



Innovation in Teaching Grant Proposal – 2007

Cover Page

Proposal Title: **Artificial Intelligence in Game Development**
 Applicant(s): Iren Valova
 Applicant(s) Faculty Rank or Title: Associate Professor
 Department(s): Computer and Information Science
 Campus Address: Dion 302D
 Campus Phone Number: 8502
 Applicant(s) signature: _____

Chair's signature: _____

Dean's signature: _____

Please provide the following information on appended pages.

1. Grant History

A CTE grant was awarded to the applicant in 2000, to be completed in 2001. The grant topic was on Development of Imaging Labs and Teaching Tools with results disseminated through course web pages as well as senior project presentations and documentation.

A second grant was awarded to the applicant in 2006, completed in 2007. The topic concerned the development of neural network architectures and learning strategies to be used in the classroom and research tools.

2. Nature of the project (5 pages).

Applying for Option 1: Enhance teaching at UMD in significant and creative ways

The goal of this work is to develop and embed intelligent bots into 3 game engines to be used as game development tools in the course of Computer Game Design (technical elective within the CIS curriculum), as well as the pilot interdisciplinary course on Game Design (to be run in Spring 2009 as a joint effort between CVPR and COE). This effort will also serve in the teaching of the undergraduate technical elective in CIS - Foundation of Artificial Intelligence, which is typically offered every Spring semester. As a far reach, it will impact the graduate course on Neural Computing, taught every other year.



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Two fundamental questions need to be answered: Why is this necessary? and How did it come about?

The most important reason is the recent boom in popularity of game design courses, minors and undergraduate/graduate programs in US colleges. Gone are the frowns upon people who work in the gaming industry. In fact, this is one of the most demanding fields, driven by consumer approval and acceptance. The impact games are having on people quality of life has only begun to be researched. Health-care industry is turning to games for rehabilitation purposes in Parkinson's patients, the memory stimulus from games has been verified in Alzheimer's patients, and so on. From educational perspective, games are now employed in training math teachers to be more effective as well as students visualizing the problems traditionally solved on paper.

The exercise of coming up with a game concept, designing all aspects of it and, finally, transforming the idea into a real, playable computer game requires a combination of various skills on part of the student, considerable time devoted to the project, and good background knowledge in English (the story driving the game), computer programming (coding the game), Physics (collision detection and other applicable forces), artificial intelligence (so the game can react intelligently with the player), art/graphics/animation (visualization of the story, portrayal of characters and environment), and software engineering (the process management from the idea to the final product).

What is a game bot? and Why is it necessary? Imagine yourself in the deep of winter season, desperately wanting to play a game of softball. You crave the exercise, the cheers of your team and the simple pleasure of being outside. Well, a Wii console can deliver on all except the last wish - being outside. However, you get all the rest - the exercise, the cheers, the team, and the ball park field. But how, you ask - you are all alone at home. Well, the Wii bots of the game will be your team. Some of them will be on your opponent team. A great, invigorating game will result. Again with the question how will that happen - well, the artificial intelligence will be responsible for throwing the ball, calculating the trajectory of the ball and the force of the bat hitting the ball, adapting to your game skills, observing the game rules, and otherwise shaping the game and choosing moves to provide you, the player, with a great experience, complete with the sound, visuals, and exercise of a softball game. As a matter of fact, my winter lethargic body ached after a vigorous game one recent weekend.

Based on the applicant's experience with the first Computer Game Design course offering in Spring 2008, the fact that artificial intelligence (AI) is mind-boggling to students came out. Although the CIS department offers a course on foundations in artificial intelligence, the connection with game design has never been made, as it would require a significant departure from the AI curriculum. Bottom line, the abilities of students in the game design class to create reasonably large games based on AI are seriously deficient. Also based on this semester's experience, the game design engines facilitating the creation of successful games were identified. With this work, the applicant projects the creation of several AI strategies (bots) to be studied and used in the future offering of the Computer Game Design course, the Foundation of AI



course and the pilot course on Game Development to be offered jointly with the Design and Electronic Imaging departments in CVPR.

