

FEATURE RELATIONSHIP RECOMMENDATION METHOD, APPARATUS, COMPUTING DEVICE, AND STORAGE MEDIUM

TECHNICAL FIELD

5 [0001] The present specification relates to the field of computer security technologies, and in particular, to feature relationship recommendation methods, apparatuses, computing devices, and storage media.

BACKGROUND

10 [0002] As ALIPAY services develop, a security environment of ALIPAY is constantly changing, and manually generating a feature relationship in conventional technologies becomes inefficient.

[0003] Currently, in the existing technologies, the feature relationship is usually recommended by using the following methods: manual search, selection, and determining, but this solution depends on manpower, and brute-force search consumes
15 too many resources.

[0004] A heuristic search algorithm is used to perform search, and then selection is performed by using a certain evaluation model. However, in the solution, service knowledge is not introduced, search space is still large, and it is difficult to find a valid feature relationship.

SUMMARY

20 [0005] In view of this, embodiments of the present specification provide feature relationship recommendation methods, apparatuses, computing devices, and storage media, to alleviate a technical problem in the existing technology.

[0006] Some embodiments of the present specification disclose a feature relationship
25 recommendation method, where the method includes: determining parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities; constructing a knowledge graph based on feature relationships between the parameter instances and

predetermined operator entities; and extracting a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

[0007] According to another aspect, some embodiments of the present specification disclose a feature relationship recommendation apparatus, where the apparatus includes: a determining module, configured to determine parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities; a construction module, configured to construct a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities; and an extraction module, configured to extract a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

[0008] According to another aspect, the present specification further provides a computing device, including a memory, a processor, and computer instructions that are stored in the memory and that can run on the processor, where when executing the instructions, the processor implements step of the feature relationship recommendation method.

[0009] According to another aspect, the present specification further provides a computer readable storage medium, where the computer readable storage medium stores computer instructions, and steps of the feature relationship recommendation method are implemented when the program is executed by a processor.

[0010] The present specification provides feature relationship recommendation methods, apparatuses, computing devices, and storage media. The method includes: determining parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities; constructing a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities; and extracting a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

BRIEF DESCRIPTION OF DRAWINGS

[0011] FIG. 1 is a structural block diagram illustrating a computing device,

according to some embodiments of the present specification;

[0012] FIG. 2 is a flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification;

[0013] FIG. 3 is a schematic diagram illustrating a parameter instance, according to
5 some embodiments of the present specification;

[0014] FIG. 4 is a flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification;

[0015] FIG. 5 is a flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification;

10 [0016] FIG. 6 is a flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification; and

[0017] FIG. 7 is a schematic structural diagram illustrating a feature relationship recommendation apparatus, according to some embodiments of the present specification.

15 DESCRIPTION OF EMBODIMENTS

[0018] Many specific details are described in the following descriptions to facilitate full understanding of the present specification. However, the present specification can be implemented by using many different methods from those described here. A person skilled in the art can perform similar promotion without departing from the intension
20 of the present specification. Therefore, the present specification is not limited to the specific embodiment disclosed below.

[0019] Terms used in some embodiments of the present specification are only used to describe specific embodiments, and are not intended to limit the some embodiments of the present specification. The terms "a" and "the" of singular forms used in some
25 embodiments of the present specification and the appended claims are also intended to include plural forms, unless otherwise specified in the context clearly. It should be further understood that the term "and/or" used in some embodiments of the present specification indicates and includes any or all possible combinations of one or more associated listed items.

30 [0020] It should be understood that although terms "first", "second", "third", etc. may be used in some embodiments of the present specification to describe various types of information, the information is not limited to these terms. These terms are only used to

distinguish between information of the same type. For example, without departing from the scope of some embodiments of the present specification, first can also be referred to as second, and similarly, second can be referred to as first. Depending on the context, for example, the word "if" used here can be explained as "while", "when", or "in response to determining".

[0021] First, technical terms used in some embodiments of the present specification are explained.

[0022] A knowledge graph/vault is also referred to as a scientific knowledge graph, is a knowledge cluster organized in a form of a graph in knowledge engineering, and is formed by using different types of entities as nodes and relationships as edges that connect the nodes.

