

OntoJogo: An Ontology for Game Classification

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Abstract—Games are no longer just an entertainment activity. Various games are being adopted in different fields, such as psychology, education, and healthcare. Their usage requires professionals to be capable of categorizing games to take the most advantage out of them. Therefore, we argue that a uniform classification for games can facilitate and improve the work on numerous investigations that focus on the usage of games. Along with research work on the matter, in this paper, we present an ontology, OntoJogo, for the classification of games according to different perspectives or categorization axes. In the paper, OntoJogo is described in detail (classes and relations are explained), and examples of use are shown.

Index Terms—Ontology, Game, Game Types, Game Studies

I. INTRODUCTION

The primary purpose of games even now is the entertainment, as it was since the beginning. However, people become aware that games' possibilities are ample in a variety of areas and bring tremendous advantages. Serious games – games used for training, advertising, simulations, or education – are remarkably popular and recognized by governments, scientists and educators [1]. The application of these games facilitates experiencing activities that, in reality, may imply safety risks and extreme costs [1]. Additionally, as games are such an immersive activity, the use of games on training and education may lead to a better learning outcome [2].

Exploring some of the areas where games are currently being used, the most notorious are military, health and rehabilitation, brain training, psychology, and education. In the military, simulation games have been used for training combat skills [1], [3]. As for health and rehabilitation, games are handled as a therapy treatment, to promote the practice of physical exercise and as a vehicle to educate people on healthy habits [1], [4]. On a neurological level, games are great for exercising the brain, enhancing reasoning skills, memory, concentration, and alertness [4]. Researchers, namely

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psychologists, are studying and even applying games as tools to determine the players' personalities by examining the player behavior in the game [5]. Lastly, on education, Game-Based Learning has been proven to be highly motivational to students [1], [6].

Having so numerous applications and considering the uses, professionals, researchers, and even gamers must be able to classify games according to different sets of attributes. However, there is not a consensual classification for games, leading games to be described with different categories and even different values in the same category, depending on the person [7]. Considering, for instance, the game genres, different researchers and game designers define different sets of values for this category. Game designer Tracy Fullerton [8] believed that should exist twelve genres of games, being them: action, strategy, role-playing, sports, racing/driving, simulation/building, flight and other simulations, adventure, educational, children's, casual, and experimental. As for Philip Hanna [9], he lectured that games should be divided into the following genres: adventure, action, action-adventure, platform, fighting, first-person shooter, real-time strategy, turn-based strategy, RPGs, massively multiplayer online role-playing games (MMORPGs), stealth, survival horror, simulation, racing, sports, rhythm, puzzle, traditional, and educational.

With these examples of genres, it is intended to demonstrate that an agreement is needed not only on the categories in which a game should be classified but also in the set of values of each one. We are in a data era, where everything revolves around datasets and statistics [10]. Therefore, more than ever, it is critical to generate formatted and consistent data. This is why we propose an ontology for game classification, OntoJogo¹, where a detailed and consistent definition of a game is possible.

An ontology, first defined as a specification of a conceptualization [11], is a data model that represents a set of concepts within a domain and the relationships between them. Ontologies are vastly used and are beneficial in the

communication about a domain, computational inference, and construction and organization of knowledge [12]. Therefore, we believe that an ontology is a proper model to develop a classification.

The first version of OntoJogo was presented in a previous article where we discuss the motivation for the creation of the ontology [13]: the need to relate game types to students' psychological profile in order to choose the most suitable games for each student, leading to a more personalized education. Since then, many changes have been made in the ontology, following our desire to produce a universal classification for games, useful in different researches and application fields. In this paper, we present the renewed version of OntoJogo, explaining all the decisions made through its construction and displaying some games classified accordingly to the ontology.

This paper after the Introduction is organized in five sections. Section II reviews the methodology adopted in the construction of the ontology. After that, Section III presents research work on existing game ontologies. In Section IV OntoJogo is extensively described and depicted in the form of a conceptual graph. Section V presents examples of the use of OntoJogo, being displayed the classification of three distinct games. The paper is concluded in Section VI.

