

# Workload-Adaptive Training Scenarios for Synthetic Training Environments



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# Introduction

- Enhancements in soldier training systems using synthetic training environments (STEs)
- STEs often encourage brute-force lesson based administration as it is very easy to create and save static scenarios
- Students need rich feedback and guidance
- Adaptive scenario administration is needed in STEs to enhance individual training effectiveness



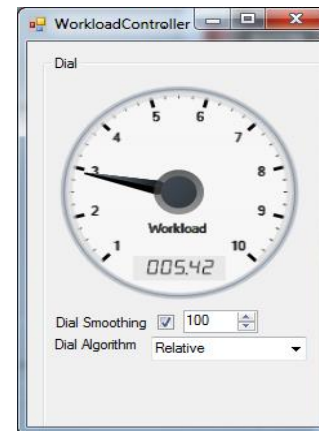
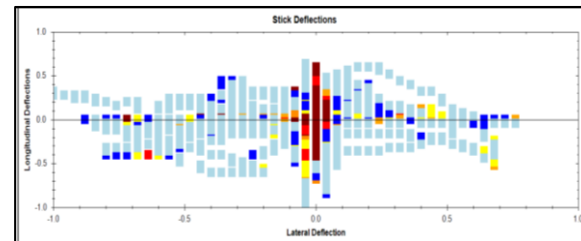
# Unobtrusive Physiological and Adaptive Training

- Adapts training according to trainee performance and workload
- Combination of GIFT, VBS3 and CATS
- Generalized Intelligent Framework for Tutoring (GIFT)
  - Computer-based adaptive tutoring system
- Virtual Battle Space 3 (VBS3)
  - Serves as the STE
- Cognitive Assessment Tool Set (CATS)
  - Workload quantification library
- GIFT learner affect classifier
  - Not used to invoke scenario adaptations



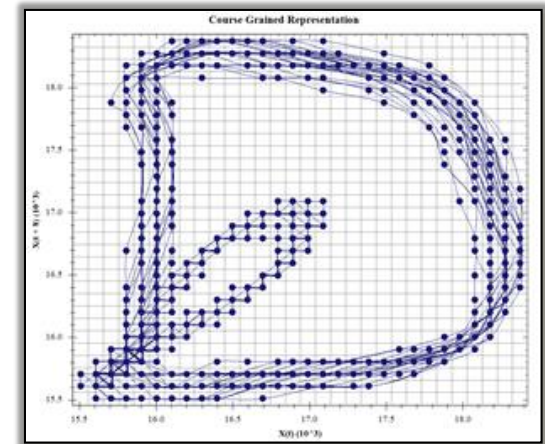
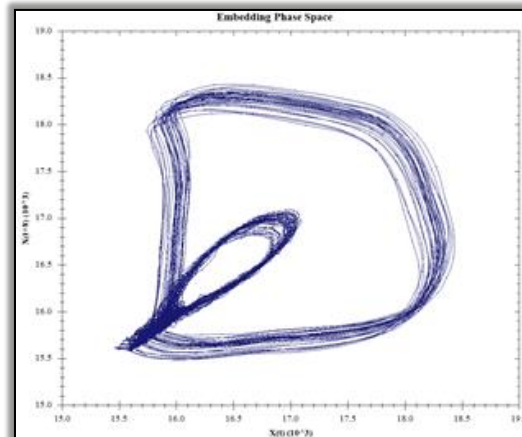
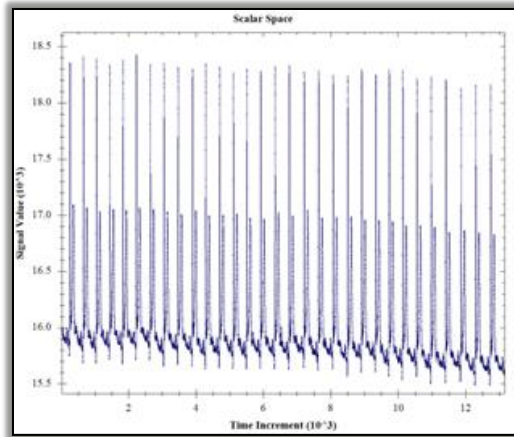
# Cognitive Assessment Tool Set (CATS)

- Relational database repository of all data
- Over a decade of physiological based assessment work
- For cognitive workload, preferred sensor is electrocardiogram (ECG) waveform
  - Proven workload assessment
  - NeXus 4 Bluetooth to monitor ECG (creator MindMedia)
    - Unobtrusive device for trainee
  - Deterministically nonlinear classifier



# Representation of ECG

- Normal scalar space time series (left)
- Embedding phase space (center)
- Course grained representation of phase space (right)
  - Numerical array to represent quantitative signature
  - Chaotic Physiological Classifier method (CPC)

