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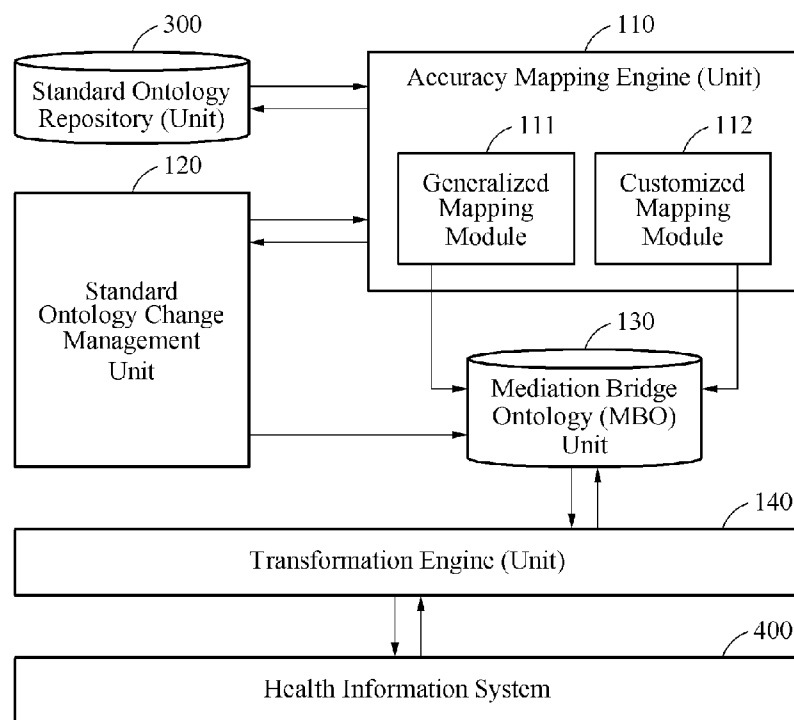
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(54) Title: ADAPTIVE SEMANTIC BASED MEDIATION SYSTEM AND METHOD



(57) Abstract: Disclosed is an adaptive semantic based mediation system providing adapter interoperability engine mediation for efficient and effective exchanges of data/information among health information systems having different medical standards. Using the adaptive semantic based mediation system, accuracy of transformation process among different standard formats in mappings stored in (a) mediation bridge ontology may be evaluated.



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Description

Title of Invention: ADAPTIVE SEMANTIC BASED MEDIATION SYSTEM AND METHOD

Technical Field

- [1] The present invention generally relates to an adaptive semantic based mediation system and method (using the same) among/between health information systems (HMIS) and specifically, to an adaptive semantic based mediation and method for efficient and effective data/information exchange for interoperability among HISs compliant to heterogeneous clinical standards.

Background Art

- [2] A medical institution or organization that is in compliance with or conforms to a particular clinical standard requires interoperable or interoperability protocol using mappings containing an applicable institution's standard information, in order to communicate with other medical institutions that conforms to other heterogeneous clinical standards.
- [3] Interoperability protocol regulates flow of information and enables seamless exchange of information among health information systems.
- [4] By using a mediation system, HISs that conform to clinical standards that are different from one another may easily share information by using the proposed solution/method.
- [5] Conventional mediation systems are based on ontology matching for generating semantic mappings. However, ontology mapping has limitations in terms of generalized mappings generation only and not handling conformance issues of organizations for customized mappings.
- [6] Also, conventional mediation systems has limitations in terms of data-level interoperability, as these are concerned only with mapping accuracy in mappings generation process among clinical standard ontologies, and lacking the effectiveness of generated mappings

Disclosure of Invention

Technical Problem

- [7] Provided in the present invention is adaptive semantic based mediation system and method (using the same), which use a Mediation Bridge Ontology (MBO) for attaining interoperability among different standard models. The generalized mappings are generated using the matching between clinical standards ontologies, while customized mappings utilizes the concept of Personalized-Detailed Clinical Model (P-DCM).
- [8] Also the invention ensure mapping accuracy and continuity based on generalized and

customized mappings among different standard ontologies, by using mediation bridge ontology MBO based on ontology matching techniques.

- [9] Also provided are adaptive semantic based mediation system and method (using the same), which increases accuracy of transformation process among different standard formats by using mappings stored in a mediation bridge ontology (MBO).

Solution to Problem

- [10] According to an embodiment of the present invention, an adaptive semantic based mediation system, comprises: an accuracy mapping engine, generating generalized mappings by matching between/among different standard ontologies and customized mappings among the different standard ontologies based on a personalized detailed clinical model (P-DCM); a mediation bridge ontology (MBO) unit; storing the generalized and the customized mappings; a standard ontology change management unit, managing changes in the mappings in the mediation bridge ontology (MBO) unit; and a transformation engine; converting a pattern among the different standard ontologies based on pattern matching information acquired from the mediation bridge ontology (MBO) unit by communicating with health information systems.
- [11] According to an embodiment, the accuracy mapping engine may further comprise: a generalized mapping module, generating the generalized mapping by analyzing a matching concept in the different standard ontologies and storing the generated generalized mapping in the mediation bridge ontology (MBO) unit; and a customized mapping module, generating the customized mapping for linkage between/among concepts in the different standard ontologies based on organization conformance issues and storing the generated customized mapping in the mediation bridge ontology (MBO) unit.
- [12] According to an embodiment, the standard ontology change management unit may further comprise: a change detector, detecting non-conforming concept from a personalized detailed clinical model (P-DCM) ontology; a change collector, accessing stale mappings from the change detector; and a change formulator, collecting modified mappings and new mappings, which are identified by the change collector, and formulating the collected modified and new mappings to be compatible with the mediation bridge ontology unit.
- [13] According to an embodiment, the personalized detailed clinical model (P-DCM) ontology may include information concerning relationships among the non-conforming concepts, conforming concepts, other standard concepts, and clinical model concepts.
- [14] According to an embodiment, the change detector may store a mapping based on the non-conforming concept as a single stale mapping, wherein: the mapping based on the non-conforming concept is identified in the mediation bridge ontology (MBO) unit,

and the single stale mapping comprises a conforming concept aligned with the non-conforming concept.

