Development of an Ontology-based Flexible Clinical Pathway System

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Abstract: The efficient storage of medical knowledge is critical for the advancement of medicine; a flexible platform for the storage of knowledge is the need of the hour. Therefore, this work focuses on clinical pathways—tools that effectively maintain the quality and control the cost of medicine—to formulate a model for knowledge storage. In this work, ontology was employed as the fundamental theory to facilitate the construction of a flexible system. Using task and domain ontologies, clinical pathway knowledge becomes more accessible, as domain and operation knowledge are available separately. Moreover, taking into account the continued refinement of clinical pathways, this work developed cost-effective and quality health care systems, using quartile and variance computations to identify problematic treatments and pathways and to refine decision support systems. The integration of an ontological approach with quartile and variance algorithms for clinical pathways was implemented by system development, the outcome of which is presented in this paper.

Keywords: Ontology, Clinical pathways, Domain ontology, Task ontology, Ontology-based system

1 Introduction

Due to financial difficulties and business competition, hospitals adopt several measures such as quality assurance, total quality management, outcome management, clinical pathways, and benchmarks. Conceived in the 1980s, clinical pathways are one of the most widely used tools for managing healthcare quality. In Webster's study on laparoscopic pyeloplasty, clinical pathways were effective in decreasing the length of hospital stays [11]. Hauck's research also demonstrates that clinical pathways significantly reduce the rate of deaths in hospitals [5].

The benefits of clinical pathways have been significant in terms of treatment quality and medical costs; for instance, hospital efficiency and bed use. However, there is currently no means to record clinical pathway data. Therefore, each hospital creates its own clinical pathways, without exchanging knowledge with other institutions. Moreover, an available clinical pathway has to pass through three stages: preparation, implementation, and refinement. This process requires many human and medical resources. Furthermore, the outcome of a clinical pathway is not very effective and does not facilitate the advancement of medical science.

In an attempt to address the abovementioned situation, this paper proposes a knowledge storage platform for clinical pathways, which makes it possible to visualize, share, and reuse knowledge. Taking into account the continued refinement of clinical pathways, the idea of cost-effective quality health care has also been developed. Within the knowledge storage function, the theory of computational ontology was employed in the construction of a flexible system. Domain and task ontologies were applied for better knowledge description. In addition, the concepts of relative times and distribution were utilized and quartile and variance computations applied, in order to identify and eliminate any excessive and inefficient treatments. The aim of this study is to present a novel approach that incorporates ontology and quartile and variance algorithms to develop a complete framework and a practical system.

The clinical pathway system presented in this study facilitates the automatic storage of information that can be easily shared, developed, and reused. The sharing of clinical pathway knowledge necessitates an effective modeling approach that uses ontological descriptions. Once the knowledge framework is complete, clinical pathway creation will require little effort from medical personnel. Further, the aspect of continued refinement allows the evaluation of clinical pathways using a systematic approach.

2 Related works

In this section, the relevant applications and techniques for clinical pathways are discussed.

2.1 Clinical Pathways

Also known as critical pathways or care paths, clinical pathways are the primary tools of hospital management. They are used for quality control of medical care. Conceived in the early 1980s, clinical pathways gained popularity in the mid-1990s and are used worldwide in various medical situations [13]. They are successfully applied in both private and public health care systems across the world [2].
Clinical pathways were developed to improve medical practices including the quality of healthcare, and maintaining that quality while providing cost-effective care [1]. The purpose of clinical pathways is to standardize the clinical practices of a group of specialists, and to deliver consistent treatments to patients in order to improve the quality and efficiency of medical care. The benefits of clinical pathways are (a) it creates uniformity and protocol to orders for provision of quality healthcare; (b) it identifies and eliminates the excessive or inefficient treatments that exist in current practices; (c) it guides and delivers consistent treatment in stable cost-effective care.
Clinical pathways are defined as clinical and quality tools that support the organization of patient care delivery for a specific population through the use of a consistent multidisciplinary process [1]. Components of clinical pathways include standardized documentation and clinically ordered pathways for tasks and interventions [9]. Based on documentation of current clinical practices and input from a team of medical specialists, the organization of a clinical pathway is displayed in Fig. 1. This pathway was designed with 10 focus areas: tests, using medicine (long-term and short-term), treatments (long-term and short- term), consults, discharge planning, exception description, consultations, and incision.
Tracking and evaluating variations in treatments used by current practices can be used to improve the efficiency of clinical pathways [9]. If clinical pathways are developed and implemented without making changes to practices, they become just another piece of paper [1]. The impact of clinical pathways has been reported in scientific studies and practices [2][5][11][12]. How to optimize care and store the knowledge of clinical pathways are the key issues in this study.

Fig. 1 Organization of a clinical pathway

2.2 Ontology-based information system

Discussing ontology is necessary for a deeper understanding of an ontology-based system [6]. The word ‘ontology’ is taken from philosophy, where it means a systematic explanation of being. Ontology can be interpreted in two ways [14]:
(1) From the viewpoint of philosophy, ontology means the theory of existence. It tries to explain what exists in the world and how the world is configured by introducing a system of critical categories to account for things and their intrinsic relations.
(2) From the viewpoint of science, ontology is defined as a system of concepts/vocabulary used as building blocks of information process systems.
The difference between these two interpretations is in their goals and scope [7]. With regard to goals, philosophical ontology seeks to know about the nature of reality, and computational ontology is focused on other pragmatic objectives in a specific application. In terms of scope, philosophical ontology deals with all reality in the entire universe of discourse, and computational ontology only deals with interest in a limited universe of discourse. Moreover, computational ontology is especially focused on computable and programmable ontology in computers. In this study, the term ‘ontology’ is associated with computational ontology.
The purpose of ontology is to provide a presentation of a particular domain. Roughly speaking, ontology includes domain ontology and task ontology, which represent static knowledge and the problem-solving process of a targeted domain, respectively [8]. Both aspects have been employed in this study and are described in detail in sections 2.2.1-2.