[0023] Knowledge inference is to supplement and discover new knowledge through certain logical inference based on existing knowledge in the knowledge graph.

[0024] In some embodiments of the present specification, feature relationship recommendation methods, apparatuses, computing devices, and computer storage media are provided. Details are described one by one in the following embodiments.

[0025] FIG. 1 is a structural block diagram of a computing device 100, according to some embodiments of the present specification. Components of the computing device 100 include but are not limited to a memory 110, a processor 120, and a communications interface 140. The processor 120 is connected to the memory 110 by using a bus 130, and a database 150 is configured to store log data of an access request.

[0026] The communications interface 140 enables the computing device 100 to perform communication through one or more networks. Examples of these networks include a local area network (LAN), a wide area network (WAN), a personal area network (PAN), or a combination of communications networks such as the Internet. A network interface can include one or more of any type of wired or wireless network interface (for example, a network interface card (NIC)), for example, an IEEE 802.11 wireless local area network (WLAN) wireless interface, a Worldwide Interoperability for Microwave Access (WiMAX) interface, an Ethernet interface, a Universal Serial Bus (USB) interface, a cellular network interface, a Bluetooth interface, or a Near Field Communication (NFC) interface.

[0027] The memory 110 is configured to store service data sent by the communications interface 140 by using the bus 130 and computer instructions that are stored in the memory 110 and that can run on the processor 120.

[0028] The processor 120 is configured to: after the service data stored in the memory 110 is obtained, execute the computer instructions stored in the memory 110, to verify the to-be-identified object.

[0029] The computing device 100 can be any type of fixed or mobile computing device, including a mobile computer or mobile computing device (for example, a tablet computer, a personal digital assistant, a laptop computer, a notebook computer, or a netbook), a mobile phone (for example, a smartphone), a wearable computing device (for example, a smart watch or smart glasses) or another type of mobile device, or a fixed computing device such as a desktop computer or a PC.

10 [0030] The processor 120 can perform steps in the method shown in FIG. 2. FIG. 2 is a schematic flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification. The method includes step 202 to step 206.

[0031] Step 202: Determine parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities.

[0032] In some embodiments of the present specification, the service data includes but is not limited to transaction data, login data, transfer data, etc.

[0033] The parameter instances are determined based on primary parameters in the service data. The primary parameters are concepts, and the corresponding parameter instances are instances of specific concepts.

[0034] For example, referring to FIG. 3, the primary parameters include entity parameters: an event, an account, a device, and a location. In a specific application scenario, the corresponding parameter instances are instances of specific parameters:
25 An intermediate entity is a certain ALIPAY event eventID: 4a8167a*****, entity 3 and entity 4 each are a certain ALIPAY account ID: 208821***** and 208890*****, entity 2 is a geohash value of location service information of a certain mobile phone device: wm6n, and entity 1 is an IP address of a certain mobile phone device: 117.136.**.*.

[0035] In practice, the parameter instances include but are not limited to specific entities such as events, accounts, identity cards, devices, mobile phone numbers, location based services (LBS), and IP addresses.

[0036] The node entities include but are not limited to device entities, account entities, and/or transaction entities.

[0037] In some embodiments of the present specification, the parameter instances

include node entities and event entities, and the node entities are associated by using the event entities. For example, the node entities include account 1 and account 2, and the event entity is transferring 3 yuan. In this case, the node entities can be associated by using the event entities, to represent transferring 3 yuan from account 1 to account

5 2. In actual use, the association can represent a relationship such as ALIPAY event transaction or login.

[0038] Step 204: Construct a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities.

[0039] In some embodiments of the present specification, the predetermined
10 operator entities can be obtained by using an existing feature. For example, if the existing feature includes "a maximum moving speed of an ALIPAY account ID in a certain time period", a corresponding operator entity includes a gradient operator. If the existing feature includes "historical location dispersion of a certain ALIPAY mobile phone", a corresponding operator entity includes an entropy operator. If the existing
15 feature includes "an accumulated red envelope amount within 3 days of a certain ALIPAY account", a corresponding operator entity includes a sum operator.

