US012393781B2

(12) **United States Patent**
Nakano et al.

(10) **Patent No.: US 12,393,781 B2**
(45) **Date of Patent: Aug. 19, 2025**

(54) **INFORMATION PROCESSING APPARATUS, OPERATION METHOD OF INFORMATION PROCESSING APPARATUS, AND OPERATION PROGRAM OF INFORMATION PROCESSING APPARATUS**

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(72) Inventors: **Norihisa Nakano**, Tokyo (JP); **Ryota Ozaki**, Tokyo (JP); **Tomoko Ohkuma**, Tokyo (JP); **Tomoki Taniguchi**, Tokyo (JP); **Yuki Tagawa**, Tokyo (JP)

(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 281 days.

(21) Appl. No.: **18/063,073**

(22) Filed: **Dec. 7, 2022**

(65) **Prior Publication Data**

US 2023/0205997 A1 Jun. 29, 2023

(30) **Foreign Application Priority Data**

Dec. 27, 2021 (JP) 2021-213437

(51) **Int. Cl.**

G06F 17/27	(2006.01)
G06F 40/295	(2020.01)
G16H 15/00	(2018.01)
G06F 40/30	(2020.01)

(52) **U.S. Cl.**
CPC ***G06F 40/295*** (2020.01); ***G16H 15/00*** (2018.01); *G06F 40/30* (2020.01)

(58) **Field of Classification Search**
CPC G06F 40/284; G06F 40/279; G06F 40/295; G06F 40/289; G06F 40/30; G16H 15/00; G16H 50/20
USPC 704/9
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0196698	A1 *	8/2011	Benja-Athon	G16H 50/20 705/2
2021/0182490	A1 *	6/2021	Guo	G06F 40/284
2021/0200949	A1	7/2021	Gao et al.	
2022/0382979	A1 *	12/2022	Klein	G06F 40/284

FOREIGN PATENT DOCUMENTS

CN	113821601	A *	12/2021
JP	2021111323		8/2021
JP	2021140483		9/2021

OTHER PUBLICATIONS

Chen Lin et al., "Entity BERT: Entity-centric Masking Strategy for Model Pretraining for the Clinical Domain", Proceedings of the BioNLP 2021 workshop, p. 191-201, Jun. 11, 2021.
"Notice of Reasons for Refusal of Japann Counterpart Application No. 2021-213437", issued on May 27, 2025, with English translation thereof, p. 1-p. 5.

* cited by examiner

Primary Examiner — Md S Elahee
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A CPU of a training data creation apparatus includes an extraction unit, a derivation unit, and a creation unit. The extraction unit extracts a plurality of unique expressions that are specific term phrases from a medical document. The derivation unit derives a degree of association indicating a degree of association among the plurality of unique expressions. The creation unit selects a target term phrase that is a term phrase as a target to be masked.

15 Claims, 24 Drawing Sheets

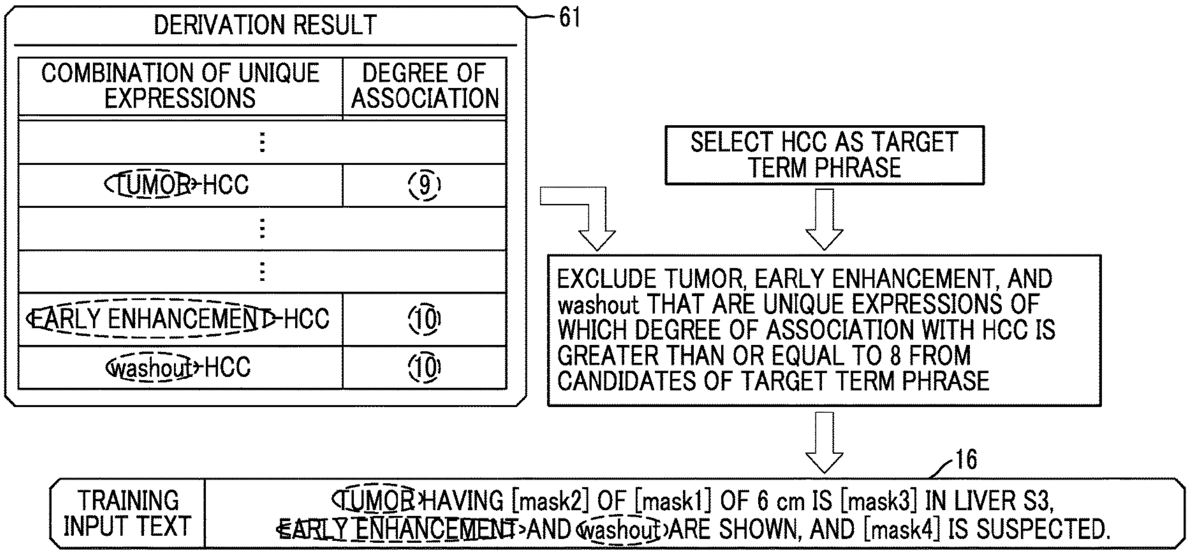

DERIVATION RESULT
61
COMBINATION OF UNIQUE EXPRESSIONS
DEGREE OF ASSOCIATION
⋮
TUMOR-HCC
9
⋮
⋮
EARLY ENHANCEMENT-HCC
10
washout-HCC
10
SELECT HCC AS TARGET TERM PHRASE
EXCLUDE TUMOR, EARLY ENHANCEMENT, AND washout THAT ARE UNIQUE EXPRESSIONS OF WHICH DEGREE OF ASSOCIATION WITH HCC IS GREATER THAN OR EQUAL TO 8 FROM CANDIDATES OF TARGET TERM PHRASE
16
TRAINING INPUT TEXT
TUMOR HAVING [mask2] OF [mask1] OF 6 cm IS [mask3] IN LIVER S3, EARLY ENHANCEMENT AND washout ARE SHOWN, AND [mask4] IS SUSPECTED.

FIG. 1

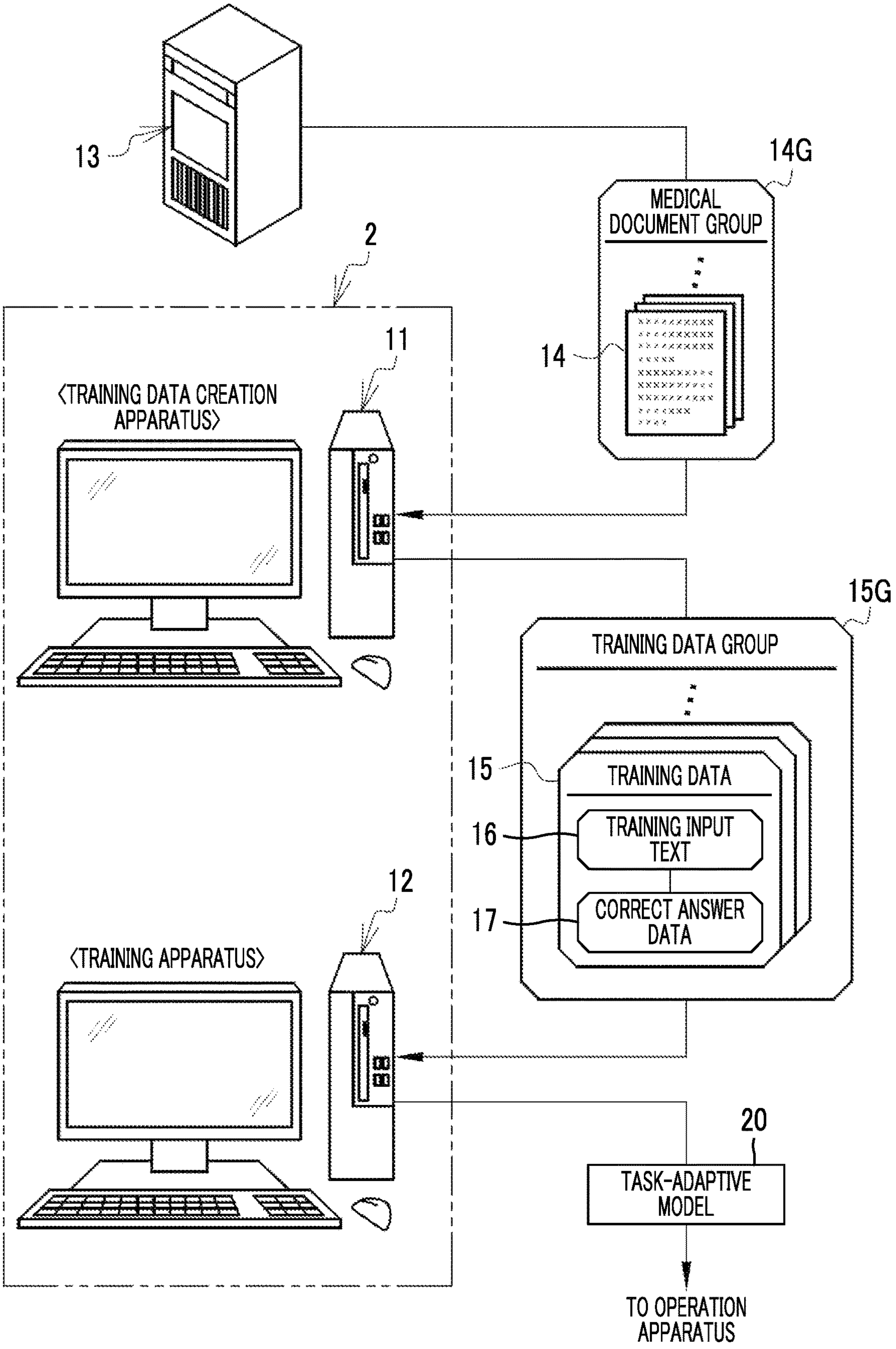
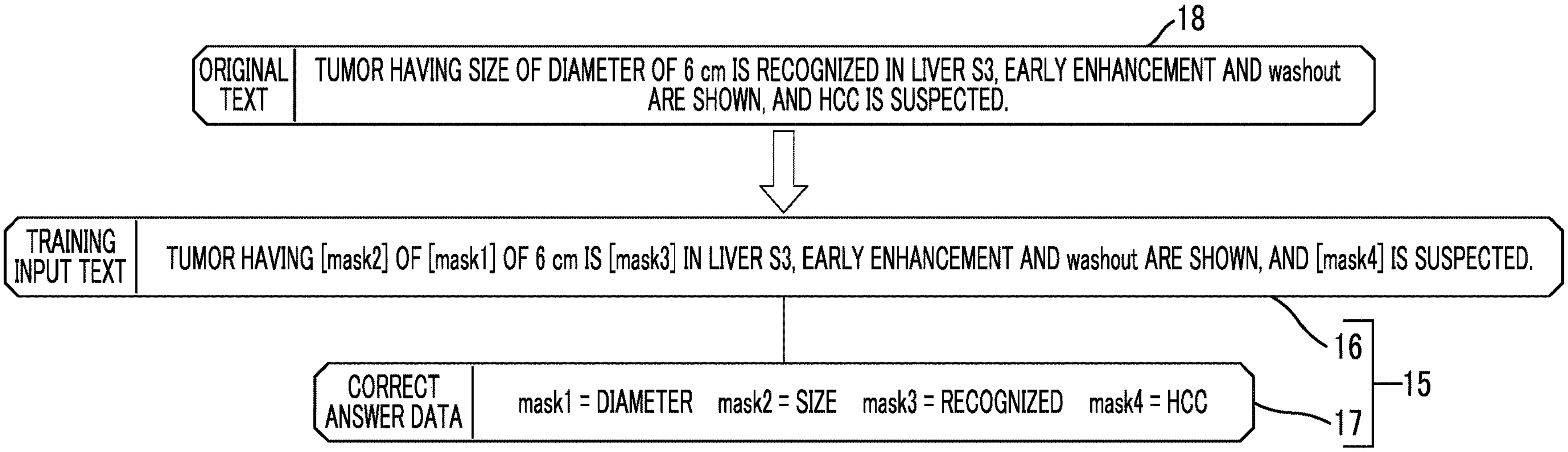

13
14G
MEDICAL DOCUMENT GROUP
2
14
11
⟨TRAINING DATA CREATION APPARATUS⟩
15G
TRAINING DATA GROUP
15
TRAINING DATA
16
TRAINING INPUT TEXT
17
CORRECT ANSWER DATA
12
⟨TRAINING APPARATUS⟩
20
TASK-ADAPTIVE MODEL
TO OPERATION APPARATUS

FIG. 2



ORIGINAL TEXT: TUMOR HAVING SIZE OF DIAMETER OF 6 cm IS RECOGNIZED IN LIVER S3, EARLY ENHANCEMENT AND washout ARE SHOWN, AND HCC IS SUSPECTED.

TRAINING INPUT TEXT: TUMOR HAVING [mask2] OF [mask1] OF 6 cm IS [mask3] IN LIVER S3, EARLY ENHANCEMENT AND washout ARE SHOWN, AND [mask4] IS SUSPECTED.

CORRECT ANSWER DATA: mask1 = DIAMETER mask2 = SIZE mask3 = RECOGNIZED mask4 = HCC

FIG. 3

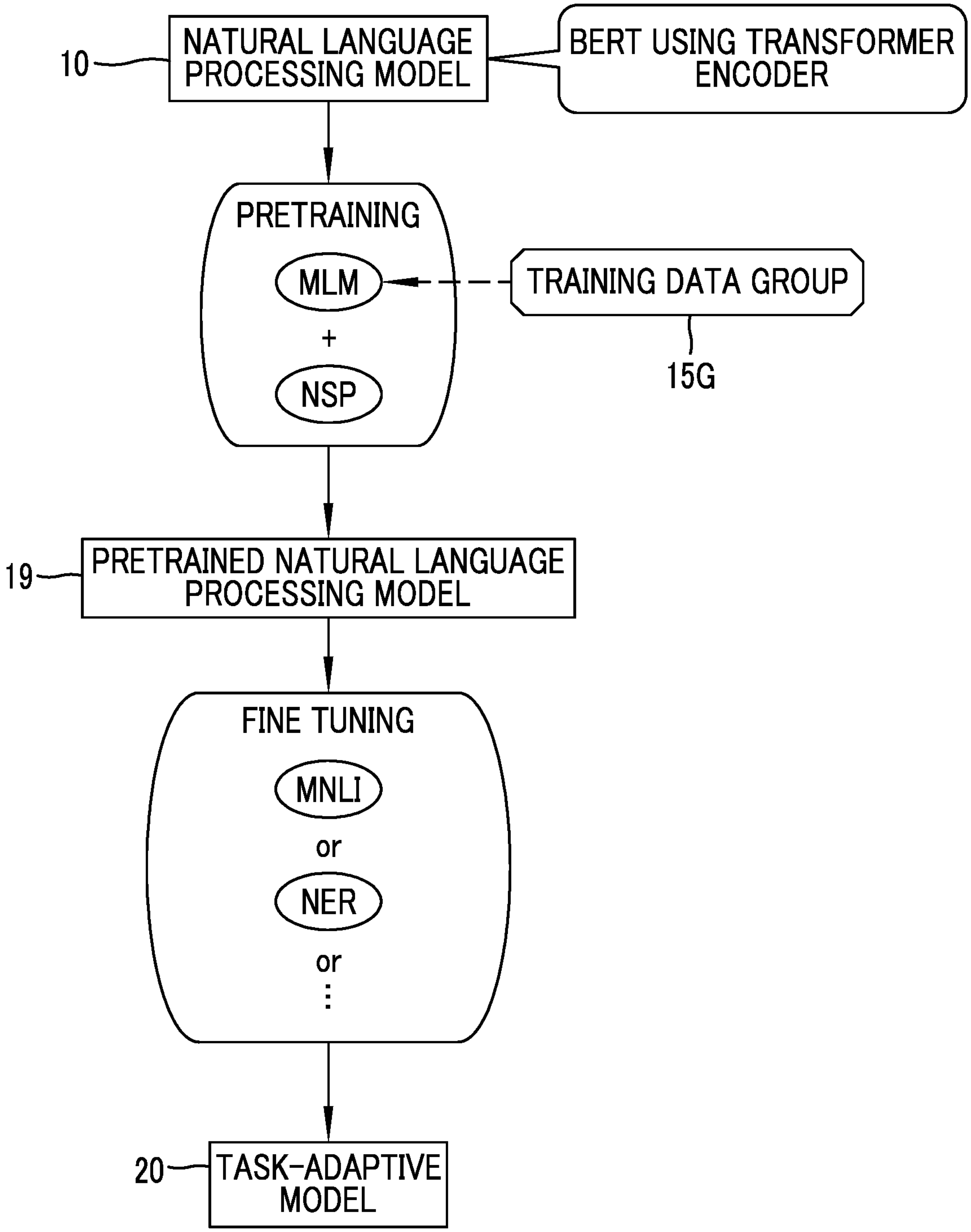

10
NATURAL LANGUAGE PROCESSING MODEL
BERT USING TRANSFORMER ENCODER
PRETRAINING
MLM
+
NSP
TRAINING DATA GROUP
15G
19
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL
FINE TUNING
MNLI
or
NER
or
⋮
20
TASK-ADAPTIVE MODEL