II. ONTOLOGY DEVELOPMENT METHODOLOGY

For proper construction of the OntoJogo, it was applied the seven step methodology "*Ontology Development 101*" [14], which consists of: 1) determine the domain, scope and purpose; 2) consider reusing existing ontologies; 3) enumerate important terms; 4) define the classes (concepts) and class hierarchy; 5) define the attributes of the classes; 6) define the attributes' restrictions; 7) create individuals (instances).

To develop OntoJogo, all steps enumerated above were followed. Step 1 was done previously in the context of a research project involving game-based learning; for that phase, it also contributed the fact that some team members are *Gamers*. Those activities were the real motivation for the work here reported and the proposal presented. To accomplish step 2 a significative amount of time was dedicated to address the analysis of existing ontologies for game classification; a synthesis of this review is presented in Section III. After that, it became clear that none of those ontologies satisfies our needs; this conclusion led us to create a new one. The outcomes of the other five steps will be presented in Section IV.

The decision of building a new ontology required the choice of a notation to write the ontology components. As described in [15], one of the XML Languages RDF-Schema or OWL [16] (the well known W3C standard language for ontologies [17]) should be our choice. However, we decided to formalize the ontology to be created resorting to OntoDL [18], [19], an Ontology Description Language designed and implemented some years ago inside our research group, and since then applied many times to different projects in different contexts. The main benefit of this decision lies on the fact that it is not a XML dialect and it has a very light, easy to use, syntax.

III. EXISTING GAME ONTOLOGIES

Before developing a new ontology on the domain of games, it was first explored what solutions already exist. From the investigation done, it is worth to mention the researches in [7], [20]–[22].

The *Game Ontology Project* (GOP) is a framework for describing, analyzing, and studying games [20]. The main goal of this project is to develop an ontology that identifies the structural elements of games and the relationships between them, hierarchically organized. On [20] are described five top-level elements: *interface*, *rules*, *goals*, *entities*, and *entity manipulation*. However, on the date of the consultation (December 23rd, 2019) there were only four top-level elements presented on the framework, having been excluded the element *entities*. In each of the four, it is possible to consult the respective entries hierarchy. For example, in *goals* are considered concepts like *agent goals*, *collectables*, *performance record*, and *score*. This is possibly the best-known and most used ontology for games. However, GOP is directed to more structural and design characteristics of games, that are not the focus on our project.

GOP lacked a specification for genres and narratives of digital games, so an ontology was constructed for that effect in [21]. On the top of this ontology are the following concepts: *mode*, *narrative*, *platform*, *target audience*, and *genre*. The concept *mode* refers to the game being *single player* or *multi-player*. The *narrative* is divided into *forced*, *emerging*, *evoked*, and *embeded*. The target audience can be *specific* or *general*. The specific target can be *educational*, *family*, or *children*. As for genres, the researchers considered nine: *strategy*, *role-playing games (RPG)*, *adventure*, *sports*, *simulation*, *puzzle*, *mythology*, *science fiction*, and *action*. Sports games can be *racing* or *fight*. Lastly, action is divided into *scenario*, *survival*, *arcade*, and *open world*. Of the analyzed works, this is the closest to what we intend to develop. However, this ontology is only to digital games, which are not our only target, leading to the necessity of changes and additions.

The next analyzed work was of an ontology model for representing digital educational games [7]. The model created was based on concepts from ELEKTRA and inspired on a classification for serious games. ELEKTRA is an ontology to a learner-centered resource description, mainly in the adaptability of educational digital games [23]. This model for digital educational games covers concepts like *adaptative feature*, *developer*, *dimensions*, *gameplay*, *language*, *learner profile*, and *pedagogic principle*. This is a well defined and useful approach, just too focused on education, which is not our only area of interest.

Lastly, the *Game Content Model* (GCM) is an ontology to support the documentation of serious games design [22]. This ontology was created to help game designers, mainly the ones with less experience, to document the specifications when developing a game. The GCM development was based on concepts used to document role-playing and simulation games, as the investigators believed these to be the most advantageous

genre of games in education and training. This ontology includes ten main concepts that describe the rules, play, and aesthetic information of a computer game, being them: *game structure*, *game presentation*, *game simulation*, *game rules*, *game scenario*, *game event*, *game objective*, *game object*, *game player* and *game theme*. Although very interesting from a design perspective, the GCM is not the most suitable in a usability and motivation perspective.

