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A cataloging matrix-based approach to unify the classification of digital games

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Abstract. The paper proposes a novel unified classification of digital games, i.e., video games and serious games, due to the recent interest of academia and industry for their use to achieve several educational purposes. The paper reviews existing cataloging systems and proposes a five-definition based matrix cataloging including a set of key digital game metadata, unifying existing knowledge and highlighting commonalities between cataloging systems. It offers a higher-level categorization of digital games that retain distinctions where necessary, thus unifying both categories of digital games. Such taxonomy enables the creation of a correlation matrix that will provide a theoretical basis necessary to specify guidelines for the concept design phase of digital games.

Keywords: Cataloging, Videogame, Serious games, Concept Design.

1 Introduction

Digital games include both entertaining videogames and edutainment serious games. Its market has grown exponentially over the years, gaining an important role in everyday life, and fitting seamlessly into a variety of sectors [1]. In 2015 it was estimated that the total revenue of the global digital game market was between \$81.5 billion and \$93 billion [2]. This situation hinges on the fact that digital games are no longer just limited to the field of entertainment but have expanded to edutainment as well. Serious games particularly incorporate various aspects, such as wellness, education, and cultural heritage [1]. Some serious games examples include: (i) *Le Village Aux Oiseaux*, a therapeutic game whose goal is to train patients with Alzheimer's disease to slow down the cognitive decline due to the condition [3] and (ii) *The Prepared Partner*, an educational video game about labor and childbirth designed to prepare for parenthood [4][5]. The growing development of the video game industry is directly proportional to the increase in the segments of the population that use it. The overall male target user is now only slightly outnumbering the female target user [2], compared with the past. Moreover, the same categories of users have expanded according to the sphere that the game embraces, including children, teachers, corporate workers, as well as patients in therapy or people with different types of disabilities. One of the challenging issues in

game design is cataloging and classification, due to the large variety of software solutions, game's scopes, target users and hence the needed interaction modality and usability requirements. The term *classification* refers to a process that "[...] involves the orderly and systematic assignment of each entity to one and only one class [...]" [6] while *cataloging* is the process that provides "[...] users with timely access to information relevant to their needs. The task of identifying resources collected by libraries, results in rich metadata that can be used for many purposes" [7]. Therefore, classifying and cataloging games has become a fundamental step to allow game designers to unravel the complexity of the current state-of-art, to identify the target users' needs and how to meet them, and hence to better guide their development.

Several authors attempted to classify them. In [8] a three-dimensional taxonomy is suggested: (i) type of computer software; (ii) the genre of the game; (iii) the mode of interaction. In [1] an in-depth multidimensional classification of serious games is proposed, focusing on the qualities that are crucial to their design, i.e., style of interaction offered to the player, activity, mode, environment, and area of application. Despite these attempts, there is still a lack of a classification that enables research to unify the various proposals identified in the literature. This paper aims to analyze these classifications by providing a unified cataloging, following a review methodology as proposed by [9]. A starting point to achieve a 'matrix cataloging' to bring out possible correlations among the collected data is here proposed. The data will be separated and organized using specific classification criteria, creating a unified digital games cataloging. In this way, applying the proposed cataloging to real use cases it will be possible to define correlation values that will form the theoretical basis necessary to specify a guideline for the preliminary conceptual design of digital games.

2 Literature review

The review is conducted by adopting the light version of the guidelines proposed by Kitchenham et al. [9], adapted to the needs of the present research. This work aims to analyze previous video and serious games cataloging to propose a unified model that encompasses all of them to guide designers in tailoring the application they want to design to their specific needs. The first step of the guidelines is to formulate a research question that will guide the review. Our review tries to answer the following:

- **RQ:** How are video and serious games catalogued, and on which criteria?

After the formulation of the research question and having defined the database pool from which to extrapolate the papers (i.e., electronic databases such as Scopus, IEEEXplore and Web of Science, including scientific papers, review articles and conference proceedings) the research question aids in the formulation of a search string. Our search string is the following: ("recategorization" OR "cataloging" OR "cataloguing") AND ("videogames" OR "digital" OR "serious") AND ("games"). The survey is limited to English-only articles in the Computer Science and Engineering fields and resulted in 1135 records, which decreased to 911 after duplication removal. Filtering the records, including only works from 2010 to 2023, resulted in 695 papers. A preliminary

