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Creating a scenario design workflow for dynamically tailored training in socio-cultural perception

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Abstract

The current operational context for military personnel necessitates development of nuanced perceptual skills, including the ability to identify and interpret a range of socio-cultural behaviors and patterns of life. To develop this capacity, we constructed the Virtual Observation Suite Demonstrator (VOSD), a simulation-based training platform combining extant simulation technologies, custom software components that enable system reconfiguration and expansion, and the Dynamic Tailoring System (DTS), a custom middleware package which adds trainee-specific scenario tailoring and feedback capabilities. Constructing socio-cultural perception scenarios, then planning dynamic tailoring to support and challenge trainees at different proficiencies, requires a complex workflow that integrates: 1) instructional design; 2) story-telling and narrative representation; 3) operational and socio-cultural subject matter expertise; 4) simulation engine implementation; and 5) identification of event alternatives, parameters, and subsequent configuration for tailoring. While instructional design for scenario-based training has been explored in detail, the additional considerations required to support dynamic tailoring introduce unique concerns. Planning tailoring options requires instructional expertise on the training efficacy tightly unified with knowledge of the technical capabilities of the system, as well as attention to maintaining narrative coherence and consistency. This paper discusses the current scenario development workflow used by our team to create prototype scenarios. We also identify and describe specific challenges and limitations for authoring, and outline preliminary recommendations for overcoming these issues in the future.

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*Keywords:*Scenario design; Simulation;Adaptive training; Perceptual–cognitive skills

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1. Introduction

Warfighters are constantly faced by the need to quickly assess a situation and make decisions under high pressure within a variety of complex situations and often with minimal information. Development of advanced perceptual-cognitive skills are vital for modern military operations, but formalized training in this area is still in its early stages. As part of the Office of Naval Research's Perceptual Training Systems and Tools (PercepTS) program, our teams have been working on simulation-based training for complex perceptual skills. The Virtual Observation Suite Demonstrator (VOSD) integrates off-the-shelf simulation technologies and tools with new custom middleware that handles communication between systems, as well as a Dynamic Tailoring System (DTS) that enables each trainee to experience a specialized version of the training scenario that both measures and adjusts to their individual proficiency at one or more skills.

The DTS is capable of automating the scenario implementation in response to performance data; however, current off-the-shelf scenario development capabilities and the ranges of potential tailoring opportunities demand that instructional/scenario designers must manually design a variety of tailoring options and scenario variations which can then be implemented into the simulation engine. A variety of considerations are added to the development process in order to accommodate tailoring, including concerns related to potential training effectiveness, narrative coherence, and technical coherence across all options. Furthermore, because this form of dynamic tailoring functions in a different manner from traditional branching narrative methods, these considerations and phases of the development process require additional design and development.

Within this paper, we will describe the current workflow used internally by our team to develop test scenarios, as well as to augment pre-existing military training scenarios with dynamic tailoring functionality. The current phase of effort involves planning and implementation for a first iteration of scenario development tools which can streamline the process. We will discuss the immediate next-step ideas and recommendations for these support tools, and address lingering concerns and risks that should drive further development of both the underlying tailoring system itself as well as user interfaces and resources for building scenarios.

2. The Dynamic Tailoring System

The VOSD incorporates training that goes beyond instructor feedback, after-action review, and other direct instructional interventions. In the VOSD, the scenario itself is tailored in real time to meet the needs of individual trainees and maximize learning. The Dynamic Tailoring System (DTS) [1,2] monitors trainee performance, estimates proficiency on multiple skills, and then carries out intrinsic instructional interventions [3], changing details of how the simulation plays out in order to provide individualized support or challenge without interrupting the flow of a scenario. Intrinsic tailoring can provide immediate feedback yet be less distracting, discouraging, or frustrating to trainees than direct feedback channels such as text error messages or spoken corrections. Tailoring in the DTS includes monitoring trainee performance, inferring reasons for performance observations, selecting instructional strategies based on inferred skill proficiency, and applying the selected strategy effectively in the context of an ongoing simulation. By this process DTS automates instructor tasks of controlling training scenario details so that the overall simulation practice delivers effective learning for trainee users.

During scenario design, the DTS adds two functional options to designers and authors for scenario development. First, authors can specify how the scenario should change for different trainees with different skills and mixes of skill levels. Second, the authors can use DTS to control hints or other repairs in case trainees stray too far from the optimal path of a training scenario. Using the DTS to automate tailoring also places constraints on scenario design that ensure new scenarios are driven by instructional principles and align with training needs for specific skills.

