Entertainment Computing 51 (2024) 100708

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: www.elsevier.com/locate/entcom

Managing and controlling digital role-playing game elements: A current state of affairs

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ARTICLE INFO

Keywords:
RPG
Artificial intelligence
Procedural content generation

ABSTRACT

Role-playing games (RPGs) are interactive gaming experiences designed and driven by the intricate development of narratives and characters. However, these games also highlight elements, such as combat, exploration, creativity, and crafting. Game developers helped to shape the market by incorporating RPGs into digital media; however, they suffered restrictions in their game design and storytelling caused by technological limitations. Fortunately, academia has studied these challenges and mitigated these latter issues to better understand and connect digital RPGs with their analog versions. Our research offers a comprehensive overview of studies centered on technologies for managing, generating, and controlling digital RPG elements. We aim to characterize Artificial Intelligence research within this domain and elucidate the diverse techniques employed. In this context, we examined 72 papers about Procedural Content Generation (PCG) in RPG, which were identified by mixing a database search with a snowballing method. In this paper, we provide an overview of PCG techniques investigated within the realm of RPGs and present the trending approaches for future developments in the field.

1. Introduction

Role-Playing Game (RPG) is a game genre that originated in the 70s, where its participants play characters that face dangers and challenges posed by another player, called *Game Master* (GM). The GM also tells and conducts the game story. This game genre brought elements of board games, bringing data to calculate the resolution of systems, tokens with numerical representations of the characters, and clear challenges [1,2]. Electronic games inspired by the RPG model were created and became remarkably popular. However, as the latter does not have a human GM controlling the game, its content needs to be previously elaborated by a game designer. Few games actually allow players to control them like a GM like NeverWinter.[6] Consequently, the player's experience is restricted when exploring the game's universe and characters [3]. For example, the game designer pre-sets the map so the characters' behavior and the story are pre-determined.

Despite being a niche within the game genres, RPG has a fair variety of subgenres, from the *Tabletop Role-Playing Game* (TRPG) to Live Action Role-Playing game (LARP). LARP, for instance, is an example of RPG style in which players not only talk about their actions but also interpret them, dress up, and, in some cases, even combat physically using padded weapons [1]. Within the scope of *Digital Role-Playing Game* (DRPG), we found games with turn-based combats, such as *Clouds Of Xeen*[7] and the famous Japanese console titles in the 90s [1]. At the turn of the millennium, DRPG titles with fictional universes shared by

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6 https://nwn.fandom.com/wiki/Dungeon_Master_client
7 https://www.mobygames.com/game/might-and-magic-clouds-of-xeen

https://doi.org/10.1016/j.entcom.2024.100708
Received 1 August 2022; Received in revised form 18 April 2024; Accepted 1 May 2024
Available online 17 May 2024

the network exploded and had their peak until around 2011, in which WoW (World of Warcraft) would be the most prevalent title. These are the so-called *Massive Multiplayer Online Role-Playing Game* (MMORPG), which had enormous success in the game industry [4]. In addition to these examples, there are other titles and genres influenced by RPG, such as Multi-User Dungeon (MUD) and text-adventure [1].

Despite progress, DRPG does not yet reach the same player experience provided by those analog RPG like TRPG and LARP. The expectation is that digital technological advances could minimize this experience gap. One of the striking elements is the interaction of many players in the same game world, something circumvented with the advent and evolution of MMORPG. However, a more specific context is the social interaction with Non-Player Character (NPC) represented and controlled by computers, as well as the creation and unfolding of a narrative. This freedom in the development and destiny of the story, given players' actions, is known in the literature as *Agency* [5]. Furthermore, with the absence of a GM participation, the ability to improvise, create and plan spaces, and balance the game is still in part the challenge of bringing TRPG and DRPG together [6].

One of the ways to bring these experiences together is the use of Artificial Intelligence (AI) to obtain a machine closer to the role of the GM [7]. In this context, it is fundamental to understand which aesthetic and technical aspects of RPG are addressed by AI technologies [8]. The most common problems are covered by *Procedural Content Generation* (PCG) techniques exploring spaces [9–12], characters [13,14], and story [5,7,15].

This paper presents the state of affairs in technologies for managing, generating, and controlling digital RPG elements. We seek to characterize AI research in this domain and map the use of its diverse techniques such as Genetic Algorithm (GA), neural networks, and planning algorithms (e.g., STanford Real-time Information Processor (STRIPS) and Hierachical Task Network (HTN)). Therefore, this paper identified articles that address these technologies and their game application contexts. We analyzed 72 studies published in journals and conferences between 2007 and 2023 that used PCG in RPG.

First, we present a classification proposal for categorizing RPG titles. Moreover, we discuss the main technologies that drive the development of this digital genre with a particular focus on how PCG and AI techniques relate to the generation and management of RPG content. We also investigate the existing assessment approaches and metrics adopted for internal and external validation of works found in the literature.

The remainder of this article is organized as follows: Section 2 discusses the fundamentals we used to classify RPG subgenres and their correlates and presents the technologies we found to support them; Section 3 details the research methodology, which includes the inclusion and exclusion criteria, the problems to be tackled, and the research questions we answered; Section 4 presents an overview of the process and the works we found; Section 5 contains the analysis of the articles considering the research questions; and, finally, we conclude this paper by presenting reflections on this study and notes for future work in Section 6.

2. Background

The foundational definitions regarding RPG and PCG serve as the guiding principles of this study. In this section, we will explore the definitions that facilitate categorizing various products and technologies used for content generation or maintenance.

2.1. RPG

RPG is a relatively new game genre, being attributed to Gary Gygax and Dave Arneson, in 1974, for the first title of TRPG called *Dungeons & Dragons* (D&D), which is still in production today [1]. RPG is a game genre that originated in the analog universe (i.e., "pen and paper") but that rapidly started to be explored in the digital games industry.

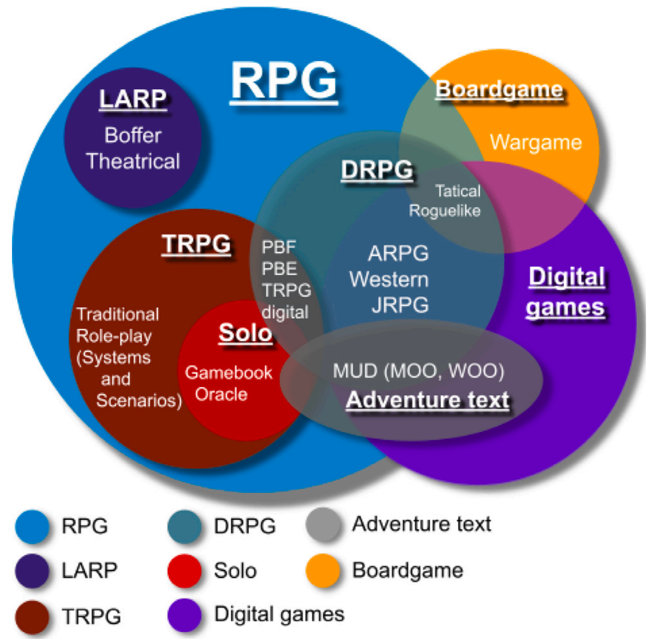

Fig. 1. RPG genres, subgenres, and their relationships.

José P. Zagal and Sebastian Deterding categorize RPG in distinct types and subgenres, such as: LARP, TRPG, and *Computer Role-Playing Game* (CRPG) (or DRPG) [16]. LARP, also known as "live-action RPG", consists of two subgenres. The first is the *boffer* subgenre, which includes safe combat with padded weapons. The other subgenre uses similarly harmless gear with a more "theatrical" and performative experience [16]. On the other hand, the traditional TRPG can be divided into genres focused on combat and strategy, as opposed to pure role-playing games. The TRPG subgenre can also be divided into solo players [17], where a book-game can guide it, or a more open version, in which the players follow an oracle or similar. Some subgenres are broader, such as the MMORPG, and other more specific subgenres as the *Japanese Role-Playing Game* (JRPG) [1,17]. The work of [18] encompasses analyses of the *Play-by-Forum* (PBF) subgenre and the dimensions of its actions of characters inside a game story.

The literature shows that the boundaries between genres are clearly blurred, and often a game can belong to more than one type in its entirety or have parts of it categorized into more than one genre or subgenre. We structured these genres and their interceptions in the diagrams shown in Fig. 1.

