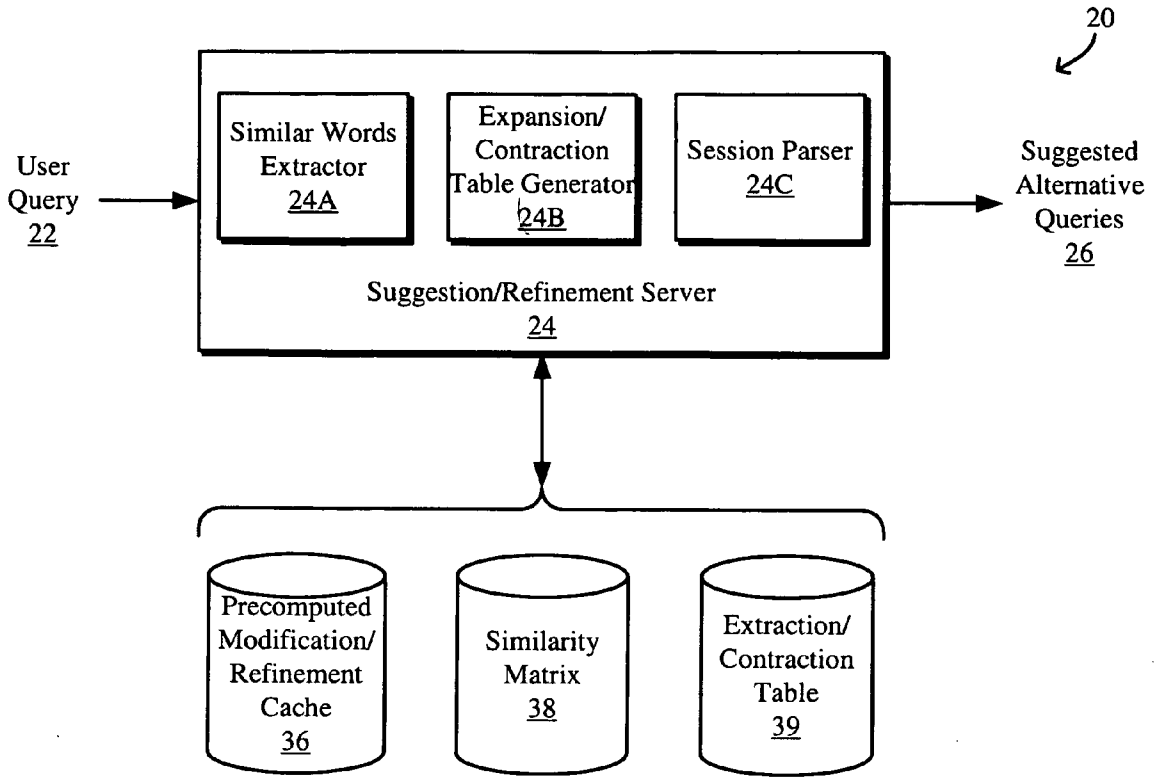

FIG. 1A

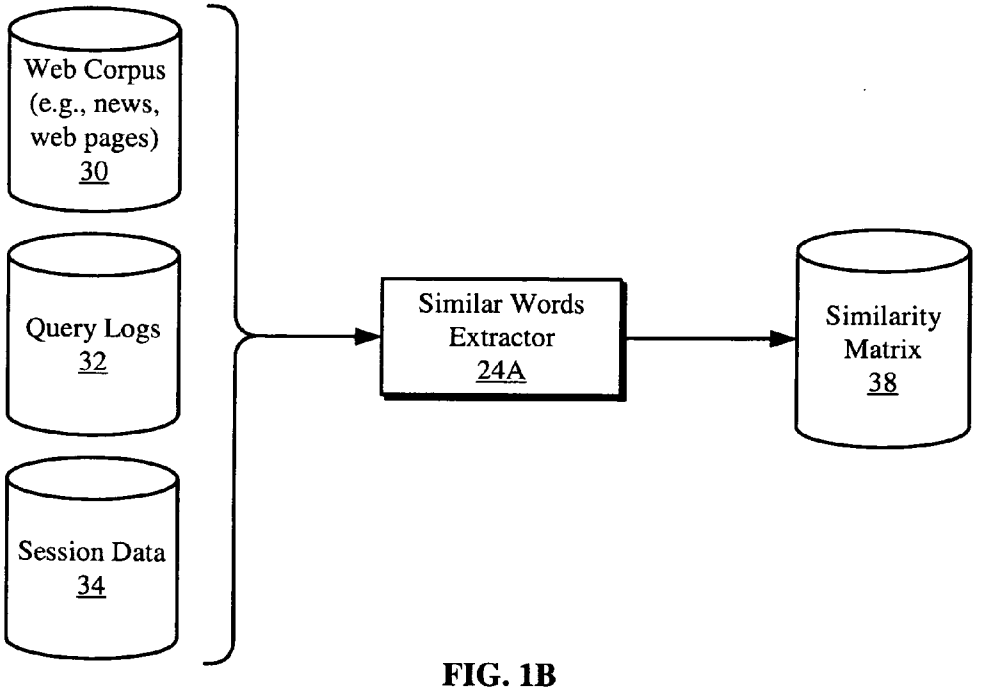

FIG. 1B

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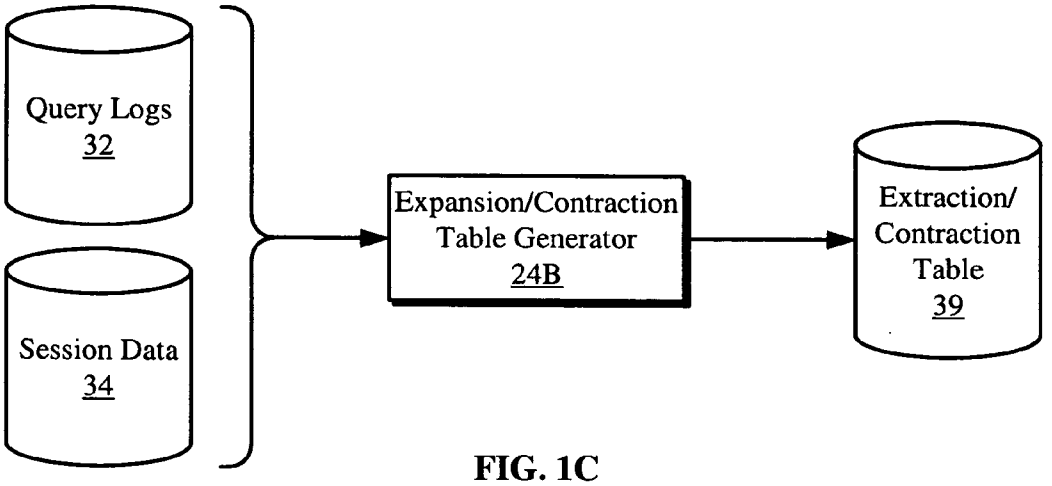

