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GameTable COST action: kickoff report

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Abstract. The GameTable COST Action kickoff, focusing on "Computational Techniques for Tabletop Games Heritage," took place at Leiden University in the Pieter de la Court Building from January 29th to 30th, 2024. This event aimed to convene researchers from diverse backgrounds involved in the Action, offering an opportunity to present an overview of the key research areas, share concrete case studies, and facilitate discussions and idea exchanges across fields that may not typically intersect, thereby enhancing the organization of the Action. This report provides a summary of the organization and discussions of the event, and future plans for GameTable.

1. GAMETABLE

Games have served as a research focal point across various disciplines, yet these domains have often operated in isolation from one another. In fields like computer science and mathematics, games have served as invaluable testbeds for pioneering methodologies spanning economics, engineering, and artificial intelligence (AI) (von Neumann and Morgenstern, 1944; Yannakakis and Togelius, 2018). Concurrently, archaeologists, historians, and anthropologists have delved into the intricate motivations behind human play, illuminating its profound social implications on both individual and societal levels. Moreover, games have long been integral to pedagogical development (Colliver and Veraksa, 2019) and are increasingly acknowledged as vital components of humanity's tangible and intangible cultural heritage (Crist et al., forthcoming). Unfortunately, much of this rich heritage has been eroded by both natural forces, and more devastatingly, by the forces of colonialism, imperialism, and commercialization.

The GameTable Action (http://gametable.network), funded for four years by COST (European Cooperation in Science & Technology), endeavors to forge an international, interdisciplinary network comprising scholars and stakeholders at all career stages, spanning academia, industry, and heritage institutions. The aim is to inspire novel methodologies and applications that harness game AI to study, reconstruct, and preserve the tangible and intangible cultural heritage embedded within games. By cultivating more human-like AI techniques, analyzing the mathematical underpinnings of games, integrating game-theoretic models, and infusing insights from historical games and cross-cultural gameplay understanding, the initiative seeks to foster more comprehensive methodologies. These collaborations will be facilitated through conferences, workshops, and other cross-disciplinary engagements,

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fostering the creation of publications and digital tools to propel both theoretical insights and practical applications in game research. Ultimately, the endeavor seeks to develop sophisticated preservation methods for games as embodiments of ancient and contemporary cultural heritage, alongside the creation of game-centric educational programs.

The GameTable COST Action CA22145, initiated on October 24th, 2023, currently boasts a membership of 178 individuals from 48 countries actively engaged in its working groups. Overseen by a committee (MC) comprising 60 members representing 37 distinct COST countries, the initiative reflects a diverse and international collaboration (See Figs 1 and 2).

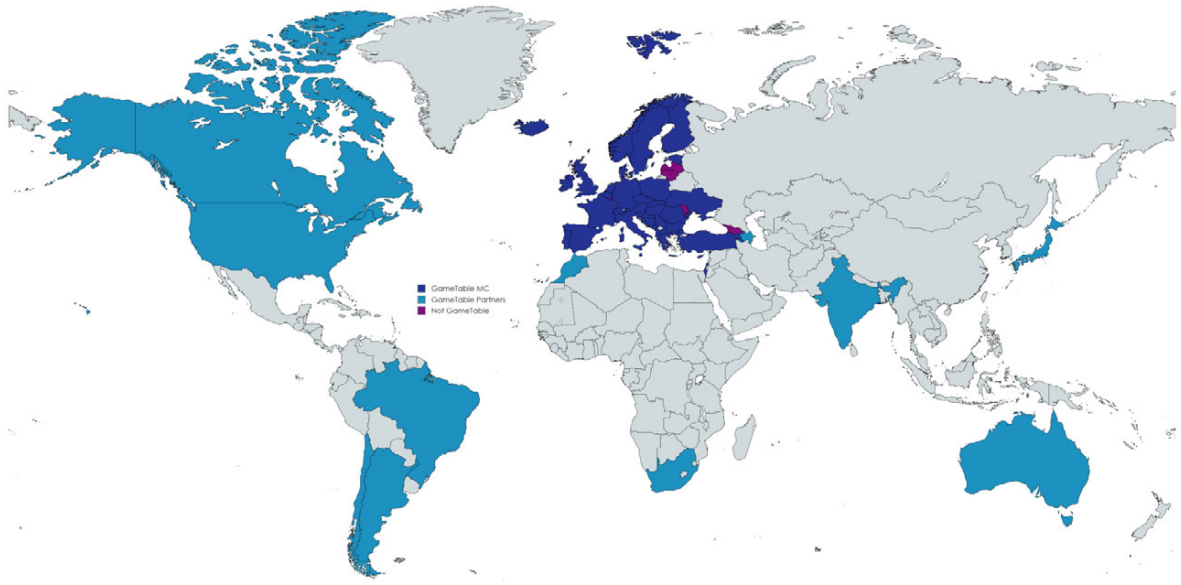

Fig. 1. Countries represented within GameTable WG members.

The Action is organized into five distinct working groups (WGs), which are as follows:

(1) WG1 – Search, Planning, Learning, and Explainability
(2) WG2 – Cultural Heritage of Games
(3) WG3 – Automated Game and Puzzle Design
(4) WG4 – Mathematics in Games
(5) WG5 – Implementation, Dissemination, and Education

The action is led by a core group composed of 14 members consisting of the chairs, the leaders from each working group, the Science Communication Coordinator, the Grant Awarding Coordinators, the General Inclusivity Coordinator, and the Industrial Relationship Coordinators.

