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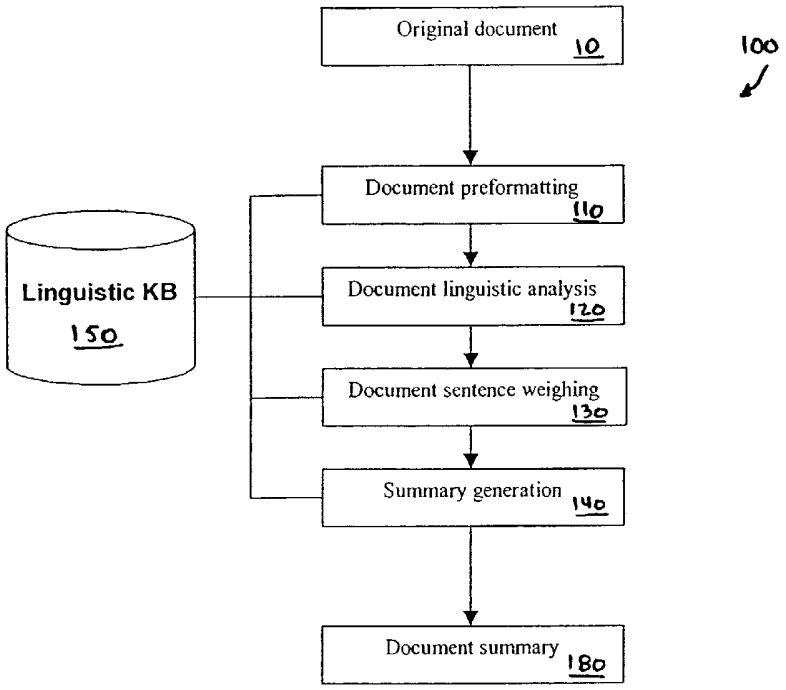
(54) Title: COMPUTER BASED SUMMARIZATION OF NATURAL LANGUAGE DOCUMENTS



(57) Abstract: A system and method for summarizing the contents of a natural language document provided in electronic or digital form includes pre-formatting the document (10), performing linguistic analysis (120), weighting each sentence (130) in the document as a function of quantitative importance, and generating one or more document summaries (140), from a plurality of selectable document summary types, as a function of the sentence weights.

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COMPUTER BASED SUMMARIZATION OF NATURAL LANGUAGE DOCUMENTS

Cross References to Related Applications

[0001] This application claims the benefit of priority under 35 U.S.C. §119(e) from co-pending, commonly owned U.S. provisional patent application serial number 60/308,886, entitled COMPUTER BASED SUMMARIZATION OF NATURAL LANGUAGE DOCUMENTS, filed July 31, 2001.

Field of the Invention

[0002] This invention relates to systems and methods of automatically summarizing the contents of natural language documents stored in electronic or digital form.

Background

[0003] There are several known approaches of solving the problem of automatic summarization of stored electronic documents. These approaches include (1) the use of different kinds of statistics gathered from the text, (2) information extraction, based on a word's position in the text or based on a document design, (3) search of "cue words" as marks for text of importance and desired for representation in the summary, and (4) usage of discursive text analysis to define elements, which represent the center of a document subtopic discussion.

[0004] These methods were modified as the means of linguistic text analysis evolved. At the earliest stages, these forms of analysis only allowed one to divide text into words and sentences and to conduct elementary morphological words analysis. Commonly, the summary was made up from the sentences of initial text that received the highest rank, or that met some other criteria. The statistics, in such cases, were collected on text word usage rate. That is, the more the word was found in the text, the weightier it was considered. Auxiliary words and other words considered not to be significant were filtered out according to a set of predetermined lists.

[0005] Alternatively, so called "tf*idf" word estimation was used, where the distribution of a word in a document set was taken into consideration. Such estimation is discussed in U.S. Patent No. 6, 128,634 to Golovchinsky, et al., for highlighting significant terms for the purpose of making a quick review of the document relatively easy.

[0006] A similar approach is used in U.S. Patent No. 5, 924,108 to Fein, et al., where the estimation of a sentence is made as the arithmetic mean of word estimation. The method of "cue words" in this patent relies on the presence of certain words or their combinations in the

sentence. In U.S. Patent No. 5,638,543 to Peterson, et al. a method is described to extract single sentences.

[0007] There are some systems that use different combinations of the aforementioned approaches. For example, U.S. Patent 5, 978, 820 to Mase, et al. defines a document's type with the help of different statistic values, such as the average number of words and symbols in a sentence, the average number of sentences in the paragraph, and so on. Then, the topic of the document is defined on the basis of the specific word usage. A summary is compiled as the totality of sentences, which are included in the original document or those that have certain predetermined words.

[0008] In Kupiec, et al., "A Training Document Summarizer", ACM Press Proceeding of the 18th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, 1995, pp. 68-73, the probability of a sentence being included in the summary is computed on the basis of such characteristics as sentence length, presence of certain words, sentence position, presence or frequency words and proper names.

[0009] However, in all of these prior works, only shallow text analysis is carried out, which cannot produce high accuracy. All of these prior methods fail to determine the significance of information content. The use of more advanced means of text analysis, such as tagging, advance the work of these methods due to more exact significant word determination, usage of lemmas in the calculations of statistics, and the search of patterns. Nevertheless, these improvements are limited and do not offer efficiency.

[0010] The next stage in the development of means of linguistic text analysis using some measure of abstracting is the appearance of systems that mark out syntactic structures, such as noun phrases, surface subjects, actions and objects in the sentences, but for very limited purposes. That is, as implemented, it is possible to make the simplest semantic text analysis to reveal deep text objects and relations between them. For example, results of deep text analysis is used in U.S. Patent No. 6,185, 592 to Boguraev, et al., where, for text segments, the most significant noun phrase groups are marked on the basis of their usage frequency in weighted semantic roles. A resulting document summary report presents the number of these noun phrases and their context.

[0011] Thus, a limited attempt has been made to build a summary report on the basis of automatically extracted knowledge from a text document at the object level. However, determining deep semantic relations between the objects themselves, in particular knowledge on the level of facts and also the main functional relations between the facts themselves, has not been considered.

Summary of the Invention

[0012] The inventive concepts alleviate the above noted problems in generating a document summary by performing deep linguistic analysis on text within a document. A plurality of methods of text analysis are performed by a system and method in accordance with the present invention to generate the document summary. For example, such methods may include one or more of statistical analysis, positional analysis and the method of using "cue words". However, in accordance with the present invention, such methods are modified and provided for creating the document summary using deep linguistic text analyses.

[0013] Document summary generation is based on the semantic relations described in the document, rather than on significant words or syntactic structures. In the inventive approach, analysis is based on an understanding at the level of objects, facts, and regularities of the knowledge domain to which the document refers. Such a complex approach provides high precision.

[0014] Preferably, in accordance with the present invention, a user is provided with a wide range of selectable summary outputs, which can be especially important if working with a large number of documents and with relatively large documents. That is, the present invention may be configured to provide the ability to obtain different types of summaries of a document, based on preformatting and linguistic, statistical and empirical analysis that is performed on the document during processing.

[0015] Preformatting the document includes detecting the documents special fields (if any). For example, given a certain type of document, it may be known that certain fields will exist. For instance it may be known that if the document is an article, the article will have a title field. Preformatting may also include error detection and correction, wherein errors such as mismatches and misspellings are found by an error correction and detection module. Document to word splitting is performed and then document to sentence splitting is performed, wherein the document is broken into smaller units for analysis. A preformatted document is produced and then used in linguistic analysis.

[0016] Linguistic analysis includes part-of-speech tagging, parsing and semantic analysis. Semantic analysis includes extraction of knowledge bits, corresponding to *objects*, *facts* and *rules* of the knowledge domain. Objects proper and their *object attributes* are differentiated. Facts can include a *subject*, *action*, or *object* (SAO). Rules are applied to determine *cause-effect* relationships. The rules may be accessed from a linguistic knowledge base having cause-effect models stored therein. The linguistic knowledge base may include a database of dictionaries, classifiers, statistical data, and so on, a database for linguistic models

recognition (e.g., for text-to-word splitting, recognizing of subject, object, action, attributes, and so on) and a database for empiric model recognition (e.g., for preformatting of the document and its empirical evaluation).

[0017] The linguistic analysis outputs a functionally analyzed document with attributes for subject, action, and object and their inner structure and cause-effect relationships recognized, wherein an extended SAO is defined, or eSAO, that includes at least seven types of elements: Subject, Action, Object, Adjective, Preposition, Indirect Object, and Adverbial.

[0018] The eSAOs are represented as extracted bits or lexical units that later allow one to obtain statistical (or empirical and semantic) scores of the sentences from the document. However, only those lexical units (e.g., patterns or identifiers) with significance are used for the above procedure; by *significance* it is meant that significant lexical units carry major meanings within the document.

[0019] A document sentence weighting module is used to quantitatively evaluate each sentence of the functionally analyzed document. For example, one or more of the following techniques may be used for weighting. Statistical weighting is based on assessing the weight of each sentence by calculating the frequency of its words and thereby determining whether the sentence would be relevant in the document summary. Using this approach the weight of a eSAO can be calculated by dividing the sum of the frequencies of its elements by the total number of words in the eSAO.

[0020] Cue-weighting can be used to provide a quantitative score of the importance of the information, taking into account explicit lexical signs (e.g., certain words or phrases). Further, this score is added to the empirical score obtained from an expert knowledge database (or base) in the form of patterns that operate with separate lexical units and tags.

[0021] Cause - effect (CE) weighting can be performed to provide a quantitative score of a sentence having a cause-effect relationship. The output of the weighting module is a function, or includes, the weights provided by the above weighting methods. A summarizer is used to analyze and output an integrated score for each sentence that is used during the process of summary generation.

[0022] A wide variety of different types of selectable documents summaries is made available, wherein different document summaries require different depths of analysis. Such document summaries can include a summary in the form of a list of keywords, topics, or eSA0s, or a field-oriented summary, or a classic summary. A classic summary is a document summary comprised of key phrases, concepts or sentences from the original document.

Brief Description of the Drawings

[0023] The drawing figures depict preferred embodiments by way of example, not by way of limitations. In the figures, like reference numerals refer to the same or similar elements.

[0024] FIG. 1 is a diagram of a method of document summarization, in accordance with the preferred embodiment of the present invention.

[0025] FIG. 2 is a diagram of an embodiment of a method for preformatting a document, in accordance with FIG. 1.