[0040] In practice, operators in the feature are first classified based on the existing feature, and different types of operators are named as different operator entities, for example, a velocity operator, a sequence operator, and a topology operator. After the
20 different operator entities are specifically instantiated, operator entities corresponding to the operator entities are obtained, for example, a sum operator, an entropy operator, and a gradient operator.

[0041] The knowledge graph is constructed based on the feature relationships between the parameter instances and the predetermined operator entities. The operator
25 entity can complete basic query, annotation, calculation, inference, and prediction based on the knowledge graph.

[0042] Step 206: Extract a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

30 **[0043]** In some embodiments of the present specification, the inference rule includes a path ranking algorithm, and a new feature relationship is extracted based on the knowledge graph by using the path ranking algorithm, to obtain a newly added feature relationship and recommend the newly added feature relationship.

[0044] Referring to FIG. 4, extracting a feature relationship from the knowledge

graph based on an inference rule includes step 402 to step 406.

[0045] Step 402: Search the original node entities and event entities for a newly added event entity in the original node entities based on the inference rule.

[0046] Referring to FIG. 5, in some embodiments of the present specification, for example, the node entities include account A, account B, and account C, and the event entity includes transferring 3 yuan. The three node entities are associated by using the event entities as follows: Account A transfers 3 yuan to account B, and account B transfers 3 yuan to account C. Based on the path ranking algorithm, the newly added event entity in the original node entities can be obtained: Account A transfers 3 yuan to account C.

[0047] Step 404: Match, for the newly added event entity and the original node entities and event entities, an operator entity that satisfies a first predetermined condition, and determine combined feature relationships among the newly added event entity, the original node entities and event entities, and the operator entity.

[0048] In some embodiments of the present specification, the first predetermined condition includes but is not limited to an actual need feature. FIG. 5 is used as an example. If the first predetermined condition includes "an accumulated quantity of transfer times of account A in two days", the matched operator entity is a sum operator.

[0049] For example, the newly added event entity includes transferring 3 yuan from account A to account C, association between the original node entities and the event entities includes: transferring 3 yuan from account A to account B, transferring 3 yuan from account B to account C, and transferring 1 yuan from account A to account D, and the operator entity includes a sum operator. The combined feature relationships among the newly added event entity, and the original node entities and event entities, and the operator entity are determined, and the combined feature relationships include "an accumulated quantity of transfer times of account A", "an accumulated transfer amount of account A", etc.

[0050] Step 406: Represent, based on the combined feature relationships, a first feature relationship extracted from the knowledge graph.

[0051] In some embodiments of the present specification, the first feature relationship is a combined feature relationship.

[0052] In actual use, the relationships between the node entities and the event entities are first supplemented by using the inference rule to determine, through inference, which node entities can form an abstract key-collection relationship. Then, an operator

entity that satisfies the condition is matched based on the key-collection relationship and the relationships between the original node entities and the event entities, to determine the combined feature relationships.

[0053] For example, the node entities include an identity card, a card number, a mobile phone number, an ALIPAY account, an IP address, a mobile phone device number, etc. Then, the node entity is used as a key, and statistics about other event entities and node entities including a transaction amount, a login lbs location, a transaction time, a login city, an identity card, a card number, a mobile phone number, etc. are collected as a group, to collect statistics about a key-collection relationship between the identity card as the key and each of the transaction amount, the login lbs location, the transaction time, the login city, another identity card, the card number, the mobile phone number, etc., and a key-collection relationship between the card number as the key and each of the transaction amount, the login lbs location, the transaction time, the login city, the identity card, another card number, the mobile phone number, etc.

[0054] After the key-collection relationship is obtained, a feature relationship can be formed by cooperating with the operator entity. An ALIPAY account is used as the key. All identity cards that appear in the account are grouped, and a combined feature relationship "a quantity of identity cards obtained in a certain ALIPAY account after removing duplications" can be formed by combining with a count operator. An identity card number is used as the key. Transaction amounts of the identity card are grouped, and a combined feature relationship "an accumulated consumption amount of a certain ALIPAY account" can be formed by combining with a sum operator. A mobile phone device account is used as the key. Lbs of the mobile phone device account are grouped, and a combined feature relationship "a maximum moving distance of the mobile phone device" is formed by combining with a maxDistance operator.