FIG. 1C

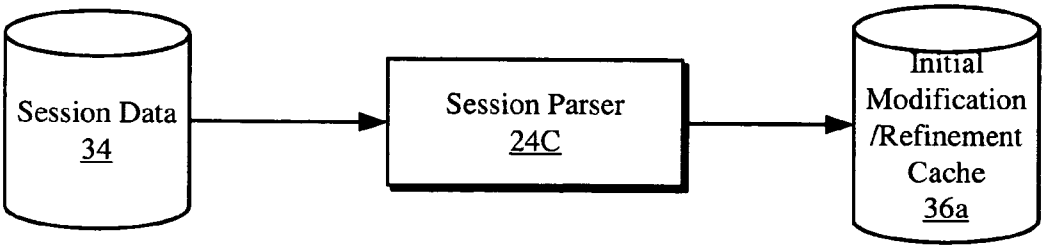

FIG. 1D

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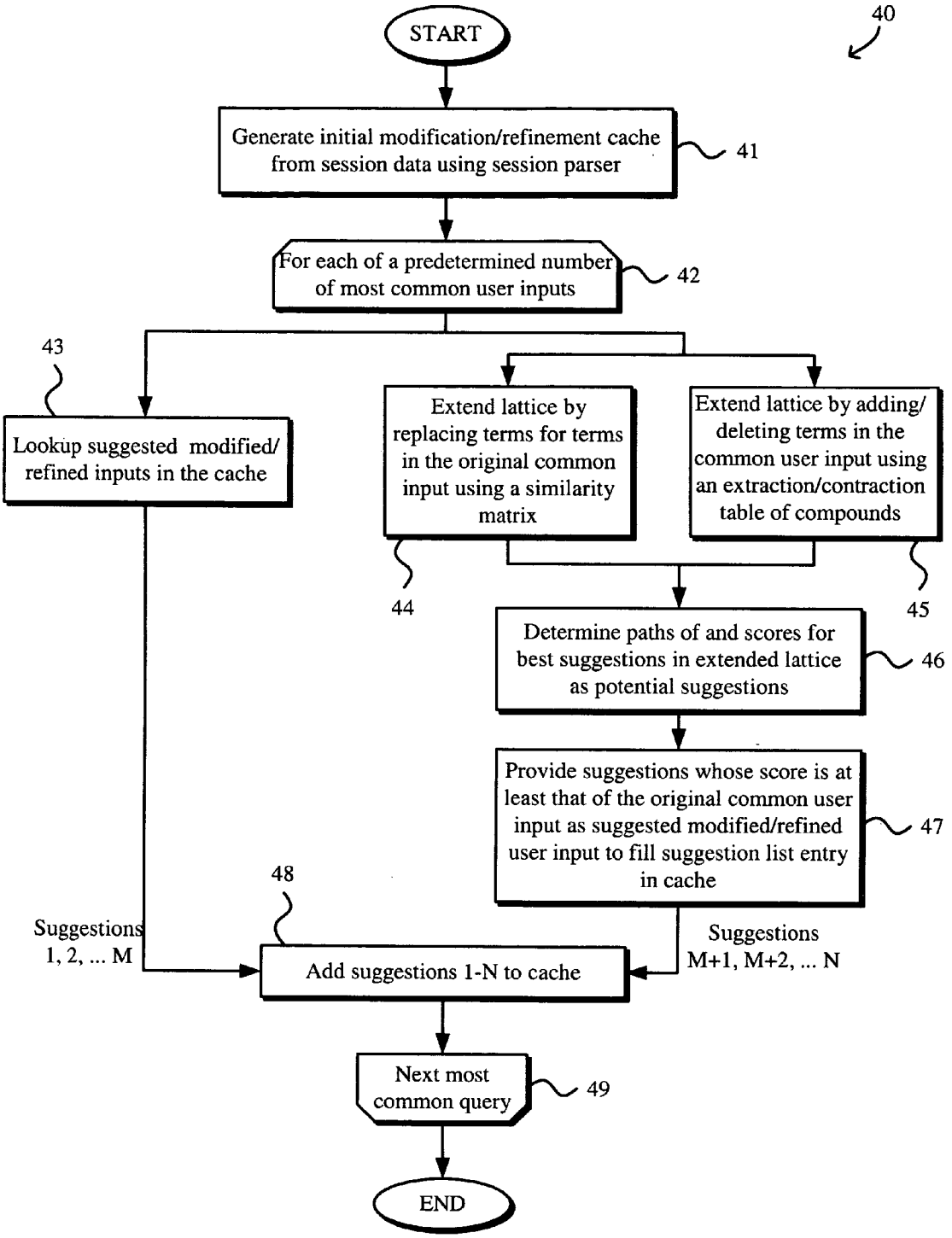

FIG. 2A

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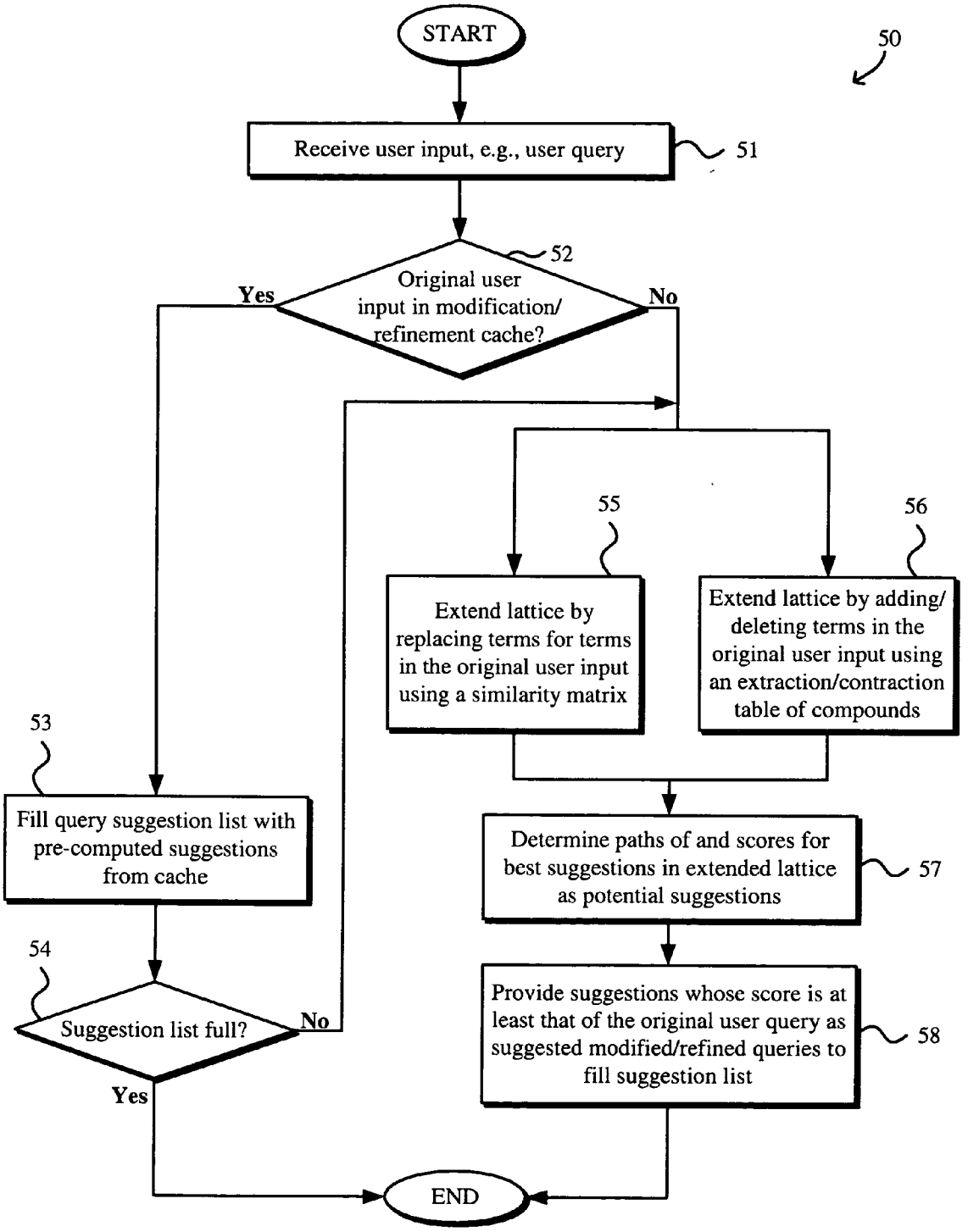

FIG. 2B

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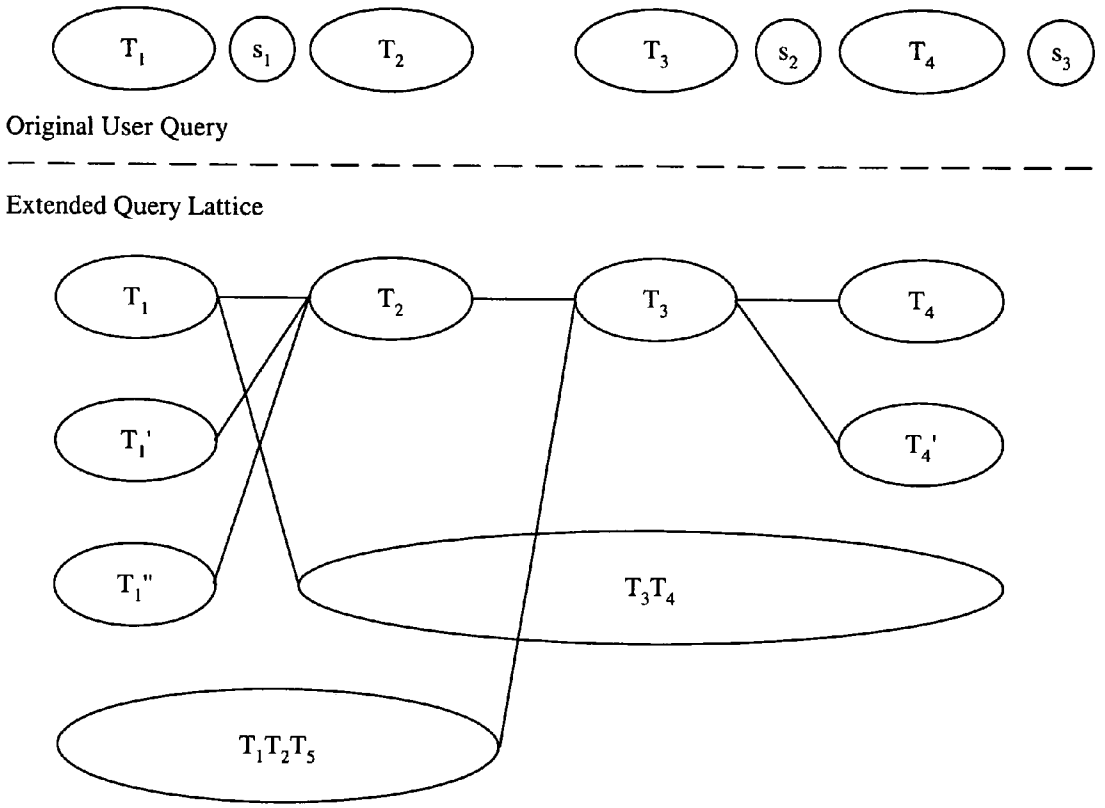