[0026] FIG. 3 is a diagram of an embodiment of a method for linguistic analysis, in accordance with FIG. 1

[0027] FIG. 4 is a diagram of an embodiment of a method for parsing a document, in accordance with FIG. 3.

[0028] FIG. 5 is a diagram of an embodiment of a method for semantic analysis, in accordance with FIG. 3.

[0029] FIG. 6 is a diagram of an embodiment of a method for sentence weighting, in accordance with FIG. 1.

[0030] FIG. 7 is a list of informative tags, in accordance with FIG. 1.

[0031] FIG. 8 is a diagram of an embodiment of a method for generating document summaries, in accordance with FIG. 1.

[0032] FIG. 9 is an example of a key-word summary, in accordance with FIG. 8.

[0033] FIG. 10 is an example of a topic oriented summary, in accordance with FIG. 8.

[0034] FIG. 11 is an example of a eSAO summary, in accordance with FIG. 8.

[0035] FIG. 12 is an example of a classic summary, in accordance with FIG. 8.

[0036] FIG. 13 is an example of a field-oriented summary, in accordance with FIG. 8.

Detailed Description of the Preferred Embodiments

[0037] A system and method for summarizing the contents of a natural language document provided in electronic or digital form includes preformatting the document, performing linguistic analysis, weighting each sentence in the document according to a set of weighting techniques, and generating one or more document summaries, from a set of selectable document summary types. Document summaries may be generated as a function of a set of weights of the sentences in the document.

[0038] One embodiment of a summarizer in accordance with the present invention may

be appreciated with reference to FIG. 1. The summarizer processes an original document 10 to generate at least one document summary 180. In this embodiment, the summarizer implements the steps 100 of FIG. 1 and includes a preformatter (for preformatting the original document in step 110), a linguistic analyzer (for performing linguistic analysis in step 120), a sentence weighting module (for weighting sentences in step 130), a summary generator (for generating one or more document summaries in step 140) and a linguistic knowledge base 150. The functionality of all of the modules of the document summarizer may be maintained within the linguistic knowledge base 150, which includes various databases, such as dictionaries, classifiers, statistical data, and so on, and a database for recognizing linguistic models (for text-to-words splitting, recognition of noun phrases, verb phrases, subject, object, action, attribute, cause-effect recognition, and so on). In various embodiments, preformatting may not be required.

[0039] A method 200 in accordance with the preferred embodiment for preformatting document 10 is shown in FIG. 2. The preformatter receives original document 10 and in step 202, removes any formatting symbols and other symbols that are not part of natural language text. As examples, formatting symbols may include, but are not limited to, paragraph marks, tab characters and other symbols may include, but are not limited to, font color, font size and so on. In step 204, any mismatches and mistakes are identified and are automatically corrected. An example of a mismatch includes "the value depend on" and an example of a mistake includes "the values depens on". Other types of mismatches and mistakes are known to those skilled in the art. Mismatches and misspellings may be corrected, for example, by an Error Detection and Correction module.

[0040] In step 206, document text is divided into words and, in step 208, document text is divided into sentences. Summarizer 110 also recognizes, in step 210, certain fields in the document text, such as, for example, in the text of an issued U.S. patent, as shown in Table 1.

Parts of a patent	**Contents of the part**
Number	Patent number
Date	Date
Inventor	Inventor's name
Assignee	Assignee's name
Reference	References to related documents
Title	Patent title
Abstract	Brief patent description

Background	Description of the drawbacks of previous solutions and problem formulation
Summary	General invention description
Drawings	Drawings description
Detailed Description	Detailed description of the preferred embodiment of the invention
Claims	Statements defining the scope of the property rights owned by the Assignee via the patent

Table 1 - Recognition of Fields, Patent Document

Part of an article	**Contents of the part**
Title	Title of the article
Author	Author of the article
Abstract	Brief article description
Introduction	Introduction
Discussion	Discussion of the problem
Conclusion	Conclusions
Acknowledgment	Acknowledgement

Table 2 - Recognition of Fields, Article

[0041] Therefore, with regards to Table 1 and Table 2, several fields have been identified and the original document will be processed by the preformatter with knowledge of this context. The output of the preformatter is a preformatted document 220.

[0042] A method 300 in accordance with the preferred embodiment of performing linguistic analysis on the preformatted document 220 is shown in FIG. 3. Linguistic analysis may be performed by an analyzer that accomplishes tagging of words based on part of speech, its parsing 304, semantic analysis 306, and the output of a functionally analyzed document 320.

[0043] Additionally, semantic processing may be appreciated in light of commonly owned U.S. Patent Application No. 09/541182, entitled *Sentence Processor and Method with Knowledge Analysis of and Extraction From Natural Language Documents*, filed April 3, 2000, which is incorporated herein by reference.

[0044] At the step 302, each word of the document is assigned a part-of-speech tag. The

analysis of the text to determine how to tag words is supplemented with statistical data included in linguistic knowledge base 150. Tags typically correspond to parts of speech. Examples of tags include: JJ - adjective, VB - verb, NN - noun, and so on. A list of such tags is provide in FIG. 7.

[0045] A more detailed view of the parsing step 304 is provided in FIG. 4. During parsing, verbal sequences and noun phrases are recognized, in steps 404 and 406 respectively, from a tagged document 402 produced by in step 302 of FIG. 3. These verbal sequences and noun phrases are recognized by a parser.

[0046] In step 406, a syntactical parsed tree is built. To facilitate generation of the syntactical parsed tree, the linguistic knowledge base 150 includes Recognizing Linguistic Models. These models include rules for the structuring of a sentence, i.e., for correlating part-of-speech tags, syntactic and semantic classes, and so on, which are used in text parsing and extended subject (S), action (A), and object (O) (eSAO) extraction for building syntactic and functional phrases, as discussed below.

[0047] The syntactical parsed tree construction includes a plurality of separate stages. Each stage is controlled by a set of rules. Each rule creates a syntactic group, or *node* in the syntactical parsed tree. As an example, a core context-sensitive rule can be defined by the following formula:

UNITE

[element_1 ... element_n] *AS* Group_X

IF

left_context = L_context_1... L_context_n

right_context = R_context_1 ... R_context_n

[0048] This rule means that the string in brackets, i.e., [element_1 ... element_n] must be united and further regarded as a syntactic group of a particular kind, i.e., Group X in this case, if elements to the left of the string conform to the string defined by the left-context expression, and elements to the right of the string conform to the string defined by the right-context expression. An *element* is a word that has been tagged as previously described. Elements can be POS-tags or groups formed by the UNITE command. All sequences of elements can include one or more elements. One or both of the context strings defined by left-context and right-context may be empty.

[0049] In the preferred form there are two types of stages (or progressions) - forward and backward stages. With a forward stage, the sentence is scanned beginning from the first element to the last element, element by element, position by position. With a backward stage, the

sentence is scanned from the end of the sentence to the beginning of the sentence. At each position of the scan stage, the rules are applied to the sentence. If the element or elements being scanned match the ones defined in brackets in one of the stage rules, and context restricting conditions are satisfied, these elements are united as a syntactic group, or node, in the parsed tree. Once this is accomplished, the scanning process returns to the first (or the last, in case where the stage is backward) position of the sentence, and the scan begins again. The stage is over only when the scanning process reaches the end (or the beginning, depending on which stage it is, forward or backward) of the sentence not starting any rule. In accordance with the present invention, after a rule has worked, elements united into a group become inaccessible for further rules. Instead, the group that was formed represents these elements from that point forward.

[0050] To better illustrate the above, take a very simple example:

Input sentence:

The device has an open distal end.

*The*_DEF_ARTICLE *device*_NOUN *has*_HAVE_s *an*_INDEF_ARTICLE *open*_ADJ_*distal*_ADJ *end*_NOUN._PERIOD

[0051] Grammar:

BEGIN BACKWARD STAGE

UNITE

[(ADJ or NOUN) (NOUN or Noun-Group)] *AS* Noun-Group

IF

left_context = empty

right-context = empty

UNITE

[(DEF_ARTICLE or INDEF_ARTICLE) (NOUN or Noun_Group)] *AS* Noun_Group

IF

left_context = empty

right-Context = empty

END_BACKWARD_STAGE

Rule 1 (ADJ and NOUN): Pass 1:

*The*_DEF_ARTICLE *device*_NOUN *has*_HAVE_s *an*_INDEF_ARTICLE *open* (Noun Group: *distal* ADJ *end*_NOUN)._PERIOD

Rule 1 (ADJ and Noun - Group): Pass 2:

*The*_DEF_ARTICLE *device*_NOUN *has*_HAVE_s *an*_INDEF ARTICLE (Noun_Group: *open*_ADJ (Noun_Group: *distal*_ADJ *end*_NOUN))._PERIOD

Rule 2 (INDEF_ARTICLE and Noun_Group): Pass 3:

*The*_DEF ARTICLE *device*_NOUN *has*_HAVE_s

(Noun_Group: *an*_INDEF_ARTICLE (Noun_Group: *open*_ADJ (Noun Group: *distal*_ADJ *end*_NOUN)))._PERIOD

Rule 1 (DEF_ARTICLE and NOUN): Pass 4:

(Noun_Group: *The*_DEF_ARTICLE *device*_NOUN) *has*_HAVE_s

(Noun-Group:*an*_INDEF_ARTICLE (Noun_Group: *open*_ADJ (Noun_Group: *distal*_ADJ *end*_NOUN)))._PERIOD

Now there exists two nodes or groups, i.e., noun groups. Only one more rule is needed to unite a noun group, i.e., HAS_verb, and another noun group as a sentence.

[0052] Thus, in the preferred form, the first stage in parsing deals with POS-tags, then sequences of POS-tags are gradually substituted by syntactic groups. These groups are then substituted by other groups, higher in the sentence hierarchy, thus building a multi-level syntactic structure of sentence in the form of a tree, i.e., the syntactical parsed tree. For instance, with reference to the tags of FIG. 7, consider a semantic tree for the following examples:

Input sentence 1:

A guide cascaded with the dephasing element completely suppresses unwanted modes.

w_Sentence

w_N_XX

w_NN

*a*_AT

*guide*_NN

w_VBN_XX

*cascaded*_VBN

w_1N_N

*with*_IN

w_NN
*the*_ATI
w_NN
*dephasing*_NN
*element*_NN
w_VBZ_XX
w_VBZ
*completely*_RB
*suppresses*_VBZ
w_NNS
*unwanted*_JJ
*modes*_NNS

[0053] Input Sentence 2:

The maximum value of x is dependent on the ionic radius of the lanthanide element.

w_Sentence
w_NN
w_NN
*the*_ATI
w_NN
*maximum*_JJ
*value*_NN
*of*_IN
*x*_NP
w_BEX_XX
*is*_BEZ
w_JJ_XX
*dependent*_JJ
w_IN_N
*on*_IN
w_NN
w_NN
*the*_ATI
w_NN

*ionic*_JJ
*radius*_NN
*of*_IN
w_NN
*the*_ATI
w_NN
*lanthanide*_NN
*element*_NN

[0054] Returning to FIG. 3 and FIG. 4, the product of step 406, which is the final sub-step of the semantic analysis 306, is a parsed document 320, including the syntactical parsed tree.