FIG. 4

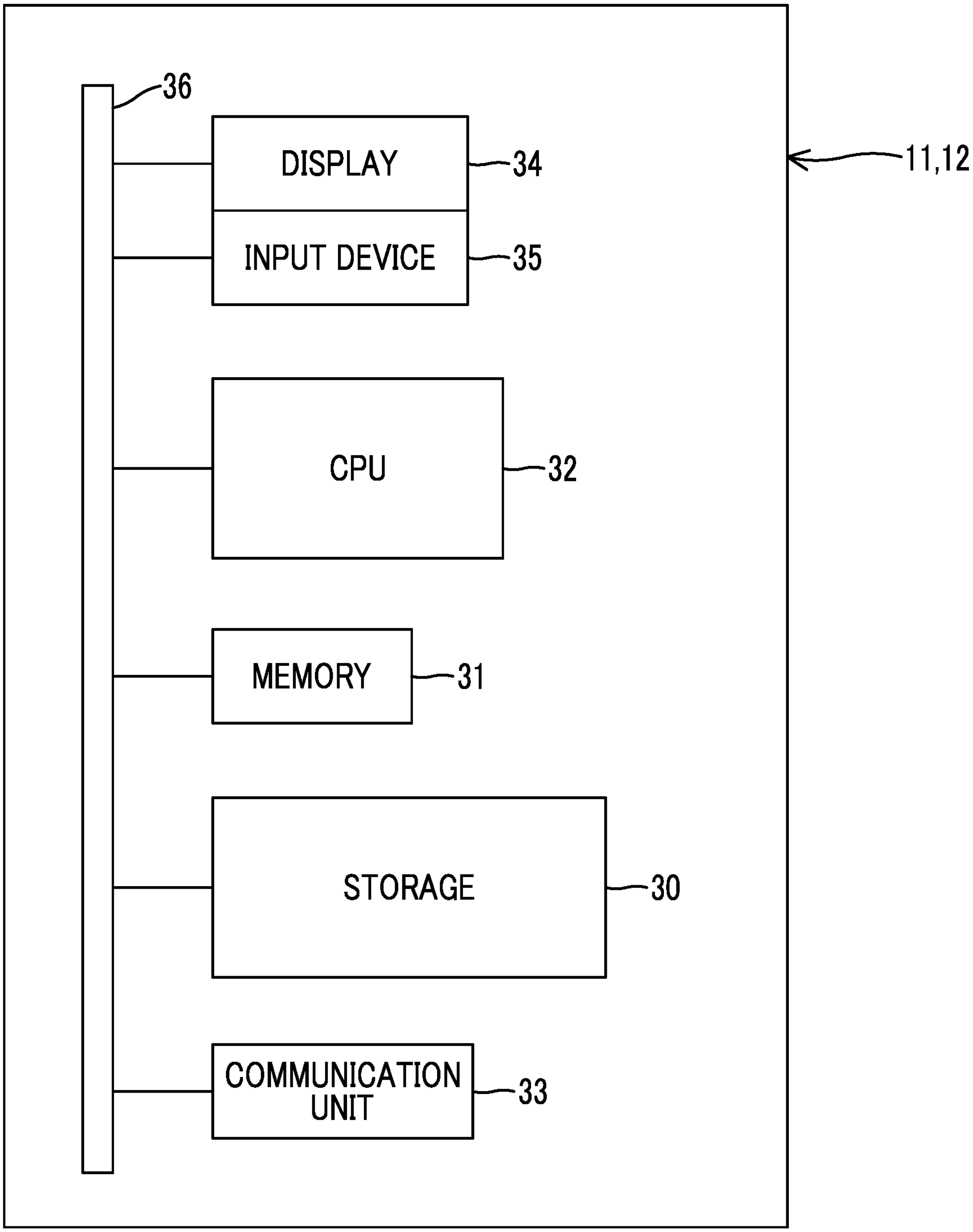

36
DISPLAY
34
INPUT DEVICE
35
11,12
CPU
32
MEMORY
31
STORAGE
30
COMMUNICATION UNIT
33

FIG. 5

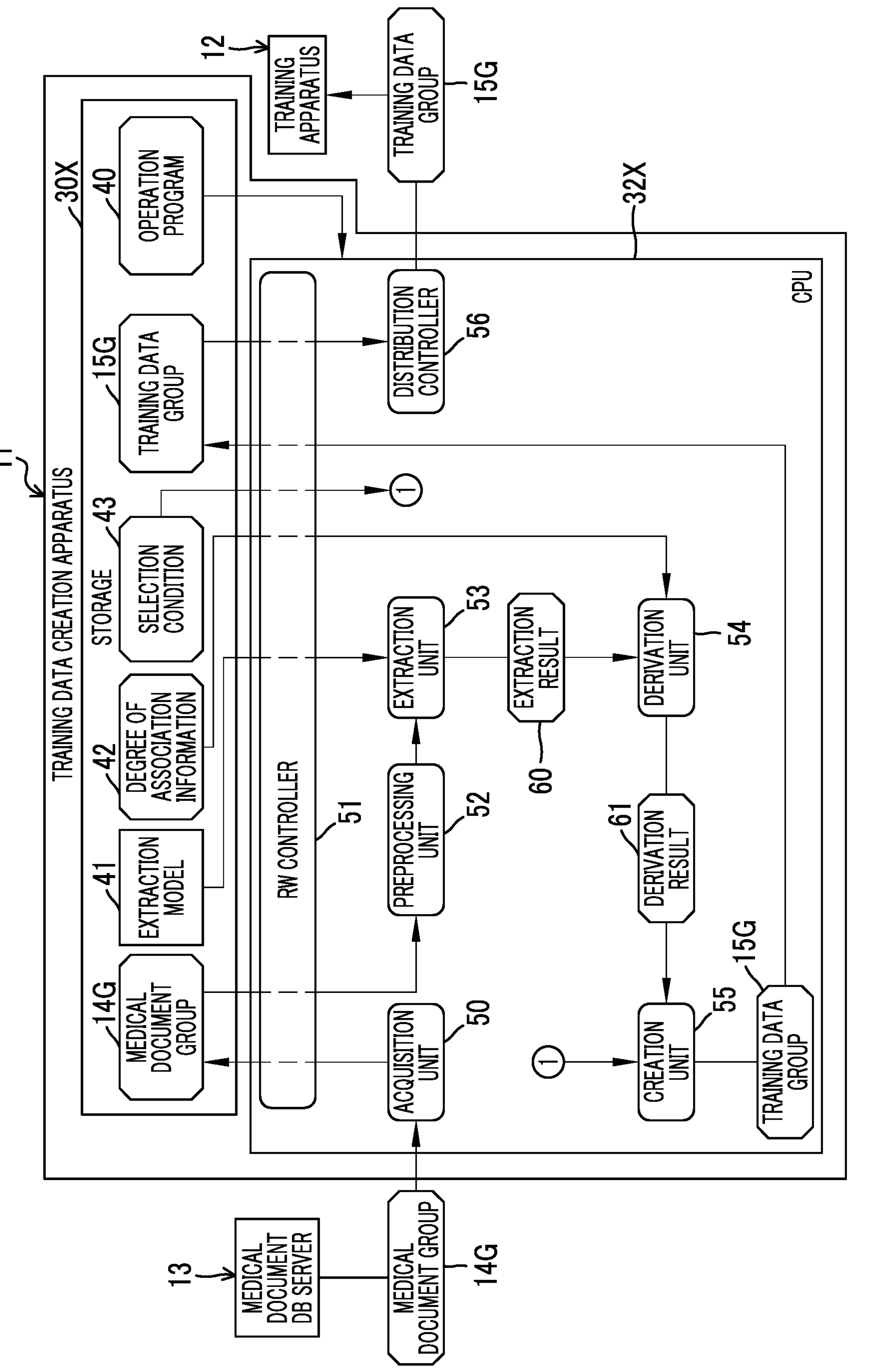

11
TRAINING DATA CREATION APPARATUS
30X
STORAGE
14G
MEDICAL DOCUMENT GROUP
41
EXTRACTION MODEL
42
DEGREE OF ASSOCIATION INFORMATION
43
SELECTION CONDITION
15G
TRAINING DATA GROUP
40
OPERATION PROGRAM
12
TRAINING APPARATUS
15G
TRAINING DATA GROUP
32X
CPU
51
RW CONTROLLER
50
ACQUISITION UNIT
52
PREPROCESSING UNIT
53
EXTRACTION UNIT
56
DISTRIBUTION CONTROLLER
1
60
EXTRACTION RESULT
54
DERIVATION UNIT
61
DERIVATION RESULT
1
55
CREATION UNIT
15G
TRAINING DATA GROUP
13
MEDICAL DOCUMENT DB SERVER
MEDICAL DOCUMENT GROUP
14G

FIG. 6

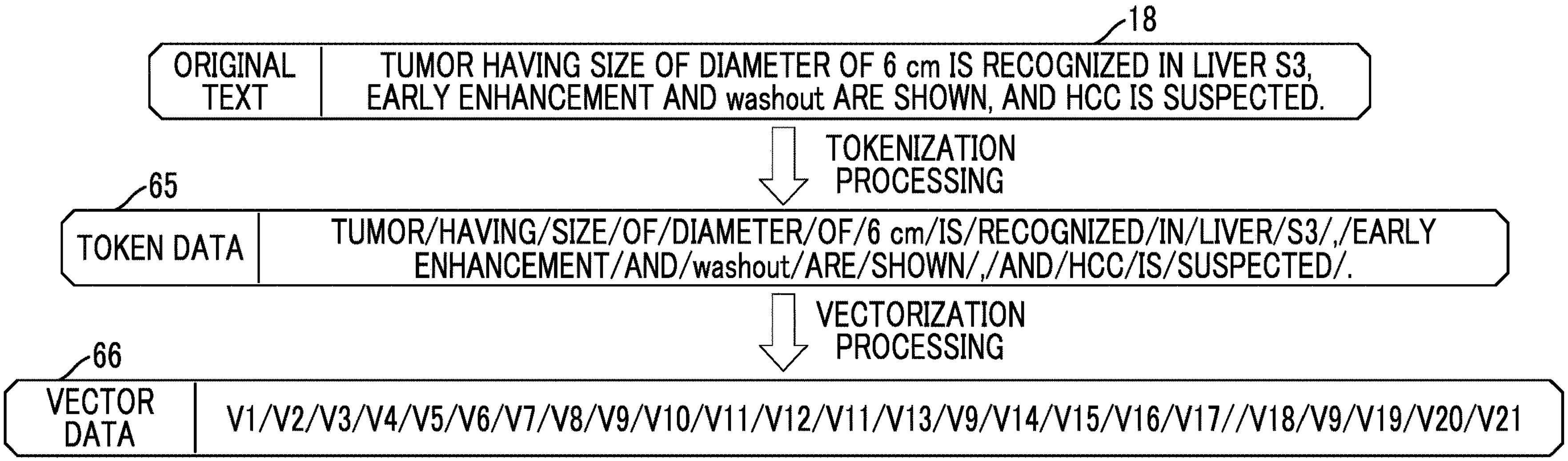

18
ORIGINAL TEXT
TUMOR HAVING SIZE OF DIAMETER OF 6 cm IS RECOGNIZED IN LIVER S3, EARLY ENHANCEMENT AND washout ARE SHOWN, AND HCC IS SUSPECTED.
TOKENIZATION PROCESSING
65
TOKEN DATA
TUMOR/HAVING/SIZE/OF/DIAMETER/OF/6 cm/IS/RECOGNIZED/IN/LIVER/S3/,/EARLY ENHANCEMENT/AND/washout/ARE/SHOWN/,/AND/HCC/IS/SUSPECTED/.
VECTORIZATION PROCESSING
66
VECTOR DATA
V1/V2/V3/V4/V5/V6/V7/V8/V9/V10/V11/V12/V11/V13/V9/V14/V15/V16/V17//V18/V9/V19/V20/V21

FIG. 7

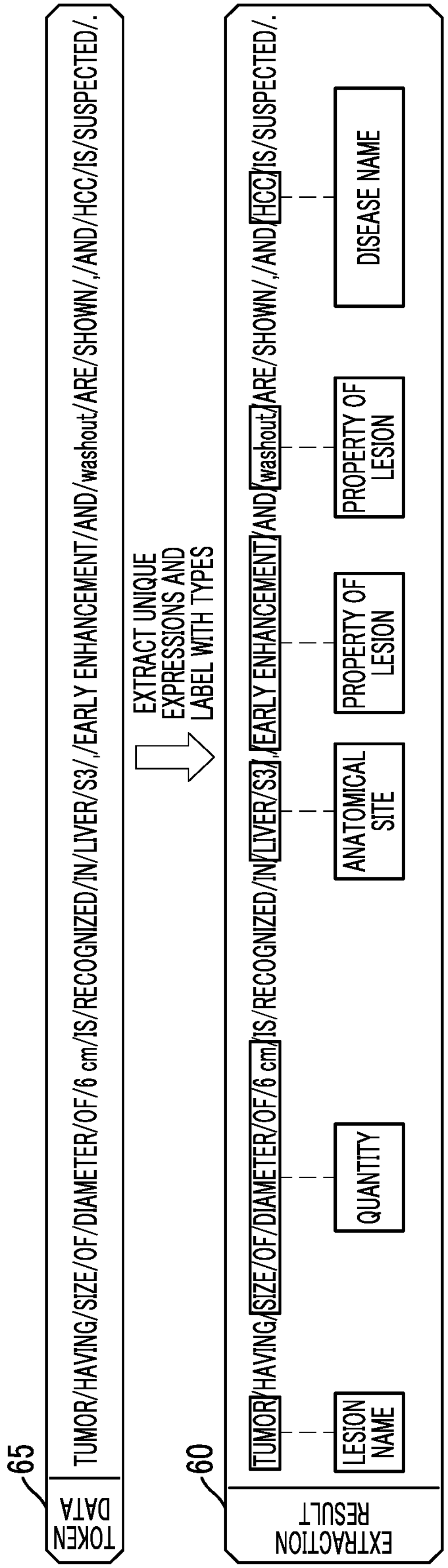
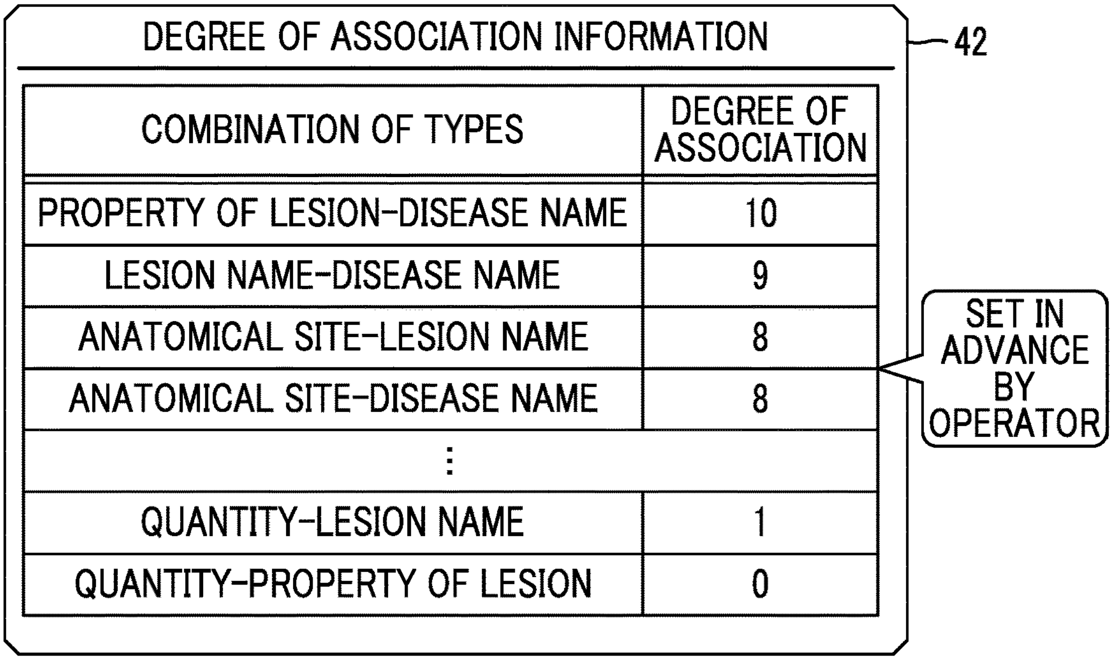

65
TOKEN DATA
TUMOR/HAVING/SIZE/OF/DIAMETER/OF/6 cm/IS/RECOGNIZED/IN/LIVER/S3/,/EARLY ENHANCEMENT/AND/washout/ARE/SHOWN/,/AND/HCC/IS/SUSPECTED/.
EXTRACT UNIQUE EXPRESSIONS AND LABEL WITH TYPES
60
EXTRACTION RESULT
TUMOR/HAVING/SIZE/OF/DIAMETER/OF/6 cm/IS/RECOGNIZED/IN/LIVER/S3/,/EARLY ENHANCEMENT/AND/washout/ARE/SHOWN/,/AND/HCC/IS/SUSPECTED/.
LESION NAME
QUANTITY
ANATOMICAL SITE
PROPERTY OF LESION
PROPERTY OF LESION
DISEASE NAME

FIG. 8

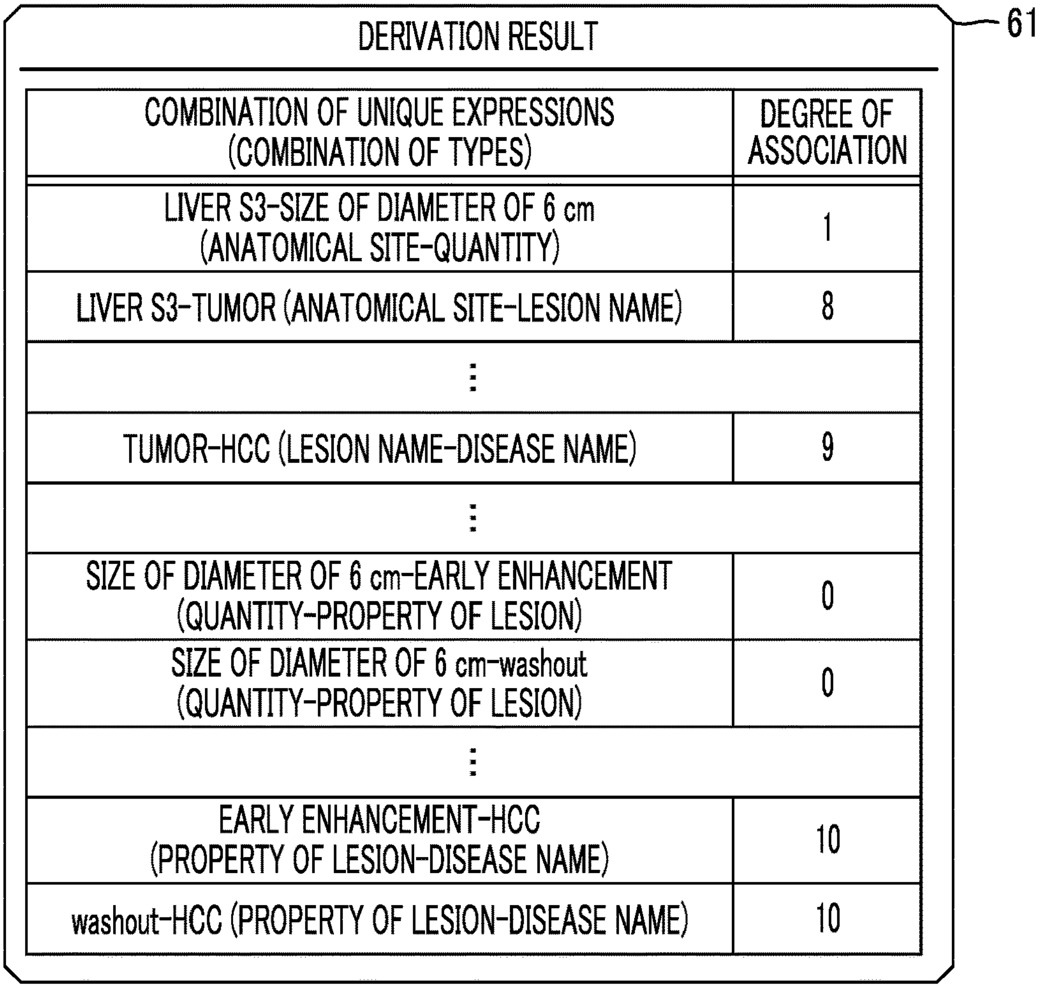


DEGREE OF ASSOCIATION INFORMATION

COMBINATION OF TYPES	DEGREE OF ASSOCIATION
PROPERTY OF LESION-DISEASE NAME	10
LESION NAME-DISEASE NAME	9
ANATOMICAL SITE-LESION NAME	8
ANATOMICAL SITE-DISEASE NAME	8
⋮	
QUANTITY-LESION NAME	1
QUANTITY-PROPERTY OF LESION	0

42
SET IN ADVANCE BY OPERATOR

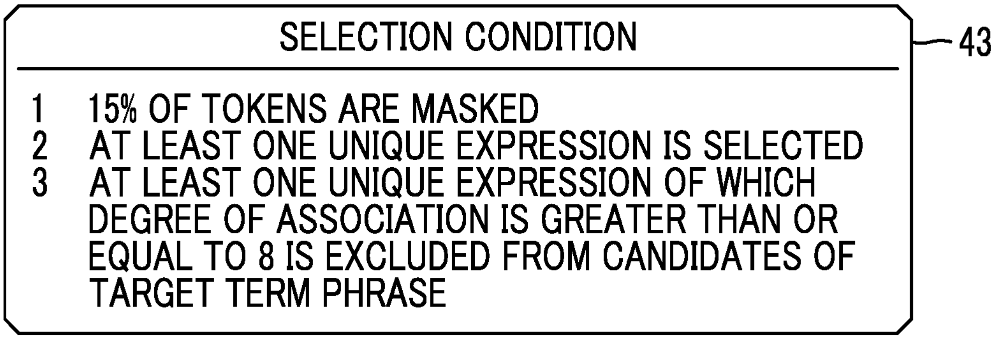
FIG. 9



DERIVATION RESULT

COMBINATION OF UNIQUE EXPRESSIONS (COMBINATION OF TYPES)	DEGREE OF ASSOCIATION
LIVER S3-SIZE OF DIAMETER OF 6 cm (ANATOMICAL SITE-QUANTITY)	1
LIVER S3-TUMOR (ANATOMICAL SITE-LESION NAME)	8
⋮	
TUMOR-HCC (LESION NAME-DISEASE NAME)	9
⋮	
SIZE OF DIAMETER OF 6 cm-EARLY ENHANCEMENT (QUANTITY-PROPERTY OF LESION)	0
SIZE OF DIAMETER OF 6 cm-washout (QUANTITY-PROPERTY OF LESION)	0
⋮	
EARLY ENHANCEMENT-HCC (PROPERTY OF LESION-DISEASE NAME)	10
washout-HCC (PROPERTY OF LESION-DISEASE NAME)	10

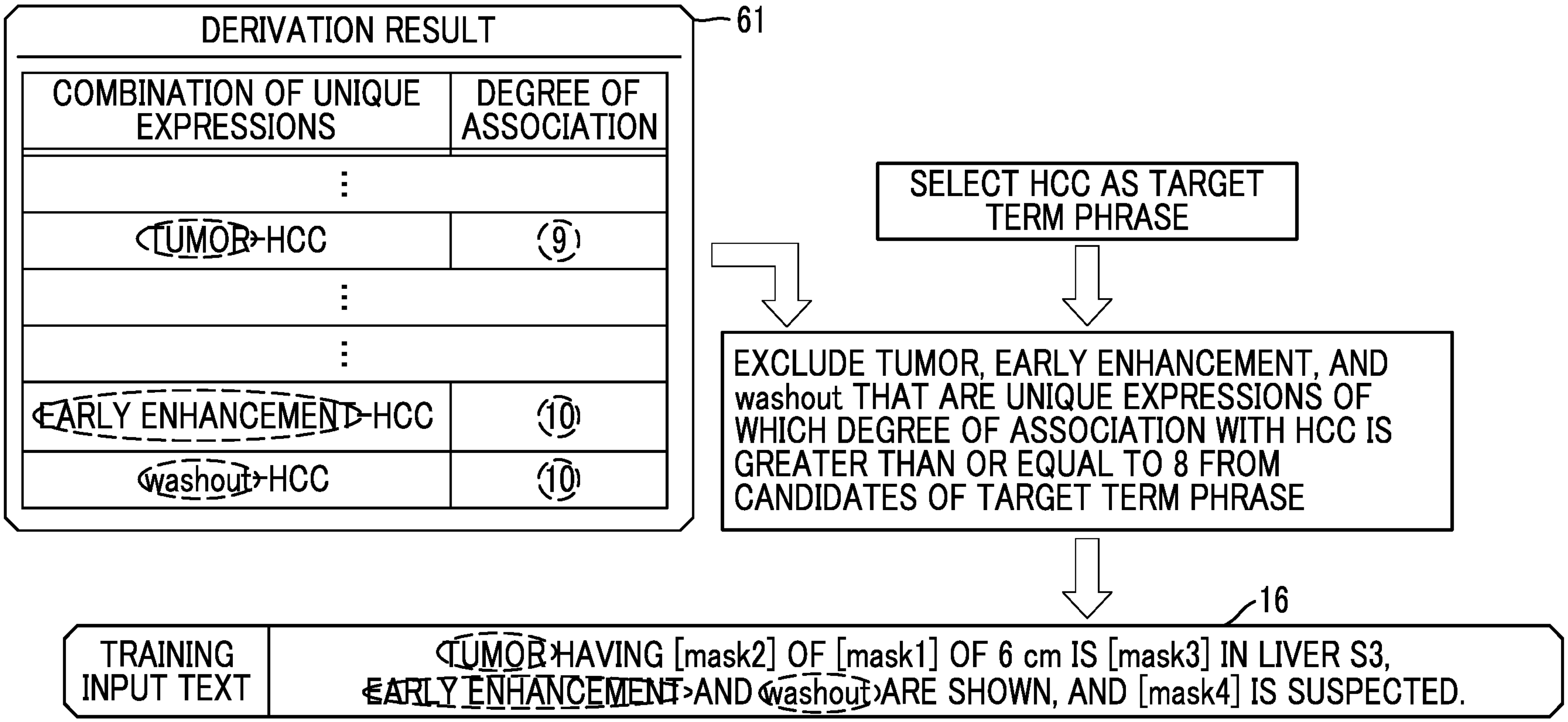
FIG. 10



SELECTION CONDITION

1 15% OF TOKENS ARE MASKED
2 AT LEAST ONE UNIQUE EXPRESSION IS SELECTED
3 AT LEAST ONE UNIQUE EXPRESSION OF WHICH DEGREE OF ASSOCIATION IS GREATER THAN OR EQUAL TO 8 IS EXCLUDED FROM CANDIDATES OF TARGET TERM PHRASE

FIG. 11



DERIVATION RESULT

COMBINATION OF UNIQUE EXPRESSIONS	DEGREE OF ASSOCIATION
⋮	
TUMOR-HCC	9
⋮	
⋮	
EARLY ENHANCEMENT-HCC	10
washout-HCC	10

SELECT HCC AS TARGET TERM PHRASE

EXCLUDE TUMOR, EARLY ENHANCEMENT, AND washout THAT ARE UNIQUE EXPRESSIONS OF WHICH DEGREE OF ASSOCIATION WITH HCC IS GREATER THAN OR EQUAL TO 8 FROM CANDIDATES OF TARGET TERM PHRASE

TRAINING INPUT TEXT	TUMOR HAVING [mask2] OF [mask1] OF 6 cm IS [mask3] IN LIVER S3, EARLY ENHANCEMENT AND washout ARE SHOWN, AND [mask4] IS SUSPECTED.