[0055] In some embodiments of the present specification, the apparatus is further subject to a second predetermined condition, and the apparatus further performs: filtering the combined feature relationships based on the second predetermined condition; and representing, based on the filtered combined feature relationships, a second feature relationship extracted from the knowledge graph.

[0056] In some embodiments of the present specification, the second predetermined condition includes but is not limited to a node entity in the knowledge graph that is newly added to the combined feature relationships.

[0057] For example, the combined feature relationships include "a maximum moving distance of the mobile phone device", and the second predetermined condition includes a newly added node entity "time window three days" in the knowledge graph. In this case, a combined feature relationship "a maximum moving distance of the mobile phone device within three days" can be obtained, and the combined feature relationship is the second feature relationship.

[0058] In actual use, different relationship paths are used as one-dimensional features in the path ranking algorithm, and feature vectors of relationship classification are constructed by collecting statistics about a large quantity of relationship paths in the knowledge graph, to establish a relationship classifier to extract a new feature relationship.

[0059] In some embodiments of the present specification, the inference rule is implemented in a form of a Horn clause under a first-order logical inference framework, and can be written based on knowledge, or can be obtained through learning by using a machine learning method based on data. For example, the rule is implemented through learning and training of an artificial neural network, parameter instances, operator entities, and relationships between the parameter instances and the operator entities are input by using the inference rule, and the extracted new feature relationship is output, to recommend the newly added feature relationship.

[0060] In some embodiments of the present specification, based on the method, the service data is implemented in the knowledge graph by using the parameter instances, the operator entity, and the feature relationships between the parameter instances and the operator entity, and searching of the new feature relationship is instructed and restricted based on the original feature relationship by using the inference rule, thereby alleviating searching for and recommending a large quantity of meaningless feature relationships.

[0061] FIG. 6 is a schematic flowchart illustrating a feature relationship recommendation method, according to some embodiments of the present specification. The method includes step 602 to step 612.

[0062] Step 602: Determine a parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities.

[0063] Step 604: Construct a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities.

[0064] Step 606: Extract a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

5 [0065] Step 608: Determine a label corresponding to the newly added feature relationship based on a pre-trained classification model, where the label includes a black label and a white label.

[0066] In some embodiments of the present specification, pre-training the classification model includes the following steps: obtaining a training sample data set, where the training sample data set includes a feature relationship sample between a parameter instance sample and an operator entity sample and a sample label corresponding to the feature relationship sample, and the sample label includes a white sample label and a black sample label; and training the classification model based on a tree-type model, where the classification model associates the feature relationship sample with the sample label.

15 [0067] In some embodiments of the present specification, an importance degree of each feature relationship sample corresponding to the white sample label is obtained by using the classification model.

[0068] In some embodiments of the present specification, the tree-type model includes an XGBoost model.

20 [0069] In some embodiments of the present specification, if the classification model is applied to anti-fraud in the financial industry, the white label can be a label without a fraud risk, and the black label can be a label with a fraud risk.

[0070] Determining a label corresponding to the newly added feature relationship based on a pre-trained classification model includes: determining, based on the pre-trained classification model, which newly added feature relationship is a white label without a fraud risk, and which newly added feature relationship is a black label with a fraud risk.

25 [0071] Step 610: Determine an importance degree of a newly added feature relationship corresponding to the white label based on the pre-trained classification model.

30 [0072] In some embodiments of the present specification, after the label corresponding to the newly added feature relationship is determined, the importance degree of the newly added feature relationship corresponding to the white label is determined. An importance degree of a newly added feature relationship corresponding

to the black label does not need to be obtained, to reduce workload and improve working efficiency of the classification model.

[0073] Step 612: If the importance degree is greater than a predetermined threshold, add, to the knowledge graph, the newly added feature relationship corresponding to the white label.

[0074] In some embodiments of the present specification, the predetermined threshold can be set based on actual applications, and can be set to 80%, 95%, or 100%. Embodiments are not limited in the present specification.

[0075] If the predetermined threshold is 80%, an importance degree of a newly added feature relationship corresponding to a certain white label is 85%, and the importance degree of the newly added feature relationship is greater than the predetermined threshold, the newly added feature relationship is added to the knowledge graph.

