Intelligent Tutoring Systems Technologies for Military Training

Traditional computer-based training (CBT) systems test factual recall and narrow skills by prompting students to answer simple multiple-choice or fill-in-the-blank questions. By contrast, **scenario-based intelligent tutoring systems (ITSs)** let students assess situations, generate solutions, make decisions, and carry out actions in realistically complex situations. By enabling students to apply their knowledge and skills in a wide range of typical and exceptional situations, ITSs help students quickly acquire expertise that would ordinarily require years of experience.

Stottler Henke is a leader in the development of scenario-based intelligent tutoring systems. These systems augment free-play simulators (e.g., of battlefields, weapon systems, devices, software applications) with automated student performance assessment and instructional feedback. At the beginning of each scenario, these systems present briefings that describe the student's situation and goals. During each scenario, these systems can provide hints and coaching, where appropriate. At the end of each scenario, the systems evaluate the student's actions carried out within the simulator to assess the student's knowledge and skills, generate appropriate critiques, and identify relevant background information (remediation) that should be reviewed by the student.

Stottler Henke's ITS technologies include:

- **authoring tools and run-time systems** for specifying task knowledge, performance assessment algorithms, and adaptive instructional strategies rapidly and intuitively, and
- **innovative, computer-based pedagogical approaches** such as meta-cognitive learning, Socratic tutoring, fine-grained hierarchical skills decomposition, and probabilistic skills assessment.

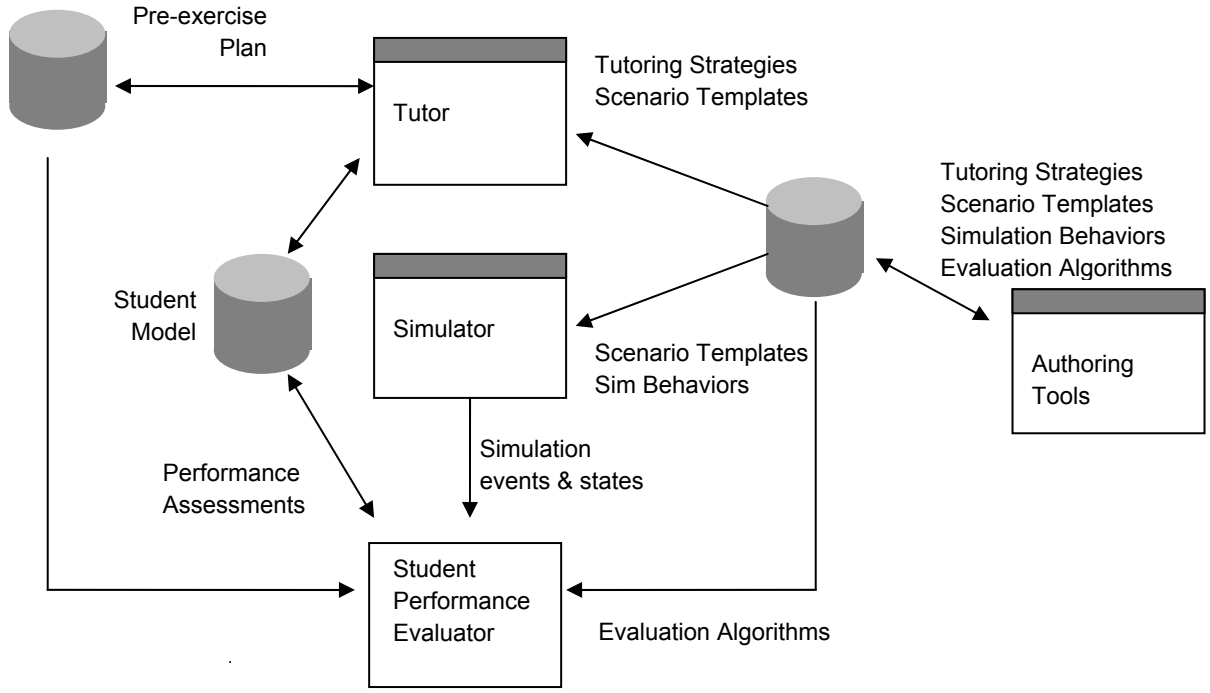

Figure 1 – Authoring Tools capture knowledge used by the Tutor, Simulator, and Student Performance Evaluator to present simulated scenarios, assess performance, and provide instructional feedback to students.

SimBionic: Intelligent Automation of Computer-Generated Forces

Intelligent simulations let you automate (or semi-automate) friendly, neutral, and opposing forces, so you can run realistic training scenarios without the cost and complexity of having human operators control those positions manually. Traditional development methods require programmers to code these automated behaviors within software, so it is difficult for tactical subject matter experts to specify these behaviors directly. Instead, experts must describe the desired behaviors to programmers who then translate these descriptions into software. This multistep approach is cumbersome, time-consuming, and error-prone.