2. KICKOFF

The GameTable COST Action kickoff was held as a hybrid event at Leiden University in the Pieter de la Court Building from January 29th to 30th, 2024. These two days were designed to bring together researchers from diverse backgrounds involved in the Action. The event provided an opportunity to present an overview of the key research areas, share concrete case studies, and foster discussions and idea exchanges across fields that may not typically intersect, thereby enhancing the organization of the

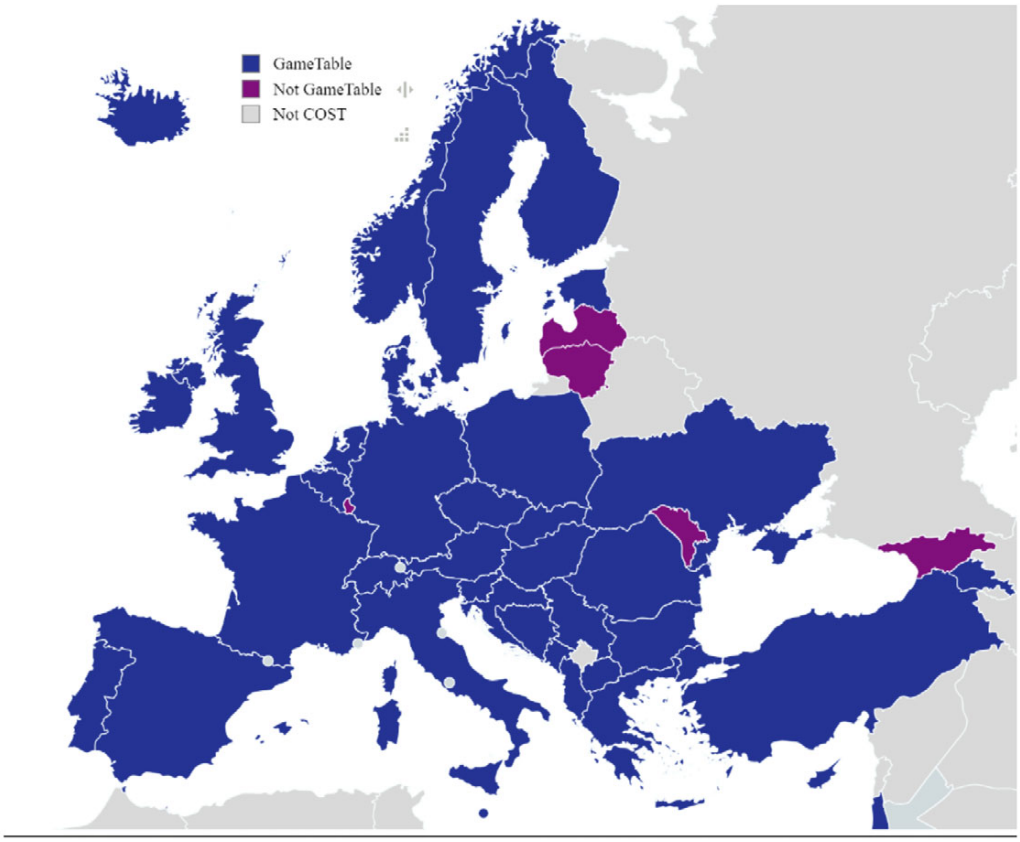

Fig. 2. COST countries represented within GameTable MC.

Action. A total of 58 participants from 38 countries attended, with multiple talks and panels delivered by the chairs and core group members to stimulate discussions and debates.

The first day was dedicated to introducing GameTable members and outlining the main objectives, as well as delving into the fundamentals of the most prominent research fields related to tabletop games. Concrete case studies were presented as examples of interdisciplinary collaborations within these fields. The second day focused on all aspects of organization and communication within the Action, with open discussions among the members. Detailed descriptions of each session are provided in the following subsections.

2.1. Session 1 – introduction

The opening session of the Workshop commenced with GameTable chairs, Éric Piette and Walter Crist, extending a warm welcome to all attendees. They introduced themselves and briefly outlined the kickoff objectives before addressing important logistical details. Subsequently, participants were invited to introduce themselves with a few sentences.

During this introduction session, participants were encouraged to contribute to a word cloud representing their views on the Action. The resulting word cloud is depicted in Fig. 3.

Fig. 3. Word cloud illustrating the GameTable views from its members.

2.2. Session 2 – GameTable

The second session began by outlining the roles of each member of the GameTable core group within the Action. This was followed by a panel discussion featuring all the working group (WG) leaders, who fielded questions and provided detailed insights into their respective plans.

The GameTable core group is comprised of 14 members:

- **Actions Chairs**: Éric Piette and Walter Crist, bear the responsibility for overseeing the Action on behalf of the Management Committee. They are tasked with approving or rejecting nominated new Management Committee members, managing all Working Group applications with the assistance of the WG leaders, assigning leadership positions, submitting the Work & Budget plans, and overseeing progress reports. Given their deep involvement with a wide array of GameTable topics, they actively participate in all Working Groups.
- **Science Communication Coordinator**: Summer Courts plays a pivotal role in both internal and external communication by coordinating the dissemination efforts of the Action. As the primary contact for communicating with the public and external parties regarding Action communication, dissemination, and valorization, she ensures a cohesive strategy. Summer implements the Action's communication and dissemination strategy in accordance with the visual identity requirements of COST Visual Identity and manages various social networks and communication channels. This comprehensive communication strategy will be detailed in the forthcoming GameTable Science Communication Plan. Summer is also credited with designing the GameTable logo, as depicted in Fig. 4, and the GameTable website. Part of GameTable's communication strategy, the official website at http://gametable.network is hosted by the Chair's institution at UCLouvain.
- **Grant Awarding Coordinators**: Fatih Parlak and Ilaria Truzzi oversee and manage the Grant Awarding process within the Action. They are responsible for approving, on behalf of the Management Committee, the awarding of all types of grants for the mobility of researchers and innovators and to help the presentations of Action results at conferences organized by third parties.
- **General Inclusivity Coordinator**: Raluca Gaina plays a crucial role in ensuring the balanced representation of all participants in events. Her focus includes addressing the under-representation of female researchers, especially in fields such as Computer Science and Artificial Intelligence. Raluca is also responsible for leading initiatives aimed at promoting inclusivity within the Action, receiving full support for her efforts.
- **Industrial Relationship Coordinator**: Spyridon Samothrakis serves as the primary contact for GameTable members interested in collaborating with industrial partners. He is responsible for establishing connections with industrial partners regarding the diverse projects undertaken within the Action, whether at the level of individual working groups or the Action as a whole. Spyridon will communicate any industrial opportunities to the network, ensuring widespread awareness among members.
- **Working Group leaders**: Each working group is led by one or two leaders. Dennis Soemers and Jakub Kowalski lead WG1 (Game AI), Walter Crist and Tim Penn lead WG2 (Cultural Heritage),

Antonios Liapis leads WG3 (Procedural Content Generation), Lisa Rougetet and Tiago Hirth lead WG4 (Mathematics), and Theodora (Dorina) Moullou leads WG5 (Implementation, Dissemination, and Education).

