Expanding Domain Modeling in GIFT: 2018 Update

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INTRODUCTION

Building upon last year's domain modeling update (Sottilare, 2017), the purpose of this paper is to educate users of the Generalized Intelligent Framework for Tutoring (GIFT; Sottilare, Brawner, Goldberg, & Holden, 2012; Sottilare, Brawner, Sinatra, & Johnston, 2017) about new and emerging capabilities to represent a broader variety of task domains in Intelligent Tutoring Systems (ITSs) in support of adaptive instruction. Adaptive instruction delivers content, offers feedback, and intervenes with learners based on tailored strategies and tactics with the goal of optimizing learning, performance, retention, and transfer of skills for both individual learners and teams.

GIFT is a tutoring architecture that has evolved over the last six years with three primary goals: 1) reduce the time and skill required to author ITSs, 2) automate best practices of instruction in the policy, strategies, and tactics of tutoring, and 3) provide a testbed to assess the effectiveness of adaptive instructional tools and methods with respect to learning, performance, retention, and transfer of skills. Another overarching goal for GIFT has been to adapt ITSs to provide instruction in militarily-relevant training and educational domains. For training domains, this means psychomotor tasks that involve both physical and cognitive aspects.

Currently, most ITSs are focused on cognitive task domains (e.g., problem solving and decision making) in academic topics that primarily include software programming, physics, and mathematics. While there are many military task domains that involve cognitive skill development (e.g., military planning processes and assessment of battlespace strategies and tactics), many more involve interdependent team processes (e.g., building clearing) and psychomotor skills (e.g., marksmanship). It is for this reason that we desire to extend current capabilities in GIFT to support content delivery, assessment, and remediation processes for more complex team and psychomotor tasks while simultaneously enhancing the effectiveness of individual instruction in cognitive and affective domains. In 2015, Sottilare, Sinatra, Boyce, & Graesser documented domain modeling goals, challenges and approaches to providing adaptive instruction in various domains. The following section describes some of the challenges to expanding domain modeling beyond cognitive tasks and beyond the current model of desktop training.

The following sections examine areas of enhanced, new or emerging capabilities in support of expanding GIFT to a wider variety of task domains.

TUTORING MARKSMANSHIP

While this was reported in last year's update (Sottilare, 2017), it is worth noting that there remains growth potential in the marksmanship task domain. Althought, GIFT has now been integrated with PEO STRI's Engagement Skills Trainer (EST) to demonstrate interaction of the learner, there is more to be done to fully demonstrate GIFT as a psychomotor task tutor. The current implementation provides training with stationary targets, assessment of the learner's performance, and remediation of any detected errors by the tutor with respect to the Army marksmanship principles. Ideally, future versions of GIFT will also allow the integration of new weapons (e.g., different rifles and pistols) and their associated expert models. We project that many of the sensors needed to acquire weapon cant and aimpoints could remain the same depending on the size of the weapon and certainly the breathing harness would not change with a change in weapons.

To ease the process for developing ITSs for psychomotor task domains, we have invested in an agent-based approach to guide authoring of psychomotor tasks (see paper #2 in this year's GIFTSym by Brown, Goldberg, Bell, & Kelsey, 2018). This approach includes automated acquisition of sensor data and uses this data with reinforcement learning to develop expert models for psychomotor tasks.

TUTORING MEDICAL TASKS

Previously, we reported that GIFT had been used to provide tailored training of military tasks using desktop applications (e.g., Virtual Battlespace and Virtual Medic). The degree of transfer of skills from training to operations was limited in these environments since the training primarily exercised cognitive functions. So in 2016, Sottilare, Hackett, Pike & Laviola examined how commercial sensor technologies might be adapted to work with GIFT and support tailored computer-guided instruction in the psychomotor domain for a military medical training task, specifically hemorrhage control. While this concept was well-thought out, the implementation has been hampered by changes in technology, specifically the turnover of commercial smart glasses in the market.

Recently, Julian (2018) applied GIFT to the task of basic robotic surgical skills. The purpose is to help train physicians on both the cognitive and basic knowledge of skills needed to use the most commonly known robotic surgical system, the da Vinci. Two skills were taught in the GIFT-based course: camera control and interrupted suturing. Again, the focus of the instruction was primarily cognitive (knowledge components) and GIFT's ability to support physical measures during practice were limited. Ideally, some type of board or mannequin might be used in combination with sensors to detect the delicate control required for this type of robot-assisted surgery and we are evaluating how this might be accomplished across a variety of tasks. One approach could be embedded training where GIFT is used to stimulate a system (e.g., da Vinci) and the interface used by the learner is the same one used during the actual work task. This type of approach would reduce any negative training introduced by poor attempts to replicate the interface.

Another potential medical domain application of GIFT is being developed at Columbia University and the Morgan Stanley Children's Hospital in New York. The pediatric physicians on staff at the hospital are exploring the use of GIFT to train pediatric residents. The ARL adaptive training team provided a short course on authoring using GIFT in January 2018 and the staff is assembling content for their first course. The intent is to use GIFT to augment the instruction of pediatric residents in a self-regulated (computer-regulated) learning environment.