FIG. 12

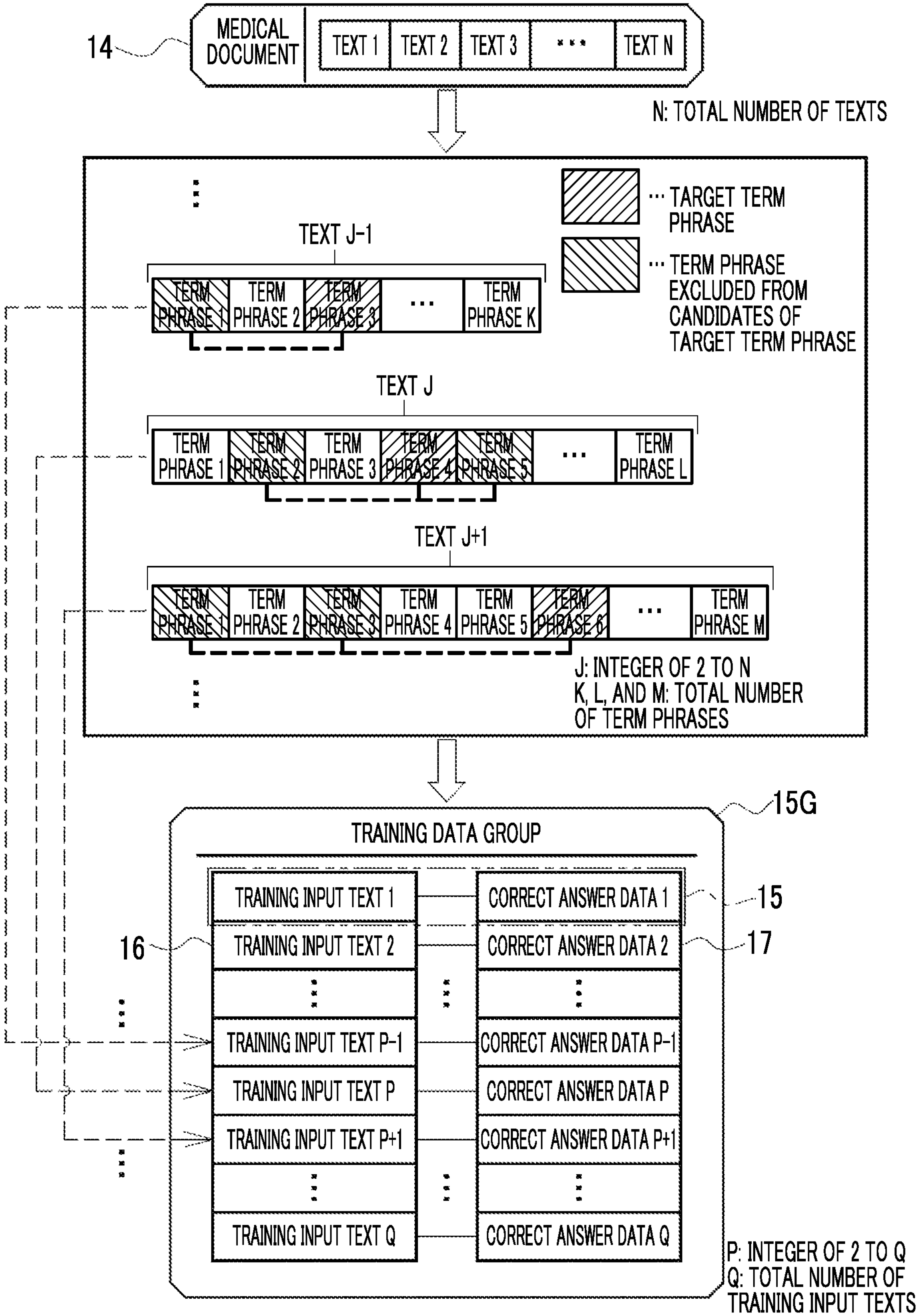

14
MEDICAL DOCUMENT
TEXT 1
TEXT 2
TEXT 3
...
TEXT N
N: TOTAL NUMBER OF TEXTS
... TARGET TERM PHRASE
... TERM PHRASE EXCLUDED FROM CANDIDATES OF TARGET TERM PHRASE
TEXT J-1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
...
TERM PHRASE K
TEXT J
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
...
TERM PHRASE L
TEXT J+1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
TERM PHRASE 6
...
TERM PHRASE M
J: INTEGER OF 2 TO N
K, L, AND M: TOTAL NUMBER OF TERM PHRASES
15G
TRAINING DATA GROUP
TRAINING INPUT TEXT 1
CORRECT ANSWER DATA 1
15
16
TRAINING INPUT TEXT 2
CORRECT ANSWER DATA 2
17
TRAINING INPUT TEXT P-1
CORRECT ANSWER DATA P-1
TRAINING INPUT TEXT P
CORRECT ANSWER DATA P
TRAINING INPUT TEXT P+1
CORRECT ANSWER DATA P+1
TRAINING INPUT TEXT Q
CORRECT ANSWER DATA Q
P: INTEGER OF 2 TO Q
Q: TOTAL NUMBER OF TRAINING INPUT TEXTS

FIG. 13

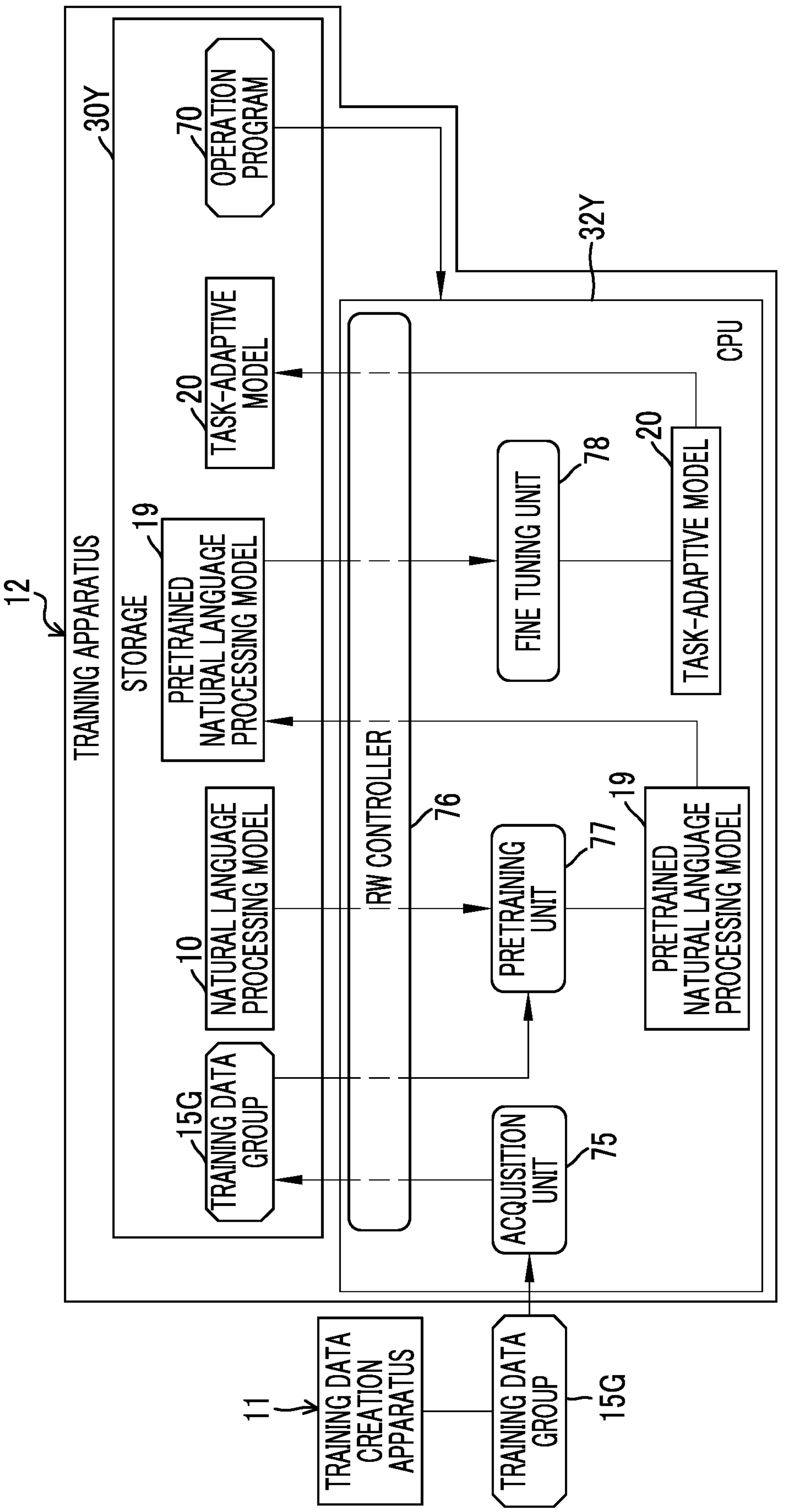

12
TRAINING APPARATUS
30Y
STORAGE
15G
TRAINING DATA GROUP
10
NATURAL LANGUAGE PROCESSING MODEL
19
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL
20
TASK-ADAPTIVE MODEL
70
OPERATION PROGRAM
32Y
CPU
76
RW CONTROLLER
75
ACQUISITION UNIT
77
PRETRAINING UNIT
78
FINE TUNING UNIT
19
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL
20
TASK-ADAPTIVE MODEL
11
TRAINING DATA CREATION APPARATUS
TRAINING DATA GROUP
15G

FIG. 14

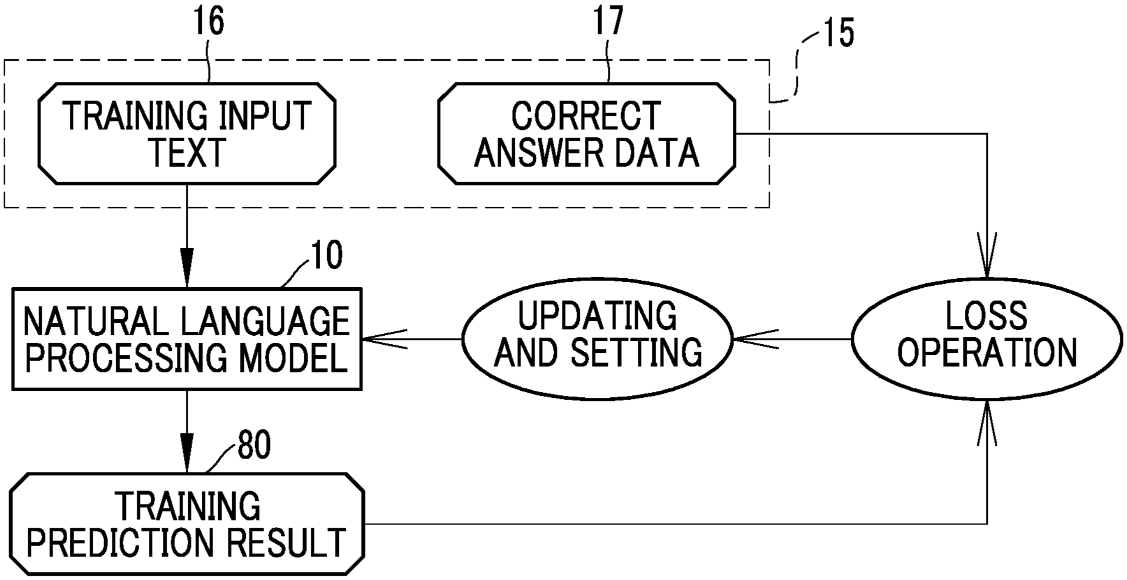

16
17
15
TRAINING INPUT TEXT
CORRECT ANSWER DATA
10
NATURAL LANGUAGE PROCESSING MODEL
UPDATING AND SETTING
LOSS OPERATION
80
TRAINING PREDICTION RESULT

FIG. 15

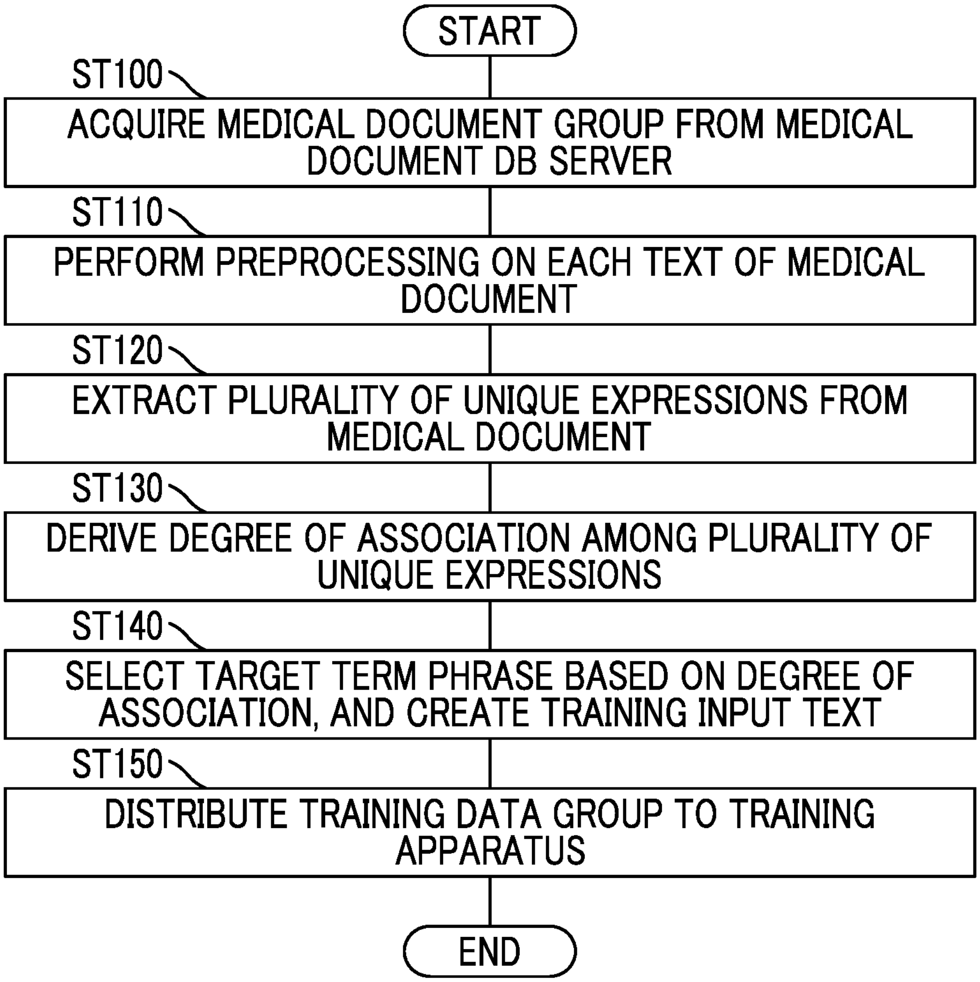

START
ST100
ACQUIRE MEDICAL DOCUMENT GROUP FROM MEDICAL DOCUMENT DB SERVER
ST110
PERFORM PREPROCESSING ON EACH TEXT OF MEDICAL DOCUMENT
ST120
EXTRACT PLURALITY OF UNIQUE EXPRESSIONS FROM MEDICAL DOCUMENT
ST130
DERIVE DEGREE OF ASSOCIATION AMONG PLURALITY OF UNIQUE EXPRESSIONS
ST140
SELECT TARGET TERM PHRASE BASED ON DEGREE OF ASSOCIATION, AND CREATE TRAINING INPUT TEXT
ST150
DISTRIBUTE TRAINING DATA GROUP TO TRAINING APPARATUS
END

FIG. 16

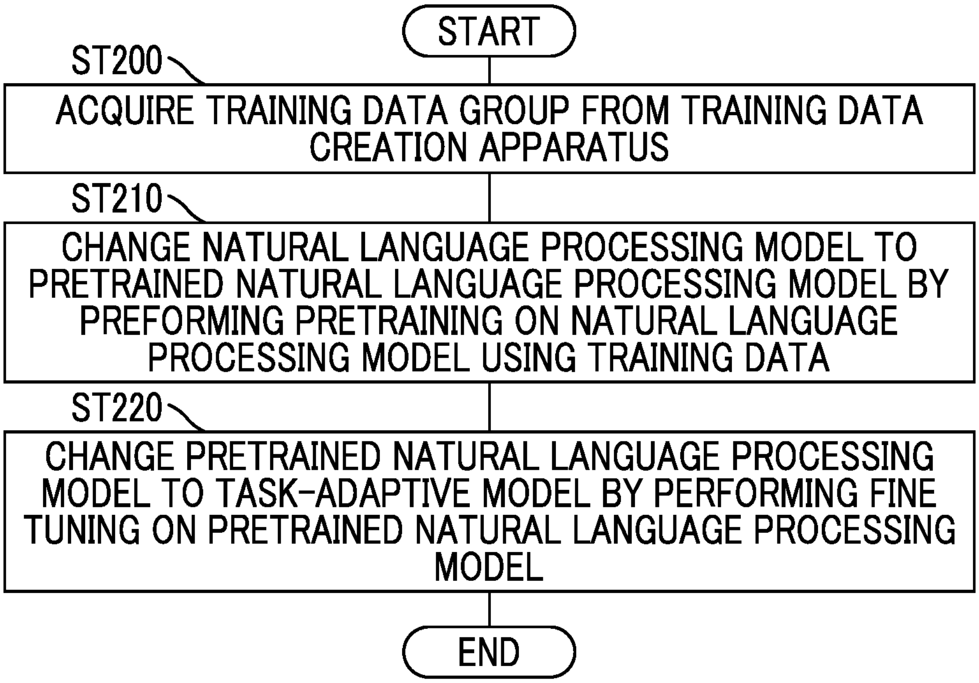

START
ST200
ACQUIRE TRAINING DATA GROUP FROM TRAINING DATA CREATION APPARATUS
ST210
CHANGE NATURAL LANGUAGE PROCESSING MODEL TO PRETRAINED NATURAL LANGUAGE PROCESSING MODEL BY PREFORMING PRETRAINING ON NATURAL LANGUAGE PROCESSING MODEL USING TRAINING DATA
ST220
CHANGE PRETRAINED NATURAL LANGUAGE PROCESSING MODEL TO TASK-ADAPTIVE MODEL BY PERFORMING FINE TUNING ON PRETRAINED NATURAL LANGUAGE PROCESSING MODEL
END