- [15] According to an embodiment, the transformation engine may further comprise a content handler, communicating with the health information systems; a conversion manager, managing transformation between/among the different standard ontologies; a pattern matcher, matching input pattern by analyzing a suitable alignment from the MBO unit; and a pattern transformer, converting the input pattern to output pattern based on the pattern matching information acquired from the mediation bridge ontology (MBO) unit.
- [16] According to an embodiment of the present invention, an adaptive semantic based mediation method comprises: a step of generating a generalized mapping by matching between/among different standard ontologies and (a step of generating) a customized mapping based on a personalized detailed clinical model (P-DCM); a step of storing and maintaining the generalized mapping and the customized mapping; a step of managing mapping changes in a mediation bridge ontology (MBO); and a step of converting pattern between/among the different standard ontologies based on pattern matching information acquired by communicating with health information systems.
- [17] According to an embodiment, the step of generating the generalized mapping may further comprise: generating the generalized mapping by analyzing a matching concept in the different standard ontologies, and storing the generated general mapping.
- [18] According to an embodiment, the step of generating the customized mapping may further comprise: generating the customized mapping for linkage between/among concepts in the different standard ontologies, and storing the generated generalized mapping.
- [19] According to an embodiment, the step of converting pattern may further comprise: matching input pattern by analyzing a suitable alignment, and converting the input pattern to output pattern based on the acquired pattern matching information.
- [20] According to an embodiment, the step of managing mapping changes may further comprise: detecting non-conforming concept information from a personalized detailed clinical model (P-DCM) ontology; accessing a stale mapping using the detected non-conforming concept information; collecting modified and new mappings identified from the accessed stale mapping; and converting formats of the collected modified and new mappings.

Advantageous Effects of Invention

- [21] According to an embodiment of the present invention, interoperability between/among different standard models may be attained by using a concept of personalized detailed clinical model (P-DCM) and ontology matching techniques.

[22] Further, according to an embodiment of the present invention, mapping accuracy and continuity may be ensured based on generalized and customized mappings of/among different standard ontologies, by using mediation bridge ontology based on ontology matching techniques.

[23] Furthermore, according to an embodiment of the present invention, an accuracy of transformation process between/among different standard formats may be increased by using mappings stored in a mediation bridge ontology (MBO).

Brief Description of Drawings

[24] FIG. 1 is a block diagram showing an adaptive semantic based mediation system according to an embodiment of the invention.

[25] FIG. 2 is a block diagram showing a generalized mapping module in an adaptive semantic based mediation system according to an embodiment of the invention.

[26] FIG. 3 is a block diagram showing a standard ontology change management unit in an adaptive semantic based mediation system according to an embodiment of the invention.

[27] FIG. 4 is a block diagram showing a transformation engine in an adaptive semantic based mediation system according to an embodiment of the invention.

[28] FIG. 5 is a flow-chart diagram describing an adaptive semantic based mediation method according to an embodiment of the invention.

Mode for the Invention

[29] Hereinafter, various embodiments of the present invention are described in detail with reference to the FIG.'s in the drawings. To note, the embodiments are merely exemplary, and as such, the present invention is not limited thereto.

[30] In the present disclosure, a singular term may denote and include a plurality, unless specifically defined otherwise. Further, the terms "comprises" or "comprising," as used in the present disclosure, do not exclude an existence or an addition of (at least one of) other components or elements, steps, and/or functions and operations, aside from those already disclosed.

[31] Unless otherwise defined, all of the terms used in the present disclosure are to be interpreted as ordinarily understood by a person skilled in the art. Also, unless otherwise defined, the terms with ordinary dictionary definitions and usage are not to be interpreted inordinately.

[32] The terms and terminology as used in the present disclosure are used to properly describe the various embodiments and not, to limit the present invention there. Further, the terms may be differently interpreted according to a user, operator, and custom or usage of the terms, etc., in the applicable art. As such, the terms are to be interpreted based on the content/context of the present disclosure. In the present disclosure, details

related to commonly known structure, function or operation are omitted where the details are found to unnecessarily hinder the disclosure (description) of the present invention.

[33] FIG. 1 is a block diagram showing an adaptive semantic based mediation system according to an embodiment of the invention.

[34] Referencing FIG. 1, an adaptive semantic based mediation system (100), according to an embodiment of the invention, comprises an accuracy mapping engine (unit) (110), a standard ontology change management unit (120), a mediation bridge ontology (MBO) unit (130), and a transformation engine (unit) (140).

[35] The accuracy mapping engine (110) generates a generalized mapping by matching among different (medical) standard ontologies and a customized mapping among the different standard ontologies based on a personalized detailed clinical model (P-DCM).

[36] The accuracy mapping engine (110) may apply and execute bridge algorithms for generating and storing ontology mappings between different standard ontologies (e.g., ontologies with different medical standards). The bridge algorithm may perform a matching process by loading different standard ontologies.

[37] Also, the accuracy mapping engine (110) may generate mappings of/for different standard ontologies and store the generated mappings in a mediation bridge ontology (unit) (130) using ontology matching techniques.

[38] For these, the accuracy mapping engine (110) may comprise a generalized mapping module (111) and a customized mapping module (112).

[39] The generalized mapping module (111) may generate the generalized mappings by analyzing matching concept(s) in different standard ontologies and store the generated general mappings in the mediation bridge ontology (MBO) unit (130).

[40] The generalized mapping module (111) may be an ontology matching system, which performs computationally intensive operations using an optimized matching algorithm on/over matched (medical) ontologies.

[41] For example, the generalized mapping module (111) may improve ontology matching performance by utilizing multicore hardware of Cloud platform.

[42] The customized mapping module (112) may generate customized mappings for linkage between concepts in different standard ontologies and store the generated customized mappings in the mediation bridge ontology (MBO) unit (130).