As we mentioned beforehand, the classification of RPGs and the research about them following Fig. 1 are complex tasks. The challenge is not related to study qualities but to the diversity of authors' definitions of their studies and contributions to the RPG domain. The same goes for the games and genres they described in their papers. However, in our study, we defined a decision model for categorizing the games. Fig. 2 shows the proposed decision tree for this task. The decision model accounts for RPG definitions provided by many authors. Moreover, it considers the RPG classifications indicated by other literature authors, such as [1,8]. Subgenres of DRPG can be considered niche and specific due to their peculiar technology (MMORPG) and regional aesthetics (JRPG and Western RPG), instead of the gameplay style being turn-based or real-time action. On the other hand, regarding analog RPG, LARP features live action where the manipulating elements such as books (Gamebook and Oracle), messages (PBF and PBF), sheets, maps, miniatures, and digital support apps (Digital TRPG) better describe the actions of TRPG players.

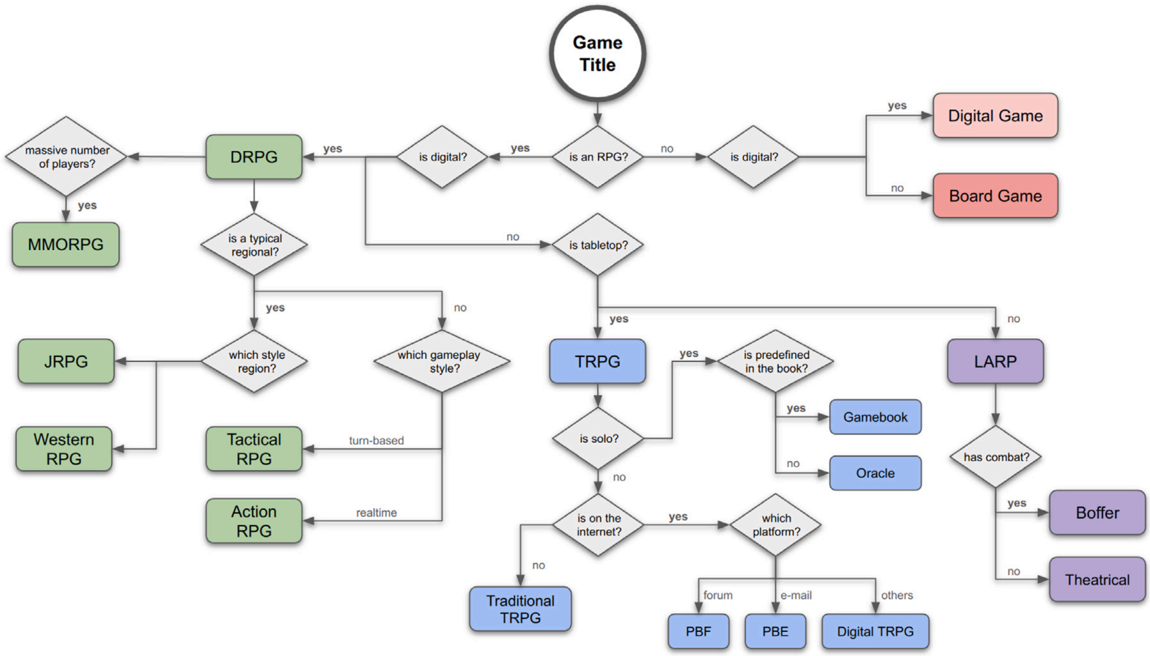

Fig. 2. Decision tree for classifying RPGs, given a title belongs to the genre. Regarding Digital RPGs, which are the main focus of this work, we assume it is reasonable to consider MMORPGs and typically regional titles as more specific categories. We propose to group other Digital RPGs according to the gameplay style, where interaction unfolds more tactically in turns or through real-time actions. On the other hand, our classification of analog RPGs primarily depends on a choice between tabletop and acting, then moving on to aspects such as the presence of combat in LARP and the use of books and/or predefined story, allowing multiple players, and a possible digital platform in Tabletop RPGs.

2.2. Procedural content generation (PCG)

PCG is a group of techniques directed to the creation of different types of content, including images, videos, sounds, and others, and it is not restricted to the game domain [19,20]. PCG techniques are often associated with stochastic processes; however, they are not exclusive, and deterministic methods are frequently observed [19]. For instance, Lindenmayer and Prusinkiewicz presented both deterministic and stochastic models with generative grammars for generating plants [21].

Games and PCG have a very comprehensive relationship, ranging from solver-based methods, passing through constructive generation methods, to AI approaches [22]. The PCG investigation is a recurrent theme in the digital games field, where the work of Hendrikx et al. [10] stands out. Hendrikx et al. present a hierarchical structure of game types of game content that can benefit from PCG methods (Fig. 3). There are elements found in RPG that can be manipulated to approximate TRPG and DRPG. Based on the topics from Fig. 3: *World Design* (5.2); all the elements of *Game Scenarios* (4.3 to 4.4); *Entity Behavior* (3.4); *Ecosystems* (3.1); and all the elements of the *Game Space* (2.1 to 2.3). Therefore, we mainly identified two sets of such elements: the entities distribution as in "Game Design", including challenges and balances; and the narrative elements and their adaptation in RPGs.

On several occasions, works involving PCG address space generation [9,11,12]. For instance, many authors and industry games use PCG for maps and dungeons generation considering titles from "Roguelike", MUD, and RPG genres [9,11,12]. In addition, there is a good variety of PCG techniques and applications, as seen in other literature reviews [9,11,12]. Works involving RPG and PCG were influenced by games that already made use of techniques for generating random maps [6]. For example, classic titles like Dwarf Fortress,[8] released in 2002, and later titles like Minecraft,[9] which generates biomes with relatively intricate reliefs.

[8] http://www.bay12games.com/dwarves/
[9] https://www.minecraft.net/

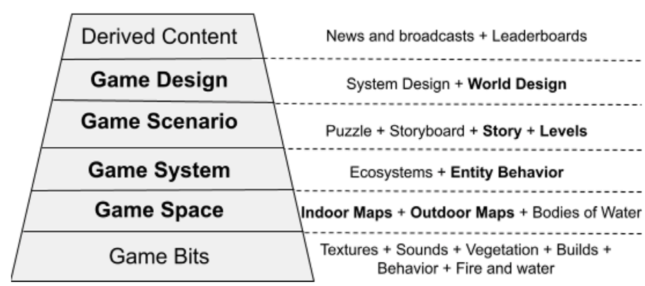

Fig. 3. Hendrikx et al.'s Pyramid [10]. Topics highlighted in bold are those used in the context of games.

In the last decade, *Deep Learning* [23] techniques have emerged in several types of game content, including applications in the gaming type of game content about PCG [22]. More precisely, *deep learning* techniques were capable of creating text, textures, game levels, character models, and sound effects. These elements are produced by resorting to various methods and techniques [22]: *Reinforcement Learning* (RL); *Adversarial Learning* (AL); recurrent natural language techniques like *Long short-term memory* (LSTM), an architecture of Neural Networks commonly used for sequence data (e.g., time series, text, or speech); and pre-trained, transformer models like *Bidirectional Encoder Representations from Transformers* (BERT) and *Generative Pre-Trained Transformer* (GPT) [24].

In this study, we show an overview of the use of those PCG methods in the RPG context. In some studies of PCG, authors detailed how their approaches manage content in their games. These details allowed us to propose some general classification guidelines. However, we must highlight that those techniques are applied in heterogeneous contexts, even within the RPG genre. Games like DRPG, MMORPG, and TRPG, for instance, have specific features that make their classification hard. Moreover, game genres, such as MUD, board games, and others out of the RPG set (Fig. 1) need to be broken down, classified, and analyzed. This demands exploratory analysis when capturing data and productions from games and companies, such as in the work reported by Doran and Parberry [25] where they analyzed **quests**[10] from four MMORPG games.

3. Methodology

This section describes our methodology, detailing the objectives of the work and the formulated questions and activities to achieve them. A significant portion of the terminology used in the work is also introduced or coined within the methodology.

3.1. Main goal

This study aimed to investigate the state of affairs in the use of PCG in RPGs, seeking to identify the current techniques used for controlling, generating, and managing RPGs reported in the scientific literature. We focused on articles relevant to RPGs, so those on general terrain, water, vegetation, and texture generation, plus those on combat strategies and movements in sports unless they directly relate to the RPG genre were excluded. This approach differs from other works that use heuristic methods and user evaluations.

3.2. Review planning

This research follows a literature review process similar to Viana et al. [26]. We used the general guidelines of Systematic Literature Reviews (SLRs) to structure our review and select the literature works [27]. For instance, we established research questions, an initial search string, and inclusion/exclusion criteria, then we searched documented sources. However, we did not follow all the SLR procedures strictly.

We used both *database search* and *snowballing* techniques to compose the final set of analyzed documents. First, we applied the traditional process of SLR and searched papers in databases using string queries. Then, we carried out a manual procedure based on the Snowballing technique [28], in which we first analyzed their references. Finally, we carried out a citation analysis on the studies selected during the database search. The purpose of the snowballing technique is to make the search coverage more complete. Therefore, in our case, studies that meet the objectives of our review that were not returned by the database search may appear in the snowballing phase.