On the research side of GIFT domain applications, we are engaged in the development of an experimental protocol to investigate accelerated learning models in GIFT for medical military and civilian training (Sottilare & DeFalco, 2018). Data collection has already begun and will involve several user groups from United States Military Academy, Columbia University, University of Wisconsin, and Amazon Mechanical Turk (MTurk).

TUTORING PSYCHOMOTOR TASKS WITH TACTICAL BREATHING

Last year, we reported information about an experimental approach involving psychomotor tasks and tactical breathing (Kim, Dancy, Goldberg, & Sottilare, 2017). Tactical breathing is a is a specific breath-control technique used by individuals to perform a precision action required for a psychomotor task in a stressful environment (Neumann & Thomas, 2009; Neumann & Thomas, 2011). The focus of this research is to examine the relationship between cognitive (e.g., attentional resources) and physiological (e.g., breathing) factors during the execution a psychomotor task (i.e., golf putting). It is not well understood that how the corresponding mechanisms of attentional control interact with the physiological factors as the learner progresses to the learning stage. An experimental protocol has been drafted and the experimental apparatus is being developed to support the measurement of critical factors during task performance. Data collection is scheduled for the Fall of 2018.

TUTORING IN THE WILD (LIVE, AUGMENTED OR MIXED REALITY)

An important aspect of the value of ITSs is associated with their accessibility or ability to go where learners go. Often referred to as *mobile learning*, instruction delivered to portable computing devices (e.g., laptops computers, smartphones or tablet computers) and managed remotely by either human or artificially-intelligent tutors, we are advocating an expanded capabilility that could be delivered to learners in either live, augmented, or mixed reality environments. We consider this an important design feature for ITSs so that they can support learning as an augmentation in a variety of environments where military personnel might be assigned.

To this end, we continue to examine opportunities to link GIFT through interfaces that can expand learner experience and knowledge.

As reported last year, we are continuing to evaluate the application of various hardware platforms (e.g., smartglasses, mobile devices). A large part of our domain application effort this year has been dedicated to providing a proof of concept for land navigation training to USMA. This concept provides learners a means of planning their routes (Virtual BattleSpace) and executing their routes (live environment augmented with a phone-based mobile application (Figure 1).

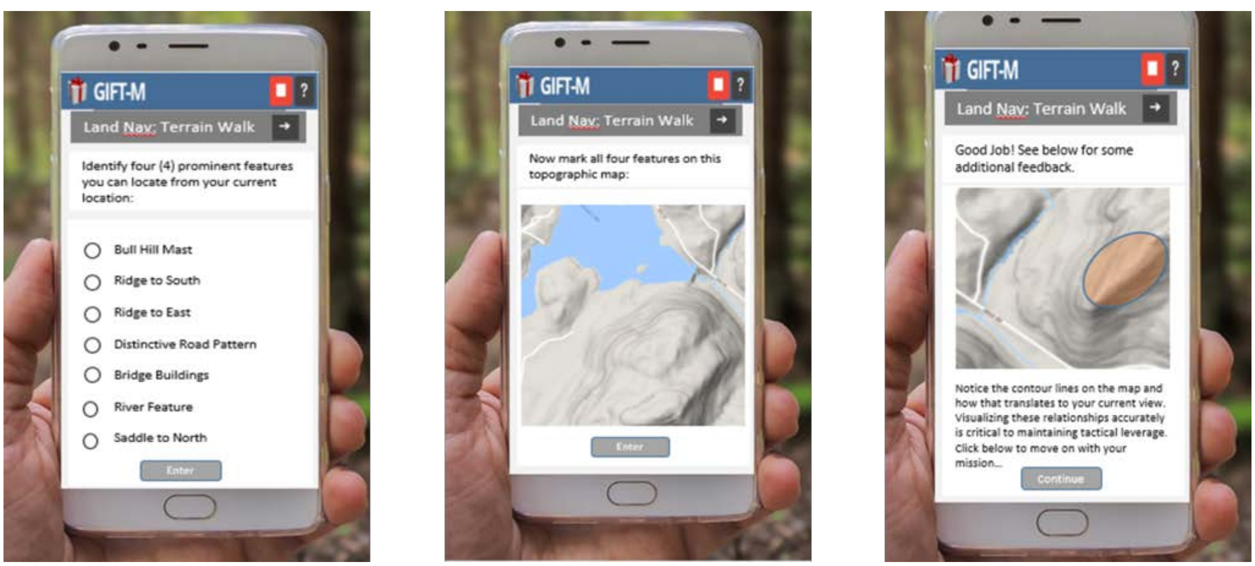

Figure 1. GIFT Mobile Application for Land Navigation Training

Moving we anticipate more eyes on the *tutoring in the wild* problem space. Last year, the North Atlantic Treaty Organization (NATO) approved a research task group (RTG) to examine existing and emerging augmentation technologies to enhance human performance in both instructional (training and educational) domains as well as work/operational domains. The broad scope of this RTG includes the use of ITSs to deliver and manage instruction as well as support mission essential tasks as a job aid. In addition to the US, this group has garnered interest from eight NATO countries which implies its importance.

