Generalized Intelligent Framework for Tutoring (GIFT)

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31 July 2012
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People

• Adaptive Tutoring Research @ the Learning in Intelligent Tutoring Environments (LITE) Laboratory

- Dr. Robert Sottilare, ARL-HRED AD for S&T, LITE Lab Director
- Dr. Heather Holden, Trainee Modeling & HCI Lead for LITE Lab
- Mr. Keith Brawner, Authoring and Expert Modeling Lead for LITE Lab
- Mr. Benjamin Goldberg, Instructional Strategy Lead for LITE Lab
- Mrs. Janice Connor, Research Assistant
- Dr. Anne Sinatra, Post-Doc

Co-creators of GIFT
We don’t work alone…
Tutoring Methods and Effect Sizes...

.42 Unskilled human tutors (Cohen, Kulik, & Kulik, 1982)  
(↑ median score from 50th percentile to 66th percentile)

.79 Skilled human tutors (VanLehn, 2011)  
(↑ median score from 50th percentile to 79th percentile)

.80 AutoTutor (20 experiments) (Graesser and colleagues)

1.05 Other tutoring systems (↑ median score from 50th to 85th)
  PACT Geometry Tutor (Anderson, Corbett, Koedinger & Pelletier, 1995)
  Diagnoser - physics (Hunt & Minstrell, 1994)
  Sherlock (Lesgold, et al, 1988)

2.00 Skilled human tutors (Bloom, 1984)

Adapted from information provided by Dr. Art Graesser, University of Memphis, and Dr. Beverly Woolf, University of Massachusetts - Amherst.
Computer-based tutoring systems (CBTS) have demonstrated significant promise in tutoring individuals in well-defined domains, but...

Fifty years of research have been unsuccessful in making CBTS ubiquitous in military training... Why?

CBTS are expensive to author and are insufficiently adaptable to support the tailored, self-regulated, individual & small unit tutoring experiences required to support:

- U.S. Army Learning Model (ALM) for 2015 (TRADOC, 2011)
- U.S. Air Force (AETC, 2008)
- U.S. Navy STEM Grand Challenge (ONR, 2012)
- OSD R&T Vision for PAL
- NATO HFM RTG 237 (Advanced ITS)
- TTCP HUM TP-2 (Training Panel)
GIFT Research Objectives

• **Tutor Authoring**
  - promote reuse through *common tools and standards*
  - promote reuse through *domain-independent modules*
  - leverage *open source solutions*
  - leverage existing training environments (e.g., *games*)

• **Tutor Adaptability**
  - develop methods to *accurately classify learner states* (e.g., cognitive, affective, psychomotor, social)
  - develop methods to *select optimal instructional strategies given the learner's existing states*

**Adaptive Tutoring Learning Effect Chain**

- learner data 
  - informs 
  - learner states 
  - informs 
  - instructional strategy selection 
  - influences 
  - learning gains
- Research and prototype a computer-based tutoring framework to evaluate adaptive tutoring concepts, models, authoring capabilities, and instructional strategies across various populations, training tasks and conditions, thus enabling summative and formative evaluations including between system evaluations.

- Empirically assess CBTS, CBTS models, methods, and components using GIFT.

- Use results to build CBTS standards.
GIFT’s Instructional Elements

local tutoring processes

- Sensor Module
- Learner Module
- Pedagogical Module
- Domain Module
- Tutor-User Interface

Sensors → Learner

- Training App Client
  - to/from Training App Server

- Gateway(s)
  - to/from Domain Module
  - to/from Training App Client

Learning Management System (LMS)
  - to/from Learner Module

Service-Oriented Architecture

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Authoring Goals for GIFT
(adapted from Murray, 1999; Murray, 2003; Sottilare & Gilbert, 2011)

• Decrease the effort (time, cost, and/or other resources) for authoring and assessing CBTS;

• Decrease the skill threshold by tailoring tools for specific disciplines to author, assess and employ CBTS;

• Provide tools to aid the designer/author/trainer/researcher organize their knowledge;

• Support (i.e. structure, recommend, or enforce) good design principles (in pedagogy, user interface, etc.);

• Enable rapid prototyping of CBTS to allow for rapid design/evaluation cycles of prototype capabilities.

