Proceedings of the Fourteenth Artificial Intelligence and
Interactive Digital Entertainment Conference (AIIDE 2018)

Games as Co-Creative Cooperative Systems

Rodrigo Canaan
Tandon School of Engineering
New York University
5 Metrotech Center, Brooklyn, NY 11201
rodrigo.canaan@nyu.edu

Abstract

Many modern creative industrial processes rely on the collaboration between multiple humans, assisted by one or more computational systems, in a complex environment. However, most traditional systems lack the adaptability required to contribute in a flexible, co-creative manner, instead executing a fixed set of tasks in a preset time schedule. We believe games, especially cooperative games offer an ideal platform to conduct research in co-creativity. We present our motivation, preliminary work and future goals to study, build and measure game-inspired co-creative AI systems.

Introduction

Many modern creative industrial processes rely on the collaboration between multiple humans, assisted by one or more computational systems, in a complex environment. High-level plans might be broken down to lower level tasks, such that individual actors lack full information on most tasks they are not directly involved with.

This requires a great deal of flexibility of the human actors, who must be able to infer missing information from context or pro-actively request additional instructions when unable to proceed. An accurate model of the behaviors and intentions of their peers is needed. Moreover, the team must deal with changing requirements and uncertain resource availability, which can often change the original plan.

However, most traditional computational systems lack such adaptability, instead executing a fixed set of tasks, fully specified by the human users, when explicitly prompted to do so or on a preset time schedule. Two approaches have been proposed to address these gaps: first, we have systems that attempt to display creativity on their own right, such as (Guckelsberger et al. 2017; Colton 2012). Those are typically called computational creativity systems.

The second approach, which is our main interest, features systems where creativity emerges from the interaction between one or more humans and one or more computational systems (Davis 2013). According to Davis, this interaction “does not follow a predefined script” and “the contributions of human and computer are mutually influential”. A closely related idea refers to mixed-initiative systems, where humans and machine make by proactive contributions to the solution of a problem. (Yannakakis, Liapis, and Alexopoulos 2014) argue that these systems have the potential to foster human creativity, achieving co-creativity.

We believe the advent of co-creative systems would yield great benefits to the processes and activities where they are involved, and would revolutionize the way people interact with machines. We also believe modern AI techniques such as machine learning, evolutionary algorithms and planning algorithms can help achieve this goal.

In particular, we believe games offer an ideal platform to conduct this research. Games have long been used as benchmarks for advancements in AI. Playing and making games are activities traditionally considered to require human intelligence. They also offer researchers a controllable environment, easier to describe, measure and reproduce. Finally, games are fun and appeal to a wide audience.

As such, this research seeks to draw inspiration from games, especially cooperative games, to study, build and measure more effective co-creative AI systems.

Preliminary work

Literature review and vision write-up: Our first step was to dig into the definitions of creativity and computational creativity (Boden 1998), metrics of novelty and interestingness (Reehuis et al. 2013) and open research problems are involved in the cooperation between human an machine (Burstein and McDermott 1996). We also described our initial vision for the kind of game-like interactive system that would provide a good environment for measuring the impact and success of a co-creative, fully cooperative agent. The result was published as a vision paper in (Canaan et al. 2018a).

Evolving behaviors for cooperative play: In Hanabi, players must work together to build piles of cards in each of five colors in ascending order of value, without seeing the cards in their own hands. The only communication allowed is the use of a limited number of hints to inform their color or value of cards in another player’s hand. While Hanabi-playing agents are not necessarily co-creative, Hanabi is nonetheless an interesting problem for our research. It is a cooperative game with imperfect information, where player modeling and communication can play a large part.

We used an evolutionary algorithm to evolve rule-based agents for the game, showing that the currently existing rule-based agents, such as the ones seen in (Walton-Rivers et al. 2017) can be improved while decreasing the reliance on human expertise. We also developed new rules of our own, further increasing the agent's performance both when playing with copies of itself and when playing with a set of unknown agents. The results were published in (Canaan et al. 2018b) and were be submitted to a competition taking place at CIG 2018.

Holistic PCG (Procedural Content Generation) in Minecraft: We also took part in organizing a Minecraft settlement generation competition. Minecraft is a game where players can mine cubes of different materials to create structures such as buildings and cities, often inspired by real-world or fictional locations. The game is often played without regard for any externally defined goals. And while the game is equipped with a built-in settlement generator, the generated settlements lack many features of human-created settlements such as adapting to terrain or evoking a narrative. As such, rather than attempt to develop an AI to play the game effectively (an ill-defined task), the competition encourages participants to submit agents that can build settlements in a holistic manner. The settlements will be judged using criteria such as adaptability, functionality, evoked narrative and visual aesthetics. The competition is described in (Salge et al. 2018a) and on the competition website: http://gendesignmc.engineering.nyu.edu.

While the competition itself has no cooperative elements, developing AI techniques that are able to generate content in a human-like fashion is very relevant to our purposes. We also plan to extend the challenge to include completing settlements started by a human, which requires a model of human intentions.

Empowerment maximization as intrinsic motivation: Empowerment is a mathematical formalism that attempts to capture the degree of influence an agent has on the world it can perceive (Salge, Glackin, and Polani 2014). The more options an agent has, leading to different, predictable outcomes, the higher the empowerment. As an intrinsic motivation (Oudeyer and Kaplan 2008), it has the potential to result in sensible behavior even in the absence of externally defined goals. This can be useful for our purposes, as an agent can attempt to provide a human user with a varied range of options even without an learned model of the user's intentions. Empowerment maximization has been used to generate general supportive and antagonistic NPC (Non-Player Character) behavior in (Guckelsberger et al. 2016).