3.3. Research questions

We established three general research questions to help us achieve this survey goal. We used the structure of Hendrikx's Pyramid [10] to assist in the design. This strategy also allowed us to search and classify the works involved with PCG for RPGs. Table 1 shows the three research questions and their rationales.

Table 1
Research Questions and their rationales.

	Question	Rationale
RQ1	Which categories in Hendrikx's Pyramid are closely related to the role-playing genres?	Relations (categories HP x genre RPG) are made by observing whether the works really focus on RPG or related genres and how close they are to such elements.
RQ2	What techniques are used to manage or produce RPG content?	Techniques are extracted manually from the manuscripts and listed as keywords.
RQ3	What metrics and assessments are involved?	Similar to RQ2, keywords are extracted from the article and listed for analyses.

3.4. Inclusion and exclusion criteria

The protocol establishes that, for each article, we must evaluate whether it should be included and what contributions are drawn from it. The process includes the assessment in three stages: reading the title, the abstract, and the full text. The following criteria were analyzed at each stage:

- **Presence of production or RPG techniques, or related genre** The feature must be explicitly targeted or include some game of the RPG genre, but we also consider close content "Rogue-Likes" and text adventures such as MUD.
- **Presence of AI applications** The presence of AI can be presented by different types of applied intelligence such as symbolic, connectionist, and behaviorist. Since the application contexts are wide, these can be executed online or offline.
- **PCG techniques** PCG techniques do not necessarily include AI, as the latter includes analysis and planning techniques for generating and maintaining different types of content.

3.5. Database search

The techniques, filters, and means employed for collecting and processing the works comprising this study will be presented in this subsection. Portions of the selected works come from heterogeneous sources; the majority are articles, but books, theses, and book chapters are also included.

3.5.1. Search string

Some search terms are related to the game genre such as: "RPG", "DRPG", "CRPG",[11] "TRPG", "MMORPG" and "role-playing games' ". In addition to these, there are similar or commonly cited terms such as "MMO", "artificial intelligence", "AI" in addition to "procedural", "procedural content generation" and "PCG' techniques '. Quotes for generated content are recurring such as "maps", "space", "behavior", "quests" and "NPC", "Non-Player Character".

3.5.2. Sources

We applied different combinations of the search string in five engines: "*ACM*", "*Core*", "*Science Open*", "*IEEE Explore*", and "*Scopus*". These search engines allow performing queries with simple keywords and restrictions such as "AND". Therefore, we need to assemble a list of terms that direct the works used and reduce the search volume to a viable amount to be analyzed. This problem is partially due to the multiple ambiguities that the acronym RPG can represent. The term "Role-Playing Game" is not always found in search engines, while the acronym "RPG" presents better results despite its ambiguities. Popular "RPG" variants such as "MMORPG" and "CRPG" are virtually unambiguous. Therefore, applying a search string with variations could easily reach over 10 thousand documents. We then used string combinations in each database to produce an initial amount of 150 or fewer articles.

[10] "Quests" in RPGs refer to specific tasks and missions assigned to players in the game world. Quests involve objectives such as combat, puzzle-solving, item collection, crafting, and exploration. Completing a quest usually grants rewards to players.

[11] The term CRPG is often used as a synonym for DRPG; however, as it refers specifically to computers we prefer to use a more general term to make clear the inclusion of RPGs for consoles and *mobile*.

We discovered a total of 551 articles up to 2020, excluding duplications. Between 2021 and 2023, we identified over 1000 additional articles. After reading the title and/or abstract and applying the inclusion and exclusion criteria.

3.6. Snowballing

The "snowballing" process is a searching technique in which the reviewer checks both references or citations of source papers. Subsequently, these candidates are revisited, including sources, based on title, abstract, and content, applying the inclusion and exclusion criteria. Snowballing has two main processes: forward when new articles are found citing the source documents, and backward, done by scrutinizing the references of the source documents.

We used the convenient Google Scholar citation mechanism for the forward snowballing. From the 17 documents reported in the database search, we added six new papers by "backward snowballing" and nine by "forward snowballing".

We also added one work, the article *S31*, suggested by a specialist in the RPG domain. This peculiar article describes an application called Dungeon AI, which applies PCG techniques in text-based RPG. We then reached the 72 texts analyzed in our review.

The snowballing process proved unnecessary with the expansion of the study from 2021 to 2023. This was due to the increased volume of potential works identified. This matter will be discussed in Section 4, where the results of the collections indicate a greater accumulation of works in the last 3 years than in the previous 15 years, as shown in Fig. 4.

3.7. Data collection

At this stage, we extracted the metadata from the 72 researchers. Some materials can already be extracted directly from the "bibtex" format, or similar, such as year of publication, authors, congress, and work format (whether it is a full article, a short paper, or a thesis).

Various metadata require the reading and interpretation of the work. In particular, in the classification following the *Hendrikx's Pyramid* (HP), we need to identify the techniques used and the type of contribution for each paper. For example, a "model" paper presents a model, either theoretical or applied.

All data collected were cataloged in a spreadsheet and later reused for analysis and graph generation using Python3 and the Google Drive API. Data on the "origin" of searches and relationships is also available.

The 72 listed works below are arranged chronologically and by the contributions of the works. Fig. 7 shows an overview of their distribution and categories. Another listing containing specifications we identified can be found in Tables 2 and 3, presenting five columns. The first column pertains to the article identification with "Si" where "i" is the unique index value. Following is the "Techniques" column, where keywords defining more specific technologies are listed if explicitly stated in the work. The "Categories" column contains more general terms that will be reused in Table 4. The last two columns refer to external evaluations, conducted by volunteers, and internal evaluations carried out through metrics and indices by the researchers themselves. These tables are extensively discussed in Section 5, but it is worth noting that they were assembled based on readings of the extracted works.

S1: [29], S2: [30], S3: [31], S4: [32], S5: [33], S6: [34], S7: [25], S8: [35], S9: [36], S10: [37], S11: [38], S12: [39], S13: [40], S14: [3], S15: [41], S16: [42], S17: [43], S18: [44], S19: [45], S20: [46], S21: [47], S22: [48], S23: [49], S24: [50], S25: [51], S26: [52], S27: [53], S28: [54], S29: [55], S30: [56], S31: [57], S32: [58], S33: [59], S34: [60], S35: [61], S36: [62], S37: [63], S38: [64], S39: [65], S40: [66], S41: [67], S42: [68], S43: [69], S44: [70], S45: [71], S46: [72], S47: [73], S48: [74], S49: [75], S50: [76], S51: [77], S52: [78], S53: [79], S54: [80], S55: [81], S56: [82], S57: [83], S58: [84], S59: [85], S60: [86], S61: [87], S62: [88], S63: [89], S64: [90], S65: [91], S66: [92], S67: [93], S68: [94], S69: [95], S70: [96], S71: [97], S72: [98].

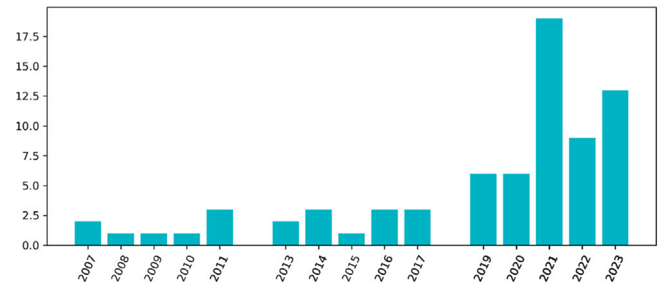

Fig. 4. Papers found per year.

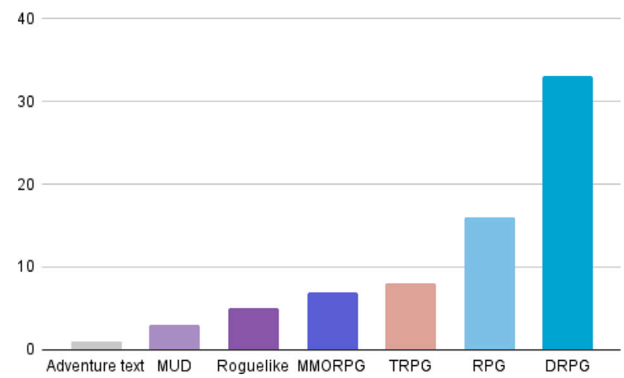

Fig. 5. Number of papers per RPG subgenre.