2.2.1 Domain ontology

Domain ontology is considered to be a thesaurus containing all the information about domain concepts and their associations [15]. It enumerates all the important concepts and their associations to represent the static knowledge of a particular domain. In domain ontology, every concept is described by class and sub-class and is associated by relevance, inheritance, and belongs to. These concepts are defined as follows: relevance refers to the concept that a common class will possess the same attributes; inheritance is the concept that a bottom class will inherit the greatest number of attributes in its hierarchy, and the belongs to is a concept that something occurs in one or several classes.

In this study, the description logic of domain ontology follows the frame-based logic of Protégé: knowledge concepts are described by class, attributes of those knowledge concepts are slots, and the attribute values are facets.

In summary, domain ontology has many classes, which are expressed by slots and facets, and has a number of clarified associations, which are indicated by relevance, inheritance and belongs to. The entire result of which constructs a bounded domain of static knowledge. The depth of description in domain ontology relies on the demands of its application as mentioned in section 2.2. An example of domain ontology is shown bellowing Fig. 2. The association of belongs to is noted as 'is-a' and inheritance is shown as in Fig. 2.

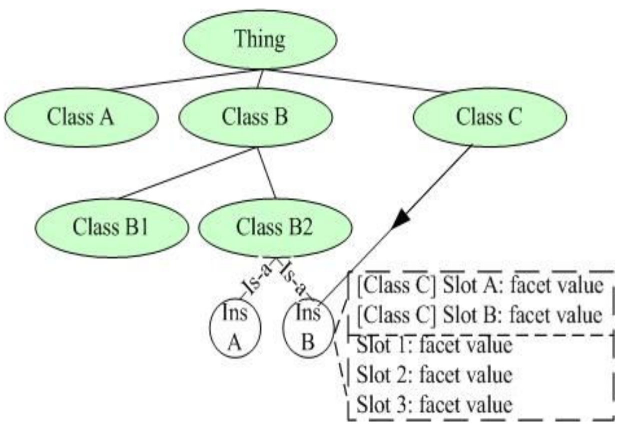


Fig. 2 Example of domain ontology

Domain ontology is constructed in a complex tree structure, which can be a balance of nodes or a fixed shape. The structure of domain ontology depends on the contents of the targeted domain. In Fig. 2, instances A and B are associated by relevance, and both of them belong to the common class of B2. The slots of Class B2 are Slots 1, 2, and 3, but it also inherits the slots of Class C; therefore, five slots are required to describe the knowledge concept of Class B2.

However, the domain ontology contains only the static knowledge of a particular domain, and it lacks universality, which is made up by task ontology.

2.2.2 Task ontology

Task ontology, also known as method ontology, is independent of method, domain, and application. Task ontology provides the necessary vocabulary used to characterize the problem solving behavior for a generic task [3]. Task ontology can be defined in the following two ways [13]:

(1) Task-subtask decomposition together with task categorization

(2) An ontology for specifying the problem-solving process

Task ontology is employed for modeling the problem-solving process (task knowledge) into generic tasks. It consists of the terminology of domain ontology and is associated with a specific problem. The two exemplary cases of task ontology are given below.

IF instance x, instance y coexists in z (1)

IF class A with Slot 1, Slots 2 and 3 coexist in z (2)

If/else is one of the most common elements of formal language in task ontology. Formula 1 is a determination of the instance compatible rule on instances x and y in situation z. Formula 2 is a determination of inclusion rule for class A and Slots 1-3 in situation z.

By introducing the dynamic knowledge of task ontology, the knowledge of a particular domain will become an inducible process and more knowledge will be reused. In a word, domain ontology and task ontology are indispensable to a knowledge system. The knowledge of clinical pathways is represented as ontology concepts (instances and associations of static knowledge) and generic tasks (rule sets of the problem-solving process) by the ontology approach in this study, and therefore become more definite, complete, consistent, and convenient to share, store and reuse knowledge.

3 The proposed system

Due to the existing problems with clinical pathways in medicine, this study aims to present an ontology-based platform system to construct and enhance the knowledge of clinical pathways. The architecture of this study is shown in Fig. 3.

1. In order to build the knowledge of clinical pathways, an ontological method was employed to

propose a procedure for knowledge construction by using knowledge schema, knowledge rules, and knowledge instances.

(1) With regard to knowledge schema, this study employed domain ontology to utilize the description properties of the storage media (Protégé). It took a top-down approach to assist the knowledge constructor in defining the knowledge schema of clinical pathways according to class, slot, facet, instance, and the function of multiple inheritance, as shown in the upper left of Fig. 3.

(2) With regard to knowledge rules, this study employed task ontology to develop an inference mechanism for classes, slots, and facets, and to inherit the relationships of clinical pathway domain ontology in order to assist the knowledge constructor in defining the knowledge rules, as shown in the upper right of Fig. 3.

(3) With regard to knowledge instances, the constructor was able to create knowledge instances in order of class, slot and facet by using the constructed knowledge schema to complete the domain knowledge by the defined knowledge rules. The procedure of knowledge construction using knowledge schema, knowledge rules, and knowledge instances will make the constructed domain knowledge of clinical pathways fit in with the real world in effectively.

2. In terms of the usefulness of clinical pathways, the calculation rationales of relative frequency and variance were utilized to identify the difference between historical cases and clinical pathways to retain its universal effectiveness.

(1) To obtain cost-effective care, this work intended to monitor the cost variance in case histories by using a variance algorithm to obtain the outlier of case studies. Standard deviation was used to trace common inconsistent treatments between the outlier and the clinical pathway, as shown in lower left of Fig. 3.

(2) To obtain quality healthcare, this work attempted to determine the relative frequency of treatments in case histories by using a quartile algorithm to obtain the discrepancies in treatment between case histories and clinical pathways. They were compared to identify common treatments that are not covered in clinical pathways as well as rarer treatments that are covered in clinical pathways, as shown in the lower right of Fig. 3. The following sections will explain the proposed systems in detail.

