Interactive Soft Skills Training using Responsive Virtual Human Technology

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When it occurs, interaction skills training usually relies on peer-to-peer role playing or passive learning through videos. These forms of training lead to a critical training gap, because the students are limited in the practice time and the variety of scenarios that they encounter. But it is exactly this practice, studies show, that leads to significant on the-job benefits. This paper describes responsive virtual human (RVH) technology that allows natural, interactive dialog between the student and system. RVH's can improve training by reducing the need for training personnel, by providing students with more practice time and consistent interaction experiences, and by leading to improvements in problem-solving ability and engaging and motivating students. Most importantly, RVH technology provides the benefits of reduced training costs, increased student-teacher ratios, individualized tutoring, and greater student convenience that are associated with computer-based training.

Introduction

Intelligent assistive agents are being used in fields as diverse as computer generated military forces, manufacturing, medicine, and theater. Some agents are used for information management and data mining, some for autonomous control of simulated entities (e.g., aircraft in a wargame, or characters in an accident scene), and some for electronic commerce. Some agents act in the background, whereas others present to the student a human face or caricature. Some follow preprogrammed routines, others employ natural language (NL) dialog interfaces, still others run via a behavior or simulation engine. Where intelligent agents have not been employed, though, is in interaction skills training. Yet interaction skills (e.g., interviewing, negotiating, presenting, eliciting information, customer service) are critical in practically all fields, and advanced technologies for training these "soft skills" offer tremendous returns.

Responsive virtual human (RVH) technology is a relatively recent advance in training technology. RVH technology uses an intelligent agent framework to combine virtual reality (VR), NL processing, and behavior modeling. Portraying realistic RVH's—that is, full-body animated, conversant agents with whom the student interacts and who exhibit emotional, social, gestural, and cognitive intelligence—requires clearly defined emotional state, action that shows thought processes, and accentuation to reveal feelings. Computer-based interaction training requires RVH's who use gaze, gesture, intonation, and body posture as well as verbal feedback during the interaction, since reading body language is part of the training. The benefit is engaged and motivated students, learning interaction skills in a mode more like actual encounters rather than learning via peer-to-peer role-playing or watching and analyzing videos. RVH technology opens entirely new capabilities for computer-based training of interpersonal skills, and can provide the benefits of reduced training costs, increased student-teacher ratios, individualized tutoring, ease of modification, upgrading, and extension, and greater student convenience that are commonly associated with computer-based training.

The Need for RVH's

Practicing interaction skills in a safe and supportive environment allows the student to learn flexible approaches. Flexibility is critical for performing well under time constraint, information-poor, and other difficult conditions (Frank et al., 2002; Groves & Couper, 1998; Klein, 1998). The consistency that is gained by repeating this practice in virtual environments leads directly to good decisions on the job (Ross et al., 1998). By practicing skills in safe, computer-generated settings, students have the opportunity through repetition to develop practical experience and skills which would otherwise be difficult to acquire (Psotka, 1995). Practice also leads to increased confidence prior to the first real on-the-job experience (Frank et al., 2002; Link et al., 2002).

RVH applications provide an opportunity for practice with numerous case-based scenarios in a reproducible, objective learning environment prior to the challenge of actual engagement. RVH training is useful for initial training, sustainment training, and ongoing assessment of interaction skills. Training and sustainment benefits include enhanced adaptability, availability, and assessment, and reduced loss of effectiveness for students at distributed locations. RVH architectures can be implemented with software that is designed to run on a relatively inexpensive laptop computer, so that it can be used on widely available personal computers, with distribution via compact disc or a network.

Since approximately 1996, RTI has worked on a series of PC-based applications in which the student interacts with RVH's. Applications have ranged from learning tank maintenance diagnostic skills (Guinn & Montoya, 1997) to trauma patient assessment (Kizakevich et al., 1998) to gaining skills in avoiding non-response during field interviews (Camburn et al., 1999) to learning to handle encounters with the mentally ill (Frank et al., 2002). In these applications, collectively categorized as involving RVH technology, the PC simulates behavior in response to student input. Students interact with the RVH's via voice, mouse, menu, and/or keyboard. RTI is certainly not alone in developing training, assessment, marketing, and other RVH applications, but the breadth across domains and combination of technologies is unusual.