[43] The customized mapping module (112) may generate customized mappings for linkage between conforming medical standard concepts and clinical model concepts to ensure data interoperability among (various) health information systems (400).

[44] The customized mappings may invalidate some of the generalized mappings in the mediation bridge ontology (MBO) unit (130) due to organization's conformance/compliance issues by bringing changes in existing mappings. These changes may be

necessary for evolution of mappings to ensure continuity of mappings.

- [45] According to an embodiment, the customized mapping module (112) may further comprise customized bridge (not shown in the drawings), which is used to represent medical standard ontologies and personalized detailed clinical model (P-DCM) based mappings stored in the mediation bridge ontology (MBO) unit (130).
- [46] Also, according to an embodiment, the accuracy mapping engine (110) may further comprise an expert verification module (also not shown) for mapping accuracy.
- [47] The standard ontology change management unit (120) manage changes in the mappings in the mediation bridge ontology (MBO) unit (130).
- [48] Also, the standard ontology change management unit (120) may perform management functions or operations for evolution in the mappings) for changes applied in the mediation bridge ontology (MBO) unit (130).
- [49] According to an embodiment, the standard ontology change management unit (120) may enhance and increase mapping accuracy for attaining data interoperability among the health information systems (400).
- [50] The mediation bridge ontology (MBO) unit (130) stores the generalized mappings and the customized mappings.
- [51] For example, the mediation bridge ontology (MBO) unit (130) stores the generalized mappings and the customized mappings generated by the generalized mapping module (111) and the customized mapping module (112), respectively.
- [52] Also, the mediation bridge ontology (MBO) unit (130) may be a centralized mediation point for all other components in the adaptive semantic based mediation system (100).
- [53] The transformation engine (140) communicates with the health information systems (400) and converts a pattern among different standard ontologies based on pattern matching information acquired from the mediation bridge ontology (MBO) unit (130).
- [54] The transformation engine (140) may provide to a certain/given level of effectiveness, data interoperability among the health information systems (400).
- [55] Also, the transformation engine (140) may perform structural and sequential data transformation for transforming and generating valid medical standard formats. The transformation engine (140) is described in more detail with reference to FIG. 4, later.
- [56] The health information systems (HIS's) (400) may include at least one of the electronic medical record (EMR), electronic health records (EHR), personal health record (PHR), clinical decision supporting system (CDSS), computerized physician order entry (CPOE) and health information exchange (HIE).
- [57] FIG. 2 is a block diagram showing the generalized mapping module in the adaptive semantic based mediation system according to an embodiment of the invention.
- [58] Referencing FIG. 2, the generalized mapping module or mapping module (111)

comprises string matching bridge (201), synonym bridge (202), polysemous bridge (203), label bridge (204), property based structural bridge (205), overlap bridge (206), and child based structural bridge (207).

- [59] The string matching bridge (201) may identify similar (ontology) concepts by using string matching techniques.
- [60] The synonym bridge (202) may identify similar meaning concepts by using information from such online dictionary as WordNet.
- [61] The polysemous bridge (203) may validate exact matching concepts by using an online dictionary to compare concept meanings.
- [62] Also, the polysemous bridge (203) may identify concepts with same name but different meaning.
- [63] The label bridge (204) may match labels of matching concepts stored in the ontology to identify similar labels for concluding matched concepts as similar concepts.
- [64] Also, the label bridge (204) may use string matching techniques for matching label of the concepts.
- [65] The overlap bridge (206) may find concepts that contain overlapping information and are necessary for information exchange.
- [66] Also, the overlap bridge (206) may use structural hierarchy information for finding the overlapping information.
- [67] The property based structural bridge (205) and the child based structural bridge (207) may use concepts similarity matching and concepts children similarity matching techniques, respectively.
- [68] According to an embodiment, ontology alignment patterns may be used in bridge algorithms for alignment in ontology mediation process.
- [69] The bridge algorithms may generate the generalized mappings between (medical) ontologies and store in the mediation bridge ontology (MBO) unit (130).
- [70] FIG. 3 is a block diagram showing the standard ontology change management unit in the adaptive semantic based mediation system according to an embodiment of the invention.
- [71] The standard ontology change management unit (120) may manage changes in the mappings in the mediation bridge ontology (MBO) unit (130) and detect non-conforming concepts from personalized detailed clinical model (P-DCM) ontology.
- [72] The personalized detailed clinical model (P-DCM) ontology may include information concerning relationships among (the) non-conforming concepts, conforming concepts, other standard concepts, and clinical model concepts.
- [73] Referencing FIG. 3, the standard ontology change management unit (120) comprises a change detector module (121), a change collector module (122), and a change transformer module (123).

- [74] The change detector (121) may include a single stale mapping composed of conforming concepts aligned with non-conforming concepts.
- [75] The non-conforming concepts may be accessed from the personalized detailed clinical model (P-DCM) ontology, and mappings based on the non-conforming concepts may be identified by the mediation bridge ontology (MBO) unit (130) and stored as stale mappings.
- [76] The change collector (122) may access the stale mappings from the change detector (121).
- [77] Also, the change collector (122) may collect the conforming concepts from the stale mappings and search in the personalized detailed clinical model (P-DCM) ontology, annotated mappings based on the conforming concept.
- [78] Also, the change collector (122) may identify corresponding conforming concept of target standard concept from the annotated mapping(s) information.
- [79] For example, if conforming concept A belongs to standard 1 and non-conforming concept B belongs to standard 2, then the change collector (122) may generate annotated mappings by accessing corresponding conforming concept C of the standard 2, based on the conforming concept A (of the standard 2) from personalized detailed clinical model (P-DCM) ontology.
- [80] Also, according to an embodiment, the change collector (122) may search annotated mapping information in the personalized detailed clinical model (P-DCM) ontology to find new mappings that did not exist prior to being stored in the mediation bridge ontology (MBO) unit (130).
- [81] For example, concept X and concept Y of standard 1 and 2, respectively, may be related with clinical model concept Z in personalized detailed clinical model (P-DCM) ontology, which is annotated information. Here, the concepts X and Y are candidates for alignment; therefore, if this alignment does not exist in the mediation bridge ontology (MBO) unit, then this alignment is a candidate for new mapping.
- [82] The change formulator (123) collects modified mapping and new mapping, which are identified by the change collector, and formulates the collected modified and new mappings to be compatible in format with the mediation bridge ontology (MBO) unit (130).
- [83] FIG. 4 is a block diagram showing the transformation engine in the adaptive semantic based mediation system according to an embodiment of the invention.
- [84] The transformation engine (140) performs conversion between different standard ontologies by communicating with the health information systems (400), which have the different standard ontologies.
- [85] For this conversion, referencing FIG. 4, the transformation engine (140) according to an embodiment comprises a content handler module (141), a conversion manager