selection based on title, keywords and abstract results in 31 titles, further reduced to 5 records after a rigorous selection based on inclusion criteria. The criteria are that a screened record is admitted to the review only if it proposes a video and/or serious game cataloging system. The first reviewed paper [10] proposes a cataloging system based on G/P/S (gameplay, purpose, scope) concept, gaming platform and UX for container terminal logistics serious games. Then, [11] proposes a simple genre-based cataloging system for entertainment videogames, while [12] proposes a comprehensive cataloging system for health rehabilitation serious games based on UX (feedback, adaptation), interaction, technology, and other domain-specific criteria. Finally, [1] proposes a cataloging system for serious games based on the style of interaction offered to the player, activity, mode, environment, and area of application, while [13] proposes a cognitive stimulation serious games' cataloging based on similar criteria to that of [12].

3 Data analysis

The review results in five different cataloging systems, each with several metadata. A higher-level framework proposed by [8] is followed to achieve the objective of unifying such cataloging systems. The framework illustrated in [8] proposes to classify digital games by three definitions, namely:

- **D1**, “The game is seen as a computer program and all its related properties such as the admissible number of users, networking features and the like are considered”
- **D2**, “The game as a piece of artwork and media has a genre”
- **D3**, “Through intense interaction, players act and experience engagement such as building, fighting, or trading, e.g., Interaction determines the psychological/social impact”.

The first step is to remove the domain-specific parameters (e.g., patient monitoring/assessment in [12]) from the cataloging systems obtained from the literature review. The following step is to identify the definition to which each parameter belongs. Some criteria are omitted from the three-definition classification: the target audience and the application area. This is because such classification is of general application and is not targeted towards serious games. As a matter of fact, videogames aim to entertain and amuse the player, while serious games present a practical purpose (e.g., training, education, well-being). Therefore, to include the left-out parameters too, the three-dimensional high-level classification system is extended to include two other definitions, namely:

- **D4**, a digital game is always oriented towards a specific audience and market. The Design phase must take the target into consideration to tailor the product to the user that is intended for
- **D5**, serious games always have a practical purpose that, in conjunction with the audience and market, guides the Design phase.

Once each parameter is categorized in one of the five high-level definitions (where parameters are contained in two or more cataloging system, these are joined together),

the result is obtaining a model that unifies the five cataloging systems obtained from the review. Four of the five definitions enable the abstraction of four classification dimensions that can be useful for classifying digital games. Those dimensions are:

- **Genre**, is the dimension that specifies the genre of the digital game (e.g., RPG, strategic, puzzle) and suggests to both the user and the designer which kind of experience the game should deliver. It is derived from definition D2
- **Engagement**, is a quantitative dimension that specifies the intensity of the interaction between the player and the digital game. It can be affected by several factors (e.g., immersiveness, narrative, fidelity), and it's derived from definition D3
- **Target**, combines the targeted market (e.g., healthcare, education, culture & art) and the targeted audience (e.g., the general public, professionals, students). It is the dimension that characterizes a digital game based on who it is targeted. It is derived from definition D4
- **Purpose**, specifies the goal of the digital game, whether it is intended for entertainment only (videogames) or for more pragmatic goals such as serious games (e.g., marketing, training). It is derived from definition D5.

These dimensions, abstracted from the unified cataloging system proposed here, enable the classification of digital games. D1 is left out of the abstraction process because it is not strictly related to digital games but rather to the features that designate them as software (as the authors stated). Figure 1 shows how two digital games could be classified with this system. The three qualitative dimensions (Genre, Target, and Purpose) are depicted one for each axis of the Cartesian space: their arrangement on the axis is not ordinal and only serves as a visual representation of their differences in value. The quantitative parameter (Engagement) is defined by the dimension of the sphere representing the game.

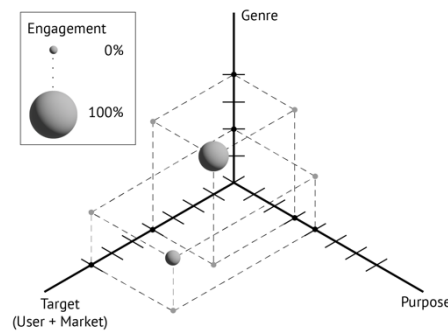


Fig. 1. A classification example of two digital games

4 Metadata for cataloging

Although excluded from the process of abstraction of classification dimensions, the D1 definition in conjunction with the other four remains useful for defining the

metadata that enables cataloging digital games. From D1, it is possible to derive the metadata useful to determine the software and hardware characteristics that characterize a digital game.

