Game-Based Training for Complex Multi-Institutional Exercises of Joint Forces

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Abstract. This paper presents a new concept for modular, Web-based training tools for complex, multi-institutional joint forces exercise scenarios, based on the motivational principles of digital game based learning (serious games). In multi-national, large-scale exercises for NATO Joint Intelligence, Surveillance, and Reconnaissance (JISR) various participants in different roles and backgrounds must understand the processes and information flow between the participating heterogeneous hardware systems and software appliances. The high variability of multi-dimensional requirements result in the need for pre-exercise preparation and training tools. Further, participants must be motivated to engage in the preceding training activities. This paper presents the modular concept for the game-based exercise training tool as well as its application for a real exercise scenario.

Keywords: assistant systems; serious games; modularity; joint training

1 Introduction

In multi-national, large-scale exercises for NATO *Joint Intelligence, Surveillance and Reconnaissance* (JISR) [9] various participants in different roles with different backgrounds must understand the processes and information flow between the participating heterogeneous hardware systems (e.g., air-borne drones) and software appliances (e.g., image processing tools). The high variability of vertical (different roles) and horizontal (varying complex interactions) requirements result in the need for pre-exercise preparation and training tools. The objective of these multi-national exercises (e.g., NATO interoperability projects CAESAR or MAJIIC) is to improve the overall interoperability between the technical systems of the partnering nations. For these complex exercises thorough preparation of the participants is needed to effectively conduct the exercise and reach all objectives. People with different professional backgrounds (e.g., civilian managers or army personnel) and roles (e.g., officers or trooper) must understand the exercise plans be able to answer the questions how, when, and why certain systems are directly or indirectly interconnected. Complex data and information processes

must be handled and understood. Although the exercises are normally thoroughly planned in advance, the often conducted last-minute changes and hotfixes revealed the need for adapted preparation and training tools. Additionally the given pre-exercise documentation is too voluminous to be thoroughly studied by all participants. This raises the need for effective training tools which intrinsically motivate the exercise participants to conduct pre-exercise preparation and even on-site training (learning about the processes and information flow while the exercise is running).

The solution approach is to provide the participants with a game-based learning and training solution which is adapted to the exercise scenarios. This paper presents a new approach for a modular and adaptable game-based learning concept, called Exercise Trainer (EXTRA), which exploits the motivational aspects of serious gaming. Serious games introduce narratives and playful components to computer simulations or assistance systems to increase the users motivation to interact, e.g., by keeping the user in the *flow channel* and to increase their immersion [3,6]. The objective of EXTRA has been the development of technical and content-wise modular, game-based training concepts for interoperability exercises which can be easily adapted to changing requirements.

Our contribution is the concept for adaptable, modular concepts (technical and content-wise) for game-based training tools which target interoperability aspects, and the results of technical studies how to implement such training systems as Web-based applications using scenario description languages.

2   Related Work

Assistance and training applications for the handling of system-of-systems tasks have long been an active research topic. For example, the mobile scenario assistant SCENAS assists with the automatic configuration of complex systems for demonstration scenarios [8]. Furthermore, substantial results have been shown in the field of emergency training with game-based learning techniques [2,7].

Immersive training environments, i.e., digital game based learning systems (serious games), are increasingly being used by the military to provide training on a range of skills, team operations, navigation and route clearance, operationally relevant language skills, small unit tactical operations, and mission rehearsal [5].

So far, we could not find a combination of game-based technologies with scenario or exercise training applications for the military domain. In particular, the approach to combine scenario description languages and game-based learning as a training tool for multi-institutional exercises has not yet been presented.

3   Modular Game Design Concept

A modular (serious) game design concept allows authors to easily exchange parts or efficiently create new games. The goal is to achieve modularity on multiple levels to allow for an easy and effective transfer to other application scenarios.

Our game design [1] follows Prenskys proposal [6] to first define your audience and your learning objectives in order to find the ideal game genre which matches both, and therefore leads to a high rate of acceptance. The proposed modular game design concept is based on a structural design pattern approach to break down the concerns of the game design process for an exercise trainer, as proposed in this work, into three levels: technical, scenario and game level. Besides the breakdown of concerns at the game design process an additional modularity comes in by using standardized scenario representation formats.

At the technical level the general structure (business processes) of the exercises is modeled using standard modeling formats and tools from the *Modeling and Simulation* domain. We propose to use SysML [4] with the *XML Metadata Interchange* (XMI) format, which allows for effective interoperability of the UML2-based models. The interoperability is needed for the implementation of EXTRA as a generic training tool which must be flexible towards varying scenarios and game mechanics.