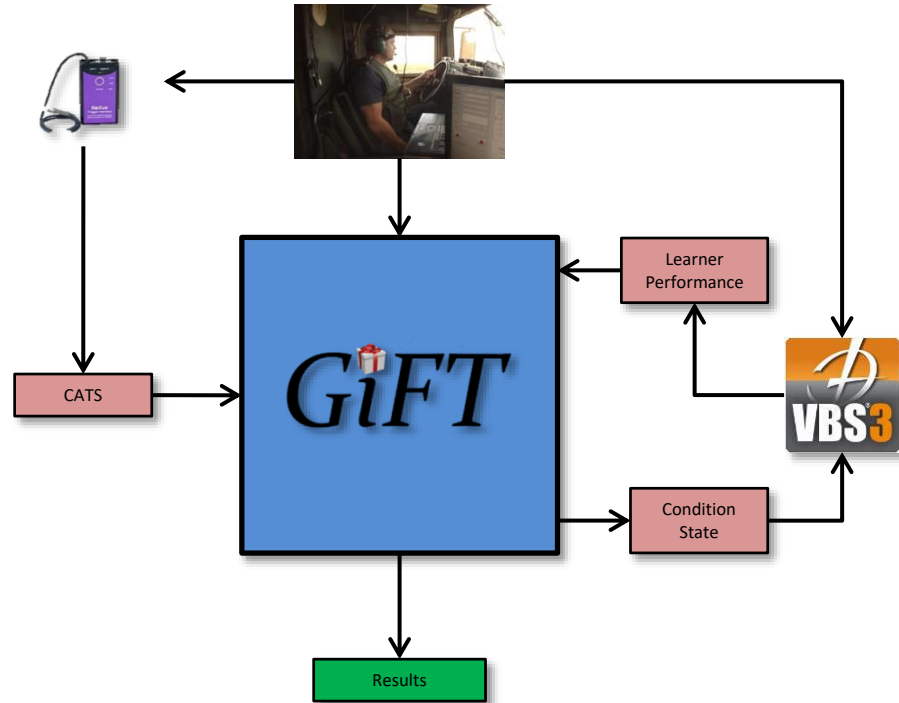


# Study

- This paper describes a study that we are preparing to conduct over the next few months
- The present study is intended to assess the value of adaptive training systems that use measures of subject workload
- We intend to test the hypothesis that adaptation using performance and workload (P+WL) will lead to better training outcomes than adaptations using performance only
- In this experiment, both groups (A and B) will receive task training using their respective P only or P+WL adaption scheme
- The effectiveness of that training will then be assessed in a graded capstone checkride