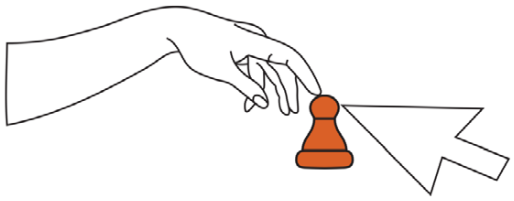

Fig. 4. GameTable's logo designed by Summer Courts.

During the working group panels, each leader described their working group, emphasizing that participation is not limited to specialists in their own field. The primary purpose of these groups is to foster collaboration with other Working Groups. Here is a brief description of each working group:

- **Working Group 1 – Search, Planning, Learning, and Explainability**: This working group focuses on topics related to Artificial Intelligence (AI) techniques for decision-making within games. Decision-making, in this context, refers to selecting moves to make in a game. The AI techniques considered in this group include (but are not limited to):
  - ∗ Search and Planning Algorithms: These algorithms anticipate potential sequences of moves that players might make to gain a strategic advantage, evaluating which moves are likely to be optimal in the long term.
  - ∗ Learning Algorithms (primarily reinforcement learning): Algorithms that improve their gameplay through experience, recognizing relevant patterns, and generalizing learned behaviors from encountered situations (game states) to new, unseen situations.
  - ∗ Explainability: Techniques aimed at automatically generating explanations for the decisions made by algorithms, or more broadly, producing explanations of relevant strategies and tactics to enhance human understanding of the game.

  For any of the techniques listed above, the focus should generally be on general game-playing settings. We aim to develop approaches applicable to a wide variety of games, both in principle and practice. This means they should be implementable and usable in frameworks capable of running many different games. Typically, these frameworks describe game rules in a highly convenient, succinct, and user-friendly game description language (or in natural language), rather than specialized and complex languages or general-purpose programming languages.
  The three major research topics identified so far are:

  (1) Human-like AI: This topic explores the development of AI techniques that not only aim to play as effectively as possible but also accurately model the experiences humans have when playing games. Ideal algorithms provide distributions of different playing strengths, make human-like mistakes, avoid biases towards obviously non-human mistakes, exhibit various play styles, and adhere to unwritten rules and etiquette. Their behavior can ideally be adjusted using information provided by anthropological or archaeological research in WG2 for different case studies.
  (2) Imperfect-information games: Games with hidden information, such as card games, have received relatively little attention in truly general game-playing settings. Algorithms for this class of games are often evaluated on one or a few games, with programmers manually encoding extensive knowledge, such as functions to generate or sample from information sets.

(3) Explainable search and reinforcement learning (RL): Explainability is a significant and growing area in AI and machine learning. This group brings specific focus to search and RL algorithms, exploring their applications in games and how they can be made more explainable.

The primary channel for communication within WG1 is the following Google Group: https://groups.google.com/g/gametable-ai.

- **Working Group 2 – Cultural Heritage of Games**: This working group adopts humanistic and social science approaches to games, aiming to explore the intangible heritage of games. It operates at the intersection of multiple disciplines, including archaeology, history, heritage studies, the museum sector, education, and private enterprises. The core objective is to devise methods for studying and preserving tabletop games by leveraging all available textual, material, and ethnographic information. Its scope is global, encompassing all tabletop games from prehistory to the present day.
Traditionally, games research has been centered in Western Europe and North America. WG2 seeks to broaden the study of games to include regions beyond these areas. Within the context of GameTable, this working group explores how the cultural heritage of games intersects with recent developments in AI techniques. The group envisions several ways in which cultural and historical research can contribute to and benefit from AI research, including but not limited to:

  (1) Identifying research questions that can be answered using AI techniques, including AI playout simulation of games, game evaluation, and other unexplored applications.
  (2) Providing cultural and/or social data to AI researchers to enhance more humanistic modeling and assist in developing AI agents with more 'human' styles of play.

  The group aims to explore innovative data management approaches while expanding data collection to underrepresented regions in games scholarship. Recent developments in board games history and archaeology have seen an emphasis on the ancient Mediterranean region; in the interests of representation and broadening engagement with other gaming traditions, they are particularly interested in welcoming scholars whose research focus includes East and Southeast Asia, post-antique West Asia, Africa, and the indigenous Americas and Oceania. While their current strength lies in board games, they strongly encourage scholars focused on card games to participate. They are also keen to collaborate with colleagues experienced in or interested in working with Digital Humanities techniques. The primary channel for communication within WG2 is the following Google Group: https://groups.google.com/u/1/g/gametable-cultural.
- **Working Group 3 – Automated Game and Puzzle Design**: This working group is dedicated to the use of AI in game design, focusing on two main objectives:

  (1) Developing methods to reconstruct missing rules in incomplete traditional games.
  (2) Creating new, high-quality games and expansions for existing games, especially with commercial applications in mind.

  WG3 tackles intriguing questions such as how to generate games without clear definitions of winners, when some rules are unknown or undocumented, or when social aspects are integral to a game's value.
  The group specializes in reconstructing ancient games from partial historical evidence, employing sophisticated techniques to generate possible rules based on available knowledge. In the realm of education, WG3 aims to enhance educational materials by developing software programs that assist in generating and evaluating games used for educational purposes. They are also committed to refining their research skills to develop new algorithms for automatically generating high-quality and original tabletop games. Additionally, the group focuses on creating new puzzles and content for existing puzzles, delving into the psychology of player engagement. Collaborating closely with

WG1, WG3 works on the reconstruction of traditional tabletop games. Lastly, they plan to conduct experiments aimed at identifying mathematical principles that may have existed in certain games, furthering our understanding of these ancient forms of entertainment. The primary channel for communication within WG3 is the following Google Group: https://groups.google.com/u/1/g/gametable-pcg.