FIG. 17

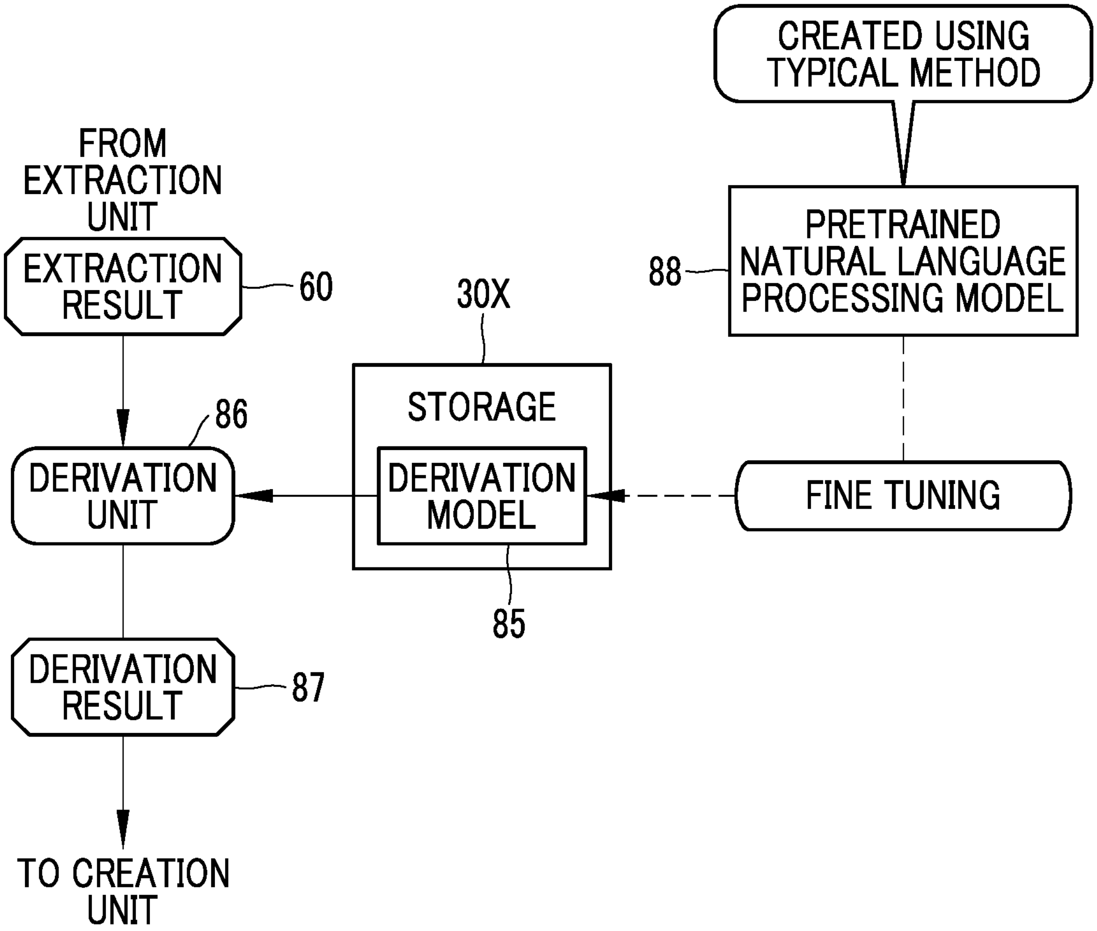

CREATED USING TYPICAL METHOD
FROM EXTRACTION UNIT
EXTRACTION RESULT
60
30X
88
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL
86
STORAGE
DERIVATION UNIT
DERIVATION MODEL
FINE TUNING
85
DERIVATION RESULT
87
TO CREATION UNIT

FIG. 18

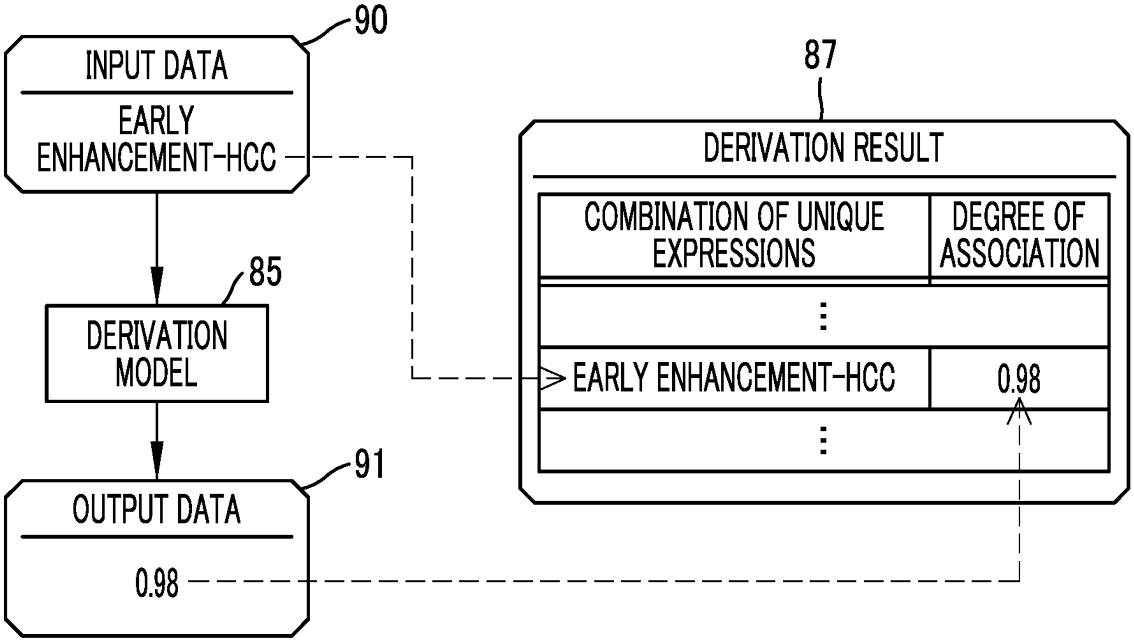
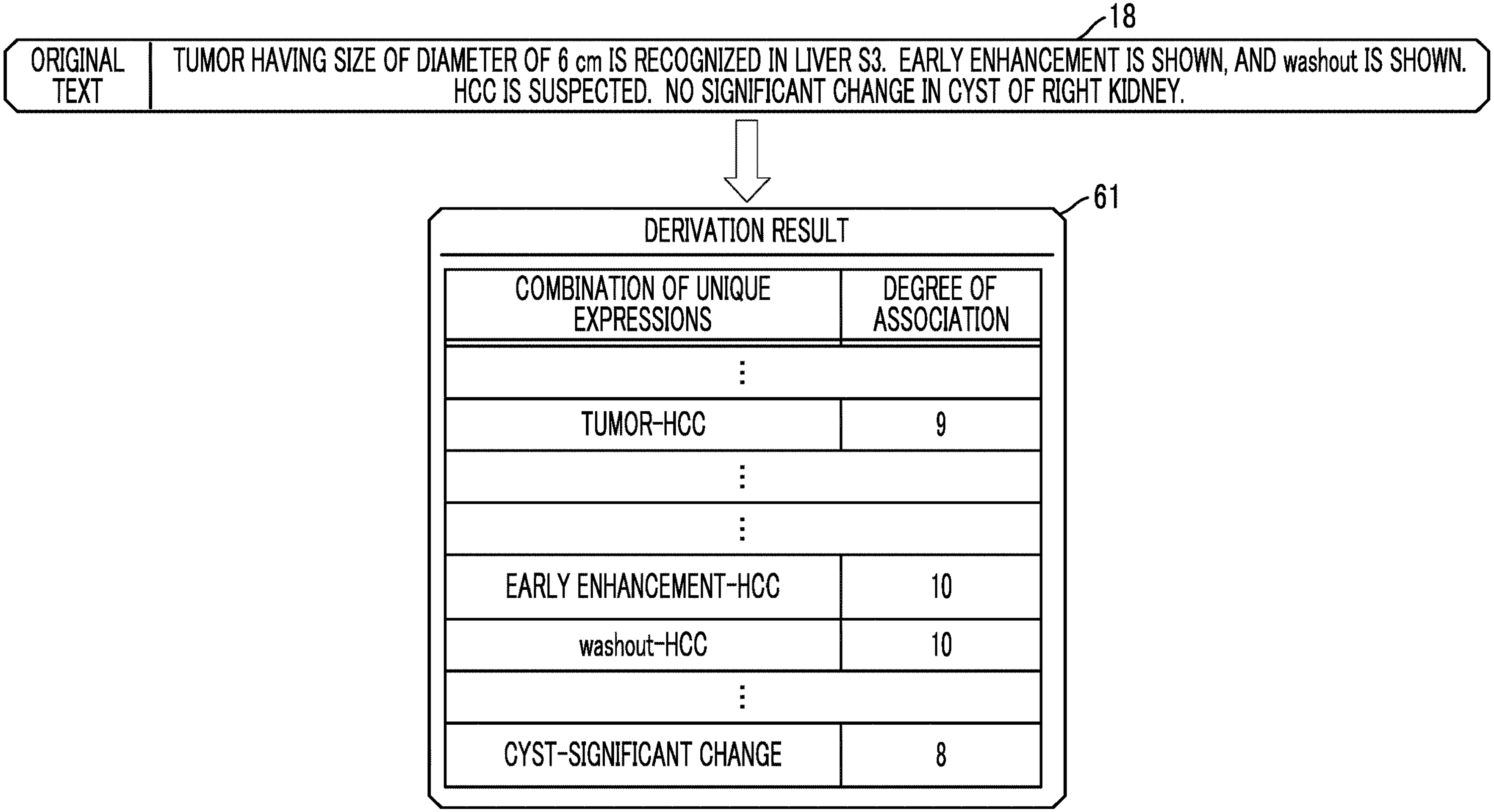

90
INPUT DATA
EARLY ENHANCEMENT-HCC
85
DERIVATION MODEL
91
OUTPUT DATA
0.98
87
DERIVATION RESULT
COMBINATION OF UNIQUE EXPRESSIONS
DEGREE OF ASSOCIATION
⋮
EARLY ENHANCEMENT-HCC
0.98
⋮

FIG. 19



ORIGINAL TEXT

TUMOR HAVING SIZE OF DIAMETER OF 6 cm IS RECOGNIZED IN LIVER S3. EARLY ENHANCEMENT IS SHOWN, AND washout IS SHOWN. HCC IS SUSPECTED. NO SIGNIFICANT CHANGE IN CYST OF RIGHT KIDNEY.

DERIVATION RESULT

COMBINATION OF UNIQUE EXPRESSIONS	DEGREE OF ASSOCIATION
⋮	
TUMOR-HCC	9
⋮	
⋮	
EARLY ENHANCEMENT-HCC	10
washout-HCC	10
⋮	
CYST-SIGNIFICANT CHANGE	8

FIG. 20

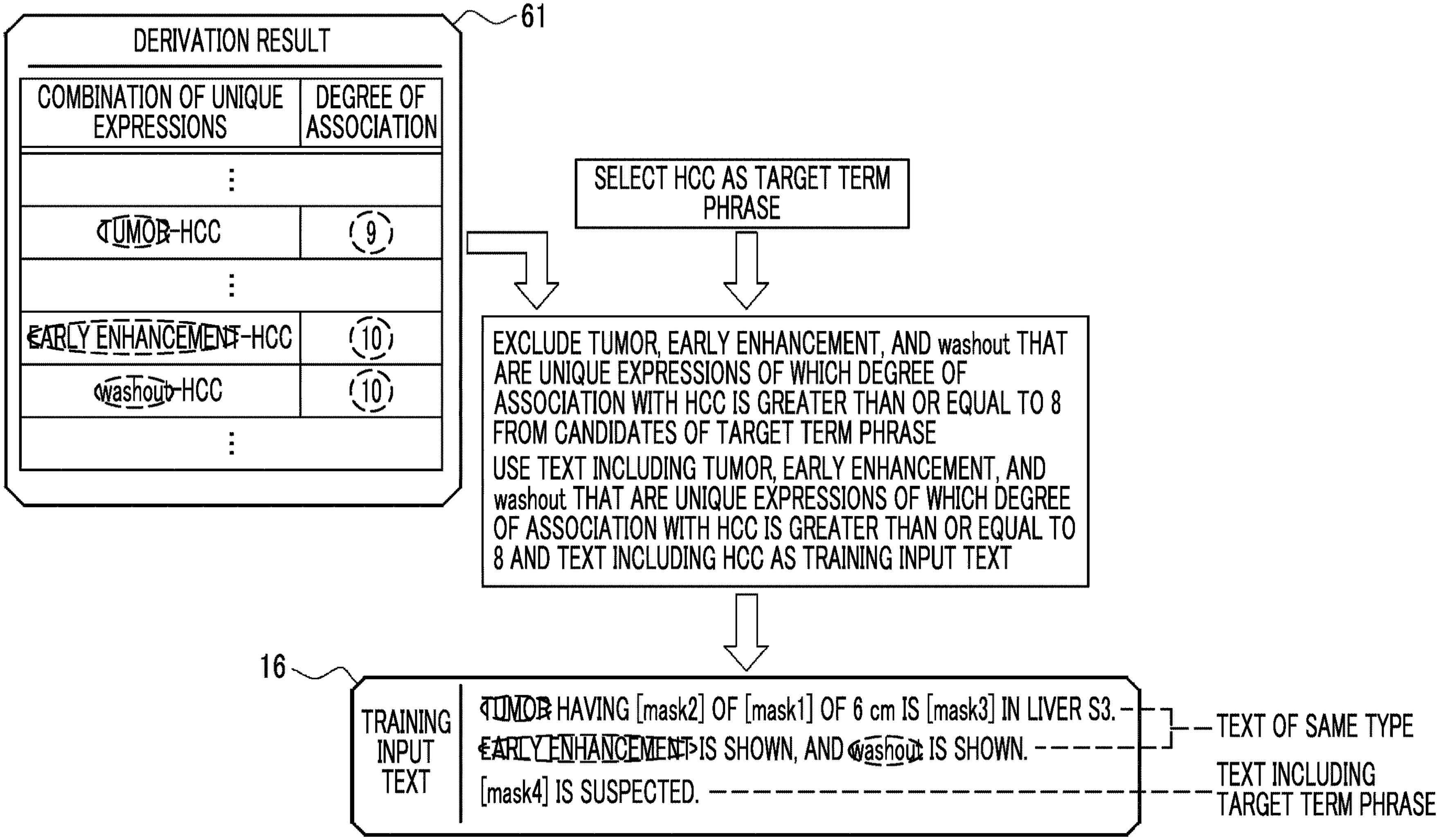

61
DERIVATION RESULT
COMBINATION OF UNIQUE EXPRESSIONS
DEGREE OF ASSOCIATION
⋮
TUMOR-HCC
9
⋮
EARLY ENHANCEMENT-HCC
10
washout-HCC
10
⋮
SELECT HCC AS TARGET TERM PHRASE
EXCLUDE TUMOR, EARLY ENHANCEMENT, AND washout THAT ARE UNIQUE EXPRESSIONS OF WHICH DEGREE OF ASSOCIATION WITH HCC IS GREATER THAN OR EQUAL TO 8 FROM CANDIDATES OF TARGET TERM PHRASE
USE TEXT INCLUDING TUMOR, EARLY ENHANCEMENT, AND washout THAT ARE UNIQUE EXPRESSIONS OF WHICH DEGREE OF ASSOCIATION WITH HCC IS GREATER THAN OR EQUAL TO 8 AND TEXT INCLUDING HCC AS TRAINING INPUT TEXT
16
TRAINING INPUT TEXT
TUMOR HAVING [mask2] OF [mask1] OF 6 cm IS [mask3] IN LIVER S3.
EARLY ENHANCEMENT IS SHOWN, AND washout IS SHOWN.
[mask4] IS SUSPECTED.
TEXT OF SAME TYPE
TEXT INCLUDING TARGET TERM PHRASE

FIG. 21

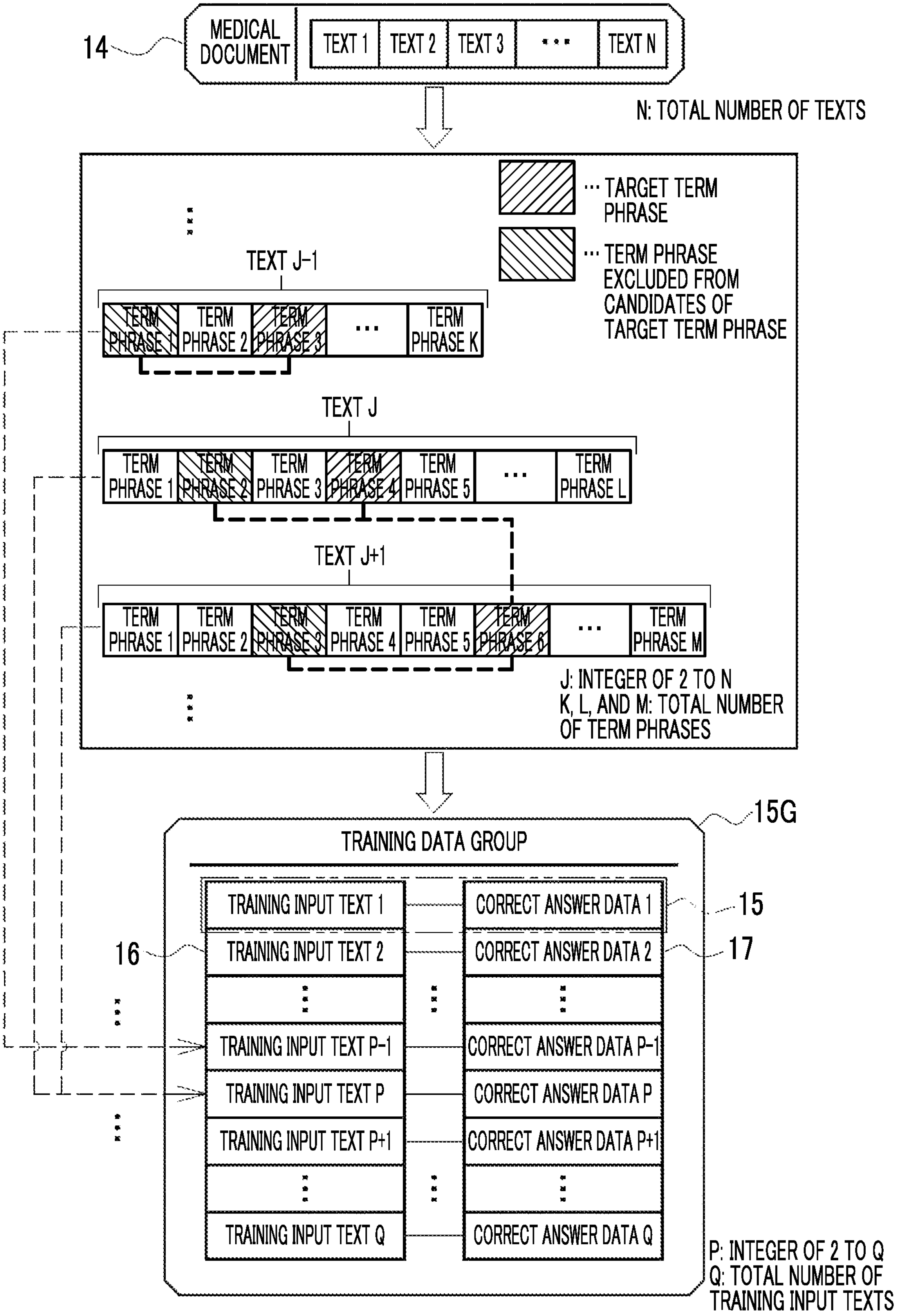

14
MEDICAL DOCUMENT
TEXT 1
TEXT 2
TEXT 3
TEXT N
N: TOTAL NUMBER OF TEXTS
··· TARGET TERM PHRASE
··· TERM PHRASE EXCLUDED FROM CANDIDATES OF TARGET TERM PHRASE
TEXT J−1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE K
TEXT J
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
TERM PHRASE L
TEXT J+1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
TERM PHRASE 6
TERM PHRASE M
J: INTEGER OF 2 TO N
K, L, AND M: TOTAL NUMBER OF TERM PHRASES
15G
TRAINING DATA GROUP
TRAINING INPUT TEXT 1
CORRECT ANSWER DATA 1
15
16
TRAINING INPUT TEXT 2
CORRECT ANSWER DATA 2
17
TRAINING INPUT TEXT P−1
CORRECT ANSWER DATA P−1
TRAINING INPUT TEXT P
CORRECT ANSWER DATA P
TRAINING INPUT TEXT P+1
CORRECT ANSWER DATA P+1
TRAINING INPUT TEXT Q
CORRECT ANSWER DATA Q
P: INTEGER OF 2 TO Q
Q: TOTAL NUMBER OF TRAINING INPUT TEXTS