All of the mentioned researches offer compelling proposals for game ontologies. However, we still see a need for a new ontology with a categorization focused on aspects notorious for gamers. Nevertheless, these works have valuable content and are a support for the created OntoJogo.

IV. DEVELOPMENT OF ONTOJOGO

The first step to construct the ontology was to determine a list of main terms that are used to define a game. At this time it was discussed on what categories should a game be defined, originating the first version of the OntoJogo, which can be consulted on [13]. Since that first version, a lot of decisions were made, and many concepts were reorganized aiming at reducing the number of classes and increasing the set of their instances. This long categorization effort led to the present version of OntoJogo that we propose to support any work based on games. OntoJogo is now composed of thirteen classes, being the main one the concept *Game* and the other twelve: *Available*, *Character Choice*, *Ending*, *Game Mode*, *Gaming Platform*, *Genre*, *Information*, *Input*, *Player Number*, *Player Perspective*, *Progression*, and *Story*. These twelve classes and corresponding instances are described in Section IV-A.

Focusing now on the class *Game*, this one is the center of the ontology, being related to all the other classes, which correspond to the categories of the game. *Game* is the only concept with attributes, being them: *name*, *description*, *age rating*, and *storyline*. The attributes *name* and *description* are of type string. The *age rating* is an enumeration, having necessarily to be one of the numbers 3, 7, 12, 16, or 18, which are the ages used by Pan European Game Information (PEGI). Lastly, the *storyline* is also an enumeration and refers to the narrative of the game, which can be *real world*, *fiction*, or *null*. The *null* was added in the enumeration for the games that do not have a story, as it makes no sense to associate a value to the attribute *storyline* in those cases.

All the ontology generic concepts, classes, are declared in OntoDL inside the block "concepts" as shown in Listing 1.

```

1 concepts {
2   Available , Character_Choice , Ending , Game[name:
   string , description:string , age_rating:enum(3 ,
   7 , 12 , 16 , 18) , storyline:enum('real world' , '
   fiction' , 'null')], Game_Mode , Gaming_Platform ,
   Genre , Information , Input , Player_Number ,
   Player_Perspective , Progression , Story }

```

Listing 1. Concepts that describe the domain of games in OntoJogo.

Addressing the relations of the ontology, as was stated before, these are all between *Game* and all the other twelve

classes. Listing 2 displays the OntoDL fragment that defines the existing relations.

```

1 relations {
2   belongs_to_genre , belongs_to_platform ,
   has_information , has_mode , has_perspective ,
   has_player_number , has_progression , has_story ,
   involves_character_choice , is_available ,
   with_ending , with_input }

```

Listing 2. Relations used in OntoJogo.

These relations are applied as illustrated in Listing 3. To facilitate reading when we need to handle the instances, it was appended the name of the class that the relation connects at the end of the relation name.

```

1 Game =is_available=> Available;
2 Game =involves_character_choice=> Character_Choice;
3 Game =with_ending=> Ending;
4 Game =has_mode=> Game_Mode;
5 Game =belongs_to_platform=> Gaming_Platform;
6 Game =belongs_to_genre=> Genre;
7 Game =has_information=> Information;
8 Game =with_input=> Input;
9 Game =has_player_number=> Player_Number;
10 Game =has_perspective=> Player_Perspective;
11 Game =has_progression=> Progression;
12 Game =has_story=> Story;

```

Listing 3. Triples that define the relations between the concepts of OntoJogo.

As for the cardinality, it was decided not to make any relation required or unique, being all of 0..*. This decision was made because of the significant variety of games that exist and will be created. For example, for some games, it can be necessary to specify more than one *Player Perspective*, as for other games, it can make sense to have no perspective. Despite of this liberty to define relations, the ontology still has some restrictions that need to be followed for the classification to be coherent. These restrictions are elaborated on Section IV-B.

For a better understanding, a full view of the ontology is given in Fig. 1, where all the classes, respective instances, relations, and attributes are pictured.

