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Review Article

AI and Games: The Remarkable Case of Malta

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Abstract. We currently witness a technological revolution that is attributed primarily to artificial intelligence (AI) advancements. Even before this AI Spring, however, the plethora of machine learning, search and optimization breakthroughs have been made possible through the direct applications of AI algorithms in digital games. As AI advances, games also advance since AI can continuously test, improve, design and complexify the environments it plays. This symbiotic relationship between AI and games is currently shaping the research frontier of AI and boosts the innovation potential of games across multiple domains. This short paper has a dual purpose and corresponding parts. Throughout the first *general* part of the paper, I survey briefly the current state of the art in the AI and games field. Then I outline the critical role of games in AI research, the importance of AI for game development, and the impact their relationship has on current and future scientific breakthroughs. In the second *specific* part of this paper, I focus on the Institute of Digital Games of the University of Malta as a successful centre of excellence on AI and games research, education, and innovation. Specifically, I provide evidence suggesting that a national focus and targeted investment in AI and video game development has managed to place a small island country like Malta—in just under a decade—among the leading players of AI and games research, education and innovation globally.

Keywords: Artificial Intelligence, Games, Malta

1 Introduction

Artificial Intelligence (AI) is arguably the leading driving force in what we experience as the 4^{th} industrial revolution nowadays. Since the birth of the very idea of AI, games have been the key enabler of AI breakthroughs including deep learning and artificial general intelligence (Yannakakis et al., 2018). It is not only AI that advances through games, however; AI has been assisting games to evolve in the ways we play them, test them, design them, and in the ways we understand play, learning, interaction and creativity. As games get increasingly richer and more complex through creative AI processes, AI advances further and, in turn, it advances the environments it is trained on, in a continuous and evolving relationship. The methods and technology we build *through* and *for* video games today will run the world of tomorrow: from self-driving cars, manufacturing and cyberphysical systems, to social media and even the *metaverse*. Video games are perhaps the most important domain to develop AI for, while AI is arguably the most important technological leap forward for games.

The aim of this paper is two-fold: first, it puts an emphasis on the importance of the AI and games research field as a whole and the significant impact this field has had beyond AI research and game development; second, it considers the particular case of Malta—representing a small island state and the academic residence of the author—and explores the significant scientific, research and socioeconomic effects the AI and games field has had on the country as a whole. On that basis, in the first part of the paper, I outline the advancements that games have offered to AI research, the ways AI has boosted game technology and I conclude with an observation about their continuous co-evolution which drives technological advancements across numerous domains and research fields. In the second part of the paper I focus on the impact the field of AI and games has had on the research, educational and innovation ecosystem of Malta, through the establishment of the *Institute of Digital Games*[1]. In just under a decade, AI and games have become a key enabler of research and technological innovation on a small island state that experiences high degrees of economic vulnerability (Moncada et al., 2021). Building on and benefiting from the national focus on AI and video game

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development, and the flexibility and versatility of the University of Malta—the oldest and largest small state university in the world (Moncada et al., 2021)—the Institute of Digital Games has put the University of Malta and the country on the world-map of technical games research (Nelson, 2022). Importantly, the AI and games research and educational activities performed at the Institute of Digital Games have helped the country excel in exceptional ways across a number of key socioeconomic factors and research and innovation indexes as set by Malta and the European Commission.

2 Part I: Artificial Intelligence and Games

In this first, general, part of this paper I will outline the ways AI and games have benefited from each other—games for AI versus AI for games. I will conclude this first part by emphasizing the constant co-evolution between the domain (games) and the field (AI) and the significant impact of this symbiotic relationship on future scientific discoveries and technical advancements.

2.1 Games for AI

The dominant use of AI within games and simulated environments has been for playing games well, ideally better than humans. Ever since the birth of AI, over 70 years ago, games are used to test the capacity of algorithms to perform tasks better than humans. It is a widely adopted idea that games offer challenging tasks to humans which, in turn, require some form of intelligence. Designing algorithms that are able to beat humans in games including Chess (Campbell et al., 2002), Go (Silver et al., 2017), Atari games (Mnih et al., 2015), Racing (Wurman et al., 2022) and strategy games (Berner et al., 2019; Vinyals et al., 2019) have defined the core milestones of AI research. Algorithms such as variants of tree search and Monte Carlo tree search (Checkers and Go), reinforcement learning (RL) and deep RL (Atari, Go, Dota 2, and StarCraft), multi-agent deep RL (StarCraft), and combinations of those, have been invented through research on AI gameplaying (Risi et al., 2020a). Those algorithms were able to beat the best of humans in a particular game; however, we are far from AI beating human players in every game out there.