• Employ standards to support rapid integration of external training/tutoring environments (e.g., games) (Sottilare & Gilbert, 2011)
GIFT’s Authoring Construct

- **Approach: functional user modeling**

- **standard structures and graphical user interfaces**

- **GUIs based on function (e.g., researcher) and functional competency**
  - learners
  - subject matter experts
  - instructional system designers
  - system developers
  - trainers
  - researchers

- Approaches: functional user modeling

- Includes:
  - authors & components
  - user models
  - domain-specific knowledge
  - instructional strategies
  - user-tutor interfaces
  - tutor compiler
  - learner model
  - expert model
  - instructional system designer model
  - training system developer model
  - trainer model
  - researcher model

**Unclassified – Distribution A – Unlimited**
• **Approach: learner affect modeling**

• **what does the tutor need to know about the learner to classify their affect?**

• **how does the tutor get that information?**

• **which affective states are important to recognize?**

• **how does classification of state influence instructional decisions?**

Boredom (23%)  Confusion (25%)  Delight (4%)

Flow (28%)  Frustration (16%)  Surprise (4%)

Graesser and D'Mello (2012, in press)
• **Approach: learner configuration authoring tool**

• simple interface for authoring learner models

• tree structure driven by XML schema

• prevents learner model authoring errors by validating against the learner model XML schema

• provides ability to validate learner model using GIFT source w/o having to launch the entire GIFT architecture
GIFT’s Authoring Construct

• **Approach: sensor configuration authoring tool**
  
  • **Implemented sensors**
    
    • Affectiva QSensor
      
      • electro-dermal activity (EDA)
      
      • skin temperature and acceleration
    
    • Emotiv EEG
    
    • temperature and humidity mouse (custom)
    
    • Surrogate sensors for temp, humidity and assessment
  
  • **behavioral sensors**
  
  • **physiological sensors**
  
  • **state classification models**
  
  • **Sensors under consideration**
    
    • NeuroSky and ABM EEGs
    
    • Webcam (1Hz)
    
    • Zephyr heart rate monitor
    
    • Sonar distance sensor
    
    • Pressure chair (custom)
    
    • Pupil diameter (custom)
    
    • Design Interactive EmoPro
Passive Sensing – Q Sensor

Research question: what is the minimum set of sensors needed to assess engagement, workload, motivational level and emotional state?
- **Approach: clustering, classification & optimization**

**Growing Neural Gas Clustering Technique**

Reinforcement learning in Markov Decision Processes

\[
V^\pi(s) = E_\pi \{ R_t | s_t = s \} = E_\pi \left\{ \sum_{k=0}^{\infty} \gamma^k r_{t+k+1} \mid s_t = s \right\}
\]
• **Approach: Domain Knowledge File (DKF) authoring tool (DAT)**

  - simple interface for authoring DKFs
  - tree structure driven by XML schema
  - prevents DKF authoring errors by validating against DKF XML schema
  - provides ability to validate DKF content using GIFT source w/o having to launch the entire GIFT architecture
GIFT’s Authoring Construct

- **Approach: survey authoring tool**

- **author questions**
- **author surveys**
- **assign surveys**
- **present surveys**
• **Approach:** leverage elements of AutoTutor & AutoTutor Lite
GIFT's Authoring Construct

• **Approach:** game-based tutoring

• **prototype integration with VBS2**

• **real-time feedback**

• **learner model influences challenge level within game**

and now for something really interesting!
GIFT’s Authoring Construct

- **Hard to demo an architecture** – but here it is
- Completely **separable processes** using **standardized communications**
  - Developers need not be sensor experts AND Instructional Strategy experts
  - Each box an active area of research
- **Functional architecture** and **experimental platform**
- Ability to **author** questions
- Ability to pull in any content which is **web-enabled**
- Content developed here is directly pulled from **another trainer** (PEO-STRI)
  - The idea that you can latch ITS tech onto any trainer
  - Two things need to be written – assessments and feedback
    - “You bring the content, we bring the tutoring”
- Mission briefing developed with SME aid, things on the mission briefing are **assessments**
- Surveying the building
- In the event that you can’t assess something, you can directly ask (**authored questions**)
GIFT’s Authoring Construct

- Nighttime
  - Survey->sensorAssessment->TraineeModule->Ped->Domain->selected intervention
  - Sensor can turn it back to day (same information channel)
- Sensors can trigger instructional events
  - Cue the fog!
- [remediation Feedback] Selecting a door
  - These could all be within-game interactions with 1 line of code changed
- [remediation feedback] shooting the guy
- [Reflective feedback] clearing the room
- [2nd level remediation Feedback] shooting guy 2
  - Supports n levels of feedback
- [Feedback]
  - Note that these feedbacks are authored, have an authoring tool, and are stored in the ‘Domain Knowledge File (DKF)’. They are somewhat customizable
    - Mention SIMILE?
- Filling out a report (additional functionality supported by TUI)
- Experimenter questions
  - Authorable
- AAR
  - Can be fed via this information
- LMS
  - Data is stored about the student
GIFT’s Instructional Management Construct

