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A Physician's Decision-making Oriented Model of Cancer Chemotherapy toward Computer-assisted Chemotherapy Planning and Alerting System

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Abstract

Objective: *For the development of computer-assisted chemotherapy planning system, we present a chemotherapy planning model emphasizing on decision-making process and associated heuristic knowledge.* ***Methods:*** *We analyzed the information structure of chemotherapy regimens based on the requirements that we set. i) Creating a chemotherapy planning model emphasizing on physician's decision-making process. ii) Building up expressions to reason about particular knowledge associated with each decision-making process.* ***Results:*** *We developed a model consisting of three kinds of sub-models: an entity model of chemotherapy regimen, a process model of chemotherapy work-flow, and a model of expression language to represent decision criteria. For experiment and evaluation of the model, we implemented a prototype system.* ***Conclusions:*** *We developed a model for chemotherapy planning, which emphasize on physician's decision-making. Through the implementation of the prototype system, our model seems promising because it seems to reflect the knowledge of chemotherapy correctly.*

Keywords:

knowledge representation, decision support system, chemotherapy

Methods

We analyzed the information structure of chemotherapy regimens [1] and divided it according to the role. Also, we clarified typical scenes of decision-making in chemotherapy work-flow through discussing with physicians. To document our results of requirement analysis, we applied the Unified Modeling Language [2]. For experiment and evaluation, we developed a prototype system of computer-assisted chemotherapy planning and alerting system based on the proposed model.

Results

Classification of chemotherapy knowledge

We classified the knowledge of chemotherapy into three categories. 1) Entities of chemotherapy. 2) Process of chemotherapy work-flow. 3) Heuristic knowledge for a physician to intervene in a chemotherapy schedule. Then, we developed sub models for each category: an entity model of chemotherapy, a process model of chemotherapy work-flow, and a model of expression language to represent decision criteria.

Entity model of chemotherapy

Figure 1 shows an entity model of chemotherapy. *Therapy cycle* class consists of *Chemotherapy drug* class that has a standard dosage, a dosage rate, a maximum dosage, and an administration specification as attributes. An administration schedule is conducted by the *Date allocation* class and the administration specification.

Recommendations, which consist of combination of a specific patient status and a therapy action, are important for decision-making of a physician. *Pretreatment evaluation* is carried out at the time of beginning of chemotherapy, therapy cycle, and daily administration. When a patient status doesn't meet each criterion, discontinuance of chemotherapy or therapy cycle is recommended. *Dosage modification* represents a recommendation of modification of a drug dosage according to a patient status.

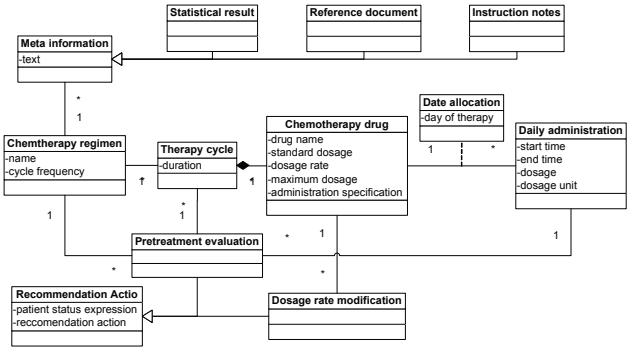


Figure 1 - The entity model of chemotherapy regimen

Process model of chemotherapy work-flow

Whole chemotherapy work-flow consists of repetition of a therapy cycle, and a therapy cycle consists of repetition of a daily administration. There are four kinds of decision-making process in those repetitions, *Pretreatment evaluation of chemotherapy, Pretreatment evaluation of therapy*

cycle, Pretreatment evaluation of daily administration, and *Dosage modification of chemotherapy drug.* Figure 2 shows a perspective of a work-flow of chemotherapy.