[0055] Referring to FIG. 5, at this stage of document semantic analysis, semantic elements are recognized as being of the type: subject (S), action (A), object (O), in steps 502 and 504. Additionally, in step 506, explicit attributes of the elements are expressed as being a preposition, an indirect object, an adjective, or adverbial. The inner structure (i.e., the objects proper and their attributes) of Subject-S, Object-O and Indirect Object-iO are recognized in step 508. Also, certain semantic relations between eSAOs are recognized, such as Cause-Effect relationships, in step 508.

[0056] Note that in prior art systems SAOs included only three components or element types: subject (S) , Action (A), and Object (O). From these, at least one of them must be filled. However, in accordance with the present invention, expanded SAOs (or eSAOs) are used. In the preferred embodiment, eSAO's include seven components, from which at least one of them is filled, but these additional distinctions provide a greater depth and quality of analysis. In other embodiments, the eSAOs could be expanded to include more or different components.

[0057] In the preferred form, eSAO components include:

1. Subject (S): which performs action A on an object O;
2. Action (A): performed by subject S on an object O;
3. Object (O): acted upon by subject S with action A;
4. Adjective (Adj) - an adjective which characterizes subject S or action A which follows the subject, in a SAO with empty object O (ex: "The invention is efficient.", "The water becomes hot.");
5. Preposition Prep: a preposition which governs an Indirect Object (e.g., "The lamp is placed *on* the table.", "The device reduces friction *by* ultrasound.");
6. Indirect Object (iO): a component of a sentence manifested, as a rule, by a noun

phrase, which together with a preposition characterizes action, being an adverbial modifier. (e.g., : "The lamp is placed on the *table.*", "The device reduces friction by *ultrasound.*");

7. Adverbial (Adv): a component of a sentence, which characterizes, as a rule, the conditions of performing action A. (e.g., "The process is *slowly* modified.", "The driver must not turn the steering wheel *in such a manner.*")

[0058] Examples of application of the eSAO format are:

Input sentence 1:

A guide cascaded with the dephasing element completely suppresses unwanted modes.

Output:

Subject: *guide cascaded with the dephasing element*

Action: *suppress*

Object: *unwanted mode*

Preposition: (none)

Indirect Object: (none)

Adjective: (none)

Adverbial: *completely*

[0059] Input sentence 2:

The maximum value of x is dependent on the ionic radius of the lanthanide element.

Output:

Subject: *maximum value of x*

Action: *be*

Object: (none)

Preposition: *on*

Indirect Object: *ionic radius of the lanthanide element*

Adjective: *dependent*

Adverbial: (none)

[0060] Subject S, Object O and Indirect Object iO have their inner structure, which is recognized by the summarizer and includes the components proper (Sm, Om, iOm) and their

attributes (Attr (Sm), Attr (Om), Attr (iOm)). The elements of each of the pairs are in semantic relation *P* between each other. The elements Sm, Om, iOm can be denoted as (Ôm, then Subject S, Object O and Indirect Object iO are predicate elements of the type P(Attr (Ôm), Ôm). In the preferred form, the summarizer considers and recognizes the following types of relations for P: Feature (Parameter, Color, etc.), Inclusion, Placement, Formation, Connection, Separation, Transfer, and so on.

[0061] Examples are provided as follows, wherein, for simplicity, only sentence fragments are given, which correspond to the S, O or iO.

Input sentence fragment 1:

Cc-TZP materials with CeO_2 content

Output:

P = Formation / *with*

Attr (Ôm) = *CeO_2 content*

Ôm = *Ce-TZP materials*

[0062] Input sentence fragment 2:

rotational speed of freely suspended cylinder

Output:

P = Feature (Parameter)/*of*

Attr (Ôm) = *rotational speed*

Ôm = *freely suspended cylinder*

[0063] Input sentence fragment 3:

ruby color of Satsuma glass

Output:

P = Feature (Color)/ *of*

Attr (Ôm) = *ruby color*

Ôm = *Satsuma glass*

[0064] Input sentence fragment 4:

micro-cracks situated between sintered grains

Output:

P = Placement / *situated between*

Attr (Ôm) = *sintered grains*

Ôm = *micro-cracks*

[0065] Input sentence fragment 5:

precursor derived from hydrocarbon gas

Output:

P = Formation / *derived from*

Attr (Ôm) = *hydrocarbon gas*

Ôm = *precursor*

[0066] Input sentence fragment 6:

dissipation driver coupled to power dissipator

Output:

P = Connection/ *coupled to*

Attr (Ôm) = *power dissipator*

Ôm = *dissipation driver*

[0067] Input sentence fragment 7:

lymphoid cells isolated from blood of AIDS infected people

Output:

P = Separation / *isolated from*

Attr (Ôm) = *blood of AIDS infected people*

Ôm = *lymphoid cells*

[0068] Input sentence fragment 8:

one-dimensional hologram pattern transferred to matrix electrode

Output:

P = Transfer / *transferred to*

Attr (Ôm) = *matrix electrode*

Ôm = *one-dimensional hologram pattern*

[0069] The components Ôm proper can also be predicate elements. In the above examples, that is, for instance, Ôm = *freely suspended cylinder*, Ôm = *one-dimensional hologram pattern*. It should be noted that for information retrieval and summarization purposes it is beneficial to recognize the structure of Subject, Object and Indirect object, that is Attr (Ôm) and Ôm than the types of relation P.

[0070] The recognition of all these elements is implemented by means of the corresponding Recognizing Linguistic Models. These models describe rules that use the part-of-speech tags, lexemes and syntactic categories, which are then used to extract from the parsed text eSAOs with finite actions, non-finite actions, and verbal nouns. One example of an action extraction rule is:

<HVZ><BEN><VBN> then (<A>=<VBN>)

[0071] This rule means that "if an input sentence contains a sequence of words wl, w2, w3 which at the step of part-of-speech tagging obtained HVZ, BEN, VBN tags, respectively, then the word with VBN tag in this sequence is an Action". For example, *has*_HVZ *been*_BEN *produced*_VBN **then** (A = produced).

[0072] The rules for extraction of Subject, Action and Object are formed as follows:

[0073] 1. To extract the Action, tag chains are built, e.g., manually, for all possible verb forms in active and passive voice with the help of a classifier. For example, *have been produced* = <HVZ><BEN><VBN>.

[0074] 2. In each tag chain the tag is indicated corresponding to the main notion verb (e.g., in the above example - <VBN>). Also, the type of the tag chain (e.g., active or passive voice) is indicated.

[0075] 3. The tag chains with corresponding indexes formed at steps 1-2 constitute the basis for linguistic modules extracting Action, Subject and Object. Noun groups constituting Subject and Object are determined according to the type of tag chain (e.g., active or passive voice).

[0076] There are more than one hundred rules in the exemplary embodiment of the present invention for action extraction. Generally, these rules take the above form and are created according to the above steps. As will be appreciated by those skilled in the art, rules of extraction are similarly formed for Subject and Object.

[0077] The recognition of such elements as Indirect Object, Adjective and Adverbial is

implemented in the substantially the same way, that is, taking into account the tags and the structure itself of the syntactical parsed tree.

[0078] Recognition of Subject, Object and Indirect Object attributes is carried out on the basis of the corresponding Recognizing Linguistic Models. These models describe rules (i.e., algorithms) for detecting subjects, objects, their attributes (e.g., placement, inclusion, parameter, and so on) and their meanings in the syntactic parsed tree.

[0079] To identify parameters of an Object (e.g., Indirect Object, Subject) a Parameter Dictionary is used. A standard dictionary defines whether a noun is an object or a parameter of an object. Thus, a list of such attributes can easily be developed and stored in linguistic knowledge base 150 of FIG. 1. For example, temperature (= parameter) of water (= object). To identify attributes such as placement, inclusion and so on., linguistic knowledge base 150 includes a list of attribute identifiers, i.e. certain lexical units. For example, to place, to install, to comprise, to contain, to include and so on. Using such lists, the summarizer may automatically mark the eSAOs extracted by an eSAO extractor that corresponds to the attributes.

[0080] These algorithms work with noun groups and act like linguistic patterns that control extraction of above-mentioned relations from the text. For example, for the relations of type parameter-object, basic patterns are:

<Parameter> of <Object> and <Object> <Parameter>

[0081] The relation is valid only when the lexeme which corresponds to <parameter> is found in the list of parameters included in the linguistic knowledge base 150. These models are used in attribute recognition, step 506 of FIG. 5, of the semantic analyzer module. Thus, the semantic analyzer outputs, in step 506, an eSAO in the form of a set of 7 fields, where some of the fields may be empty, as previously discussed.

[0082] Also, in FIG. 5 step 508, a cause-effect relations recognizer uses the Recognizing Linguistic Models for detecting semantic relations between eSAOs, which are stored into linguistic knowledge base 150. These models describe algorithms for detecting cause-effect relations between eSAOs using linguistic patterns, lexemes and predefined codes (or tags) from a list of codes (or tags). The cause-effect relations recognizer recognizes semantic relations such as Cause-Effect between eSAOs (complete or incomplete). For this purpose, a large corpus of sentences which include two or more eSAOs (complete or incomplete) automatically extracted by cause-effect relations recognizer are analyzed to build a list of patterns or identifiers (i.e., certain lexical units) indicating the presence of the semantic relations in the sentence. Each type of identifier designates which of the eSAOs is Cause and which is Effect. For example:

1. "*if* eSAO-1=Cause *then* eSAO-2=Effect" This phrase means that if two

eSAOs are found in a sentence, the first one preceded by word "if" and the second one preceded by word "then", then the first eSAO is considered the Cause and the second one is considered the Effect.

2. "eSAO-1=Effect *if* eSAO-2=Cause" This phrase means that the first of two eSAOs is considered the Effect and the second one is considered the Cause if there is a word "if" is between them.