FIG. 3

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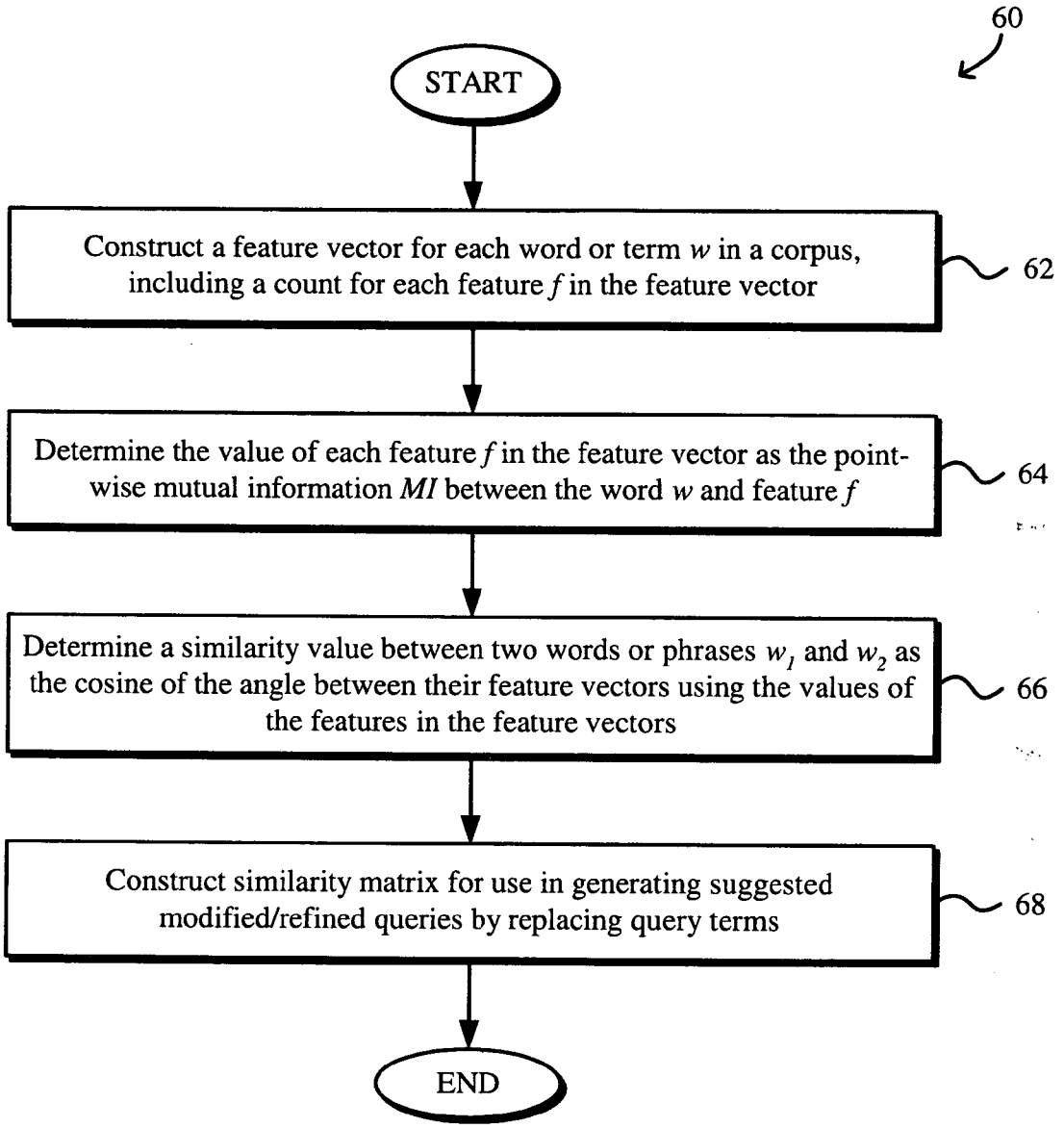

FIG. 4

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Feature	Count
L:because	1
R:assess	1
L:rates	0.5
L:between	0.5
R:is	0.33
R:by	0.33
R:using	0.33

FIG. 5

Feature	Count	MI
L:outlying	530	7.16619
L:disadvantaged	682.49	6.61504
L:marginalized	75.66	5.84836
L:close-knit	97.5	5.79445
L:enriching	123.5	5.78579
L:Mountain	2856	5.74945
L:Appalachian	63	5.29764
L:bedroom	498.5	5.08576
R:across	6285.07	4.83219
R:bordering	60	4.51492
R:clashed	84.5	4.25515
R:prosper	47.32	4.17204
R:impacted	70.57	3.64408
R:grapple	13.75	3.38906
R:namely	19	3.31465
R:encompassing	11	3.30112

FIG. 6

Similarity Matrix							
	w_1	w_2	w_3	w_4	w_5	...	w_n
w_1	---	s_{12}	s_{13}	s_{14}	s_{15}		s_{1n}
w_2		---	s_{23}	s_{24}	s_{25}		s_{2n}
w_3			---	s_{34}	s_{35}		s_{3n}
w_4				---	s_{45}		s_{4n}
w_5					---		s_{5n}
...						---	...
w_n							---

FIG. 7

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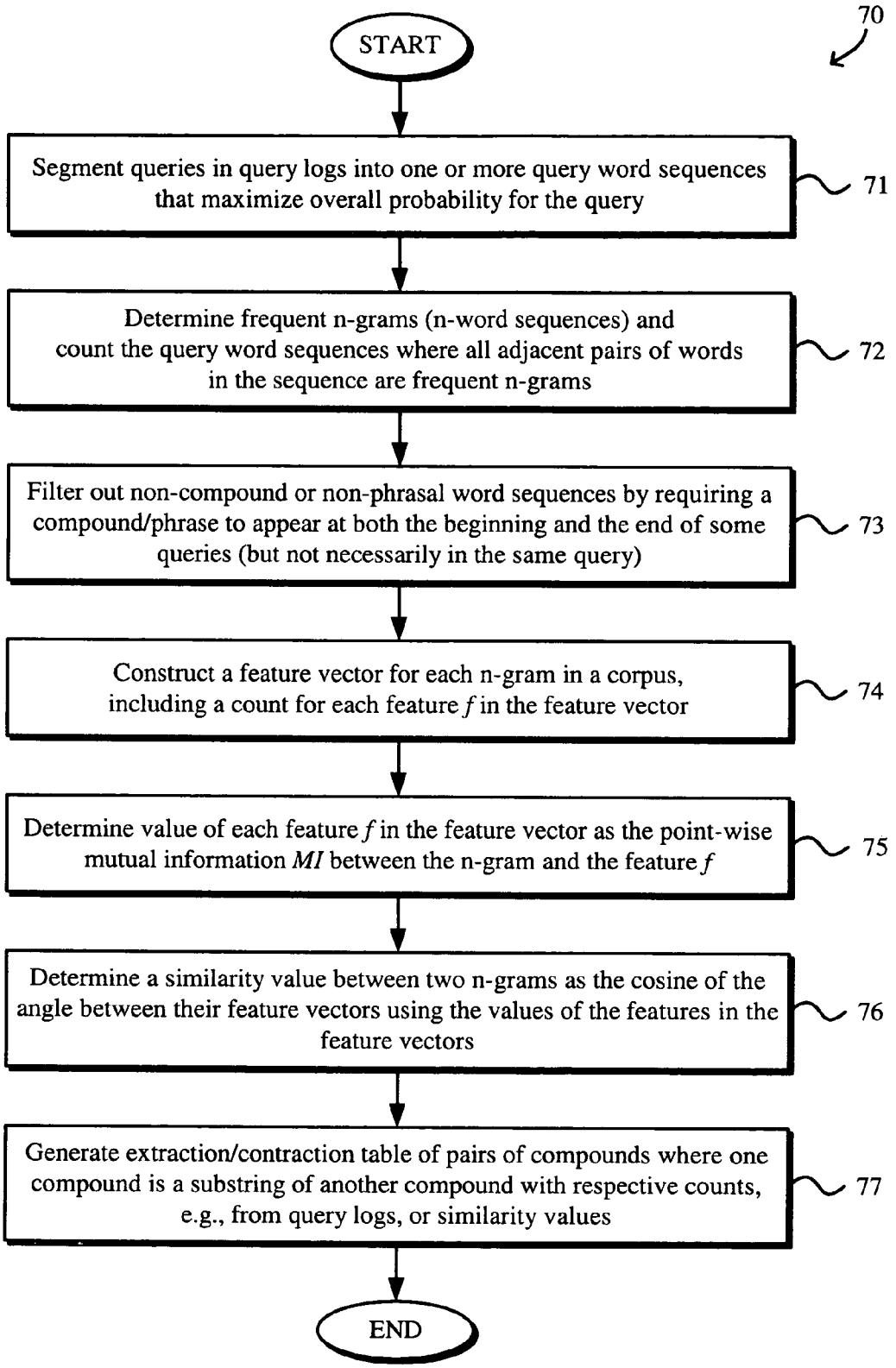

FIG. 8

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Expansion/Contraction Table			
Coumpound	Count	Compound	Count
c_1 c_2 c_3 c_4 c_5 c_6	56	c_1 c_2 c_3	6849
c_1 c_2 c_3 c_4 c_5 c_6	56	c_1 c_2 c_3 c_4	58
c_1 c_2 c_3 c_4 c_5 c_6	56	c_1 c_2 c_3 c_4 c_5 c_6 c_7 c_8	2
c_1 c_2 c_3 c_4 c_5 c_6	56	c_1 c_2 c_3 c_4 c_5 c_6 c_9 c_{10} c_{11}	3
c_1 c_2 c_3 c_4 c_5 c_6	56	c_4 c_5 c_6	2336