- **Working Group 4 – Mathematics in Games**: The primary goal of this Working Group (WG) is to facilitate the exchange of mathematical research related to games, aiming to uncover the intricate connections between games and mathematics. The group is interested in exploring how individuals in the mathematics field approach the study of games, including the mathematical tools and concepts essential for developing strategies. Additionally, they are interested in understanding how individuals in the game design realm utilize mathematics in creating games.
  Games analysis involves a wide array of mathematical branches, each focusing on different aspects of gameplay such as rulesets, game space, pieces, strategies, tactics, players, and more. Whether a game features perfect information, random elements, varying numbers of players, simultaneous moves, and so forth, any field of mathematics can be relevant. This includes set theory, number theory, graph theory, combinatorial game theory, probabilities, statistics, game theory, topology, cryptography, among others. Studying games as unique mathematical objects allows for a deeper exploration of mathematics, an ever-evolving field with a rich history. Understanding these processes of knowledge production is crucial for modern teaching methods. Members of this WG are particularly interested in:

  * Algorithms and methodologies for studying games and their mathematical properties.
  * Breaking down games into mathematical properties, such as game states/positions.
  * Examining the variability and stability of games.
  * Exploring the interplay between the histories of games and mathematics.
  * Utilizing mathematics in game creation.
  * Defining game aspects mathematically and assessing playability.

  The core objectives of this group include sharing mathematical methodologies from various disciplines, presenting case studies in mathematical game studies, and connecting researchers involved in games and mathematics. Discussions have also been initiated regarding dedicated issues in the *Recreational Mathematics Magazine*. The primary communication channel for WG4 is the Google Group: https://groups.google.com/g/gametable-maths.
- **Working Group 5 – Implementation, Dissemination, and Education**: Working Group 5 (WG5) serves as the central hub connecting all other Working Groups within the Action, focusing on implementing new tools based on the solutions developed throughout our research and on initiating scientific papers for all the actions. At the core of WG5's mission is collaboration between end-users and researchers/developers, ensuring that the work meets practical needs and adheres to performance criteria. WG5 aim to create tools that are not only fit-for-purpose but also widely embraced by the relevant communities, including researchers, educators, and the general public. In addition to the tool development efforts, WG5 is responsible for the dissemination aspect of the Action. Their goal is to maximize the impact of the Action on the general public while fostering partnerships with cultural and industrial entities. Some of the key tasks and activities of WG5 include executing the Dissemination Plan to ensure optimal visibility for the main activities, events, outcomes, and deliverables of all WGs, effectively reaching the relevant stakeholders. They also coordinate the development of a user-friendly general game system, making it accessible not only to researchers outside of computer science but also to the wider public. This includes establishing partnerships with institutions and organizations, organizing educational events such as training schools (TS) and meetings, and creating tutorials and videos released on social media channels to

promote and facilitate the use of the AI-based tools produced. Furthermore, WG5 actively engages in targeted meetings with museums, hosting workshops, classes, and other programming events in collaboration with local cultural heritage and games organizations. They work on connecting heritage education with game-based learning activities within Europe, sharing experiences, methodologies, and best practices. To support teacher training in both primary and secondary schools, WG5 will produce booklets, videos, and tutorials on games, history, and mathematics. Finally, the WG5 team is tasked with organizing the final conference and is working on creating a digital exhibition showcasing applications of Game AI to traditional games.

The primary channel for communication within WG5 is the following Google Group: https://groups.google.com/u/1/g/gametable-dissemination.

2.3. Session 3 – fundamentals

This session delved into the Fundamentals of Cultural Heritage of Games, Game AI, and Mathematics in Games. The purpose of this session was to bring everyone up to speed about some of the methods and concepts that are relevant to the different disciplines within GameTable. Walter Crist, Lisa Rougetet, and Dennis Soemers presented three talks:

• W. Crist, *Cultural Heritage of Games*: This presentation framed games as a global phenomenon that began in prehistory to properly conceptualise how we think about games in the context of GameTable. In the present day, we are used to learning new games from their rulebooks, but for the majority of human existence people learned games from one another, rather than through written rules. This model of transmission allows for people to easily alter games as they see fit, leading to changes in game preferences through time and space. Games function to bind communities together as well as to facilitate interaction between them (Crist et al., 2016).

One of the problems within the cultural disciplines is that games have largely been ignored as a legitimate topic of research. This has led to a situation where a considerable amount of information that is readily available about the history of games is outdated methodologically or because it does not take into account recent data. To counter this, as part of the Digital Ludeme Project, the Ludii Games Database (https://ludii.games/) was compiled to accomplish the historiography of board games – that is, a consistent documentation of what exactly is known about traditional board games, using archaeological, historical, representational, and ethnographic evidence. After exploring the structure of the database, discussion followed surrounding the goals of the database as a powerful tool for preserving the heritage of games. We emphasized that, while the database is currently focused on board games, it needs to be expanded to include other kinds of games. Furthermore, we discussed the fact that the database as it was built for the Digital Ludeme Project is structured in a way to make Ludii function (Browne et al., 2023). With GameTable, we now have the opportunity to refocus it so that heritage preservation is its primary goal. We discussed ways to allow for more people to contribute data to the database, as well as how to ensure the long-term survival of this resource that has already become useful to people.

• L. Rougetet, *WG 4 Mathematics in Games: presentation and perspectives*:

The objects of this presentation were twofold.

Firstly, it aimed at providing a general introduction to game theory, its issues and the questions that underlie it. Game theory is a theoretical discipline that enables us to (formally) understand situations in which players, or decision-makers, interact. In this framework, a game is defined as a universe in which each decision-maker has a set of possible actions determined by the rules of the game. The

outcome of the game depends jointly on the actions taken by each decision-maker (Osborne, 2004). Thus, key questions include (among many others): Can we predict each player's choice? What will be the outcome of these actions? Can we find a winning strategy for one of the players? Etc.

Of course, the models differ greatly depending on the characteristics of the games being studied: cooperative or non-cooperative, simultaneous moves or not, complete information or not, chance or not, winner determined by the last move or not, etc. Depending on the characteristics considered, the mathematics involved to analyze the game will be varied. For example, combinatorial game theory is the mathematical theory that focuses on the analysis of two player-games, playing alternately, with complete information and no chance (such as Go or Chess) (Albert et al., 2007). Of course, WG4 intends to cover any kind of game, not only combinatorial ones.

Secondly, the presentation highlighted some links that can be made with other working groups in the Action via very specific approaches (comparing the strategies and tactics played by each AI agent to the strategies played by humans for WG1; determining what the evidence from history and archaeology can tell us about the use of mathematics in the games of past societies for WG2; performing experiments in reconstructing games which may identify mathematical principles that must have existed in certain games for WG4; and connecting heritage education and game-based learning for WG5) thus demonstrating the coherence of the Action as a whole and the fruitful relationships that can emerge through it.

