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Model-Driven in Serios Games and Serious Games with User-Centered Design in the Last Decade: A Review

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Abstract. This paper reviews the literature on automatic code generation of user-centered serious games. We decided to break the study in two parts: one study about serious games with model driven engineering, and another study about user-centered serious games. This paper presents an extension of a paper presented at CONISOFT 20 where a systematic review of 5 years old at the time of writing was presented exclusively. The systematic literature review conducted in this paper covers a decade of information from January 2012 to June 2022. The main objective is to know the literature that helps to mitigate the costs and time of software development in serious games. The overall conclusion is that there is still work to be done to combine serious user-centered games and automatic generation. This paper is a systematic review that identifies relevant publications and provides an overview of research areas and publication venues. In addition, Research perspectives were classified according to common objectives, techniques, and approaches. Finally, is presented point out challenges and opportunities for future research and development.

Keywords: user-centered design; automatic code generation; serious games; systematic literature review

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Модельно-ориентированная разработка серьезных игр и серьезные игры с ориентированным на пользователя дизайном в последнее десятилетие: обзор

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Аннотация. В этой статье представлен обзор литературы по автоматической генерации кода для серьезных игр, ориентированных на пользователя. Мы решили разделить исследование на две части: одна часть посвящена серьезным играм с модельно-ориентированным проектированием, а другая – серьезным играм, ориентированным на пользователя. Статья представляет собой продолжение статьи, представленной на CONISOFT 20, в которой был представлен систематический обзор литературы 5-летней давности к моменту написания. Систематический обзор литературы, проведенный в данной статье, охватывает десятилетие с января 2012 года по июнь 2022 года. Основная цель – выявить результаты, которые помогает снизить затраты и время на разработку программного обеспечения для серьезных игр. Общий вывод заключается в том, что еще предстоит проделать работу, чтобы объединить серьезные игры, ориентированные на пользователя, и автоматическую генерацию. В статье указаны соответствующие публикации, а также представлен обзор областей исследований и мест публикации. Кроме того, исследования были классифицированы в соответствии с общими целями, методами и подходами. Наконец, представлены проблемы и возможности для будущих исследований и разработок.

Ключевые слова: ориентированный на пользователя дизайн; автоматическая генерация кода; серьезные игры; систематический обзор литературы

Для цитирования: Сильва-Васкес П.О., Росалес-Моралес В.Я., Бенитес-Герреро Э. Модельно-ориентированная разработка серьезных игр и серьезные игры с ориентированным на пользователя дизайном в последнее десятилетие: обзор. Труды ИСП РАН, том 34, вып. 3, 2022 г., стр. 127-144. DOI: 10.15514/ISPRAS–2022–34(3)–9.

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1. Introduction

Serious Games (SG) can be defined as digital games with educational objectives, and can be considered as an alternative and effective way to convey new knowledge to people [1]. SGs mix, with pedagogical principles, the engaging and motivational characteristics of video games (history, character design, game rules, to name a few [2]), and touch on a wide range of subjects such as science, healthcare, business practices, and history [3].

It is important to notice that a SG is a software where a student/player must do a learning task with ease of use and high levels of playability. This can be accomplished if User-Centered Design (UCD) is used. UCD is based on the needs and interests of the user so that the resulting products are useful, usable, and subsequently desirable [4]. It has been argued [4], [5], however, that most educational video games have been developed with greater emphasis on the educational aspect, losing the

effectiveness, playability, and immersion that can be achieved with UCD. The study of user centeredness in SGs is then important.

The increasing complexity of systems development creates the need for tools to improve productivity in terms of time, cost, and quality [5]. One approach is automatic code generation (ACG) from models, as in model-driven engineering (MDE). MDE introduces a paradigm shift as models become the basis for software development, maintenance, and evolution [6]. By focusing on models that specify systems rather than code, a higher level of abstraction is achieved, and automation of the development process is possible. MDE and ACG have been applied in several domains.