FIG. 9

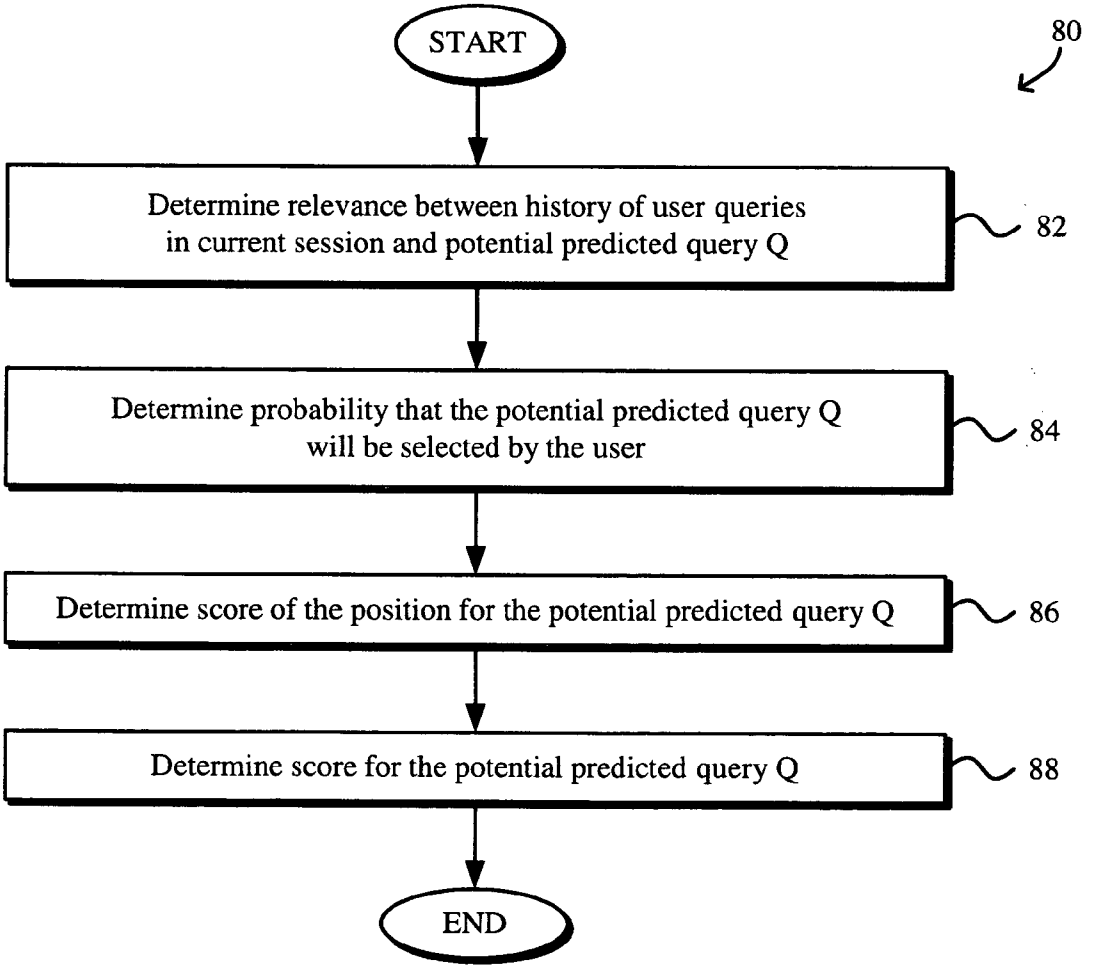

FIG. 10

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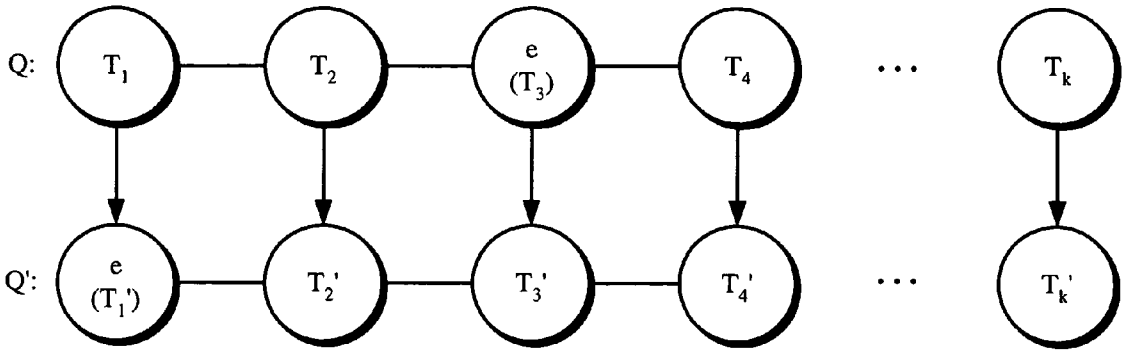

FIG. 11

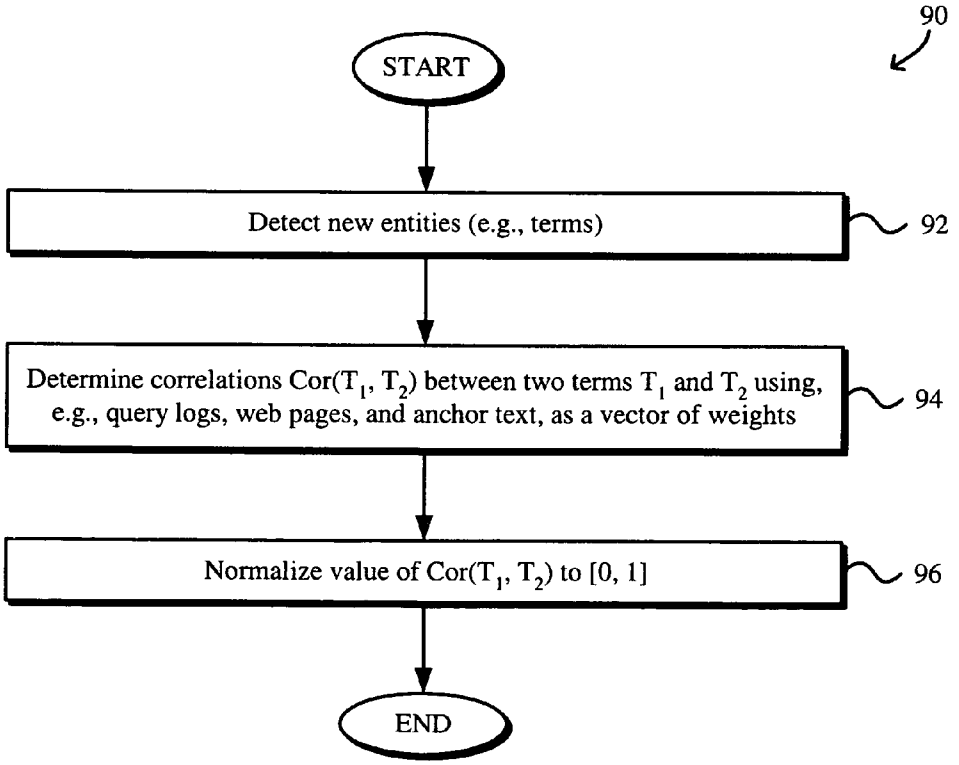

FIG. 12

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SUGGESTING AND REFINING USER INPUT BASED ON ORIGINAL USER INPUT

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to generating alternative user inputs. More specifically, systems and methods to generate modified or refined user inputs based on an original user input, such as a search query, are disclosed.

[0003] 2. Description of Related Art

[0004] Many users often modify or refine, sometimes repeatedly, their original search query during a given search session. For example, the user may modify an original search query to a more specific search query, a broader search query, and/or a search query using alternative query terms until desired search results are generated. User search query refinement occurs with queries in Roman-based languages, e.g., English, as well as with queries in non-Roman-based languages, e.g., Chinese, Japanese, Korean (CJK), Thai, etc. Users typically modify or refine their search queries when the original search query did not yield a good set of search results, e.g., if the search query is too specific or too broad or if the search query used improper terms. For example, the original user search query may yield too many irrelevant results when one or more of the search terms are ambiguous and some of the returned documents are related to a meaning of the ambiguous search term that is different from what the user intended and/or when the user is interested in only one aspect of a given search term among the many aspects of the search term. The original user search query may also yield too many irrelevant results when the user is merely exploring concepts related to a given search term.

[0005] Many search engines offer a list of suggested search queries related the user's original search query. For example, if a user's original search query is "Amazon," the search engine may suggest other related search queries such as "Amazon.com", "Amazon Rainforest", and "Amazon River." Search query suggestion may be particularly useful for non-Roman based language users such as CJK users. Specifically, non-Roman based language users may prefer clicking or selecting a suggested search query over typing modified search queries because non-Roman-based languages generally have a large set of characters and each character may require several keystrokes using a conventional Roman-based keyboard. For example, many Chinese language users use pinyin (phonetic spelling) to input Chinese characters. The conventional pinyin input system typically converts a pinyin input and provides a list of candidate Chinese character sets from which the user may select the intended set of Chinese characters. As is evident, the multi-step input process may be tedious and time-consuming.

[0006] Search query suggestion may also be useful for Roman-based language users. Many search engines, such as Yahoo, Teoma, Alta Vista, Askjeeves, AllTheWeb, and Baidu offer such as feature in the form of related search, query refinement, or query clustering.

SUMMARY OF THE INVENTION

[0007] Systems and methods to generate modified or refined user inputs based on an original user input, such as a search query, are disclosed. It should be appreciated that the present invention can be implemented in numerous ways, including as a process, an apparatus, a system, a device, a method, or a computer readable medium such as a computer readable storage medium or a computer network wherein program instructions are sent over optical or electronic communication lines. The term computer generally refers to any device with computing power such as personal digital assistants (PDAs), cellular telephones, and network switches. Several inventive embodiments of the present invention are described below.