We also stressed the importance of a historical approach within WG4. The history of mathematics, and more specifically of games and their mathematical theories, provides a better in-depth understanding of mathematics, is essential for teaching today, and enables fruitful interaction with AI methods. An example was provided with the recent collaborative work focused on the French Military Game (Piette et al., 2021b).

• D. Soemers, *Fundamentals of Game AI*: This presentation introduced some of the fundamentals behind research in artificial intelligence (AI) for automated decision-making in games. This area of research, with its roots tracing back all the way to the beginnings of the field of AI research as a whole (Shannon, 1950; Turing, 1953), revolves around the development of computer programs that can autonomously decide which moves to make or actions to take in games – ideally in an intelligent manner. Researchers in this field have primarily focused on achieving strong, superhuman, or optimal levels of play, with tabletop games such as backgammon, checkers, chess, Go, and poker having served as important benchmarks for many decades, leading to landmark results of AI research such as TD-Gammon (Tesauro, 1995), Chinook (Schaeffer et al., 1996), Deep Blue (Campbell et al., 2002), AlphaGo (Silver et al., 2016), DeepStack (Moravčík et al., 2017), Libratus (Brown and Sandholm, 2017), and Pluribus (Brown and Sandholm, 2019). Of particular interest to this Action is the subfield of *General Game Playing* (GGP) (Pitrat, 1968), which challenges researchers to develop programs that are broadly applicable to a wide variety of games with no need for intermediate human intervention or advice.

Within the context of this Action, the primary use case of game-playing AI would be to estimate various statistics of the human game-playing experience using automated AI play as a substitute for (substantially more time-consuming and expensive) human playtesters. This will likely require a shift away from the more common and established focus areas of strong or superhuman play, towards more human-like AI.

2.4. Session 4 – case studies

This session featured concrete case studies showcasing AI applications in the study of ancient games. These examples highlighted the interdisciplinary collaboration between AI and Archaeology researchers within the ERC-funded Digital Ludeme Project. It was through this collaboration that the foundations of digital archæoludology (Browne et al., 2019) were laid, ultimately leading to the creation of the GameTable COST Action.

This presentation focused on some of the applications that were explored during the course of the Digital Ludeme Project that used AI techniques to explore archaeological research questions with respect to games. The first highlighted example explored the Roman board game of Ludus Latrunculorum, and placed the rules for games that most closely reflect what is known about the Roman game on the different board sizes, and performed playout simulations to examine various metrics to determine which board sizes were plausibly used for the Roman game (Crist et al., in press). Based on several factors including playout metrics and archaeological evidence, it was concluded that boards larger than 10×10 were not suitable for the rules as described by the Roman authors, and thus were probably meant for some other game. This study serves as an example of a way that AI-driven play can help researchers to identify which boards belong to games which are known primarily from written sources.

The second case study focused on the exploring the possibility of identifying the rules for a previously undocumented game. An object in the Thermenmuseum in Heerlen, the Netherlands, exhibits a unique geometric patter on its face, with evidence for use-wear that is consistent with its use as a game board. Rules from other small board games from Northern Europe were adapted to the possible board configurations presented on this object, and it was fund that several versions of blocking games produced the disproportionate use seen on the object in the playout simulations.

In the discussion that followed, we clarified Ludii's concept of rulesets, which are the individual sets of rules that can be assigned to a particular game. These can include multiple actual rulesets that were observed as played for the same game, as well as different rulesets produced by scholars and games enthusiasts for ancient games, as well as calculated reconstructed rulesets made by Ludii itself. We also discussed the issue of determining whether a reconstructed ruleset would be the correct one for an ancient game, and emphasized that traditional games such as these were likely did not have one particular set of rules according to which they were always played, but probably varied considerably, especially considering some of these games were played for millennia and across many different cultures.

All GameTable members are encouraged to propose and develop similar cases in the upcoming years, leveraging the full potential of the network.

The first day concluded with a summary from Walter Crist and Éric Piette, highlighting the key topics discussed. The chairs urged all GameTable members to reflect on the structures, goals, and methodologies presented, aiming to stimulate further discussions during the evening events and on the second day.

2.5. Session 5 – discussions and debate

2.5.1. Ludii

As the Ludii software (Piette et al., 2020) (available at http://ludii.games) stands as a significant outcome of the Digital Ludeme Project and holds potential for many GameTable members, Éric Piette

commenced the second day, to present its significant features (Piette et al., 2021), showcasing its potential for many GameTable members. He provided insights into the workings of *General Game Playing* (Björnsson and Schiffel, 2016), delved into the unit-game information, and described the ludemes (Browne, 2021; Browne et al., 2020) used within Ludii through a demo. These ludemes serve as the building blocks to model all game components – equipment, mechanisms, and concepts (Browne et al., 2022) – to comprehensively describe the rules of a game.

This presentation sparked numerous inquiries from GameTable members, particularly about the potential applications of Ludii within the Action. Questions arose about its potential role in organizing competitions (Stephenson et al., 2019b; Piette et al., 2023), its contributions to teaching activities (Stephenson et al., 2019a), and its utility in aiding the design of new games. In terms of research activities, examples of previous and ongoing projects were discussed. These included the prediction of AI approaches and heuristics based on game concepts (Stephenson et al., 2021), the generation of board game manuals (Stephenson et al., 2022), and the integration of puzzle-solving approaches (Piette et al., 2019). Notably, for the interdisciplinary aspects of the Action, there was an overview of a reconstruction process designed to propose ruleset candidates for incomplete ancient and traditional games. This process is aided by computing conceptual (Piette et al., 2021a), geographical, and cultural board game distances (Stephenson et al., 2023).

Discussions also revolved around the game data Ludii captures from human plays and plans to include card games within the software. Ludii captures all game trials played online (anonymized) to preserve game traces for future research. Regarding the incorporation of card games, recent findings (Soemers et al., 2022) have shown that the Ludii language is universal and can accommodate finite non-deterministic and imperfect-information games. However, challenges remain due to current grammar and models. To address this, new research projects have begun to propose an extension of the language and game representation to integrate card games and board games with imperfect information.

