Bio-inspired Computational Algorithms in Educational and Serious Games: Some Examples

Michela Ponticorvo(✉), Andrea Di Ferdinando, Davide Marocco, and Orazio Miglino

Department of Humanistic Studies, University of Naples "Federico II", Naples, Italy
michela.ponticorvo@unina.it

Abstract. Bio-inspired computational algorithms can be effectively employed to develop games for learning. Game design, which we propose to describe according to a multi-level framework where the external level is distinguished from the game engine and the tutoring level, can host different bio-inspired computational algorithms.

Some examples of educational games employing bio-inspired algorithms at different levels are reported: BreedBot in which bio-inspired computational algorithms are used at game level and Infanzia Digi.tales project where these techniques are used at tutoring level.

Keywords: Technology Enhanced Learning · Serious games · Educational games · Bio-inspired computational models · Game design

1 Introduction

In recent years an epochal turn has been observed in education coming from a twofold pathway. On one side, a growing effort has been devoted to the use of new technologies, in particular ICT (information and communication technologies), as educational tools. Technology-Enhanced learning (TEL) has intercepted this tendency by promoting new educational practices, new communities and new ways of communication [1]. On the other side, a lot of interest has arisen about the use of game for learning. This interest is witnessed by the numerous research branches that emerged, game-based learning [8], edutainment [2], gamification of learning [6], just to cite some. In particular many games have been developed under the label Educational Games and Serious games. Educational games include card, board and videogames. Playing a game always requires to learn something, at least game content and dynamics and in educational games this aspect can be exploited to convey specific contents. Serious Games (SG) are games that educate, train, and inform [7], sharing the same educational mission. The design process is crucial to fully express educational potential of digital games and, in the domain of digital SG, computational models can be exploited for this goal. Between the

K. Verbert et al. (Eds.): EC-TEL 2016, LNCS 9891, pp. 636–639, 2016.
DOI: 10.1007/978-3-319-45153-4_80

computational models that can be chosen, bio-inspired computational models are extremely fit for educational purpose if the goal is to teach biological, psychological and social matters, because they allow to convey knowledge about dynamic and complex system, emergence, evolution and development better than other computational models.

2 Serious and Educational Game Design According to a Multi-level Framework

In this section we will describe the SG design process according to a multi-level framework where we can distinguish two concentric levels, the shell and core level and a ubiquitous one, the evaluation and tutoring level [3], represented in Fig. 1. The shell and the core level are present in every kind of game, and, more in general in almost every cultural product. The shell level represents the visible content that is immediately accessible to the player. It frames the game engine, the game dynamics that are hold in the core level. The third level, the evaluation and tutoring level, even if it is present in many entertainment games, is characterizing for Educational and Serious games, as it allows, on the teachers side, to understand if and how the player/learner has acquired the concepts conveyed by the Educational game.

The shell level represents what the player sees, the setting she is immersed in. Here we find what we call the game narrative. Digital games, as many other cultural products, are expressed through a narrative metaphor that carries out the crucial role to give sense to the game. In designing the shell level we have to define the context: who are the agents, what actions they can display, what interactions are possible between them.

The shell level, based on narrative, holds an hidden level with a specific operation, the game engine, what we call the core level. The game engine, a term that is commonly used in the context of videogames creation and development, allows to implement core functionalities related to game dynamics, for example related

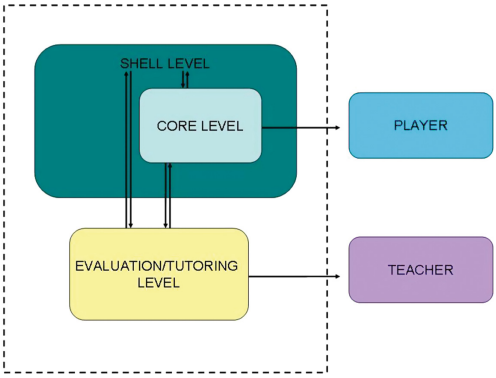

Fig. 1. Multi-level framework for educational games

to physics, animation, artificial intelligence, etc. These levels are in dynamic interaction and have strong effects one on the other: the narrative provides a frame where the hidden content resides. In educational context, the shell level is necessary in providing a semantic context to educational activities whereas the core level defines the skills or the abilities to be transferred.

If our goal is to build educational tools and materials which are related to biology, psychology and sociology or if we want to transmit different subjects adopting a point of view that takes into account aspects related to emergence, complex and dynamic systems, evolution and development, we can resort to a wide class of bio-inspired algorithms. Bio-inspired computing exploits the study of natural phenomena to apply it to machine learning: from evolution to genetic algorithms, from natural complex systems to cellular automata, from the nervous systems to artificial neural networks.