The RVH applications are representative of those developed in RTI's Technology Assisted Learning (TAL) division to meet customers' training and assessment needs. TAL is defined as "proactively applying the benefits of technology to help people train more safely, learn better, retain skills longer, and achieve proficiency less expensively". TAL applications are appropriate for jobs requiring complicated knowledge and skills, complex or expensive equipment or work material, a high cost of on-the-job training or failure on the job, jobs where safety or spatial awareness is essential, and for large student throughput requirements (Frank et al., 2000).

Technology Overview

RTI's PC-based architecture, Avatalk (see Figure 1), enables students to engage in unscripted conversations with RVH's and see and hear their realistic responses. Among the components that underlie the architecture are a Language Processor and a Behavior Engine. The Language Processor accepts spoken input and maps this input to an underlying semantic representation (i.e., its meaning), and then functions in reverse, mapping semantic representations to gestural and speech output. RTI's applications variously use spoken NL interaction, text-based interaction, and menu-based interaction. The Behavior Engine maps Language Processor output and other environmental stimuli to RVH behaviors. These

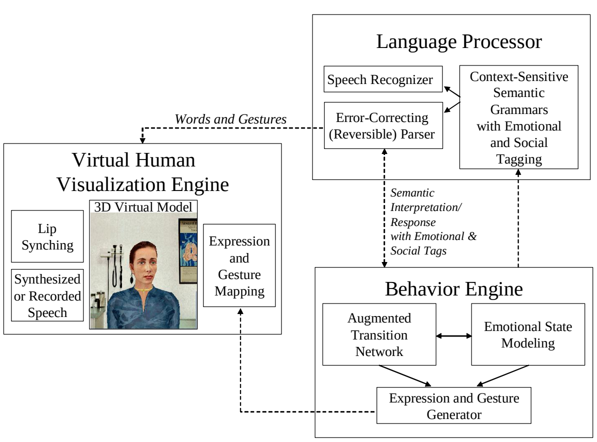


Figure 1. Avatalk Architecture

behaviors include decision making and problem solving, performing actions in the virtual world, and spoken dialog. RVH action takes the form of observable behavior, choice of utterances, conversational expectancies, and branching logic within the application. The RVH's are rendered via a Visualization Engine that performs gesture, movement, and speech actions, through morphing of vertices of a 3D model and playing of key-framed animation files (largely based on motion capture data). Physical interaction with the RVH (when appropriate, e.g., using medical instruments) is realized via object-based and instrument-specific selection maps. These interactions are controlled by both the Behavior Engine and Visualization Engine. (See Hubal et al., 2003, for implementation details.)

Although learning scenarios are pre-defined, the student interaction itself is unscripted. The scenario establishes initial conditions, but the student's responses to the RVH, as well as inherent flexibility in how the RVH is allowed to react, cause the conversational flow to vary from interaction to interaction. Behavior models specify how the emotional, physiological, and cognitive states of the RVH's change based on student input and time course. They also specify how the RVH should act given its new states. For instance, the RVH should know to shake its head or hold up its hands when disagreeing with the student, but the emotional or physical state can temper or amplify the reaction. Similarly, an answer to a query on how the RVH feels will depend on whether it represents a depressed person, a confused person, an injured person, or someone in a neutral state. This leads to a realistic learning application wherein the student must learn to handle each interaction individually.

Considerations for Interaction Skills Training

For simulation-based training of skills in general, and RVH-based training in particular, student activity needs to be assessed to ensure that the student has succeeded in achieving the learning objectives for the scenario. Measures include outcome of the simulation, tracking whether or not the student has obtained the information necessary to make appropriate decisions, and monitoring whether or not the student is practicing desired skills, such as politeness, responsiveness to the RVH's questions, and empathy for the RVH's feelings. In RVH applications, student actions are measured through context-specific linguistic analysis of the student's verbal responses to the situation, the student's use of virtual tools (such as meters and scopes, if any are present), negative student habits (such as the use of gratuitous profanity, impoliteness, and overuse of technical terminology and jargon), and the extent to which the student follows guidelines or protocols established by content experts.

The engine underlying RVH behavior provides appropriate semantic and emotional reactions to the student's inputs, following a flexible script. For training situations, the student needs to practice skills by applying them in a varying set of scenarios. However, the scenarios should provide consistent feedback and results to the student. Scripts are created to define how the RVH behaves at a specific point under specific conditions within the scenario. Subject matter experts (SME's) provide the basic inputs for the scripts, and also review the scripts to ensure appropriate and consistent results. The semantic models allow the RVH's to respond with answers, denials, objections, and challenges to the student's requests, questions, and commands that are consistent with the script. Student input is analyzed to select the most appropriate group responses. The actual response depends on both the topic of the student input and the current emotional state of the RVH. It easy to add scenarios or to adapt a script with variations in initial states, conversational flow, and virtual environment activities. (See also Gratch, 2000; Johnson et al., 2000.)