Our proposed cataloging metadata derive from the cataloging systems resulted from literature review and are arranged according to the five definitions: D1, D2, D3, D4, and D5.

The first four definitions (D1-D4) are generalizable to all types of video games since they are based on game characteristics that are closely related to (i) the software, (ii) the artistic choices related to the video game's genre, (iii) the user's interaction experience with the game, and (iv) the end user.

The fifth dimension (D5) is distinctive to Serious games since it is centered on game qualities that vary depending on the specific objective of the game.

Each definition embraces several categories, subdivided into more detailed metadata relating to the core issue.

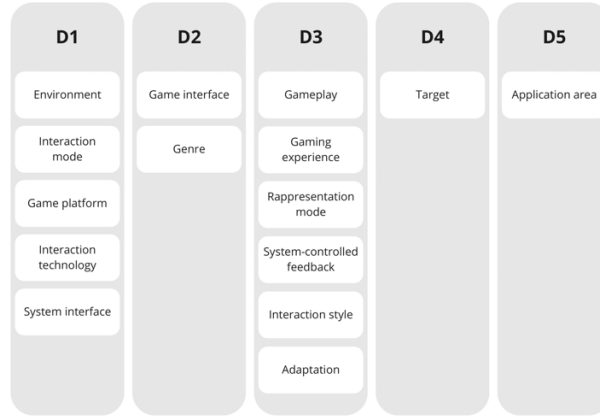


Fig. 2. The unified model with the five definitions

Figure 2 depicts the unified model with only the categories to produce a compact scheme presenting essential information. The next sub-paragraphs provide a comprehensive overview of each definition. Each sub-paragraph presents a list of categories and its metadata, with the corresponding author(s) that discussed each of them.

4.1 Definition 1

Definition 1 (D1) provides information on the different aspects of software-related games, including the environment, interaction modes, game platform, interaction technology, and system interface. The category “Environment” lists the different types of environments the gaming system supports, including (i) *Social presence*, (ii) *Mixed reality*, (iii) *Virtual environment*, (iv) *Location awareness*, and (v) *Online*. These metadata were discussed by [1][13]. The second category is “Interaction Modes”, which includes two metadata: (i) *Single-player* and (ii) *Multiplayer*. The paper [11] includes these metadata.

The third category, “Game Platform”, includes two metadata, (i) *Hardware architecture* and (ii) *Deployment*, which were discussed by [10][12][13]. The fourth category is “Interaction Technology”, which comprises several metadata such as (i) *Keyboard*, (ii) *Mouse*, (iii) *Voice/speech*, (iv) *Motion capture*, (v) *TUI*, (vi) *Touch/multitouch*, (vii) *Eye gaze tracking*, (viii) *Haptics*, (ix) *Facial expression recognition*, (x) *Biofeedback*, and (xi) *Gamepad*. The works [1][12] addressed these metadata. The fifth category is “System Interface”, which comprises four metadata: (i) *Visual*, (ii) *Auditory*, (iii) *Haptic*, and (iv) *Mixed*. These metadata were discussed by [12].

4.2 Definition 2

Definition 2 (D2) appears to provide information regarding the design of a game interface, with a focus on two essential components: “Game interface” and “Genre”. Two metadata are given under the “Game interface” category: (i) *2D graphics* and (ii) *3D graphics*, with the authors [1][13] associated with both. The second category is “Genre”, which is discussed by the authors [11][13]. It includes various metadata such as (i) *RPG (Role Playing Games)*, (ii) *Adventure*, (iii) *Puzzle*, (iv) *Action*, (v) *Strategy*, (vi) *Sports*, (vii) *Learning*, (viii) *Exercise*, and (ix) *Simulation*.