SimBionic® software lets you define intelligent behavior for free-play training simulations quickly and easily, without programming, using a visual user interface. These behaviors specify how computer-generated forces and other entities respond to user actions and other simulated events. The SimBionic authoring tool lets you specify *smarter* behaviors that would be too costly or difficult to develop using traditional programming methods, to create systems that are more realistic, challenging, and engaging.

SimBionic behaviors are implemented as augmented finite state machines comprised of states and transitions. SimBionic extends the usual notion of finite state machines by making it possible for states to refer to other finite state machines hierarchically, to define modular behaviors that can be combined powerfully. SimBionic software also provides four extensions that increase the power and expressiveness of the basic engine: interrupt transitions, "blackboards" for sharing knowledge among finite state machines, global and local variables, and polymorphic indexing for run-time selection of the most appropriate behaviors.

SimBionic: Intelligent Student Performance Assessment

It is challenging to assess student performance during dynamic, free-play simulations. Because the actions taken by realistic, computer-generated forces depend upon the student's own actions, the timing and sequence of tactical situations, student actions, and other simulated events that may unfold during a scenario run can vary widely. Thus, one cannot assess student performance simply by recognizing student actions at pre-specified times or in a specified sequence. Instead, student actions must be evaluated in the context of the tactical situation by considering the state of other friendly and opposing forces and their recent actions.

Many of Stottler Henke's simulation-based tutoring systems employ SimBionic augmented finite state machines (FSMs) to look for significant temporal *patterns* of student actions, events, and state conditions that represent the tactical situation. By associating tactical principles with each pattern, a tactical expert can direct the tutoring system to identify areas where the student's knowledge and skills are weak or strong when it recognizes a temporal pattern.

We have been very successful applying *case-based* reasoning methods that combine scenario-specific knowledge with domain-specific knowledge that is shared across scenarios. Scenario-specific FSMs can interpret and evaluate student actions with impressive accuracy because they need only discriminate among the small number of possible interpretations that are likely within the scenario, rather than large number of interpretations that are, in general, possible. Other FSMs can be shared across scenarios to recognize patterns of actions and states that have standard interpretations or evaluations.

Task Tutor Toolkit: Intelligent Tutors for Technical Training

The Task Tutor Toolkit™ (T3) is a set of Java software libraries and applications that lets you create **intelligent tutors for technical training** quickly and easily, without programming. The Task Tutor Toolkit coaches students in subject areas in which there is a single correct solution for each specific scenario, with variation allowed in the ordering of the actions and in their details. For example, the Task Tutor Toolkit can be used to rapidly develop tutoring scenarios for software and equipment operations and maintenance.

However, the Task Tutor Toolkit teaches more than just rote memorization or mechanical skills. Scenarios let students apply their knowledge and skills, by:

- Assessing realistic, complex situations (common and exceptional),·
- Identifying relevant facts, procedures, guidelines, and strategies, and
- Selecting and carrying out appropriate actions to achieve desired results.

Instructors and subject matter experts (scenario authors) create new T3 scenarios rapidly and easily by using the simulator to **demonstrate** a correct sequence of actions for the scenario. The T3 Authoring Tool records these actions to create an initial solution template. Scenario authors then use the T3 Authoring Tool to:

- **Generalize** this solution template so that it accepts other valid sequences of actions. For example, the author could specify that the actions in a group of actions can be carried out in any order.·
- **Specify conditions** on simulation state variable values that must be satisfied in order for an action to be correct. For example, instructor could specify that an action should be carried out only when temperature < 200 and power = "off".
- **Annotate** the solution template by linking principles with actions or groups of actions. These links let the T3 tutoring system identify principles the student appears to know when the student carries out the action or group of actions.

During each T3 scenario, the T3 Tutor evaluates each student action by comparing it to the solution template. It also responds to student requests for help (e.g., "What do I do now?"). At the end of each scenario, the T3 Tutor displays the principles passed and failed by the student, based on the student's actions.

Authoring Tools for Instructional Planning

Instructional planning, defined as deliberate selection of instructional actions suited to a student's learning needs, is a key component of intelligent tutoring systems, but is often embedded deep in the tutoring system without an explicit declarative representation. This makes these ITSs inflexible with respect to changes in instructional philosophy, experimentation with different instructional approaches, and application of an ITS to achieve different training objectives. To address this problem, Stottler Henke has developed an ITS authoring tool (IITSAT) that enables ITS authors to specify not only content, but also instructional strategies by specifying student expertise categories, evaluation criteria for dynamically classifying students into those categories, and articulating teaching methods adapt to a student's expertise level. We are currently developing an enhanced ITS authoring tool that lets course creators specify instructional plans that take into account factors like personality, learning styles, and emotional and motivational states in addition to student expertise levels.

Socratic Tutoring

For many subject areas, lessons are best learned when students realize them on their own. Stottler Henke is developing Socratic tutoring methods that:

- Assess the student's knowledge and skills by actively probing for the student's intentions and rationale, and
- Help the student reflect upon their performance and consider alternative courses of action by pointing out facts, posing questions, and providing hints.

Stottler Henke is currently developing this instructional technology to support the creation of the ComMentor system that teaches high-level battlefield reasoning skills to Army and Marine commanders.