[0008] The method may be applied to queries in a non-Roman based language such as Chinese. The method may generally include receiving and identifying core terms in an original user input, determining potential alternative user inputs by replacing core term(s) in the original input with another term according to a similarity matrix and/or substituting a sequence of words in the original input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, computing likelihoods of the potential alternative user inputs, and selecting most likely alternative user inputs according to a predetermined criteria, e.g., the likelihood of each selected alternative user input is at least that of the original user input. The method may also include determining whether the original user input is in a pre-computed cache of suggested alternative user inputs and, if so, outputting pre-computed most likely alternative use inputs stored in the pre-computed cache.

[0009] The similarity matrix may be generated using a corpus and may have similarity values between two similar terms including phrasal terms such as "New York" and "Los Angeles" which may have a very high similarity although each pair of corresponding terms (New and Los and York and Angeles) does not have high similarity. In one embodiment, the similarity matrix can be generated by constructing feature vectors for words in the corpus and determining a similarity value between two words/phrases using their feature vectors.

[0010] The expansion/contraction table may be generated from a user input database and may have a frequency value associated with each pair of sequence of terms. In one embodiment, the expansion/contraction table may be generated by determining frequent word sequences, filtering out non-phrasal word sequences, and associating a count with each sequence of terms as the frequency value. Merely to illustrate, an example of an entry in the expansion/contraction table may be "The United States of America" and "United States."

[0011] The likelihoods of the potential alternative user inputs may be computed by determining at least one of: (a) a relevance between the original user input and the potential alternative user input, (b) a probability that the potential alternative user input will be selected by the user, and (c) a score of the position for the potential alternative user input. In particular, the relevance between the original user input and the potential alternative user input may be determined using correlation values between aligned terms of the original input and the potential alternative user input.

[0012] In another embodiment, a system for suggesting alternative user inputs generally includes a suggestion/refinement server configured to receive an original user input

having at least one core term, to identify the core terms in the original user input, to determine potential alternative user inputs by performing at least one of (a) replacing at least one core term in the original user input with another term according to a similarity matrix, the similarity matrix having a similarity value between the two terms and (b) substituting a sequence of words in the original user input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, the expansion/contraction table having a frequency value associated with each sequence of terms, to compute likelihoods of the potential alternative user inputs, and to select and output most likely alternative user inputs according to a predetermined criteria.

[0013] In yet another embodiment, a computer program product for suggesting alternative user inputs is used in conjunction with a computer system, the computer program product including a computer readable storage medium on which are stored instructions executable on a computer processor. The instructions may generally include receiving and identifying core terms in an original user input, determining potential alternative user inputs by replacing core term(s) in the original input with another term according to a similarity matrix and/or substituting a sequence of words in the original input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, computing likelihoods of the potential alternative user inputs and optionally a predicted user satisfaction with the potential alternative user inputs, and selecting most likely alternative user inputs according to a predetermined criteria, e.g., the likelihood of each selected alternative user input is at least that of the original user input.

[0014] An application implementing the system and method may be implemented on a server site such as on a search engine or may be implemented, e.g., downloaded, on a client site such as a user's computer to provide suggested alternative inputs or to interface with a remote server such as a search engine.

[0015] These and other features and advantages of the present invention will be presented in more detail in the following detailed description and the accompanying figures which illustrate by way of example principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements.

[0017] **FIG. 1A** is a block diagram of an exemplary system for generating suggested modified/refined user inputs such as user search queries.

[0018] **FIG. 1B** is a block diagram illustrating a process for generating a similarity matrix by a similar words extractor of the suggestion-refinement server.

[0019] **FIG. 1C** is a block diagram illustrating a process for generating an extraction/contraction table by an expansion/contraction table generator of the suggestion-refinement server.

[0020] **FIG. 1D** is a block diagram illustrating a process for generating an initial modification/refinement cache by a session parser of the suggestion-refinement server.

[0021] **FIG. 2A** is flow chart illustrating an exemplary process for generating a modification/refinement user inputs cache as may be implemented by the system shown in **FIG. 1A**.

[0022] **FIG. 2B** is a flow chart illustrating an exemplary process for generating suggested modified/refined user inputs such as user queries as may be implemented by the system shown in **FIG. 1A**.

[0023] **FIG. 3** illustrates an exemplary query lattice diagram generated by parsing an original user query.

[0024] **FIG. 4** is a flowchart illustrating an exemplary process for constructing a similarity matrix for use in generating suggested modified/refined queries by replacement of query terms.

[0025] **FIG. 5** is a table listing features and corresponding counts for the term "communities" generated from exemplary text.

[0026] **FIG. 6** is a table listing exemplary features and corresponding counts for the term "communities" generated from a corpus.

[0027] **FIG. 7** is an exemplary similarity matrix for use in replacing terms to generate suggested modified/refined queries.

[0028] **FIG. 8** is a flowchart illustrating an exemplary process for constructing an extracting/contraction table of pairs of compounds for use in generating suggested modified/refined queries by substituting compounds in queries.

[0029] **FIG. 9** is table illustrating some exemplary entries in an expansion/contraction table for use in substituting compounds in queries to generate suggested modified/refined queries.

[0030] **FIG. 10** is a flowchart illustrating an exemplary process for determining the score of a suggested modified/refined query.

[0031] **FIG. 11** illustrates an example of an alignment mapping of terms two queries Q and Q'.

[0032] **FIG. 12** is a flowchart illustrating an exemplary process for generating correlation values for detected new entities.

DESCRIPTION OF SPECIFIC EMBODIMENTS

[0033] Systems and methods to generate modified or refined user inputs based on an original user input, such as a search query, are disclosed. It is noted that for purposes of clarity only, the examples presented herein are generally presented in terms of Chinese query inputs. However, the systems and methods for suggesting refined/modified user inputs may be similarly applicable for other non-Roman based languages such as Japanese, Korean, Thai, etc., as well as Roman-based languages. In addition, the systems and methods for suggesting refined/modified user inputs may be similarly applicable for other non-query user inputs. The following description is presented to enable any person skilled in the art to make and use the invention. Descriptions of specific embodiments and applications are provided only

as examples and various modifications will be readily apparent to those skilled in the art. The general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, the present invention is to be accorded the widest scope encompassing numerous alternatives, modifications and equivalents consistent with the principles and features disclosed herein. For purpose of clarity, details relating to technical material that is known in the technical fields related to the invention have not been described in detail so as not to unnecessarily obscure the present invention.

[0034] The systems and methods to generate modified or refined user inputs based on the original user input, such as a query, based on the user's query history and relationships between the terms of the user query. The systems and methods may include systems and methods for extracting new terms including new name entities (e.g., proper names, names of movies, songs and products, etc.) and the relationships between terms. The systems and methods described herein are suitable for use in generating query (or other user input) refinement but may also be adapted for many other applications such as news article classification, spelling correction, media search and segmentation. For many user, the initial search query is often not the best search query and the user thus modifies or refines the search query, sometimes multiple times, during a given search session.

[0035] **FIG. 1A** is a block diagram of an exemplary system **20** for generating suggested modified/refined inputs **26** from an original user input such as a user search query **22**. The system **20** generally includes a suggestion/refinement server **24** that generates suggested modified/refined queries **26** using probabilities that may be derived from the various data sources. Examples of the various data sources include an optional suggestion/refinement cache **36** that stores a cache of pre-computed query suggestions or refinements. The suggestion/refinement cache **36** may be initially generated by a session parser **24**C of the suggestion/refinement server **24**. Another data source may be a similarity matrix **38** that may be generated by a similar words extractor **24**A of the suggestion/refinement server **24** and an expansion/contraction table **39** that may be generated by an expansion/contraction table generator **24**B. The similarity matrix **38** and the expansion/contraction table **39** generally approximate relationships between the terms and/or sequence of terms. The system **20** may periodically update and/or regenerate the similarity matrix **38** and/or the expansion/contraction table **39**. The similar words extractor **24**A, expansion/contraction table generator **24**B, and session parser **24**C of the suggestion/refinement server **24** will be described in more detail below with reference to **FIGS. 1B-1D**, respectively.

[0036] **FIG. 1B** is a block diagram illustrating a process for generating the similarity matrix **38** by the similar words extractor **24**A. As shown, the similar words extractor **24**A may utilize various data sources for generating the similarity matrix **38**. Examples of the data sources utilized by the similar words extractor **24**A include a corpus such as a web corpus **30** (e.g., news, web pages, and anchor text information), queries and associated user selections such as those stored in the query logs **32**, and/or session data **34** that may include the history of queries in each given session. The web corpus **30** may also include anchor text information. The query logs **32** may include not only a log of user queries but also the search result selections made by the user as well as the duration that the user stayed at the selected search result before returning to the search results, for example.

[0037] **FIG. 1C** is a block diagram illustrating a process for generating the extraction/contraction table **39** by the expansion/contraction table generator **24**B. As shown, the expansion/contraction table generator **24**B may utilize query logs **32** and/or session data **34** as data sources for generating the extraction/contraction table **39**. **FIG. 1D** is a block diagram illustrating a process for generating an initial modification/refinement cache **36***a* by the session parser **24**C. As shown, the session parser **24**C may utilize session data **34** as its data source for generating the initial modification/refinement cache **36***a*.

[0038] **FIGS. 2A and 2B** are flowcharts illustrating exemplary processes that may be performed by the suggestion/refinement server **24**. In particular, **FIG. 2A** is flow chart illustrating an exemplary process **40** for generating a modification/refinement user inputs cache as may be implemented by the system **20** shown in **FIG. 1A**. At block **41**, an initial modification/refinement cache can be generated from session data using a session parser. As noted, session data may include the history of queries in each given user input or query session. The process **40** then enters a loop that includes blocks **43-48** for each of a predetermined number of most common user input, e.g., queries, at block **42**. In particular, at block **43**, the process performs a lookup of suggested modified/refined queries in the cache. The lookup at block **43** may result in suggestions 1, 2, . . . M.