FIG. 22

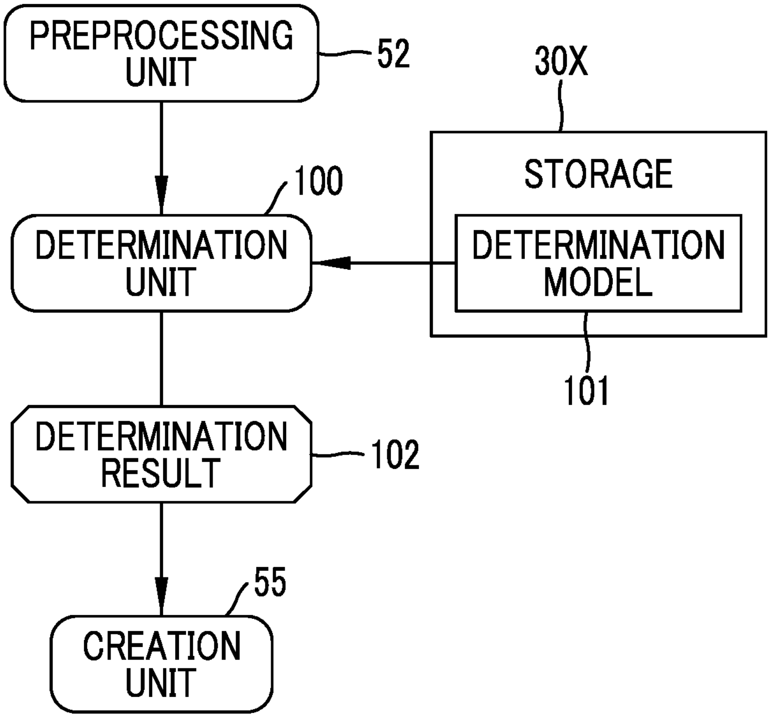
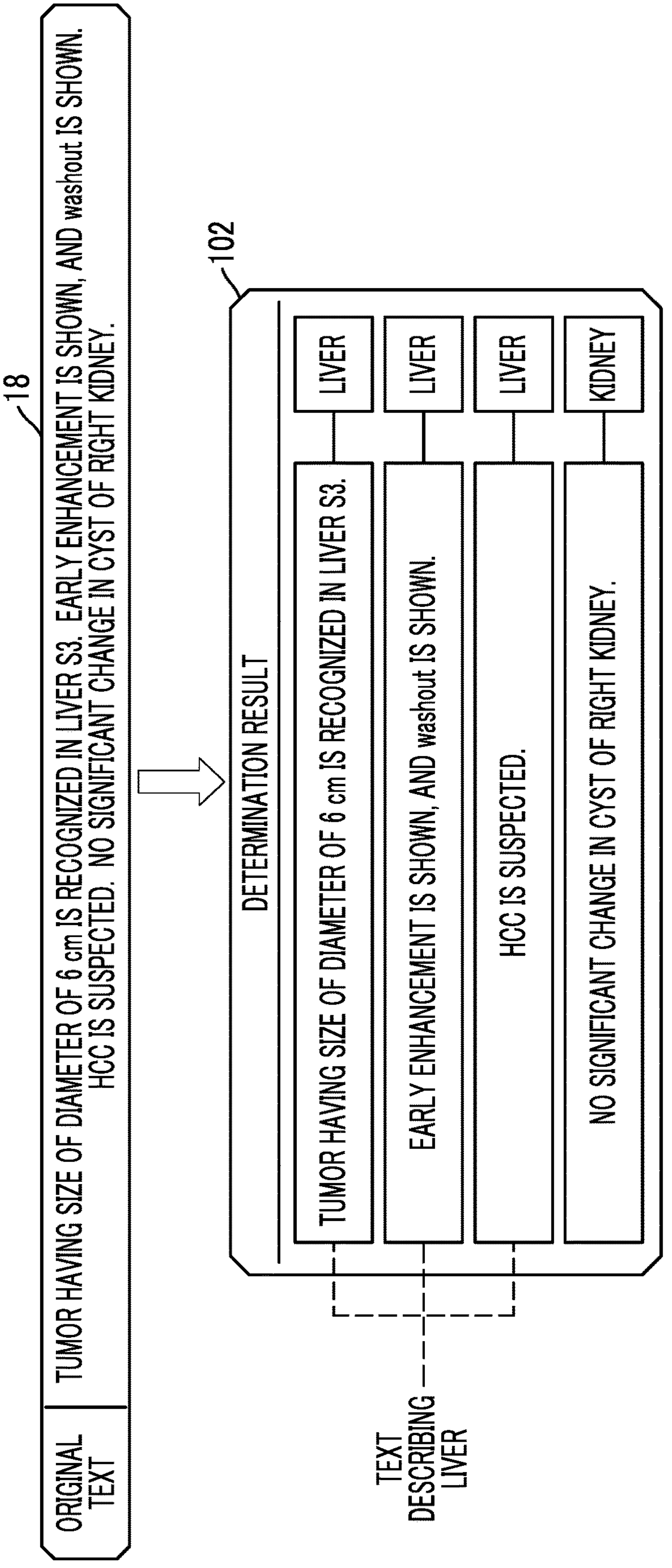

PREPROCESSING UNIT
52
30X
STORAGE
100
DETERMINATION UNIT
DETERMINATION MODEL
101
DETERMINATION RESULT
102
55
CREATION UNIT

FIG. 23



TUMOR HAVING SIZE OF DIAMETER OF 6 cm IS RECOGNIZED IN LIVER S3. EARLY ENHANCEMENT IS SHOWN, AND washout IS SHOWN. HCC IS SUSPECTED. NO SIGNIFICANT CHANGE IN CYST OF RIGHT KIDNEY.

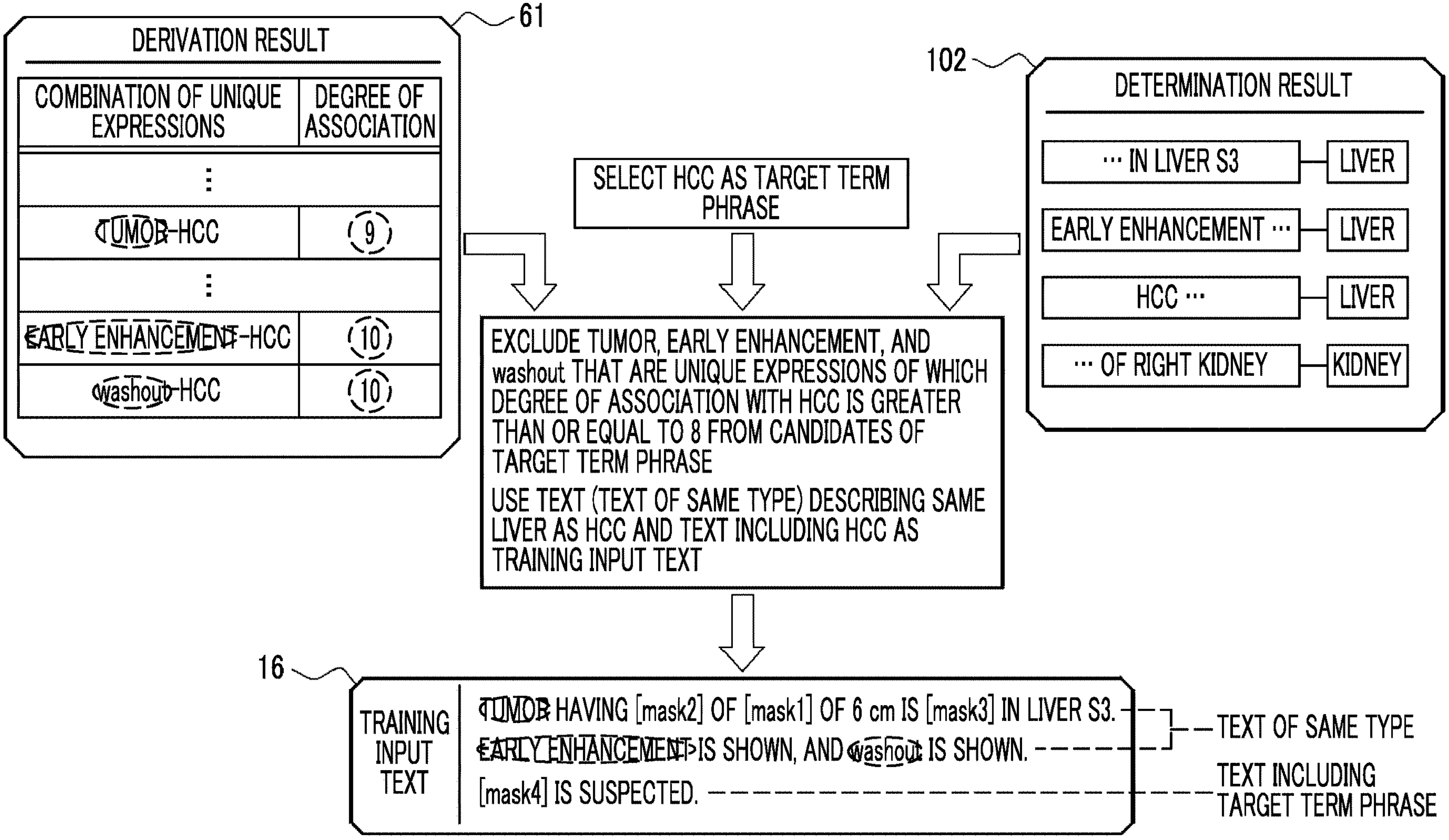
TUMOR HAVING SIZE OF DIAMETER OF 6 cm IS RECOGNIZED IN LIVER S3.

EARLY ENHANCEMENT IS SHOWN, AND washout IS SHOWN.

HCC IS SUSPECTED.

NO SIGNIFICANT CHANGE IN CYST OF RIGHT KIDNEY.

FIG. 24



COMBINATION OF UNIQUE EXPRESSIONS	DEGREE OF ASSOCIATION
⋮	
TUMOR-HCC	9
⋮	
EARLY ENHANCEMENT-HCC	10
washout-HCC	10

SELECT HCC AS TARGET TERM PHRASE

EXCLUDE TUMOR, EARLY ENHANCEMENT, AND washout THAT ARE UNIQUE EXPRESSIONS OF WHICH DEGREE OF ASSOCIATION WITH HCC IS GREATER THAN OR EQUAL TO 8 FROM CANDIDATES OF TARGET TERM PHRASE

USE TEXT (TEXT OF SAME TYPE) DESCRIBING SAME LIVER AS HCC AND TEXT INCLUDING HCC AS TRAINING INPUT TEXT

TUMOR HAVING [mask2] OF [mask1] OF 6 cm IS [mask3] IN LIVER S3.
EARLY ENHANCEMENT IS SHOWN, AND washout IS SHOWN.
[mask4] IS SUSPECTED.

FIG. 25

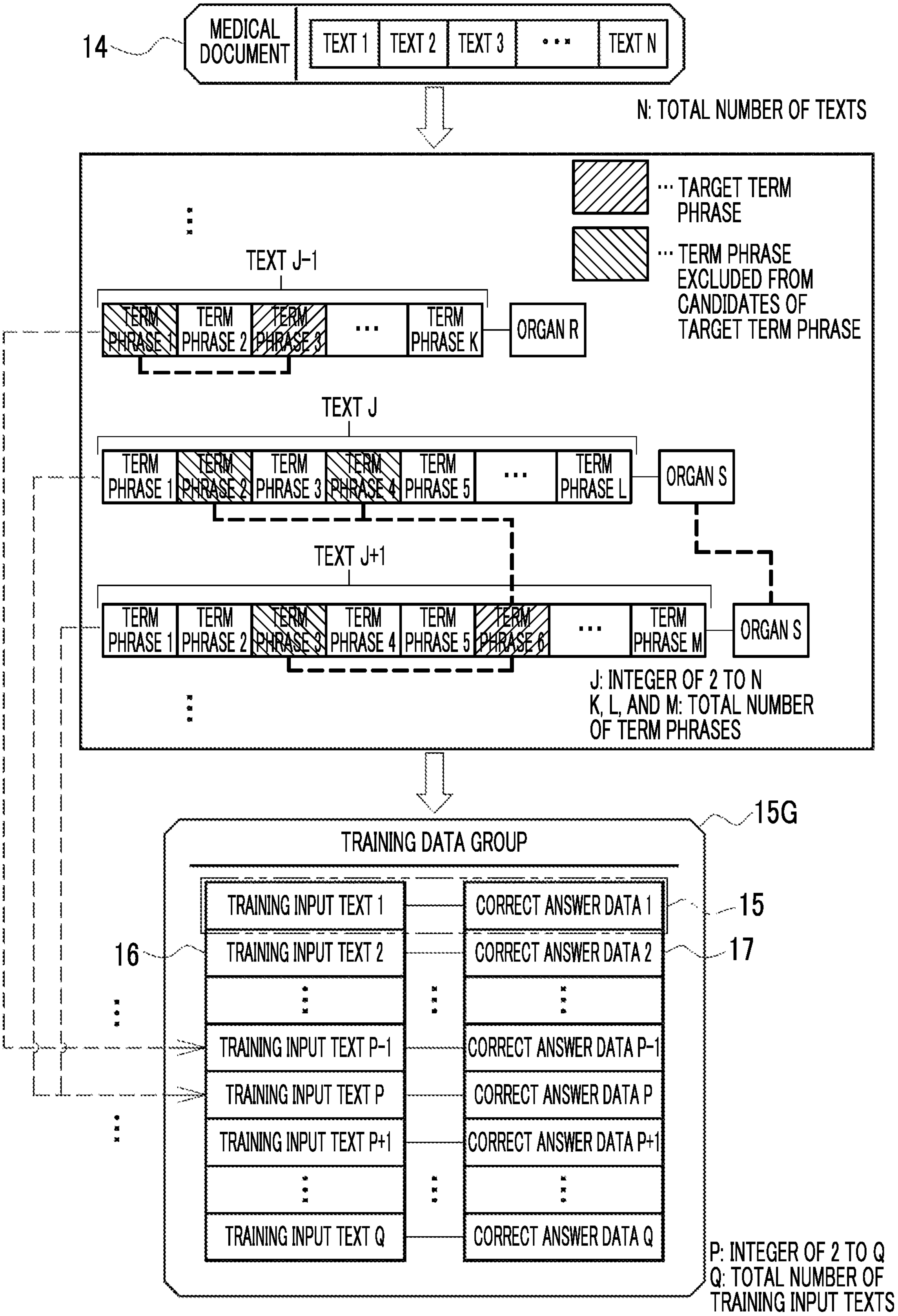

14
MEDICAL DOCUMENT
TEXT 1
TEXT 2
TEXT 3
• • •
TEXT N
N: TOTAL NUMBER OF TEXTS
··· TARGET TERM PHRASE
··· TERM PHRASE EXCLUDED FROM CANDIDATES OF TARGET TERM PHRASE
TEXT J−1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE K
ORGAN R
TEXT J
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
TERM PHRASE L
ORGAN S
TEXT J+1
TERM PHRASE 1
TERM PHRASE 2
TERM PHRASE 3
TERM PHRASE 4
TERM PHRASE 5
TERM PHRASE 6
TERM PHRASE M
ORGAN S
J: INTEGER OF 2 TO N
K, L, AND M: TOTAL NUMBER OF TERM PHRASES
15G
TRAINING DATA GROUP
TRAINING INPUT TEXT 1
CORRECT ANSWER DATA 1
15
16
TRAINING INPUT TEXT 2
CORRECT ANSWER DATA 2
17
TRAINING INPUT TEXT P−1
CORRECT ANSWER DATA P−1
TRAINING INPUT TEXT P
CORRECT ANSWER DATA P
TRAINING INPUT TEXT P+1
CORRECT ANSWER DATA P+1
TRAINING INPUT TEXT Q
CORRECT ANSWER DATA Q
P: INTEGER OF 2 TO Q
Q: TOTAL NUMBER OF TRAINING INPUT TEXTS

FIG. 26

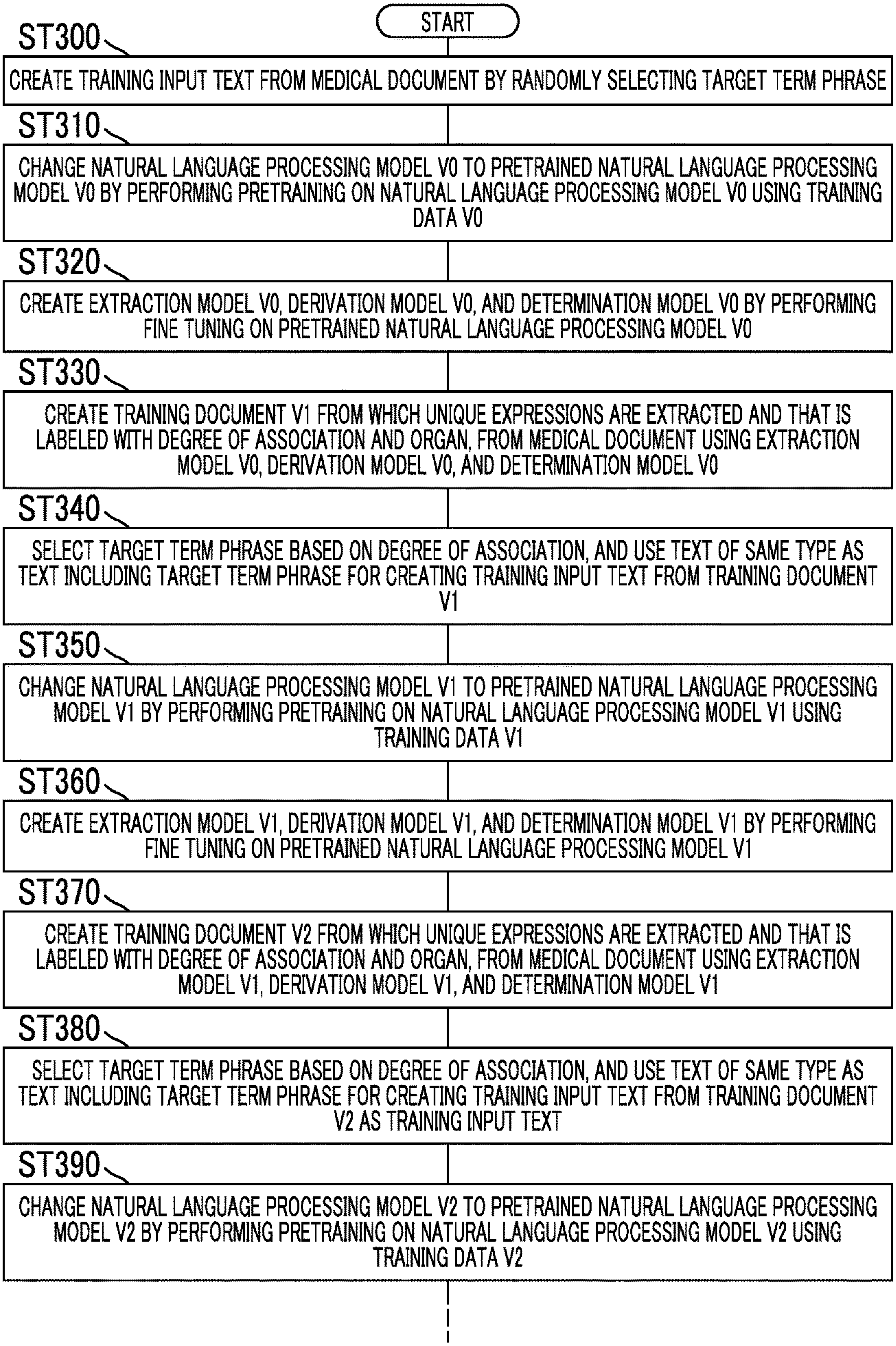
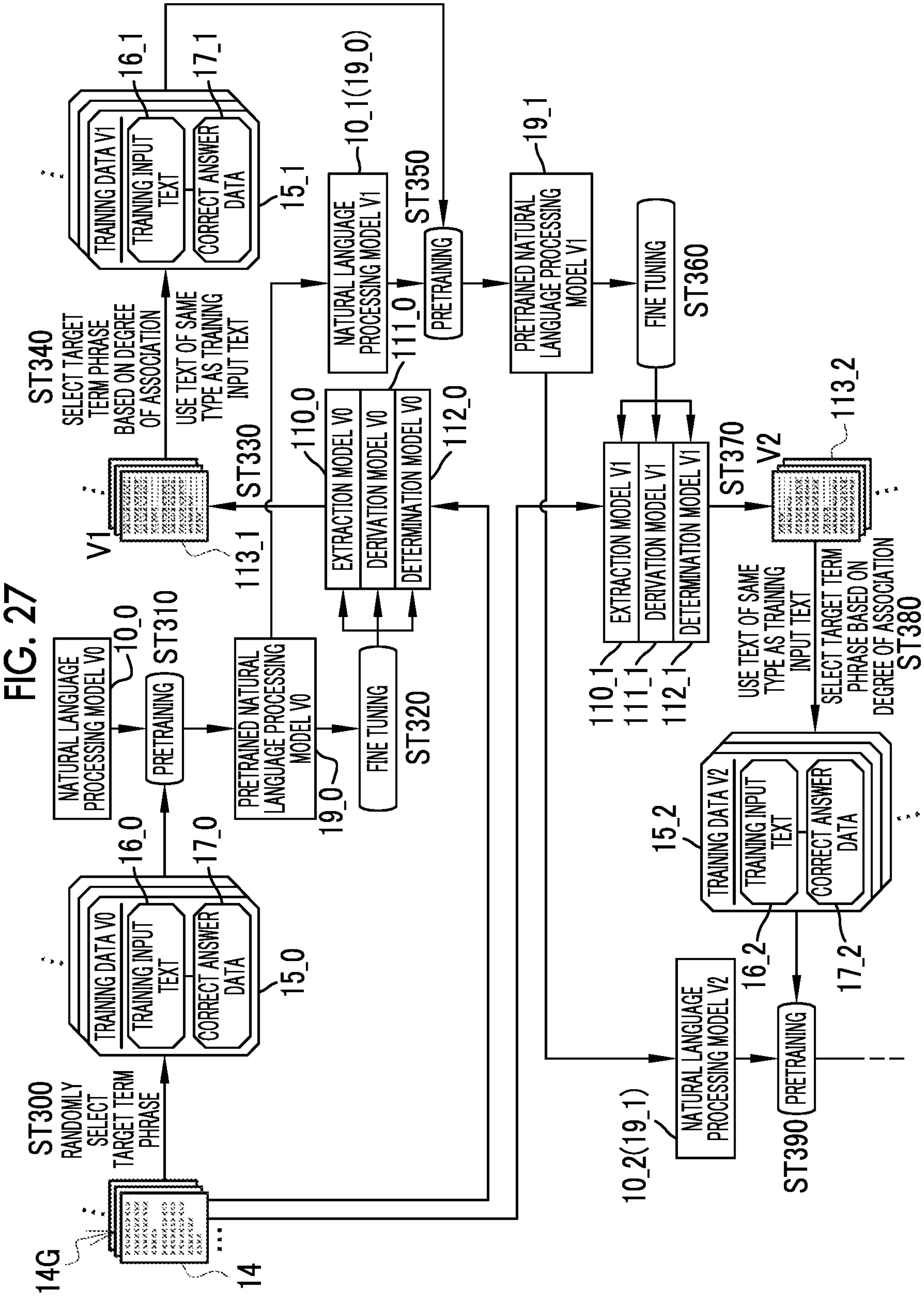