4. Results

Figs. 4 and 6 show the distribution of 72 documents according to the publication year and types of game content respectively. Articles obtained in database search are: S3, S5 S6, S7, S10, S11, S14, S15, S17, S18, S19, S20, S21, S22, S24, S26, S28, S33 to S71; "backward snowballing": S8, S12, S27, S29, S30 and S32; "forward snowballing": S1, S2, S4, S9, S13, S16, S23 and S25.

We classified the methods found briefly in Table 2, observing whether the works actually focus on RPG or related genres and how close they are to such elements. The "Techniques" column enumerates the manuscript keywords we extracted manually. We also categorize the studies by grouping them into nine categories: deep learning, rule-based, planning, graph, grammar, evolutionary, *Natural Language Generation* (NLG), and *Finite State Machine* (FSM).

The search filtered out works between 2004 and 2023, whose frequency has increased in recent years, as seen in Fig. 4. In addition to Computer Science, there are studies in Communication, Pedagogy, and even Medicine [10,100,101]. This suggests that the academy has been paying more attention to games. Such research may be correlated with the industry's interest in developing new techniques for improving incoming titles. Despite its scope in the type of game content, the present survey narrows the context of games to RPG and the technologies used for the sake of autonomous management and control, forcing direct citation to the genre or a similar concept.

Fig. 5 presents the counts of the relationships of works directly linked to the RPG genres. DRPG are predominant in applications, both by the 32 direct citations and by the other 7 contained in the MMORPG, since the latter would be a subcategory of DRPG. This is illustrated by Figs. 1 and 2, which totals 39 articles for DRPG. Following the same idea, the genre RPG got 16 direct citations without specifying subgenres, but the other counts 8 of TRPG, 32 DRPG, and 7 MMORPG. Finally, the other 6 supported applications are very close genres and easily reproducible in the context of RPG.

Table 2
Summary of the features found in the analyzed papers.

	Techniques	Categories	External evaluation	Internal evaluation
S1	Rule-based, evaluators, Example: Charbitat	rule-based		
S2	rule-based, scripting, quest pattern	rule-based		
S3	Planning, FAtiMA	planning		
S4	NLG, ConceptNet	NLG		
S5	Planning	planning		
S6	NLG	NLG	PICTIVE [99]	
S7	Planning	planning		
S8	NLG	NLG		
S9	Knowledge graph	graph		Graph analyses
S10	grammar-based, graph	graph, grammar		Graph complexity
S11	Evolutionary algorithm, ASP-evolution hybrid approach, Answer Set Programming, planning	evolutionary, planning		Fitness, distance for damage, time processing
S12	Planning, Answer Set Programming	planning		
S13	Evolutionary algorithm	evolutionary		
S14	Rule-based, planning	rule-based, planning		
S15	Generative grammar	grammar		Mission Linearity, Map Linearity, Leniency, Path Redundancy
S16	Planning	planning		
S17	grammar-based, graph	graph, grammar		Shortest path, exploration, variation, dispersed rewards, balanced rewards
S18	Planning, STRIPS, Belief Desire Intention (BDI), multi-agent models, counter-example guided planning procedure	planning	Model checkers	
S19	Rule-based algorithm, PCG	rule-based		Distribution of data
S20	Rule-based randomized algorithm	rule-based	Preferences (binary)	Distribution of data
S21	BRNN, deep learning, NLP, Ontology, OCC, Comme il Faut	deep learning, NLG	Volunteers evaluated sentences in terms of similarity, meaning and relationship between words	BLEU scores, PINC scores
S22	ontology, OCC, Comme il Faut (CiF), CiF-CK, planning	ontology, planning	User Experience and Believability	
S23	FSM, rule-based	FSM, rule-based		
S24	genetic algorithm, planning, STRIPS, evolutionary	evolutionary, planning	User evaluation	Technical evaluation (performance)
S25	Markov Chains, neural language model, PCG, LSTM	deep learning	Coherence, Originality, Unpredictability, Accomplishment	
S26	roles, rule-based	rule-based	Quality, matched and desired	
S27	planning, Z3 SMT, Separation constraints	planning		Distribution of data
S28	FSM, rule-based	FSM, rule-based	Gameplay, enjoyment	
S29	FSM, rule-based	FSM, rule-based	Demographic and Game Experience Questionnaire (GEQ)	
S30	deep learning,GPT-2, transformers, LSTM, data mining, quest generation	deep learning	English, Content, Novelty, Surprise, Creativity	

(*continued on next page*)

Table 2 (*continued*).

S31	deep learning,GPT-2,GPT-3	deep learning	Good and bad labels (binary)	
S32	genetic algorithm, PCG, evolutionary	evolutionary		Distribution of data
S33		Evolutionary algorithm,	Gameplay data	Fitness function
S34		Planning, FSM		
S35	DQN	Reinforcement learning, deep learning		Time wastes for training and counting steps
S36	GPS (global position system)	Pathfinding, rule-based, heuristic search		
S37	BDI	planning		
S38	GPT	Deep learning	Player Engagement Perceived Conversation Quality; Open player feedback	
S39	Fine-tuning GPT-2	Deep learning		
S40	GPT-2	Deep learning	Questionnaire	
S41	GPT-2	Deep learning	Creativity, interestingness, comprehensibility, consistency	
S42		Behavior tree		
S43	Genetic algorithm	Genetic algorithm	Turing test	MSE, fitness function
S44	GPT-2	deep learning		
S45		Planning, ontology		

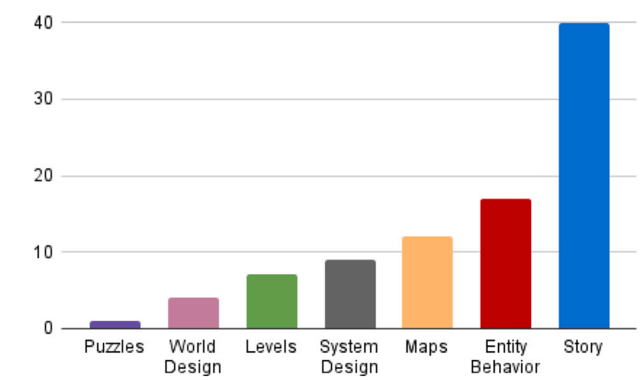

Fig. 6. Contribution count per type of game content.

5. Research questions

This section provides the answers to the research questions (see Table 1), along with the analysis of the selected articles. Therefore, each subsection corresponds to a research question and deals with more detailed discussions of the works and their characteristics.

5.1. Which categories of Hendrikx's pyramid are closely related to RPG genres?

Seven types of game content of Hendrikx's Pyramid were presented in Section 2. We classified the 72 approaches found in the literature according to those types of game content. In Fig. 6, we list the frequency of each type of game content, and Fig. 7 shows the studies' classifications from a timeline perspective. Moreover, sometimes "Indoor Map" and "Outdoor Map" are treated as the same unique category.

As seen in Fig. 6, there is a high frequency of works within the "Story" category. The result indicates the importance, as one should expect, of the narrative for RPG models. Other PCG works involve "Entity Behavior", "Indoor Maps", "System Design", and "Levels".

As many DRPG and similar genres are tied to dungeon exploration like other subgenres like MUD and "Roguelike", it is expected that there will be a fair frequency of "Indoor Maps" for map generation of the dungeons and "Levels" for the elaboration of the game levels. In the context of dungeons, there are also "Puzzles" elements that are worked in conjunction with the maps. However, only one work, S1, contained this approach, focusing on generating maps by distributing game mechanics resources such as keys and locks. In S1, the player must establish strategies to navigate the map. Nonetheless, this article is still linked to the generation of open scenarios ("Outdoor Maps"), which is another unique category among the works covered, as seen in Fig. 6.

The use of GPT-2 in "Story" for quest creation or related elements is prominent, as seen in S39, S41, S44, and S57. These studies use different datasets. In the case of S39, it generates dialogues dependent solely on quests and lacks a connection with player responses, akin to a chatbot. S41 introduces "Buncho", an auxiliary tool for Japanese writing, along with a case study on TRPG. Concerning S44 and S57, these are distinct publications from the same project that follow a structure similar to S39, generating descriptions of game quests.

Other quest generation models resorted to planning or a Knowledge Graph (KG), such as S40, S43, S45, S47, S69, and S70. The use of genetic algorithms with planning is evident in S43, S47, and S67, where S47 builds upon S43, incorporating a quest generation system under the arcs of the story, utilizing Heuristic Search Planner (HSP)-2 for searches. A graphical interface control tool for the S43 and S47 models was introduced in the S67 paper. In S40, Knowledge Graph (KG) and GPT-2 were employed for quest generation. Similarly, S70 also leveraged a KG but used the Llama2 model to convert the KG into text in the so-called KG2Text model.

In S45 and S58, Creation Of Novel Adventure Narrative (CONAN) was directly or similarly employed for quest creation. In these systems, one can define a set of rules that model the story's universe and its actions, combining aesthetic values to craft the design of quests.