[0039] Each user input or query entry in the modification/refinement cache may contain a list of predetermined number N of suggested queries. Thus, to generate suggestions M+1, M+2 . . . N, i.e., to fill up the suggested queries list for each query, blocks **44-47** may also be performed. In particular, at blocks **44** and **45**, an extended query lattice may be (conceptually) built to generate additional suggested modified/refined (alternative) queries. Block **44** generally represents a term replacement query modification/refinement method while block **45** generally represents an expansion/contraction query modification/refinement method. Specifically, at block **44**, the extended query lattice may be built by replacing terms in the original query with similar terms using a similarity matrix of similar terms. Term replacement replaces a word or term (including phrasal term) in the original query with a similar word or term. Similar terms may include synonyms or near synonyms (e.g., community and neighborhood), acronyms, and/or terms in the same syntactic/semantic category (e.g., Toyota and Honda, Dell and HP, DVD and digital camera, and Nokia and Motorola).

[0040] At block **45**, the extended query lattice may additionally and/or alternatively be built by adding/deleting terms in the original query using an expansion/contraction table of pairs of compounds. In particular, each entry in the expansion/contraction table is a pair of compounds where one compound is a substring of another, e.g., $T_1T_2 <=> T_1T_2T_3$, and $T_4T_5T_6 <=> T_4T_5$. Examples of Chinese compound pairs include Shanghai and Shanghai City as well as television and television set. Compound pairs may include ambiguous terms and their unambiguous context (e.g., Amazon and Amazon rain forest and/or Amazon.com), concepts

and their refinement (e.g., cell and stem cell and/or cell phone), terms and their attributes (e.g., computer and memory, hard disk drive, and/or DVD drive), and names (e.g., names of people, companies, and the like) and their corresponding activities, job, products, etc. (e.g., actor-movie such as Tom Hanks and Forrest Gump, company-product such as Apple and iPod, person-company or title Bill Gates and Microsoft or CEO, author-book, singer-song, etc.).

[0041] After the extended query lattice is built to contain various alternative paths, the paths and scores for a predetermined number of best queries in the extended query lattice are identified as potential suggested queries at block **46**. At block **47**, the score of the original common user query is computed so that only the potential suggested queries whose score is at least that of the original common user query are provided as the suggested modified/refined queries. The score may represent the likelihood of the given query (original or potential suggested query) being the query selected or intended by a user. The queries whose score is at least that of the original common user query can be provided as suggested modified/refined queries to fill the suggestion list entry in the modification/refinement cache. The resulting suggested queries may be stored to the pre-computed modified/refined queries cache. Note that the process **40** or the loop includes blocks **42-49** may be repeated periodically to update the modification/refinement cache.

[0042] **FIG. 2B** is a flow chart illustrating an exemplary process **50** for generating suggested modified/refined user inputs such as user queries as may be implemented by the system **20** shown in **FIG. 1A**. At block **51**, a user input such as a user query is received. At decision block **52**, the original user input received at block **51** may be compared to entries in the optional pre-computed modification/refinement cache. If the original user query is determined to be in the suggestion/refinement cache at decision block **52**, then a query suggestion list of size N is at least partially filled with up to N pre-computed query suggestions from the pre-computed modification/refinement cache at block **53**. If the suggestion list is full as determined at decision block **54**, the process **50** is complete. Note that the suggestion list may be of a predefined size N, e.g., 10 suggestions or a single best suggestion. Alternatively, if the suggestion list is not full as determined at decision block **54**, then the process **50** continues at blocks **55** and **56**. Similarly, if the original user query is determined not to be in the suggestion/refinement cache at decision block **52**, the process also continues at blocks **55** and **56**. Note that blocks **55-58** are similar to blocks **44-47** of process **40** as described above with reference to **FIG. 2A**. Accordingly, the descriptions, to the extent they are similar, are not repeated here for purposes of clarity.

[0043] At blocks **55** and **56**, an extended query lattice is (conceptually) built to generate suggested modified/refined (alternative) queries. After the extended query lattice is built to contain various alternative paths, the paths and scores for a predetermined number of best queries in the extended query lattice are identified as potential suggested queries at block **57**. At block **58**, the score of the original user query is computed so that only the potential suggested queries whose scores are at least that of the original user query are provided as the suggested modified/refined queries. The queries whose score is at least that of the original user query can be provided to the user as suggested modified/refined queries to fill the suggestion list or the remainder of the suggestion list. Although not shown, a single best query may alternatively be provided. In addition, the original user query and the resulting suggested queries may be additionally stored to the pre-computed modified/refined queries cache.

[0044] The various blocks of the processes **40** and **50** as shown and described above with reference to **FIGS. 2A and 2B** for generating suggested modified/refined user inputs will be described in further detail below.

[0045] **FIG. 3** illustrates an exemplary extended query lattice diagram. As shown, the original query may include various core words or terms T_1, T_2, T_3, T_4 and non-core words or terms s_1, s_2, s_3. For example, in a Chinese query "URL's of sina", the core term or entity is "sina" rather than "URL's." Non-core terms generally also include stop words. A non-stop word is generally defined as, for example, the 30 most frequently occurring Chinese words or the 100 most frequently occurring English words in the corpus such as a web corpus.

[0046] After the core entities of the original query are identified, one or more query modification or refinement methods, e.g., term replacement and/or expansion/contraction, can be applied to build the extended query lattice. As noted above, term replacement refers to the replacement of words and/or terms that are similar (e.g., synonym or a near synonym) to the core entities and that may be identified using, for example, the similarity matrix. Merely for illustrative purposes, **FIG. 3** illustrates that the extended query lattice may be built by replacing the term T_1 with T_1' or T_1'' and/or by replacing the term T_4 with T_4'.

[0047] As also noted above, expansion/contraction refers to the adding core entities to and/or deleting some of the core entities from in the original query using, for example, the expansion/contraction table of compounds. Merely for illustrative purposes, the expansion/contraction table of compounds may include a table entry for the pair of compounds T_1T_2 and $T_1T_2T_5$ such that the compound T_1T_2 in the original query in **FIG. 3** may be replaced with the compound $T_1T_2T_5$ (i.e., adding a new term T_5) so as to further build on the extended query lattice. Similarly, the expansion/contraction table of compounds may also include a table entry for the pair of compounds $T_2T_3T_4$ and T_3T_4 such that the compound $T_2T_3T_4$ in the original query in **FIG. 3** may be replaced with the compound T_3T_4 (i.e., deleting core entity T_2) so as to further build on the extended query lattice.

[0048] One exemplary method for generating the similarity matrix of similar terms is described in more detail with reference to **FIGS. 4-7**. **FIG. 4** is a flowchart illustrating an exemplary process **60** for constructing the similarity matrix for use in generating suggested modified/refined queries by replacement of query terms. The similarity matrix can be a matrix of distributional word similarities between each pair of words or terms w. The distributional word similarities for each word w may be obtained by constructing a feature vector for each word w in a corpus, e.g., web pages, and determining the similarity between each pair of words as the cosine of the angle between their respective feature vectors. The feature vector of a word or term may include the surrounding words at all occurrences of the word or term.

[0049] One example of the construction of feature vectors and the similarity matrix is presented with reference to **FIG.**

4 although various other feature vector and similarity matrix construction methods may be similarly employed. In particular, at block **62**, a feature vector for each word/term w in a corpus, such as a web corpus, along with a count for each feature f in the feature vector is constructed. The features of a word/term w may include words occurring before and after the word/term w, up to the first non-stop word. Merely for illustrative purposes, given the sentence "Because communities assess at different percentages of fair market value, the only way to compare tax rates among communities is by using equalized rates," the features of the word communities and their corresponding co-occurrence counts are listed in the table of **FIG. 5**. Note that in a language having different forms of a given word, e.g., singular and plural such as "community" and "communities" or different tenses such as "walk,""walking", and "walked", the system may treat the different forms of the word as separate words but are generally similar terms. Such treatment of different forms of a given word may not be relevant for languages that do not have such differentiations such as is typically the case in, for example, Chinese. In addition, also note that a feature with prefix "L:" or "R:" is a word that appears on the left or right of the word w, respectively. In this embodiment, the sum of the counts of the one or more features on each left and right side of a given instance of the word w is 1. For example, in the first instance of the word "communities," each of the left and right features is assigned a count of 1. In addition, when there are one or more stop words adjacent to the word "communities," e.g., "between,""is," and computed "by," the counts of the features for each side of the given instance of the word "communities" can be equally divided and thus computed as a fraction. In the second instance of the word "communities," there are two left features such that each left feature is assigned a count of 0.5. Similarly, in the second instance of the word "communities," there are two right features such that each right feature is assigned a count of 0.33.

[**0050**] Referring again to **FIG. 4**, at block **64**, the value of the each feature f in the feature vector may be determined as the point-wise mutual information MI between the word w and feature f. The value of the point-wise mutual information MI is used because, while words that occur frequently, e.g., stop words, tend to have higher counts, such words are often semantically vacuous. Accordingly, as the counts of the features may not be good indicators of the importance of the features, the point-wise mutual information MI(w, f) between a word w and a feature f may be used as the value of the feature f. The point-wise mutual information MI(w, f) may be defined as the logarithm of the ratio between the observed joint probability of w and f, P(w, f), and the expected probability of w, P(w), and the expected probability of f, P(f), co-occurring if they were independent:

$$MI(w, f) = P(w \cdot f) \cdot \log \frac{P(w \cdot f)}{P(w) \cdot P(f)}$$

where the probabilities (e.g., relative frequencies) of the features P(f) and words P(w) may be determined using, for example, their respective probabilities in the corpus. Merely as an example, **FIG. 6** is a table listing exemplary features and corresponding probabilities for the term "communities" generated from a web corpus. The feature vector table shown in **FIG. 6** lists a subset of the features of the word "communities" as well as the probabilities and the mutual information between the features and the word "communities." Note that feature vectors can be fairly large. For example, the full set of the features of the word communities extracted from the corpus includes approximately 2,000 elements.