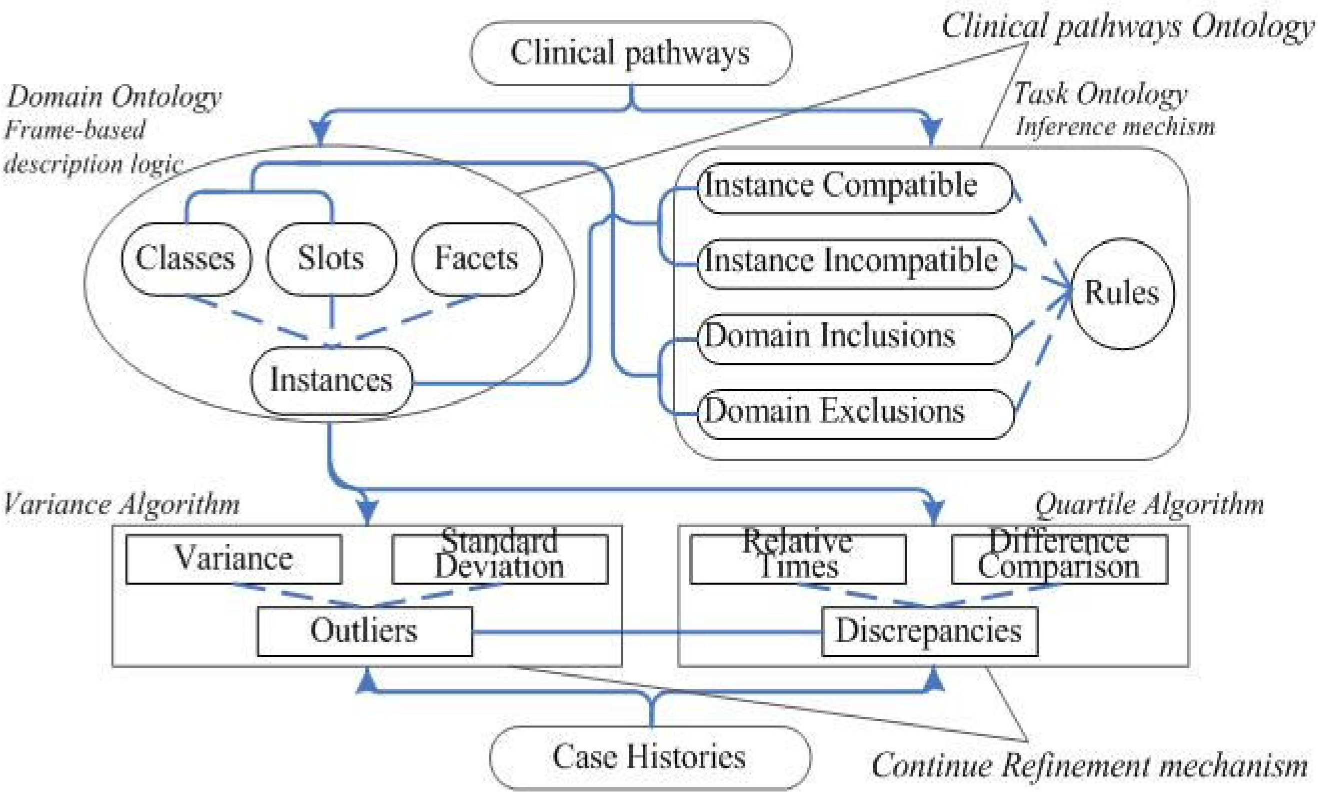


Fig. 3 Architecture of an Ontology-based Flexible Clinical Pathway System

3.1 Knowledge schema-method of domain ontology

The first step of knowledge construction is to define the knowledge schema of a clinical pathway. Using domain ontology, knowledge can be represented by a complex tree architecture according to class, slot, facet, and relationship as mentioned in section 2.2.1. In this study, domain ontology was employed to facilitate the knowledge constructor in displaying the clinical pathway. Meanwhile, this work adopted a top-down approach to knowledge analysis for intuitive operations. For clarity, the flow chart of knowledge schema construction is shown as Fig. 4.

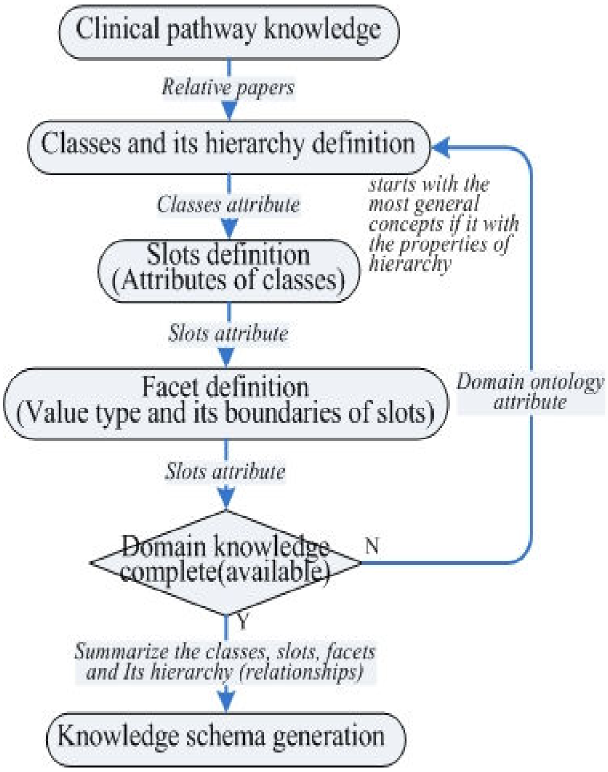


Fig. 4 Flow chart of knowledge schema generation

3.2 Knowledge rule-method of task ontology

The second step of knowledge construction is to define the knowledge rules of the clinical pathway. As mentioned in section 2.2.2, task ontology was employed to model the problem-solving knowledge into generic tasks in order to complete the domain knowledge of the clinical pathway.

In this study, four basic principles were designed to infer the correctness and completeness of the clinical pathway. These principles are described by the following rules.