A model employed for generating concise detective stories is demonstrated in the S69 project. This work also featured an interface with graphs and configurations tailored for composing a *Planning Domain*

Table 3
Summary of the features found in the analyzed papers.

	Techniques	Categories	External evaluation	Internal evaluation
S46	Q-learning	Reinforcement learning		similarity test
S47	HSP2 heuristic search planner	planning		
S48	context-free grammar	Grammar	User study	Expressivity analysis
S49	ABL, GPT	Planning, agency		
S50	MAS			
S51	Breadth First Search (BFS)	Rule-based, pathfinding, breadth first search, heuristic search		
S52	Finite State Machine	FSM	gameplay and interface	
S53	POPF planner, STRIPS	Planning		Scalability
S54	KNUDGE (KNowledge constrained User-NPC Dialogue GEneration), game ontology, dialogue trees	Ontology, deep learning	Coherence, non-violation, biography, quest usage	BertScore, BLEU
S55	BERT, RoBERTa-based	Deep learning		classification_report (from scikit-learn)
S56		Survey has not specific technology		
S57	GPT-2	Deep learning, GPT	"Turing-style test"	Cross entropy loss
S58	GPT-3, Shotgun Hill Climbing	Rule-based, deep learning		Fitness, counting desires
S59	n-gram, LSTM,GPT-2	Deep learning		BLEU, BertScore
S60	Grammar, BSP, l-system	Generative grammar		Performance, estimated time
S61	generative grammar, genetic algorithm	Generative grammar, evolutionary algorithm, genetic algorithm		Fitness function error
S62		Survey has not specific technology		
S63	GODEL	Deep learning, NLG	skill, preciation and imagination	
S64	GPT-3	deep learning		
S65	prolog	Planning		
S66	ChatGPT	Deep learning	Narrative Coherence, Narrative Immersion, Adaptability	
S67	POPF planner, STRIPS	Planning	Comparing programmers users with not programmers users	computational performance
S68		rule-based		
S69	PDDL language, Graphviz	Planning, rule-based, graph		
S70	Llama2, KG2text	Knowledge graph, deep learning, LLM		BertScore, metrics (Relatedness, Contradiction, Coherence, Value)
S71		Ontology		Pairwise correlation, Counting subscore domain
S72		SVM, linear regression, rule-based	Questionnaire, Turing-style test	Fitness error

Table 4
Techniques by category.

	Maps	Entity behavior	Puzzles	Story	Levels	System design	World design
evolutionary	5			1	2	2	
ontology		3		1		1	
graph	2	1		4	2		
deep learning		8		11	1	1	1
FSM		2		3			
NLG		1		3			
grammar	7			1	2		
rule-based	2	1	1	8		3	1
planning	3	5		13	3	1	1

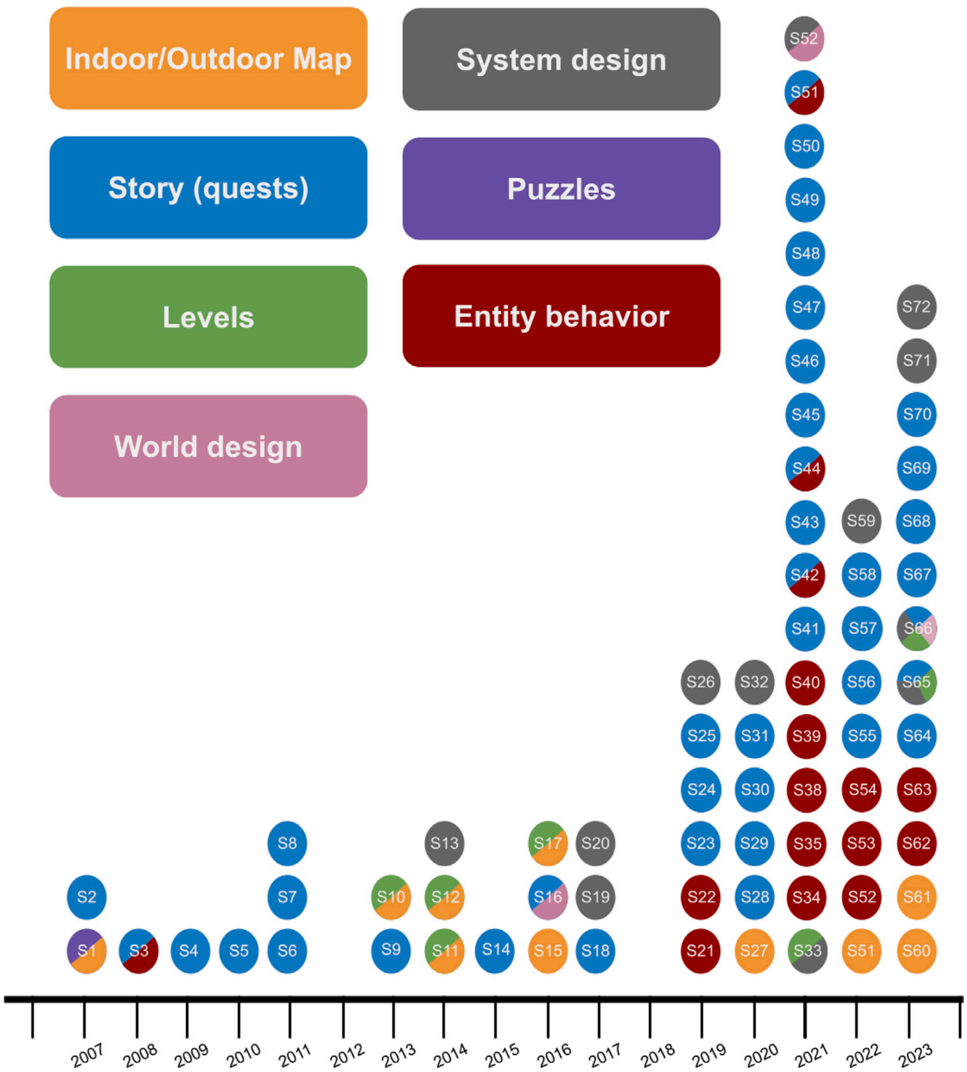

Fig. 7. Timeline for RPG publications under the light of the Hendrikx's Pyramid. Colors indicate which type of game content was explored, so items with more than one color explored more than one type of game content. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Definition Language (PDDL) file. In S48, a tool entitled Questgram was introduced to assist in quest generation, applying generative grammar, similar to S72.

Some works lie further from others in terms of techniques and objectives related to the "Story" category. S46 introduced story creation through Q-learning, which is a type of RL. In S55, there is a study that used data from the game *Fallout: New Vegas* as a corpus for sentiment analysis. It employed a robust RoBERT model, a variant BERT. S56 is a chapter on *Interactive Storytelling* (IS), which references RPGs and various distinct technologies of Interactive Storytelling (IS). Finally, S68 is a short paper that introduced a rule-based event generation model through world definitions.

The "Maps" category kept a limited presence during the past three years, marked by the introduction of S51, S60, and S61. The Orbital Dungeon Generation was introduced in S51, a method developed to draw a dungeon around nodes, inspired by Copernicus' theory of distributing new map elements in an orbit. Meanwhile, S60 used binary space partitioning and L-systems, while S61 employed a methodology reminiscent of generative grammars to create paths and beds. This approach combines the mentioned structure with GA to determine weights that align more closely with a designer's preferences without compromising variety.

In Fig. 6, most recurrent contributions of these works involving RPG are certainly in the narrative plot, with 40 results distributed between 2007 and 2020. We believe this was partly due to the popularity of this theme with its proximity to the concept of role-playing ("role-play"). In its turn, the procedural generation of spaces is a quite recurrent theme in PCG, as pointed out by the literature reviews in Section 2. Finally, works on dungeon generation have been pointed out since the middle of the 2000s [9].

5.2. What techniques are used to manage or produce RPG content?

The PCG techniques used in RPG are usually applied according to the content type, which is a category from HP. For example, it is usual to find typical applications of "*rule-based*" techniques for generating maps and "*planning*" techniques for narrative [6]. While reading the articles, we enumerated keywords linked to the techniques used. We then associated each article with a subset of these keywords. At the end of the process, the keywords constitute broader categories based on two criteria: (a) are more frequent or (b) are more interesting to represent an inherent part of the research.

The use of "planning" techniques is recurrent and appears in 9 articles. This is more frequently used for PCG with the "Story" category since it is a recurrent solution in IS applications [7]. These *planning* models describe rules for a narrative universe, including states and actions. When the particular prerequisites of a given action are met, that action can be executed to yield a change to the narrative state.