[**0051**] Referring once again to **FIG. 4**, at block **66**, a similarity measure or value sim between two words or phrases w_1 and w_2 may be determined as the cosine of the angle between their feature vectors using the values of the features in the feature vectors. In particular, the similarity sim between two terms or words w_1 and w_2 can be defined as:

$$sim(w_1, w_2) = \frac{\sum_i f_{1i} \cdot f_{2i}}{\sqrt{\sum_i f_{1i}^2} \sqrt{\sum_i f_{2i}^2}}$$

where the feature vectors of w_1 and w_2 are represented by $(f_{11}, f_{12} \ldots f_{1n})$ and $(f_{21}, f_{22} \ldots, f_{2n})$, respectively.

[**0052**] At block **68**, the similarity matrix is then constructed from the similarity values for each pair of words for terms and may be used in generating suggested modified/refined queries by replacing query terms with similar terms. In particular, the similarity values may be used in determining the scores for a potential suggest query, for example. Note that the similarity matrix may be recomputed periodically and/or the similarity value for terms, such as those for newly identified terms, may be added to the matrix. **FIG. 7** is an exemplary similarity matrix that may be employed in replacing similar terms to generate suggested modified/refined queries.

[**0053**] An exemplary method for generating the similarity matrix for use in applying the term replacement query modification/refinement method having been presented, an exemplary method for generating the expansion/contraction table of pairs of compounds for use in applying the expansion/contraction query modification/refinement method will now be described in more detail below with reference to **FIGS. 8-11**. **FIG. 8** is a flowchart illustrating an exemplary process **70** for constructing the extracting/contraction table of pairs of compounds. As noted above, each entry in the expansion/contraction table is a pair of compounds where one compound is a substring of another such that if a query contains a compound that is one of the pair of compounds in an entry in the expansion/contraction table, the compound may be substituted by the other compound in the compound pair entry in extending the lattice. Ideally, each compound in the extracting/contraction table should be a meaningful phrase. Merely as examples, a compound pair may be Shanghai and Shanghai City or television and television set. As noted above, compound pairs may include, for example, ambiguous terms and their unambiguous context (e.g., Amazon and Amazon rain forest), names of people and their corresponding activities, attributes of terms, refinement of concepts, actors, authors, products, person-position, etc.

[**0054**] At block **71**, queries in query logs (or another database of user inputs) may be segmented into a word

sequence that maximizes the overall probability for the query. In particular, because Chinese words need not be explicitly delineated with spaces or other breaks such that a query may be a string of Chinese characters without breaks, a segmentor may be employed to segment a sequence of characters into a sequence of words. The sequence of words can be such that the product of the probabilities of the words is the maximum among all possible segmentations of the sequence of characters. As is evident, block **71** need not be performed for certain languages such as English where there are clear delineations between adjacent words.

[**0055**] To identify compounds/phrases, frequent word sequences or n-grams (sequence of n sequences) are identified at block **72**. Also at block **72**, a count of the word sequences where all adjacent pairs of words in the word sequence are frequent n-grams is made so as to identify frequent word sequences of any length. Note that frequent word sequences may or may not be compounds. For example, some of the frequent word sequences may be compounds while others may be non-phrasal or non-compound sequences.

[**0056**] At block **73**, non-phrasal sequences are identified by requiring a compound/phrase to appear at the beginning as well as the end of a minimum number of queries (but not necessarily in the same query). The minimum number of queries may be any number greater than or equal to 1 but is typically much greater than 1, e.g., 50 or 100.

[**0057**] At block **74**, a feature vector for each n-gram in a corpus, such as a web corpus, along with a count for each feature f in the feature vector is constructed. At block **75**, the value of the each feature f in the feature vector may be determined as the point-wise mutual information MI between the n-gram and feature f. At block **76**, a similarity measure or value sim between two n-grams may be determined as the cosine of the angle between their feature vectors using the values of the features in the feature vectors. Note that blocks **74**, **75**, and **76** are similar to blocks **62**, **64**, and **66** of process **60**, respectively, as described above with reference to **FIG. 4**. Accordingly, the descriptions, to the extent they are similar, are not repeated here for purposes of clarity.

[**0058**] The expansion/contraction table may then be constructed as pairs of compounds where one compound is a substring of another at block **77**. In addition, the counts of the compounds can also be determined and stored in the expansion/contraction table.

[**0059**] **FIG. 9** is table illustrating some exemplary entries in an expansion/contraction table for use in substituting compounds in queries to generate suggested modified/refined queries. As shown, each row of the expansion/contraction table contains two compounds or word sequences in which one compound is a substring of the other. Each compound is also associated with a count (or other frequency value) which may be determined from the query log or some other user input database, for example. The count may be used as a cut-off to decrease the size of the database and/or may be used, at least in part, to determine a weight for a term or a compound, e.g., by using log(count). As described above with reference to **FIGS. 2A and 2B**, once the query lattice is extended by replacing terms and/or by adding/deleting terms in the original query, the paths and scores of the N best queries are determined from the extended lattice as potential suggested queries. **FIG. 10** is a flowchart illustrating an exemplary process **80** for determining the score of a suggested modified/refined query, e.g., a path in the extended query lattice.

[**0060**] The determination of query suggestions can be treated as a prediction problem based on previous queries in the current query session. Given the history of queries Q_1, Q_2, . . . , Q_{n-1} in the current search session, a prediction may be made as to what the next query Q_n the user is most likely to select. The suggested or predicted next query Q_n should not only be relevant to the history of queries Q_1, Q_2, . . . , Q_{n-1} in the current session but also yield good search results. A measurement of how good the search results are may be a function of, for example, click position (the position of the search result that the user selects) and click duration (how long the user stays at the selected search result page).

[**0061**] In one embodiment, the score for each potential suggested query can be determined as the value of the object function F:

$$F(Q, Q_1, \ldots, Q_{n-1})=\mathrm{Rel}(Q, Q_1, \ldots, Q_{n-1})*\mathrm{Click}(Q)*\mathrm{Position}(Q);$$

where:

[**0062**] $\mathrm{Rel}(Q, Q_1, \ldots, Q_{n-1})$ is the relevance between the history of queries Q_1, . . . , Q_{n-1} and the candidate suggested query Q;

[**0063**] Click(Q) is the probability that the candidate suggested query Q will be selected by the user; and

[**0064**] Position(Q) is the position of the search result for the candidate suggested query Q that will be clicked.

[**0065**] As described above with reference to **FIG. 2**, one or more suggested or predicted next query Q can be provided to the user. Thus, the best N suggest next queries (e.g., paths in the extended query lattice) are the N queries with the highest object function values and the best (e.g., most likely) suggested next query can be expressed as the query that maximizes the value of the object function F:

$$Q_n=Arg\mathrm{Max}_Q\{F(Q, Q_1, \ldots, Q_{n-1})\}$$

[**0066**] The determination of the scores for each potential suggested or predicted next query Q **90** is shown in the flowchart of **FIG. 10**. At block **82**, the relevance $\mathrm{Rel}(Q, Q_1, \ldots, Q_{n-1})$ between the history of user queries, Q_1, . . . , Q_{n-1} in the current session and a predicted query Q is determined using correlations of aligned terms in the queries. In particular, to estimate the relevance function Rel, the terms or core entities in the original query Q are identified. Using the correlations between core entities, the relevance Rel(Q, Q') between two queries Q and Q' can be derived from the correlation of their core entities. In particular, the relevance Rel(Q, Q') can be expressed as:

$$Rel(Q, Q')=\mathrm{Max}_f\mathrm{Prod}_\{i=1\}\hat{}k\ Cor(T_i, T_i')*w(T_i)$$

where:

[**0067**] alignment function $f=f(T_1, T_2, \ldots, T_k, T_1', T_2', \ldots, T_k')$ maps the terms of the related queries Q and Q', e.g., a mapping between $\{T_1, \ldots, T_k, e\}$ and $\{T_1', \ldots, T_k', e\}$, an example of which is shown in **FIG. 11**;

[**0068**] $\mathrm{Cor}(T_i, T_i')$ is the correlation between terms T_i, T_i' and is a vector of real numbers;

[0069] $Q=T_1, T_2, \ldots, T_k$ (core entities in query Q in which any term T_i may be an empty term e);

[0070] $Q'=T_1', T_2', \ldots, T_k'$(core entities in query Q' in which any term T_i' may be an empty term e); and

[0071] $w(T_i)$ is the importance of term T_i, e.g., TF/IDF for T_i, where TF represents a term frequency (e.g., count of the term) and IDF represents an inverted document frequency.

[0072] Next, at block **84**, the probability that query Q will be selected by the user, Click(Q), is determined from, for example, click duration or normalized click duration. At block **86**, the score of the position for the predicted query Q, Position(Q), is determined from, for example, the click position, normalized click position, or inverted click position. Lastly, at block **88**, the value of the object function F for the potential suggested or predicted next query Q is determined from the results of blocks **82**, **84**, and **86** as described above.

