

CADI — An Intelligent, Multimedia Tutor for Cardiac Auscultation

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Cardiac auscultation is the difficult skill of listening to the human heart and using the sounds heard as clues in diagnosis. The CADI (*Cardiac Auscultation Diagnosis Instruction*) system is designed to tutor medical students and residents in both phases of auscultation: hearing the sounds and diagnosing illness based on what is heard. The system's design draws on the case-based teaching architecture (Schank 1991), which in turn is built on goal-based scenarios and case-based reasoning (Hammond 1989).

Cardiac auscultation is challenging because it requires both special listening skills and extensive domain knowledge. Teachers and students have found that the best way to learn this skill is to listen to hundreds of hearts with an experienced listener. Unfortunately, faculty time for teaching in medical schools is scarce, and experienced auscultators are rare.

Auscultation begins with listening, but the goal is diagnosis. But one must understand the underlying structures and causes of heart sounds before listening can be used as an aid to diagnosis. Thus, much of CADI's development will be devoted to a hypermedia textbook.

Goal-based scenarios are a formalization of the criteria needed to create effective "learning by doing" environments, particularly through the use of computer simulation; the theory is particularly appropriate for CADI's design, since it is partly based on research in medical problem-based learning (Barrow & Tamblyn 1980). Both theories emphasize the importance of placing the learning task in an authentic context.

We have observed that students need two things to become effective auscultators: a library of prototypical sounds and related heart conditions, and some method for comparing a current patient's sounds to those in the library. (There is evidence that complex auditory recall uses a schema-based mechanism which is similar to case-based reasoning (Bregman 1990).) Case-based reasoning captures both these phenomena. By listening to the new patient(s), we hope the student will develop a heightened awareness he can now bring to the original patient. We are currently researching the errors students make and developing case-based strate-

gies to address each one.

By using a rich case representation, CADI will retrieve the most pedagogically appropriate cases for a particular student. In CADI, the retrieved case will not be the one most similar to the student's problematic case, but instead the most helpful from a teacher's view. In fact, the retrieved cases are likely to not be very similar in the traditional sense, but instead will differ in some key aspect.

Although case-based tutoring systems have been built before (Schank 1991), we are not aware of a case-based approach to tutoring a perceptual skill. By building a tutoring system to help students perceive better we hope to learn about the nature of perception. In addition, we claim that a successful case-based tutoring system is at least a partial validation of our assumption that auscultatory reasoning is case-based.

The key elements of the CADI environment are the extensive use of multimedia, realistic simulation of a plausible scenario and its case-based approach to teaching. Multimedia will offer students a better way to study the complex hemodynamic system. The realism of the environment will not only motivate students to learn, but also offer the necessary context to frame the learning task. When combined with its theoretical foundation, CADI provides a rich and effective environment for learning cardiac auscultation.

References

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