3. Scenario development workflow

Due to the nature of the proficiency-based variation offered by DTS, the process of designing and developing a scenario differs from standard simulation-based authoring, and even diverges from authoring for traditional narrative branching. In addition to narrative and storyboarding, tailoring considerations also play a role in outlining a new scenario. Thoughtful scenario design will enable tailoring that enhances learning while incorrect design can bog down nontechnical authors in unwanted details [4].

3.1. Initial scenario framework

The first phase of scenario planning requires instructional and subject matter knowledge in order to set up the core factors, or framework, of the scenario. The framework identifies the objectives and requirements for the scenario, establishes the high level parameters and supporting information for the scenario, and outlines the default narrative progression of the scenario (i.e., the key sequences of events that drive the scenario action, and which all trainees should experience). Our scenario framework phase resulted in the following products, some of which are necessary to future phases and some of which are optional but can prove helpful, especially for larger teams or more complex scenarios:

- *Training or learning objectives (Required)* – In addition to driving the content, these must be identified in order to establish the trainee proficiency model within the DTS; they should be described as specifically as possible; tasks which can be directly measured via input to the simulation system are ideal to reduce facilitator workload and develop a more accurate profile.The design of the skill model is simplified to reduce authoring burden [5]. All DTS needs to know at this stage is a list of skills; no relationship graphs or link weights introduce technical barriers to entry or sensitivity to incorrect definitions.
- *Scenario narrative (Required)*– This should identify the mission parameters, relevant contextual information (i.e., supplemental background information which would be provided during a mission briefing), and set up all of the major characters and the sequence of key events.
- *Trainee tasks/performance observations (Required)*– During the course of the scenario, what is the trainee expected to accomplish and how can the system observe the trainee's performance? The DTS is capable of monitoring the state of simulated world events, characters, and actions the trainees take in the world. The author must define how these should be interpreted as observations of trainee skill. Typical definitions include a cue, an action, and a time limit for that action. If the trainee completes the specified action after the cue and before the end of the time limit, this is often described as evidence in support of proficiency at one skill or another. More detail on defining these in a general observation representation is available in [6].
- *Storyboards (Optional)*– Storyboarding involved drawing out maps of the scenario location with key locations labeled, and roughly indicating positioning and movement of key characters. Because the training context for these scenarios was based on perception and observation, we found mapping locations and paths of action quite helpful to ensure control over whether the trainee would or would not be able to see key individuals and events.
- *Approved asset manifest (Optional)*– As not all of our scenario development personnel were familiar with the locations or context of the scenario, we assembled documentation with thumbnails and filename/location data for usable assets in VBS2's asset library; these could be either approved or rejected by subject matter experts as appropriate for the general location, or as good fits for specific key locations and actors. Based on approvals, a final manifest can be compiled for reference by personnel building the scenario in the simulation's editor. However, if individuals constructing the scenario have subject matter knowledge this step may be unnecessary.

These products feed into the next two phases, which in distributed development can be done simultaneously: the tailoring design, and the implementation of the basic scenario into the virtual environment. At this phase, the simulation can be populated with the relevant terrain, buildings, characters, and vehicles, and the scripting required for the "default" narrative can be implemented. Further variations will be added onto this later based on the tailoring design. We do not discuss the virtual implementation here as it is standard, and dependent on the simulation environment's capabilities and constraints. The following section describes how tailoring is designed for a scenario.

3.2. Tailoring design

The Dynamic Tailoring System controls tailoring with a string of pearls representation [7]. As a computer program, the DTS is capable of tracking convoluted interactions and branches in a scenario story. However, instructor-mediated design patterns [4] suggest that end users, including both scenario designers and instructors who need to understand and control scenario execution, are not interested in laying out and maintaining such convolutions. Instead, the complex tasks of copying configuration back and forth, tracking differences between branches, and making changes in multiple places are all examples of authoring tasks that would be likely to induce errors in tailoring. As a result, cognitive ergonomics principles suggest that the string of pearls in DTS makes authors more able to correctly express the kinds of tailoring that they need for a useful scenario.