Considering the principles of MDE presented in the study [7], which is a paradigm that encompasses the set of methods, techniques and technologies aimed at building software faster and easier, through the development and transformation of models, software development is accelerated. In research study [6] the authors direct model-driven engineering, called as Model-Driven Game Development (MDGD), towards video games.

Our general work is then interested in (semi) automatic generation of user-centric serious games. It was necessary to analyze the works previous, so we conducted a preliminary systematic literature review conducted in this paper covers a decade of information from January 2012 to June 2022.

In this paper presented the analysis and classification of the state of the art, a compilation is presented that contemplates the parts of model-driven engineering and integrates the UCD for the development of SG from the various proposals found in the systematic literature search. Articles about SG, ACG and UCD were previously analyzed; some of them are mentioned below.

The document is structured as follows: Section 2 introduces the research method that has been followed. Section 3 presents the results of the first search string. Section 4 presents the results of the second search string. Section 5 discusses our findings. Section 6 presents challenges and opportunities for future works. Finally, section 7 concludes this paper.

2. Research Method

The systematic review of the literature is based on the guidelines advanced [8] and inspired by proposals such as that of [9].

Accordingly, the main objectives of this review were to answer the following questions:

- How many papers related to serious games that have used Model-driven for serious game development were proposed from January 2012 to June 2022?
- How many papers related to serious games that have used user-centered design were proposed from January 2012 to June 2022?
- What are the shortcomings of the models found for the development of serious games?

As stated before, in a first effort, a single search string was considered, but given its limited results, the decision was made to consider two search strings, which would have better results and would allow us to analyze, describe and classify the results. As stated above, the literature review was divided into two different search strings. The first one ["Serious Games" AND "Model-Driven" AND ("Engineering" OR "Development" OR "Architecture" OR "Code Generation")] was composed in this way as there may already be a wide range of definitions related to model-driven and we were concerned about discarding some of these. The second ["Serious Game" AND "User-Centered Design"] is simpler because only two areas were considered. This paper presents these two parts, in which a total of 170 papers were analyzed.

Inclusion and Exclusion criteria were used to select articles to be reviewed. These criteria helped us limit the search and meet the objectives of this research. If the documents did not meet the selection criteria, then they were excluded. A selection criterion was applied to narrow the search:

- Paper analyzes the articles published from January 2012 to June 2022.
- Paper published on scientific international journals.
- Papers in English.
- Paper focuses on serious games with user-centered design
- Paper focuses on the serious games that were developed using Model-Driven

With these selection criteria and with the search strings defined to obtain the most accurate results, the sequence of the information search is the presented below.

It was examined whether the article had specified its objective, problem, and solution. Finally, the results presented in the articles must be related to our search strings. Once the search was performed, the title, keywords and abstract of the papers were checked to ensure that they met the inclusion and exclusion criteria. They also had to be related to the search strings.

3. First Search String

3.1. Application of the method

Concerning the first question, as mentioned above, a detailed search in a journal database was conducted to obtain a complete bibliography, as mentioned in one of the criteria. In the first search string which is ["Serious Games" AND "Model-Driven" AND ("Engineering" OR "Development" OR "Architecture" OR "Code Generation")], which amounts to a total of 397 papers.

The criteria of the time (January 2012-june 2022) After excluding the results regarding the fact that they are only from journals, the total found was 75 of the 397.

To finalize the selection of the articles that we considered for this research, a quick search was carried out in titles, abstracts, and related key words, considering "Model-Driven", and most of all, "serious games" to discard the research that was not related to serious games. Leaving us only with 35 works directly related.

3.2. Quantitative Analysis

In this article presents 35 papers related to the search string ["Serious Games" and "Model-Driven" and ("Engineering" or "Development" or "Architecture" or "Code Generation")] nine online databases to search the articles were used. The results were as follows: a) Science Direct: 11, b) Springer Link: 13, c) Emerald: 1, d) Wiley Online Library: 2, e) ACM Digital Library: 3, f) SAGEPUB: 1, g) MDPI: 3 and h) Hindawi: 2. Based on these results, IEEE Xplore were discarded because they did not present results.