A. Classes and Respective Instances

1) Available

This class was created to distinguish the games that do not require any electronic device from the digital ones. In digital games, there is also the need to divide them into the ones that need access to the internet and the ones that do not.

- *Digital Offline* - The game is played with an electronic device but without needing an internet connection.
- *Digital Online* - The game is played with an electronic device and internet connection is required to play.
- *Non-Digital* - The game does not require any electronic device to be played.

2) Character Choice

Games can have available one or a set of characters to be played, or a new one can be created. Therefore, this class is used to categorize how the characters are chosen in the game.

- *Customization* - The player as the freedom to create his characters and choose how they look based on in-game

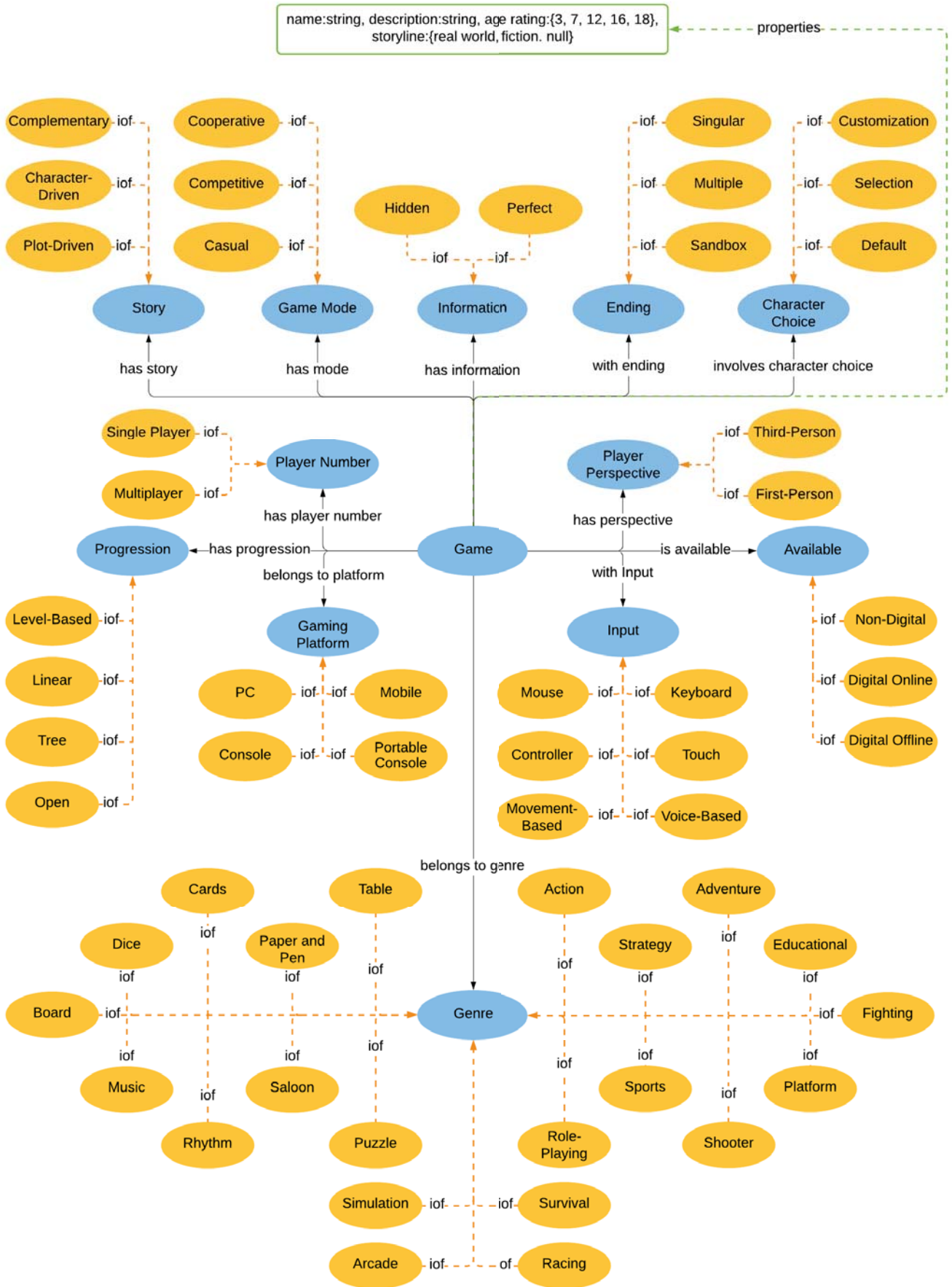


Fig. 1. Graphical representation of OntoJogo.

options such as type of hair, color of the eyes, among others.