Despite its user-friendly interface, Ludii's extensive ludeme library (over 700 ludemes) and its language complexity pose accessibility challenges for non-computer science researchers. To address this, plans were discussed during the meeting regarding Ludii training initiatives. One proposed solution is the establishment of a training school funded through the next grant period of the Action, open to all stakeholders interested in learning Ludii. In this session and wider discussions during the Kickoff meeting, it was noted that the vast majority of the already considerable data currently contained within Ludii was compiled by a very small group of scholars. Due to practical limitations on how much data this group was able to collect, it is highly desirable to facilitate the ability to contribute to the Ludii database, allowing a wider pool of participants in the GameTable action to quickly and efficiently share their datasets about board games. Crucially, any upload processes need to be relatively time-efficient to enable scholars to contribute their datasets as a secondary product of their main research initiatives. Since many of these datasets are accurate to the building level, this may require modifications to the geospatial components of the database. There were also discussions around interlinking with other existing databases concerned with historical board games (e.g., the Ludus database, focusing on Classical Antiquity – [https://locusludi.ch/the-ludus-database/]) to avoid duplication of effort. Additionally, there was consideration for designing a graphical user interface (GUI) that would simplify the process of designing common game components and rules, eliminating the need to master the language.

During the discussion, limitations of Ludii were also acknowledged. These include challenges with modeling certain game mechanisms, such as conceding the winning position, creating human-like AI,

and issues with the current AI APIs. To improve this last aspect, the proposal of a GYM AI interface (Brockman et al., 2016) was suggested as a potential avenue for enhancing Ludii's capabilities.

2.5.2. Open discussion

During the same session, an open discussion was initiated. The first topic, introduced by Jakub Kowalski, proposed the idea of hosting our own AI competition through a coding game challenge focused on the historical aspects of the GameTable Action or on games automatically generated by approaches developed by WG3 members. This initiative aims to gather a substantial amount of data on these critical topics, which hold significance for multiple research fields represented within GameTable. The discussion evolved into the concept of organizing Game Jams to introduce traditional games to the general public. Participants would have the opportunity to create their own reconstructions of incomplete ancient games based on available historical knowledge, allowing for comparisons with reconstructions generated through AI techniques. Such comparisons could shed light on the expectations of modern gamers versus historical gameplay, providing insights into human/AI biases. To enhance these events, the proposal includes the production of 3D-printed versions of traditional games for use during these occasions, potentially extending their utility for future exhibitions organized by GameTable members.

Another key discussion point was the proposal to improve communication between AI researchers and historians, aiming to better understand the perspectives of both communities and share expertise to address challenges in both fields. Ludii software was highlighted as a potential bridge between these communities, facilitating communication between developers and stakeholders in humanities. An example discussed was the development of human-like Game Playing AI, which would have objectives beyond just winning, such as identifying loops or end positions within games. This collaborative effort aims to merge the realms of AI and historical research, potentially yielding novel insights and approaches for both disciplines. This particular topic will be delved by WG1 and WG2 members.

The subsequent topic, introduced by Ulrich Schädler, highlighted the significant advancements in research on the history of games over the past 30 years, leading to numerous discoveries. However, despite these findings, many individuals referencing traditional games, even the most renowned ones, remain unaware of this wealth of knowledge. This gap often results in inaccuracies or outdated information being disseminated without proper citation of sources. To address this issue, GameTable members proposed the creation of a comprehensive publication that consolidates fundamental and widely known knowledge into a single resource. This paper or book could serve as a reference for researchers across various communities, providing a centralized and authoritative source. Additionally, the proposal included plans to enhance the Ludii database (Crist et al., 2022), to allow it to become a venue for the preservation of cultural knowledge relating to games, including games which are at risk of loss. It was also suggested that GameTable members could actively contribute digital information to prominent platforms such as Wikipedia, and develop educational materials, such as open educational resources. While acknowledging that this endeavor may be time-intensive, the ultimate goal is to preserve our cultural game knowledge and combat misinformation about our past.

The last topic discussed in this session focused on the development of digital content showcasing traditional board games, featuring presentations, gameplay demonstrations, and explanations by experts within GameTable. This initiative aims to disseminate these videos through platforms like YouTube and other diverse communication channels. Additionally, there was discussion about live streaming traditional game plays on platforms such as Twitch, with the goal of engaging younger generations and introducing them to the historical significance of these games.

2.6. Session 6 – organisation and communication

Led by Summer Courts, this session focused on developing GameTable's organizational and communication strategies. She emphasized the significant impact of effective communication on our work, highlighting its role in securing partnerships, publishing traditional academic outputs, and attracting future funding for our research endeavors. Summer also highlighted the importance of public engagement and outreach as part of GameTable's long term strategy. Facilitating community use of the action's research will ensure that games, both ancient and modern, continue to play an important role in social interaction and community building in an increasingly disconnected world.

Over the coming months, Summer is developing a comprehensive GameTable communication plan based on her expertise, feedback from active members, and their preferences. This plan will encompass traditional communication channels such as academic publications, media coverage, and in-person meetings, as well as modern methods like social media (Twitter, Facebook, Instagram), blogs/vlogs, and "Pint of Science" events (https://pintofscience.co.uk/), which bring researchers to local bars/cafes/spaces to share scientific discoveries. Additionally, Summer plans to develop a series of downloadable content packets in collaboration with working group 5. These packets will focus on disseminating our research to dispersed communities of learners and enthusiasts, especially young individuals and older adults who comprise underrepresented target audiences. Members were encouraged to submit their communication preferences through MentiMeter – https://www.mentimeter.com/. In response to the members' input, Summer has opened a Discord server to facilitate easier peer-to-peer communication and will be expanding GameTable's social media offerings in the near future.

2.7. Session 7 – deliverables

The final session delved into funding opportunities, potential collaborations with industrial and institutional partners, and the dissemination objectives within WG5.