- module (142), a pattern matching module (143), and a pattern transforming module (144).
- [86] The content handler (141) may communicate with (various) health information systems (400) having different standard formats. Also, the content handler (141) may obtain clinical documents, which includes patient information, in a clinical document architecture (CDA) format from the health information systems (400).
- [87] For example, when the adaptive semantic based mediation system (100) converts to virtual medical record (vMR) standard from the clinical document architecture (CDA) standard in conformance/compliance with the health information systems (400), the health information systems (400) may communicate with the content handler (141) and provide clinical documents, which includes patient information, in the clinical document architecture (CDA) format.
- [88] Basic purpose of the content handler (141) may be to receive recommendations or guidelines in the virtual medical record (vMR) standard from clinical decision support systems (CDSS).
- [89] Also, the content handler (141) may send information to the conversion manager module (142) for (performing) transformation process in the pattern matching module (143), which performs pattern matching to identify matched patterns from the mediation bridge ontology (MBO) unit (130), based on input information.
- [90] The pattern matching module (143) may match input pattern by analyzing most suitable alignment from the mediation bridge ontology (MBO) unit (130).
- [91] The pattern matching module (143) may send pattern matching information to the pattern transforming module (144), which converts an input in a first standard format to an output in a second standard format, by using the pattern identified from the mediation bridge ontology (MBO) unit (130).
- [92] The pattern transforming module (144) may convert the input pattern to an output pattern based on the pattern matching information acquired from the mediation bridge ontology (MBO) unit (130).
- [93] Also, the pattern transforming module (144) may convert input information in one standard format to output in another standard format by using the patterns identified from the mediation bridge ontology (MBO) unit (130).
- [94] The case of converting or transforming the clinical document architecture (CDA) standard format (for clinical decision support systems (CDSS) processing) to the virtual medical record (vMR) format may (merely) be an example of the adaptive semantic based mediation system according to the present invention.
- [95] The transformation engine (140) may convert the clinical document architecture (CDA) format to the virtual medical record (vMR) format by applying transformation patterns modeled in the mediation bridge ontology (MBO) unit (130).

[96] The clinical decision support systems (CDSS) may process information and generate (additional) recommendation or suggestive information in virtual medical record (vMR) output format for retransforming (back) to the clinical document architecture (CDA) format via the transformation engine (140), including the pattern matching module (143) and the pattern transforming module (144).

[97] Hereafter, transformation algorithms is described for mediation bridge ontology (MBO) in the adaptive semantic based mediation system according to an embodiment of the invention.

[98] The transformation process in the mediation bridge ontology (MBO) unit (130) may use and be described by using ALGORITHM's (1) and (2) below for process of instance level transformation among different standards by using.

[99]

[100] ALGORITHM (1)

[101] **Input:** SMR_{SA} /*MR $\rightarrow$ Source Medical Record & SA $\rightarrow$ Standard' A'*/
Output: TMR_{SB} /*MR $\rightarrow$ Target Medical Record & SB $\rightarrow$ Standard' B'*/

```

1 begin
2   Let  $MBO := LoadMBO()$  /* where  $MBO$  is Mediation Bridge Ontology */
3   let  $TMR_{SB} = \emptyset$ 
4    $ListConceptsSMR_{SA} \leftarrow SMR_{SA}.RetrieveConceptsList()$ 
5    $ListMappedConceptsTMR_{SB} \leftarrow RetrieveMappings(ListConceptsSMR_{SA}, MBO)$ 
6    $ListConceptsTMR_{SB} \leftarrow$   

    $TMR_{SB}.InsertConceptList(ListMappedConceptsTMR_{SB})$ 
7   let  $SC_i \leftarrow ListMappedConceptsTMR_{SB}.first()$ 
8   for  $SC_i \in ListConceptsSMR_{SA}$  do
9      $SC_i.Value \equiv SC_i.Value$ 
10     $SC_i \leftarrow ListMappedConceptsTMR_{SB}.next()$ 
11  end
12  return  $TMR_{SB}$ 
13 end

```

[102] ALGORITHM (1) explains a procedure of source standard instance SMR_{SA} conversion to target standard instance TMR_{SB} , and the conversion is based on loading patterns stored in the mediation bridge ontology (MBO) unit (130) using LoadMBO() method.

[103] Initially, target instance is empty ($TMR_{SB}=0$), and concepts from source instance is retrieved, SMR_{SA} .

[104] Mapping for the retrieved concepts is explained in ALGORITHM (2) below and is performed using RetrieveMapping(ListConceptsSMR_{SA}, MBO) method.

[105]

[106] ALGORITHM (2)

[107] **Input:** *ListConceptsSMR_{SA}*, *MBO*
 Output: *ListConceptsTMR_{SB}*

```

1 begin
2   Let  $SC_i$  is Source Ontology Concepts
3   while  $SC_i \leftarrow ListConceptsSMR_{SA}.next()$  do
4      $TC_j \leftarrow MBO.FindCorrespondingConcept(SC_i)$ 
5      $SCP_s := SC_i.GetProperties()$ 
6     for  $SCP \in SCP_s$  do
7        $TCP_j \leftarrow MBO.FindCorrespondingProperty(SCP)$ 
8        $TC_i.add(TCP_j)$ 
9     end
10     $ListConceptsTMR_{SB}.add(TC_i)$ 
11  end
12  return ListConceptsTMRSB
13 end

```

[108] ALGORITHM (2) is executed until all corresponding concepts and properties of source standard are identified from the mediation bridge ontology (MBO) unit (130).