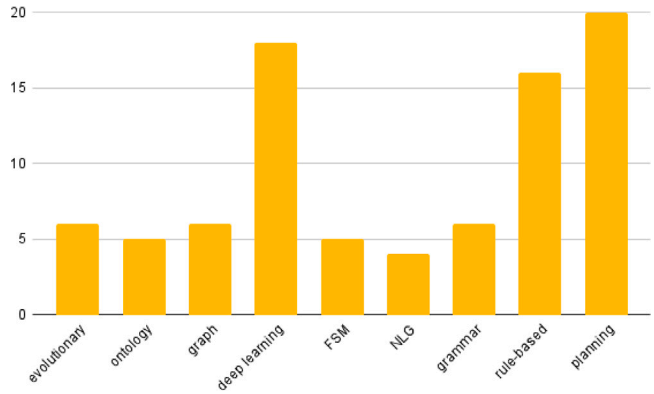

Fig. 8. Number of techniques used.

Therefore, a formal *planning* language such as PDDL is often needed, as well as a "solver" algorithm that produces the plans. The character planning concerns generating action sequences that take it from a current state to a desired state, generally representing the plan to reach that character's goal.

In the context of IS, the commonly cited "solvers" are STRIPS, HTN, and *Goal-Oriented Action Planning* (GOAP), the latter being developed specifically for games [13,15,102]. On the other hand, other unstructured models are gaining prominence thanks to the advances of *Deep Learning* [23] in text processing, especially procedural text generation. This technology enabled the creation of text games whose interactions are developed from user input, also in text using natural language [22]. More specifically, *transformer* neural network architectures seem very promising for this task, something that showed remarkable potential in general *Natural Language Processing* (NLP) tasks [103]. For example, S30 and S31 used this technology for generating quests like text segments. In fact, as *deep learning* technologies have presented outstanding results in this decade for many problems, there is a strong tendency to use such techniques in IS [22]. Consequently, deep learning methods will likely gain more and more space in the research field with the new developments in *transformers*, similar models, and high-level deep learning frameworks.

Both indoor and outdoor map generation are among the most classic elements of PCG [6]. This systematic review identified this type of contributions in S1, S10, S11, S12, S15, S17, S27, S34, S51, S60 and S61. A type of recurrent technique in algorithms that generates maps is established with formation rules. We found a good plurality of techniques in the analyzed works, from the most common ones such as *grammars* and *rule-based* to the most unusual ones for this type of application, like "planning". Regarding this last type of technique, two works are presented, one with a complex hierarchical approach made through *Answer Set Programming* (ASP), in S12. In addition to this, there is a work that cites it directly while competing with it, S27, which features an unusual application of the Z3 solver.[12]

We observed a significant increase in the number of works starting from 2021, something that was influenced by the existence of GPT, which had its first version released in 2018. However, its GPT-2 version, released in 2019, started to attract attention, leading to several works in 2020. Even with the release of the GPT-3 version in the same year, GPT-2 remains popular for more specific retrained models. This is because, despite being costly, it is still more accessible than GPT-3 [24] as it can be used on smaller infrastructures.

The GPT technology has brought forth the possibility of creating elements of the story and behaviors of entities, particularly in the case of character dialogues. These dialogues benefit from deep networks, especially transformers due to their ability to capture complex patterns and dependencies in language. Other elements, such as descriptions of objects, have also been generated. Furthermore, it is important to emphasize that the works do not exclude other types of content, such as map generation.

The conventional Interactive Storytelling techniques that use planning and rule-based approaches have markedly declined in comparison to the widespread adoption of deep learning. As illustrated in Fig. 8, it is evident that the latter, despite gaining prominence only around 2020, is rapidly approaching in terms of quantity. It is worth noting that deep learning techniques, although often associated with GPT in a more utilitarian manner, in Tables 2 and 3, either by using it directly or repurposing the neural network (i.e., transfer learning) and retraining for other tasks. For individuals engaged in retraining deep neural networks or focused on developing their custom networks, the pursuit is for models proficient in handling sequential data, including text. Consequently, technologies such as BERT and other iterations stemming from Large Language Model (LLM) emerge as prospective choices, capturing the attention and interest of researchers. This enthusiasm may be traced back to foundational models and methodologies, reminiscent of those introduced by Doran and Parberry [33].

In the "Story" category, the use of planning remains common, but the growth of deep learning is undeniably evident. Classic IS studies, such as Façade, which utilize A Behavior Language (ABL), a reactive planning language, have not proven attractive. This was perhaps due to their challenges in development and maintenance, or possibly because of the lack of a reference product employing this technology. Notably, we have categorized NLG, deep learning, and grammar generation separately, although the latter two may fall under the umbrella of NLG. Therefore, when referring to NLG, we assume the exclusion of the latter two and focus specifically on techniques related to text processing, extraction, and classification.

In Fig. 8, we have a high frequency of rule-based techniques. These involve specific programming approaches to problem-solving. Some examples include "behavior trees" and heuristic searches, while broader techniques like Multi-Agent System (MAS) are discussed in the article S47.

Table 4 provides a count of works presenting technologies used in general terms and their application areas, correlated with what was presented in Table 2. It is worth noting that a single article may employ more than one technology and be associated with more than one category of Hendrikx's Pyramid, as observed in several multicolored works depicted in Fig. 7, such as the works S1, S3, S10, S12, S13, S16, S17, S33, S40, S42, S49, S50, S65, and S87. Therefore, the total sum in Table 4 surpasses the number of collected articles shown in Fig. 8.

That being said, it is important to note the significant number of works involving narratives ("Story") with "deep learning" and "planning" having 11 and 13 occurrences, respectively. Notably, such elements are linked to player behavior, such as texts.

Much of the work involving "Levels" is closely related to the generation of maps, as with S10, S11, S12, and S17. In S10, S11, S12, and S17, the automatic map generation is linked to the distribution of resources and challenges. The recurrent techniques in these papers involved internal rules, hence the recurrent use of graphs, "*grammars*", and even " *planning*" methods.

Paper S33 proposed a model that generates dungeon maps tailored to the challenge using a behavior tree. Meanwhile, papers S65 and S66 applied this approach to a horror and investigation TRPG called "Cthulhu Confidential", which features a system designed to provide clues. Unlike other TRPGs, this system follows a One-to-One format, i.e., with one narrator and one player. Therefore, S65 provided an assistant to help the game master maintain the main storyline and offer suggestions for extensions. To achieve this, S65 utilized Prolog to model rules and make queries, allowing functions such as "Find New Lead", "Character Knows Clue", and "Overhear Conversation". By assisting the

[12] https://rise4fun.com/z3/tutorial

narrator, it affects both the system design and the levels, as well as the narrative itself.

Article S64 is related to S65, as it generated dialogue suggestions and extracted text for relevant questions utilizing GPT-3 in both tasks. On the other hand, S66 is responsible for generating the game almost entirely using ChatGPT under the d20 system. However, S66 presented a more direct use of ChatGPT, clearly delineating the designer's role in the experiment.

"Systems Design" is used to generate tokens or determine attributes for characters or items. Challenges are usually presented as structures for game balancing. In the case of balancing "evolutionary methods", such as GA, as in the case of the S32 work to generate characters and their progression to face the challenges of a game made in RPGMV,[13] as well as the equipment "drop system" in S13. However, the other works have less rigid aspects and shift to rules modeled by the researchers and evaluated by external participants.

In S59, descriptions and rules for D&D spells are generated and compared with two models: an LSTM and another using GPT-2 implemented with a transformer library from Hugging Face. An analysis of various games, including RPGs, was presented in S71, allowing for the construction of a domain ontology for game mechanics. Lastly, S72 introduced the conversion of creature sheets from different RPG systems, including the integration between various TRPG and DRPG systems. The conversion techniques are relatively simple, including *Support Vector Machine* (SVM), linear regression, and a rule-based model built on top of statistical analysis and system context.

Only one model was identified as *puzzle generation*. In work S1, the proposed model generated open maps for DRPG. Therefore, there were sequences of actions in these maps that generated dependencies to get items to traverse the map in a 3D game called "Charbitat". This work was carried out by using formation rules. Although it cites a "grammar", its use was unclear, so it was not classified as having used it.

The "Entity Behavior" presents different models. S3 managed the character's behavior based on changes in game states and the NPC relationship with the scenario. This is done by resorting to a "*planning*" method. In the S21 work, dialogues were controlled using *Bidirectional Recurrent Neural Network* (BRNN) networks. Finally, the work S22 made use of *Comme il Faut* (CiF), which is a model that makes social representations and reuses interactions applied to the online game *Conan Exile*.[14]

Entity behavior is indeed complex, and many Deep Learning (DL) works address this challenge. However, there is a noticeable need for modeling and control, given the existence of technologies such as FSM, ontology, planning, and rule-based systems. As shown in Table 4, there is a reasonable distribution of these other elements after deep learning, particularly ontology and planning. This is because having a domain of knowledge modeled and applying rules over this model are still the most commonly used approaches in the market, and perhaps even deep learning technologies tend to align with these approaches. Ontologies are viewed in philosophy as a separate discipline; however, in computer science, they are often regarded as knowledge bases. For example, FOAF and DBPedia are quite general and treat different aspects.