(1) Instance compatible rules: one instance requires coexistence with another instance.

(2) Instance incompatible rules: one instance cannot occur with another instance at the same time.

(3) Identify domain inclusions: these slots are inclusions that should exist in a specific class.

(4) Identify domain exclusions: these slots are exclusions that should not exist in a specific class.

The flow chart for the generation of knowledge rules is shown in Fig. 5. Table 1 presents some simple cases of knowledge rules in the clinical pathway domain.

In Table 1, compatible and incompatible rules allow the inference of an instances correctness or collision according to instance assignment. Domain inclusion and exclusion rules allow domain completeness and limitation inferences according to the slot and class assignment of domain ontology. An example of a correct inference regarding VOREN and Mgo is shown in the first line of Table 1. According to this rule, the constructor should create an Mgo instance to retain the correctness of the clinical pathway domain ontology for a hernia operation if there is VOREN is already present or vice versa.

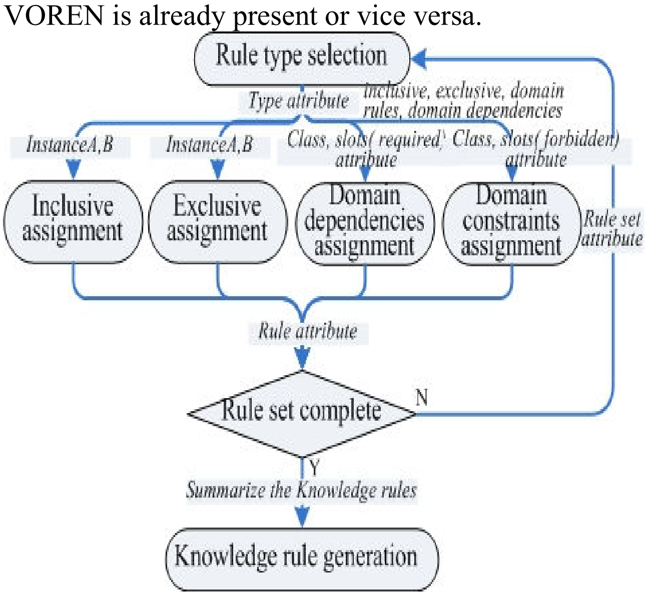


Fig. 5 Flow chart of knowledge rule generation

3.3 Knowledge instance-domain knowledge construction

The final step of knowledge construction is to fill the knowledge instances of a clinical pathway. Knowledge instances are the actual objects, and they are the lowest level concepts of domain knowledge, such as VOREN, Mgo, and Cough_mixture, as shown in Fig. 2. The constructor describes the knowledge instances by class, slot, and facet of knowledge schema, and then infers its completeness and collision using the knowledge rules. An example of constructed domain knowledge is shown in Fig. 6.

Table 1 Simple cases of knowledge rules in clinical pathway of Hernia operation

Type	The units of rules	Disease(s)
Compatible	Instance (VOREN), Instance (Cough_mixture)	Hernia operation
Incompatible	Instance (Cough_mixture), Instance (Lederscon)	Hernia operation
Domain Inclusions	Slot (Dosage_unit), Slot (Dosage_value), Slot (Frequency), Slot (Form_of_drugs), Class (Ext_physic)	Hernia operation
Domain Exclusions	Slot (Frequency), Slot (Form_of_drugs), Class (Examine)	Hernia operation

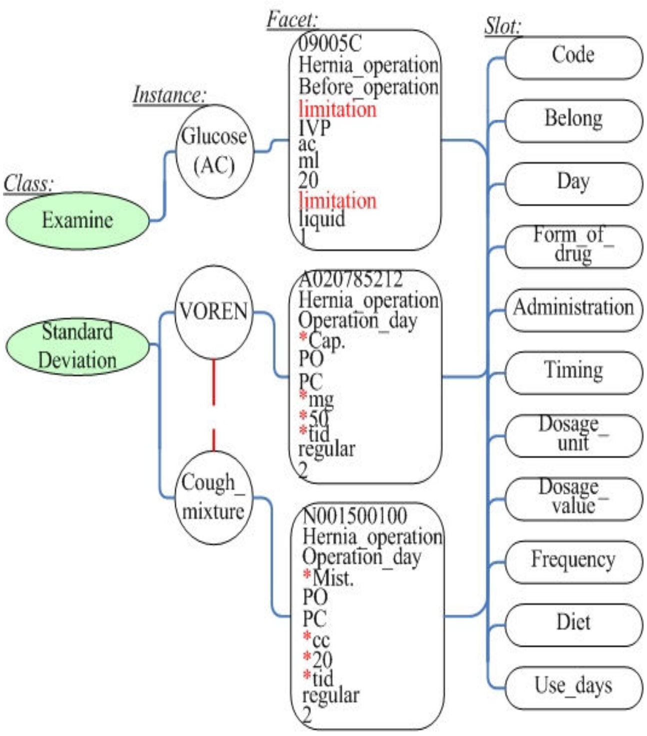


Fig. 6 Example of constructed domain knowledge

There are three instances within the example shown in Figure 6. The knowledge schema is defined as 2 classes and 11 slots, and the knowledge rule is defined by 4 principles, as shown in Table 1. In Fig. 6, the Glucose (AC) instance belongs to the Examine class, and it is composed of 9 slot descriptions. In the same figure, VOREN and Cough_mixture instance belong to the Ext_physic class, and have 11 slot descriptions. Furthermore, VOREN should coexist with the Cough_mixture instance so that it is in accordance with the compatibility rule in Table 1. The slots labeled Form_of_drug, Dosage_unit, Dosage_value, and Frequency in the Ext_physic class describe the value to obey the domain inclusion rule. The slots labeled Form_of_drug and Frequency in the Examine class have to be excluded to obey the domain exclusion rule.

In Figure 6, the compatible rules are identified by a red line, the domain inclusions are noted by an asterisk (*), and the domain exclusions have the word limitation written in red.