[109] Corresponding target concepts TC_j and target properties TCP_j are matched from source corresponding concept from the mediation bridge ontology (MBO) unit (130), using each of $MBO.FindCorrespondingConcept(SC_i)$ and $MBO.FindCorrespondingProperty(SCP)$ methods.

[110] $FindCorrespondingConcept()$ and $FindCorrespondingProperty()$ methods uses different patterns for finding appropriate concepts and properties.

[111] Mapping concept of target standard $ListConceptsTMR_{SB}$ is returned to $RetrieveMappings(ListConceptsSMR_{SA}, MBO)$ of ALGORITHM (1).

[112] ALGORITHM (1) utilizes mapped concept $ListConceptsTMR_{SB}$ from ALGORITHM (2) and insert it into TMR_{SB} by using $TMR_{SB}.InsertConceptList(ListMappedConceptsTMR_{SB})$ method.

[113] Value are finally assigned to all matched concepts using $SC_i.ValueSC_i$.

[114] Hereafter, an example/embodyment of the adaptive semantic based mediation system is described for performance evaluation.

[115]

[116] Example 1

[117] Performance evaluation has been made for the adaptive semantic based mediation system. Results with (comparative) analysis follow.

[118] Accuracy of mappings for the transformation process of the adaptive semantic based mediation system has been evaluated using the generalized mapping module (111) and the mediation bridge ontology (MBO) unit (130), with an evaluative conversion of clinical document architecture (CDA) to virtual medical record (vMR) Input.

[119] Portions of the clinical document architecture (CDA) that is most related with the virtual medical record (vMR) is body part (of the virtual medical record (vMR)).

[120] The body part contains patient observation details, which require clinical decision supporting system (CDSS) processing for recommendations or guidelines generation.

[121] Using the adaptive semantic based mediation system according to the invention, smooth transformation process was observed, as a number of vMR transformation

constructs are subset of CDSS transformation constructs.

[122] FORMULA (1) below was used to measure accuracy of the adaptive semantic based mediation system.

[123] FORMULA (1)

[124]
$$\text{Accuracy} = \{\text{True Positives(TP)} + \text{True Negatives(TN)}\} / \{\text{True Positives(TP)} + \text{True Negatives(TN)} + \text{False Positives(FP)} + \text{False Negatives(FN)}\}$$

[125] Here, Positives and Negatives denote of accuracy of concepts of the transformation process.

[126] TABLE (1) below shows CDA-to-vMR Input transformation process results for the adaptive semantic based mediation system according to an embodiment, using the generalized mapping module (111) and the mediation bridge ontology (MBO) unit (130) in the adaptive semantic based mediation system, according to an embodiment.

[127] TABLE (1)

[128]

	Precision	Recall	F-Measure
Concepts	1	0.767	0.867
Attributes	1	0.799	0.888
Values	1	0.799	0.888

Overall Accuracy = 79%
(MBO Mappings with SPHeRe)

[129] Referencing TABLE (1), an overall accuracy level of 79% was achieved for the evaluative CDA-to-vMR Input transformation process using the generalized mapping module (111) and the mediation bridge ontology (MBO) unit (130). Recall for mapping construct was between 0.75 to 0.8, and F-Measures, approximately 0.877.

[130] Also, a low accuracy level of 79% was achieved, because customized stored mappings for the mapping construct were not utilized.

[131] TABLE (2) below shows CDA-to-vMR Input transformation process results for the adaptive semantic based mediation system according to an embodiment, using the generalized mapping module (111), the customized mapping module (112), and the mediation bridge ontology (MBO) unit (130) in the adaptive semantic based mediation system, according to an embodiment.

[132] TABLE (2)

[133]

	Precision	Recall	F-Measure
Concepts	1	1	1
Attributes	1	1	1
Values	1	0.799	0.888

Overall Accuracy = 93%
(MBO Mappings with SPHeRe and P-DCM Approach)

[134] Referencing TABLE (2), an overall accuracy level of 93% was achieved for the evaluative CDA-to-vMR Input transformation process using the generalized mapping module (111), the customized mapping module (112), and the mediation bridge

ontology (MBO) unit (130).

[135] Organization-specific conformance information is stored in the personalized detailed clinical model (P-DCM) ontology.

[136] The organization-specific conformance information is used to generate customized mappings, which contributed to an increase in the overall accuracy level from (the previous) 79% to 93%.

[137] Via the adaptive semantic based mediation system in TABLE's (1) and (2) above, handling of the organization conformance information is (determined to be) necessary for generating customized mappings to support generalized mappings for data interoperability,

[138] Hereafter, another example/embodiment of the adaptive semantic based mediation system is described for performance evaluation.

[139]

[140] Example 2

[141] Performance evaluation has been made for the adaptive semantic based mediation system. Results with (comparative) analysis follow.

[142] Accuracy of mappings for the transformation process of the adaptive semantic based mediation system has been evaluated, with an evaluative conversion of virtual medical record (vMR) Output to clinical document architecture (CDA).

[143] TABLE (3) below shows vMR Output-to-CDA transformation process results for the adaptive semantic based mediation system according to an embodiment.

[144] TABLE (3)

[145]

	Precision	Recall	F-Measure
Concepts	1	1	1
Attributes	1	1	1
Values	1	0.856	0.922

Overall Accuracy = 95%

[146] Referencing TABLE (3), the adaptive semantic based mediation system according to an embodiment achieved an overall accuracy level of 95% in the evaluative vMR Output-to-CDA transformation process.

[147] Also, Recall and F-Measure were (both) 1 in Concepts and Attributes (criteria), and respective values for Recall and F-Measure were 0.856 and 0.922.es).