TUTORING TEAM DOMAINS: TEAMWORK AND TASKWORK

One way of extending domain-independence in GIFT to the modeling of teams is to separate domain-independent teamwork behaviors from task-specific, domain-dependent behaviors. Salas (2015) distinguishes teamwork, interactions between team members, from taskwork, behaviors demonstrated in executing the task. An examination of teamwork activities (e.g., coaching or conflict management) via a meta-analysis of the team training and performance literature led to the identification of several behavior markers for high performing teams (Sottilare, et al, 2017). Next steps are to seek methods to unobtrusively acquire these behavioral markers in order to identify team states and subsequently assign the ITS to manage them.

Currently, there are no tools or methods available in the public baseline for modeling or tutoring teams in GIFT. We are continuing to develop a model of team tutoring in which we will incrementally provide team instruction through GIFT without human intervention. While the specific approach is not yet set in stone, it might look something like this:

- Configure GIFT to identify hierarchical concepts or learning objectives associated with team taskwork (GIFT can already do this)
- Configure GIFT authoring tools to support the development of team models and associated measures
- Configure GIFT authoring tools to support the development of sub-team and multiple individual models and associated measures, roles, and responsibilities
- Configure GIFT authoring tools to support the development of a team strategy engine based on teamwork (domain independent) best practices.

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REFERENCES

Brown, D., Goldberg, B., Bell, B., & Kelsey, E. (2018, *in press*). Incorporating psychomotor skills training into GIFT tutors: Supporting outside-the-box authoring. In Proceedings of the 6th GIFT Users Symposium. Orlando, Florida, May 2018.

Kim, J., Dancy, C., Goldberg, B., & Sottilare, R. (2017; *in press*). A Cognitive Modeling Approach - Does Tactical Breathing in a Psychomotor Task Influence Skill Development during Adaptive Instruction? In *Foundations of Augmented Cognition* (pp. xx-xx). Springer International Publishing.

Julian, D. (2018). Final Report for IDS6938 – Intelligent Tutoring System Design: Basic Robotic Course. University of Central Florida, Orlando, FL.

Neumann, D.L. & Thomas, P.R. (2009). The relationship between skill level and patterns in cardiac and respiratory activity during golf putting. Int. J. Psychophysiol. 72(3), 276–282.

Neumann, D.L. & Thomas, P.R. (2011). Cardiac and respiratory activity and golf putting performance under attentional focus instructions. Psychol. Sport Exerc. 12(4), 451–459.

Salas, E. (2015). Team Training Essentials: A research-based guide. Routledge Publishing. New York & London.

Sottilare, R.A., Brawner, K.W., Goldberg, B.S. & Holden, H.K. (2012). The Generalized Intelligent Framework for Tutoring (GIFT). Concept paper released as part of GIFT software documentation. Orlando, FL: U.S. Army Research Laboratory – Human Research & Engineering Directorate (ARL-HRED). Retrieved from: https://gifttutoring.org/attachments/152/GIFTDescription_0.pdf

Sottilare, R. & DeFalco, J. (2018). Experimental Protocol (ARL 17-251) - Developing accelerated learning models in GIFT for medical military and civilian training. US Army Research Laboratory, Orlando, FL.

Sottilare, R., Hackett, M., Pike, W., and LaViola, J. (2016). Adaptive Instruction for Medical Training in the Psychomotor Domain. In J. Cohn, D. Fitzhugh, and H. Freeman (Eds.) Special Issue: Modeling and Simulation Technologies to Enhance and Optimize the DoD's Medical Readiness and Response Capabilities of the *Journal for Defense Modeling & Simulation (JDMS).*

Sottilare, R., Brawner, K., Sinatra, A., & Johnston, J. (2017). An Updated Concept for a Generalized Intelligent Framework for Tutoring (GIFT). Orlando, FL: U.S. Army Research Laboratory – Human Research & Engineering Directorate (ARL-HRED).

Sottilare, R., Sinatra, A., Boyce, M., and Graesser, A. (2015). Domain Modeling for Adaptive Training and Education in Support of the US Army Learning Model: Research Outline. US Army Research Laboratory (ARL-SR-0325), June 2015.

Sottilare, R. (2017, May). Expanding Domain Modeling in GIFT. In R. Sottilare (Ed., 2017) 5th Annual GIFT Users Symposium (GIFTSym5). Army Research Laboratory, Orlando, Florida. ISBN: 978-0-9977257-1-1.

Sottilare, R.A., Burke, C.S., Salas, E., Sinatra, A.M., Johnston, J.H. & Gilbert, S.B. (2017). Towards a Design Process for Adaptive Instruction of Teams: A Meta-Analysis. In R. Sottilare, A. Graesser, J. Lester & R. Baker (Eds.) Special Issue: Generalized Intelligent Framework for Tutoring (GIFT): Creating a stable and flexible platform for innovations in AIED research. *International Journal of Artificial Intelligence in Education.*

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