Tool for Knowledge Acquisition and Knowledge Visualization

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Abstract

Concept maps are useful tools for representing general knowledge in order to organize and communicate information but they are difficult and tedious to build by hand. In this paper, we describe a system to help automate the knowledge acquisition process by using user-initiated automatic concept map generation. Our system can also display any part of the concept map already developed to help the user visualize any part of the knowledge base.

1. Introduction

Concept maps have many applications in ethnography, in curriculum development, and in educational tools. One remarkable advantage of using concept maps is that they provide a visual image of the concepts under study in a tangible form (Shneiderman 1985). They allow us to identify a particular focus or to shift perspective easily. During the process of formulating a knowledge base the concept map consolidates a concrete and precise understanding of the meaning and interrelations of concepts (Gaines and Shaw 1996). Thus it makes learning an active process, not a passive one. Concept maps can also provide valuable learning experiences (de Vries and Kommers 1993). Active learning is not something that is done for students, it something that students do for themselves (Rovick and Michael 1986). Concept maps can prepare students to become active learners and help them to become good problem solvers (Chappel and Wilson 1993).

Our major experience with concept maps is in an intelligent tutoring system called CIRCSIM-Tutor that is designed to tutor first year medical students about the effects of perturbations to the cardiovascular (CV) system, particularly on the negative feedback mechanism that responds to these perturbations and stabilizes blood pressure (Kim et al. 1989). The CV system consists of many mutually interacting components, and the student must understand various system relationships. But it is not easy for first year medical students to understand relationships between individual components of the system. So we adopted a concept map to provide students with a better environment for understanding. For CIRCSIM-Tutor we painfully constructed a knowledge base by hand (Khuwaja et al. 1992). In order to move this tutor to other domains we need to build knowledge bases for those domains. This paper describes our system for knowledge acquisition and knowledge visualization.

2. Domain Knowledge Base

So that the reader can understand the complexity of this task we describe the domain knowledge base for CIRCSIM-Tutor here. CIRCSIM-Tutor has been designed as part of a course in physiology at Rush Medical College, so the emphasis is on causal relationships between physiological parameters. The cardiovascular system consists of many mutually interacting components, physiological and anatomical entities. In CIRCSIM-Tutor, there are three levels of knowledge bases -- top level, intermediate level, and deep level -- to represent the relationships between the physiological parameters of the baroreceptor reflex (Khuwaja et al. 1992). The top level of the knowledge base, Figure 1, corresponds to a concept map containing the baroreceptor reflex / central nervous system and the seven most important parameters. This is the material we want the students to internalize.

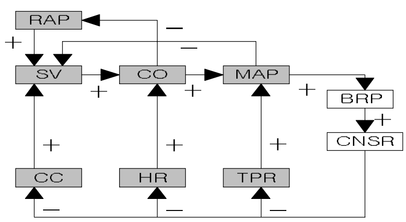

Figure 1. Concept Map for the Top Level of the Knowledge Base. (Plus signs indicate directly proportional relationships, minus signs indicate inversely proportional relationships.)

The intermediate level of the knowledge base, Figure 2, contains the same core parameters but some of the links are expanded for use in providing explanations and developing hints.

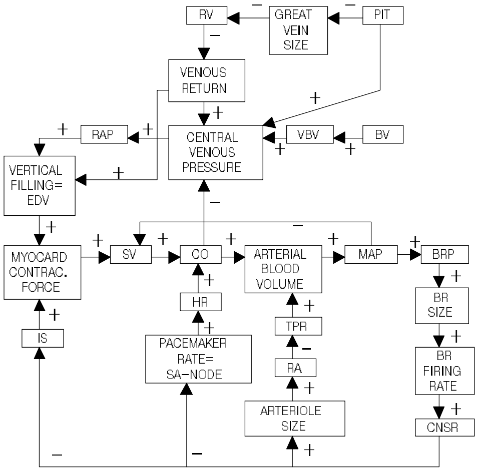

Figure 2. Concept Map for the Intermediate Level of the Knowledge Base

The deep level of the knowledge base, Figure 3, contains more detailed information about CV physiology. This is needed to understand some student questions.