[0076] In some embodiments of the present specification, for example, if the newly added feature relationship is "a maximum moving speed of an ALIPAY account within 6 hours", the feature is input into the XGBoost model, it is evaluated that an importance degree of the feature is 89%, and the predetermined threshold is 85%, a feature relationship among "an ALIPAY account entity", "an lbs entity", and "a gradient operator entity" is constructed in the knowledge graph.

[0077] In some embodiments of the present specification, based on the method, newly added feature relationships are classified and the importance degree of the newly added feature relationship corresponding to the white label is evaluated based on the classification model, and a newly added feature relationship whose importance degree reaches a specified requirement is added to the constructed knowledge graph, to enrich the knowledge graph, thereby improving extension performance of the knowledge graph.

[0078] Referring to FIG. 7, some embodiments of the present specification provide a feature relationship recommendation apparatus, including: a determining module 702, configured to determine parameter instances based on service data, where the parameter instances include event entities and node entities, and the node entities are associated by using the event entities; a construction module 704, configured to construct a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities; and an extraction module 706, configured to extract a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

[0079] Optionally, the apparatus further includes: a label selection module, configured to determine a label corresponding to the newly added feature relationship based on a pre-trained classification model, where the label includes a black label and a white label.

5 [0080] Optionally, the apparatus further includes: an importance degree determining module, configured to determine an importance degree of a newly added feature relationship corresponding to the white label based on the pre-trained classification model; and an addition module, configured to: if the importance degree is greater than a predetermined threshold, add, to the knowledge graph, the newly added feature
10 relationship corresponding to the white label.

[0081] Optionally, the classification model is trained by using the following steps: obtaining a training sample data set, where the training sample data set includes a feature relationship sample between a parameter instance sample and an operator entity sample and a sample label corresponding to the feature relationship sample, and the
15 sample label includes a white sample label and a black sample label; and training the classification model based on a tree-type model, where the classification model associates the feature relationship sample with the sample label.

[0082] Optionally, the apparatus further includes: an acquisition module, configured to obtain an importance degree of each feature relationship sample corresponding to the
20 white sample label by using the classification model.

[0083] Optionally, the extraction module includes: an addition submodule, configured to search the original node entities and event entities for a newly added event entity in the original node entities based on the inference rule; and a combined feature relationship determining submodule, configured to: match, for the newly added event
25 entity and the original node entities and event entities, an operator entity that satisfies a first predetermined condition, and determine combined feature relationships among the newly added event entity, the original node entities and event entities, and the operator entity; and a feature relationship extraction submodule, configured to represent, based on the combined feature relationships, a first feature relationship extracted from the
30 knowledge graph.

[0084] Optionally, the apparatus is further subject to a second predetermined condition, and the apparatus further performs: filtering the combined feature relationships based on the second predetermined condition; and representing, based on the filtered combined feature relationships, a second feature relationship extracted from

the knowledge graph.

[0085] Optionally, the tree-type model includes an XGBoost model.

[0086] Optionally, the inference rule includes a path ranking algorithm.

[0087] Optionally, the operator entity includes a sum operator, an entropy operator,
5 or a gradient operator.

[0088] In some embodiments of the present specification, based on the apparatus,
the service data is implemented in the knowledge graph by using the parameter
instances, the operator entity, and the feature relationships between the parameter
instances and the operator entity, and searching of the new feature relationship is
10 instructed and restricted based on the original feature relationship by using the inference
rule, thereby alleviating searching for and recommending a large quantity of
meaningless feature relationships.

[0089] The embodiments in some embodiments of the present specification are
described by using a progressive method. For the same or similar parts in the
15 embodiments, references can be made to each other. Each embodiment focuses on a
difference from other embodiments. Particularly, an apparatus embodiment is similar
to a method embodiment, and therefore is described briefly. For a related part,
references can be made to some descriptions in the method embodiment.

[0090] Some embodiments of the present specification further provide a computer
20 readable storage medium, where the computer readable storage medium stores
computer instructions, and when the instructions are executed by a processor, steps of
the feature relationship recommendation method are implemented.