Training Interaction Skills using RVH Technology

In addition to RVH's as interaction partners, an RVH can serve as an individualized virtual tutor, and can operate in a variety of modes (Hubal & Guinn, 2001). In Demonstrator mode, the virtual tutor acts as a surrogate SME to demonstrate good practices and techniques, showing the appropriate steps of a task and what operations need to be performed at each step. This mode is typically used to familiarize the student with the skill or skills being learned. In Coach mode, the virtual tutor prompts the student through the sequence of steps. For example, the virtual tutor may ask the student to select a topic for an interview, and then provide general recommendations for how to pose questions. This mode is typically used when the student is acquiring a skill or skills. In Mentor mode, the virtual tutor offers suggestions, remediation, or critiques on the request of the student. This mode is typically used when the student is practicing skills already acquired. In Observer mode, the virtual tutor records and evaluates the student's actions but does not interfere with the student's efforts unless the student has acted outside the acceptable forms of behavior, particularly if the student's actions in the real world could risk harm to the student or harm to people or valuable objects in the environment. The virtual tutor either provides an after action review (AAR) of the student's performance after the student has completed the scenario, or provides the data collected back to the instructor so that the instructor can provide the review. This mode is typically used when the student is validating skills already acquired and practiced.

When tied in with an intelligent tutoring system (Piskurich, 1993), feedback to the student is provided in the form of dialogs with the student (Chi et al., 2001; Graesser et al., 2000). When the student is acquiring or practicing skills, the virtual tutor provides recommendations for future student actions, and immediate and direct feedback on the student's previous actions. The virtual tutor uses the information collected on the student's activities, such as information on topics that have been discussed in an interview or mistakes made in performing certain diagnostic tests, to make suggestions to the student.

Training Considerations for Use of RVH Systems

A typical approach to training interaction skills is to provide lectures, reading materials, or video tapes for familiarization, and then have the student acquire and practice the skills on the job. This can be an expensive and risky approach, but the costs and risks are hidden in operational costs and failures. A more sophisticated but much more expensive approach is to again use lectures, reading materials, and video tapes for familiarization, but use an experienced worker as a mentor for the apprentice worker while the apprentice acquires and practices the skills. Validation is often a subjective evaluation by the mentor. This approach suffers from two drawbacks, the expense of the one-on-one training, and the variability of training experience due to its unstructured nature. A third approach uses group sessions where carefully designed scripts are acted out. This is also an expensive approach, particularly for large classes, since these interactions are one-on-one. This cost severely limits the number of scenarios in which a student will participate. Our TAL approach suggests that using RVH technology as an adjunct to existing training is appropriate for "learning-by-doing" while mastering interaction skills. However, RVH technology should be integrated closely into the training regimen, and should be used in combination with other training methods to achieve the most cost-effective training.

We analyze interaction skills training in terms of a four step process (Frank et al., 2000), considering the training methods appropriate for four steps in the learning process for each task to be learned. As illustrated in Figure 2, the four steps are Familiarization, Acquisition, Practice, and Validation (FAPV). Familiarization involves acquiring knowledge about the task by absorbing a presentation, watching a demonstration (e.g., by a virtual tutor in Demonstrator mode), or by reading. This is a relatively passive process for the student. Acquisition involves learning techniques and procedures by being tutored within a simulation. The virtual tutor