In 2021, as depicted in Fig. 7, there was a survey, S34, exploring works involving NPC conversations. It distinguished various classifications, such as the role of AI in character control, whether as a designer or producer. Additionally, it discussed technologies like NLP, ASR, and TTS [60]. Furthermore, there were also two models designed to behave as player models for game completion or exploration. Specifically, S35 and S36 presented a bot for a version of the Pokémon[15] game using RL and another bot for playing an MMORPG called Tibia,[16] created through FSM and employing various algorithms for bot functionality.

In S52, published in 2022, the article discussed a bot for an educational RPG called Save Karang Mumus. This model was created using FSM and focuses more on the production process and technical details. There are several works involving dialogues and conversations with NPCs. For instance, S38 evaluated the effects of dialogue generation using an LLM model in games, accounting for the scenario, NPC personalities, and even voice context. Similarly, S40 utilized GPT-2 for dialogue generation. S54 generated ontologically faithful dialogue trees using the T-5 model from HuggingFaces.[17] These dialogues are applied to the game "The Outer Worlds", specifying an ontology fueled by English texts from the game; this model is called KNowledge constrained User-NPC Dialogue GEneration (KNUDGE). Finally, S63 generated dialogues using T5-large, creating a model called Godel, which takes dialogue from the story, environment data, and user responses as input to generate other lines of dialogue.

There were 2 surveys on the theme of "Entity Behavior". First, S49 seeks to establish a theoretical model for what could be a digital RPG narrator and which technologies would be involved. This work points to interactive systems like Façade, which uses ABL and GPT. In its turn, S62 focuses on NPC decision-makers and examines technologies such as decision and behavior trees, FSMs, rule-based systems, GOAP, and Artificial Neural Network (ANN).

Other behavior models focusing on narrative can be seen in S37 and S54. In S37, an extension of the Belief-Desire-Intention model (BDI) model was presented, focusing on doxastic discussions and prioritized belief bases, goal recognition including epistemic situations, and planning including speech acts. On the other hand, S53 introduced a planning model inspired by STRIPS, called the POPF planner, a rule-based system aimed at enhancing character narrative. Finally, to close the models, there is S5, which is a behavior model implemented with a behavior tree in the Unreal Engine for an RPG called Shriek.

Note that these articles represent just a small selection of PCG and AI techniques, as they are bounded within, or close to, the RPG, as seen in Fig. 1. Therefore, the present survey does not include all the literature on digital game techniques, thus, more distant, or too general genres were not included. For example, it is possible to find other works that involve the generation of narratives that could be used in RPG games, but these works do not explicitly mention such applications.

5.3. What metrics and assessments are involved?

Most works present models with approaches that demand evaluation during the improvement process, such as machine learning models and evolutionary algorithms. Other works resort to heuristic approaches (e.g., *rule-based*) and do not have an evaluation inherent to the method. Such cases usually resort to analyses of distributions and descriptive statistics, or even the adaptation of other specific techniques such as analysis of centrality in graphs. Qualitative human evaluations are recurrent answers regarding aesthetic qualities, comparisons between computational methods, and human work. These evaluations can be divided into two groups: (a) internal evaluations, carried out by the researchers' analysis; and (b) external evaluations, which are carried out by volunteers or specialists.

5.3.1. Internal evaluations

A total of 52 out of the 72 studies used internal evaluation methods. The internal evaluations are subdivided into two sets. The first set contains the evaluations inherent to the methods, such as termination criteria in genetic algorithms or error distances. The second set is composed of evaluations of a more subjective aspect, e.g., analyzing

[13] https://www.rpgmakerweb.com/products/rpg-maker-mv
[14] https://www.conanexiles.com/pt/siptah-br/
[15] https://www.pokemon.com/br
[16] https://www.tibia.com/
[17] https://huggingface.co/google-t5/t5-large

and interpreting distributions, measures of centrality and dispersion, correlations, and evaluations of centrality in graphs. Within this more subjective scope, evaluations were usually applied to verify whether or not the method achieves an objective.

Some analysis approaches involved graph structures. For example, maps and "*levels*" generation result in graphs, such as in S9, S10, S15, and S17. It is important to highlight that we found three articles that, despite being representative of different categories, share an intersection. For example, S9 belongs to the "Stories" category, S10 has "Levels" and map generation, S15 for map generation, and S17 belongs to map generation and "Levels". This can be seen in Fig. 7.

Graph analysis concepts (e.g., centrality, lengths, and number of leaves) are interpreted as aesthetic values given the different application contexts. In the case of S9, there is a set of qualities like the following: "narrative content", "longest/shortest path", "number of branches", "cost", "highest/lowest cost", "encounters", "uniqueness", "narrative richness", and "weight of choices". In S10, the number of subgraphs of the final rooms is calculated. In S15 there is "Mission Linearity", "Map Linearity", "Leniency", and "Path Redundancy". Finally, in S17 there are: the length of the shortest path between the start and the end; exploration value, which is calculated from the number of nodes explored before reaching the end node; "variation" which is the proportion of edge connections; and the number of rewards with "secure" nodes around.

Since some methods are more sophisticated and require simulations to validate their results when verifying or evaluating success. In the S11, given the application of A^* search algorithms [6], it was necessary to evaluate the optimal actions for the challenges found in an automatically generated dungeon. In S32, on the generation of class progression data in a DRPG, the performance was evaluated through simulations of combats in turns, specifically in terms of how close the victory rates are to the challenge defined at design time. In S24, performance evaluation was carried out from an Evolutionary Algorithm (EA) perspective while the quality evaluation resorted to external evaluators.

With the increase in works using Deep Learning, it is natural that measures associated with these models appear in their current methodologies. Therefore, we highlighted only those that seek to go beyond error measures in Tables 2 and 3. For example, S54 and S59 resorted to BiLingual Evaluation Understudy (BLEU) and BertScore for their models. It is important to note that few works aim for efficiency, such as S11, S17, S35, and S67, perhaps because the cost is low, the process is offline, or because there are no efficiency comparisons with other models.

Other evaluations seek to analyze the distributions of attributes generated by their algorithms in S19, S20, and S27. Such analyses have a more descriptive perspective, generating a better understanding of the phenomena of the algorithms used, allowing the elaboration of summaries and inferences [104,105]. For example, S19 and S20 dealt with creating items through PCG techniques, so the researchers tried to analyze the effects of their models in terms of the distributions of the generated attributes. In S27, the authors resorted to a descriptive analysis of the distributions of rooms and corridors made by the map generator using *linear constraints* and *Satisfiability Modulo Theories Solver* (SMT Solver).

5.3.2. External evaluations

Only 24 out of the 72 studies used external evaluation methods. Some of these evaluations prove and analyze the proposed method. Other evaluations indicate weaknesses that must be addressed. The work in S6 made interesting use of external participation by using the *Plastic Interface for Collaborative Technology Initiatives through Video Exploration* (PICTIVE) methodology in its construction process. PICTIVE is a technique created in 1991, which tries to include participants in the design development process through interactions with objects related to the product and while these interactions are recorded [99]. However, other works do not have an expository evaluation, despite citing it as an essential part of the process. For example, S18 proposed a model based on data from interactions in social networks and similar platforms, but it did not detail evaluations or metrics.

Further evaluations on the best-generated result or performance done by users are seen in S20. The authors counted the plain players' preferences over the old or new models the first proposed. In S24, in its turn, a simple Turing Test was performed to identify whether a quest was created by humans or by a machine. Similarly, users classified quests as "good labels" or "bad labels" in S31. Nevertheless, a binary assessment may prove inadequate in certain instances. Another alternative is the application of qualitative questions in an agreement scale. The Likert scale was proposed by Rensis Likert in the 1930s. It is widely utilized in surveys across various fields. This scale is used in S21, S22, S25, S26, S38, S41, S44, S54, S57, S63, S66, S69, S70.

Many works did not present explicit evaluations but rather discussions of the results, where the findings themselves suffice for the work. However, some works sought to explore by observing the player, as in the case of S33 and S52, where gameplay was analyzed, as shown in Tables 2 and 3. Due to the clear increase in technologies over the past 3 years focused on "Entity Behavior and "Story", as indicated by Fig. 7 of the timeline, the reflection of which can be seen in Table 4, where deep learning has 7 occurrences with "Entity Behavior" and 12 with "Story".