[0091] The previous descriptions are schematic solutions of the computer readable
storage medium in this embodiment. It is worthwhile to note that the technical solutions
25 of the storage medium and the technical solutions of the previous feature relationship
recommendation method belong to a same concept. For details that are not described in
detail in the technical solutions of the storage medium, references can be made to
descriptions of the technical solutions of the previous feature relationship
recommendation method.

[0092] Specific embodiments of the present specification are described above. Other
30 embodiments fall within the scope of the appended claims. In some situations, the
actions or steps described in the claims can be performed in an order different from the
order in the embodiments and the desired results can still be achieved. In addition, the
process depicted in the accompanying drawings does not necessarily need a particular

execution order to achieve the desired results. In some embodiments, multi-tasking and concurrent processing is feasible or may be advantageous.

[0093] Technical carriers related to payment in the embodiments of the present specification can include, for example, Near Field Communication (NFC), Wireless Fidelity (Wi-Fi), 3G/4G/5G, a technology of swiping card by using a point of sale (POS) machine, a quick response code scanning technology, a bar code scanning technology, Bluetooth, infrared, a short message service (SMS), and a multimedia messaging service (MMS).

[0094] The computer instructions include computer instruction code, and the computer instruction code can be in a source code form, an object code form, an executable file, some intermediate forms, etc. The computer readable medium can include any entity or apparatus that can include the computer instruction code, a recording medium, a USB flash drive, a removable hard disk, a magnetic disk, an optical disc, a computer memory, a read-only memory (ROM), a random access memory (RAM), an electrical carrier signal, a telecommunication signal, a software distribution medium, etc. It is worthwhile to note that content included in the computer readable medium can be appropriately increased or decreased based on a need of legislation and patent practice in a jurisdiction. For example, in some jurisdictions, based on legislation and patent practice, the computer readable medium does not include an electrical carrier signal and a telecommunication signal.

[0095] It is worthwhile to note that, for brief description, the previous method embodiments are expressed as a combination of a series of actions. However, a person skilled in the art should appreciate that the present specification is not limited to the described action sequence because some steps can be performed in other sequences or performed simultaneously according to the present specification. In addition, a person skilled in the art should also appreciate that all the embodiments described in the present specification are examples of embodiments, and the mentioned actions and modules are not necessarily mandatory to the present specification.

[0096] In the previous embodiments, the description of each embodiment has respective focuses. For a part not described in detail in some embodiments, references can be made to related descriptions in other embodiments.

[0097] The embodiments of the present specification disclosed above are merely intended to help describe the present specification. Not all details of the optional embodiments are described in detail, and the present specification is not limited to the

specific embodiment. Clearly, many modifications and changes can be made based on the content of the present specification. In the present specification, these embodiments are selected and specifically described to better explain principles and practical applications of the present specification, so a person skilled in the art can better
5 understand and use the present specification. The present specification is only limited by the claims and all the scope and equivalents thereof.

CLAIMS

What is claimed is:

1. A feature relationship recommendation method, comprising:
determining parameter instances based on service data, wherein the parameter
5 instances comprise event entities and node entities, and the node entities are associated
by using the event entities;
constructing a knowledge graph based on feature relationships between the
parameter instances and predetermined operator entities; and
extracting a feature relationship from the knowledge graph based on an inference
10 rule, to obtain a newly added feature relationship and recommend the newly added
feature relationship.
2. The method according to claim 1, further comprising:
determining a label corresponding to the newly added feature relationship based
on a pre-trained classification model, wherein the label comprises a black label and a
15 white label.
3. The method according to claim 2, further comprising:
determining an importance degree of a newly added feature relationship
corresponding to the white label based on the pre-trained classification model; and
if the importance degree is greater than a predetermined threshold, adding, to the
20 knowledge graph, the newly added feature relationship corresponding to the white label.
4. The method according to claim 2, wherein the classification model is trained by
using the following steps:
obtaining a training sample data set, wherein the training sample data set
comprises a feature relationship sample between a parameter instance sample and an
25 operator entity sample and a sample label corresponding to the feature relationship
sample, and the sample label comprises a white sample label and a black sample label;
and
training the classification model based on a tree-type model, wherein the
classification model associates the feature relationship sample with the sample label.
- 30 5. The method according to claim 4, wherein after the classification model
associates the feature relationship sample with the sample label, the method further
comprises:
obtaining an importance degree of each feature relationship sample corresponding

to the white sample label by using the classification model.