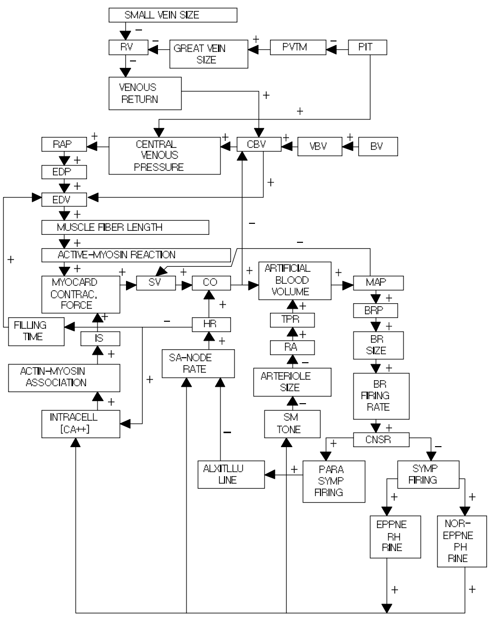

Figure 3. Concept Map for the Deep Level of the Knowledge Base

Figure 4 shows the knowledge base for anatomical relationships between various components of the CV system as organized to teach physiology.

3. Knowledge Acquisition Tool

We want to retarget our tutor to a new domain, to build a GASP-Tutor for the pulmonary system. The first step is to build a knowledge base for this new domain. With this tool, we are trying to discover the expert's knowledge of the domain. The knowledge acquisition tool operates as follows: When tool is first activated, the system's main menu appears on the screen shown in Figure 5.

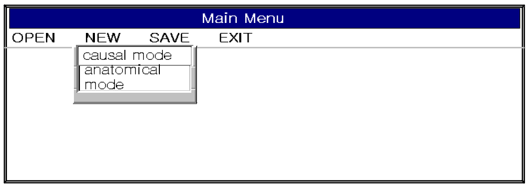

Figure 5. Tool Menu in Use Starting to Build the Concept Map for GASP-Tutor

From the Main Menu, the user can move to the window shown in Figure 6 that allows the user to create and edit the concepts and relationships.

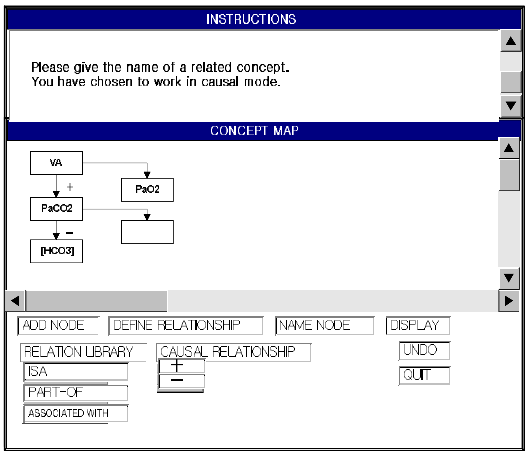

Figure 6. A Window for Creating Concepts

In Figure 6, the tool contains two windows: the INSTRUCTIONS window and the CONCEPT MAP window. A question will be given in the INSTRUCTIONS window and then the user responds with his/her answer in the CONCEPT MAP window. The knowledge base is built as follows:

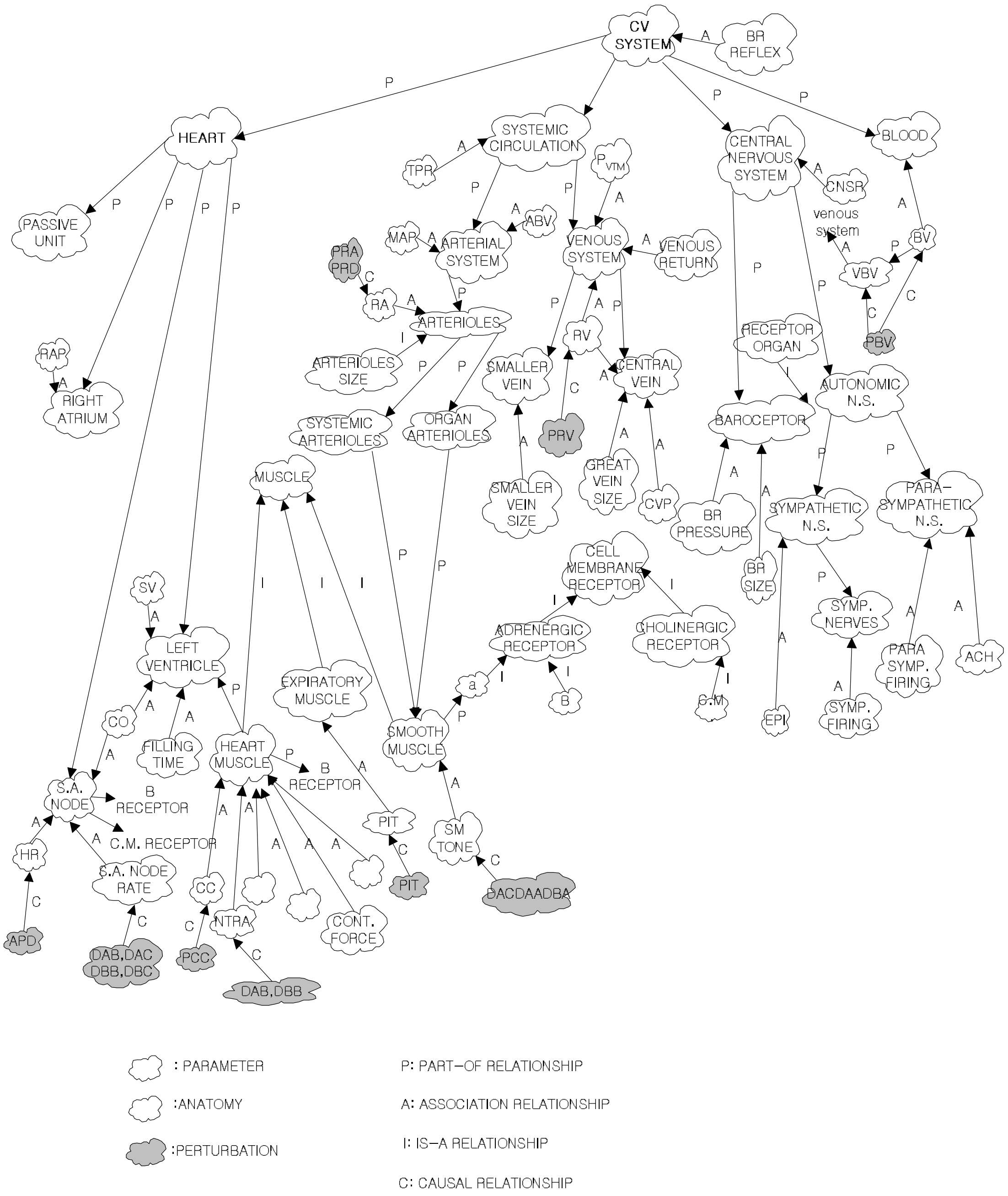

Figure 4. Anatomical Structure of the CV System

1) In the Causal Mode

- Present the user with a blank box in the INSTRUCTIONS window and ask the user to give the name of an important concept.

Figure 7. Giving the Name of a Concept

• Ask the user to name a related concept.

Figure 8. Giving the Name of a Related Concept

• Ask about whether these two concepts are directly related (i.e. Does one concept determine the other?). If so, then the user will be asked to define which one is determinant (**Art P O2**) and which the determined (**Art Hb Sat**) by clicking in the CONCEPT MAP window. Then the relationship will be shown in the CONCEPT MAP window.

Figure 9. Defining the Relationship

• When the system is in the causal mode, the user is asked whether this relationship is direct or inverse. Then the user clicks on the direct or inverse button for causal relationships in the CONCEPT MAP window.

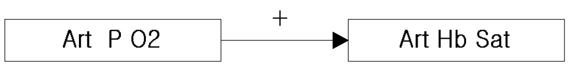

Figure 10. Defining the Type of a Causal Relationship

2) In the Anatomical Structure Mode

In addition to the causal relations described here the tool has several relation libraries containing the list of relations defined by (Casagrande and Hale 1967), (Markowitz, Nutter and Evens 1992), and (Mel'cuk and Zholkovsky 1988). For each relation we include whether it is reflexive, symmetric, transitive or one-to-one.