Local tutoring processes

- Sensor Module
- Learner Module
- Pedagogical Module
- Domain Module
- Tutor-User Interface

Sensors

Learner

Training App Client

- Tin Can Interface
- Game Interface
- Simulator Interface

PAL VH Interface

Learning Management System (LMS)

Service-Oriented Architecture

Gateway(s)

- to/from Learner Module
- to/from Training App Client
- to/from Domain Module

- Team Performance State Model
- Team Competency State Model
- Team Cognitive State Model
- Team Affective State Model
- Team Trust State Model
- Team Communication State Model

Tutors for Trainees B, C…

1. Tutor asks a question.

2. Student answers the question.

3. Tutor gives feedback on the answer.

4. Tutor and student collaboratively improve the quality of (or embellish) the answer.

5. Tutor assesses student’s understanding of the answer”
• **Approach: model successes of expert human tutors to support pedagogy**

  - INSPIRE model (Lepper, Drake & O’Donnell-Johnson, 1997)
  - facts about human tutoring (Person & Graesser, 2003)
  - importance of questioning (Dillon, 1988)
  - relation between deep reasoning questions and exam scores (Graesser & Person, 1994)
  - nine events of instruction (Gagne, 1985)
  - politeness strategies (Person, et al, 1995)
GIFT’s Instructional Management Construct

• **Approach:** investigate the influence of learning class in selecting effective instructional strategies for computer-based tutoring

• **Learning Classes**
  - cognitive learning (Anderson and Krathwohl, 2000)
  - affective learning (Krathwohl, et al, 1964; Goleman, 1995)
  - psychomotor learning (Simpson, 1972)
  - social learning (Sottilare, et al, 2011; Soller, 2001)
  - hybrid learning
**GIFT’s Instructional Management Construct**

- **Approach:** leverage objective-task framework in **SIMILE**

  - **Student Information Models for Intelligent Learning Environments (SIMILE)**
  - standardized, adaptable, and generic mechanism for learner assessment in simulated training environments
  - middleware with tools for the creation of assessment models that are distinct and separate from the simulation itself

    - Example Shown: Model rules for applying a tourniquet in the TC3 vMedic Trainer
GIFT’s Assessment Construct

• **Approach: event report tool**

• post-hoc analysis tool

• provides a user interface to select important pieces of data from gift output file(s) such as the message logs, sensor data and IOS/EOS bookmarks

• creates a single output file (currently csv) with the selected events of interest

• output file can be consumed by third party applications for sorting by time, filtering by values, statistical analysis, etc.
Generalized Intelligent Framework for Tutoring (GIFT)

Description

GIFT is an empirically-based, service-oriented framework of tools, methods and standards to make it easier to author computer-based tutoring systems (CBTS), manage instruction and assess the effect of CBTS, components and methodologies. GIFT is being developed under the Adaptive Tutoring Research Science & Technology project at the Learning in Intelligent Tutoring Environments (LITE) Laboratory, part of the U.S. Army Research Laboratory - Human Research and Engineering Directorate (ARL-HRED).

Background

The technology gap for a reusable CBTS framework to support individual and small team tutoring was identified through a review of the intelligent tutoring systems (ITS) literature in 2009-2010 and the Training and Doctrine Command (TRADOC) formalized the Army requirement for GIFT in their Army Learning Concept (2011). GIFT was brought to practice in 2011 by the LITE Lab team. The first public demonstration of GIFT was conducted at the Interservice/Industry Training Systems and Education Conference (I/ITSEC) in December 2011. The first release of GIFT was completed in May 2012.

While GIFT is being developed to facilitate the use of CBTS by the U.S. Army, the intent is to collaboratively develop GIFT and have it function as a “nexus” for CBTS research being conducted within government, industry and academia.

Research Goals

Adaptive Tutoring research goals that are driving future GIFT development include:


References


Recommended Reading

- Woolf (2010)
- TRADOC (2011)
- Committee on Science Learning (2011)
Stuff we talked about...

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- How to get GIFT
- References
Thank you for your attention

Questions?