3.4 Cost-effective care-calculation rationale of variance

With hopes for the continued refinement of clinical pathways, this work developed a variance algorithm to identify the outlier cases by cost in order to trace any inconsistent treatments between clinical pathway and case history.

In the variance algorithm used by this study, the inputs are the costs of long-term case history and the clinical pathway, the calculation rationales are deviation and variance, and the deviation is defined as 1 in order to trace any outlier cases using real situations.

This study takes account of whether the amount of the clinical pathway is bounded by a +1 and –1 deviation range of case histories, in order to judge the effect of the clinical pathway. Meanwhile, the treatments used in outlier cases were identified and integrated into the outcome of the quartile calculation mentioned in section 3.5 to generate suggestions for the revision of the clinical pathway. If the costs of the case history are close to the clinical pathway, the mean is close to clinical pathway and the deviation is small. This means that the treatments of the clinical pathway are designed well, and that the treatments used in the case were similar to those in the clinical pathway. Basically, the treatment is adhering to the clinical pathway.

The flow chart of the cost-effective care calculation is shown in Fig. 7.

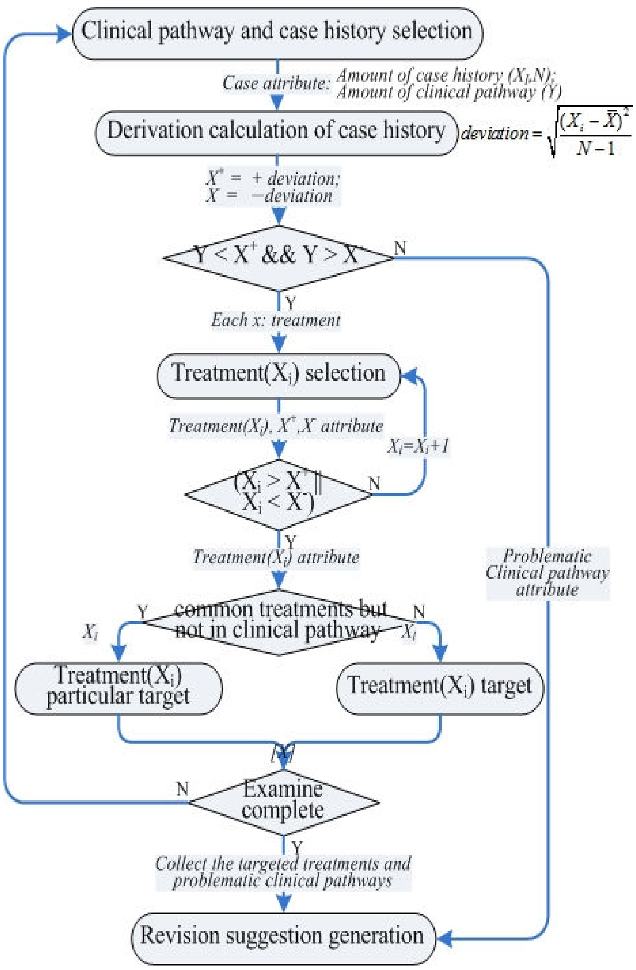


Fig. 7 Flow chart of the cost-effective care calculation

3.5 Quality health care-calculation rationale of quartile

For further refinement of clinical pathways, this work attempted to retain quality health care by using treatments consistent with the clinical pathway in order to determine any discrepancies between case history and the clinical pathway. The quartile calculation was employed to determine the relative frequency of treatments in the case history, and then contrast them with the treatments suggested by the clinical pathway. After add preprocess of each treatment by times, it is able to be sorted in ascending order. Next, the Q1 and Q3 times were extracted using the quartile calculation in order to generate the common and rare treatments of the case history. Finally, the generations were contrasted with the treatments used in the clinical path to obtain the treatments that were common, but not in clinical pathway, and those that were rare, but in it.

In general, the discrepancies between the treatments in the case history and the clinical path are able to reflect the effect of the clinical pathway. In a standard situation, the treatments will be effective if the clinical pathway is effective. The flow chart of the cost-effective care calculation is shown in Fig. 8.

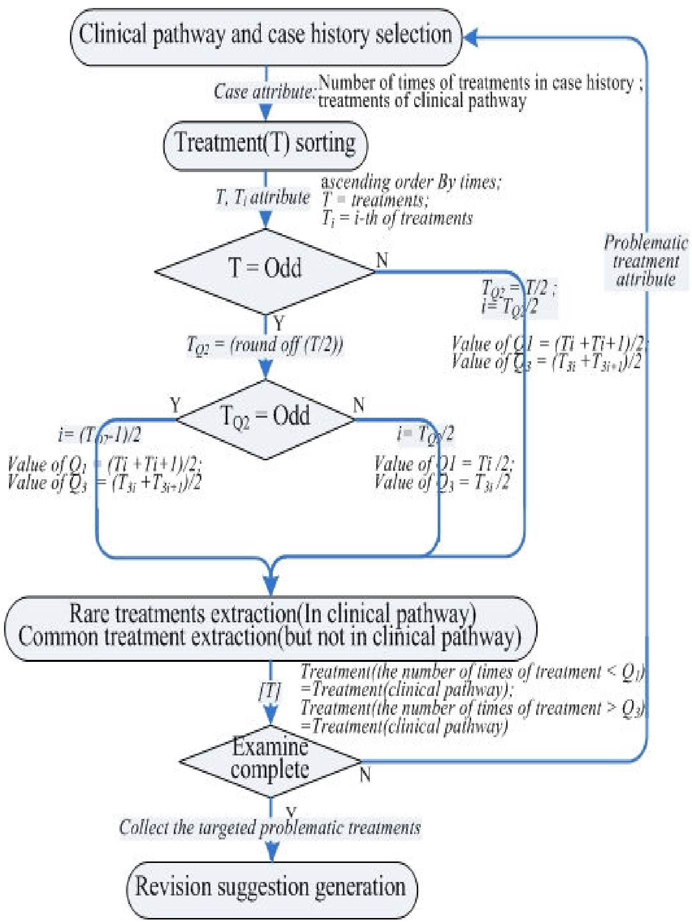


Fig. 8 Flow chart of the cost-effective care calculation

4 Implementation and exemplary case results

Using the proposed method, a system structure for a flexible clinical pathway is presented. A clinical pathway was conducted to verify the usefulness of the system in a real setting.