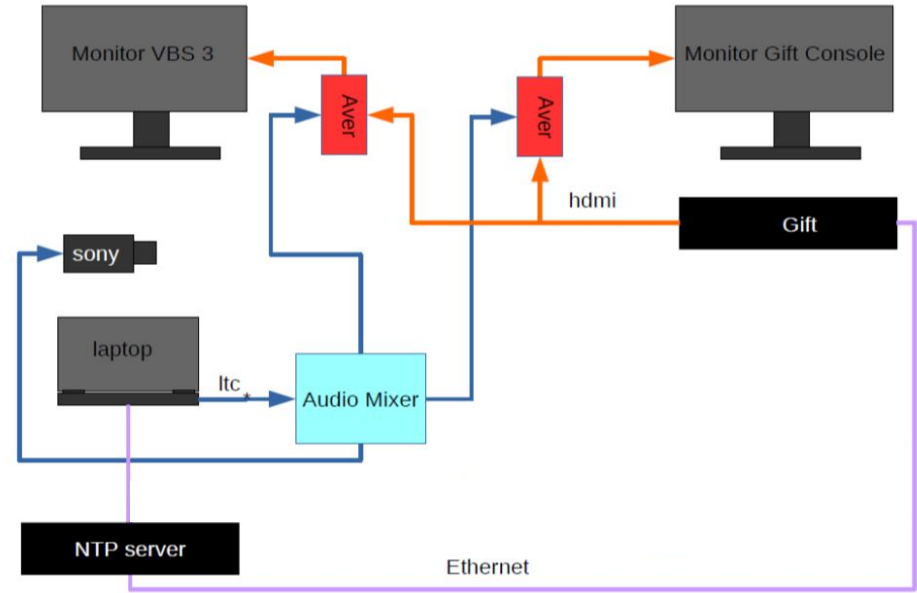


# UPCAT System Architecture



# Audio and Video Data Capture System Architecture

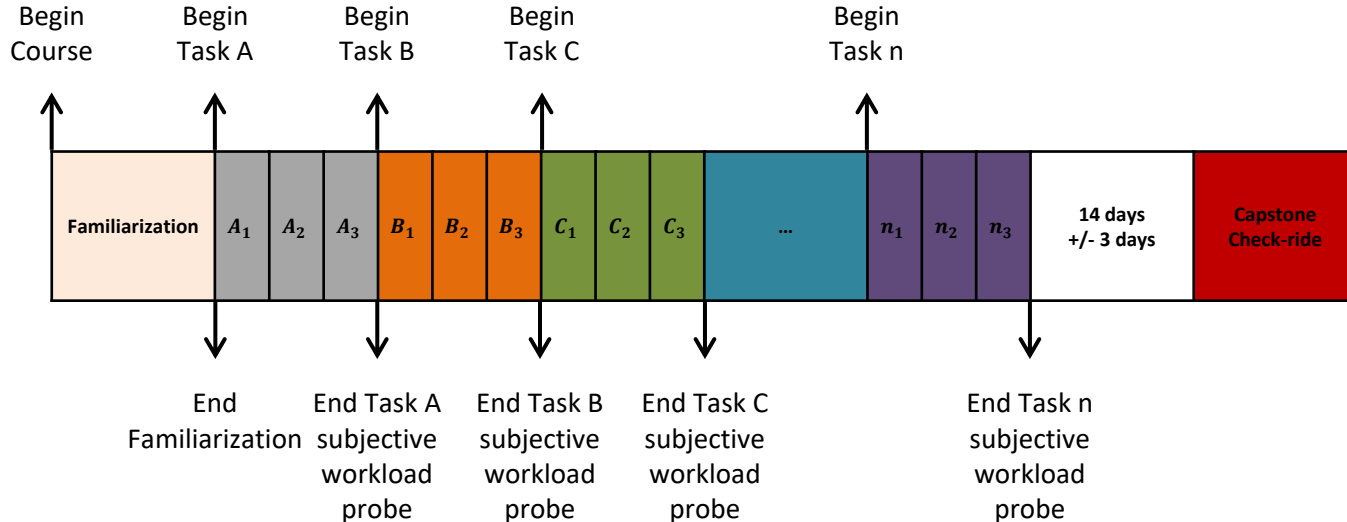
All audio and video from the Human Machine Interface (HMI) and of the subject is recorded and synchronized





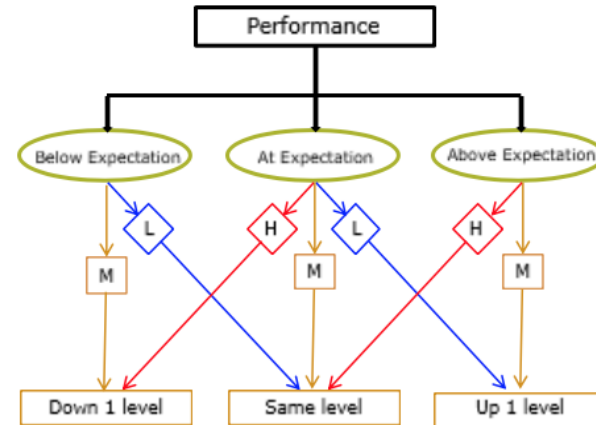
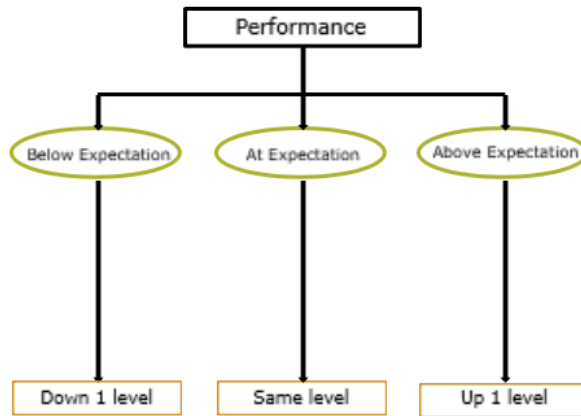
# Adaptive Course Flow

- Complete a number of tasks
  - Each task has three levels of difficulty
  - Periodically administer subjective workload probes



# Adaptation Decision Trees

- First attempt at the medium difficulty level ( $A_2, B_2, C_2, \dots, n_2$ )
- Each attempt is first classified based on subject performance score
- Adaptation for subsequent attempts follow the decision trees
- Tasks are completed when “Up 1 Level” is achieved at difficulty 3.



# Capstone Checkride

- One ever increasingly difficult task
  - All task elements from all previous part tasks
  - Continue through capstone checkride until they fall below performance thresholds
- Later failure being better than an early one
- Avoids ceiling or floor effects
  - Many or all participants pass or fail a checkride of a selected level of difficulty



# Condition Evaluation

- GIFT
  - Corridor Boundary Condition
  - OPL Workload Classifier
- VBS 3
  - Maintain Speed Condition
  - Collision Avoidance Condition
- VBS 3 maintained state variables
  - Corridor Boundary
  - Workload Classifier
  - Maintain Speed conditions



# Condition Evaluation

- Six new Environmental Control Enums

- One for each condition at each evaluation
  - CORRIDOR\_AT
  - CORRIDOR\_ABOVE
  - ...
- Work the same way as existing enums
  - FOG\_L1
  - FOG\_L2
  - ...

