An Adaptive and Customizable Feedback System for VR-Based Training Simulators

(Short Paper)

Maite Lopez-Garate
CEIT and Tecnun,
University of Navarra.
Manuel de Lardizabal 15, 20018
San Sebastián, Spain
0034-943-21-28-00
mlgarate@ceit.es

Alberto Lozano-Rodero
CEIT and Tecnun,
University of Navarra.
Manuel de Lardizabal 15, 20018
San Sebastián, Spain
0034-943-21-28-00
alozano@ceit.es

Luis Matey
CEIT and Tecnun,
University of Navarra.
Manuel de Lardizabal 15, 20018
San Sebastián, Spain
0034-943-21-28-00
lmatey@ceit.es

ABSTRACT

This paper describes a proposal to build an intelligent feedback selection system for Virtual Reality-based training simulators. The system is aimed at generating multimodal feedback in real-time for advising the students while training with the simulator. Focused on driving tasks, we analyze how to customize the system to exhibit different behaviors. We examine educational and human factors that have influence on the behavior, so that the instructors can use or refine the behavior they prefer in each training session. The selection process is based on the analysis of the information coming from a diagnostic component and adapts the feedback to the performance of each student, since the process takes into account whether previous feedbacks were ineffective. The objective is to emulate the behavior of the instructor. In this way, the feedback system can be helpful for him/her, as while the system decides which the appropriate feedback is, the instructor can focus on other instructional tasks.

Categories and Subject Descriptors

I.2.11 [ARTIFICIAL INTELLIGENCE]: Distributed Artificial Intelligence – *Intelligent agents.*

Keywords

Feedback system, simulators, adaptive, customizable, training, VR

1. INTRODUCTION

Traditionally, the area of Virtual Reality (VR) has pointed out the training systems as one of its more obvious practical applications. It has been used in diverse fields such as surgery [4] or simulation of in industrial environments[6]. One of the multiple advantages offered by this kind of training is that people can practice tasks that are potentially dangerous in secure conditions. In addition, it reduces the costs that the training in real environments implies.

Cite as: An Adaptive and Customizable Feedback System for VR-Based Training Simulators (Short Paper), Maite Lopez-Garate, Alberto Lozano-Rodero, and Luis Matey, *Proc. of 7th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2008)*, Padgham, Parkes, Müller and Parsons (eds.), May, 12-16., 2008, Estoril, Portugal, pp. 1635-1638.

This study is focused on the use of VR-based simulators for educational purposes. Specifically, a truck simulator is used as a demonstrator. The simulator allows the student to feel like driving a real truck and will be presented in section 2.

Although the use of simulators has positive effects on learning, a lot of work is still to be done in order to maximize its benefits. For example, the control of the training sessions can be difficult in complex domains like driving. The instructor has to monitor a great number of parameters and analyze them to determine the performance of the students. Then, the instructor interacts with them to provide assistance if necessary. However, real-time simulators generate much more information than other traditional computer-based learning systems. It is, therefore necessary to provide the instructors with tools that facilitate their work.

The study presented in this paper is aimed at automating the process of giving feedback to the students during the training sessions. The feedback system has to extract from the data coming from the simulation those events that are significant enough to communicate with the student, and also, decide how to do it. This functionality emulates the behavior of the human instructor, so it could be related to intelligent tutoring techniques, although they are usually focused on the instructional planning [1]. In addition, traditional ITSs do not have such wide interaction capabilities as real-time simulators have. Thus, the problems we address are directly related to the analysis of the continuous data flow that represents the students' activity in the simulator, while the human instructor is in charge of the instructional planning. Different behaviors can be expected from such a feedback system, and our central proposal is designing a customizable system. Each behavior can be appropriate in different learning contexts, like exams, beginners training,… In this way, the tool can fit the preferences of the instructors so they find it helpful.

Next we present the truck simulator used in the study and the starting point for the development of the system.

2. THE TRUCK SIMULATOR

The simulator consists of a real truck cabin mounted on a dynamic platform with 6 degrees of freedom (d.o.f.) which transmits movement sensations, force feedback on the steering wheel, 3 large flat screens that visually immerses the driver and a surround audio system (Figure 1). In this way, the complete immersion, one of the objectives of the simulation, is obtained.