[0083] Such a list of identifiers makes it possible to automatically recognize semantic relations between eSAOs. As will be appreciated by those skilled in the art, these are two examples of the many identifiers that may defined. These patterns describe the location of cause and effect in the input sentence. For example, the condition: *when caused + TO + VB* shows that the Cause is to the right of the word *caused* and is expressed by an infinitive and a noun group that follows it. The Effect is to the left from the word *caused* and is expressed by a noun group, e.g.:

Isolated DNA regulatory regions can be employed, for example, in heterologous constructs to selectively alter gene expression.

Cause:

Subject: *Isolated DNA regulatory regions*
Action: *can be employed*
Adjective:
Object:
Preposition: *in*
Indirect Object: *heterologous constructs*
Adverbial:

Effect:

Subject:
Action: *to alter*
Adjective:
Object: *gene expression*
Preposition:
Indirect Object:
Adverbial: *selectively*

[0084] Thus, with reference to FIG. 3 and FIG. 5, the output of the semantic analysis 306 is a functionally analyzed document 320, that is a document in which eSAOs (complete or incomplete) with attributes for S, A, O and their inner structure and Cause-Effect relations

between eSAOs are recognized. The functionally analyzed document is passed to document sentence weighting, step 108 of FIG. 1.

[0085] The document sentences weighting module, the method of which is depicted in FIG. 6, determines and assigns weights to sentences 602 of the document 320. That is, the document sentences weighting module evaluates quantitatively the importance of each sentence 602 of the document. In the preferred form, one or more of three types of weighting are used, as described below, although other types of weighting could be used.

[0086] Statistical weighting (or St-weighting), 604 in FIG. 6, is based on assessing the weight of each sentence by calculating the frequency of its words and, thus, determining whether the sentence would be relevant in the summary. In preferred embodiment, the statistical weighting method is used to calculate the weight of eSAOs, so extraction of eSAOs is first required. However, in other embodiments, sentence weighting may be first accomplished, and then eSAO extraction. In the preferred form, the weight of a sentence is equal to the maximum weight of all of its eSAOs. At a first stage the weighting module calculates frequencies of notion words (meaning words tagged as verbs, nouns, adjectives or adverbs). On the whole, in the preferred embodiment, there are 32 such tags, shown in FIG. 7. However, in other embodiments, the set of tags may be fewer, greater or different than those shown in FIG. 7. It also makes a difference whether the tagged word is an object proper or whether it is an attribute of an object. For example, a tagged word that is an object proper may be weighted more heavily than a tagged word that is an object attribute. The frequencies calculated are then modified according to a formula (below) depending on the part of document (e.g., patent or article) where the word was found. For example, the frequency may be modified according to the following:

$$Qmodified = Qreal * kmax,$$

where kmax is the maximum of weight coefficients (specified in a table) among those defined for the document (e.g., patent or article), Qreal is the determined weights and Qmodified is the modified weight. For instance, assume the document was an issued U.S. patent or an article, the coefficients may be defined according to Table 3.

Part of a patent	**Weight coefficient**	**Part of an article**	**Weight coefficient**
Title	5	Title	5
Abstract	1	Abstract	1
Background	1	Introduction	1
Summary	2	Discussion	0.8
Drawings	1	Conclusion	1

Embodiment	0.8		
Description	0.8		
Conclusion	1		
Claims	1.5		

Table 3 - Weight Coefficients

[0087] Words with a frequency lower then the average for the text are sorted out. The average frequency is determined by

$$f = t/m$$

where *t* is the number of all forms of notion words in the text, *m* is the number of all lemmas of notion words in the text, including synonyms. The weight of an eSAO is calculated by division of the sum of frequencies of its elements by the total number of words in the eSAO.

[0088] Cue-weighing, item 606 in FIG. 6, provides a quantitative score of the importance of the information (or "informativity"), taking into account explicit lexical signs of importance, i.e., separate words and phrases. Such cue words are determined as a function of lexical patterns of sentences, phrases or other text. As an example, it is known in the art that, thorough analysis of a large number of documents, these patterns can be determined. Additionally, the weight of each pattern, i.e., positive or negative, can also be determined from this same analysis. In such cases, *positive* corresponds to informative and *negative* corresponds to uninformative.

[0089] Examples of such patterns are as follows:

1. Cue pattern utilized to select sentences characterizing feature of the invention:

(economical + $Formula (technique | technology) {$p = 3 } + of { $P = 1 })
{ $W = 0.9 }

This pattern selects sentences containing a phrase like "economical : technology of", where the dots means two or less words. The weight of this pattern is 0.9, in the preferred embodiment. It is taken as Wcue for sentences corresponding to the above pattern.

[0090] 2. Cue pattern utilized to filter uninformative sentences from the summary may be determined according to the following:

Relation ($Type = ESAO
Subject (!$Every { $a })
Action (contain)
Object (design & feature | design & embodiment)

Preposition (in)

IndirectObject (figure:figures)

)) {$W = 100}

This pattern selects sentences containing a specific relationship, which indicates that the sentence is for locating the design of embodiment in some figures. The weight of this pattern is 100 and the weight of corresponding sentences is decreased by 100 percent. The final estimation of sentence will be 0. In the preferred form, there exists over 600 of these "positive" patterns and nearly 250 "negative" patterns. As will be appreciated by those of ordinary skill in the art, these patterns can be generated as a function of analysis of commonly available documents, without undue experimentation.

[0091] CE-weighing, item 608 in FIG. 6, provides quantitative scores of a sentence having a Cause-Effect relationship, i.e., if a Cause-Effect relationship is detected within a sentence, this sentence is given a certain weight. The output weight W of the sentence weighting module, which contains the weight of every sentence of the document, is calculated using the following formula:

$$W = a_{st} * W_{st} + a_{cue} * W_{cue} + a_{ce} * W_{ce}$$

where:

W_{st} - statistical score of the sentence;

W_{cue} - cue score of the sentence (0, if cue words were not found);

W_{ce} - CE-score of the sentence (0, if the sentence did not contain cause-effect relations);

a_{st}, a_{cue}, a_{ce} - preliminarily provided values for each weight type.

[0092] The value of the weight of each sentence varies from -1 to 1, and the values of all other weight elements of the formula vary from 0 to 1.

[0093] As an example of the weighting module output, the preferred embodiment of the present invention may be applied to U.S. Patent No. 5,742,908.

[0094] 1. Document preformatting.

In the given patent the following text parts were determined: Title of patent, Abstract, Background, Summary, Drawing, Description, and Claims. The preferred summarizing algorithm may be appreciated by applying it to a sentence from Description of the patent. Therefore, as an example, assume the following input sentence:

According to one embodiment of the present invention, the satellite can

precompensate its transmit frequency so that the error due to Doppler is cancelled at the center of the cell or beam.

[0095] 2. Linguistic analysis of the document.

As a result of the lexical-grammatical analysis every word and set phrase of the sentence obtains a lexical-grammatical code, as follows:

*According to*_IN *one*_CD1 *embodiment*_NN *of*_N *the*_ATI *present*_JJ *invention*_NN ,_, *the*_ATI *satellite*_NN *can*_MD *precompensate*_VB *its*_PP$ *transmit*_NN *frequency*_NN *so that*_CS *the*_ATI *error*_NN *due to*_IN *Doppler*_NP *is*_BEZ *cancelled*_VBN *at*_IN *the*_ATI *center*_NN *of*_IN *the*_ATI *cell*_NN *or*_CC *beam*_NN ._.

[0096] As a result of the grammatical and semantic analysis, the following semantic relations are identified for the given sentence: two SAOs (Table 4) and one Cause-Effect (Table 5). For brevity, a simplified version of the eSAO is shown, that is SAO:

Subject	**Action**	**Object**
Satellite	precompensate	its transmit frequency
X	cancel	error

Table 5 - Sample Partial SAO

[0097] Table 2

Cause	**Effect**
satellite - precompensate - its transmit frequency	X - cancel - error

Table 6 - Sample Partial Cause - Effect

[0098] According to the algorithm, only some words are informative, the codes (or tags) of which are included in the list of 32 meaningful tags in FIG. 7. In the given sentence such words are: embodiment, present, invention, satellite, precompensate, transmit, frequency, error, Doppler, cancelled, center, cell, beam (see Table 7).

[0099] 3. Getting statistical SAO estimation.

In this example, a combination of positional method (when calculating the word frequency) and statistical method is used. In table 7, in the last column the frequencies of the words that will be used to calculate the SAO estimation are cited. For instance, the word "frequency" occurred in the text 85 times in different text parts, including the Title. As this text

part has the greatest weight coefficient (being equal to 5), the modified value will be: 85 * 5 = 425, for use in further calculations. The average frequency of word occurrence in the given patent is 4.47, which is why all words with a lesser frequency are not considered in the further analysis. In this case, the words "precompensate" and "cancel" do not meet the average.

Word lemma	**Real frequency**	**Text part which used to compute final frequency**	**Final frequency**
Embodiment	11	Summary	22
Present	18	Summary	36
Invention	23	Summary	46
Satellite	66	Summary	132
Precompensate	4	Description	0
Transmit	9	Summary	18
Frequency	85	Title	425
Error	31	Title	155
Doppler	50	Summary	100
Cancel	1	Description	0
Center	10	Description	8
Cell	13	Description	10.4
Beam	28	Description	22.4

Table 7 - Word Frequency

[00100] The maximum unnormalized statistical SAO estimation in the given text (marked as "M") is equal to 425. The estimations of SAOs are calculated in the given sentence as follows:

a) The first SAO contains three informative words: satellite, transmit, and frequency.

Unnormalized estimation: (132 + 18 + 425) / 3 = 191.67

Normalized estimation: $W_{st}' = 191.67 / M = 0.45$

b) The second SAO contains one informative word: error.

Unnormalized estimation: 155 / 1 = 155

Normalized estimation: $W_{st} = 155 / M = 0.36$

[00101] 4. Getting an estimation from cue words.

In the given sentence one of the patterns from the linguistic knowledge base 150 was found:

"embodiment of ... invention"

Its formal description is the following:

($Formula (arrangement | embodiment) + of { $p = 1 } + invention { $p = 3})

{ $w = 0.3}

The estimation of the weight of the given pattern is equal to 0.3, i.e. we have $W_{cue} = 0.3$.

[00102] 5. Getting estimation from Cause-Effect.

Cause-Effect is a special type of a cue word with a permanent, preset weight of 0.8. In this case, as Cause-Effect is present in the sentence (see Table 7), where $W_{ce} = 0.8$.

[00103] 6. Getting final estimation of a sentence.