4.1 Implementation

An ontology-based flexible clinical pathway was developed using Java, JSP, JavaScript, Java Applet, Flash, and Jfreechart, and the data was stored using Protégé 3.2 knowledge database on a Windows system. Fig. 9 shows the system structure of the proposed system. This system interacts with users through a web-based, front-end interface. Within the system, there are four modules: knowledge schema, knowledge instance, knowledge rule, and application. Knowledge creation of the clinical pathway is a function of the knowledge schema and knowledge instance modules. Knowledge verification of the clinical pathway is a function of the knowledge rule module, and Cost-effective care and Qualify health care are functions of the application module. Meanwhile, visualization is also a function of the application module that presents the concrete clinical pathway. The knowledge schema and knowledge instance modules interact with the knowledge rule module through the inference engine to form the knowledge of the clinical pathway. The application module interacts with the knowledge instance module to enhance the usefulness of the clinical pathway. In summary, the system delivers a flexible shell and the applicable functions for a user to input their domain knowledge of the clinical pathway.

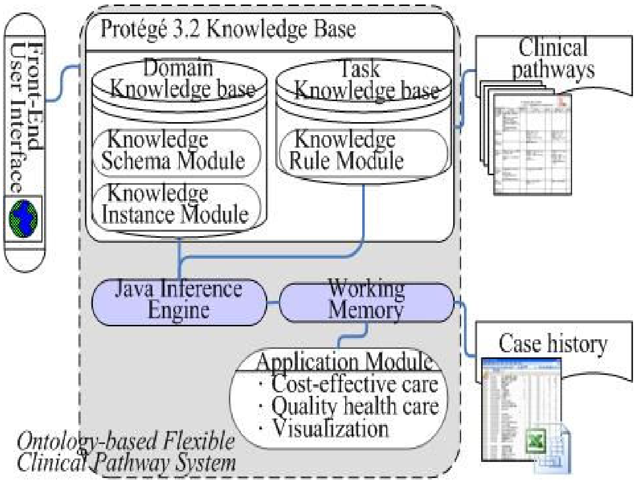


Fig. 9 Ontology-based flexible clinical pathway system structure

4.2 Exemplary case results

The case of a hernia operation clinical pathway, obtained from a well-known city hospital in Taiwan, was used to demonstrate the function and capacity of the ontology-based flexible clinical pathway system.

In this system, the first step of the clinical pathway was to build a schema. According to the requirements for data description, the constructor defined a common schema by its class, slot, and inheritance. In this example, the constructor created 10 classes, 12 slots, and facets for a common schema in the hernia operation clinical pathway, as shown in Figs. 10a, 10b, and 10c. In this case, the slots were defined for all of the classes by the constructor and were constrained by the knowledge rules in order to avoid an illegal description. Next, the constructor defined the knowledge rules of the clinical pathway to model the problem-solving knowledge into generic tasks to complete the hernia operation clinical pathway. The constructor defined three compatible rules for a correct hernia operation, as shown in Fig. 10d: VOREN and Mgo, Mgo and Cough_mixture, and Glucose (AC) and Mgo. In addition, the constructor defined a domain inclusion rule for a complete hernia operation, as shown in Fig. 10e: Ext_physic should include slots for dosage_unit, dosgage_value, form_of_drug, and frequency. At this point, only domain inclusion and domain exclusion rules are able to be defined prior to knowledge instances. The constructor then created the knowledge instances for the hernia operation clinical pathway in order of class, slot, and facet using the constructed knowledge schema and knowledge rules, as shown in Fig. 10f. The knowledge rule is located in the lower left of the figure, and the map of the hernia operation is present in the right of the same figure.

Additionally, an eight-month case history for a hernia operation was entered into the applications of cost-effective care and quality health care.

Cost-effective care was displayed using a graph, as shown in Fig. 10g. The boundaries of the exemplary case were Mean (15505) add/sub 1 deviation (2907), and they are represented by yellow and purple lines. The points that go beyond these boundaries are treated as problematic cases by this system, as shown in the lower right of Fig. 10g. The effect determinant of the clinical pathway is the difference between the cost of the clinical pathway and the mean of the case history. In this case, the hernia operation clinical path is an effective one; however, there are a number of points that exceed the limits, so this problem needs to be addressed in the future.

In medicine, a clinical pathway is a treatment guideline, not a strict regulation. Therefore, doctors are able to adjust their approach for different patient situations. A few variations in cost caused by alternate treatments is a reasonable and acceptable variation in practice.

Regarding quality health care, = a frequency rationale was employed to determine the discrepancies between the clinical pathway and the case history in order to generate a list of those treatments that are common, but not in the clinical pathway, and those treatments that are rare, but in the clinical pathway, as shown in Fig. 10h. In this case, there were a number of common treatments that were not in the clinical pathway. Some of these treatments came from the inconsistencies between the terms of the clinical pathway and the case history, and this must be addressed in the future. Additionally, a visualization function was developed to display the knowledge of the clinical pathway, as shown in Fig. 10i. This function is able to reorganize the domain ontology of the clinical pathway into printable format to facilitate the user's understanding.

This system delivers a flexible platform for users to construct, store, share, reuse, and analyze their clinical pathways, as shown in Figs. 10a-10i. At present, there are 36 clinical pathways and 2 one-year case histories that have been constructed using this system.

5 Implications, contributions and limitations

The knowledge storage and sharing of clinical pathways are an important issue in modern medicine. In this study, the knowledge of a clinical pathway that uses a flexible shell to integrate the abilities of domain specialists, system engineers, and knowledge creators was constructed.