[148] As vMR output uses more concepts than vMR (input) and contains recommendations, about 95% of accuracy is achieved to use generalized and customized mappings for conversion from vMR output to CDA output.

[149] FIG. 5 is a flow-chart diagram describing an adaptive semantic based mediation method according to an embodiment of the invention.

[150] Referencing FIG. 5, the adaptive semantic based mediation method in Step 510, generates a generalized mapping by matching (between/among) different (medical)

standard ontologies and a customized mapping based on a personalized detailed clinical model (P-DCM).

[151] Step 510 may apply and execute bridge algorithms for generating and storing an ontology mapping between/among different medical standard ontologies, and (in) the bridge algorithm (there) may be a step for inputting different medical standard ontologies and performing a matching process.

[152] Also, Step 510 may be a step for generating mappings of/for different medical standard ontologies and storing the generated mappings in a standard ontology repository (unit) using an ontology matching technique.

[153] Hereafter in Step 520, the generalized and customized mappings are stored and maintained.

[154] Step 520 may be a step for storing the generalized mapping and customized mapping generated by a generalized mapping module and a customized mapping module (respectively).

[155] Hereafter in Step 530, mapping changes in a mediation bridge ontology (MBO) are managed.

[156] Step 530 may be a step for executing and managing functions or operations for mapping evolution (i.e., evolution in the mappings) for the changes applied in the mediation bridge ontology (MBO).

[157] Also, Step 530 may be a step for ontology change management aspect of a process for the mapping evolution.

[158] According to an embodiment, Step 530 may be a step for enhancing and increasing mapping accuracy for attaining data interoperability among (various) health information systems.

[159] Hereafter in Step 540, patterns between/among different standard ontologies are converted based on pattern matching information acquired from the mediation bridge ontology by communicating with health information systems.

[160] Step 540 may be a step for and providing at a certain/given level of effectiveness of data interoperability between/among health information systems.

[161] Also, Step 540 may be a step including structural and sequential data transformation mechanism for transforming and generating a valid medical standard format.

[162] According to an embodiment, the health information system (HIS) may include at least one of the electronic medical record (EMR), electronic health records (EHR), personal health record (PHR), clinical decision supporting system (CDSS), computerized physician order entry (CPOE) and health information exchange (HIE).

[163] According to an embodiment, the method may be implemented as program commands, which are executable through various types of computer means and recorded in a computer-readable medium. The computer-readable medium may include

program commands, data files, data structures, etc., in a singular/stand-alone or plural/combined form(s). Program commands recorded in the medium may be specially designed or constructed for the embodiments (of the present invention) or commonly known and thus, usable by those skilled in computer software (industry). Examples of the computer readable and recordable medium include: magnetic media such as a hard disk, floppy disk, and magnetic tapes; optical media such as a CD-ROM and DVD; magneto-optical media such as a floptical disk; as well as other hardware device such as a ROM, RAM, flash memory that are capable of storing and executing program commands. Examples of the computer commands include not only machine language codes, which are made by compilers, but also, high-level or special-type languages, which are executable by a computer through an interpreter. Same applies to examples of the hardware device, which includes at least one software module for operation of the embodiments.

[164] The present invention has been disclosed in reference to the above exemplary embodiments and drawings. However, a person skilled in the art will understand that various alterations and modifications may be made to the present disclosure. For example, the disclosed techniques may be implemented in an order, which is different from the method disclosed, and the system, layout, devices, modules, circuitry, etc. may be assembled or arranged in a manner, which is different from the one disclosed. Elements may be replaced or substituted with other (e.g., equivalent) elements, yet desired results may be attained.

[165] Therefore, other realizations and embodiments, as well as those analogous to the above disclosure are within the scope of the following claims.

[166]

Claims

- [Claim 1] An adaptive semantic based mediation system, comprising:
an accuracy mapping engine, generating generalized mapping by matching between/among different standard ontologies and customized mapping between/among the different standard ontologies based on a personalized detailed clinical model (P-DCM);
a mediation bridge ontology (MBO) unit, storing the generalized mapping and the customized mapping;
a standard ontology change management unit, managing changes in the mappings in the mediation bridge ontology (MBO) unit; and
a transformation engine, communicating with health information systems and converting a pattern between/among the different standard ontologies based on pattern matching information acquired from the mediation bridge ontology (MBO) unit.
- [Claim 2] The adaptive semantic based mediation system according to Claim 1, wherein the accuracy mapping engine further comprises:
a generalized mapping module, generating the generalized mapping by analyzing a matching concept in the different standard ontologies and storing the generated generalized mapping in the mediation bridge ontology (MBO) unit; and
a customized mapping module, generating the customized mappings for linkage between/among concepts in the different standard ontologies and storing the generated customized mapping in the mediation bridge ontology (MBO) unit.
- [Claim 3] The adaptive semantic based mediation system according to Claim 1, wherein the standard ontology change management unit further comprises:
a change detector, detecting non-conforming concept from personalized detailed clinical model (P-DCM) ontology;
a change collector, accessing stale mapping from the change detector; and
a change formulator, collecting modified mapping and new mapping, which are identified by the change collector, and formulating the collected modified and new mappings to be compatible in format with the mediation bridge ontology (MBO) unit.
- [Claim 4] The adaptive semantic based mediation system according to Claim 3, wherein

the personalized detailed clinical model (P-DCM) ontology includes information concerning relationships among the non-conforming concept, conforming concept, other standard concept, and clinical model concept.

[Claim 5] The adaptive semantic based mediation system according to Claim 3, wherein the change detector stores mapping based on the non-conforming concept as a single stale mapping, wherein:
the mapping based on the non-conforming concept is identified in the mediation bridge ontology (MBO) unit, and
the single stale mapping comprises a conforming concept aligned with the non-conforming concept.