The final SAO estimation is calculated using the formula:

$$W = a_{st} * w_{st} + a_{cue} * W_{cue} + a_{ce} * W_{ce}$$

where a_{st}, a_{cue}, a_{ce} are coefficients preset according to the results of the research. For example, their values are: $a_{st} = 0.6$, a_{cue} 0.2, $a_{ce} = 0.2$. Accordingly, we have:

a) $W1 = 0.6 * 0.45 + 0.2 * 0.3 + 0.2 * 0.8 = 0.49$

b) $W2 = 0.6 * 0.36 + 0.2 * 0.3 + 0.2 * 0.8 = 0.44$

The final estimation of the sentence is equal to the largest SAO estimation, i.e. 0.49. According to the results of the comparison to other sentences, this estimation lets the given sentence get in the summary of the document.

[00104] After the weighted score for each sentence of the document is obtained in step 130 of FIG. 1, the document is sent to the input of the summary generator, in step 802 FIG. 8, which can generate a certain type of summary from one or more available summary types, depending on the request. The request may come from a user, or some other system or subsystem. As examples, one or more of the following types of document summaries may be generated:

[00105] 1. Keyword Summary, in step 804, produces a summary in the form of a list of keywords that are weighted noun groups (e.g., subjects and objects of complete or incomplete eSAO). These keywords are sorted by their St-weighted values, from the largest value to the smallest. A part of such a summary 900 for US Patent 5359324 is shown in FIG. 9.

[00106] 2. Topic-oriented Summary, in step 806, produces a structured keyword summary 1000, as shown in FIG. 10.

[00107] 3. eSAO Summary, in step 808, produces a summary presented as a list of eSAOs of the document, sorted by their weight, calculated as previously described. A part of such summary 1100 for the above mentioned patent is shown in FIG. 11.

[00108] There is a possibility to obtain a readable text representation of all of the above mentioned types of summary. This text would contain a list of the sentences in the summary along with corresponding elements, i.e. keywords, topics, and eSAOs. Sentences adjacent and logically bound to the sentences found are also included in this list. As previously noted, such logical connections are recognized by means of a set of patterns available from the linguistic knowledge base 150. Moreover, in the case of eSAO-summary, another type of summarized text representation can be obtained if requested by the user, which has the form of a list of simple sentences grammatically, correctly generated from the eSAOs found.

[00109] 4. Classic Summary, in step 810, produces a document summary in the form of a list of the most informative sentences of the document, having their 'informativeness' calculated according to the formula described above. The order in which the sentences appear in the original document is conserved while presenting the summary. FIG. 12 shows a part of such a summary 1200.

[00110] 5. Field-oriented Summary, in step 812, produces a summary as a set of predefined fields. Below is shown a variant of the nomenclature of such fields, as well as the nomenclature of document parts from which they are obtained.

Summary Field	**Patent parts used**	**Article parts used**
Task	Background, Summary, Abstract	Introduction
Solution	Summary, Description, Embodiments, Conclusions	Introduction, Discussion, Conclusion.
Features	Abstract, Description, Embodiments, Conclusions	Introduction, Discussion, Conclusion
References	Patent number, Title, Date, Inventor(s), Assignee	Title, Author(s)

Table 8 - Summary Fields for Documents

[00111] The summary generator, which may be a module configured to implement any of the foregoing document summaries, or other summaries (if defined), selects the most informative sentences (their weight is calculated using weighting formulae above) for each field of the

summary, using "its own" parts of the document. This helps to avoid duplication of the sentences based on the priority of the fields of the summary provided by a user, for example. A part of such a summary 1300 is shown in FIG. 13.

[00112] Classic and Field-oriented summary generators may provide a certain amount of contraction, for example, deleting of an introductory part or sentences included in the summary. This function is implemented via linguistic patterns. Their number is about 120 in the preferred embodiment. Samples of these patterns are as follows:

1. Cue patterns utilized to delete parenthesis.

($Formula ('c_VBN' { $p = 1} + in {$p = 1} + word {$p = 2} + 'c_Comma' { $a & $p = 1})
{ $r = ""})

2. Find and delete phrases like "Expressed in other words", "In that case", At this/that rate", "Due to such considerations", and so on.

($Formula ($Formula (in | on | to | by | at | under | due^to) +
$Formula (this | that | other | all | such | any | each | either | similar | these | most^of) {$p = 2} +
$Formula (end | case | basis | connection | context | way | mean:'c_NNS' | regard | manner | fashion | event | example | rate | circumstances | consideration) { $p = 2 } +
c'_Comma' { $p = 1 & $a}) { $r = ""})

[00113] While the foregoing has described what are considered to be the best mode and/or other preferred embodiments, it is understood that various modifications may be made therein and that the invention or inventions may be implemented in various forms and embodiments, and that they may be applied in numerous applications, only some of which have been described herein. As used herein, the terms "includes" and "including" mean without limitation. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the inventive concepts.

CLAIMS

1. A method for summarizing the contents of a natural language document including a plurality of sentences and provided in electronic or digital form, said method comprising:

A. extracting from said document eSAOs, including extracting subjects, objects, and actions and extracting one or more of adjectives, prepositions, indirect objects and adverbials;

B. determining a weight for each eSAO;

C. for each sentence in said document, using the weights of all eSAOs for said sentence to obtain a sentence weight; and

D. generating one or more document summaries as a function of said sentence weights.

2. The method of claim 1, further including in step A determining attributes for at least some of said subjects, objects, and indirect objects, wherein an attribute represents a word or phrase having a relationship to the subject, object, or indirect object for which it is an attribute.

3. The method of claim 2, wherein said relationship is one or more of a feature, inclusion, placement, formation, connection, separation, or transfer.

4. The method of claim 3, wherein said relationship is a feature of a type of parameter.

5. The method of claim 1, wherein step A includes determining Cause - Effect relationships between said eSAOs.

6. The method of claim 1, wherein step B is accomplished using statistical weighting, including determining said eSAO weight as a function of the frequency of appearance of components of said eSAOs in said document.

7. The method of claim 6, wherein the statistical weight of said sentence is a function of the maximum weight of each eSAO in said sentence.

8. The method of claim 1, further including determining a cue weight for each sentence using cue weighting, including determining said cue weight as a function of a quantitative

importance of assigned to words and phrases, wherein said sentence weights are further determined as a function of said cue weights.

9. The method of claim 8, further including determining a Cause-Effect weight for each sentence using Cause-Effect weighting, including determining said Cause-Effect weight as a function of a quantitative score assigned to words and phrases having a Cause-Effect relationship, wherein said sentence weights are further determined as a function of said Cause-Effect weights.

10. The method of claim 1, further including determining a Cause-Effect weight for each sentence using Cause-Effect weighting, including determining said Cause-Effect weight as a function of a quantitative score assigned to words and phrases having a Cause-Effect relationship, wherein said sentence weights are further determined as a function of said Cause-Effect weights.

11. The method of claim 1, wherein one or more document summaries are selectable from a set of document summary types including at least one of a key-word summary, a topic-oriented summary, an eSAO summary, a classic summary, and a field-oriented summary.

12. The method of claim 1, wherein step D includes contracting said document summary by deleting introductory phrases and sentences as a function of a set of document patterns, wherein said document patterns identify said introductory phrases and sentences as having low relevance.

13. A method for summarizing the contents of a natural language document provided in electronic or digital form, said method comprising:

A. performing linguistic analysis, including:

i) tagging substantially each word as a function of a part of speech of said word;

ii) parsing verbal sequences and noun phrases from said tagged words; and

iii) building a syntactical parsed tree from said verbal sequences and noun phrases, according to a set of rules, wherein words grouped by a rule become inaccessible to other rules;

B. weighting each sentence in the document as a function of quantitative importance and said syntactical parsed tree; and

C. generating one or more document summaries, from a plurality of selectable document summary types, as a function of the sentence weights.

14. The method claim 13, further comprising, before step A:

D. preformatting the document, including:

i) removing symbols that are not part of the natural language text;

ii) correcting mismatches and misspellings;

iii) dividing the document into words and sentences; and

iv) recognizing document fields.

15. The method of claim 13, wherein step A includes extracting from said document eSAOs, including extracting subjects, objects, and actions and extracting one or more of adjectives, prepositions, indirect objects and adverbials;

16. The method of claim 14, wherein step B includes determining a weight for each eSAO.

17. The method of claim 14, wherein step B includes determining a cue weight for each sentence.

18. The method of claim 14, wherein step B includes determining a Cause-Effect weight for each sentence.

19. A system for summarizing the contents of a natural language document provided in electronic or digital form, said system comprising:

A. at least one memory having a set of linguistic rules stored therein;

B. a linguistic analyzer coupled to said at least one memory and configured for:

i) a tagging substantially each word as a function of a part of speech of said word;

ii) parsing verbal sequences and noun phrases from said tagged words; and

iii) building a syntactical parsed tree from said verbal sequences and noun phrases, according to said set of rules, wherein words grouped by a rule become inaccessible to other rules;

C. a sentence weighting module configured to access said syntactical phrase tree and to weight each sentence in the document as a function of quantitative importance

and said syntactical parsed tree; and

D. a summary generating for one or more document summaries, from a plurality of selectable document summary types, as a function of the sentence weights.

20. The system as in claim 19, further comprising:

E. a preformatter configured for:

i) removing symbols that are not part of the natural language text;

ii) correcting mismatches and misspellings;

iii) dividing the document into words and sentences; and

iv) recognizing document fields.

21. The system of claim 19, wherein said linguistic analyzer includes an eSAOs extractor, configured for extracting subjects, objects, and actions and further configured for extracting one or more of adjectives, prepositions, indirect objects and adverbials.

22. The system of claim 21, wherein said sentence weighting module is further configured for determining a weight for each eSAO.

23. The system of claim 21, wherein said sentence weighting module is further configured for determining a cue weight for each sentence.

24. The system of claim 21, wherein said sentence weighting module is further configured for determining a Cause-Effect weight for each sentence.

25. A system for summarizing the contents of a natural language document including a plurality of sentences and provided in electronic or digital form, said system comprising:

A. at least one memory having a set of linguistic rules stored therein;

B. a linguistic analyzer coupled to said at least one memory and configured for extracting from said document eSAOs, including extracting subjects, objects, and actions and extracting one or more of adjectives, prepositions, indirect objects and adverbials;

C. a weighting module for determining a weight for each eSAO and, for each sentence in said document, using the weights of all eSAOs for said sentence to obtain a sentence weight; and

D. a summary generator for generating one or more document summaries as a function of said sentence weights.

26. The system of claim 25, wherein said linguistic analyzer is further configured for determining attributes for at least some of said subjects, objects, and indirect objects, wherein an attribute represents a word or phrase having a relationship to the subject, object, or indirect object for which it is an attribute.