Studying the capacity of systems that are capable of performing well across tasks is a long-standing goal of AI. In the domain of games, think of AI algorithms that are capable of playing not just a specific game, but any given game. The idea of artificial general intelligence was unsurprisingly first tested within board games (Genesereth et al., 2005; Thawonmas et al., 2019; Yannakakis et al., 2018) and has evolved nowadays to the study of generalised agents that are capable of playing different video games (Perez-Liebana et al., 2015; Reed et al., 2022; Silver et al., 2018).

It is easy to explain why games have been (and will be) so popular and important for AI research: they are well-controlled environments that can be simulated rapidly. This makes AI testing more efficient as the focus is put on the AI algorithm rather than the real world implications of AI systems. Beyond these unique properties, however, games very often represent facets of the real world. Thus certain aspects of what we learn in games, including decision making, control, optimization and behaviour, can be transferred to real-world applications. From research on computer vision (Trivedi et al., 2021; Trivedi et al., 2022) all the way to autonomous car driving (Kim et al., 2021; Martinez et al., 2017) and architecture (Radford, 2000; Xylakis et al., 2021), games can rapidly test and improve any AI approach before it is transferred into the wild.

2.2 AI for Games

What is often surprising to many AI researchers is that the AI and games field (or game AI for simplicity) is not only associated with AI-based gameplaying with the sole purpose of beating humans at a game. Thankfully there are multiple other uses of AI in games within gameplaying and beyond that are benefiting games themselves (Yannakakis et al., 2018). When it comes to gameplaying for instance, AI can be extremely useful for testing games (Holmgård et al., 2014), for imitating the ways humans behave and experience a game (Yannakakis et al., 2014b), for simulating human cooperation (Bard et al., 2020; Sfikas et al., 2021), and even for automatically detecting glitches of designed levels (Yannakakis et al., 2022).

Beyond gameplaying, AI finds applications primarily in the areas of game generative systems and player modelling. In the former, algorithmic frameworks including search (Togelius et al., 2011), evolutionary algorithms (Gravina et al., 2019), machine learning (Summerville et al., 2018), deep learning (Liu et al., 2021) and reinforcement learning (Khalifa et al., 2020; Shu et al., 2021) can drive the generation and evaluation of game content. The content generated can be anything existent in a game: visuals, narrative, levels, game rules, audio, and even gameplay patterns (Liapis et al., 2014). Such content can be generated autonomously or in a creative dialogue with a designer in a mixed-initiative fashion (Yannakakis et al., 2014a). Procedural content generation algorithms have been applied to a variety of game genres and game content types including tracks for racing games (Togelius et al., 2007), weapons (Gravina et al., 2016) and levels for first person shooters (Cachia et al., 2015),

strategy games (Togelius et al., 2010), platformers (Shu et al., 2021; Summerville et al., 2016) and 3-match tile games (Volz et al., 2020), audio for horror games (Lopes et al., 2015), and levels for arcade games (Perez-Liebana et al., 2019). Arguably the most popular task for procedural content generation throughout the decades of this field's existence is automated level design.

When it comes to player modelling, AI is tasked to capture aspects of player behaviour or experience (Yannakakis et al., 2018). The former is usually achieved by imitating human behavioural demonstrations including play traces and action sequences. The latter refers to the prediction of human experience demonstrations (such as arousal traces) based on multimodal data obtained from the player and the game including physiology (Chanel et al., 2011; Martínez et al., 2014), ad-hoc designed features (Melhart et al., 2021) but even player-agnostic representations such as the game footage pixels (Makantasis et al., 2019, 2021).