As opposed to the typical usage of string of pearls, wherein the metaphor might describe how a trainee can change a scenario, we use the string of pearls in the DTS to describe how an author can exercise control in advance of scenario execution. The string of pearls refers to a scenario structure wherein a single overarching storyline, the “string,” passes through any number of “pearls.” Each pearl represents a branching out of possible scenario events into not just two or three paths, but a whole sphere of possible directions representing the different interacting choices of the DTS. Then after branching out, the many paths of each pearl arc converge back toward each other, so that by the end of the pearl all possible paths have rejoined the overarching scenario. In the VOSD implementation, the different ways the DTS can tailor the scenario do not create permanent branches in the string, so that the author does not need to coordinate similarities and differences across branches and does not need engineering-level knowledge of the system to decide what variables to change when.

3.2.1. Process for designing tailoring options

The first level of tailoring will be explicit prompts or corrections that trainees should receive when they do not perform key tasks. Trainees will likely have to perform many tasks during the scenario, so prompting or correcting explicitly for every instance is not optimal. Therefore, we identify some of the key tasks where trainees might make errors; once identified, the types of errors most likely to occur can be estimated. Scenario designers can then develop audio messages and/or visual cues which can prompt the trainee to perform the desired action. Audio messages from fictional unit members (e.g., a secondary observation point in the area) can also serve to fill in or identify information the trainee missed.

The more complex element of tailoring a scenario for proficiency is in the often subtle, ongoing adjustments to the scenario content intended to match the trainee’s current proficiency level, i.e., creating additional challenges for a trainee who performs well, or providing support for trainees at a novice level. Scenario content types that DTS can

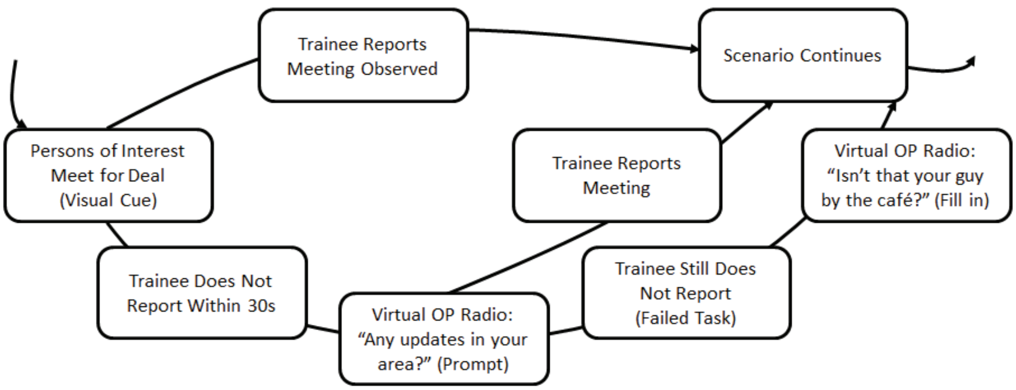

Fig. 1. Example of scenario task flow with optional direct audio prompt for repair.

currently tailor include manipulation of event outcomes, non-player character kinesics and proxemics, and simple narrative manipulations such as the location of an event [1]. DTS can change event locations and durations to make them easier or harder to observe. Individual gestures and behavioral cues can be tailored in their magnitude relative to nearby masking behaviors or clutter. Finally, events such as radio communications or scripted character interactions can be injected purposefully to draw trainees' attention toward a key event or to distract. Together, these tailoring modes can not only increase or decrease challenge in a scenario, but also subtly cue trainees as to appropriate performance for the purpose of instructional strategies such as scaffolding and fading [8]. These forms of tailoring are not tied to an individual task. Instead, the DTS' aggregated proficiency evaluation for different training objectives or skills indicates to the system whether it should consider executing an average, helpful, or challenging version of the scenario content at a given event.

The initial step is to select key events within the scenario where we would like to introduce variation, or where we anticipate that the scenario should preferably be matched with the trainee's proficiency level. Specifically, we isolate key events for our targeted training objectives and then define whether trainees might need additional support or increased challenge. The selected events can either be groupings of actions or smaller, discrete aspects. Tailoring smaller actions or portions of an event can potentially result in a greater degree of variation with more efficiency, or at a level more targeted toward proficiency in specific skills.