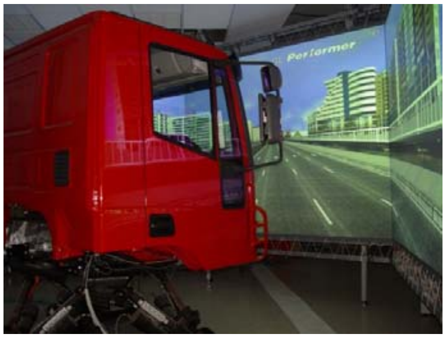

Figure 1. Outside view of the truck

The instructor controls the training session from the Instructor Position (IP), while the students sit in the truck cabin. The IP is composed of several displays where the instructor can see the simulation scenario and the console used to operate, control and evaluate what the student does. The instructor confronts the students with various tasks, monitors their activity and makes instructional decisions about what to do next in order to correct the students' mistakes.

In case the instructor needs to explain something, the IP has a microphone to enable communication with the cabin. The instructor, besides informing the students about their mistakes, usually encourage [8] them or gives instructions about the next action to do. The instructor can not point to any element of the scene or the simulator while giving an explanation. However, this kind of assistance can be automated by means of an intelligent system that reinforces the work of the instructor.

In our proposal, the base for building such a system is a generic diagnostic component which can be integrated with VR-based systems [7] in order to analyze the students' activity and detect their errors. The messages generated by this analysis are available to the instructor in the IP. The instructor uses this information to decide what to do next.

The base of the feedback system lies in the analysis of the messages provided by the diagnostic component. The analysis is in charge of deciding which messages are relevant enough to interrupt the students and how to interrupt them. In the next section, we detail the factors that influence the feedback selection in our system.

3. THE FACTORS THAT INFLUENCE THE FEEDBACK SELECTION PROCESS

Our objective is that the feedback system behaves as a human instructor does. However, different instructors can behave differently in the same situation. Even the same instructor can behave differently in the same situation depending on his/her instructional strategy and the students' characteristics. Therefore, the feedback system must be adaptive and customizable for emulating desired behaviors or objectives.

When we talk about feedback, we focus our work on the communication with the students in response to their actions. We deal with neither choosing the objectives of the task nor updating the student model. The instructor or the ITS (if it exists) must do this work. However, when deciding how to give feedback to the students, the objectives of the task and a simple student model are necessary to provide each student with feedback adapted to them.

As regards the design of a customizable feedback system, we mean that the instructors must be allowed to choose and refine the behavior of the system according to their needs. We decided that the main factor that must characterize the feedback system behavior is the intrusiveness, that is, how and how much the system can interrupt the student (section 5).

The behavior of the instructor is characterized both by personal factors and by instructional factors. Some instructors tend to interrupt the student, others let the students explore with freedom [2]. The selected criterion usually depends on the objectives considered by the instructor in the training session, the learning level of the student, his skills, etc. These factors, in addition to the personal characteristics of the instructor, determine if giving feedback is convenient or not, and how to do it at any moment.

When deciding how to give feedback, we have to consider that the simulator can communicate the same message in different ways (using different channels): by means of an avatar [6], a video, an audio message or force feedback. Therefore, in addition to deciding whether giving feedback is appropriate and the message to be transmitted, the most suitable channel must also be chosen. In the specific case of the truck simulator, visual messages can be shown on the dashboard as well as on the screens in which the virtual scene is projected. In addition, benefits from multimodality can be exploited using more than one channel at the same time.

The next section presents the feedback system we propose.

4. THE FEEDBACK SELECTION SYSTEM

In this section, we describe the architecture of the real time feedback selection system as well as the selection process and criterions that it follows. It is built as a FIPA agent [3] and the decision making process is designed using a rule system. Input data comes from the diagnostic component and as result, the system generates sets of commands that handle the communication channels provided by the simulator.

Two modules that we detail next cooperate to make decisions and a third one is the responsible for the presentation of the feedback. The architecture is shown in Figure 2. As the third module does not contribute to the feedback selection, it is not explained.

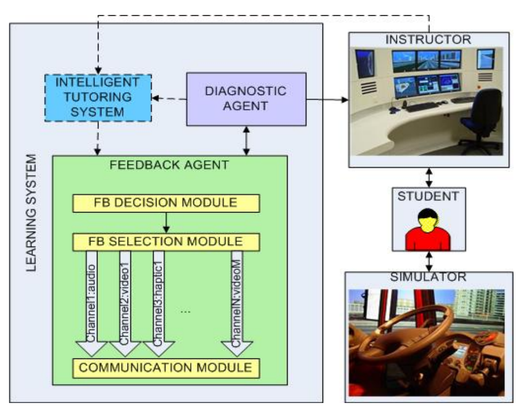

Figure 2: Architecture of the feedback system where dashed lines represent optional components.