START
ST300
CREATE TRAINING INPUT TEXT FROM MEDICAL DOCUMENT BY RANDOMLY SELECTING TARGET TERM PHRASE
ST310
CHANGE NATURAL LANGUAGE PROCESSING MODEL V0 TO PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V0 BY PERFORMING PRETRAINING ON NATURAL LANGUAGE PROCESSING MODEL V0 USING TRAINING DATA V0
ST320
CREATE EXTRACTION MODEL V0, DERIVATION MODEL V0, AND DETERMINATION MODEL V0 BY PERFORMING FINE TUNING ON PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V0
ST330
CREATE TRAINING DOCUMENT V1 FROM WHICH UNIQUE EXPRESSIONS ARE EXTRACTED AND THAT IS LABELED WITH DEGREE OF ASSOCIATION AND ORGAN, FROM MEDICAL DOCUMENT USING EXTRACTION MODEL V0, DERIVATION MODEL V0, AND DETERMINATION MODEL V0
ST340
SELECT TARGET TERM PHRASE BASED ON DEGREE OF ASSOCIATION, AND USE TEXT OF SAME TYPE AS TEXT INCLUDING TARGET TERM PHRASE FOR CREATING TRAINING INPUT TEXT FROM TRAINING DOCUMENT V1
ST350
CHANGE NATURAL LANGUAGE PROCESSING MODEL V1 TO PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V1 BY PERFORMING PRETRAINING ON NATURAL LANGUAGE PROCESSING MODEL V1 USING TRAINING DATA V1
ST360
CREATE EXTRACTION MODEL V1, DERIVATION MODEL V1, AND DETERMINATION MODEL V1 BY PERFORMING FINE TUNING ON PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V1
ST370
CREATE TRAINING DOCUMENT V2 FROM WHICH UNIQUE EXPRESSIONS ARE EXTRACTED AND THAT IS LABELED WITH DEGREE OF ASSOCIATION AND ORGAN, FROM MEDICAL DOCUMENT USING EXTRACTION MODEL V1, DERIVATION MODEL V1, AND DETERMINATION MODEL V1
ST380
SELECT TARGET TERM PHRASE BASED ON DEGREE OF ASSOCIATION, AND USE TEXT OF SAME TYPE AS TEXT INCLUDING TARGET TERM PHRASE FOR CREATING TRAINING INPUT TEXT FROM TRAINING DOCUMENT V2 AS TRAINING INPUT TEXT
ST390
CHANGE NATURAL LANGUAGE PROCESSING MODEL V2 TO PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V2 BY PERFORMING PRETRAINING ON NATURAL LANGUAGE PROCESSING MODEL V2 USING TRAINING DATA V2

FIG. 27


14G
14
ST300
RANDOMLY SELECT TARGET TERM PHRASE
TRAINING DATA V0
TRAINING INPUT TEXT
CORRECT ANSWER DATA
15_0
16_0
17_0
NATURAL LANGUAGE PROCESSING MODEL V0
10_0
PRETRAINING
ST310
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V0
19_0
FINE TUNING
ST320
EXTRACTION MODEL V0
DERIVATION MODEL V0
DETERMINATION MODEL V0
110_0
111_0
112_0
ST330
V1
113_1
ST340
SELECT TARGET TERM PHRASE BASED ON DEGREE OF ASSOCIATION
USE TEXT OF SAME TYPE AS TRAINING INPUT TEXT
TRAINING DATA V1
TRAINING INPUT TEXT
CORRECT ANSWER DATA
15_1
16_1
17_1
NATURAL LANGUAGE PROCESSING MODEL V1
10_1(19_0)
PRETRAINING
ST350
PRETRAINED NATURAL LANGUAGE PROCESSING MODEL V1
19_1
FINE TUNING
ST360
EXTRACTION MODEL V1
DERIVATION MODEL V1
DETERMINATION MODEL V1
110_1
111_1
112_1
ST370
V2
113_2
USE TEXT OF SAME TYPE AS TRAINING INPUT TEXT
SELECT TARGET TERM PHRASE BASED ON DEGREE OF ASSOCIATION
ST380
TRAINING DATA V2
TRAINING INPUT TEXT
CORRECT ANSWER DATA
15_2
16_2
17_2
NATURAL LANGUAGE PROCESSING MODEL V2
10_2(19_1)
PRETRAINING
ST390

INFORMATION PROCESSING APPARATUS, OPERATION METHOD OF INFORMATION PROCESSING APPARATUS, AND OPERATION PROGRAM OF INFORMATION PROCESSING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. § 119 to Japanese Patent Application No., 2021-213437 filed on Dec. 27, 2021. The above application is hereby expressly incorporated by reference, in its entirety, into the present application.

BACKGROUND

1. Technical Field

The disclosed technology relates to an information processing apparatus, an operation method of an information processing apparatus, and an operation program of an information processing apparatus.

2. Description of the Related Art

In the field of natural language processing (NLP), attention has been paid to bidirectional encoder representations from transformers (BERT) using a transformer encoder. In BERT, masked language modeling (MLM) is performed as pretraining. MLM is a so-called cloze test for predicting which term phrase fits in a masked part of a training input text in which a part of term phrases is masked. After such pretraining, fine tuning corresponding to a desired natural language processing task is performed in BERT. The term phrase is a single term (word) and/or a phrase consisting of a combination of one or more single terms.

Typically, a term phrase (hereinafter, referred to as a target term phrase) that is a target to be masked in the training input text used in MLM is randomly selected. However, in this case, a term phrase that is not important in a target document of the natural language processing task is often selected as the target term phrase. Performing MLM using such a training input text loses a training opportunity for an important term phrase in the target document of the natural language processing task. Thus, there is a concern that effective pretraining is not performed.

Particularly, in a field such as the medical field in which it is difficult to obtain a large amount of documents as a base of the training input text, the concern that the effective pretraining is not performed is increased because of the loss of the training opportunity for the important term phrase. For example, in a text "Early enhancement is recognized in a tumor found in a liver S3.", in a case where a term phrase such as a preposition "in" that is not important is selected as the target term phrase, and an important term phrase such as "tumor" or "early enhancement" is not selected as the target term phrase, the training opportunity for the important term phrase is lost, and the effective pretraining is not performed. Therefore, for example, a method for studying how to select the target term phrase has been suggested as in Chen Lin, et al: EntityBERT: Entity-centric Masking Strategy for Model Pretraining for the Clinical Domain, Proceedings of the BioNLP 2021 workshop, pages 191-201 Jun. 11, 2021.

Chen Lin, et al: EntityBERT: Entity-centric Masking Strategy for Model Pretraining for the Clinical Domain, Proceedings of the BioNLP 2021 workshop, pages 191-201 Jun. 11, 2021 discloses a technology for creating a training input text used in MLM of BERT that targets medical documents. Specifically, a unique expression that is a term phrase such as a disorder, a sign, a symptom, a drug, an anatomical site, a procedure, and a time expression unique to a medical document is extracted, and the target term phrase is selected based on the extracted unique expression.

SUMMARY

In a case where a term phrase necessary for predicting the masked term phrase is not present in the training input text used in MLM, it is apparently difficult to predict the masked term phrase. For example, in the medical document, the early enhancement that is a term representing a property of a tumor of a liver is a term highly related to hepatocellular carcinoma (HCC). However, in a case where both of "early enhancement" and "HCC" in a text "Early enhancement is recognized in a tumor found in a liver S3. HCC is suspected." are masked, terms necessary for predicting "early enhancement" and "HCC" from each other are not present in the text. Thus, it is difficult to predict one of "early enhancement" and "HCC" from the other. This problem is not considered in Chen Lin, et al: EntityBERT: Entity-centric Masking Strategy for Model Pretraining for the Clinical Domain, Proceedings of the BioNLP 2021 workshop, pages 191-201 Jun. 11, 2021. Accordingly, there is still a concern that the effective pretraining is not performed.

One embodiment according to the disclosed technology provides an information processing apparatus, an operation method of an information processing apparatus, and an operation program of an information processing apparatus that can create a training input text contributing to effective training of a natural language processing model.

An information processing apparatus according to an aspect of the present disclosure is an information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the information processing apparatus comprising a processor, in which the processor is configured to extract a plurality of specific term phrases from the document, derive a degree of association indicating a degree of association among the plurality of specific term phrases, and select a target term phrase that is a term phrase as a target to be masked based on the degree of association.

It is preferable that the processor is configured to exclude the specific term phrase of which the degree of association with the term phrase selected as the target term phrase satisfies a condition set in advance, from candidates of the target term phrase.

It is preferable that the processor is configured to determine a text of the same type as a text including the term phrase selected as the target term phrase, and use the text including the target term phrase and the text of the same type as the training input text.

It is preferable that the processor is configured to determine that a text including the specific term phrase of which the degree of association with the term phrase selected as the target term phrase satisfies a condition set in advance is the text of the same type.

It is preferable that the document is a medical document, and the processor is configured to determine that a text describing the same organ as an organ related to the term phrase selected as the target term phrase is the text of the same type.

It is preferable that the processor is configured to derive the degree of association using degree-of-association information in which the degree of association corresponding to a combination of types of the specific term phrases is set in advance.

It is preferable that the document is a medical document, and the types include at least one of an anatomical site, a quantity, a lesion name, a property of a lesion, or a disease name.

It is preferable that the processor is configured to derive the degree of association using a trained derivation model.

It is preferable that the derivation model is created based on a trained natural language processing model.

It is preferable that the processor is configured to train the natural language processing model using the training input text.

It is preferable that the processor is configured to repeat a cycle of a series of processing including creating an extraction model for extracting at least the specific term phrases from the natural language processing model, creating a training document from which the specific term phrases are extracted using the extraction model, creating the training input text from the training document, and updating the natural language processing model by training the natural language processing model using the created training input text.

It is preferable that the processor is configured to, in an initial cycle, create the extraction model from a natural language processing model created by training using a training input text in which the target term phrase is randomly selected regardless of the degree of association.

It is preferable that the processor is configured to further create a derivation model for deriving the degree of association from the natural language processing model, and create the training document labeled with the degree of association using the derivation model.

It is preferable that the document is a medical document, and the processor is configured to further create a determination model for determining which organ a text describes from the natural language processing model, and create the training document labeled with the organ using the determination model.

An operation method of an information processing apparatus according to another aspect of the present disclosure is an operation method of an information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the operation method comprising extracting a plurality of specific term phrases from the document, deriving a degree of association indicating a degree of association among the plurality of specific term phrases, and selecting a target term phrase that is a term phrase as a target to be masked based on the degree of association.

An operation program of an information processing apparatus according to still another aspect of the present disclosure is an operation program of an information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the operation program causing a computer to execute a process comprising extracting a plurality of specific term phrases from the document, deriving a degree of association indicating a degree of association among the plurality of specific term phrases, and selecting a target term phrase that is a term phrase as a target to be masked based on the degree of association.

According to the disclosed technology, an information processing apparatus, an operation method of an information processing apparatus, and an operation program of an information processing apparatus that can create a training input text contributing to effective training of a natural language processing model can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments according to the technique of the present disclosure will be described in detail based on the following figures, wherein:

FIG. **1** is a diagram illustrating a training system and the like including a training data creation apparatus and a training apparatus;

FIG. **2** is a diagram illustrating a training input text and correct answer data created from an original text of a medical document;

FIG. **3** is a diagram illustrating a training procedure of a natural language processing model;

FIG. **4** is a block diagram illustrating computers constituting the training data creation apparatus and the training apparatus;

FIG. **5** is a block diagram illustrating a processing unit of a CPU of the training data creation apparatus;

FIG. **6** is a diagram illustrating processing of a preprocessing unit;

FIG. **7** is a diagram illustrating processing of an extraction unit;

FIG. **8** is a diagram illustrating degree-of-association information;

FIG. **9** is a diagram illustrating a derivation result;

FIG. **10** is a diagram illustrating a selection condition;

FIG. **11** is a diagram illustrating processing of a creation unit;

FIG. **12** is a diagram of overall processing of the training data creation apparatus;

FIG. **13** is a block diagram illustrating a processing unit of a CPU of the training apparatus;

FIG. **14** is a diagram illustrating a summary of processing in MLM in pretraining of the natural language processing model;

FIG. **15** is a flowchart illustrating a processing procedure of the training data creation apparatus;

FIG. **16** is a flowchart illustrating a processing procedure of the training apparatus;

FIG. **17** is a diagram illustrating Embodiment 2 in which a degree of association is derived using a trained derivation model;

FIG. **18** is a diagram illustrating a derivation result in Embodiment 2;

FIG. **19** is a diagram illustrating a derivation result in Embodiment 3_1;

FIG. **20** is a diagram illustrating processing of a creation unit in Embodiment 3_1;

FIG. **21** is a diagram of overall processing of a training data creation apparatus in Embodiment 3_1;

FIG. **22** is a diagram illustrating a processing unit of Embodiment 3_2 including a determination unit that determines which organ a text of a medical document describes;

FIG. **23** is a diagram illustrating a determination result;

FIG. **24** is a diagram illustrating processing of a creation unit in Embodiment 3_2;

FIG. **25** is a diagram of overall processing of a training data creation apparatus in Embodiment 3_2;

FIG. **26** is a flowchart illustrating a processing procedure of Embodiment 4; and

FIG. **27** is a diagram illustrating the processing procedure of Embodiment 4.

DETAILED DESCRIPTION

Embodiment 1

As illustrated in FIG. **1** as an example, a training system **2** is a system for training a natural language processing model **10** (refer to FIG. **3**) that is BERT using a transformer encoder, and is composed of a training data creation apparatus **11** and a training apparatus **12**. For example, the training data creation apparatus **11** and the training apparatus **12** are desktop personal computers or workstations. The training data creation apparatus **11** and the training apparatus **12** are connected through a network (not illustrated) such as the Internet. The training data creation apparatus **11** and the training apparatus **12** are an example of an "information processing apparatus" according to an embodiment of the disclosed technology.

A medical document data base (hereinafter, abbreviated to DB) server **13** is connected to the training data creation apparatus **11** through the network (not illustrated) such as the Internet. The training data creation apparatus **11** receives a medical document group **14**G from the medical document DB server **13**. The medical document group **14**G is a collection of a plurality of medical documents **14** such as a medical paper and a radiologic interpretation report.

The training data creation apparatus **11** creates a plurality of pieces of training data **15** from the medical document **14**. The training data **15** is a set of a training input text **16** and correct answer data **17**. The training data creation apparatus **11** distributes a training data group **15**G that is a collection of the plurality of pieces of the training data **15** to the training apparatus **12**.

As illustrated in FIG. **2** as an example, the training input text **16** is a text in which a part of term phrases of an original text **18** included in the medical document **14** is masked. The correct answer data **17** is data indicating what the masked term phrase is. In FIG. **2**, the original text **18** of "Tumor having a size of a diameter of 6 cm is recognized in a liver S3, early enhancement and washout are shown, and HCC is suspected." is illustrated. The training input text **16** in which four term phrases "diameter", "size", "recognized", and "HCC" (mask**1** to mask **4**) are masked, and the correct answer data **17** indicating each term phrase of mask**1** to mask **4** are illustrated.

The training apparatus **12** receives the training data group **15**G from the training data creation apparatus **11**. The training apparatus **12** creates a task-adaptive model **20** from the natural language processing model **10** by training the natural language processing model **10** using the training data group **15**G.

More specifically, as illustrated in FIG. **3** as an example, the training apparatus **12** performs training in two stages of pretraining and fine tuning. In the pretraining, MLM and next sentence prediction (NSP) using the training data group **15**G are performed. MLM is a task of causing the natural language processing model **10** to predict which term phrase fits in the masked part of the training input text **16**. NSP is a task of causing the natural language processing model **10** to determine whether or not, for a training input text prepared separately from the training input text **16**, two training input texts are continuous texts. In the disclosed technology, MLM is the main part, and thus, NSP will not be described in detail.

The natural language processing model **10** is changed to a pretrained natural language processing model **19** by the pretraining. The fine tuning is performed on the pretrained natural language processing model **19**. The pretrained natural language processing model **19** is changed to the task-adaptive model **20** by the fine tuning. The task-adaptive model **20** is distributed to an operation apparatus, not illustrated, from the training apparatus **12**.

The fine tuning is training of adjusting values of various parameters of the pretrained natural language processing model **19** set in the pretraining to values adapted to a desired natural language processing task. In the fine tuning, the medical document **14** in which a class related to the desired natural language processing task is labeled is prepared as the training data.

Examples of the natural language processing task include a task (multi-genre natural language inference (MNLI)) of determining whether two input texts are semantically implicative, contradictory, or neutral, and unique expression extraction (named entity recognition (NER)). In addition, besides these examples, examples of the natural language processing task include a task (quora question pairs (QQP)) of classifying whether or not question contents are the same, and a task (semantic textual similarity benchmark (STS-B)) of evaluating a similarity between two texts. As in the case of NSP, since MLM is the main part in the disclosed technology, the fine tuning will not be described in detail.

As illustrated in FIG. **4** as an example, the computers constituting the training data creation apparatus **11** and the training apparatus **12** have the same basic configuration and each comprises a storage **30**, a memory **31**, a central processing unit (CPU) **32**, a communication unit **33**, a display **34**, and an input device **35**. These units are connected to each other through a busline **36**.

The storage **30** is a hard disk drive that is incorporated in the computers constituting the training data creation apparatus **11** and the training apparatus **12** or is connected to the computers through a cable or a network. Alternatively, the storage **30** is a disk array in which a plurality of hard disk drives are connected. The storage **30** stores a control program such as an operating system, various application programs, and various data and the like pertaining to the programs. A solid state drive may be used instead of the hard disk drive.

The memory **31** is a work memory for executing processing by the CPU **32**. The CPU **32** loads the programs stored in the storage **30** into the memory **31** and executes processing corresponding to the programs. Accordingly, the CPU **32** controls each unit of the computers. The CPU **32** is an example of a "processor" according to the embodiment of the disclosed technology. The memory **31** may be incorporated in the CPU **32**.

The communication unit **33** controls transmission of various information to an external apparatus. The display **34** displays various screens. An operation function based on a graphical user interface (GUI) is comprised on the various screens. The computers constituting the training data creation apparatus **11** and the training apparatus **12** receive an input of an operation instruction from the input device **35** through the various screens. The input device **35** is a keyboard, a mouse, a touch panel, a microphone for voice input, or the like. In the following description, a suffix "X" and a suffix "Y" will be attached to a reference numeral of each unit of the training data creation apparatus **11** and a reference numeral of each unit of the training apparatus **12**, respectively, for distinction.

As illustrated in FIG. **5** as an example, the storage **30**X of the training data creation apparatus **11** stores an operation program **40**. The operation program **40** is an application program causing the computer to function as the training data creation apparatus **11**. That is, the operation program **40** is an example of an "operation program of an information processing apparatus" according to the embodiment of the disclosed technology. The storage **30**X also stores the medical document group **14**G and the training data group **15**G In addition, the storage **30**X also stores an extraction model **41**, degree-of-association information **42**, and a selection condition **43**.

In a case where the operation program **40** is started, the CPU **32**X of the computer constituting the training data creation apparatus **11** functions as an acquisition unit **50**, a read write (hereinafter, abbreviated to RW) controller **51**, a preprocessing unit **52**, an extraction unit **53**, a derivation unit **54**, a creation unit **55**, and a distribution controller **56** in cooperation with the memory **31** and the like.

The acquisition unit **50** acquires the medical document group **14**G from the medical document DB server **13**. The acquisition unit **50** outputs the medical document group **14**G to the RW controller **51**.

The RW controller **51** controls storage of various data in the storage **30**X and readout of various data in the storage **30**X. For example, the RW controller **51** stores the medical document group **14**G from the acquisition unit **50** in the storage **30**X. In addition, the RW controller **51** reads out the medical document group **14**G from the storage **30**X and outputs the medical document group **14**G to the preprocessing unit **52**.

The RW controller **51** reads out the extraction model **41** from the storage **30**X and outputs the extraction model **41** to the extraction unit **53**. In addition, the RW controller **51** reads out the degree-of-association information **42** from the storage **30**X and outputs the degree-of-association information **42** to the derivation unit **54**. Furthermore, the RW controller **51** reads out the selection condition **43** from the storage **30**X and outputs the selection condition **43** to the creation unit **55**.

The preprocessing unit **52** performs preprocessing on each text of each medical document **14** constituting the medical document group **14**G. The preprocessing is processing of converting a text into data that can be handled in the extraction model **41**.