The scenario level entails the modeling of the actual scenario (e.g., roles or processes) which differ between different exercises. Whereas the actual scenario varies, the underlying technical model does not necessarily need to be modified, if the technical description of the processes and data flows remains the same (e.g., same business processes).

The game level imposes narratives, playful interactions, game mechanics, etc. on the scenario. In the case of EXTRA we propose to use a scalable game design based on logistics processes (details in the next sections).

4   Exercise Trainer (EXTRA)

The aforementioned modular game design concept for the Exercise Trainer (EXTRA) has been implemented to empirically verify its feasibility and flexibility towards changing requirements.

For our game design we used military terminology and metaphors which reflect the real JISR systems as game models, e.g., a factory paraphrases a processing unit, a market place paraphrases a data distribution facility. The semantic encoding of the metaphors ought to be obvious to the users, because non-intuitive object names could lead to an aggravated understanding which could negatively influence the playing experience. The EXTRA game concept is designed as an isometric, browser-based, turn-based simulation game (Fig. 2). The game objects can easily be exchanged to reflect other application scenarios. However, the general shape of the game is fixed to games for training of processes which can be reduced to logistics or business processes. The complex roles, activities, and processes, as well as the technical system-of-systems structure of complex and large scenarios are abstracted to a flexible game world, in which one has to build factories and logistics infrastructures (e.g., Fig. 2).

The definition of the learning objectives has been conducted in close cooperation with experts in NATO multi-national exercises, i.e., participants, operators, and planners. The main learning objective of EXTRA is to provide the

users with information on the scenario and train them in preparation for the planned exercise. Of core importance is the mediation of knowledge on how the whole scenario is designed (macro-perspective), i.e., the involvements and interconnections of the (sub-)systems. Two main levels for the learning objectives in EXTRA have been identified: technical and procedural knowledge transfer. Whereas the technical view explains which systems are interconnected in which way, the procedural view looks at the different roles, processes, and activities. In the procedural mode EXTRA must mediate knowledge how a business process is modeled and executed. As an example, this could be the training of a process on imagery-based reconnaissance which includes the activities tasking, collection, processing, exploitation, and dissemination.

The goal of the game is to satisfy demanding "customers" (metaphor for essential users) with their changing product requests (metaphor for information requests) by constructing optimal logistic chains (metaphor for data or information interconnections) to optimally distribute the products to the markets. The narrative is called "Boston Harbor". It plays in a fictitious Boston, where at the famous harbor demanding international customers request certain products. A high-score contest motivates the players to repeatedly play the game as optimizing the logistics and optimally satisfying the customers demands increases the score (consisting of reputation and gold). When the demands are not satisfied in time, the score decreases; if the score drops to zero the game is lost. The learning objects are interweaved with the gameplay for not to impair the immersion. Hence, the terminology and characteristics of factories or connections reflect real world systems, and the gameplay transparently supports the training and the receptive knowledge transfer.
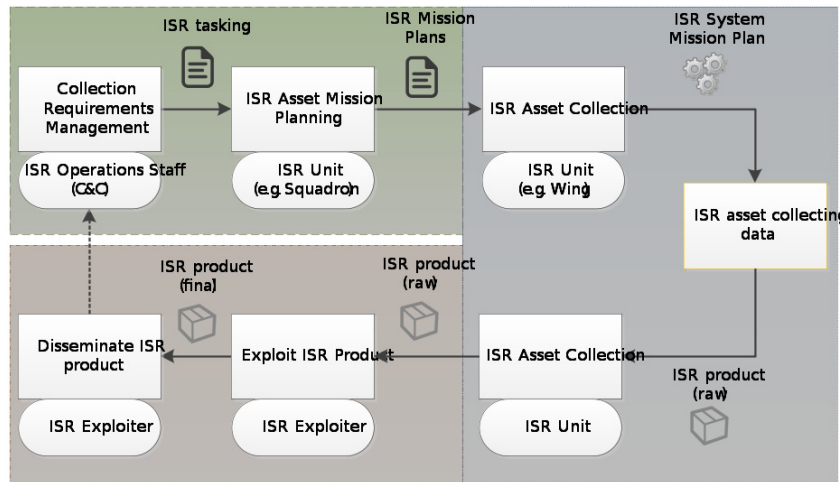