The journal articles were published in 19 journals related to the first search string. The journal "Multimedia Tools and Applications" published most of the articles related to our search string; that is four papers. "Entertainment Computing" contributed with three papers. While "International Journal of Computer Games Technology" and “Procedia Computer Science” contributed only with two papers. The remaining 24 journals also published papers related to the search string.

3.3. Qualitative analysis

The works found were classified into 3 categories, which are explained below. Although they fall withing the criteria of the search string, we are aware that they have a different approach to the problems they want to solve.

3.3.1. Model-Driven Engineering of Serious Games

Serious or playful games need a well-defined framework to develop them. That is why the alternative to implement the phases of conceptualization, application, and monitoring in the generated applications was taken. This helped them to focus only on what is crucial for the success of the learning strategies. In the classification phase, the guide of the model-driven engineering was made use. Among these, those using the Model-Driven Engineering were presented because specifically, the tool in these documents provides a detailed description of the proposed component-based model and it also presents a validation of the requirements obtained through the use of game activity, [10]–[15]. Likewise, some papers define themselves as using the Model-Driven Architecture since they argue that most educational games are not supported by specific architectures because the existing ones do not include fundamental aspects such as collaboration, adaptation, or playability, or their conceptual language is difficult to understand for the educational team. To fill this gap, the architectures for designing, executing, monitoring, and adapting the learning processes supported by video games are described, considering the design and customization aspects, [16]-[26].

Among the works reviewed, some considered following a Model-Driven Development, where the novelty is based on the complexity of the design of the games, seeking to facilitate the design of the final user. This model does not impose the cognitive overload of learning a new design language to describe game designs that can be exported to XML files, and a game engine capable of interpreting those files and automatically generating a serious game, [27] & [28].

Finally, In [29] and [30] the authors used the Model-Driven Framework, since it allows geolocation based games to be edited and deployed in many places quickly. The core models and represents the structure of the game and its multimedia content (e.g. video, 3D objects), while [31] and [32] present a Model-Driven Game, which serves to adapt the game design to the players' personality type. This improved the effectiveness of the games. The intention is to change the behavior and self-efficacy by changing the context concerning the player. Besides, it shows that the benefits of customizing the game improve the player's experience.

3.3.2. Application Domains

For this classification, works that have developed a serious game that was guided in the model-driven engineering are presented. In this classification, only the serious game with its characteristics is presented but details of the development are not described.

Educational. In [33] introduced the importance of making this type of software as an educational alternative for students, since some applications present it as a support for distance education that can raise the quality of education and student satisfaction. In the case of some, they present a tool that allows monitoring students and tracks their improvement while using the video game [34]–[36].

Rehabilitation. In [37] and [38] the system that has been developed with the main objective of improving the physical and cognitive skills of students with special needs is presented. The different activities are configurable, and the tutor can modify the settings according to the needs of the student. The activities are game oriented to attract the students' attention and motivate them to learn. It is highly interactive and encourages students to be active learners. The results showed that students will be able to use the computer while improving their digital competence and their cognitive and physical skills.

3.3.3. Evaluate Gameplay

The objective of this category is to involve the final user in the discussion of the use of the serious game. For this, the category investigations, such as [39] and [40], use diverse tools that can inform us of the observations of the user. For their evaluation, these two studies were introduced in the digital games, as they played with the application. Whatever their presentation in mobile, console

or pc, they discussed the motivations that the game offers them and the obstacles for the current game.

The increasing familiarity and age ranges play an important role in this type of classification. In most of the works it is concluded that the creation of a safe, comfortable and accessible space for learning must be considered for serious games, as a valuable tool for learning [35], [41]-[43]

Most of the research presented a model-driven engineering that helps serious game developers with tools that reduce development times and abstraction of concepts for serious games. Considering that a video game developer does not know the concepts that a serious game must have incorporated so that the users have an experience with playability.