Another question to be asked is: How strong is the connection between AI and game design? This also leads to questioning the complexity of the AI included in the development of games. By a purist definition, if a player cannot determine if they are playing with a human player or the game itself, then the game has passed a limited Turing test. The Turing test is asking the question: if a human is conversing with another human and a machine and they cannot distinguish between the two, then the machine has passed the Turing test. Returning to the world of gaming - many games are available as multiplayer, online massive multiplayer and single player modes. The simplest explanation about the importance of AI in game development is in imagining a single player game, e.g. Wii tennis. The illusion that the player is sharing the game with somebody with similar level of skills is complete. That illusion and immersion in the game is achieved by programming an artificial intelligence module, which will adapt to the human player, determine where to throw the ball, the strategy the machine player should employ to win. In other words, we have a fully functional AI bot in the background, running the game, adapting its behavior, and providing for a very realistic experience for the human player. Having said all that, it is now obvious that AI is not about finding the shortest path between two points, neither is it a simple search problem of locating a goal from a certain starting position. Rather it is a multifaceted task of evaluating strategies, adapting and making the game environment as realistic as possible. The final goal being to achieve maximum immersion for the player.

The objective of the applicant is to study, design, create, and test four bots with increasing level of abilities and complexity to be utilized in the development of games either as class assignments, or student competitions, or the Game Design Club, founded four years ago. Such undertaking will require the team work of students who are well-versed in the discipline of AI, neural computation, software engineering, computer networking and communication, and human-computer interaction. Considering all these requirements, it is clear that game programming emerges as a final test of the skills of CIS graduates, since all these disciplines are represented in the curriculum. This feeds directly into the program goals of the CIS department, which include “Graduates who succeed in advanced study in computer science.” as well as “Graduates who adapt and evolve in complex technological environments such as those found in the workplace.” Although our graduates will not be developing games in companies such as Raytheon or General Dynamics, the training and the rigorous evaluation the students have passed as game developers is a test as to their fitness to handle tight deadlines, to multitask, to plan, to apply knowledge learned in the classroom and from research, and to “sell” their ideas and developed solutions.

The “innovation in teaching” of the proposed work stems from two directions: 1) Artificial intelligence; 2) Game development.. The AI aspect forces both faculty and students to unveil a facet in the discipline of AI that has been a neglected part of the course syllabus. The game applications of AI, can, in fact serve as examples for majority of algorithms and divisions of AI discussed in both, the undergraduate and graduate versions of the course - starting with the



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search strategies, going through the evolutionary and genetic algorithms, presenting the learning and knowledge representation, and finishing with planning of agent actions. From perspective of game development, the inclusion of a significant AI portion in the Game Design course is crucial to its success in future. This section of the syllabus will center around the developed bots to facilitate proper presentation of the game design process. The development of the proposed bots will allow for bigger dreams and further reach into the realms of true strategic games, sports games, and educational games. This is important for building a good hands-on college experience for the students. We have to remember that building a game is a demanding, time consuming, planned activity, which draws on the extensive knowledge from many classes, and carries a reward of being recognized by your colleagues and faculty as a designer of a product which satisfies its customers. My students in this semester's class are very involved, and the quality of their products show their commitment to excel.

Before defining what will be done along with timetable and deadlines, a clarification must be made. While AI and bots are very similar when it comes to game development, it should be noted that AI generally refers to players in the game not controlled by the human player. Bots, however, are more specialized, and appear in multiplayer games. They should do everything a human player can do, and, if on the human player's team, they are going to protect and otherwise help the player. It is obvious by these definitions that the programming such systems is not trivial and can range in complexity from simple surprise randomness, to full-fledged military strategy.

The general definition of a game bot is "an intelligent independent computer program which has the logic to affect a computer game". The game bots work with AI routines to facilitate and suit the game rules, type, map and other parameters.

Directing the attention to bot characteristics and types, it should be noted that many human players prefer, in fact, to play exclusively with bots, rather than other human players. The reasons range from banal slow Internet connection to "geeks" exploring the weaknesses of the game AI.

Bots can be classified as static and dynamic depending on whether they are capable of adapting during gameplay. There is also another division based on where they are housed - on the computer server side or the client side. Depending on the type of game, the bot must have different abilities: from finding a way around obstacles, to decisions on strategies and behaviors.

The four bots proposed to be developed are not the garden variety projects on playing checkers. Such assignments can be handled as a month-long projects and involve simple search algorithms. The proposed work concentrates on two static and two dynamic bots and can be characterized as follows:

Bot 1: Static variety to reside on the server, meaning the AI is provided by the producer of the game (our team that is). This portion of the work does not require network communications and our focus will be on the development of several behaviors the game can choose from. This can



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be likened to deterministic finite automata, but with several different behaviors defined. In every behavior, aspects of the virtual world are considered and this is utilized to algorithmically determine the next best behavior.

Bot 2: Similar to Bot 1, but designed to reside on client side. This feature entails embedding networking protocols for connection, communication and interpretation of the bot to the server.