Testing, content generation, and player modelling have collectively changed the ways we design and develop games and have boosted the entire game production process. It is nowadays possible to automatically test parts of or entire games with only limited demonstrations (Barthet et al., 2022). It is also entirely possible to generate aspects of such games in a semi-autonomous fashion as, for instance, the *Candy Crush Saga* (King, 2012) level generator (Volz et al., 2020). One can also automate large parts of the quality assurance and user experience testing process by detecting aspects of player motivation, player engagement or toxicity in popular titles such as *PUBG: Battlegrounds* (Tencent Games, 2017) (Melhart et al., 2020), *Tom Clancy's the Division* (Ubisoft, 2016) (Melhart et al., 2019), and *For Honor* (Ubisoft, 2017) (Canossa et al., 2021). Needless to say, all aforementioned AI technology has reframed the design of monetization strategies followed within game production.

2.3 The AI and Games Co-Evolution and The Road Ahead

One might argue that the evolution of AI via games and the development of games via AI are independent lines of research and innovation. Recent studies, however, have showcased that AI and games are intertwined to such a degree that the domain (games) influences and advances the field (AI) and vice versa. This relationship, in turn, has multiplying effects and impacts several other domains beyond games. AI algorithms that build continuously larger, more challenging, multimodal and rich environments are setting continuously harder milestones for AI to achieve (Risi et al., 2020b). Moreover, AI that is able to capture human demonstrations of behaviour and experience is, in turn, able to automatically play and test unseen new environments in a human-like fashion (Barthet et al., 2021; Holmgård et al., 2014). Everybody wins with this competitive co-evolution of AI and games: game worlds become interesting, novel and increasingly complex and AI learns to complete downstream tasks of growing difficulty.

So where do we stand currently with this relationship and what does the road ahead look like? Representation learning appears to be key for unlocking technological breakthroughs such as foundation models (Bommasani et al., 2021). While the focus on games as testbeds (games for AI) has given us promising solutions to near-optimal play in complex real-time strategy games like *StarCraft II* (Blizzard Entertainment, 2010) (Vinyals et al., 2019) it seems that the next leap forward comes from advancements achieved within the representation of games. The dominant ways of approaching testing and player modelling via forms of self-supervised learning, for instance, are likely to become a game changer for the AI we develop for games and beyond. Recent studies suggest that unsupervised and self-supervised learning methods are able to represent the game state in an aesthetics-agnostic (Trivedi et al., 2021) and task-agnostic fashion (Trivedi et al., 2022) which we can then use in a generalised manner beyond games (Reed et al., 2022). These findings showcase that it is possible to create general representations of games that capture the very context of a game (e.g. "I now see a football game!") independently of the game's aesthetics (e.g. arcade, retro, photo-realistic, etc.) and the downstream task (e.g. playing a game or modeling a player). Such computer vision methods may equip us with powerful tools for representing the mechanics of games which can, in turn, be transferred and evaluated on real world applications (e.g. a real football game).

The long-term vision for AI is to be able to capture the dynamics of games and play in such a generalised manner that it would be able to play any given game made by human designers or AI (Yannakakis et al., 2018). As such, the recently celebrated metaverse is another unique opportunity for algorithmic advancements in AI. It is important to be reminded, however, that games are essentially the front-end of the metaverse; at least the first instance of what is envisaged as a multi-user immersive interactive world. It is not a surprise that game engine giants such as Unity and Unreal are invested to the development of such massively online multi-user worlds. The underlying game technology is already there and can be adopted from successful massively multiplayer online games like *World of Warcraft* (Blizzard Entertainment, 2005). The immersive and interfacing technologies like VR and AR, on the contrary, still define the core technical obstacles for enabling an immersive experience in such virtual spaces. The need

for intelligent entities (i.e. agents) that behave and experience their virtual worlds like humans will be ever growing. AI will also likely take, in part, the role of a metaverse designer, as it currently does in game design. Once human and AI authored worlds are generated and populated, AI will be tasked to test them and make sure that they are operational, that they satisfy the metaverse's rules and that they are fun to "live" in.

3 Part II: AI and Games at the Institute of Digital Games

By now it should be obvious that the interaction between AI and games has impacted the research world and has led to breakthroughs across multiple domains and disciplines. In this second part of the paper I will look through the local lens of Malta as an exceptional case study in this research field and outline a brief history of what AI and games have brought collectively to the country over the last decade. In particular, I will explore important research and development indicators that provide evidence for this nationwide impact. Such research intensity showcases, in turn, how a small island state (Baldacchino et al., 2018) that invested in highly multidisciplinary research and education has managed to reach and enjoy global recognition.