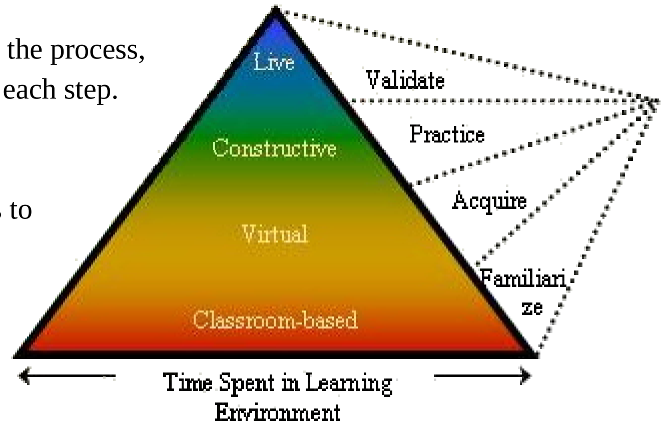


Figure 2. Training Triangle

(in Coach mode) guides the student through each step of the process, prompting the student to perform the action required for each step. If a student makes a mistake, the virtual tutor provides immediate feedback. Practice involves internalizing techniques and procedures by doing the skill with access to help from a virtual tutor (in Mentor mode). The student performs the actions or the procedure without prompting from the virtual tutor. At any point, the student may ask the virtual tutor for help. If the student makes a mistake, the virtual tutor provides feedback shortly after the incorrect action. Validation involves testing the ability to perform the skill without help from a virtual tutor. The student is on his/her own until either the task is successfully completed, or the virtual tutor (in Observer mode) determines that the student cannot complete the task successfully (e.g., because s/he failed certain performance measures that underlie one or more of the learning objectives). When the performance test has ended, either with success or failure, the virtual tutor provides an AAR, interacting with the student to determine what went right, what went wrong, and how to improve his/her performance.

As with any training technology, RVH technology has its limits to use. For instance, in many interaction skills training situations, students are being taught knowledge, skills, and attitudes. RVH's are seen as useful for acquiring and practicing skills, but knowledge is often best gained through less costly media (such as lectures, reading materials, and video tapes), and attitude changes is best taught through interactions with people with experience, not through the use of RVH technology. Similarly, actual use of diagnostic tools needed within interactions (such as medical instruments or other environmental objects that get manipulated) cannot be taught in a virtual world; students must learn these uses hands-on. Also, while RVH technology addresses the need to learn to interact with diverse populations (e.g., in age, ethnicity, gender, personality), there is no substitute for validating skills in as real an environment as is possible. Again, RVH applications should be integrated with other forms of training to enable the student to achieve all learning objectives.

Training Applications of RVH Systems

Beginning in 1998 (though some development work had already begun prior to that), RTI invested internal research and development funds to develop RVH capability. Since then, numerous federal agencies have expressed interest (and several are funding) RVH technology at RTI. A partial list of RVH applications, across content domains, follows.

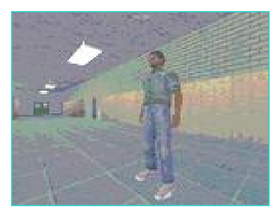
- VirtualEMS. VirtualEMS is an interactive, multimedia, VR-based simulator that offers realistic practice for emergency medical technicians, medics, corpsmen, medical students, physician assistants, nurses, and physicians. The system presents the student with a 3D visual and aural scenario in which a trauma incident has occurred. The student may freely navigate within the scene and view the scene and patient from any position. The trauma patient is a 3D virtual model with realistic visible injuries and internal trauma, exhibiting medical signs and symptoms with real-time physiological behavior. (Kizakevich et al., 1998)

- VirtualClinic Simulated Patients for Bioterrorism Response Training. In concert with web-based training materials designed to train clinicians for a potential incident of bioterrorism, an RVH clinic-based simulation of a virtual patient was developed. The simulation involves a bioterrorist agent as well as emerging infectious agents. The clinician makes specific inquiries regarding patient history and physical condition, orders diagnostic tests, enters differential diagnoses, and plans treatment and patient management. The patient's medical record is updated as new findings become available. The purpose of these materials is to provide health care providers with an historical overview, basic clinical information, and practical training in the areas of bioterrorism and rare or emerging infections. (Kizakevich et al., 2003)

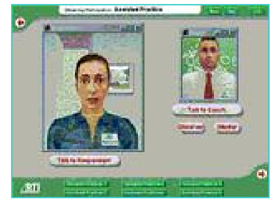
- Virtual Pediatric Standardized Patient. Interaction skills are crucial to medicine and emergency response. Physicians learn a variety of techniques on the job to communicate effectively, but the training and evaluation of these skills (usually through standardized patients) is limited. With a view toward providing effective and efficient training for medical students rotating through Pediatrics, VPSP supports learning not only of verbal interaction skills, but also of medical diagnostic skills, strategies for dealing with the spectrum of behavioral responses, and other types of high-level problem solving. (Hubal, Deterding, et al., 2003)

