Government of Russian Federation

Federal State Autonomous Educational Institution of High Professional Education

«National Research University Higher School of Economics»

National Research University
High School of Economics
Faculty of Psychology

Syllabus for the course
« Artificial Intelligence in Video Games »

(Искусственный интеллект в видеоиграх)

010302 «Applied Mathematics and Informatics», Bachelor of Science

Authors:
Ilya Makarov, Senior Lecturer, iamakarov@hse.ru

Approved by:

Recommended by:

Moscow, 2016

Introduction to Data Science

Course Syllabus

I. Introduction: Subject and background

Author, Lecturer:

Ilya A. Makarov, Department of Data Analysis and Artificial Intelligence, Senior Lecturer, Deputy Head

Summary

This course is designed to learn one element of game development: artificial intelligence (AI). There have been many works on different aspects of game AI. We cover all aspects of Game AI, which is a field where techniques and methods are shared more often on the job than in academic papers. We study models of Game AI, its techniques, path finding and path planning, decision making and learning through the game process; learn how to implement tactics and strategy in Game AI; code execution management and interface; cover tools and content creation, and, finally, design your own Game AI. The course is associated with a website, at www.ai4g.com , that contains a library of source code that implements the techniques found in the core book for this course.

Prerequisites

No special skills are required. We will talk about design of models and algorithms, so some base course on these subjects will be appreciated. The course has elective status.

Aims

- To develop practical skills of building AI in Games.
- To develop fundamental knowledge of concepts underlying artificial intelligence.
- To develop practical skills needed in modern game developing.
- To explain how algorithms and data structures meet in AI models and their verification.
- To give a hands-on experience with real-world game AI design.
- To develop applied experience with graphical engines and programming.

Background and outline

Methods of Artificial Intelligence arise in many areas of data science, automated control, planning, robotics, etc. This course is aimed at providing our students with a direct AI training in Games, which could boost their careers in one of highly required professions in the world. The course covers the most recent AI tools and developments in Game programming.

While the choice of AIG, its problems and projects already defines the novelty of this class, we are trying to do our best to provide our students with the most up-to-date learning experience.

This class topic is new to HSE and Russian universities in general – and this is precisely the void we are trying to fill. Game design programs start gaining their momentum in leading universities abroad, which is another reason for HSE to cease the opportunity and to offer a competitive class in this field.

Teaching notes

The lecture material is uploaded to the site.

To keep the students as engaged as possible, we use a combination of teaching tools and methodology:

- Good theoretical background.
- Class projects. While home project is building small game AI, current homeworks will be devoted to the current topics and methods of AI in different game aspects.
- Well-timed interaction during classes and office hours should stand for development and improvement of students' practical skills.

Teaching outcomes

The main outcome of this class is to train a student to make a working prototype of AI for a certain type of gameplay. Career-wise, we expect our students to be able to develop into Game programmers or Game analytics.

After completing the study of the discipline PA the student should:

- Know basic notions and definitions in artificial intelligence and machine learning.
- Know standard methods of data analysis and information retrieval from gameplay
- Be able to formulate the problem of constructing proper AI model as combination of controllers, BTrees and arbiter.
- Be able to translate a real-world problem into mathematical terms.

- Possess main definitions of subject field.
- Possess main software and development tools of game programming.
- Learn to develop complex hierarchical AI models.

After completing the study of the discipline PA the student should have the following competences:

Competence	Code	Code (UC)	Descriptors (indicators of achievement of the result)	Educative forms and methods aimed at generation and development of the competence
The ability to reflect developed methods of activity.	SC-1	SC-M1	The student is able to reflect developed mathematical methods to AI problems.	Lectures and classes
The ability to propose a model to invent and test methods and tools of professional activity	SC-2	SC-M2	The student is able to improve and develop research methods of AI and ML in real-world game with current optimization restrictions	Classes, labs, home works.
Capability of development of new research methods, change of scientific and industrial profile of self-activities	SC-3	SC-M3	The student obtain necessary knowledge in AI, which is sufficient to develop new methods on other sciences	Home tasks, game reviews
The ability to describe problems and situations of professional activity in terms of humanitarian, economic and social sciences to solve problems which occur across sciences, in allied professional fields.	PC-5	IC-M5.3_5.4_5.6_2.4.1	The student is able to describe real-world problems in terms of AI.	Lectures and tutorials, group discussions, paper reviews.
The ability to	PC-8	SPC-M3	The student is able to	Discussion of games; cross

Competence	Code	Code (UC)	Descriptors (indicators of achievement of the result)	Educative forms and methods aimed at generation and development of the competence
detect, transmit common goals in the professional and social activities			identify information and mathematical aspects in gameplay, so he could switch deterministic behavior of players under computer control to the non-deterministic intellectual model	discipline lectures

Recommendations to the students

This class is meant to be interesting, but it's more oriented to the theory of applications AI methods in solving in-game problems with the best possible efficiency, but having zero knowledge on the assumption that lead to these boundaries. You can learn analytical and computational skills instead of hard coding deterministic models. To anyone thinking about taking this class I would suggest the following:

- Take it only if you are interested in learning something new
- Be prepared to work
- Be independent, and look for new, unusual solutions.
- Do not miss/skip classes and homework.

II. Schedule

No	Topic	Total hours	In class hours		Self-study
			Lectures	Labs	
1	What is AI?	8	2	2	4
2	Game AI	8	2	2	4
3	Movement	12	2	2	8
4	Path Finding	12	2	2	8
5	Decision Making	18	6	4	8
6	Tactics and Strategy	12	2	2	8
7	Learning	20	6	6	8
8	Board Games	12	2	2	8
9	Execution Management	12	2	2	8
10	World Interface	12	2	2	8
11	Tools and Software	14	2	4	8
12	Designing Game AI	12	2	2	8
	Total	152	32	32	88

III. Assessment

The assessment includes current homeworks/projects, 1 final project and 1 final exam:

- Class homework/projects, assigned after each 2 lectures
- Final project

  The class grade is computed as 40% of homeworks/projects + 20% of the final project + 40% final exam.

In addition to this, student attendance, originality of work and contributions to the class will be taken into account, especially for those with non-zero fractional grade part.

IV. Content

1. What is AI?
Academic and Game AI. Movement. Decision Making. Strategy. Infrastructure. Agents.

2. Game AI
The Complexity. Changes of Behavior. The Kind of AI in Games. Hacks. Heuristics. Algorithms. Speed and Memory. CPU and GPU. PC and Console Constraints. The AI Engine.

3. Movement
The Basics of Movement: 2D Movement, Statics, Kinematics. Steering Behaviors. Predicting Physics. Jumping and Crouching. Coordinated Movement. Motor Control. 3D Movement.

4. Path Finding
The Pathfinding Graph. Graph Search Algorithms. Hierarchical Pathfinding. Continuous Time and Incremental Pathfinding. Movement Planning.

5. Decision Making
Decision Trees. State Machines. Behavior Trees. Fuzzy Logic. Markov Chains. Goal-Oriented Behavior. Rule-Based Systems. Blackboard Architectures. Scripting. Action Execution.

6. Tactics and Strategy
Waypoint Tactics. Tactical Analyses. Tactical Pathfinding. Coordinated Action.

7. Learning
Online and Offline Learning. Parameter Modification. Action Prediction. Decision Learning. Naive Bayes vs. Decision Tree vs. Random Forest vs. XG Boosting. Reinforcement Learning. Artificial Neural Networks.

8. Board Games
Game Theory. Minimax Games. Transposition Tables and Memory. Memory-Enhanced Test Algorithms. Turn-Based Strategy Games.

9. Execution Management
The Scheduler. Interruptible Processes. Load-Balancing Scheduler. Hierarchical Scheduling. Priority Scheduling. Level of Details: AI LOD, Scheduling LOD, Behavioral LOD, Group LOD.