The Institute of Digital Games (IDG), established in 2013, is a unique multidisciplinary and multicultural research centre of the University of Malta (UM). Since its establishment such a centre—with a sole focus on the domain of games—offered an attractive proposition to game researchers. In particular, IDG combined uniquely i) an English speaking Institution in an English speaking country ii) a focus on the multidisciplinary domain of games; iii) the support of a national strategy on video game development; and iv) the lack of any other such centre in the vicinity (i.e. Southern Europe and the Mediterranean) at the time. Due to its unique proposition the IDG has managed to attract and host top researchers with multidisciplinary interests in games from Malta and other (mostly Mediterranean) countries. Among other notable achievements, the multidisciplinary group of IDG has managed to publish top-cited books in game studies (Calleja, 2011; Gualeni, 2015; Gualeni et al., 2020) and game design (Calleja, 2022) with top-tier publishers such as MIT press, and win awards for published games.

IDG contributes to and is benefited from other Faculties, Centres and Institutes at the UM by offering courses to a wide range of educational programs that use games in their curriculum including ICT, media, English, architecture, and psychology. The Institute also co-hosts joint-research projects and training seminars with a number of UM departments and corresponding disciplines including (but not limited to) AI, distributed ledger technologies, literature, philosophy, creative thinking and innovation, and linguistics and language technology. Importantly, IDG is a key stakeholder of GamingMalta, the independent non-profit foundation tasked with the remit of promoting Malta as a centre of excellence in digital game development[2]. Notably, IDG has assisted the Government of Malta to shape its research and innovation strategy around video game development and eSports; the Unity Centre of Excellence is an indicative initiative of the IDG[3].

Among other disciplines and fields and importantly for this paper, IDG hosts an active AI research group with an emphasis on applied game AI[4]. The group also offers graduate (MSc and PhD) education in game technology and game AI. Research on AI and games performed at the IDG feeds directly the graduate program in game design and game technology which, since 2017, is placed within the Top 25 Game Design programs worldwide by *The Princeton Review* (The Princeton Review, 2022).

During the last decade, the IDG AI group has been successful in implementing a strong research program on game AI, procedural content generation and player modeling which is demonstrated through the number of highly cited articles in globally recognized journals and conference proceedings. In particular, more than 250 papers have been published in the broader area of AI and games and have received more than 22,000 citations (h-index: 170) collectively (Institute of Digital Games, University of Malta, 2020). As a result the research outreach of IDG has reached a world-class standard currently (2022) ranked 6^{th} in the list of the top 100 technical games research institutions globally (Nelson, 2022). Beyond its rich publication output, the Institute has coordinated and managed numerous national, FP7, H2020, and Horizon Europe projects attracting a total budget of over 6m Euro for supporting its research activities in game AI and game design. According to the Malta Council for Science and Technology, the Institute also hosts the most active researcher in the country[5]. The research and innovation (R&I) projects administered by the AI group of IDG have led to outcomes that collectively have advanced AI methods for affective computing and generative systems, but also fostered the creative use of AI for media, cultural heritage, architecture and engineering. Moreover, the successful implementation of the aforementioned projects has enhanced and empowered the ways we teach, bring-

[2] https://www.gamingmalta.org/

[3] https://timesofmalta.com/articles/view/the-gamingmalta-foundation-announces-partnership-with-unity.931927

[4] https://www.um.edu.mt/digitalgames/airesearchgroup/

[5] https://www.um.edu.mt/newspoint/news/2021/02/most-active-researcher

ing innovative game technology, AI and machine learning to the epicentre of education. The projects collectively contributed to a gradual shift from digital to AI literacy and engaged students in Malta and abroad to become responsible citizens with regard to creative thinking, societal challenges and even ethical implications of AI.

Beyond its research and educational agenda, the AI group of IDG also excels in technical innovation. Its spin-out, modl.ai[6] is currently listed within the top 100 most innovative AI start-ups worldwide and the only one within the games sector (CB Insights, 2022). Several faculty and alumni of IDG are nowadays actively contributing to the company's vision to build an AI engine that would be able to test any given game rapidly via sophisticated testing technology. Indicative of its success—at the time of the writing this paper—the IDG spin-out received an investment of $8.4m led by top-tier commercial and strategic actors including Microsoft's M12 Venture Fund[7].