- JUST-TALK Police Training. JUST-TALK was designed to train civilian police officers to handle mentally disturbed individuals. An officer responding to a situation where the subject is mentally ill must first realize the mental illness, and once realized must quickly make a number of difficult decisions. In situations involving criminal actions, the officers are trained to use aggressive verbal techniques to quickly bring the situation under control. However, interaction with the mentally ill requires very different verbal interaction skills to de-escalate the situation. Law enforcement personnel using JUST-TALK decide which verbal approach is most effective in a particular situation. (Frank et al., 2002)

- Dealing with Anger. A number of programs for adolescent substance abuse are effective, however, there is invariably a substantial subgroup that does not respond favorably. As part of a study to identify specific underlying neurocognitive components of psychosocial risk factors associated with adolescent drug abuse under laboratory conditions, a series of vignettes invoke a specific cognitive function consistent with risky decision-making, impulsivity and sensitivity to penalties. The vignettes assess adolescents' situation-specific behavior rather than merely test their understanding of risk, impulsiveness, or sensitivity to penalties. (Manuscript in preparation.)



- Predicting Correctional Treatment Response. A small number of correctional treatment programs are reportedly effective for a significant number of inmates, but these numbers do not provide support for their widespread clinical utility in aggressive offenders. As part of a study investigating the underlying mechanisms for the differential effects of a substantial subgroup that does not respond favorably to treatment, a series of vignettes are being employed to measure risky decision making pre- and post-intervention.



- AVATALK-Survey. AVATALK-Survey addresses survey nonresponse, a critical training need in survey research. Research suggests that, to train how to solicit participation in surveys, effective training programs must address respondent concerns, train interviewers to develop strategies to adapt to cues, and create a realistic learning environment. Current survey practice leads interviewers to follow complex, standardized interviewing procedures. AVATALK-Survey, on the other hand, generates a variety of respondents showing a range of emotions, creates a virtual environment in which contextual cues can be added or changed, and can be used for home study to supplement current training agendas. (Camburn et al., 1999; Link et al., 2002)

Research Issues

There remain multiple research issues that RTI and others are actively pursuing which must be resolved if RVH's are to reach the level of sophistication required for robust interaction skills training. For instance, student input in current systems is limited. NL technology allows free-form spoken input only within constrained environments, necessitating considerable up-front work by application developers in building language grammars. The technology also captures words only; vocal affect, facial expression, and body movement exhibited by the student are as yet unanalyzed. Similarly, the behavior exhibited by the RVH's need to be refined if they are to be viewed as highly realistic. Refined behavior entails more realistic rendering of gestures and whole-body movements, facial expressions, lip synching, and environmental stimuli. It also entails further detailed models of cognitive, social, emotional, and physiological characteristics, that is, how these components get updated and how they affect observed behavior. Also, the right mix of learning environments (classroom, PC, and on-the-job) is not fully understood when RVH technology is integrated into existing interaction skills training courses. Open questions include how many scenarios are sufficient, how broad do the scenarios need to be, how do student learning styles affect scenario and script development, and what kind of tools will enable application designers to rapidly incorporate intelligent virtual tutoring based on elicited SME knowledge.

Addressing these research issues will open up a broad range of training and educational opportunities. RVH-based training is not intended to replace instructor-led training, but, based on experience with VR-based maintenance training, it is expected that combinations of RVH-based training and instructor-led training will significantly reduce training costs and increase the number of people who can be effectively and consistently trained. As an additional return-on-investment, RVH-based training can provide inexpensive, focused sustainment training. The key to opening up this broad range of applications is more robust and effective RVH models and more efficient means of creating the models, as well as a better understanding of how to use RVH technology in combination with other training methods to provide cost-effective training on critical interaction skills.

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Robert C. Hubal, Senior Research Engineer, RTI International, 919/541-6045, rhubal@rti.org, conducts educational technology research focusing on development, presentation, and evaluation of advanced learning environment materials. Dr. Hubal headed up an experimental evaluation for the U.S. Army of the effectiveness of a virtual maintenance trainer, and led an evaluation of a constructive driving skills assessment application. He has investigated the interaction effects among cognitive task demands, expertise, and presentation of information. Most recently, Dr. Hubal has developed behavioral software that enables RVH’s to act and behave realistically in controlled learning contexts. Dr. Hubal holds an M.S. in Computer Science from North Carolina State University and a Ph.D. in Cognitive Psychology from Duke University.

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