- Example

1. Subject has trouble tracking vehicle within the corridor
2. Corridor Boundary evaluates to *below expectation*
3. Corridor boundary *from anything to below* state transition strategy executed
  1. sends VBS 3 command ["*BELOW*"] call *setCorridorState*
4. State variable maintained by VBS 3 is updated to *BELOW*
5. The same happens for all evaluations and accompanying state transition strategies



# Evaluation: Maintain Speed Condition

- Graded through the use of a target speed and a speed window
  - If the subject is outside the speed window, they are evaluated to below expectation
  - If the subject is inside the center one-third of the speed window, then they are evaluated to above expectation
  - If the subject is between inner one-third and outside of the speed window, then they are evaluated to at expectation



# Maintain Speed and Corridor Boundary

- Called inside an event handler
- Event handler includes a timer
  - Evaluations only called at every evaluation interval
- VBS 3 maintains a timer for each of the below, at or above expectation evaluations
  - Elapsed times are added to their corresponding timers
  - The final evaluation for each is assigned based on percentage of total time spent in each state

Below/Total	At/Total	Above/Total	Evaluation
0%	0%	100%	<b>ABOVE</b>
0%	25%	75%	<b>ABOVE</b>
0%	50%	50%	<b>ABOVE</b>
0%	75%	25%	<b>AT</b>
0%	100%	0%	<b>AT</b>
25%	0%	75%	<b>ABOVE</b>
25%	25%	50%	<b>AT</b>
25%	50%	25%	<b>AT</b>
25%	75%	0%	<b>AT</b>
50%	0%	50%	<b>AT</b>
50%	25%	25%	<b>BELOW</b>
50%	50%	0%	<b>BELOW</b>
75%	0%	25%	<b>BELOW</b>
75%	25%	0%	<b>BELOW</b>
100%	0%	0%	<b>BELOW</b>



# Evaluation: Collision Avoidance Condition

- Graded through the use of upper and lower bounds
  - Fewer collisions than the lower bound
    - above expectation
  - More collisions than the upper bound
    - below expectation
  - Anything in between
    - at expectation





# Evaluation: Aggregate Performance

- Each task weights the evaluation of the three performance conditions differently
- Example: driving in reduced visibility, where the subject is evaluated on maintaining speed and corridor
  - Important to maintain speed
  - More important to stay within the corridor
  - $aggPer = 0.40 \times speedEvaluation + 0.60 \times corridorEvaluation$
  - Aggregate performance and workload evaluations used by the adaptation trees



# VBS 3 Evaluation and adaptation logic

- Controlled by various scripts and event handlers
- VBS 3 *init.sqf* compiles multiple scripts
  - Set-up global variables
  - VBS 3 waypoints
  - Create data collection files
  - Task, time, grading and GIFT message related functions
  - Event handlers
  - Evaluation of conditions
- Scenario adaptations are also contained within their own scripts



# Modified Corridor Boundary Condition

- The current GIFT Corridor Boundary condition does not allow an evaluation of above expectation
  - Concerned about fairness in the evaluations of the two groups (A & B)
  - Group A to reach an evaluation of above expectation and an adaptation of up 1 level
  - Group B's ability to reach the same adaptation through an evaluation of at expectation with a decreasing workload
- It works in much the same way as the Maintain Speed condition
  - If the subject is outside the corridor, they are evaluated to below expectation
  - If the subject is inside the center one-half of the corridor, then they are evaluated to above expectation
  - If the subject is between inner one-half and outside the corridor, then they are evaluated to at expectation



# Data Collection

- All data related to decision
  - Evaluation of the different conditions
  - Aggregate scoring
  - Adaptations throughout the course
  - Written to .csv files
- Each data point is timestamped with the system time



# Conclusions and Recommendations for Further Research

- GIFT learner affect classifier library (Ocumpaugh et al., 2017)
  - Uses a Microsoft Kinect sensor to classify learner affect
  - To date we are not yet able to gain a reliable classification
- Hard-coded commands are restrictive
  - VBS 3 allows for thousands of commands
  - Able to send multiple commands with a single call to *sendCommand()*
  - We believe the ability to create custom commands for use by state transition strategies to be an appropriate addition to GIFT
  - Add CUSTOM\_COMMAND enum to the list of GIFT Environmental Control Enums
  - The command(s) could then be written into, and read from, the course .dkf file



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