- *Default* - The game already has a character created that is essential to the story and the only thing the player may change is the gender of the character. In this case, the player is forced to play with this character.
- *Selection* - The game offers a roster of characters that the player can choose from. In this type of game, the player usually can freely alternate between characters.

3) *Ending*

This class refers to the different types of ending in games. Games can have one fixed ending, multiple possible endings or no true ending at all.

- *Multiple* - The ending can be different depending on the choices the player made during the game.
- *Sandbox* - There is no true ending and final goal. The player can play indefinitely.
- *Singular* - There is only one ending to the game and no player action can change it.

4) *Game Mode*

A game can have various modes to attract different kinds of players, being related to the mindset with which the player should be playing the game. It may have its focus on entertainment elements or competitive ones or it can even allow the players to work together as teammates.

- *Casual* - Simple gameplay that is fun and easy to understand, where the player can play it spontaneously, with a calm mindset, or infrequently without losing its entertainment. It is usually targeted to the majority of the players.
- *Competitive* - A game that incorporates competition, such as player versus player or team versus team match ups.
- *Cooperative* - Type of game where the players embrace teamwork to surpass challenges.

5) *Gaming Platform*

The platform/device that runs the game. Outputs sound, image and possibly other stimuli to the player, depending on the platform. Each platform may have inherent limitations or benefits.

- *Console* - An electronic device that is generally meant to be connected to a monitor, and with power supplied through an outlet, therefore requiring it to be used in fixed locations.
- *Mobile* - Phone oriented games.
- *PC* - Games played on Laptops or Desktops.
- *Portable Console* - A lightweight version of the console with a built-in screen and a battery so it is easy to carry around, allowing the player to use it anywhere.

6) *Genre*

A genre is a classification assigned to a game based on its gameplay interaction, not focusing on visual or narrative differences.

- *Action* - Emphasizes physical challenges, hand-eye coordination and reaction-time.

- *Adventure* - Includes elements of storytelling, exploration and puzzle solving.
- *Arcade* - The games played on arcades found in public places like malls, restaurants and amusement arcades.
- *Board* - A traditional game that involves counters or pieces moved or played on a specific surface or board.
- *Cards* - Any game that uses cards as the primary tool for the game to be played.
- *Dice* - Games focused on dice rolls, usually for randomness purposes.
- *Educational* - Games that are designed to help people learn about certain subjects, expand concepts, reinforce development, understand a historical event or culture, or assist them in learning or training a skill as they play.
- *Fighting* - Game based around close combat, where the player battles against another character controlled by another player or the game's artificial intelligence in a stage in which the boundaries are fixed. Often requires precise control and player skill.
- *Music* - Game where the gameplay is oriented around player's interactions with a musical score or individual songs.
- *Paper and Pen* - Games that can be played only with paper and writing material.
- *Platform* - Game where the character has to jump and climb between suspended platforms while avoiding obstacles.
- *Puzzle* - Game that emphasizes puzzle solving, where the player can test many problem-solving skills including logic, pattern recognition, sequence solving, spatial recognition, and word completion.
- *Racing* - Games involving vehicles moving fast inside a course.
- *Role-Playing* - Game where the player controls the action of a character that is immersed in a world.
- *Rhythm* - Games where the rhythm, often from music, plays a crucial role in the gameplay. It usually challenges a player's sense of rhythm and timing.
- *Saloon* - Games played by a group of people, that do not require almost any object, being usually played just by talking with each other.
- *Shooter* - Focuses on engaging in combat with a weapon, which usually is a firearm or some other long-range weapon. It often tests the player's spatial awareness, reflexes, and speed in single player situations or against other players.
- *Simulation* - Game where multiple activities from real life are reproduced, usually with the purpose of training, analyzing, or experiencing such activity.
- *Sports* - A game that focuses on simulating the practice of sports or emphasizes the strategy behind the management of one.
- *Strategy* - Emphasizes strategic, tactical and logistic management in order to surpass a challenge.
- *Survival* - Player in a hostile environment with low resources, where the goal is focused on trying to survive.