4. Second Search String

4.1. Application of the method

Concerning the second question, as mentioned above, a detailed search to obtain a complete bibliography was conducted. In the second search string, which is ["serious games" AND "User-Centered Design"]. In total 616 articles were found.

The criterion of the time (January 2012 to June 2022) After eliminating those articles that were not published in journals, the total was reduced to 214 out of the 569.

To finalize the selection of the articles that were considered for this research, a quick search was conducted in titles, abstracts, and related words considering "User-Centered Design" and mainly "Serious Games", with the aim of discarding research that was not related to serious games. Leaving us only with 135 pieces of directly related to the topic.

4.2. Quantitative analysis

In this article presents 135 papers related to the search string ["Serious Game" and "User-Centered Design"]. nine online databases to search the articles were used. The results were as follows: a) Science Direct: 50, b) Springer Link: 55, c) Wiley Online Library:15, d) Emerald: 4, e) ACM Digital Library: 12, f) IEEE: 4, g) SAGEPUB: 1, h) MDPI: 2 and i) Hindawi: 1.

The journal articles are divided into 78 journals that published articles related to the second search string. The journal “Entertainment Computing” published most of the articles related to our search string, with eleven papers. “British Journal of Educational Technology”, "Journal of Ambient Intelligence and Humanized Computing", “Procedia Computer Science” comprises seven papers, “International Journal of Human-Computer Studies” comprises six papers each one while “Multimedia Tools and Applications” supplied four papers. There were 72 other journals that also published papers related to the search string.

4.3. Qualitative analysis

In the search 135 papers have a direct relationship with the topic. The works found were classified into four categories, which are explained below. Even though the criteria for the search string was observed, it can be ascertained that they have a different approach to the problems they want to solve.

4.3.1. Application Model or Framework

The papers in this classification presented a guide for the development of projects in serious games. In these investigations, the authors give their views on how a serious game should be developed. They describe the process of generating the project from the point of view of software engineering.

For the model, they make a graphic presentation of what they consider should compose the application, but they are not specific in the points. They leave the generation of the analysis of requirements and the development of the project, as well as the evaluation, it to the criterion of the developer. The papers that work it this way are [23], [44]-[53]

Those that present a framework provide a more specific guide of how it should be implemented, giving details of what the best practices are to determine whether the application will have the success that the developer seeks. In [54]-[72] the author explained the framework.

4.3.2. User Model

For the user model classification, these are investigations that consider that users have a particularity that does not allow them to use a serious game as engineers would design it for the public to which it is addressed.

It is interesting to talk about the users because most of them for whom the user models were generated are people who have a disease or people who want to know if they can be diagnosed with this disease, as such in [12], [37], [73]-[77] Likewise, there is a project [78] where the user model is oriented to a general aspect; for example, they take a single user "child" between "5-7" and with "kindergarten schooling", for the model of these users. Although the model is focused on the user, it does not provide specific details of the user. But this classification helps the developers to know the particularities and pay attention if they plan to generate an application where their target audience is children with these characteristics.

Similarly, we found these papers [79]-[133], that present an application that undergoes an evaluation with the target audience. They present a list of adjustments to achieve better usability. After this, they provide details of the model of the user and develop changes in the application to reevaluate and contrast the new changes with the list of requests, ending up with the requirements of the user, as the final part of the project.

4.3.3. Application Domains

In this classification are the papers that aim to use the tool to achieve an objective in a specific area.

Learning: They are all those that have the objective of being before a specific user so that the person who uses it obtains information that can later be considered acquired knowledge. This is true of [74]-[85], [90], [92], [94], [98], [100], [101], [105], [108], [109], [111], [112], [115], [117], [119], [120], [129], [130], [134]-[144], where that is the principal

In some cases, they implemented an improvement of the serious game, and they re-submitted it to evaluation, to know if everything they considered adding was enough or if they had omitted some requirements again. As an example of this, we found [122]-[126].