Studies and applications that use deep learning usually resort to comparison against the results of human work as a baseline. Therefore, starting from 2021 works in these lines show concerns with more subjective qualities. This leads to works like S38, S40, S41, and S66 to establish or seek references for subjective qualities that are assessed by external evaluators. The qualities in the "External evaluation" column often aim for "coherence" and "creativity". However, each research seeks to establish its parameters without having a universal evaluation model.

Some works feature models that perform activities equivalent to humans to the extent that they can deceive a viewer or player. S43, S57, and S72 resorted to an evaluation akin to the "Turing Test", i.e., volunteers determined whether a product was made by a human. Identifying whether a product was made by humans may become a more common evaluation approach depending on the content generation purpose, as realizing that something was made by a machine tends to be interpreted as a flaw when noticing repetitions or even defects.

It is possible to observe that a significant part of the evaluations is summarized by comparing the quality of the final results obtained by humans and the computational models. In short, these evaluations consist of letting volunteers choose which contents are the best, without knowing which ones were made by humans and which were made by the computational model. In this way, such evaluation operates similarly to a Turing Test, where intuition will expect that human work has better results in content management. There are many qualities to explore, but the most common relate to fun or creativity. However, these qualities vary depending on the application.

Given the analyses presented in Section 4, we can extend the observations in this section. It can be concluded that there is a reasonable heterogeneity of research concerning RPG, especially in the context of narratives ("Story"), and that they may differ slightly from what is explored in the industry. The most recurrent concern in the gaming industry is game balance and clear narratives, which makes these titles adopt linear narratives. There is a significant effort in academic games research to automate underlying production processes to generate greater possibilities during "gameplay' ' with varied narratives.

On the other hand, even in the academic context, studies of AI for games tend to focus on conflict resolution, as is expected in *Real Time Strategy* (RTS) titles or in shooting games, in which AI models are trained to compete or simulate player behavior, for example.

Despite the considerable frequency of "planning" techniques in research, especially in the "Story" category, the growth in other types of game content of *Computer Science* (CS) probably will affect these

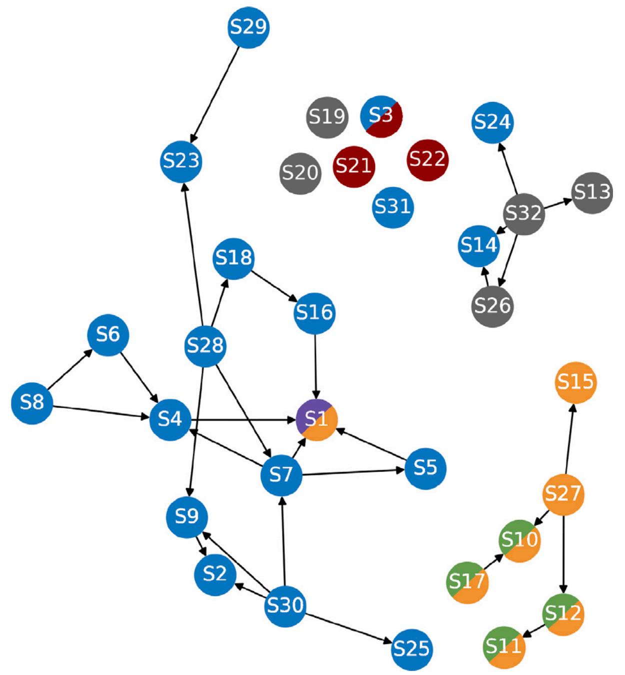

Fig. 9. Citation graph of the analyzed articles. Edges start from the citation to the cited. The colors of the articles follow the same scheme as in Fig. 7.

numbers in the coming years. The most promising ideas resort to *deep learning*: the very adoption of a *Transformer* to generate narratives and *quests* in S31 is a clear demonstration of this, as presented in Section 5.2.

A significant part of the works is directly related by citations, as shown in Fig. 9. We identified four paper groups:

- "**Story**": a large set composed of various narrative elements.
- "**Indoor/outdoor map**" and "**Levels**": map and level generators, in the context of "*Rogue-like*" and MUD.
- "**System design**" and "**Story**": has a related set, especially according to article S32, citing them all. This is partially because this is one of the most up-to-date works in a more specific set.
- "**Unlinked**": on the other hand, we have a set of "Entity behaviors" that are not cited directly in S3, S21, and S22, in addition to S19 and S20, which, despite having the same author, are not mentioned, possibly because they submitted the two works without having each other's confirmation. Despite citing studies on games, S31 did not directly mention research on RPGs.

6. Final considerations

This work sought to investigate which RPG genres and subgenres are directly explored by technologies developed in Computer Science, especially AI and PCG, for control and management support. Starting with an RPG definition, we delimited the genres and rules needed for defining the set of RPGs and their categorization, as shown in Figs. 1 and 2. The categories of types of game content based on Hendrikx's Pyramid and the technologies, in terms of techniques, are presented in Table 4. We can conclude that the technologies used in RPGs are especially geared towards narrative. There is evidence that this application field will remain an active research field with new advances, though further developments are not limited to narrative.

However, it is worth noting that there has been a considerable increase in applications since 2021. In part, this is due to the popularization of deep learning technologies. One of the most common potentials of these technologies is content generation, whether by texts or images. An interesting and remarkable point is that the use of Language Models has been recurring, but the same cannot be said for Generative Adversarial Networks (GANs). The latter are potential resources for image and model generation, and perhaps, for this reason, they have not yet stood out in the context of RPG text.

We can say that DL is a technology that has sparked a high interest in PCG applications, and the complex context of RPGs presents an interesting challenge for this technology. Therefore, current RPG research is naturally influenced by DL, so this technology will likely lead to profound impacts on the field itself in the future. Furthermore, we observed from the most recent works a trend of using LLMs, such as ChatGPT and Llama2, in RPG research.

The RPG game market is bringing the TRPG genre closer to its digital counterpart, even if it does not do so through technological innovations, but through design or simply by making new, inventive use of existing tools. As an example, we can observe that TRPG itself has been used more traditionally in the digital environment employing PBF and *Play-by-Email* (PBE) in addition to videoconferencing platforms such as GoogleMeet or Discord, or online virtual tabletop systems like Roll20,[18] Burn Bryte,[19] Astral Tabletop[20] or Taulukko.[21] The commercial growth of these technologies tends to emerge as bolder applications and possible research interests.

Some digital games have a strong relationship with the role-playing aspect and could, in this sense, be categorized as RPG because these titles are closer to the genre than other DRPG titles. For example, social games like *Habbo Hotel* and *Club Penguin*, lack progressions and combats, but present social interactions and mini-games between players. Another commercial success that could be classified as RPG despite not claiming to be an RPG is the *Grand Theft Auto* (GTA) franchise, which has similar structures to narrative development in "quests", including "side-quests". Moreover, GTA's online version forms communities that act spontaneously to play roles within the game without necessarily worrying about the progression of a MMORPG or the competitiveness of other genres.

Finally, another recent and noteworthy commercial success was the game "Baldur's Gate 3", winner of the 2023 Steam Awards. This CRPG title explicitly sought to bring its mechanics and narratives closer to TRPGs by providing players with multiple endings and different choices. Moreover, the previous year's winner of the same award was Elden Ring, a roguelike game classified as an action role-playing game. These cases highlight how the RPG subgenres are popular and relevant.

Regarding future work, we can conclude that exploring specific themes linked to RPG research, especially the narrative aspect, is a promising research opportunity. Finally, our investigation also pointed out that, despite the typical mathematical representations of the "System design" category, such game content still lacks automation and analytical research for better clarifying and understanding these models.

The game system is intricately linked to gameplay demands and profoundly influences the overall product. Therefore, it is complex to relegate such qualities to a machine, which is why we seek to define, classify and, in short, understand so that we can create our models.

CRediT authorship contribution statement

Artur de Oliveira da Rocha Franco: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Windson Viana de Carvalho:** Writing – review & editing, Supervision, Methodology, Data curation, Conceptualization. **José Wellington Franco da**

[18] https://roll20.net/
[19] https://burnbryte.com/
[20] https://www.astraltabletop.com/
[21] https://vol2.taulukko.com.br/

Silva: Writing – review & editing, Methodology, Formal analysis. **José Gilvan Rodrigues Maia:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Investigation, Conceptualization. **Miguel Franklin de Castro:** Writing – review & editing, Validation, Supervision.

Declaration of competing interest

We have no conflict of interest to declare.

Data availability

No data was used for the research described in the article.

Acknowledgments

This work was partially supported by FUNCAP grant number BMD-0008-01237.01.25/19. All authors are employees of the Federal University of Ceará.

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