Our work used UCT, a method designed for Monte-Carlo Tree Search (Browne et al. 2012) to accelerate the computation of empowerment. We used a 3D block world similar to Minecraft to measure how well our agents equipped with UCT can calculate empowerment using using from 0.01% to 100% of the number of forward model calls required for exhaustive search (Salge et al. 2018b).

Future goals

The ultimate goal of this research is to build and evaluate a concrete example of a co-creative system where a human user and an AI agent cooperate in order to build an artifact such as a game level. We are currently interested particularly in generation of maps for StarCraft.

We plan to study and implement generation of game content such as search-based algorithms which optimize towards one or multiple desired functions, such as (Togelius et al. 2010), and data-driven algorithms, such as using neural networks and other forms of machine learning to learn from existing maps and replay data (Lee et al. 2016). We then plan to use these techniques to build an interactive design tool such as the Sentient Sketchbook (Liapis, Yannakakis, and Togelius 2013), but which can learn a model of a particular user's preferences, identify and request information that can direct the construction of an artifact or help learn the user's preferences, learn from publicly available data, etc.

We will measure the success of our system not only by metrics related to the produced artifacts (such as map balance and novelty) but related to how well the system models the user, fosters the creativity of the user and helps in the user's overall design process.

We hope this research will help lead to the advent of cooperative systems that behave more like human partners than as passive design assistance tools.

Acknowledgments

Rodrigo Canaan gratefully acknowledges the financial support from Honda Research Institute Europe (HRI-EU).

References

Boden, M. A. 1998. Creativity and artificial intelligence. *Artificial Intelligence* 103(1-2):347–356.

Browne, C. B.; Powley, E.; Whitehouse, D.; Lucas, S. M.; Cowling, P. I.; Rohlfshagen, P.; Tavener, S.; Perez, D.; Samothrakis, S.; and Colton, S. 2012. A Survey of Monte Carlo Tree Search Methods. *Trans. CIAIG* 4(1):1–43.

Burstein, M. H., and McDermott, D. V. 1996. Issues in the development of human-computer mixed-initiative planning. In *Advances in Psychology*, volume 113. Elsevier. 285–303.

Canaan, R.; Menzel, S.; Togelius, J.; and Nealen, A. 2018a. Towards game-based metrics for computational co-creativity. In *Computational Intelligence and Games (CIG), 2018 IEEE Conference on*. IEEE.

Canaan, R.; Shen, H.; Torrado, R.; Togelius, J.; Nealen, A.; and Menzel, S. 2018b. Evolving agents for the hanabi 2018 cig competition. In *Computational Intelligence and Games (CIG), 2018 IEEE Conference on*. IEEE.

Colton, S. 2012. The painting fool: Stories from building an automated painter. In *Computers and creativity*. Springer. 3–38.

Davis, N. 2013. Human-computer co-creativity: Blending human and computational creativity. In *Ninth Artificial Intelligence and Interactive Digital Entertainment Conference*.

Guckelsberger, C.; Salge, C.; Saunders, R.; and Colton, S. 2016. Supportive and antagonistic behaviour in distributed computational creativity via coupled empowerment maximisation. In *Proceedings of the Seventh International Conference on Computational Creativity*.

Guckelsberger, C.; Salge, C.; Colton, S.; et al. 2017. Addressing the" why?" in computational creativity: A non-anthropocentric, minimal model of intentional creative agency.

Lee, S.; Isaksen, A.; Holmgård, C.; and Togelius, J. 2016. Predicting resource locations in game maps using deep convolutional neural networks. In *Proceedings of the AIIDE workshop on Experimental AI in Games*.

Liapis, A.; Yannakakis, G. N.; and Togelius, J. 2013. Sentient sketchbook: Computer-aided game level authoring. In *FDG*, 213–220.

Oudeyer, P.-Y., and Kaplan, F. 2008. How Can We Define Intrinsic Motivation? In *Proc. 8th Conf. Epigenetic Robotics*, 93–101.

Reehuis, E.; Olhofer, M.; Emmerich, M.; Sendhoff, B.; and Bäck, T. 2013. Novelty and interestingness measures for design-space exploration. In *Proceedings of the 15th annual conference on Genetic and evolutionary computation*, 1541–1548. ACM.

Salge, C.; Green, M. C.; Canaan, R.; and Togelius, J. 2018a. Generative design in minecraft (gdmc), settlement generation competition. *arXiv preprint arXiv:1803.09853*.

Salge, C.; Guckelsberger, C.; Canaan, R.; and Mahlmann, T. 2018b. Accelerating empowerment computation with uct tree search. *arXiv preprint arXiv:1803.09866*.

Salge, C.; Glackin, C.; and Polani, D. 2014. Empowerment–an introduction. In *Guided Self-Organization: Inception*. Springer. 67–114.

Togelius, J.; Preuss, M.; Beume, N.; Wessing, S.; Hagelbäck, J.; and Yannakakis, G. N. 2010. Multiobjective exploration of the starcraft map space. In *Computational Intelligence and Games (CIG), 2010 IEEE Symposium on*, 265–272. IEEE.

Walton-Rivers, J.; Williams, P. R.; Bartle, R.; Perez-Liebana, D.; and Lucas, S. M. 2017. Evaluating and modelling hanabi-playing agents. In *Evolutionary Computation (CEC), 2017 IEEE Congress on*, 1382–1389. IEEE.

Yannakakis, G. N.; Liapis, A.; and Alexopoulos, C. 2014. Mixed-initiative co-creativity. In *FDG*.