GameTable is structured into four yearly grant periods, spanning from November 2023 to October 2027. Within each period, the Management Committee allocates budgets to various grant schemes, overseen by Fatih Parlak and Ilaria Truzzi. For the first grant period (November 2023–October 2024), three grant schemes are offered:

(1) Short-Term Scientific Missions (STSMs): These are exchange visits between researchers involved in a COST Action, enabling scientists to visit institutions or laboratories in other COST Member states. Grantees, who can be any Action participant, implement projects with international teams, gaining new knowledge or access to equipment and techniques not available at their home institutions. They receive a contribution covering travel, accommodation, subsistence expenses, project implementation, report delivery to the COST Action MC, and overall effort, with a maximum of EUR 4,000.
(2) Inclusiveness Target Countries (ITC) Conference Grants: These provide financial support for Young Researchers (under 40 years old) and Innovators affiliated with an Inclusiveness Target Country/Near Neighbour Country for their participation in high-level conferences. Grantees receive support for attending and presenting their work (poster/oral presentation) at conferences, fostering new contacts for future collaborations.
(3) Dissemination Conference Grants: These grants support Action Participants in presenting the GameTable COST Action at high-level conferences. The aim is to increase the Action's visibility

in the research community and develop new contacts with potential stakeholders. Both virtual (max EUR 500) and in-person (max EUR 2,000) oral presentations are eligible.

For further details on these grant schemes and their corresponding deadlines, please visit the GameTable website: http://gametable.network.

The second topic, introduced by Spyridon Samothrakis, centered on engaging with business and industry to apply our advanced research and make it relevant to their needs. It emphasized the importance of gamifying industrial problems to leverage our Game AI techniques effectively. Additionally, it was noted that sometimes simpler, older techniques might be more suitable for solving industry issues rather than pushing complex research topics. Various industrial applications were discussed, with particular interest from members in proposing General AI agents to famous online platforms such as Board Game Arena, and a proposal to partner with 3D printing businesses. The idea was to provide physical board game companies with 3D printed versions of our digitally created games, complete with historical rules and information, thus bridging the gap from digital to physical board games with accurate components.

The final topic, presented by Theodora (Dorina) Moullou, delved into the potential dissemination activities that could be coordinated through Working Group 5. She highlighted the opportunity to develop a GameTable General Game System leveraging the expertise of all GameTable members, building upon the Ludii system. Additionally, the discussion included plans for designing educational materials, an ongoing theme throughout the two days, and the role of the working group in aiding the writing of scientific papers based on results from other working groups. Working Group 5 will also lead the organization and planning for the final digital exhibition, scheduled to showcase the Action's most significant results to the public in 2026/2027.

3. CONCLUSION

The GameTable kickoff event was a resounding success over its two-day agenda, achieving its objective to assemble leading experts across various research domains involved in the Action, while also focusing on the empowerment of young researchers. This was accomplished through the creation of an inclusive, dynamic platform designed to engage them in the forefront of research and development. Offering unparalleled opportunities for collaboration, networking, and professional development, this initiative is dedicated to fostering the growth of emerging talents in the field, ensuring a robust future for academic and technological advancements.

As the event concluded, the chairs extended their gratitude to all members who actively participated in the diverse activities, discussions, and debates. Many fruitful directions were established during these days, paving the way for numerous collaborations to emerge. They also reminded everyone about the upcoming events related to each working group:

- WG1's first meeting took place in Leiden, the Netherlands, on the day following the kickoff (January 31st, 2024), hosted by LIACS.
- WG4's "Day 0 | Let's Start!" marked the first in-person meeting, held in Aveiro, Portugal (March 15th, 2024). This meeting coincided with World Maths Day and the Portuguese National Championship of Mathematical Board Games.
- WG3's inaugural in-person meeting occurred in Valletta, Malta (March 25th, 2024), focusing on identifying specific avenues for collaborations within the working group.
- WG2's first in-person meeting is scheduled for Mustafapaşa, Turkey (May 3rd, 2024).

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REFERENCES

Albert, M., Nowakowski, R. & Wolfe, D. (2007). *Lessons in Play: An Introduction to Combinatorial Game Theory*. CRC Press.

Björnsson, Y. & Schiffel, S. (2016). General game playing. In *Handbook of Digital Games and Entertainment Technologies* (pp. 1–23). Singapore: Springer Singapore.

Brockman, G., Cheung, V., Pettersson, L., Schneider, J., Schulman, J., Tang, J. & Zaremba, W. (2016). OpenAI gym, https://arxiv.org/abs/1606.01540.

Brown, N. & Sandholm, T. (2017). Superhuman AI for heads-up no-limit poker: Libratus beats top professionals. *Science*, *359*(6374), 418–424. doi:10.1126/science.aao1733.

Brown, N. & Sandholm, T. (2019). Superhuman AI for multiplayer poker. *Science*, *365*(6456), 885–890. doi:10.1126/science.aay2400.

Browne, C. (2021). Everything's a ludeme: Well, almost everything. In *Proceedings of the XIIIrd Board Game Studies Colloquium (BGS 2021)*. Paris.

Browne, C., Piette, É., Stephenson, M. & Soemers, D.J.N.J. (2022). General board geometry. In C. Browne, A. Kishimoto and J. Schaeffer (Eds.), *Advances in Computer Games (ACG 2021)*. Lecture Notes in Computer Science (Vol. 13262, pp. 235–246). Cham: Springer.

Browne, C., Soemers, D.J.N.J., Piette, É., Stephenson, M., Conrad, M., Crist, W., Depaulis, T., Duggan, E., Horn, F., Kelk, S., Lucas, S.M., Neto, J.P., Parlett, D., Saffidine, A., Schädler, U., Silva, J.N., de Voogt, A. & Winands, M.H.M. (2019). Foundations of digital archæoludology. Technical report, Schloss Dagstuhl Research Meeting, Germany.

Browne, C., Soemers, D.J.N.J., Piette, É., Stephenson, M. & Crist, W. (2020). Ludii language reference. ludii.games/downloads/LudiiLanguageReference.pdf.

Browne, C., Stephenson, M. & Crist, W. (2023). Data note: The digital ludeme project database. *Open Research Europe*, *3*(164). doi:10.12688/openreseurope.16524.1.

Campbell, M., Hoane Jr., A.J. & Hsu, F. (2002). Deep blue. *Artificial Intelligence*, *134*(1–2), 57–83. doi:10.1016/S0004-3702(01)00129-1.

Colliver, Y. & Veraksa, N. (2019). The aim of the game: A pedagogical tool to support young children's learning through play. *Learning, Culture and Social Interaction*, *21*, 296–310. doi:10.1016/j.lcsi.2019.03.001.