In educational and serious games, a relevant role is played by the evaluation and tutoring level. The evaluation and tutoring layer complements the core and shell layers. This level analyze players game performances relatively to the specified training objectives, and provides the players and the trainer, whose role is indeed relevant in educational context, with important information and data about the learning process. At this level we find learning analytics, which are the measurement, collection, analysis and reporting of data about learners to improve the whole learning process.

3 Bio-inspired Computational Models in Educational and Serious Games: Some Examples

The first examples we want to cite are about the use of bio-computational algorithms to teach evolutionary dynamics. In this case, the serious game becomes a virtual laboratory where the user can directly manipulate the relevant variables involved in the game, thus determining the game evolution in an immediate manner. At the same time, this direct manipulation takes place in a protected environment where failures or error do not determine a menacing outcome. An interesting example of this kind of games we have worked on is Breedbot[1] and its sequels Bestbot, and Brainfarm [4,5]. These are integrated software/hardware platforms that allow players, even without any particular computer skill, to breed, within customizable virtual worlds, artificial organisms that can be downloaded onto real robots.

Breeding is implemented through a user-guided genetic algorithm, where the user determine robots evolution acting as a breeder. In these games there are the following bio-inspired computational models: robots are embodied agents whose artificial intelligence is implemented with artificial neural networks and their evolution/development carries out adopting evolutionary algorithms.

Bio-inspired computational model can enter the evaluation/tutoring level, as shown by INF@NZIA DIGI.tales project. This level foresees a smart interaction with the user/player. This smartness resides in adapting, inferring, profiling and anticipation, functions that mimic human teachers actions. This level provides

[1] The interested readers can contact authors for additional materials.

an appropriate and timely feedback to player action, it adapts to player special needs according to her actual performance and the desired educational goals, it tracks player performance in terms of achievements and improvements. Up to now, this smart interaction has been mediated by the use of Intelligent Tutoring Systems (ITS).

Bio-inspired algorithms can be useful at this level too: artificial neural networks can be applied to teaching and learning processes, as they can capture interesting regularities that help profiling the student/player/user, modelling student/teacher interaction is a smart way. Learners and teachers can be conceived as cognitive agents, starting from the regularities extracted by Educational data mining.

4 Conclusions

Bio-inspired computational methods can be applied effectively in designing Serious and Educational games because they are fit to teach some arguments such as biology, psychology, sociology with an isomorphic approach; they open the way to some aspects which are indeed relevant, but are often neglected in educational contexts such as physical embodiment, autonomy, social interaction, evolution and development; they help reproducing ecological dynamics in the abstract world of digital games.

Acknowledgments. The INF@NZIA DIGI.tales has been funded by Italian Ministry for Education, University and Re-search under PON-Smart Cities for Social Inclusion programme. Authors would like to thank Onofrio Gigliotta for Breedbot, Bestbot and Brainfarm materials.

References

1. Balacheff, N., Ludvigsen, S., De Jong, T., Lazonder, A., Barnes, S.A., Montandon, L.: Technology-Enhanced Learning. Springer, Heidelberg (2009)
2. Charsky, D.: From edutainment to serious games: a change in the use of game characteristics. Games Cult. **5**, 177–198 (2010)
3. Dell'Aquila, E., Di Ferdinando, A., Marocco, D., Miglino, O., Ponticorvo, M., Schembri, M.: New perspective. In: Educational Games for Soft-Skill Training. Springer, Heidelberg (2017, in press). ISBN 978-3-319-06311-9
4. Miglino, O., Gigliotta, O., Ponticorvo, M., Nolfi, S.: Breedbot: an edutainment robotics system to link digital and real world. In: Apolloni, B., Howlett, R.J., Jain, L. (eds.) KES 2007, Part II. LNCS (LNAI), vol. 4693, pp. 74–81. Springer, Heidelberg (2007)
5. Miglino, O., Gigliotta, O., Ponticorvo, M., Nolfi, S.: Breedbot: an evolutionary robotics application in digital content. Electron. Libr. **26**(3), 363–373 (2008)
6. Kapp, K.M.: The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education. Wiley, Chichester (2012)
7. Michael, D.R., Chen, S.L.: Serious Games: Games That Educate, Train, and Inform. Muska and Lipman/Premier-Trade, New York (2005)
8. Tobias, S., Fletcher, J.D., Wind, A.P.: Game-based learning. In: Handbook of Research on Educational Communications and Technology, pp. 485–503. Springer, New York (2014)