27. The system of claim 26, wherein said relationship is one or more of a feature, inclusion, placement, formation, connection, separation, or transfer.

28. The system of claim 27, wherein said relationship is a feature of a type of parameter.

29. The system claim 25, wherein said linguistic analyzer is further configured for determining Cause - Effect relationships between said eSAOs.

30. The system of claim 25, wherein said weighting module is configured for performing statistical weighting, including determining said eSAO weight as a function of the frequency of appearance of components of said eSAO in said document.

31. The system of claim 30, wherein the weight of said sentence is a function of the maximum weight of each eSAO in said sentence.

32. The system of claim 25, wherein said weighting module is further configured for determining a cue weight for each sentence using cue weighting, including determining said cue weight as a function of a quantitative importance of assigned to words and phrases, wherein said sentence weights are further determined as a function of said cue weights.

33. The system of claim 32, wherein said weighting module is further configured for determining a Cause-Effect weight for each sentence using Cause-Effect weighting, including determining said Cause-Effect weight as a function of a quantitative score assigned to words and phrases having a Cause-Effect relationship, wherein said sentence weights are further determined as a function of said Cause-Effect weights.

34. The system of claim 25, wherein said weighting module is further configured for determining a Cause-Effect weight for each sentence using Cause-Effect weighting, including determining said Cause-Effect weight as a function of a quantitative score assigned to words and phrases having a Cause-Effect relationship, wherein said sentence weights are further determined as a function of said Cause-Effect weights.

35. The system of claim 25, wherein said one or more document summaries are selectable from a set of document summary types including at least one of a key-word summary, a topic-oriented summary, an eSAO summary, a classic summary, and a field-oriented summary.

36. The system of claim 25, wherein said summary generator is further configured for contracting said document summary by deleting introductory phrases and sentences as a function of a set of document patterns, wherein said document patterns identify said introductory phrases and sentences as having low relevance.

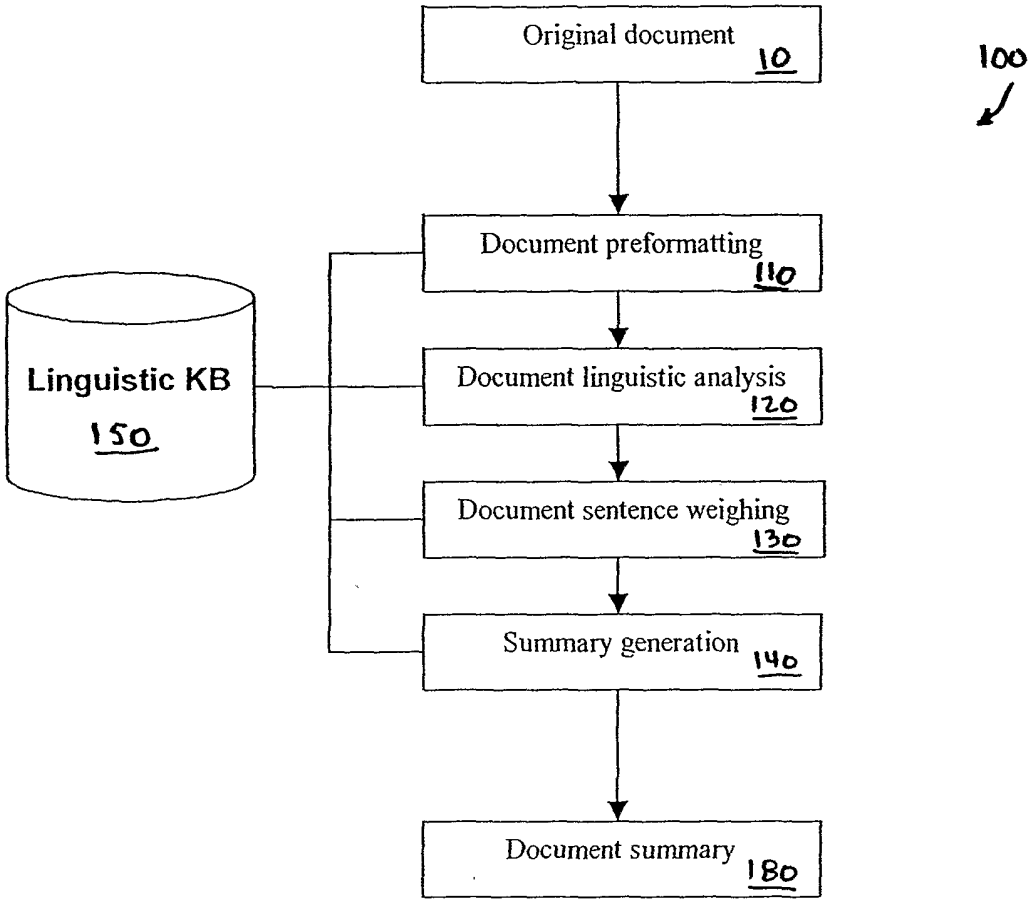
Original document
10
100
Document preformatting
110
Linguistic KB
150
Document linguistic analysis
120
Document sentence weighing
130
Summary generation
140
Document summary
180

Fig. 1

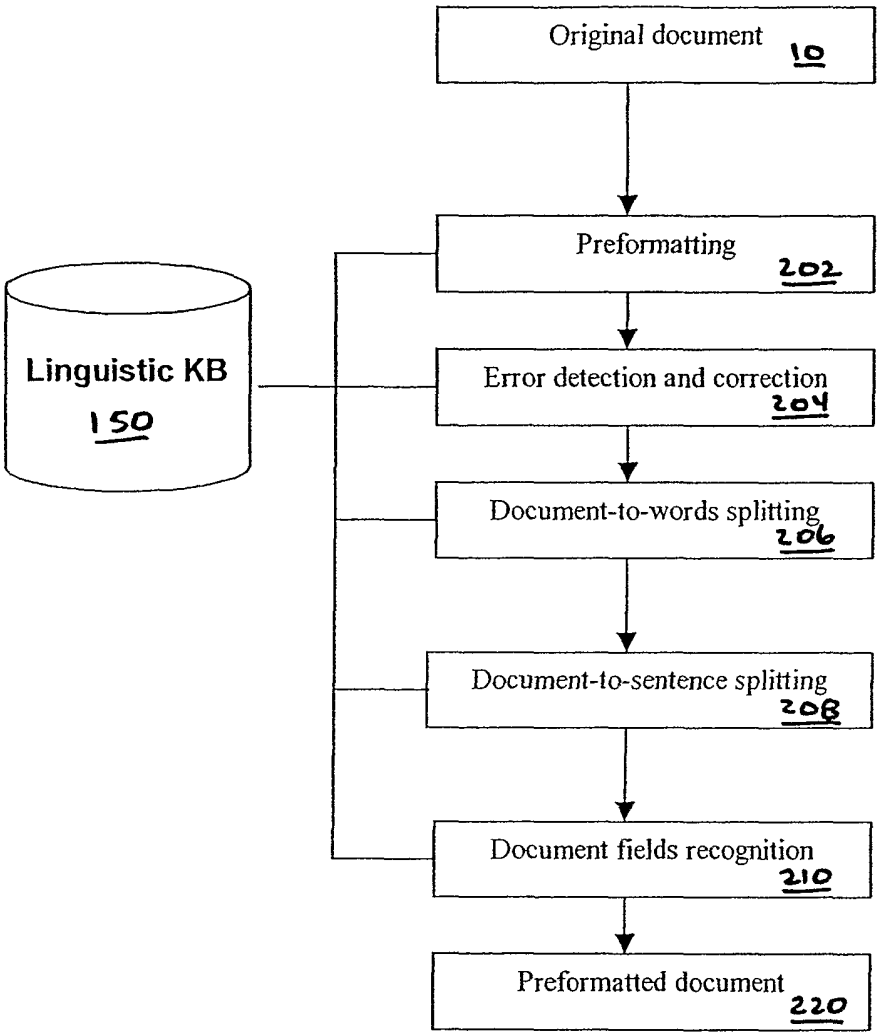
Original document
10
Preformatting
202
Linguistic KB
150
Error detection and correction
204
Document-to-words splitting
206
Document-to-sentence splitting
208
Document fields recognition
210
Preformatted document
220

Fig. 2

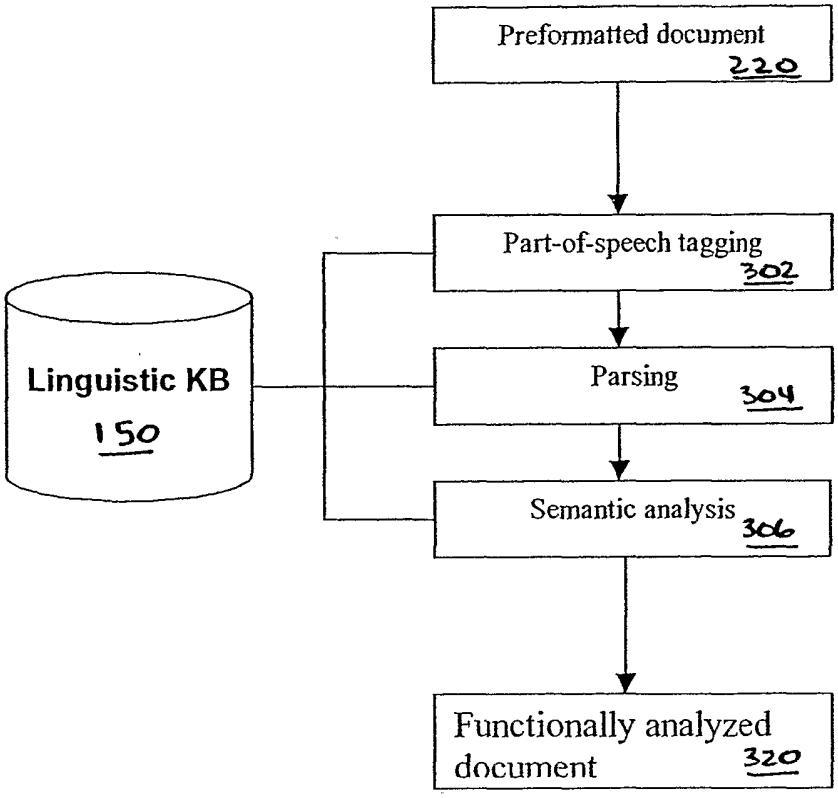
Preformatted document
220
Part-of-speech tagging
302
Linguistic KB
150
Parsing
304
Semantic analysis
306
Functionally analyzed document
320