The extraction unit **53** extracts a plurality of unique expressions from the medical document **14** using the extraction model **41**. The extraction model **41** is a model created by performing the fine tuning adapted to NER on an existing pretrained natural language processing model that is different from the pretrained natural language processing model **19** and is created using a typical method of randomly selecting a target term phrase regardless of a degree of association. The extraction unit **53** outputs an extraction result **60** of the unique expression to the derivation unit **54**. The unique expression is an example of a "specific term phrase" according to the embodiment of the disclosed technology.

Here, the "unique expression (named entity (NE))" is generally a collective term related to a proper noun such as a person name or a place name, a date expression, a time expression, or the like. The "unique expression" in the present example is a unique term phrase used in the medical document **14** and is more specifically a term phrase representing an anatomical site, a quantity, a lesion name, a property of a lesion, and a disease name (refer to FIG. **7**).

The derivation unit **54** derives the degree of association indicating a degree of association among the plurality of unique expressions extracted by the extraction unit **53**, using the degree-of-association information **42**. The derivation unit **54** outputs a derivation result **61** of the degree of association to the creation unit **55**.

Based on the degree of association, the creation unit **55** selects the target term phrase that is a term phrase as a target to be masked, by satisfying the selection condition **43** and creates the training input text **16** and the correct answer data **17**, that is, the training data **15**. The creation unit **55** creates a plurality of pieces of the training data **15**. The creation unit **55** outputs the training data group **15**G that is a collection of the plurality of pieces of the training data **15** to the RW controller **51**. The RW controller **51** stores the training data group **15**G in the storage **30**X.

The RW controller **51** reads out the training data group **15**G from the storage **30**X and outputs the training data group **15**G to the distribution controller **56**. The distribution controller **56** performs a control of distributing the training data group **15**G to the training apparatus **12**.

As illustrated in FIG. **6** as an example, the preprocessing performed on each text of the medical document **14** by the preprocessing unit **52** includes tokenization processing and vectorization processing. The tokenization processing is processing of creating token data **65** by dividing the original text **18** included in the medical document **14** into tokens such as "liver", "recognized", "early enhancement", ",", and "is". In FIG. **6**, morphemes (including punctuation marks) are illustrated as the tokens. Each token divided by the tokenization processing is a candidate of the target term phrase selected in the creation unit **55**.

The vectorization processing is processing of creating vector data **66** by converting each token of the token data **65** into vectors V1, V2, V3, . . . of multiple dimensions, for example, 64 dimensions. The preprocessing unit **52** outputs the vector data **66** to the extraction unit **53** as the "data that can be handled in the extraction model **41**".

As illustrated in FIG. **7** as an example, the extraction unit **53** extracts term phrases representing the anatomical site, the quantity, the lesion name, the property of the lesion, and the disease name from the medical document **14** as the unique expressions using the extraction model **41**. In addition, the extraction unit **53** labels types of the extracted unique expressions. The types of the unique expressions are the anatomical site, the quantity, the lesion name, the property of the lesion, and the disease name. In FIG. **7**, an example in which "liver/S3", "diameter/6 cm/size", "tumor", "early enhancement", "washout", and "HCC" are extracted as the unique expressions is illustrated. An example of labeling "liver/S3" with the anatomical site, labeling "diameter/6 cm/size" with the quantity, labeling "tumor" with the lesion name, labeling "early enhancement" and "washout" with the property of the lesion, and labeling "HCC" with the disease name is illustrated. While the extraction model **41** handles the vector data **66**, the token data **65** is illustrated in FIG. **7** for convenience of description.

As illustrated in FIG. **8** as an example, the degree of association is registered in the degree-of-association information **42** for each combination of two types of the unique expressions. The degree of association is set in advance by an operator of the training data creation apparatus **11** based on knowledge and experience acquired so far. For example, a highest value of 10 is set for a combination "property of lesion-disease name" as the degree of association. On the other hand, a lowest value of 0 is set for a combination "quantity-property of lesion" as the degree of association.

As illustrated in FIG. **9** as an example, the degree of association derived using the degree-of-association information **42** is registered in the derivation result **61** for each combination of two unique expressions. In FIG. **9**, the derivation result **61** of the text illustrated in FIG. **7** is illustrated. For example, a degree of association **8** is registered for a combination "liver S3-tumor" that is a combination "anatomical site-lesion name". In addition, a degree of association **10** is registered for combinations "early enhancement-HCC" and "washout-HCC" that are the combination "property of lesion-disease name".

As illustrated in FIG. **10** as an example, the selection condition **43** includes the following three conditions. A content of a first condition is that 15% of tokens of one text are masked. As in the example illustrated in FIG. **7**, in a case where the number of tokens of one text is 25, 25×0.15=3.75 is satisfied. Thus, in a case where at least four tokens are masked, the first condition is satisfied. A content of a second condition is that at least one unique expression is selected as the target term phrase. In the example illustrated in FIG. **7**, in a case where at least any one of "liver/S3", "diameter/6 cm/size", "tumor", "early enhancement", "washout", or "HCC" is selected as the target term phrase, the second condition is satisfied. A content of a third condition is that at least one unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 8 is excluded from the candidates of the target term phrase. In the third condition, "degree of association is greater than or equal to 8" is an example of a "condition set in advance" according to the embodiment of the disclosed technology.

FIG. **11** illustrates a case where "HCC" that is the unique expression is selected as the target term phrase in the example illustrated in FIG. **7**. In this case, according to the derivation result **61**, "tumor", "early enhancement", and "washout" are unique expressions of which the degree of association with "HCC" is greater than or equal to 8. Thus, the creation unit **55** excludes "tumor", "early enhancement", and "washout" from the candidates of the target term phrase in accordance with the third condition. In other words, the creation unit **55** does not select "tumor", "early enhancement", and "washout" as the target term phrase and leaves "tumor", "early enhancement", and "washout" in the training input text **16**. On the other hand, the creation unit **55** does not exclude "liver/S3" and "diameter/6 cm/size" that are unique expressions of which the degree of association with "HCC" is less than 8 from the candidates of the target term phrase. Thus, in FIG. **11**, each of "diameter" and "size" in "diameter/6 cm/size" is selected as the target term phrase. Here, "HCC" is an example of a "target term phrase" and a "term phrase selected as a target term phrase" according to the embodiment of the disclosed technology.

FIG. **12** is a diagram of overall processing of the training data creation apparatus **11**. In the training data creation apparatus **11**, first, the unique expressions of each text of the medical document **14** are extracted in the extraction unit **53**. The degree of association among the unique expressions is derived in the derivation unit **54**. Last, the target term phrase is selected in the creation unit **55** based on the degree of association. Specifically, at least one unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 8 is excluded from the candidates of the target term phrase. By doing so, the training input text **16** and the correct answer data **17**, that is, the training data **15**, are created. In FIG. **12**, an example of creating a training input text P−**1** and correct answer data P−**1**, a training input text P and correct answer data P, and a training input text P+**1** and correct answer data P+**1** (P is an integer of 2 to Q and Q is the total number of the training input texts **16**) from, among N texts of a text **1** to a text N of the medical document **14**, a text J−**1**, a text J, and a text J+**1** (J is an integer of 2 to N), respectively, is illustrated. The training input texts **16** also include a certain number of training input texts created using the typical method of randomly selecting the target term phrase regardless of the degree of association.

As illustrated in FIG. **13** as an example, the storage **30**Y of the training apparatus **12** stores an operation program **70**. The operation program **70** is an application program causing the computer to function as the training apparatus **12**. That is, as in the case of the operation program **40**, the operation program **70** is an example of an "operation program of an information processing apparatus" according to the embodiment of the disclosed technology. The storage **30**Y also stores the natural language processing model **10** and the like.

In a case where the operation program **70** is started, the CPU **32**Y of the computer constituting the training apparatus **12** functions as an acquisition unit **75**, a RW controller **76**, a pretraining unit **77**, and a fine tuning unit **78** in cooperation with the memory **31** and the like.

The acquisition unit **75** acquires the training data group **15**G from the training data creation apparatus **11**. The acquisition unit **75** outputs the training data group **15**G to the RW controller **76**.

The RW controller **76** controls storage of various data in the storage **30**Y and readout of various data in the storage **30**Y. For example, the RW controller **76** stores the training data group **15**G from the acquisition unit **75** in the storage **30**Y. In addition, the RW controller **76** reads out the training data group **15**G from the storage **30**Y and outputs the training data group **15**G to the pretraining unit **77**. Furthermore, the RW controller **76** reads out the natural language processing model **10** from the storage **30**Y and outputs the natural language processing model **10** to the pretraining unit **77**.

The pretraining unit **77** changes the natural language processing model **10** to the pretrained natural language processing model **19** by performing the pretraining on the natural language processing model **10** using the training data **15**. The pretraining unit **77** outputs the pretrained natural language processing model **19** to the RW controller **76**. The RW controller **76** stores the pretrained natural language processing model **19** in the storage **30**Y.

The RW controller **76** reads out the pretrained natural language processing model **19** from the storage **30**Y and outputs the pretrained natural language processing model **19** to the fine tuning unit **78**. The fine tuning unit **78** changes the pretrained natural language processing model **19** to the task-adaptive model **20** by performing the fine tuning on the pretrained natural language processing model **19**. The fine tuning unit **78** outputs the task-adaptive model **20** to the RW controller **76**. The RW controller **76** stores the task-adaptive model **20** in the storage **30**Y.

The task-adaptive model **20** is distributed to the operation apparatus by a distribution controller, not illustrated, and is used in the operation apparatus. Alternatively, the training apparatus **12** may function as the operation apparatus, and the task-adaptive model **20** may be used in the training apparatus **12**.

As illustrated in FIG. **14** as an example, in the pretraining, the training input text **16** is input into the natural language processing model **10**. The natural language processing model **10** outputs a training prediction result **80** with respect to the training input text **16**. A loss operation of the natural language processing model **10** using a loss function is performed based on the training prediction result **80** and the correct answer data **17**. Updating and setting of values of various parameters of the natural language processing model **10** are performed in accordance with a result of the loss operation, and the natural language processing model **10** is updated in accordance with the updating and the setting. The training input text **16** is converted into the vector data **66** in the natural language processing model **10**. In addition, the training prediction result **80** represents a predicted term phrase of the masked term phrase using the vector data **66**.

In the pretraining, the series of processing of the input of the training input text **16** into the natural language processing model **10**, the output of the training prediction result **80** from the natural language processing model **10**, the loss operation, the updating and the setting, and the updating of the natural language processing model **10** are repeated while the training data **15** is exchanged. The repetition of the series of processing is finished in a case where prediction accuracy of the training prediction result **80** with respect to the correct answer data **17** has reached a predetermined set level. The natural language processing model **10** for which the prediction accuracy has reached the set level is handled as the pretrained natural language processing model **19**. The pretraining may be finished in a case where the series of processing is repeated a set number of times, regardless of the prediction accuracy of the training prediction result **80** with respect to the correct answer data **17**.

Next, an action of the above configuration will be described with reference to the flowcharts illustrated in FIG. **15** and FIG. **16** as an example. First, in a case where the operation program **40** is started in the training data creation apparatus **11**, the CPU **32**X of the training data creation apparatus **11** functions as the acquisition unit **50**, the RW controller **51**, the preprocessing unit **52**, the extraction unit **53**, the derivation unit **54**, the creation unit **55**, and the distribution controller **56** as illustrated in FIG. **5**.

The operator of the training data creation apparatus **11** transmits a distribution request of the medical document group **14**G to the medical document DB server **13**. As illustrated in FIG. **15**, the medical document group **14**G distributed from the medical document DB server **13** in accordance with the distribution request is acquired in the acquisition unit **50** (step ST**100**). The medical document group **14**G is output to the RW controller **51** from the acquisition unit **50** and is stored in the storage **30**X under control of the RW controller **51**.

The medical document group **14**G is read out from the storage **30**X by the RW controller **51**. The medical document group **14**G is output to the preprocessing unit **52** from the RW controller **51**. As illustrated in FIG. **6**, the preprocessing including the tokenization processing and the vectorization processing is performed on each text of the medical document **14** in the preprocessing unit **52** (step ST**110**).

Next, as illustrated in FIG. **7**, a plurality of the unique expressions are extracted from the medical document **14** by the extraction unit **53** using the extraction model **41** (step ST**120**). The extraction result **60** of the unique expressions is output to the derivation unit **54** from the extraction unit **53**.

In the derivation unit **54**, the degree of association among the plurality of unique expressions is derived as in the derivation result **61** illustrated in FIG. **9** using the degree-of-association information **42** illustrated in FIG. **8** (step ST**130**). The derivation result **61** is output to the creation unit **55** from the derivation unit **54**.

In the creation unit **55**, the target term phrase is selected as illustrated in FIG. **11** based on the degree of association by satisfying the selection condition **43** illustrated in FIG. **10**, and the training input text **16** and the training data **15** are created (step ST**140**). More specifically, 15% of the tokens of one text are masked, and at least one unique expression is selected as the target term phrase. In addition, the unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 8 is excluded from the candidates of the target term phrase. The training data group **15**G is output to the RW controller **51** from the creation unit **55** and is stored in the storage **30**X under control of the RW controller **51**.

The training data group **15**G is read out from the storage **30**X by the RW controller **51**. The training data group **15**G is output to the distribution controller **56** from the RW controller **51**. The training data group **15**G is distributed to the training apparatus **12** under control of the distribution controller **56** (step ST**150**).

In a case where the operation program **70** is started in the training apparatus **12**, the CPU **32**Y of the training apparatus **12** functions as the acquisition unit **75**, the RW controller **76**, the pretraining unit **77**, and the fine tuning unit **78** as illustrated in FIG. **13**.

An operator of the training apparatus **12** transmits a distribution request of the training data group **15**G to the training data creation apparatus **11**. As illustrated in FIG. **16**, the training data group **15**G distributed from the training data creation apparatus **11** in accordance with the distribution request is acquired in the acquisition unit **75** (step ST**200**). The training data group **15**G is output to the RW controller **76** from the acquisition unit **75** and is stored in the storage **30**Y under control of the RW controller **76**.

The training data group **15**G and the natural language processing model **10** are read out from the storage **30**Y by the RW controller **76**. The training data group **15**G and the natural language processing model **10** are output to the pretraining unit **77** from the RW controller **76**. As illustrated in FIG. **14**, in the pretraining unit **77**, the pretraining is performed on the natural language processing model **10** using the training data **15**. Accordingly, the natural language processing model **10** is changed to the pretrained natural language processing model **19** (step ST**210**). The pretrained natural language processing model **19** is output to the RW controller **76** from the pretraining unit **77** and is stored in the storage **30**Y under control of the RW controller **76**.

The pretrained natural language processing model **19** is read out from the storage **30**Y by the RW controller **76**. The pretrained natural language processing model **19** is output to the fine tuning unit **78** from the RW controller **76**. In the fine tuning unit **78**, the fine tuning is performed on the pretrained natural language processing model **19**. Accordingly, the pretrained natural language processing model **19** is changed to the task-adaptive model **20** (step ST**220**). The task-adaptive model **20** is output to the RW controller **76** from the fine tuning unit **78** and is stored in the storage **30**Y under control of the RW controller **76**.

As described above, the CPU **32**X of the training data creation apparatus **11** comprises the extraction unit **53**, the derivation unit **54**, and the creation unit **55**. The extraction unit **53** extracts the plurality of unique expressions that are specific term phrases from the medical document **14**. The derivation unit **54** derives the degree of association indicating the degree of association among the plurality of unique expressions. Based on the degree of association, the creation unit **55** selects the target term phrase that is the term phrase as a target to be masked. Thus, the training input text **16** that contributes to effective training of the natural language processing model **10** can be created, compared to the typical method of randomly selecting the target term phrase regardless of the degree of association and the method of Chen Lin, et al: EntityBERT: Entity-centric Masking Strategy for Model Pretraining for the Clinical Domain, Proceedings of the BioNLP 2021 workshop, pages 191-201 Jun. 11, 2021 in which there is a concern that a term phrase necessary for predicting the target term phrase is also masked without considering the degree of association.

The creation unit **55** excludes the unique expression of which the degree of association with the term phrase selected as the target term phrase satisfies the condition set in advance, from the candidates of the target term phrase. Thus, the unique expression necessary for predicting the term phrase selected as the target term phrase can be left in the training input text **16**. Accordingly, a concern that it is difficult to predict the masked term phrase can be reduced. Consequently, it is possible to further contribute to the effective training of the natural language processing model **10**.

The derivation unit **54** derives the degree of association using the degree-of-association information **42** in which the degree of association corresponding to the combination of the types of the unique expressions is set in advance. Thus, in a case where the unique expressions are extracted, and the type of each unique expression is labeled, the degree of association can be easily derived using the degree-of-association information **42**. In addition, as in the present example, in a case where the operator sets the degree of association of the degree-of-association information **42**, an idea of the operator can be reflected on the creation of the training input text **16**.

A document is the medical document **14**, and the types of the unique expressions include the anatomical site, the quantity, the lesion name, the property of the lesion, and the disease name. It is difficult to obtain a large amount of the medical document **14** that is the document as a base of the training input text. Thus, a concern that the effective pretraining is not performed by losing a training opportunity for an important term phrase is increased. Accordingly, as in the present example, in a case where the document is the medical document **14**, and the types of unique expressions are the anatomical site, the quantity, the lesion name, the property of the lesion, and the disease name, an effect of being able to create the training input text **16** contributing to the effective training of the natural language processing model **10** can be further exhibited. The types of unique expressions may include at least one of the anatomical site, the quantity, the lesion name, the property of the lesion, or the disease name.

The pretraining unit **77** of the training apparatus **12** performs the pretraining on the natural language processing model **10** using the training input text **16** created in the training data creation apparatus **11** as described above. Thus, the effective training of the natural language processing model **10** can be performed.

Embodiment 2

In Embodiment 1, while the degree of association is derived using the degree-of-association information **42**, the disclosed technology is not limited thereto. As illustrated in FIG. **17** as an example, the degree of association may be derived using a derivation model **85**.

In FIG. **17**, a derivation unit **86** of Embodiment 2 derives the degree of association using the derivation model **85** and outputs a derivation result **87** to the creation unit **55**. The derivation model **85** is stored in the storage **30**X. The derivation model **85** is a model created by performing the fine tuning adapted to the derivation of the degree of association on a pretrained natural language processing model **88**. The pretrained natural language processing model **88** is a model different from the pretrained natural language processing model **19**. The pretrained natural language processing model **88** is a model created by training using the training input text **16** created using the typical method of randomly selecting the target term phrase regardless of the degree of association. The derivation model **85** is an example of a "trained derivation model" according to the embodiment of the disclosed technology. In addition, the pretrained natural language processing model **88** is an example of a "trained natural language processing model" according to the embodiment of the disclosed technology.

As illustrated in FIG. **18** as an example, the combination of the unique expressions extracted by the extraction unit **53** is input into the derivation model **85** as input data **90**. The derivation model **85** outputs output data **91** with respect to the input data **90**. The output data **91** is a score representing the degree of association among the unique expressions of the input data **90** using a numerical value between 0 and 1. The derivation unit **86** registers the score of the output data **91** in the derivation result **87** as the degree of association. In FIG. **18**, a case where the combination "early enhancement-HCC" is input into the derivation model **85** as the input data **90** and 0.98 is output as the output data **91** is illustrated. In this case, for example, the content of the third condition of the selection condition **43** is that at least one unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 0.8 is excluded from the candidates of the target term phrase.

In Embodiment 2, the derivation unit **86** derives the degree of association using the trained derivation model **85**. Thus, the degree of association can be easily derived by the derivation model **85** as long as the unique expressions are extracted. In addition, an effort of setting the degree of association by the operator as in the degree-of-association information **42** can be reduced. In addition, the derivation model **85** is created based on the pretrained natural language processing model **88**. Thus, the derivation model **85** can be simply created.

Embodiment 3

In Embodiment 3 illustrated in FIG. **19** to FIG. **25**, a text of the same type as the text including the term phrase selected as the target term phrase is determined, and the text including the target term phrase and the text of the same type are used as the training input text **16**.

Embodiment 3_1

FIG. **19** illustrates the derivation result **61** with respect to the original text **18** consisting of four texts "Tumor having a size of a diameter of 6 cm is recognized in a liver S3.", "Early enhancement is shown, and washout is shown.", "HCC is suspected.", and "No significant change in a cyst of a right kidney." In this case, unique expressions "right kidney", "cyst", and "significant change" are extracted in addition to "liver S3", "early enhancement", "HCC", and the like of Embodiment 1, and the degree of association is derived for "right kidney, "cyst", and "significant change".

FIG. **20** illustrates a case where "HCC" that is the unique expression is selected as the target term phrase as in the example illustrated in FIG. **11**. In this case, according to the derivation result **61**, "tumor", "early enhancement", and "washout" are unique expressions of which the degree of association with "HCC" is greater than or equal to 8. Thus, the creation unit **55** excludes "tumor", "early enhancement", and "washout" from the candidates of the target term phrase. In addition, the creation unit **55** determines that "Tumor having a size of a diameter of 6 cm is recognized in a liver S3." and "Early enhancement is shown, and washout is shown." that are texts including "tumor", "early enhancement", and "washout" are texts of the same type as "HCC is suspected." that is a text including "HCC". The creation unit **55** uses "HCC is suspected.", "Tumor having a size of a diameter of 6 cm is recognized in a liver S3.", and "Early enhancement is shown, and washout is shown." as the training input texts **16** to be collectively input into the natural language processing model **10** at once. Here, "HCC is suspected." is an example of a "text including a term phrase selected as a target term phrase" and a "text including a target term phrase" according to the embodiment of the disclosed technology. In addition, "Tumor having a size of a diameter of 6 cm is recognized in a liver S3." and "Early enhancement is shown, and washout is shown." are an example of a "text of the same type" according to the embodiment of the disclosed technology.