One feature of this study is the separation of domain and operation knowledge. Tasks of knowledge creation and revision traditionally require cooperation from domain specialists and system engineers. In this study, the author utilized the idea of ontology to decompose this task into knowledge schemata, knowledge rules, knowledge instances, and a flexible platform that could be operated individually. Knowledge specialists could revise the knowledge schema without the assistance of a system engineer, and knowledge creators can create a knowledge instance by simply following the knowledge schema. Separation of the knowledge schema and knowledge instances also facilitates knowledge revision when there are numerous knowledge instances.

Another feature of this study is a flexible shell that can be used for future applications. Most application domains can be described in the flexible shell of this study, and without any modifications. The integrated approach of domain and task ontology is capable of knowledge inference and knowledge description for further applications.

However, there are also recognizable limitations in the proposed method. The proposed approach relied on the fact that the domain ontology of a clinical pathway is available. This work acknowledges that some important limitations of the proposed method, such as the concepts of class, slot, facet, and knowledge rules may become a problem for the knowledge constructor. The functions of cost-effective care and quality health care are developed according to the demands of each situation and the effects remain to be proven.

These constraints will diminish the efficiency of the proposed method. However, the proposed approach is still significant since there are no effective clinical pathway systems that can be used as an alternative.

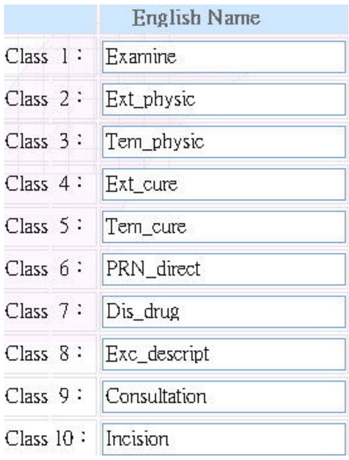
6 Conclusion and future works

This paper studied the feasibility of integrating an ontology-based approach that uses variance and quartile algorithms to construct a clinical pathway system.

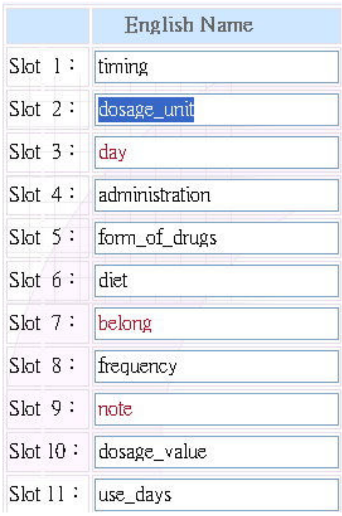
This work combined domain ontology and task ontology to develop a flexible shell for constructing clinical pathways. The static knowledge of a clinical pathway is defined using domain ontology according to the schema of class, slot, and facet. The active knowledge is defined for task ontology according to 4 fundamental principles. Cooperation between domain and task ontology forms a flexible shell of for dealing with clinical pathways.

Moreover, this work developed variance and quartile algorithms to enhance the efficiency of the clinical pathway. The efficiency of a clinical pathway is evaluated by the total variance in cost and the utility rate of treatments. These concepts are demonstrated by the empirical results from the example case conducted in this study.

In future studies, the function of natural language queries should be developed to extend the system's usability. A query function could be developed with the supports of relative documents. Additionally, the system should be demonstrated on more case histories to verify the effect of the cost-effective care and quality health care functions as well as integrating the system with treatment and clinical pathway systems in hospitals.


English Name
Class 1 : Examine
Class 2 : Ext_physic
Class 3 : Tem_physic
Class 4 : Ext_cure
Class 5 : Tem_cure
Class 6 : PRN_direct
Class 7 : Dis_drug
Class 8 : Exc_descript
Class 9 : Consultation
Class 10 : Incision

(a)


English Name
Slot 1 : timing
Slot 2 : dosage_unit
Slot 3 : day
Slot 4 : administration
Slot 5 : form_of_drugs
Slot 6 : diet
Slot 7 : belong
Slot 8 : frequency
Slot 9 : note
Slot 10 : dosage_value
Slot 11 : use_days

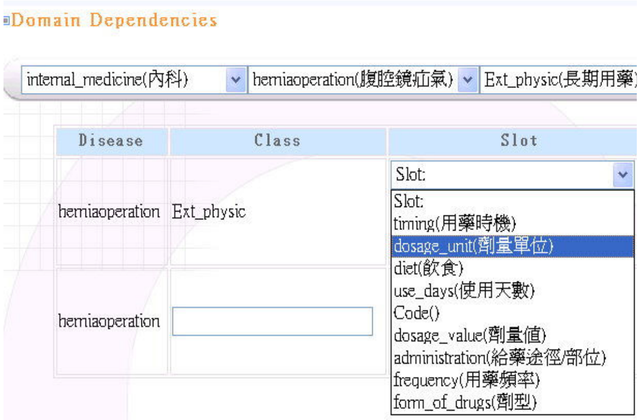
(b)


English Name : dosage_unit
Chinese Name : 劑量單位
Cardinality : Single Required Multiple
Type : String Integer Symbol
English Name Chinese Name
Facet 1 : amp 安瓿
Facet 2 : gm. 公克(質量)
Facet 3 : gal. 加侖
Facet 4 : ml 毫升
Facet 5 : mg 毫克
Facet 6 : cc 毫升
Facet 7 : g 公克

(c)


Inclusive Constraint
internal_medicine(內科)
herniaoperation(腹腔鏡疝氣)
Disease Item1 Item2
herniaoperation VOREN
Iv_dc
Mgo
Wound_CD
herniaoperation Mgo Cough_mixture
herniaoperation Glucose(AC) Mgo