For other cases, they evaluated some applications that lacked the consideration of user-centered design and advised that the list of requirements include improvements to the applications. These would improve the projects developed so that the user would not feel frustrated and would stop using the serious game as a tool for his benefit [145]-[152].

Rehabilitation: Works such as [132], [153], & [154] include projects that can be augmented with hardware to help people with a physical condition or that present a totally specific interaction for a user with a mental illness.

Diagnostic: Here all the applications such as [155]-[159] had the purpose of finding signs in the user. Whoever uses them presents particularities that can help him to know that he is a person who is suffering a condition or is prone to suffer it in a short period time.

Selecting: These applications or tools are useful to know if the user, who uses the application, has characteristics that the person who implements the tool is looking for. This is a way to evaluate the

knowledge of a person in a particular case, e.g. for a job or a subject [86], [91], [103], [110], [113], [114], [116], [118] & [120].

User-centered design: This tool gives us particularities of user-centered design. It teaches us to know if our project has user-centered design, as well as it shows us how it should be implement [70], [72] & [160]-[165].

Similarly, we can realize that some considerable overlapping still exists in the classification, as in some tools, before designing them, they modeled a user and advanced and used a model for the development of the application.

4.3.4. Evaluation of User-Centered Design

Several works decided to evaluate an application to know its user-centered design. For this, they conducted interviews with the public the application was directed to in order to know their point of view and how they considered their interaction, usability, and user experience. When they realized that they did not consider several things that the user required and that they had suggested to improve the usability, the application was modified.

5. Discussion

The combination of sound, art, control systems and artificial intelligence (AI) for a video game makes it totally different from traditional software development. However, software engineering techniques help game development achieve less effort and cost, and better design. The purpose of this study was to assess the state of research on software engineering processes for serious game development using an automatic code generation strategy, such as model-driven engineering. They have been submitted to user-centered design scrutiny, as well as highlighting areas that need further consideration by researchers.

In the first search string, several model-driven that are used for the development of applications were presented, but even though they can be a development tool that helps at the time of the creation of video games, they are still not so popular, and everyone chooses to start a serious game development from scratch, learning the programming language and designing the whole application. Game engines present a great development tool; however, the most sophisticated ones still require a knowledge of programming that can represent a challenge for a conventional user. It is considered that the tools that use model-driven and try to be useful do not have user-centered design patterns, making their use complicated.

Serious games are an alternative for educators. Research suggests that they provide knowledge to their end users, but tools are needed to facilitate their development. Therefore, it is considered necessary to explore new agile development tools that follow a model of automatic generation of serious games, but also consider the minimum requirements for the serious games that have a design focused on the user. In the analysis of user-centered serious games, these games remain specific to a particular user and context, which limits their contribution to new serious games that do not have those same features.

6. Recommendations for Future Research

Interesting areas of opportunity were discussed regarding agile SG development looking for a solution to the challenges for developing SGs: 1) developing better SGs, with 2) less budget and resources, and 3) with time [166]. This is where MDE and ACG can propose a solution, along with UCD.

Therefore, we present below the challenges, opportunities for research and the development of future work. Proposing to follow the bases of the MDE and the UCD. The deficiencies and research areas

where models need to be developed and a successful ACG that meets most of the requirements requested by the user needs to be developed.

Model-Driven Game Development (MDGD) [167] presents a structure of two essential parts. The platform independent models (PIM), the platform specific model (PSM), moving to the final part in the generation of the final source code, to perform the first evaluation of a prototype.

Consider as an example the structure proposed by [169] & [170] using UML to present the Model-driven. Presenting a structure that can be interpreted by the developer.