6. The method according to claim 1, wherein extracting a feature relationship from the knowledge graph based on an inference rule comprises:

5 searching the original node entities and event entities for a newly added event entity in the original node entities based on the inference rule;

 matching, for the newly added event entity and the original node entities and event entities, an operator entity that satisfies a first predetermined condition, and determining combined feature relationships among the newly added event entity, the original node entities and event entities, and the operator entity; and

10 representing, based on the combined feature relationships, a first feature relationship extracted from the knowledge graph.

7. The method according to claim 6, wherein the method further comprises:

 filtering the combined feature relationships based on a second predetermined condition; and

15 representing, based on the filtered combined feature relationships, a second feature relationship extracted from the knowledge graph.

8. The method according to claim 4, wherein the tree-type model comprises an XGBoost model.

20 9. The method according to claim 1, wherein the inference rule comprises a path ranking algorithm.

 10. The method according to claim 1, wherein the operator entity comprises a sum operator, an entropy operator, or a gradient operator.

11. A feature relationship recommendation apparatus, comprising:

25 a determining module, configured to determine parameter instances based on service data, wherein the parameter instances comprise event entities and node entities, and the node entities are associated by using the event entities;

 a construction module, configured to construct a knowledge graph based on feature relationships between the parameter instances and predetermined operator entities; and

30 an extraction module, configured to extract a feature relationship from the knowledge graph based on an inference rule, to obtain a newly added feature relationship and recommend the newly added feature relationship.

12. The apparatus according to claim 11, wherein the apparatus further comprises:

 a label selection module, configured to determine a label corresponding to the

newly added feature relationship based on a pre-trained classification model, wherein the label comprises a black label and a white label.

13. The apparatus according to claim 12, wherein the apparatus further comprises:
an importance degree determining module, configured to determine an importance
5 degree of a newly added feature relationship corresponding to the white label based on the pre-trained classification model; and

an addition module, configured to: if the importance degree is greater than a predetermined threshold, add, to the knowledge graph, the newly added feature relationship corresponding to the white label.

10 14. The apparatus according to claim 12, wherein the classification model is trained by using the following steps:

obtaining a training sample data set, wherein the training sample data set comprises a feature relationship sample between a parameter instance sample and an operator entity sample and a sample label corresponding to the feature relationship
15 sample, and the sample label comprises a white sample label and a black sample label; and

training the classification model based on a tree-type model, wherein the classification model associates the feature relationship sample with the sample label.

15. The apparatus according to claim 14, wherein the apparatus further comprises:
20 an acquisition module, configured to obtain an importance degree of each feature relationship sample corresponding to the white sample label by using the classification model.

16. The apparatus according to claim 11, wherein the extraction module comprises:
an addition submodule, configured to search the original node entities and event
25 entities for a newly added event entity in the original node entities based on the inference rule; and

a combined feature relationship determining submodule, configured to: match, for the newly added event entity and the original node entities and event entities, an operator entity that satisfies a first predetermined condition, and determine combined
30 feature relationships among the newly added event entity, the original node entities and event entities, and the operator entity; and

a feature relationship extraction submodule, configured to represent, based on the combined feature relationships, a first feature relationship extracted from the knowledge graph.

17. The apparatus according to claim 16, wherein the apparatus is further subject to a second predetermined condition, and the apparatus further performs:

filtering the combined feature relationships based on the second predetermined condition; and

5 representing, based on the filtered combined feature relationships, a second feature relationship extracted from the knowledge graph.

18. The apparatus according to claim 14, wherein the tree-type model comprises an XGBoost model.

19. The apparatus according to claim 11, wherein the inference rule comprises a
10 path ranking algorithm.

20. The apparatus according to claim 11, wherein the operator entity comprises a sum operator, an entropy operator, or a gradient operator.

21. A computing device, comprising a memory, a processor, and computer instructions that are stored in the memory and that can run on the processor, wherein
15 when executing the instructions, the processor executes the method according to any one of claims 1 to 10.

22. A computer readable storage medium on which computer instructions are stored, wherein steps of the method according to any one of claims 1 to 10 are implemented when the program is executed by a processor.

20