(d)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herniaoperation(腹腔鏡疝氣)
Ext_physic(長期用藥)
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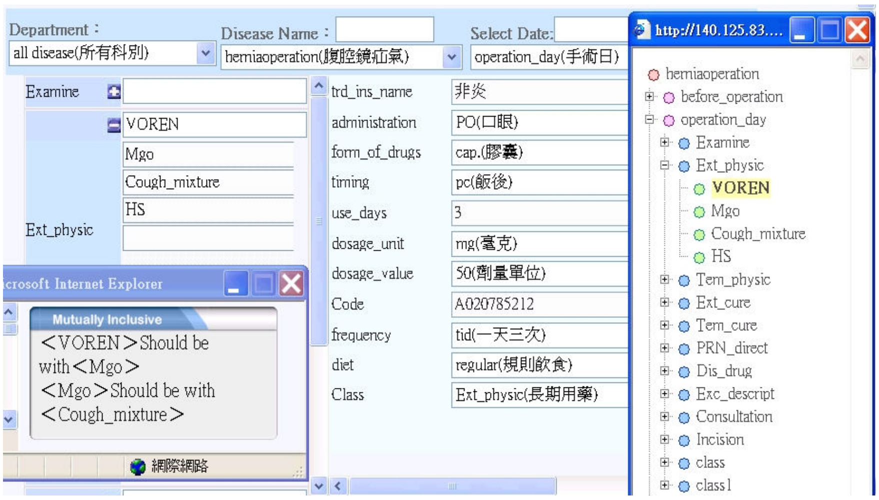
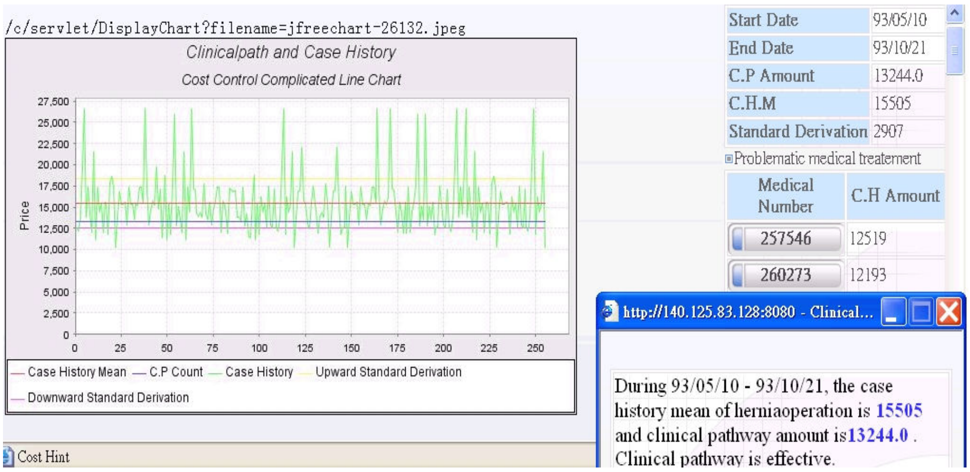
Slot:
timing(用藥時機)
dosage_unit(劑量單位)
diet(飲食)
use_days(使用天數)
Code()
dosage_value(劑量值)
administration(給藥途徑/部位)
frequency(用藥頻率)
form_of_drugs(劑型)
herniaoperation

(e)

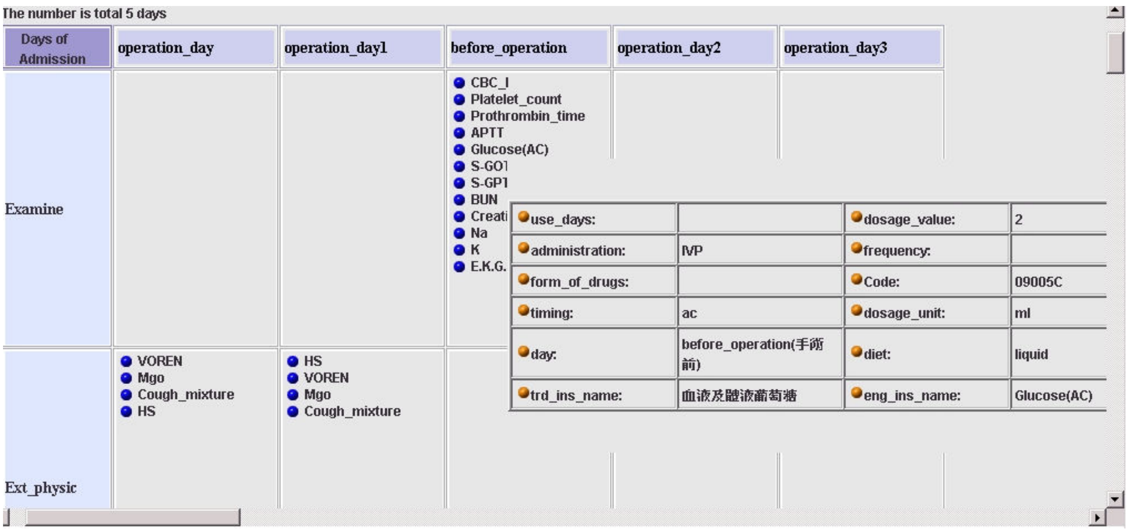

Department :
all disease(所有科別)
Disease Name :
herniaoperation(腹腔鏡疝氣)
Select Date:
operation_day(手術日)
Examine
VOREN
Mgo
Cough_mixture
HS
Ext_physic
trd_ins_name 非炎
administration PO(口服)
form_of_drugs cap.(膠囊)
timing pc(飯後)
use_days 3
dosage_unit mg(毫克)
dosage_value 50(劑量單位)
Code A020785212
frequency tid(一天三次)
diet regular(規則飲食)
Class Ext_physic(長期用藥)
Mutually Inclusive
<VOREN>Should be with<Mgo>
<Mgo>Should be with <Cough_mixture>
網際網路
herniaoperation
before_operation
operation_day
Examine
Ext_physic
VOREN
Mgo
Cough_mixture
HS
Tem_physic
Ext_cure
Tem_cure
PRN_direct
Dis_drug
Exc_descript
Consultation
Incision
class
class1

(f)



(g)

(h)



(i)

Fig. 10 Sample from 9 pages of the proposed system

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