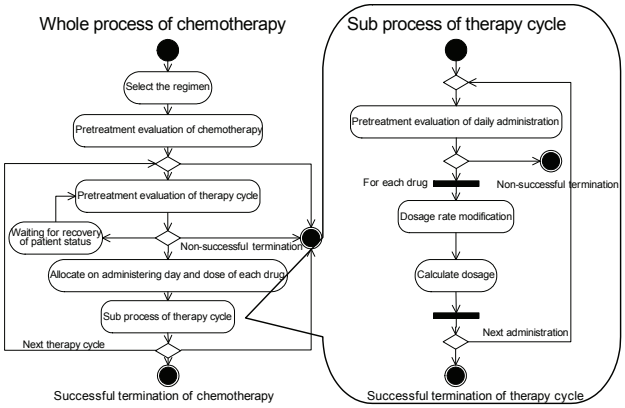
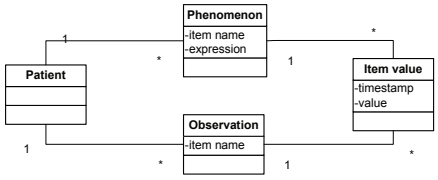


Figure 2- Perspective of a work-flow of chemotherapy

Model of expression language to represent decision criteria

To construct decision criteria by building up expressions to reason about a particular status of a patient, we defined a data model of a patient and a model of rule expression language including decision criteria (Figure 3). Here, decisions about patient status often depend on the past data as well as on the current data. Therefore, the effective time of the data has to be specified as *Time Context* in our model.



(1) Observation("creatinine") .greaterThan(2.0, "mg")

(2) Phenomenon : NCI-CTC Leukocytes grade:
IF Observation ("leukocyte").greaterThan(4000, "ul")
THEN Phenomenon("Leukocytes grade").setItemValue(0)
IF Observation ("leukocyte").lessOrEqual (4000, "ul")
AND Observation ("leukocyte").greaterThan(3000, "ul")
THEN Phenomenon("Leukocytes grade").setItemValue(1)
...

(3) Dose Modification of Doxorubicin: Time context: 14days
IF Phenomenon("Leukocytes grade").greaterThan(3)
THEN Decrease Doxorubicin to 50% dose

Figure 3 - Data model of patient and examples of heuristic rule expression. (1) "Serum creatinine is greater than 2.0mg" (2) Definition of Phenomenon "NCI-CTC Leukocytes grade" decision criteria. (3) Decision criteria of dosage modification of doxorubicin

Implementation of a prototype system

For the experiment of the proposed models, we developed a prototype system for chemotherapy planning and alerting. The entity model and the rule expression language were combined into structured chemotherapy regimen and became knowledge base of the prototype system. An overview of the system architecture is shown in Figure 4. There are two functions in the system. 1) Providing decision support for a physician to create an administration schedule. In each decision-making process such as pretreatment evaluation and dosage modification, system evaluates a decision criterion according to a patient status. 2) Providing real-time notification for the physician. When the dosage should be modified according to additional patient data, the system sends a recommendation message to the physician.

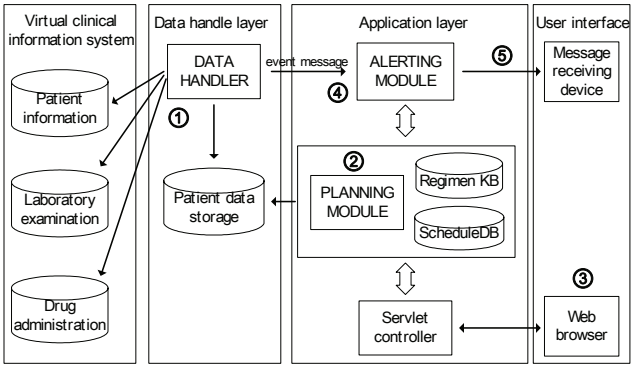


Figure 4 - 1) Different kinds of patient data are collected and unified into data storage. 2) PLANNING MODULE provides an administration schedule while evaluating recommendation criteria. 3) A physician can operate planning module to create an administration schedule. 4) ALERTING MODULE is evoked by DATA HANDLER and evaluates a drug dosage, cooperating with planning module. 5) When the drug dosage should be modified, alerting module sends a recommendation massage to the physician

Conclusion

We presented a model for chemotherapy planning consisting of three kinds of sub-models: the entity model of chemotherapy regimen, the process model of chemotherapy work-flow, and the model of expression language to represent decision criteria. Using this model, we implemented a prototype system for supporting chemotherapy planning and alerting. Our model seems promising because it seems to reflect the knowledge of chemotherapy correctly.

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