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Developing an Intelligent Tutoring System for Vehicle Dynamics

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Abstract

Intelligent Tutoring Systems (ITS) represent a substantial portion of knowledge from human tutors, therefore they are able to provide a better learning guidance than Computer Assisted Instructions (CAI). One of the most important goals of an ITS is to provide feedback tailored to the learner unique needs. There are several educational activities that are supported by these systems such as: problem solving, example review, educational games, etc. This research focus on interactive simulation to improve the learning curve of vehicle dynamics topics as it has been shown that engineer students usually find math and physics too boring and hard to understand when they are unable to map a topic to a real life problem, therefore a most interactive approach seeks to catch student attention while providing a sandbox to experiment and learn. In this paper we present our first prototype, discuss its design and provide test results based on a two year evaluation process.

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1. Introduction

The Computer Assisted Instruction (CAI) were introduced by Patrick Suppes at Stanford University since early 1960, these systems have evolved as learning tools providing students with encoded set of exercises and associated solutions. CAI system usually provides problems with a single correct answer, hence here is where the problem arises as more complex scenarios cannot be completely evaluated, as is the case of Vehicle dynamics topics where a single problem may have a lot of potential correct answers, and since we talk about nonlinear problems, it is usually required to perform the whole process to find out if the answer is correct or not. From several researches (Alexander, 1999; Leung, 2003; Jain & Getis, 2003) it has been revealed that there is indeed a difference in students achievements between a CAI assisted group and a conventional group, these differences are

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mostly positive as shown by Owens and Waxman (1994), Teh and Fraser (1995), Yalcinalp, Geban and Ozkan (1995) and Leung (2003). Even when it has been show the effectiveness of CAI systems, there is still a gap to be filled for more complex topics, and there is where the Intelligent Tutor Systems (ITS) have proved to match and even surpass CAI system performance as reviewed by Glickman and Dixon (2002).

Main goals in ITS research are, how to create computer based tutors more flexible, autonomous and adaptive for particular student needs. There are three types of knowledge that any tutor, being human or artificial needs to have in order to aid student learning (Conati, 2009):

- About the target instructional domain
- About the student
- About the relevant pedagogical strategies

Besides, an ITS needs to have communication knowledge in order to present the required useful information via the computer and the available channels. These different types of knowledge contribute to define the body of an ITS that is integrated basically by four main models according to a general consensus research (Nwana, 1990; Freedman, 2000; Nkambou et al., 2010):

- Domain model
- Student model
- Tutor model
- User interface model

The domain model, also called expert model, it is usually built on a theory developed by John Robert Anderson from Carnegie Mellon University that is called Adaptive Control of Thought—Rational (ACT-R), this theory tries to take into account all the possible steps required to solve a problem, this model has the knowledge to evaluate student performance and detect errors. The student model can be seen as overlay on the domain model, and it is usually considered a core element in a ITS, this model is responsible of tracking the student progress and raise flags or warnings if the student deviates from the domain model. The tutor model is the glue that holds the domain and student models together and is responsible of making decisions about adequate strategies and actions for better learning process. It is required to take actions when the student models set deviated flags (Anderson, H. & Koedinger, M). The user interface model finally integrates the required information for a successful communication, such as: knowledge about patterns of interpretation, domain knowledge needed for communicating content and knowledge needed for communicating intent (Padayachee, 2002).

Intelligent Tutoring Systems (ITS) may have discrepancies in their architectures, however, they are still much the same as any other instructional design process, Corbett et al., summarizes ITS design and development in four iterative stages:

- Needs assessment
- Cognitive task analysis
- Initial tutor implementation
- Evaluation

The needs assessment, is a common stage of an instructional design process, this analyses the learner based on experts and teacher experience, therefore this is the first step to develop the domain model (Corbett et al., 1997). The cognitive task analysis involves the detailed approach for developing a computational model for problem solving, observation of human tutor interaction with students provides invaluable information to develop this
stage (Farhana et al., 2002). The initial tutor implementation involves setting up a problem solving environment following for a series of evaluation activities, which according to Corbett et al. (1997) are very similar to any other software development. The fourth and final stage called evaluation perform studies to find out the usability and impact of the ITS, finding learning rates and achievements level (Corbett et al., 1997).

Our current research focus on the domain model, in this paper we present the framework that is being developed to support the first model and that will serve as the expert system for problems solving and will determine the correctness of student results, this is a very important and vital part of the system, because as we can learn from Conati (2009) researches, one main key difference between a CAI and ITS is that the latter, needs to be able to generate real-time solutions not previously defined by a human tutor. The remaining of this paper goes as follows: In section 2, we provide details for the domain model design. In section 3, the current work status of development is discussed. In section 4, an evaluation of domain model accuracy is compared with real life vehicle dynamics scenarios. In section 5, we provide statistical data about current prototype usage. In section 6, we present our conclusions and future work.

2. Domain Model Design

A physics engine is a computer software that provides an approximate simulation of certain physical systems, such as rigid body dynamics and it is the core element in our domain model as our ITS will focus on vehicle dynamics, specifically evaluating vehicle parameters to output performance characteristics under testing conditions, theoretically an endless amount of problem generation can be provided for students as long as the system is capable of process real-time unassisted results by its own.

The model is constructed mainly by three modules:

- Engine Model
- Driveline Model
- Dynamics Model

The specific details of each module are discussed below.

2.1. Engine Model

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2.2. Driveline Model

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2.3. Dynamics Model

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3. ITS Development Status
4. Domain model accuracy evaluation

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5. ITS prototype statistics data

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6. Conclusions and future work

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References

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