Fig. 3

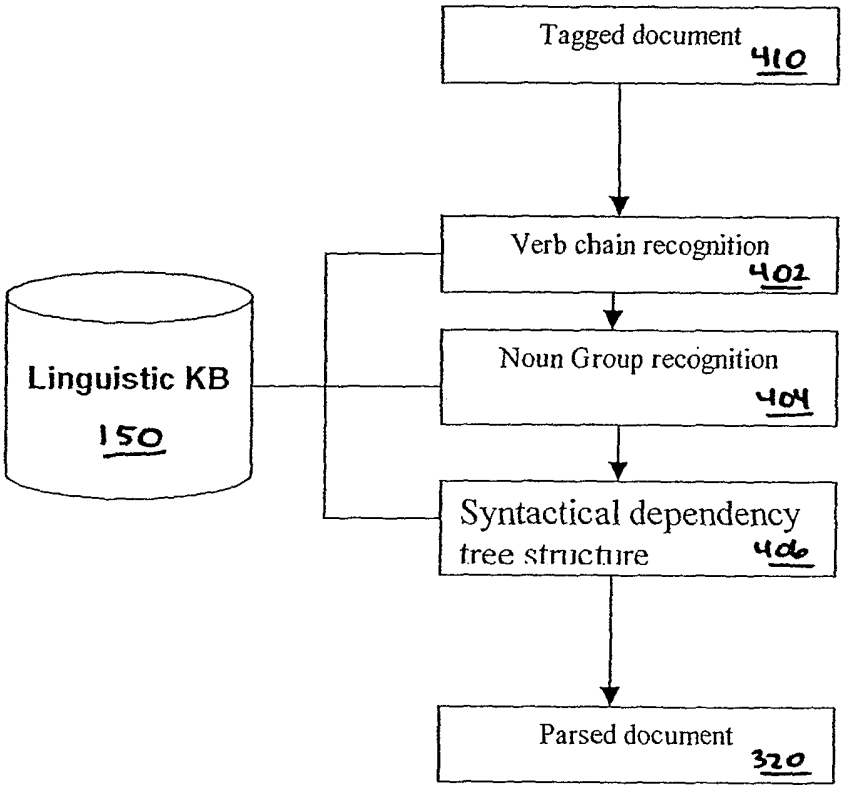
Tagged document
410
Verb chain recognition
402
Noun Group recognition
404
Syntactical dependency
tree structure
406
Linguistic KB
150
Parsed document
320

Fig. 4

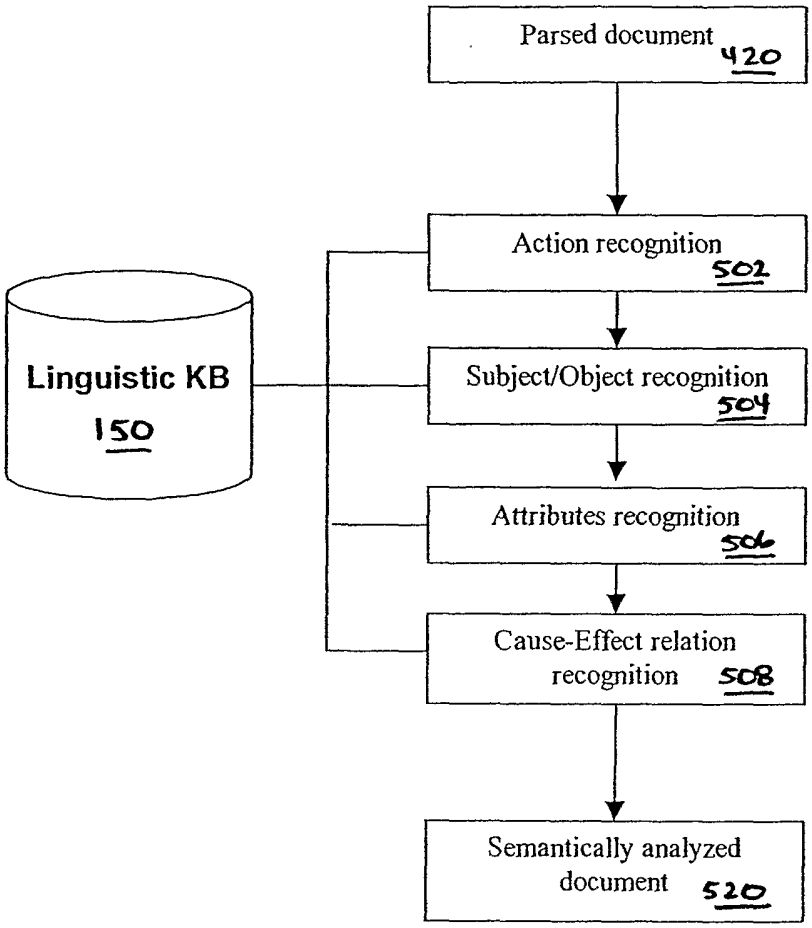
Parsed document 420
Action recognition 502
Subject/Object recognition 504
Attributes recognition 506
Cause-Effect relation recognition 508
Semantically analyzed document 520
Linguistic KB 150

Fig. 5

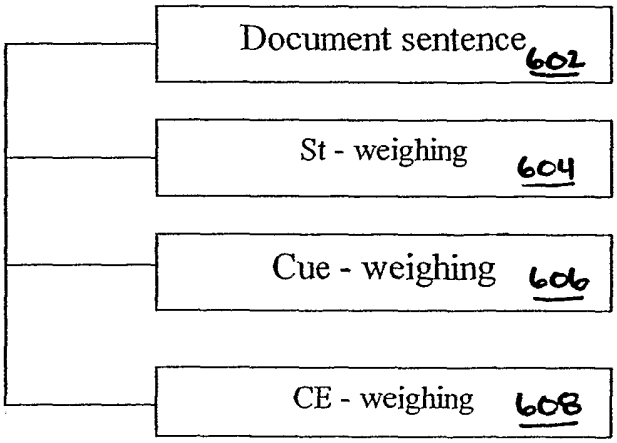
Document sentence 602
St - weighing 604
Cue - weighing 606
CE - weighing 608

Fig. 6

JJ	adjective
JJB	adjective, attributive-only
JJed	past participle in attributive function in pre-position
JJing	present participle in attributive function in pre-position
JJR	adjective, comparative degree
JJT	adjective, superlative degree
JNP	capitalized adjective
NN	common noun singular
NNP	capitalized common noun singular
NNPS	capitalized common noun plural
NNS	common noun plural
NNU	abbreviaton of units of measure without a specific number
NNUS	abbreviation of units of measure, plural
NP	proper noun singular
NPL	capitalized locative noun singular
NPLS	capitalized locative noun plural
NPS	proper noun plural
NPT	capitalized proper noun singular denoting title or rank
NPTS	capitalized proper noun plural denoting title or rank
NR	adverbial noun singular
NRS	adverbial noun plural
RB	adverb
RBR	adverb, comparative degree
RBT	adverb, superlative degree
RI	adverb, omograph of preposition
RN	nominal adverb
RP	postposition (adverbial particle)
VB	infinitive or verb in its present simple tense form except 3d person singular
VBD	verb simple past tense form
VBG	present participle
VBN	past participle
VBZ	verb in its simple present 3d person singular tense form

FIG. 7.

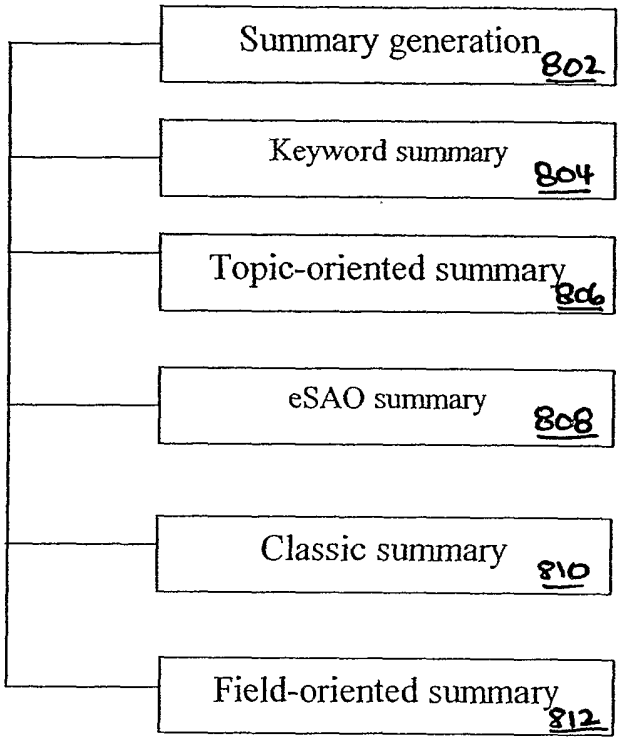
Summary generation
802
Keyword summary
804
Topic-oriented summary
806
eSAO summary
808
Classic summary
810
Field-oriented summary
812

Fig. 8

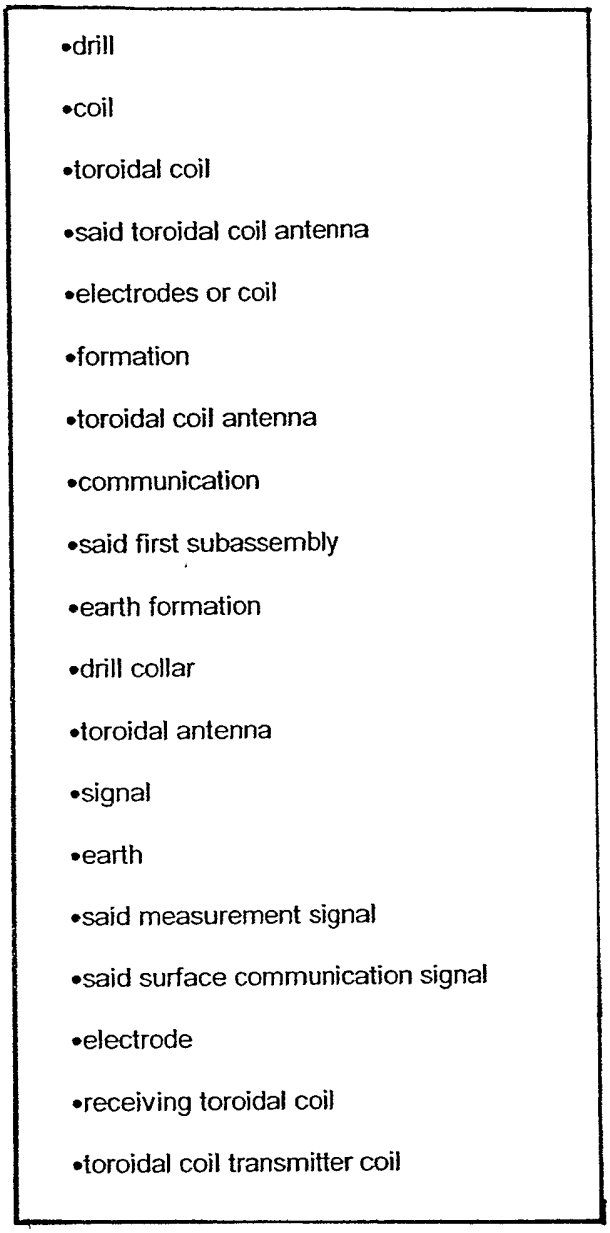
•drill
•coil
•toroidal coil
•said toroidal coil antenna
•electrodes or coil
•formation
•toroidal coil antenna
•communication
•said first subassembly
•earth formation
•drill collar
•toroidal antenna
•signal
•earth
•said measurement signal
•said surface communication signal
•electrode
•receiving toroidal coil
•toroidal coil transmitter coil