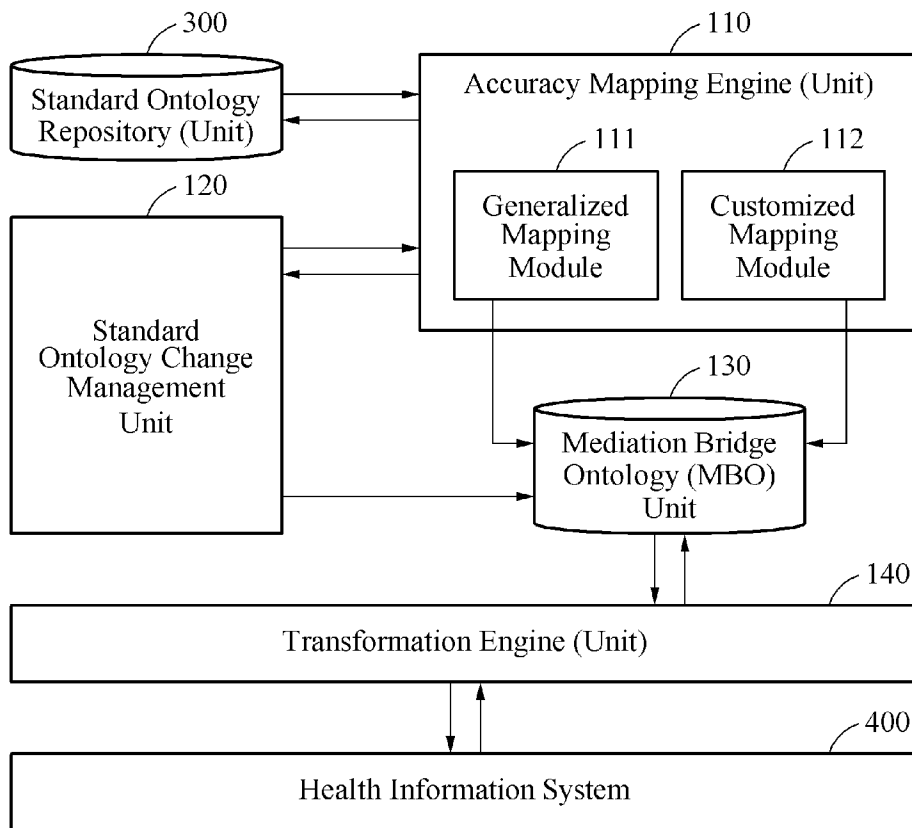
[Claim 6] The adaptive semantic based mediation system according to Claim 1, wherein the transformation engine further comprises:
a content handler, communicating with the health information systems;
a conversion manager, managing change between/among the different standard ontologies;
a pattern matcher, matching input pattern by analyzing a suitable alignment from the mediation bridge ontology (MBO) unit; and
a pattern transformer, converting the input pattern to output pattern based on the pattern matching information acquired from the mediation bridge ontology (MBO) unit.

[Claim 7] An adaptive semantic based mediation method, comprising:
a step of generating:
generalized mapping by matching between/among different standard ontologies, and
customized mapping based on a personalized detailed clinical model (P-DCM);
a step of storing and maintaining the generalized mapping and the customized mapping;
a step of managing mapping changes in a mediation bridge ontology (MBO); and
a step of converting pattern between/among the different standard ontologies based on pattern matching information acquired by communicating with health information systems.

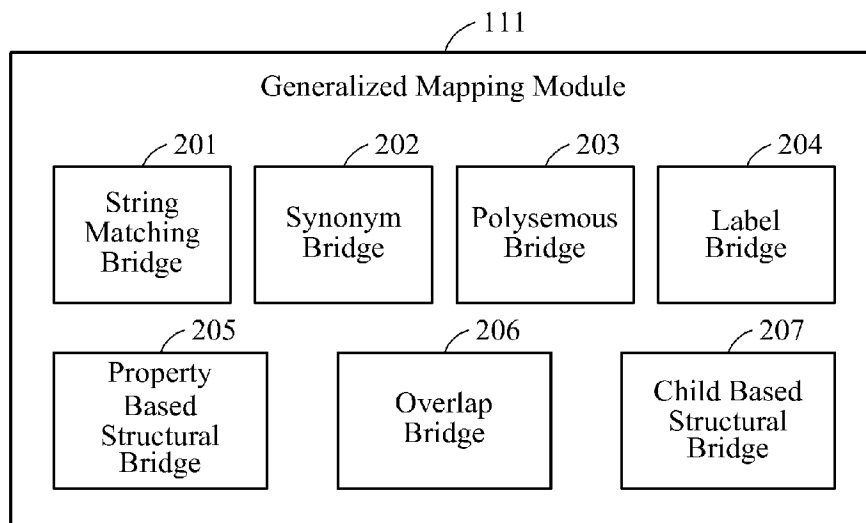
[Claim 8] The adaptive semantic based mediation method according to Claim 7, wherein the step of generating the generalized mapping further comprises:
generating the generalized mapping by analyzing a matching concept in

- the different standard ontologies, and
storing the generated generalized mapping.
- [Claim 9] The adaptive semantic based mediation method according to Claim 8,
wherein the step of generating the customized mapping further
comprises:
generating the customized mapping for linkage between/among
concepts in the different standard ontologies, and
storing the generated generalized mapping.
- [Claim 10] The adaptive semantic based mediation method according to Claim 7,
wherein the step of converting pattern further comprises:
matching input pattern by analyzing a suitable alignment, and
converting the input pattern to output pattern based on the acquired
pattern matching information.
- [Claim 11] The adaptive semantic based mediation method according to Claim 7,
wherein the step of managing mapping changes further comprises:
detecting non-conforming concept information from a personalized
detailed clinical model (P-DCM) ontology;
accessing stale mapping from the detected non-conforming concept in-
formation;
collecting modified and new mappings identified by the accessed stale
mapping; and
converting formats of the collected modified and new mappings.
- [Claim 12] A computer-readable storage medium storing a program to perform a
method of providing clinical information in real time according to any
one of claims 7 through 11.