The impact and significance of the Institute of Digital Games for UM and the country is reflected through key research and development indicators identified by the European Commission through its European Innovation Scoreboard 2021 (European Commission, 2021). Indicatively in 2021, the IDG contributed a 6.8% of Malta's new doctorate graduates in STEM, a 69% of new foreign doctorate students and, on average, three times more doctorate students per academic (i.e. 1.67) compared to the UM average (i.e. 0.57)[8]. Importantly, in the period between 2014 and 2020, IDG managed to attract research funds of 2.1 million Euro out of the 22.4 million Euro that was collectively attracted in Malta. This contribution amounts to 9.3% of the country's research funding during the Horizon 2020 research and development framework[9]. All the above indicators are key for the R&I growth and sustainability of Malta and offer clear evidence for the leading role of the Institute and its AI research group towards improving the *research intensity* of the country as a whole.

The aforementioned research, educational and innovation outcomes have been both timely and of national importance for Malta as both AI and video games define core strategic areas of growth and development. Importantly, AI and games support all thematic areas of Malta's R&I Smart Specialization Strategy (Malta Council for Science and Technology, 2020) and core niche areas including AI, IoT, big and open data, and human-centric applications. In summary, the analysis above indicates that a targeted investment in a niche multidisciplinary research area, even at a small scale, can have a tremendous socioeconomic impact on a small island state like Malta (Baldacchino et al., 2018). Evidently, a multidisciplinary research and educational group with a key focus on AI has managed to put Malta on the world map of technical games research and innovation.

4 Parting Words

As highlighted throughout this paper, the various uses of AI for and in games have led to numerous algorithmic breakthroughs including tree search, computer vision, (deep) reinforcement learning, language models and self-supervised learning. At the same time alternative applications of AI beyond mere gameplay optimization have resulted in advancements in generative systems of game worlds, automatic testing tools of various sorts and player behaviour and experience detection systems. In recent years, we have witnessed a research symbiosis of AI and games as algorithms generate continuously more complex and interesting worlds for AI to play, test and experience. The impact of this unique relationship is already shaping the ways we educate our children, the ways we develop game-based digital twins, the buildings we design and construct, all the way to the metaverse we envision.

While in the first part of the paper I focused on the *general* impact and significance of AI and games, in the second part I explored the nationwide impact of the field in the *specific* (and rather exceptional) case of Malta. In particular, I provided evidence showcasing how a national focus on AI and games has benefited the small island state (Baldacchino et al., 2018) within less than a decade since the establishment of the Institute of Digital Games in 2013. The socioeconomic impact of AI and games research on the country is evident through several factors including key objective academic performance indicators such as citations and awards, recognized global rankings of research and educational excellence, and key factors considered by the Commission's *European Innovation Scoreboard* (European Commission, 2021) and *Malta's Research and Innovation Smart Specialisation Strategy* (Malta Council for Science and Technology, 2020). Evidently, the Institute of Digital Games is a successful paradigm for Malta directly supporting its research, education and innovation ecosystem on video games and artificial intelligence. Given its bright present, the future of games and AI research in Malta brings increased responsibility for an ever-growing research and innovation intensity with a global impact.

I wish to conclude this paper with a critical note regarding any potential future challenges the Institute of

[6] https://modl.ai/

[7] https://venturebeat.com/games/modl-ai-seriesa-ai-bot-qa-testing-griffin-gaming-microsoft-m12/

[8] Source: Doctoral School, University of Malta; https://www.um.edu.mt/doctoralschool

[9] Source: Malta Council for Science and Technology; https://mcst.gov.mt/

Digital Games might face. One might question the sustainability of the IDG given its small size and the critical impact most members of staff have on its success. Arguably it is a weakness for a small Institute—being part of a country's single University—to be dependent on a few successful academics. One would argue, however, that its size is also one of its core strengths when it comes to resource management and daily operations. Given the Institute's growing reputation in games research it should be emphasized that attracting world-class researchers to Malta—for further supporting IDG's activities—should be considered guaranteed by now. The long-term availability of external funding across many disciplines beyond AI (e.g. digital humanities, education, cultural heritage, extended reality) improves and strengthens the position of IDG as a self-sustained unit. Despite being small and hosted in a small island country, IDG will likely continue to thrive as supported by its established reputation, and its versatile and multifaceted (i.e. research, education, innovation) impact across diverse disciplines within games.

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