[0073] The determination of correlation values $Cor(T_i, T_i')$ used in determining the relevance between two queries is described in more detail with reference to **FIG. 12**. In particular, **FIG. 12** is a flowchart illustrating an exemplary process **90** for generating correlation values between pairs of terms or core entities T, T'. At block **92**, new core entities may be identified from a corpus, e.g., web pages and user queries, using mutual information. In one illustrative implementation of block **92**, if Motorola is an entity and "Motorola announced,""Motorola cell phone," and "buy Motorola" as well as "Nokia announced,""Nokia cell phone," and "buy Nokia" are in the corpus, then Nokia is also identified as an entity. It is noted that although off-the-shelf dictionaries can provide the conventional core entities, many new core entities are often introduced into the vocabulary. Example of new core entities include proper names, e.g., people and company names, and various other new words and phrases such as product models, movies and song titles etc.

[0074] At block **94**, the correlation values between pairs of core entities T, T' can be determined using, for example, query logs, web pages and anchor text. The correlation between two core entities T_1 and T_2 may be defined as a function of a vector of real numbers:

$$Cor(T_1, T_2)=f(w_1, w_2, \ldots, w_n)$$

where $w_1, w_2, \ldots, w_n$ are the weights of certain predetermined relationships. Examples of the predetermined relationships include (1) synonyms, acronyms and antonyms, (2) compounded phrase such as Shanghai vs. Shanghai City, television vs. television machine, (3) terms in the same syntactic/semantic category, e.g., Toyota and Honda, (4) ambiguous terms and their unambiguous context, (5) names of people and their corresponding activities, e.g., Oprah and talk show host, (6) attributes of terms, e.g., computer and memory, (7) refinement of concepts, e.g., Amazon and Amazon River, Amazon Rain Forrest, and Amazon.com, (8) movie-actors, book-authors, company-product, person-position, etc., e.g., Tom Hanks and Forrest Gump and Bill Gates and CEO.

[0075] At block **96**, the value of the correlation vectors $Cor(T_1, T_2)$ may be normalized to [0-1].

[0076] The systems and methods for generating modified or refined user inputs can suggest queries that a user is likely to use and/or that generate a top result that the user is likely to select. The systems and methods quantitatively measure the correlation between two queries. As is evident, the two queries need not have any common terms or even synonyms. For example, the queries related to an original query (e.g., in Chinese) "'Now and Forever' mp3" for the mp3 file of the song "Now and Forever," may include "CoCo Lee" (singer of the song), as well as other songs or albums by the same artist, for example. Thus the suggested queries may not be simply an expansion of the original query but rather queries with better search results, e.g., search results that the users are more likely to select. In one example, the suggested queries may include queries that achieve query sense disambiguation where the original query is short and ambiguous. As another example, the suggested queries may include queries that split the original query into shorter queries where the original query may be long and/or contain mutually exclusive terms.

[0077] While the exemplary embodiments of the present invention are described and illustrated herein, it will be appreciated that they are merely illustrative and that modifications can be made to these embodiments without departing from the spirit and scope of the invention. Thus, the scope of the invention is intended to be defined only in terms of the following claims as may be amended, with each claim being expressly incorporated into this Description of Specific Embodiments as an embodiment of the invention.

What is claimed is:

1. A method for suggesting alternative user inputs, comprising:

receiving an original user input, the input having at least one core term;

identifying the at least one core term in the original user input;

determining at least one potential alternative user input by performing at least one of (a) replacing at least one core term in the original user input with another term according to a similarity matrix, the similarity matrix having a similarity value between the two terms and (b) substituting a sequence of words in the original user input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, the expansion/contraction table having frequency values associated with sequence of terms;

computing likelihoods of the potential alternative user inputs; and

selecting one or more most likely alternative user inputs from the at least one potential alternative user input according to a predetermined criteria.

2. The method of claim 1, wherein the predetermined criteria for selecting the one or more most likely alternative user inputs includes the likelihoods of the selected alternative user inputs being at least that of the original user input.

3. The method of claim 1, wherein the original user input is an original user search query.

4. The method of claim 1, wherein the original user input is in a non-Roman based language.

5. The method of claim 1, further comprising:

determining whether the original user input is in a pre-computed cache of suggested alternative user inputs; and

upon determining that the original user input is in the pre-computed cache, outputting at least one of the pre-computed most likely alternative user inputs stored in the pre-computed cache.

6. The method of claim 1, wherein the similarity matrix is generated from at least one of a corpus, a user input log, and user session data.

7. The method of claim 6, wherein the similarity matrix is generated by constructing feature vectors for words in the corpus and determining a similarity value between two words using their feature vectors.

8. The method of claim 1, wherein the expansion/contraction table is generated from at least one of a user input log and a user input database.

9. The method of claim 8, wherein the expansion/contraction table is generated by determining frequent word sequences, filtering out non-phrasal word sequences, and associating counts with sequences of terms as the frequency values.

10. The method of claim 1, wherein computing the likelihoods of the potential alternative user inputs includes determining at least one of: (a) a relevance between the original user input and the potential alternative user input, (b) a probability that the potential alternative user input will be selected by the user, and (c) a score of the position for the potential alternative user input.

11. The method of claim 10, wherein the relevance between the original user input and the potential alternative user input is determined using correlation values between aligned terms of the original input and the potential alternative user input.

12. A system for suggesting alternative user inputs, comprising:

a suggestion/refinement server configured to receive an original user input having at least one core term, to identify the at least one core term in the original user input, to determine at least one potential alternative user input by performing at least one of (a) replacing at least one core term in the original user input with another term according to a similarity matrix, the similarity matrix having a similarity value between the two terms and (b) substituting a sequence of words in the original user input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, the expansion/contraction table having frequency values associated with sequences of terms, to compute likelihoods of the potential alternative user inputs, and to select and output one or more most likely alternative user inputs from the at least one potential alternative user input according to a predetermined criteria.

13. The system of claim 12, wherein the original user input is an original user search query.

14. The system of claim 12, wherein the original user input is in a non-Roman based language.

15. The system of claim 12, further comprising a pre-computed cache of suggested alternative user inputs, wherein the suggestion/refinement server is further configured to determine whether the original user input is in the pre-computed cache and, upon determining that the original user input is in the pre-computed cache, to output pre-computed most likely alternative use inputs stored in the pre-computed cache.

16. The system of claim 12, further comprising at least one of a corpus, a user input log, and user session data, wherein the similarity matrix is generated using at least one of the corpus, the user input log, and user session data.

17. The system of claim 16, wherein the suggestion/refinement server is further configured to generate the similarity matrix by constructing feature vectors for words in the corpus and determining a similarity value between two words using their feature vectors.

18. The system of claim 12, further comprising at least one of a user input log and a user input database, wherein the suggestion/refinement server is further configured to generate the expansion/contraction table from at least one of the user input log and the user input database.

19. The system of claim 18, wherein the suggestion/refinement server is further configured to generate the expansion/contraction table by determining frequent word sequences, filtering out non-phrasal word sequences, and associating a count with each sequence of terms as the frequency value.

20. The system of claim 12, wherein the suggestion/refinement server is further configured to compute the likelihoods of the potential alternative user inputs by determining at least one of: (a) a relevance between the original user input and the potential alternative user input, (b) a probability that the potential alternative user input will be selected by the user, and (c) a score of the position for the potential alternative user input.

21. The system of claim 20, wherein the suggestion/refinement server is further configured to determine the relevance between the original user input and the potential alternative user input by using correlation values between aligned terms of the original input and the potential alternative user input.

22. A computer program product for use in conjunction with a computer system, the computer program product comprising a computer readable storage medium on which are stored instructions executable on a computer processor, the instructions including:

receiving an original user input, the input having at least one core term;

identifying the at least one core term in the original user input;

determining at least one potential alternative user inputs by performing at least one of (a) replacing at least one core term in the original user input with another term according to a similarity matrix, the similarity matrix having a similarity value between the two terms and (b) substituting a sequence of words in the original user input with another sequence of words according to an expansion/contraction table, one sequence being a substring of the other sequence, the expansion/contraction table having a frequency value associated with each sequence of terms;

computing likelihoods of the potential alternative user inputs; and

selecting one or more most likely alternative user inputs from the at least one potential alternative user input according to a predetermined criteria.

23. The computer program product of claim 22, the instructions further including:

determining whether the original user input is in a pre-computed cache of suggested alternative user inputs and

upon determining that the original user input is in the pre-computed cache, outputting pre-computed most likely alternative use inputs stored in the pre-computed cache.

24. The computer program product of claim 22, wherein the similarity matrix is generated from at least one of a corpus, a user input log, and user session data.

25. The computer program product of claim 24, wherein the similarity matrix is generated by constructing feature vectors for words in the corpus and determining a similarity value between two words using their feature vectors.

26. The computer program product of claim 22, wherein the expansion/contraction table is generated from at least one of a user input log and a user input database.

27. The computer program product of claim 26, wherein the expansion/contraction table is generated by determining frequent word sequences, filtering out non-phrasal word sequences, and associating a count with each sequence of terms as the frequency value.

28. The computer program product of claim 22, wherein computing the likelihoods of the potential alternative user inputs includes determining at least one of: (a) a relevance between the original user input and the potential alternative user input, (b) a probability that the potential alternative user input will be selected by the user, and (c) a score of the position for the potential alternative user input.

29. The computer program product of claim 28, wherein the relevance between the original user input and the potential alternative user input is determined using correlation values between aligned terms of the original input and the potential alternative user input.

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