4.3 Definition 3

Definition 3 (D3) is that which contains the most items. In this case, the categories are “Gameplay”, “Gaming experience”, “Representation mode”, “System-controlled feedback”, “Interaction style”, and “Adaptation”; each of them includes specific metadata. The category, “Gameplay”, includes two possible metadata: (i) *Game-based* and (ii) *Play-based*. Both were discussed by [9]. The second category includes metadata related to the gaming experience, such as (i) *Challenge*, (ii) *Competence*, (iii) *Flow*, (iv) *Negative/positive effects*, and (v) *Tension*. All these metadata were examined by [10]. The third category, “Representation mode”, includes metadata related to (i) *Visual*, (ii) *Auditory*, (iii) *Haptic representation*, and (iv) *Mixed modes*. Authors [1][12] went through these metadata. The fourth category, “System-controlled feedback”, has metadata related to feedback provided by the game (i) *During gameplay* and (ii) *After gameplay*. These metadata were discussed by [12]. The fifth category is “Interaction style”. It includes metadata that describe the different ways players can interact with the game: (i) *Standard (traditional peripherals)*, (ii) *Active (alternative peripherals or body)*, and (iii) *Pervasive*. The author [12] discussed all of them. The last category is “Adaptation”, which has three metadata: (i) *Off-game configuration*, (ii) *In-game adaptability*, and (iii) *None*. These categories define how the game can adapt to the player's preferences or abilities and were described by [10][12][13].

4.4 Definition 4

Definition 4 (D4) shows an essential aspect to consider when designing a digital game: the target. This category refers to the importance of tailoring the game to meet the needs and preferences of the target user during the design phase. It includes two metadata: (i) *Target Market* and (ii) *Audience*. These metadata were addressed by [10][12][13].

4.5 Definition 5

Definition 5 (D5) details Serious Game application areas, which are fundamental to the game design because each serious game is guided by a practical purpose that aligns with the audience and market. The only category, "Application Area," includes several metadata: (i) *Education*, (ii) *Well-being*, (iii) *Training*, (iv) *Advertising*, (v) *Interpersonal communication*, (vi) *Healthcare*, (vii) *Storytelling*, (viii) *Informative*, and (ix) *Others*. These metadata have been explored by [1][10].

5 Discussion and Conclusions

This paper proposes a unified cataloging system based on a matrix approach for digital games (video games and serious games), based on a five-dimension matrix comprising all the key digital games classification metadata (also known as "tags") proposed in the literature. It aims to collect the existing knowledge and highlight commonalities between existing cataloging systems. Considered cataloging systems proposed a heavily domain-specific or low-level approach. In [13], a cataloging of cognitively stimulating serious games based on characteristics from the conventional cataloging of serious games has been suggested. This system is limited in scope since it is domain-specific, meaning it only applies to serious games focusing on cognitive stimulation and does not give a high-level categorization. A cataloging system based on the G/P/S (game-play, purpose, scope) concept, gaming platform and UX is presented in the study [10]. The system proposed provides insights into existing studies on gamification in the container port logistics field. It considers both video games and serious games, and mainly focuses on game characteristics closely related to the user's interaction experience, the end-user, and the specific goal of the game. However, it excludes other equally important aspects, such as software-related game features and artistic choices related to the video game genre. In [11], the focus is solely on cataloging video games meant for entertainment, while [12] puts forth a cataloging system for health rehabilitation games focusing on UX (feedback, adaptation), interaction, technology, and other criteria specific to the activity. Neither [11] nor [12] encompass all types of digital games, and [12] introduces a cataloging system that is tailored to a specific domain. Finally, [1] proposes a system based only on serious games. The novelty of this work is that the proposed model unifies kind of digital games although retaining distinctions where necessary (e.g., the fifth definition specific only to serious games). This result is achieved by interpreting the cataloging identified in the literature according to a higher-level framework, as illustrated by [8]. Moreover, the paper proposes a four-dimension classification system. Although it is only hinted at in the present paper, future works will assess whether the proposed cataloging and classification systems could work together: the cataloging system and its metadata are intended to classify digital games by following the classification system. Future works will test the proposed cataloging on various video and serious games to validate the model. By applying the proposed "matrix cataloging", it will be possible to assess how the several metadata interact with each other, thus enabling the creation of a correlation matrix. This work could be considered a starting point to draft guidelines based on the correlation matrix that will help the game

designers in the Concept Design phase, enabling them to better suit the product they are designing to the users they are targeting. Starting from a general idea of the game that the designers should develop (e.g., a fantasy serious game intended to educate teenagers on the risk of smoking), the correlation matrix could suggest to them a list of optimal metadata that have a high correlation with the goal of the game. These metadata could be considered as suggested specifications that will guide the game's development (e.g., a high-engaging game developed in VR and with social networking features to capture the attention of teenagers). This work may be limited by the evaluation of only review studies rather than primary studies on video games and serious games, some key features of digital games may have been missed. Similarly, the review conducted in this study may have left out other taxonomies already proposed.

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