Fig. 1. Example process for a joint exercise for image acquisition with input handling (top left box), processing (right box), and output handling (bottom left box).
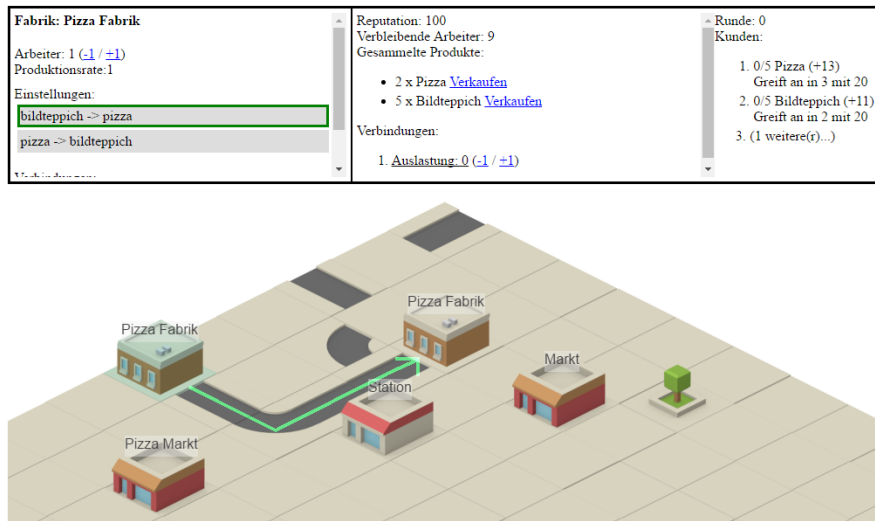
Fig. 2. Prototypical implementation of the EXTRA concept showing a cut-out of the running game (image sources from www.kenney.nl).

5 Application Example

We realized the EXTRA concept for a NATO multi-national joint exercise in 2015. Basis for the modeling of the scenario were exercise plans and general handbooks on NATO joint training exercises. The extracted example process for EXTRA is depicted in Fig. 1. It shows a high-level JISR example for an imagery acquisition process. The process starts with the collection requirement (i.e., what to collect intelligence for), to the asset mission planning (i.e., which sensor to task), to the actual acquisition and processing of data by an asset (e.g., a Recce Tornado), to the output handling with exploitation and dissemination.

In EXTRA this process has to be recreated in the game by the user using the available factories, market places or logistics centers and route types from the game inventory (Fig. 2). The user achieves the game's goal by collecting as many score points as possible. This can be achieved by optimally placing and interconnecting the available facilities, i.e., optimal according to the scenario description and technically verified by the game controller on basis of the underlying (technical) scenario model.

The concept proofed to be flexible to changing requirements. In a real application case, the learning objectives changed substantially. Whereas the original concept covered mostly technical aspects, the revised concept had to cover also procedural aspects. However, the changes in the game design concept could be kept minimal, since the game design is based on the modeling of logistics (business) processes. By adjusting only the metaphors for the game objects the game design could be easily adapted.

6   Conclusion

This paper presents a new concept for modular, Web-based exercise trainers for joint training scenarios based on the motivational principles of digital game based learning (serious games). In multi-national, large-scale exercises for NATO Joint Intelligence, Surveillance and, Reconnaissance (JISR) various participants in different roles with different backgrounds must understand the processes and information flow between the participating heterogeneous hardware systems and software appliances. The high variability of vertical and horizontal requirements results in the need for pre-exercise preparation and training tools. The application example of the implemented EXTRA concept for a NATO multi-national joint exercise according to a given exercise plan shows the feasibility of the presented concepts. Preliminary empirical application results show the flexibility of the concept towards changing requirements. The transfer of the EXTRA concept to other domains is subject of future work. Also, an evaluation is in preparation to verify the user acceptance and the learning effectiveness of EXTRA.

References

1. Crawford, C., Peabody, S., Art, T., Web, W.W., Loper, D.: The Art of Computer Game Design. Computer p. 81 (2003)
2. Crichton, M., Flin, R.: Training for emergency management: Tactical decision games (2001)
3. Csikszentmihalyi, M., Abuhamdeh, S., Nakamura, J.: Flow and the Foundations of Positive Psychology. Springer (2014)
4. Friedenthal, S., Moore, A., Steiner, R.: A practical guide to SysML: The systems modeling language (2008)
5. Hussain, T.S., Roberts, B., Menaker, E.S., Coleman, S.L.: Designing and developing effective training games for the US Navy. M&S JOURNAL p. 27 (2012)
6. Prensky, M.: Digital game-based learning (2003)
7. Stolk, D., Alexandrian, D., Gros, B., Paggio, R.: Gaming and multimedia applications for environmental crisis management training. Computers in Human Behavior 17(5-6), 627–642 (2001)
8. Streicher, A., Szentes, D., Roller, W.: SCENAS - Mobile Scenario Assistant for Complex System Configurations. In: Int. Conf. on Theory and Practice in Modern Computing, MCCSIS 2014. pp. 157–165. IADIS, Lisbon, Portugal (2014)
9. US-Joint-Publication: Joint Intelligence (2007)