10. World Interface
Event Managers. Sense Management. VR User Interface.

11. Tools and Software
Pathfinding and Waypoint Tactics. Movement. Decision Making. Data-Driven Editors. AI Design Tools. Remote Debugging.

12. Designing Game AI
Shooters. Driving. Real-Time Strategy. Sports. Turn-Based Strategy Games.

V. Reading

Recommended:

1. Ian Millington, John Funge. Artificial Intelligence for Games. 2nd edition. CRC Press, 2009
2. www.ai4g.com/
3. www.gameai.com/

Supplementary:

1. http://research.microsoft.com/en-us/projects/ijcaiigames/
2. http://www.stat.columbia.edu/~jakulin/FT/

Complete list of supplementary references is available for the course participants via Drive.Google.

A set of sample articles is presented at https://cs.hse.ru/ai/bot

VI. Game Genres for research work and class projects

- RTS
- FPS
- RPG
- Board
- Quest
- Stealth

VII. Appendix. First-Person Shooter Project Materials (www.cs.hse.ru/ai/bot)

Modelling of a Human-Like BOT in a First-Person Shooter Game

2014-2015

1. Tokmakov, M. Game Artificial Intelligence with Imitation Of Human Response to the Appearance of the Enemy
   Presentation with Video
2. Tokmakova, L. Visual Recognition of the Enemy in a three-dimensional maze in Unreal Engine 4
3. Polyakov, P. Smooting the BOT path through combined approximation based on Voronoi's diagramm
   Simple smoothing
   Smoothing with map and curve parameters
   Real-time construction of Voronoi diagram
   Voronoi pathfinding parameters

Conferences

AIST'15

Imitation of Human Behavior in 3D-Shooter Game
Presentation on SlideShare Abstract

CS 1.6

4. Goncharov, V. Parser for package of demorecords with the visuzalizing in 2D of human tracing and game events

Unreal Engine 4 Demo

5. Goncharov, V. Cinematic trailer of a space station docking

2015-2016

1. Tokmakov, M. The BOT Decision Making Model for 3D First Person Shooter in Unreal Engine 4
2. Polyakov, P. BOT's Movements Algorithms in Case of Enemy Detection for 3D First Person Shooter in Unreal Engine 4
3. Zyuzin, P. Weapon Selection Algorithms Based on Neural Networks for 3D First Person Shooter in Unreal Engine 4
4. Konoplya, O. Application of Oculus Rift VR DK2 and HTC Vive to the Navigation and Sighting for 3D First Person Shooter in Unreal Engine 4
5. Martynov, M. Adaptive Shooting for 3D First Person Shooter in Unreal Engine 4
6. Kuznetsov, G. Automated Weapon Selection for 3D First Person Shooter in Unreal Engine 4
7. Guschenko-Cheverda, I. Moving-Target Search Algorithms for 3D First Person Shooter in Unreal Engine 4
8. Uriev, M. Enemy's Pursuit Escape Algorithms for 3D First Person Shooter in Unreal Engine 4
9. Mokeev, I. Item and Bonus Collection for 3D First Person Shooter in Unreal Engine 4
10. Kosmachev, A. Adapting Targeting with Respect to a Human-Player Reaction on an Enemy Appearance
11. Karpichev, R. Strategic Planning of Collective Rule-Based Decision Making for 3D First Person Shooter in Unreal Engine 4

Conferences

AIST'16

Smoothing Voronoi-based Path with Minimized Length and Visibility using Composite Bezier Curves

Presentation Abstract

EEML'16

Modelling Human-like Behavior through Reward-based Approach in a First-Person Shooter Game

Presentation Abstract

ACM MM'16

First-Person Shooter Game for Virtual Reality Headset with Advanced Multi-Agent Intelligent System

Presentation Abstract

The syllabus was prepared by Ilya Makarov.