Bot 3: Dynamic variety with the capabilities of Bots 1 and 2. Since the bot needs to adapt, however, a learning algorithm will need to be developed and embedded successfully in the agent.

Bot 4: The learning of this agent will be based on neural networks, which is the research area of the applicant. Very broadly defined, neural networks learn by example and mimic human brain in its decision or object identification capabilities. While sounding very ambitious, the theory behind this task has already been developed. As with any theory, implementation and verification are instrumental, which is the goal of this final bot variety development. This bot will reside on the server and its projected object identifying capabilities will define a new approach in neural networks for game design.

Timeline, deliverables, and responsibilities:

Task	Time	Responsible party
Analysis of available bots and AI strategies applicable for game design	1 month	Faculty applicant
Development of algorithms for successful path navigation, avoiding of obstacles, and planning of actions	2 months	RA, Faculty applicant
Development and coding of networking protocols to facilitate the client-side based bot	1 month	RA, Faculty applicant
Development and coding of learning algorithm for Bot 3	1 month	RA, Faculty applicant
Development of the neural network code to handle object recognition and identification tasks for Bot 4	2.5 months	RA, Faculty applicant
Work on customizing the developed tools for the chosen game engines - Haaf, AGS, and DXFramework. All three are free, easy to setup and use, and the graphics produced make for good game environments and characters	2 months	RA, Faculty applicant
Testing: Development of game engine-appropriate game and testing the bots versus each other	1 month	RA, Faculty applicant



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Testing the bots versus human player	1 month	RA, Faculty applicant
Making necessary adjustments in the underlying algorithms for better projection of realism	1 month	RA, Faculty applicant
Drafting the manuscript described in the dissemination section and user manuals, final preparation of the web application and deploying for web usage	1.5 months	Faculty applicant, RA

3. Budget.

Research assistants:	\$7,500.00
Xbox gaming console:	\$350.00
PI Summer salary:	\$1,000.00
Total:	\$8,850.00

Research assistant hiring schedule is one graduate and one undergraduate assistants during Fall 2008 and one undergraduate assistant during Spring 2009 semesters. All assistants will be working 10 hours/week, at \$2,500.00. The PI summer salary will cover the design and development of algorithms and method concepts to be later coded and tested by the research assistants. The Xbox console is requested as an additional testing tool, which will expand the impact of the project achievements as well as broaden the platforms on which students can operate. Among all the game consoles available on the market today, the Xbox seems to claim the biggest chunk of customers. Based on this market research done in Spring 2008 semester, this platform was chosen as a testing ground.

4. Dissemination plans (1 page).

a. Dissemination to UMD

Results will be disseminated in the form of applications, which can be obtained from the applicant's web site and need to be embedded in the respective game engines. The site will also have a user manual and will be accompanied by discussion panels to facilitate complete understanding of the bots. The bots will be used in several classes - Game Design, joint class on Game Development, Artificial Intelligence, and the graduate Neural Computing.

The bots and their application to game design will be discussed at one seminar delivered for the CIS department during the regular CIS Seminar Series, as well as offered to be delivered at seminars in other interested departments. This will ensure that the UMD community is aware of the developed tool and interested parties can either utilize it as a teaching approach or can work with the applicant to develop a further customization.



b. Publishing in other academic venues

Publication will be sought at a Game-On conference, which is a widely recognized forum for reporting recent advances in game design and development. Due to the nature of the bots, publication also will be sought at artificial intelligence-related conferences, e.g. International Joint Conference on Neural Networks (IJCNN), International Conference on Machine Learning and Applications (ICMLA). From educational perspective, the educational forum Consortium for Computing Sciences in College is attractive. This “is a non-profit organization that promotes quality computer-oriented curricula, and the effective use of computing”. The CCSC web site goes on to specify that “the Consortium supports activities which assist faculty in making appropriate judgments concerning computing resources and educational applications of computer technology. Because departments in smaller colleges and universities are usually small and not highly specialized, the Consortium also encourages the sharing of expertise, effective curricula, and efficient technological applications. The Consortium is concerned with the advancement of major programs in both Computer Science and Computer Information Systems, and with the use of computers in the Liberal Arts and Sciences. The conference program reflects the Consortium's goals and accommodates the limited resources for travel associated with member institutions.”

Based on their characteristics, the applicant views this forum to be highly valuable in disseminating the developed tool as well as gaining valuable perspective on teaching methodologies from departments operating under conditions different from UMD.