Chapter 4.11
JavaMOO Virtual Cells for Science Learning

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ABSTRACT

One of the World Wide Web Instructional Committee (WWWIC) at North Dakota State University's (NDSU) long running projects is the Virtual Cell, a desktop immersive virtual environment developed for biology education. The focus of the content in the Virtual Cell is cellular biology, and the underlying focus of the content modules is the scientific method and analytical reasoning. However, the technical challenges encountered during the course of the project include designing deployable server architectures, designing robust simulations, and developing high quality animations without losing interactivity.

DOI: 10.4018/978-1-60960-195-9.ch411

INTRODUCTION

The World Wide Web Instructional Committee (WWWIC) at North Dakota State University (NDSU) is engaged in research aimed at developing virtual environments to assist in the education and growth of students (Slator et al., 1999). Some

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of the key factors that lead to the success of these environments are a) the theory of role-based environments on which they are based, b) the use of graduate and undergraduate students in the development process, c) the use of the environments in actual classes, and d) the application of knowledge from one environment to the others.

An educational game should be both engaging and informative. Players should acquire concepts and skills because of playing the game, and this learning should transfer to contexts outside the game. The challenge then is to construct a game of sufficiently interesting complexity that is consistent with the subject it attempts to teach. When the player acts in the simulated environment, the environment must re-act in coherent and plausible ways. Without this consistency, the game will fail the ultimate test: students will not play it (Slator & Chaput, 1996).

Virtual role-playing environments can be a powerful mechanism of instruction, provided that they are constructed such that learning how to play and win the game contributes to a player's understanding of real-world concepts and procedures. WWWIC has developed environments to enhance student understanding of geology (Planet Oit), cellular biology (Virtual Cell), programming languages (ProgrammingLand), retailing (Dollar Bay), and history (Blackwood). These systems present a number of opportunities and challenges. Players are afforded a role-based, multi-user, 'learn-by-doing' experience, with software agents acting as both environmental effects and tutors, and the possibilities of multi-user cooperation and collaboration. The Virtual Cell environment, its particular challenges, and the solutions to these are presented.

THE VIRTUAL CELL

The Virtual Cell as implemented is a client server system where the server is responsible for the persistence of the shared environments, arbitrating state changes, and facilitating communication between players. The client is responsible for constructing the appropriate view of each shared environment and for providing the user interface elements appropriate to each environment and task. In order to display the environments, the primary role of the client is to load and display the scenes which are stored on the server and that compose that environment. As a result, the client's scene loading algorithm shapes how the client and server interact.

In the Virtual Cell, the basic element of the game is the *goal*. A goal represents either a single objective or a group of simple related objectives that the player is tasked to achieve, or a set of steps which the player is tasked with achieving. Also associated with each goal is a set of reference materials to explain various aspects of the activity that the player should be attempting to accomplish.

Goals are grouped together into a sequence to form a *module*, and the module is the format presented to players and instructors. At the midpoint of the project's current history, the Virtual Cell had three modules: (1) Organelle Identification, (2) Electron Transport Chain, and (3) Photosynthesis. The Organelle Identification module is used as an introduction to the game play and the acts of performing tests and comparing results. The Electron Transport Chain (ETC) module focuses on one part of the respiration process and traces the movement of hydrogen and electrons during the conversion of adenosine diphosphate (ADP) to adenosine triphosphate (ATP) in the mitochondria. The Photosynthesis module similarly focuses on the movement of hydrogen and electrons in one segment of the photosynthesis reaction in the chloroplast.

The Organelle Identification module is an introduction to the game and begins with the simple task of flying around the cell to collect assay results from each organelle. The two follow-up tasks for this module are simple diagnostic tasks in which the player is asked to verify a diagnosis

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