4.1 Module 1: Discard insignificant messages

This module starts the feedback selection process discarding those messages coming from the diagnostic component that are irrelevant. As Hansen said, we remember about 35% of what we listen, about 45% of what we see and listen and about 70% of what we practice [5]. Therefore, the main criterion is to prioritize that the students continue practicing over interrupting them. The system estimates the significance of every received message, and discards the messages with low significance. The others are sent to the next module to determine the feedback that will be given.

The instructor can customize the way that the significance is estimated choosing the intrusiveness of the system. The intrusiveness represents the considered interruption frequency and using different intrusiveness we achieve different behaviors.

When the students success, the system will only find it significant if they have failed the action lots of times before.

When the students commit mistakes, four parameters are used to estimate its significance. Each parameter is used to estimate the partial significance before calculating the final one.

1. Time since the last feedback is important in order to avoid overloading the student [9] Therefore, the longer the time since last feedback, the greater the partial significance of the mistake.
2. Seriousness of the mistake represents the importance that the instructor assigns to a mistake. Thus, the seriousness of an error increases the need for feedback.
3. The difficulty of the action and number of repetitions of the mistake. When the students are performing difficult actions, it is usual that they need multiple trials to success and it is better to start giving feedback from the beginning to avoid errors. Significance is directly proportional to difficulty.
4. Level difference. The students reach an instructional level when they master the actions of the level below. Theoretically, it is convenient that the tasks that are proposed to the students are focused on specific objectives that involve mastering current level skills. However, we must have into account that designing a task that is strictly focused on a few objectives is not possible in domains like driving. When calculating partial significance, in the case that the action level is from the current or lower level, the partial significance is the maximum value and it decreases as the difference grows.

Once all the partial significances are estimated, the global significance is computed as the weighted average of all the partial results. The election of the weights is part of the customization process. As the other modules also contribute to it, the process is presented in section 5.

4.2 Module 2: Feedback selection

This module, taking a student's action and its significance, will be the responsible for choosing which feedback to give to the student and how. This process involves taking several decisions: (i) which is the objective of the feedback, (ii) which type of feedback is appropriate for that objective (iii) which of the available feedbacks is the appropriate one.

The existing feedback messages can be use to fulfill some of this objectives: warn students about a mistake, remind them how to do the actions, explain errors, motivate them, offer extra information and play down seriousness. In addition, there are positive feedback messages to support the student after a successful action. Moreover, in a VR-based training system, the system can do part of the work of the student, and sometimes the system can inform the instructor or the ITS about the mistake.

When selecting feedback for a correct action, the system knows if the student has failed several times before, and positive feedback motivates the student.

The feedback selection process takes into account the feedback types, the objectives they fulfill, the historical records of mistakes and the feedbacks given during the training session. In addition, level difference between the student and the action the mistake belongs to, the number of repetitions of the mistake, the threshold of allowed mistakes, the seriousness of the error and the predisposition to do part of the work for the student are also taken into account.

4.2.1 Step 1: Discard unsuitable feedbacks

After defining the possible objectives that a feedback can fulfill, we saw that some objectives are not suitable in some situations. Taking as an example warning the student, if the system gives this feedback when the mistake belongs to a higher level, the students would not understand the message and they would not be able to correct it.

4.2.2 Step 2: Choose feedback objective

When the students repeat the same mistakes, the system changes the objectives of the feedback. Initially, the system would likely warn the student. If the student continues repeating the same mistakes, the system will give different feedback, and if they do not work, it will inform the instructor or the ITS so that they can decide to replan the class.

4.2.3 Step 3: Choose feedback

When the system has chosen the feedback objective, it is possible that more than one feedback fulfill the objective. In this case, it has to choose one of them. The election depends on which communication channels are free and which is the intrusiveness of the feedback. Taking advantage of the multimodality of the simulator, the feedback can be given from different channels at the same time, but each channel can only give one feedback at each moment.

Once the feedback that should be given is chosen, the system will give it to the communication module, that adds it to a queue and processes it as soon as possible.

5. CUSTOMIZING THE FEEDBACK SYSTEM

The instructors can expect that the feedback system behaves differenly depending on the type of training session, that is why customization is so relevant. However, any behavior must respect some basic rules: First of all, the system has to control the time between feedbacks and do not give messages unceasingly. Besides, the use of different communication channels must be understandable; the student must clearly identify which is the action that the feedback relates to.