Crist, C., Stephenson, M. & Browne, C. (2022). Ludii games database. https://dataverse.nl/dataset.xhtml?persistentId=doi:10.34894/BP8G8U.

Crist, W., de Voogt, A. & Dunn-Vaturi, A.-E. (2016). Facilitating interaction: Board games as social lubricants in the ancient near East. *Oxford Journal of Archaeology*, *35*(2), 179–196. doi:10.1111/ojoa.12084.

Crist, W., Piette, É. & Browne, C. (forthcoming). Playing the games of the past: Digital tools for resurrecting traditional board games. In A. Mol, A. Politopoulos and C. Gerritsen (Eds.), *The Interactive Pasts Conference 3 Proceedings*. Van Hout. Sidestone Press. In preparation.

Crist, W., Piette, É., Soemers, D.J.N.J., Stephenson, M. & Browne, C. (in press), Approaches for recognising and reconstructing ancient games: The case of ludus latrunculorum. In A. Pace, T. Penn and U. Schädler (Eds.), *The Archaeology of Play: Material Approaches to Games and Gaming in the Ancient World*. Monographies Instrumentum (pp. 63–80). Dremil-Lafage: Mergoil. (in press).

Moravčík, M., Schmid, M., Burch, N., Lisỳ, V., Morrill, D., Bard, N., Davis, T., Waugh, K., Johanson, M. & Bowling, M. (2017). DeepStack: Expert-level artificial intelligence in heads-up no-limit poker. *Science*, *356*(6337), 508–513. doi:10.1126/science.aam6960.

Osborne, M.J. (2004). *An Introduction to Game Theory*. Oxford: Oxford Univ. Press.

Piette, C., Piette, É., Stephenson, M., Soemers, D.J.N.J. & Browne, C. (2019). Ludii and XCSP: Playing and solving logic puzzles. In *2019 IEEE Conference on Games (CoG)* (pp. 630–633).

Piette, É., Browne, C. & Soemers, D.J.N.J. (2021). Ludii game logic guide. https://arxiv.org/abs/2101.02120.

Piette, É., Rougetet, L., Crist, W., Stephenson, M., Soemers, D.J.N.J. & Browne, C. (2021b). *A Ludii Analysis of the French Military Game*. http://ludeme.eu/res/BGS_2021_French_Military_Game.pdf.

Piette, É., Soemers, D.J.N.J., Stephenson, M. & Browne, C. (2023). The 2022 Ludii AI competition. *ICGA Journal*, *45*(1), 16–27. doi:10.3233/ICG-230230.

Piette, É., Soemers, D.J.N.J., Stephenson, M., Sironi, C.F., Winands, M.H.M. & Browne, C. (2020). Ludii – the ludemic general game system. In G.D. Giacomo, A. Catala, B. Dilkina, M. Milano, S. Barro, A. Bugarín and J. Lang (Eds.), *Proceedings of the 24th European Conference on Artificial Intelligence (ECAI 2020)*. Frontiers in Artificial Intelligence and Applications (Vol. 325, pp. 411–418). IOS Press.

Piette, É., Stephenson, M., Soemers, D.J.N.J. & Browne, C. (2021a). General board game concepts. In *Proceedings of the 2021 IEEE Conference on Games (CoG)* (pp. 932–939). IEEE.

Pitrat, J. (1968). Realization of a general game-playing program. In *IFIP Congress (2)* (pp. 1570–1574).

Schaeffer, J., Lake, R., Lu, P. & Bryant, M. (1996). Chinook the world man–machine checkers champion. *AI Magazine*, *17*(1), 21–29.

Shannon, C.E. (1950). Programming a computer for playing chess. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, *41*(314), 256–275. doi:10.1080/14786445008521796.

Silver, D., Huang, A., Maddison, C., Guez, A., Sifre, L., van den Driessche, G., Schrittwieser, J., Antonoglou, I., Panneershelvam, V., Lanctot, M., Dieleman, S., Grewe, D., Nham, J., Kalchbrenner, N., Sutskever, I., Lillicrap, T., Leach, M., Kavukcuoglu, K., Graepel, T. & Hassabis, D. (2016). Mastering the game of go with deep neural networks and tree search. *Nature*, *529*(7587), 484–489. doi:10.1038/nature16961.

Soemers, D.J.N.J., Piette, É., Stephenson, M. & Browne, C. (2022). The Ludii game description language is universal. https://arxiv.org/abs/2205.00451.

Stephenson, M., Piette, E. & Browne, C. (2019a). Teaching and learning with LUDII: (BGS'19). In *Board Game Studies*.

Stephenson, M., Piette, É., Soemers, D.J.N.J. & Browne, C. (2019b). Ludii as a competition platform. In *Proceedings of the 2019 IEEE Conference on Games (COG 2019)* (pp. 634–641). London.

Stephenson, M., Piette, É., Soemers, D.J.N.J. & Browne, C. (2022). Automatic generation of board game manuals. In C. Browne, A. Kishimoto and J. Schaeffer (Eds.), *Advances in Computers Games (ACG 2021)*. Lecture Notes in Computer Science (Vol. 13262, pp. 211–222). Cham: Springer. doi:10.1007/978-3-031-11488-5_19.

Stephenson, M., Soemers, D.J.N.J., Piette, É. & Browne, C. (2021). General game heuristic prediction based on ludeme descriptions. In *Proceedings of the 2021 IEEE Conference on Games* (pp. 878–881). IEEE.

Stephenson, M., Soemers, D.J.N.J., Piette, É. & Browne, C. (2023). Measuring board game distance. In C. Browne, A. Kishimoto and J. Schaeffer (Eds.), *Computers and Games. CG 2022*. Lecture Notes in Computer Science (Vol. 13865, pp. 121–130). Cham: Springer.

Tesauro, G. (1995). Temporal difference learning and TD-Gammon. *Communications of the ACM*, *38*(3), 58–68. doi:10.1145/203330.203343.

Turing, A.M. (1953). Digital computers applied to games. In *Faster than Thought (ed. B.V. Bowden)* (pp. 286–297).

von Neumann, J. & Morgenstern, O. (1944). *Theory of Games and Economic Behavior*. Princeton, NJ, USA: Princeton University Press.

Yannakakis, G.N. & Togelius, J. (2018). *Artificial Intelligence and Games*. Springer.