Once opportunities for manipulating the scenario are identified, there are multiple available options for how the scenario content can vary. Currently, the DTS and the design workflow categorize tailoring variations across three major properties:

- *Helpfulness*, i.e., providing information or recommendations relevant to the learning objective (in-situ coaching)
- *Simplicity*, i.e., altering the difficulty level of a particular task
- *Predictability*, i.e., generating less obvious effects from causes, or presentations that vary from standardized "textbook" exemplars (this can be especially relevant in training social perception or participation, or within complex and volatile situations)

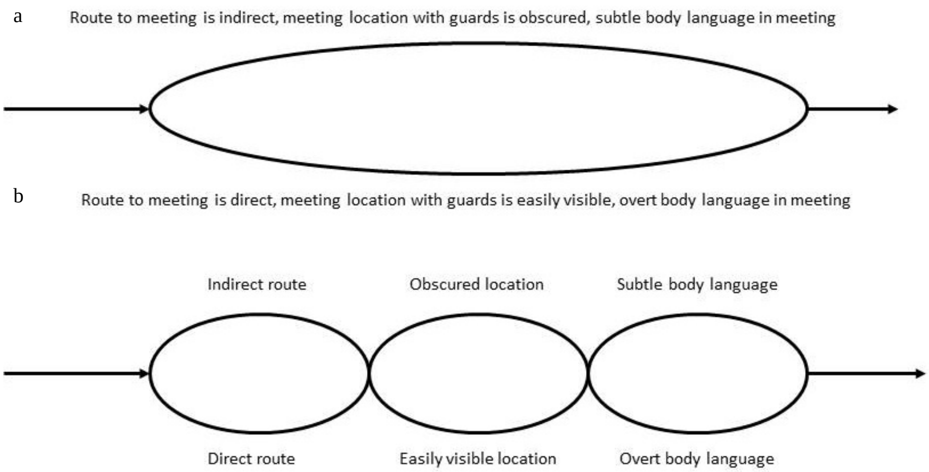

Fig. 2. Two alternate tailoring options for a single meeting event. Version (a) groups the entire meeting arc into one "challenging" version on the upper path and one "simple" version on the lower half. Version (b) breaks the individual meeting into multiple actions with a "challenging" and "simple" variation for each; if this event involves multiple skills where the trainees might have different proficiency levels, then there are 8 different potential variations trainees may encounter rather than 2.

Scenario design should attempt to include alternatives at various levels of these properties for each learning objective. Then, during execution of the scenario, the DTS can choose the most apt option (from those available at that point in the scenario) based on ongoing observations of the trainee.These three categories should be organized based on whether we anticipate trainees requiring support or challenge. For instance, increased trainee support can be achieved by higher Helpfulness, higher Simplicity, or higher Predictability. Increased levels of challenge can be achieved through lower Helpfulness, lower Simplicity, or lower Predictability. Based on the relevant H/S/P settings, the next step is to diagram potential variations for each key event. Each of these variations are linked to relevant training objectives and skills within a hierarchy of learning objectives and estimated proficiency [6].

3.2.2. Status and current issues

A few technical considerations remain that scenario authors must take into account when developing pearls. Considerations include the currently-supported scope of event effects, timing design, and understanding of the particular skill training domain.

First, under the string of pearls paradigm we require that event effects do not persist after the close of a pearl. Tailoring is not permitted to change material facts about the storyline, because any change would make later pearls mismatch depending on the previous paths chosen. The import of this limitation can be counterintuitive in that it depends on what facts are material within a scenario. For example, one way to tailor a terrorist attack might be to make it more or less deadly in terms of how many people in a crowd are casualties versus how many flee the area. The outcome of this life and death decision might actually be considered immaterial to the rest of the scenario as long as the training does not require future interaction with any characters whose lives are in the balance. On the other hand, another pearl might involve tailoring how easy it is to observe a character by making him walk on one side of the street or the other. Even this small change might be considered material if it places the character out of position to execute the next pearl following the one that is tailored. Currently, authors must manually check character positioning at pearl ends so that tailoring does not result in misalignment. In future work, we plan to automate tasks at the fine-grained level of character position and direction. This will reduce the requirement for authors to track event effects.