Apart from this basic behavior, as we want the system to exhibit different behaviors that emulate different tutors, other aspects of the system can be customized. The most important one is the intrusiveness of the behavior. It can drastically change the response of the system. Extreme cases (the intrusive and non-intrusive behavior) and corresponding results are explained below:

1. Non-intrusive behavior: Will only give feedback when both the number of repetitions and the time since the last feedback have to be high to decide to give feedback, and it tends not to give feedback in higher level actions.
2. Intrusive behavior: Almost every mistake has a response. When deciding to give feedback or not, even the number of repetitions and the time since the last feedback are low, giving feedback would be chosen.

The instructor can choose any intrusiveness between the two extremes, being the number of feedbacks greater as higher is the intrusiveness.

Apart from choosing the intrusiveness, we let the instructors decide the relevance (weight) of every parameter used in the decision making process. Using the weights and values of each parameter, and the intrusiveness of the feedback system, the system estimates the partial significances of the mistake. Then, the final significance of the mistake is a weighted average of the partial significances. As said before, the mistakes that are not significant enough will be ignored.

We define some preliminary behaviors for demonstration purposes and we explain two below. The instructors can choose one of them in different situations, or refine them adjusting any parameter. Anyway, they can create other behaviors adapted to their criterion.

- Tutor for beginners: Choosing action difficulty and level difference as the most relevant parameters, the system ignores easy and higher level actions.
- Tutor for revision training sessions: Choosing higher relevance for seriousness and level difference, the system chooses to give feedback about serious mistakes of current or lower instructional levels.

6. CONCLUSIONS AND FUTURE WORK

When building a generic feedback system for VR-based training simulators, it is of fundamental importance to take advantage of all the capacities that the simulator has to offer. This is why, it must also exploit other types of feedback that are out of reach for a human instructor We propose a customizable and adaptive system that gives feedback like a real instructor would do. In order to achieve this, we address two main sets of factors. First, the instructional factors that determine the feedback selection process from an educational point of view: the number and nature of the committed mistakes, the student's level, the mistake level, and so on. In the second set, we take care of the factors that impact on the student driver behavior, such as the intrusiveness of each kind of feedback or the influence of the elapsed time since the last feedback was given.

Our next steps involve testing the different types of feedback. The design of appropriate feedback messages is a point of interest. Variations in size, colors, location and duration for visual feedback, or tone for audio feedback, can imply different perception of the system behavior. The impact of each type of feedback on the student must be evaluated, as the behavior of the system is configured assuming that every feedback property is correctly classified. Then, we will conduct exhaustive validation experiments with real students to test the effectiveness of the system from the educational point of view.

7. ACKNOWLEDGMENTS

This work has been supported in part by the Spanish Ministry of Education and Science, grant TIN2006-14968-C02-01, the Association of Friends of the University of Navarra (Amigos de la Universidad de Navarra), the framework of Torres Quevedo Programme and co-financed by the European Social Fund

8. REFERENCES

[1] Brusilovsky, P., Ontology-based Framework for user Model Interoperability in Distributed Learning Environments. in World Conference on E-Learning, E-Learn 2005, (Vancouver, Canada, 2005), AACE, 2851-2855.

[2] Corbett, A.T. and Anderson, J.R., Locus of Feedback Control in Computer-Based Tutoring: Impact on Learning Rate, Achievement and Attitudes. in ACM CHI 2001 Human Factors in Computing Systems Conference, (Seattle, Washington, 2001), 245-252.

[3] Foundation of Intelligent Physical Agents(FIPA), FIPA Agent Managament Specification (SC00023J), 2002.

[4] Ganai, S., Donroe, J.A., Louis, M.R.S., Lewis, G.M. and Seymour, N.E. Virtual-reality training improves angled telescope skills in novice laparoscopists. American Journal of Surgery, 193 (2). 260-265.

[5] Hansen, E. The role of interactive video technology in higher education: Case study and proposed framework Educational Technology, 1990, 13-21.

[6] Johnson, W.L. and Rickel, J. STEVE: An Animated Pedagogical Agent for Procedural Training in Virtual Environments. SIGART Bulletin, 8 (1-4). 16-21.

[7] Lozano, A., Urretavizcaya, M., Ferrero, B., Castro, I.F.d., Ustarroz, A. and Matey, L. Integration of a Generic Diagnostic Tool in Virtual Environments for Procedural Training. Lecture Notes in Artificial intelligence, 3040.

[8] Person, N., Klettke, B., Link, K., Kreuz, R. and group, T.t.r., The Integration of Affective Responses into AutoTutor. in Affect Interations, (Siena, Italy, 1999), 167-178.

[9] Weevers, I., Kuipers, J., Brugman, A., Zwiers, J., Dijk, E.M.A.G.v. and Nijholt, A. The Virtual Driving Instructor: A Multi-agent Based System for Driving Instruction, 2003.