• The tool has a library of relations it knows as follows:

Relation Names	**Examples**	
- GASP-specific:		
isa	Aorta	Artery
associated with	Arterial Resistance	Artery
part-of / has-part	Arterial System	Artery
- General purpose:		

Relation Names	**Examples**	
● **Taxonomic Classification Relations**		
taxonomy	lion	animal
synonymy	speedy	fast
antonymy	hot	cold
complementarity	single	married
converseness	to buy	to sell
reciprocal kinship	husband	wife
● **Part - Whole Relations**		
head-organization	chief	tribe
count-mass	lump	sugar
set-element	flock	sheep
slice-pie	section	orange
● **Ordering Relations**		
Before	Advent	Christmas
after	Christmas	Advent
implies	lightning	thunder
next	Spring	Summer
between	mitral valve	(ventricle, atrium)
precede	Monday	Tuesday
follow	Tuesday	Monday
● **Provenience, Function, Exemplification Relations**		
comes from	milk	cow
is made from	cheese	milk
is for the use of	hammer	hit
is exemplified by	sour	lemon
is an example of	lemon	sour

• If the user defines an arc but does not label it, then the system will ask what kind of relationship exists between the two concepts. Then the user can click on the proper relation in the CONCEPT MAP window.

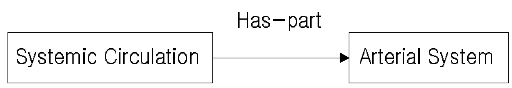

Figure 11. Labelling Relationships

Figure 12 displays an example of a concept map that shows relationships in anatomical structure.

• The tool will also allow the user to define new relations. When the user defines a new relation the system asks whether it is reflexive, symmetric, transitive or one-to-one. If it is not symmetric the system will ask for the name of an inverse.

The system keeps a list of isolated nodes and unlabeled arcs to present to the user for clarification. The user is given a choice at any point between choosing an existing label, creating new one, leaving the arc unlabelled, or deferring the decision.

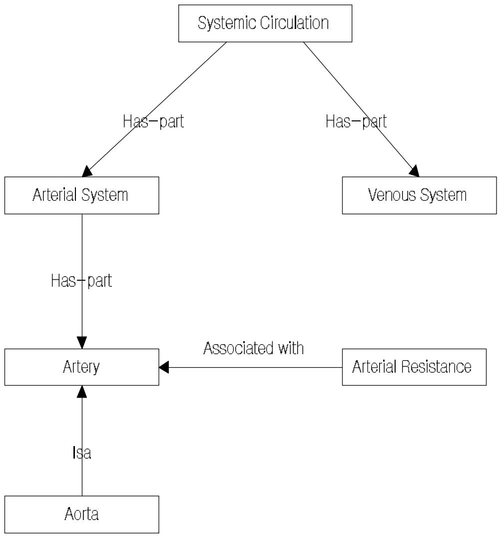

Figure 12. An Example of Concept Map with Relationships in Anatomical Structure

4. Visualization and Multiple Maps

Users can ask for a display of any part of the map already developed. They can move around by scrolling up and down or left and right or else they can type in a node name to get a display of the neighborhood of the node.

Users may switch back and forth from one map to another whenever they wish. We saw the need for this in creating our own knowledge bases because we want to switch back and forth between physiological and anatomical perspectives. So it is important for us to be able to switch contexts between the anatomical and physiological examples in Figures 1 – 4 because anatomical structure can help one understand the physiology.

5. Conclusion

In this paper, we introduced a knowledge acquisition tool based on concept map construction that can support intelligent tutoring systems. In the past, the expert's knowledge was acquired by repeated interviewing. And then the knowledge base was manually built based on the acquired knowledge. But this approach is very slow and tedious for both the expert and the knowledge engineer. So we developed a tool for automating the knowledge acquisition process. By using this tool, we can build the knowledge base more easily and also check for completeness.

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