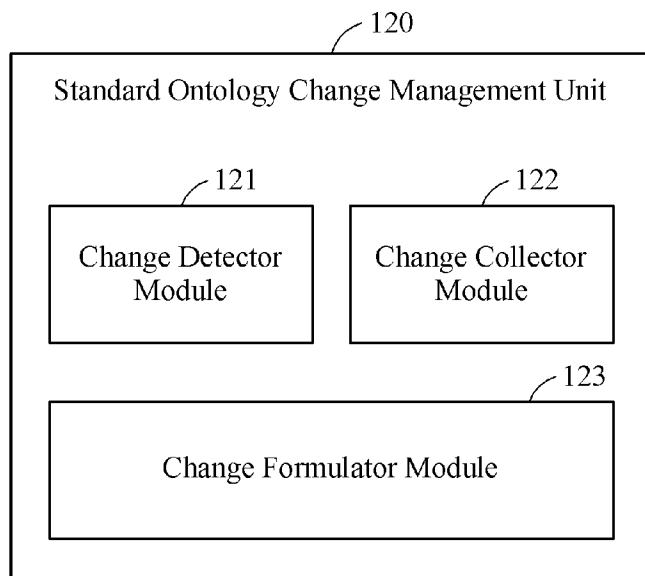
[Fig. 1]



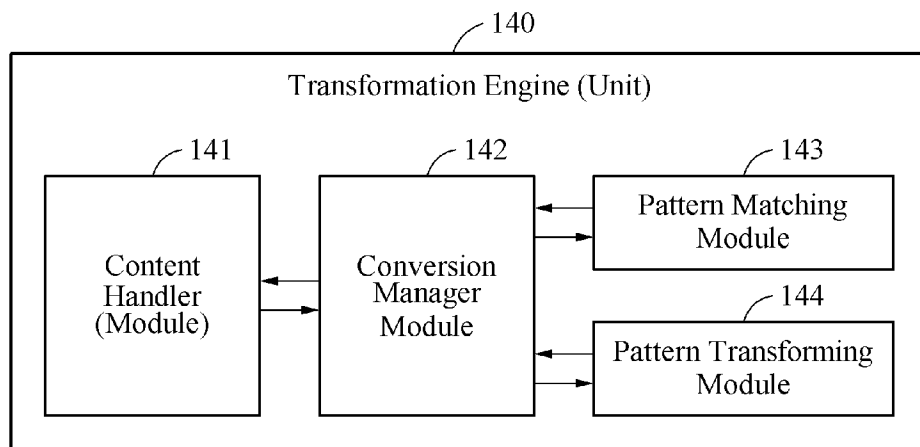
[Fig. 2]



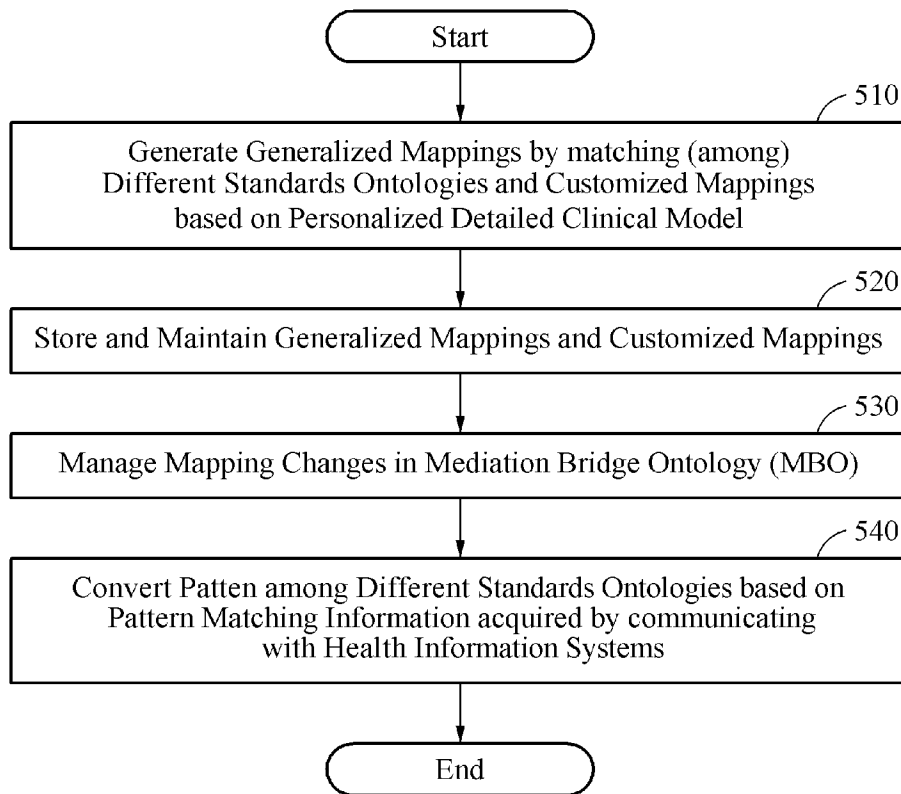
[Fig. 3]



[Fig. 4]



[Fig. 5]



A. CLASSIFICATION OF SUBJECT MATTER**G06Q 50/24(2012.01)i, G06Q 50/22(2012.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06Q 50/24; G06Q 50/22

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: ontology, adaptive, semantic, mediation, mapping, matching, P-DCM, DCM

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Sungyong Lee et al., Personalized-Detailed Clinical Model as Inter-operability Protocol among Clinical Standards, Telecommunication Technology Association, 2013, TTAR-10.0042, pp. 1-13. See the whole document	1-12
A	Sungyong Lee et al., Personalized-Detailed Clinical Model for Data Inter-operability among Clinical Standards, In: Telemedicine and e-Health, Vol. 19, No. 8, August 2013. pp. 632-642. See the whole document	1-12
A	KR 10-1441104 B1 (UNIVERSITY-INDUSTRY COOPERATION GROUP OF KYUNG HEE UNIVERSITY) 01 October 2014 See the whole document	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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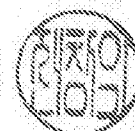
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Information on patent family members

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None