Model for functional and non-functional requirements of serious games. Some studies presented user models to solve end-user problems with positive conclusions from them. However, the problem with these studies presenting a user model is that they lack a guide to streamline the creation process from a requirements analysis. Functional and non-functional requirements that help us to describe the behavior of the SG for its functionality, and focus the change on the design or implementation, the functional requirements give priority to Learning Analytics, motivation, and types of games, while in the non-functional may be the Interoperability of learning tools, connectivity and scalability. To mention a few, work should be done to propose a guide that presents a greater diversity and that are related to the SG.

Task Model for Serious Games. The user task model helps to understand the activities performed by the user in the SG. This type of modeling is separated into four types of existing tasks: user tasks, application tasks, interaction tasks and abstract tasks. This model can be represented in a Concur Task Tree (CTT). But this model has not been integrated into the model proposals for SG development, which would provide developers with time-saving work.

User or player model for serious games. The problem that exists is that no proposal considers the integration of the UCD. The user model should describe the particularities of the target user, with an abstract representation of the information that we can know about the end user.

The player model is also considered where the role that the player has, the tasks to be performed and how to achieve them, the goals and the different states in which these goals of the SG are found. Therefore, we work on a user model that incorporates several techniques to know the characteristics of the final player and provide a UCD.

Model for game mechanics. The game mechanics would determine the rules of the video game, the definition of the rewards, the storytelling, the feedback, the debriefing, the objectives and mechanics of the game where the mobile and static actors (Player and enemies), the environment and design (scenarios), definition of the scoring rules, and hardware definitions are presented. In several works it is taken for granted that developers know the elements that a SG must have.

Model of pedagogical/playful objectives. It is necessary to work on what the teacher wishes to present in the SG and how it can be presented, since this aspect is not considered in the MDGD proposal. The teacher must determine the competencies to be achieved by the player. An example to define the model step 1 identification and description of the activity, step 2 representation of the game sequence, step 3 identification of the actions, tools and objectives of the game, description of the objective to be fulfilled with the exercise, to relate the mechanics of the game with the learning objective.

Model for scenarios and assets. A SG needs a model to define the levels and from these the scenes with a brief description, the characteristics of the playable or non-playable objects of the scene and the identification of the educational challenges. For the scenes to present their graphic part, with the graphic design sketches.

Stringent evaluations. The Evaluations they use in their research mention the success of serious games with end users with product acceptance and functionality, but do not subject the result of the serious game to strict evaluation by experts who might conclude that the serious game has playability. Some others conduct ad-hoc interviews with users to get their opinion. Consider in

evaluating the presentation of your developed product on various electronic devices (mobile, tablet, pc or game console) to determine which device is the most suitable for your SG. Therefore, it is necessary to work on an evaluation of the final product that can be provided in the MDGD. Therefore, it should not be left to drift to maintain the balance in the middle point of learning and entertainment so that a serious game can be had that provides the necessary elements for the student to continue using it and the teacher to see reflected the reinforcement of knowledge that he wants his students to obtain. The following are the final conclusions of the work presented in this academic article.

7. *Conclusion*

The research works reported above focus on streamlining the development of serious games, but they ignore an important part: the user-centered design, being the design the first thing that the user visualizes and should be more important. Because of this, even if the serious game meets all the functions and pedagogical requirements requested by the user, if the interaction does not have an appropriate design (user-centered), it becomes a poorly rated aspect by the end user. UCD is an approach to the design and development of interactive systems that seeks to make them more usable. UCD helps to determine whether the application is useful, usable and, subsequently, desirable [4]. However, in research study [168], they change the concept of usability to playability, which they define as the set of properties that describe the player's experience with a given game system whose main objective is to amuse and entertain in a satisfactory way It proposes a series of attributes, which are very similar to the aspects of usability.

The research compiles some of the information found shows the integration of various multidisciplinary points. Section 6 helps to clearly identify the user requirements and needs of user-centered design with the work found in the systematic review, as well as the integration of model-driven orientation, which provides a software engineering foundation that can serve as a guide.

We are working on user-centered educational applications to validate if the proposed methodology contributes to streamline the process to obtain applications that meet the criteria of usability and playability.

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