Second, it is often useful to make some paths through a pearl have a shorter duration than others. For example events with reduced duration might challenge a trainee's observation ability while a longer duration or even repetition of the event might support trainees. However, such changes introduce problems in the VOSD whenever DTS is directing more than one string of pearls (execution threads) simultaneously. Multiple threads are a powerful way to reduce author workload while conserving the DTS's ability to balance training tradeoffs and choose between tailoring more than one aspect of an event at once. For example, an author might want to define tailoring that targets four different trainee skills with either support or challenge. To use only a single string of pearls, the author would need to lay out and line up all sixteen possible combinations in order to define all the paths through the pearl. On the other hand, using multiple parallel strings enables authors to define four binary choices and then let the DTS choose and handle the details of how they interact. In the current implementation, multiple threads through a single pearl must all have the same duration. In order to achieve equivalent durations,we use "holding patterns" that make individual characters align with the require timing despite variable actions. We also allow entire pearls to be skipped in the case that they are not vital to the overall story. In future work we plan to improve timing communication "behind the scenes" between strings so that authors do not have to maintain pearl timing but can let the DTS automate that task.

Third, and fortunately less technical, DTS requires that scenario tailoring be associated with particular knowledge of trainee skills. This requires an understanding of the training domain during the scenario design process. In effect, scenario authors use the tailoring specification to capture their expert knowledge of how individual event changes will modify the trainee experience and impact learning. As such, the scenario design process requires, before the design cycle begins, a defined taxonomy of skills that trainees will exercise in the scenario, standards to which those skills should be demonstrated, and conditions under which they can be tested. Making this knowledge explicit helps authors ensure that scenario design aligns with established training goals. While we do not plan to remove this requirement, future work may ease the authoring burden with a learning objectives editor as part of the authoring tool suite [9].

4. Scenario testing and validation

Individual behaviour scripts and pearls can be tested iteratively over the course of development, and significant integration and testing time should be built into the development schedule for testing the entire scenario once it is assembled and the DTS configuration is fully specified. Because of the granularity at which character movements are currently defined in the virtual environment, continuity errors are possible. The author needs to ensure that the new pearl does not end with a character out of place or unable to carry out the next required action. This issue is commonly understood and recognized in computer game development, because the specifications of art assets, terrains, and behaviors can often only be fully tested for continuity after development. We have developed a tool to allow designers to “unit test” the tailoring design prior to integration in order to ensure that the tailoring specification can be verified earlier in the process, prior to integration. In future work, we plan to automate authoring further by defining character movements at a higher level of abstraction and introducing a planning or constraint satisfaction component to repair any inconsistencies at runtime or alert the author to them in advance.

5. Recommendations and next steps

Moving forward, there are several logistical and usability improvements under consideration. We have identified several short-term needs and recommendations, as well as some remaining gaps which could be addressed over the longer term. With the core string of pearls functionality and proficiency-based option selection functioning, further work can emphasize efficiency in authoring and greater flexibility in trainee adaptation.

5.1. Improved usability and authoring tools

The most acute authoring need is a designer-centric interface and process for authoring. Currently tailoring options for pearls are manually defined in a spreadsheet. This approach allows the necessary data to be mapped out for tailoring by any user familiar with Excel, but can introduces a somewhat significant learning curve due to the complexity of the data. We are exploringopportunitiesfor a GUI-based authoring suite, perhaps using flow-chart style visual design to represent key events and pearl variations. We are currently working on an “interactive storyboard” tool where sketches or other images can be linked to key events and pearls defined within the DTS and the user can progress visually through the scenario before any virtual environment development has begun. This would improve the ability for scenario designers to get a visual snapshot of the scenario flow, as well as to potentially test out rough timing and progression options prior to implementation into the virtual environment.

5.2. Additional pearls to support training variety

While variations directly intended to address trainee proficiency are a valuable addition, it may be useful to consider additional variations for the sake of more broad and, therefore, realistic cue presentation. Particularly for complex subject areas, the presentation of varied cues can not only keep training fresh but also may support better transfer of training [10, 11, 12]. While the link to proficiency may be relevant (e.g., by saving such variations for more proficient trainees who have already grasped the core concept so as not to introduce confusion), pearl variations defined via more than proficiency level could offer even more robust training options. The development of more intuitive and simple authoring interfaces, as discussed above, will likely make creation of additional pearls for this type of variation more feasible.

5.3. Improved abstraction

The current implementation of DTS and handling of pearls, as mentioned earlier, introduces some issues related to equalizing or maintaining status across pearls. In addition, at the moment control must often be exercised at a very specific per-character level. Some of these issues could be eased with use of a virtual environment supporting more robust AI than our current development environment. However, support within the DTS and VOSD for additional abstraction regarding character or environmental states, or higher-level control such as the assignment of entities to groups and allowing manipulation of specified percentages of that group, could potentially offer richer, more flexible opportunities for variation while also streamlining efficiency in the authoring process.

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