FIG. 9

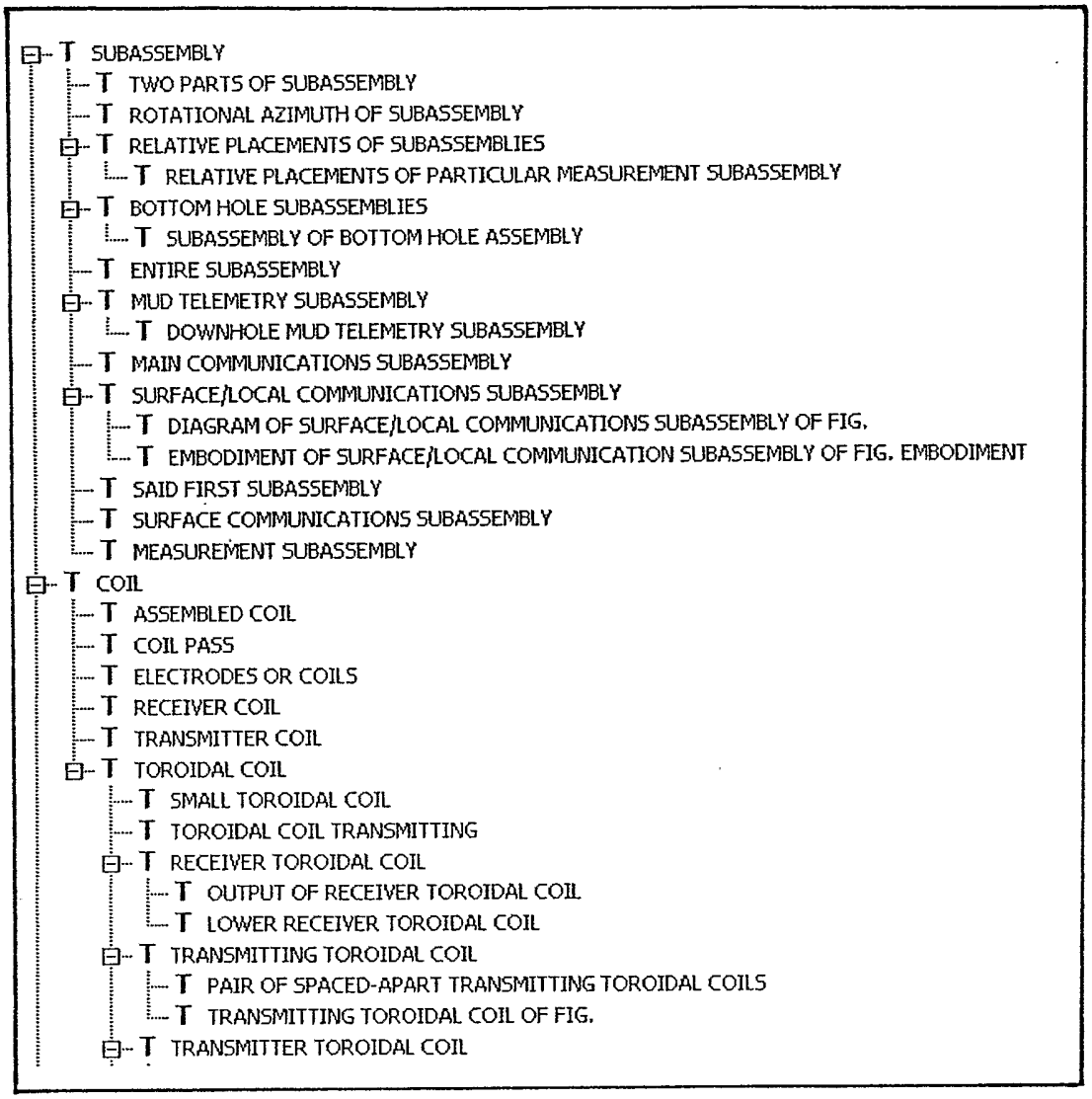
SUBASSEMBLY
TWO PARTS OF SUBASSEMBLY
ROTATIONAL AZIMUTH OF SUBASSEMBLY
RELATIVE PLACEMENTS OF SUBASSEMBLIES
RELATIVE PLACEMENTS OF PARTICULAR MEASUREMENT SUBASSEMBLY
BOTTOM HOLE SUBASSEMBLIES
SUBASSEMBLY OF BOTTOM HOLE ASSEMBLY
ENTIRE SUBASSEMBLY
MUD TELEMETRY SUBASSEMBLY
DOWNHOLE MUD TELEMETRY SUBASSEMBLY
MAIN COMMUNICATIONS SUBASSEMBLY
SURFACE/LOCAL COMMUNICATIONS SUBASSEMBLY
DIAGRAM OF SURFACE/LOCAL COMMUNICATIONS SUBASSEMBLY OF FIG.
EMBODIMENT OF SURFACE/LOCAL COMMUNICATION SUBASSEMBLY OF FIG. EMBODIMENT
SAID FIRST SUBASSEMBLY
SURFACE COMMUNICATIONS SUBASSEMBLY
MEASUREMENT SUBASSEMBLY
COIL
ASSEMBLED COIL
COIL PASS
ELECTRODES OR COILS
RECEIVER COIL
TRANSMITTER COIL
TOROIDAL COIL
SMALL TOROIDAL COIL
TOROIDAL COIL TRANSMITTING
RECEIVER TOROIDAL COIL
OUTPUT OF RECEIVER TOROIDAL COIL
LOWER RECEIVER TOROIDAL COIL
TRANSMITTING TOROIDAL COIL
PAIR OF SPACED-APART TRANSMITTING TOROIDAL COILS
TRANSMITTING TOROIDAL COIL OF FIG.
TRANSMITTER TOROIDAL COIL

FIG. 10

	well	logging apparatus
	send	information
	determine	earth formation resistivity
wireline logging	employ	technique
apparatus	determine	resistivity of formation
	surround	earth borehole
	receive	toroidal coil
	transmit	toroidal coil
	obtain	measurement
	obtain	resistivity measurement
	devise	equipment
	provide	resistivity measurement information
	provide	Improvement
system	include	second subassembly
	receive	local communication signal
	generate	surface communication signal
invention	utilize	toroidal coil antenna
	induce	current
path	include	drill collar and earth formation
	mount	toroidal coil antenna
electrode	detect	current
	provide	electrode
transmitter toroidal coil	transmit	current
electrode	provide	azimuthal resistivity measurement
electrode	span	small fraction of total circumferential locus of borehole

FIG. 11

The knowledge is essential to improve climate forecasts.

The particles also can have an indirect cooling effect on climate by acting as seeds for cloud condensation and, increasing the reflectivity, or albedo, of clouds.

With Asia 's population rising at a dramatic rate, the amount of sulfur dioxide released is expected to increase.

FIG. 12

Application :
The invention relates to the field of well logging and, more particularly, to well logging apparatus for determining earth formation resistivity and sending the information to the earth 's surface.

Techniques employed in wireline logging may or may not be adaptable for use in a measurement-while-drilling equipment.

In accordance with an embodiment of the invention, an apparatus is disclosed for determining the resistivity of formations surrounding an earth borehole.

Task :
Resistivity measurements obtained using transmitting and receiving toroidal coils on a conductive metal body are useful, particularly in logging-while-drilling applications, but it would be desirable to obtain measurements which can provide further information concerning the downhole formations; lateral resistivity information having improved vertical resolution, azimuthal resistivity information, and multiple depths of investigation for such resistivity information.

It is among the objects of the present invention to devise equipment which can provide such further resistivity measurement information.

It is among the further objects of the present invention to provide improvement in the efficiency and flexibility of communications in logging-while-drilling systems.

Method :
The system further includes a second subassembly near the drill bit which includes a second conducting body with a second toroidal coil antenna mounted on it and means to receive the local communication signal through the second toroidal coil and means to generate a surface communication signal from the local communication signal and transmit it through an acoustic transmitter to the surface, where it is received by an acoustic receiver.

A form of the present invention utilizes a toroidal coil antenna mounted, in an insulating medium, on a drill collar to induce a current which travels in a path that includes the drill collar and earth formations around the drill collar.

In accordance with a feature of the present invention, at least one electrode is provided on the drill collar and is utilized to detect currents transmitted by the transmitter toroidal coil which return via the formations to the electrode(s) laterally; approximately normal to the axis of the drill collar.

Features :
The electrodes can also provide azimuthal resistivity information.

The electrodes span only a small fraction of the total circumferential locus of the borehole and provide azimuthal resistivity measurements.

In the illustrated embodiment, the surfaces of electrodes 226, 227 and 228 have diameters of about 1 inch, which is large enough to provide sufficient signal, and small enough to provide the desired vertical and azimuthal measurement resolution.

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/24259

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) . : G06F 15/00

US CL : 707/500

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 707/500, 531; 704/9

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,246,977 B1 (MESSERLY et al.) 12 June 2001 (12.06.2001), all.	1-36
Y	US 5,748,973 A (PALMER et al.) 05 May 1998 (05.05.1998), col.7, line 51 - col.8, line 40.	1-36
Y	US 5,708,825 A (SOTOMAYOR) 13 January 1998 (13.01.1998), summary.	1-36

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 September 2002 (13.09.2002)	29 OCT 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Stephen Hong Telephone No. 703-305-9000

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

PCT/US02/24259

Continuation of B. FIELDS SEARCHED Item 3:

EAST