FIG. **21** is a diagram of overall processing of a training data creation apparatus in Embodiment 3_1. In the training data creation apparatus of Embodiment 3_1, first, the unique expressions of each text of the medical document **14** are extracted in the extraction unit **53** as in Embodiment 1. The degree of association among the unique expressions is derived in the derivation unit **54**. Last, the target term phrase is selected in the creation unit **55** based on the degree of association. Specifically, at least one unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 8 is excluded from the candidates of the target term phrase. In addition, in the creation unit **55**, the text of the same type as the text including the term phrase selected as the target term phrase is determined, and the text including the target term phrase and the text of the same type are used as the training input text **16**. By doing so, the training input text **16** and the correct answer data **17**, that is, the training data **15**, are created. In FIG. **21**, an example of creating the training input text P**−1** and the correct answer data P**−1** from the text J**−1** and creating the training input text P and the correct answer data P from the text J and the text J+**1** among the N texts of the text **1** to text N of the medical document **14** is illustrated.

Embodiment 3_2

As illustrated in FIG. **22** as an example, a CPU of a training data creation apparatus of Embodiment 3_2 functions as a determination unit **100** in addition to each of the units **50** to **56** (in FIG. **22**, only the preprocessing unit **52** and the creation unit **55** are illustrated) of Embodiment 1. The determination unit **100** determines which organ the text of the medical document **14** describes using a determination model **101** stored in the storage **30**X. The determination unit **100** outputs a determination result **102** to the creation unit **55**. While illustration is not provided, a determination model **101** is a model created by performing the fine tuning adapted to the determination of the organ on the pretrained natural language processing model on which the pretraining is performed using the training input text **16** created using the typical method of randomly selecting the target term phrase regardless of the degree of association, as in the case of the derivation model **85**.

As illustrated in FIG. **23** as an example, each text of the medical document **14** is labeled with an organ in the determination result **102**. In FIG. **23**, the original text **18** consisting of four texts "Tumor having a size of a diameter of 6 cm is recognized in a liver S3. Early enhancement is shown, and washout is shown. HCC is suspected. No significant change in a cyst of a right kidney." is illustrated as in the case of Embodiment 3_1. A case where the original text **18** is labeled with the organ is illustrated. That is, "Tumor having a size of a diameter of 6 cm is recognized in a liver S3.", "Early enhancement is shown, and washout is shown.", and "HCC is suspected." are labeled with "liver" as an organ. On the other hand, "No significant change in a cyst of a right kidney." is labeled with "kidney" as an organ. That is, in this case, the determination unit **100** determines that all of three texts "Tumor having a size of a diameter of 6 cm is recognized in a liver S3.", "Early enhancement is shown, and washout is shown.", and "HCC is suspected." are texts describing a liver. The determination model **101** may determine that the organ is not known. In this case, a text for which a determination that the organ is not known is made is not labeled with the organ.

FIG. **24** illustrates a case where "HCC" that is the unique expression is selected as the target term phrase as in the example illustrated in FIG. **11** and the like. In this case, according to the derivation result **61**, "tumor", "early enhancement", and "washout" are unique expressions of which the degree of association with "HCC" is greater than or equal to 8. Thus, the creation unit **55** excludes "tumor", "early enhancement", and "washout" from the candidates of the target term phrase. In addition, according to the determination result **102**, "Tumor having a size of a diameter of 6 cm is recognized in a liver S3." and "Early enhancement is shown, and washout is shown." are texts describing the same liver as "HCC is suspected." that is a text including "HCC". Thus, the creation unit **55** uses "HCC is suspected.", "Tumor having a size of a diameter of 6 cm is recognized in a liver S3.", and "Early enhancement is shown, and washout is shown." as the training input texts **16** to be collectively input into the natural language processing model **10** at once. Here, "HCC is suspected." is an example of a "text including a term phrase selected as a target term phrase" and a "text including a target term phrase" according to the embodiment of the disclosed technology. In addition, "Tumor having a size of a diameter of 6 cm is recognized in a liver S3." and "Early enhancement is shown, and washout is shown." are an example of a "text of the same type" and a "text describing the same organ as an organ related to a term phrase selected as a target term phrase" according to the embodiment of the disclosed technology.

FIG. **25** is a diagram of overall processing of the training data creation apparatus in Embodiment 3_2. In the training data creation apparatus of Embodiment 3_2, first, the unique expressions of each text of the medical document **14** are extracted in the extraction unit **53** as in Embodiment 1. The degree of association among the unique expressions is derived in the derivation unit **54**. Furthermore, in the training data creation apparatus of Embodiment 3_2, which organ the text of the medical document **14** describes is determined in the determination unit **100**. Last, the target term phrase is selected in the creation unit **55** based on the degree of association. Specifically, at least one unique expression of which the degree of association with the term phrase selected as the target term phrase is greater than or equal to 8 is excluded from the candidates of the target term phrase. In addition, the text including the target term phrase and the text of the same type are used as the training input text **16** in the creation unit **55**. By doing so, the training input text **16** and the correct answer data **17**, that is, the training data **15**, are created. In FIG. **25**, an example of creating the training input text P−**1** and the correct answer data P−**1** from the text J−**1** for which a determination is made that the organ is R, and creating the training input text P and the correct answer data P from the text J and the text J+**1** for which a determination that the organ is S is made among the N texts of the text **1** to text N of the medical document **14** is illustrated.

In Embodiment 3, the CPU of the training data creation apparatus determines the text of the same type as the text including the term phrase selected as the target term phrase. The text including the target term phrase and the text of the same type are used as the training input text **16**. Accordingly, for example, a concern that the training input text **16** including only one text “HCC is suspected.” and having “HCC” masked is created and it is difficult to predict the masked term phrase can be reduced. Consequently, it is possible to further contribute to the effective training of the natural language processing model **10**.

The CPU of the training data creation apparatus of Embodiment 3_1 determines that a text including the unique expression of which the degree of association with the term phrase selected as the target term phrase satisfies the condition set in advance is the text of the same type. Thus, the unique expression necessary for predicting the term phrase selected as the target term phrase can be left in the training input text **16**. Accordingly, a concern that it is difficult to predict the masked term phrase can be reduced. Consequently, it is possible to further contribute to the effective training of the natural language processing model **10**.

The document is the medical document **14**, and the determination unit **100** determines that a text describing the same organ as the organ related to the term phrase selected as the target term phrase is the text of the same type. Thus, a text highly associated with the text including the target term phrase can be used as the training input texts **16** to be collectively input into the natural language processing model **10** at once. The text of the same type may also be a text describing the same disease name as the disease name related to the term phrase selected as the target term phrase.

Embodiment 4

In Embodiment 4 illustrated in FIG. **26** and FIG. **27** as an example, a cycle of the following series of processing is repeated.

In Embodiment 4, first, first processing of creating an extraction model **110** for extracting the unique expressions, a derivation model **111** for deriving the degree of association among the unique expressions, and a determination model **112** for determining which organ the text of the medical document **14** describes from the natural language processing model **10** is performed. Next, second processing of creating a training document **113** from which the unique expressions are extracted and that is labeled with the degree of association and the organ, using the extraction model **110**, the derivation model **111**, and the determination model **112** is performed. Third processing of creating the training input text **16** from the training document **113** created in the second processing using the method according to the embodiment of the disclosed technology is performed. Furthermore, fourth processing of changing the natural language processing model **10** to the pretrained natural language processing model **19** (updating the natural language processing model **10**) by performing the pretraining on the natural language processing model **10** using the training input text **16** created in the third processing is performed. In Embodiment 4, a cycle of the first processing to the fourth processing is repeated.

Specifically, as illustrated in FIG. **26** and FIG. **27**, first, in an initial cycle, a training input text **16_0** and correct answer data **17_0** are created from the medical document **14** using the typical method of randomly selecting the target term phrase in the CPU of the training data creation apparatus (step ST**300**). Training data **15_0** that is a set of the training input text **16_0** and the correct answer data **17_0** will be referred to as training data V**0**.

In the CPU of the training apparatus, a natural language processing model **10_0** (referred to as a natural language processing model V**0**) is changed to a pretrained natural language processing model **19_0** (referred to as a pretrained natural language processing model V**0**) by performing the pretraining on the natural language processing model V**0** using the training data V**0** (step ST**310**). An extraction model **110_0** (referred to as an extraction model V**0**), a derivation model **111_0** (referred to as a derivation model V**0**), and a determination model **112_0** (referred to as a determination model V**0**) are created by performing the fine tuning on the pretrained natural language processing model V**0** (step ST**320**). Accordingly, the first processing of the initial cycle is completed.

In the CPU of the training data creation apparatus, a training document **113_1** (referred to as a training document V1) from which the unique expressions are extracted and that is labeled with the degree of association and the organ is created from the medical document **14** using the extraction model V**0**, the derivation model V**0**, and the determination model V**0** (step ST**330**). Accordingly, the second processing of the initial cycle is completed.

Next, as illustrated in Embodiment 1, the target term phrase is selected based on the degree of association. In addition, as illustrated in Embodiment 3, the text including the target term phrase and the text of the same type are used as a training input text **16_1**, and the training input text **16_1** and correct answer data **17_1** are created from the training document V1 (step ST340). Accordingly, the third processing of the initial cycle is completed. Training data **15_1** that is a set of the training input text **16_1** and the correct answer data **17_1** will be referred to as training data V1.

In the CPU of the training apparatus, a natural language processing model **10_1** (referred to as a natural language processing model V1) is changed to a pretrained natural language processing model **19_1** (referred to as a pretrained natural language processing model V1) by performing the pretraining on the natural language processing model V1 using the training data V1 (step ST**350**). The natural language processing model V1 is the pretrained natural language processing model V**0**. That is, in step ST**350**, the pretrained natural language processing model V**0** is retrained using the training data V**2**. Accordingly, the fourth processing of the initial cycle is completed.

An extraction model **110_1** (referred to as an extraction model V1), a derivation model **111_1** (referred to as a derivation model V1), and a determination model **112_1** (referred to as a determination model V1) are created by performing the fine tuning on the pretrained natural language processing model V**1** (step ST**360**). Accordingly, the first processing of a second cycle is completed.

In the CPU of the training data creation apparatus, a training document **113_2** (referred to as a training document V2) from which the unique expressions are extracted and that is labeled with the degree of association and the organ is created from the medical document **14** using the extraction model V**1**, the derivation model V**1**, and the determination model V**1** (step ST**370**). Accordingly, the second processing of the second cycle is completed.

Next, as illustrated in Embodiment 1, the target term phrase is selected based on the degree of association. In addition, as illustrated in Embodiment 3, the text including the target term phrase and the text of the same type are used as a training input text **16_2**, and the training input text **16_2** and correct answer data **17_2** are created from the training document V**2** (step ST**380**). Accordingly, the third processing of the second cycle is completed. Training data **15_2** that is a set of the training input text **16_2** and the correct answer data **17_2** will be referred to as training data V**2**.

In the CPU of the training apparatus, a natural language processing model **10_2** (referred to as a natural language processing model V**2**) is changed to a pretrained natural language processing model **19_2** (referred to as a pretrained natural language processing model V**2**; not illustrated in FIG. **27**) by performing the pretraining on the natural language processing model V**2** using the training data V**2** (step ST**390**). The natural language processing model V**2** is the pretrained natural language processing model V**1**. That is, in step ST**390**, the pretrained natural language processing model V**1** is retrained using the training data V**2**. Accordingly, the fourth processing of the second cycle is completed.

In Embodiment 4, the CPU of the training data creation apparatus and the CPU of the training apparatus create the extraction model **110**, the derivation model **111**, and the determination model **112** from the natural language processing model **10**. Next, the training document **113** from which the unique expressions are extracted and that is labeled with the degree of association and the organ is created using the extraction model **110**, the derivation model **111**, and the determination model **112**, and the training input text **16** is created from the training document **113**. Last, the natural language processing model **10** is updated by training the natural language processing model **10** using the created training input text **16**. A cycle of this series of processing is repeated.

Thus, performance of the extraction model **110**, the derivation model **111**, and the determination model **112** is gradually increased through the cycles. Accordingly, extraction accuracy of the unique expressions of the training document **113** and accuracy of labeling with the degree of association and the organ are also gradually increased. Accordingly, the training input text **16** created from the training document **113** also gradually becomes a training input text corresponding to the pretraining. Consequently, performance of the pretrained natural language processing model **19** can be gradually increased.

In the initial cycle, the CPU of the training apparatus creates the extraction model **110_0** and the like from the pretrained natural language processing model **19_0** created by training using the training input text **16** in which the target term phrase is randomly selected regardless of the degree of association. Thus, for example, the training document **113** from which the unique expressions are extracted does not need to be initially manually created, and the effort can be significantly reduced.

The CPU of the training apparatus further creates the derivation model **111** for deriving the degree of association from the pretrained natural language processing model **19**. The CPU of the training data creation apparatus creates the training document **113** labeled with the degree of association using the derivation model **111**. Thus, an effort of manual labeling with the degree of association can be reduced. In addition, the degree-of-association information **42** illustrated in Embodiment 1 does not need to be used.

The document is the medical document **14**, and the CPU of the training apparatus further creates the determination model **112** for determining which organ the text describes from the pretrained natural language processing model **19**. The CPU of the training data creation apparatus creates the training document **113** labeled with the organ using the determination model **112**. Thus, an effort of manual labeling with the organ can be reduced. The extraction model **110** may be the only model created from the natural language processing model **10** in the first processing.

In each of the embodiments, while the training data creation apparatus creates the training input text **16**, and the training apparatus trains the natural language processing model **10**, the disclosed technology is not limited thereto. One computer may create the training input text **16** and train the natural language processing model **10**.

The degree of association is not limited to the numerical value of 1 to 10 or 0 to 1. The degree of association may be a label such as high, medium, or low. In addition, while the medical document **14** is illustrated as the document, the disclosed technology is not limited thereto. The document may be a novel, a news article, patent literature, or the like. Furthermore, the document may be a document of a narrower field such as a paper related to new coronavirus infection. In addition, while the unique expression is illustrated as the specific term phrase, the disclosed technology is not limited thereto. The specific term phrase may be a term phrase set as a keyword by the operator.

In each of the embodiments, for example, the following various processors can be used as a hardware structure of a processing unit executing various processing of the acquisition units **50** and **75**, the RW controllers **51** and **76**, the extraction unit **53**, the derivation units **54** and **86**, the creation unit **55**, the distribution controller **56**, the pretraining unit **77**, the fine tuning unit **78**, and the determination unit **100**. The various processors include, in addition to the CPUs **32**X and **32**Y that are general-purpose processors functioning as various processing units by executing software (operation programs **40** and **70**) as described above, a programmable logic device (PLD) such as a field programmable gate array (FPGA) that is a processor having a circuit configuration changeable after manufacturing, a dedicated electric circuit such as an application specific integrated circuit (ASIC) that is a processor having a circuit configuration dedicatedly designed to execute specific processing, and the like.

One processing unit may be composed of one of the various processors or may be composed of a combination of two or more processors of the same type or different types (for example, a combination of a plurality of FPGAs and/or a combination of a CPU and an FPGA). In addition, a plurality of processing units may be composed of one processor.

A first example of the plurality of processing units composed of one processor is, as represented by a computer such as a client and a server, a form in which one processor is composed of a combination of one or more CPUs and software, and the processor functions as the plurality of processing units. A second example is, as represented by a system on chip (SoC) or the like, a form of using a processor that implements functions of the entire system including the plurality of processing units in one integrated circuit (IC) chip. Accordingly, various processing units are configured using one or more of the various processors as a hardware structure.

Furthermore, more specifically, an electric circuit (circuitry) in which circuit elements such as semiconductor elements are combined can be used as the hardware structure of the various processors.

Various embodiments and/or various modification examples described above can be appropriately combined in the disclosed technology. In addition, the disclosed technology is not limited to the embodiments and may employ various configurations without departing from the gist thereof. Furthermore, the disclosed technology also applies to, in addition to the program, a storage medium that stores the program in a non-transitory manner.

Above described contents and illustrated contents are detailed descriptions for parts according to the embodiment of the disclosed technology and are merely an example of the disclosed technology. For example, description related to the above configurations, functions, actions, and effects is description related to an example of configurations, functions, actions, and effects of the parts according to the embodiment of the disclosed technology. Thus, apparently, unnecessary parts may be removed, new elements may be added, or parts may be replaced in the above described contents and the illustrated contents without departing from the gist of the disclosed technology. In addition, particularly, description related to common technical knowledge or the like that does not need to be described in terms of embodying the disclosed technology is omitted in the above described contents and the illustrated contents in order to avoid complication and facilitate understanding of the parts according to the embodiment of the disclosed technology.

In the present specification, "A and/or B" has the same meaning as "at least one of A or B". This means that "A and/or B" may be only A, only B, or a combination of A and B. In addition, in the present specification, the same approach as "A and/or B" is applied to a case where three or more matters are represented by connecting the matters with "and/or".

All documents, patent applications, and technical standards disclosed in the present specification are incorporated in the present specification by reference to the same extent as in a case where each of the documents, patent applications, technical standards are specifically and individually indicated to be incorporated by reference.

What is claimed is:

1. An information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the information processing apparatus comprising:

a processor,

wherein the processor is configured to train the natural language processing model which is able to predict a part of term phrases which has been masked by:

extracting a plurality of specific term phrases from the document;

deriving a degree of association indicating a degree of association among the plurality of specific term phrases;

selecting a target term phrase that is a term phrase as a target to be masked based on the degree of association;

determining a text of a same type as a text including the term phrase selected as the target term phrase; and

using the text including the target term phrase and the text of the same type as the training input text.

2. The information processing apparatus according to claim **1**,

wherein the processor is configured to:

exclude the specific term phrase of which the degree of association with the term phrase selected as the target term phrase satisfies a condition set in advance, from candidates of the target term phrase.

3. The information processing apparatus according to claim **1**,

wherein the processor is configured to:

determine that a text including the specific term phrase of which the degree of association with the term phrase selected as the target term phrase satisfies a condition set in advance is the text of the same type.

4. The information processing apparatus according to claim **1**,

wherein the document is a medical document, and

the processor is configured to:

determine that a text describing the same organ as an organ related to the term phrase selected as the target term phrase is the text of the same type.

5. The information processing apparatus according to claim **1**,

wherein the processor is configured to:

derive the degree of association using degree-of-association information in which the degree of association corresponding to a combination of types of the specific term phrases is set in advance.

6. The information processing apparatus according to claim **5**,

wherein the document is a medical document, and

the types include at least one of an anatomical site, a quantity, a lesion name, a property of a lesion, or a disease name.

7. The information processing apparatus according to claim **1**,

wherein the processor is configured to:

derive the degree of association using a trained derivation model.

8. The information processing apparatus according to claim **7**,

wherein the derivation model is created based on a trained natural language processing model.

9. The information processing apparatus according to claim **1**,

wherein the processor is configured to:

train the natural language processing model using the training input text.

10. The information processing apparatus according to claim **9**,

wherein the processor is configured to:

repeat a cycle of a series of processing including

creating an extraction model for extracting at least the specific term phrases from the natural language processing model,

creating a training document from which the specific term phrases are extracted using the extraction model,

creating the training input text from the training document, and

updating the natural language processing model by training the natural language processing model using the created training input text.

11. The information processing apparatus according to claim **10**,

wherein the processor is configured to:

in an initial cycle, create the extraction model from a natural language processing model created by training using a training input text in which the target term phrase is randomly selected regardless of the degree of association.

12. The information processing apparatus according to claim **10**,

wherein the processor is configured to:

further create a derivation model for deriving the degree of association from the natural language processing model; and

create the training document labeled with the degree of association using the derivation model.

13. The information processing apparatus according to claim **10**,

wherein the document is a medical document, and

the processor is configured to:

further create a determination model for determining which organ a text describes from the natural language processing model; and

create the training document labeled with the organ using the determination model.

14. An operation method of an information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the operation method comprising:

extracting a plurality of specific term phrases from the document;

deriving a degree of association indicating a degree of association among the plurality of specific term phrases;

selecting a target term phrase that is a term phrase as a target to be masked based on the degree of association;

determining a text of a same type as a text including the term phrase selected as the target term phrase; and

using the text including the target term phrase and the text of the same type as the training input text.

15. A non-transitory computer-readable storage medium storing an operation program of an information processing apparatus that creates a training input text which is used for training a natural language processing model and in which a part of term phrases is masked, from a document, the operation program causing a computer to execute a process to train the natural language processing model which is able to predict the part of term phrases which is masked, the process comprising:

extracting a plurality of specific term phrases from the document;

deriving a degree of association indicating a degree of association among the plurality of specific term phrases;

selecting a target term phrase that is a term phrase as a target to be masked based on the degree of association;

determining a text of a same type as a text including the term phrase selected as the target term phrase; and

using the text including the target term phrase and the text of the same type as the training input text.

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