- *Table* - Games that are normally played on a table or other flat surface without the need of a board.

7) *Information*

The amount of information a player has, in a way that knowing or not that information can change the players' strategy.

- *Hidden* - A game that has parts of the information hidden from the players, leads the players to progress in the game while considering a set of possibilities.
- *Perfect* - A game where each player has all the information about the events that already happened and the information needed in every decision-making moment.

8) *Input*

The type of input used to identify the player's actions.

- *Controller* - Small device, usually controlled with both hands. Has buttons and sometimes analog sticks that the player uses as input.
- *Keyboard* - The buttons of the keyboard are used for the input of the player.
- *Mouse* - Device that controls the cursor which is used for interaction.
- *Movement-Based* - A camera or other sensors are used to detect human movements and use them as commands for the game.
- *Touch* - A touchpad or trackpad is used to interact.
- *Voice-Based* - A microphone is used to detect sounds and voices, which are the user input in the game.

9) *Player Number*

The number of players a game is made to handle while playing.

- *Multiplayer* - Games where two or more players can play in the same game at the same time.
- *Single Player* - Game designed for only one player at a time.

10) *Player Perspective*

Class that describes how the player views the world, that is, the player's point of view.

- *First-Person* - The player perspective is shown from the viewpoint of the player's character.
- *Third-Person* - The player sees through a camera over the top of his avatar allowing him to see the body of the controlled character.

11) *Progression*

Games have different ways to progress towards their end goal, existing games where the player choices/interaction can affect the course of the game. This class divides the possible progressions.

- *Level-Based* - The game is divided into levels which the player progresses when he meets specific goals or performs a specific task to advance to the next level.
- *Linear* - The game follows a strict path with little to no deviation, that does not change with the player interaction.
- *Open* - The player can explore and progress in the game in any way he wants, having almost complete liberty. This

may affect the order in which the player does the required events but may lead to the same end goal.

- *Tree* - The player choices in the game changes the path of the game, leading to different events or scenarios.

12) *Story*

This class is described as whether the story is the focus and relevant to the overall gameplay or acts only as a small part, and where does the story places more emphasis.

- *Character-Driven* - The plot is used to develop the character, it focus on the inner conflict of characters and the relationship between them. In this type of game, the character usually undergoes some internal changes during the story.
- *Complementary* - The game has a story but it is used to improve and deepen a game's system, serving as a complement to the game.
- *Plot-Driven* - The primary goal of the game is telling a story and the characters are only there to help move the plot from point A to B. If the characters were different the story would not change.

B. *Restrictions*

Following the definition of the concepts and respective relations, it was necessary to establish the ontology's restrictions. This ontology has three constraints, being all related to the concept *Available*.

As can be seen in Listing 4, to classify a game according to the player's perspective the game needs to be digital, regardless of being online or offline. Since the player's perspective refers to what the player sees on the screen while the game goes on, it only makes sense if we are talking about digital games.

```
1 Game =has_perspective=> Player_Perspective :-
2   Game =is_available=> Available, (Available ==
   Digital_Offline; Available == Digital_Online).
```

Listing 4. Restriction related to the concept *Perspective*.

Moving on to the second restriction, illustrated in Listing 5, it says that to classify a game according to a gaming platform the game has to be digital. Considering that all the existing gaming platforms are technological, for a game to be played in a platform, it must be a digital game.

```
1 Game =belongs_to_platform=> Gaming_Platform :-
2   Game =is_available=> Available, (Available ==
   Digital_Offline; Available == Digital_Online).
```

Listing 5. Restriction related to the concept *Gaming Platform*.

The last constraint, presented in Listing 6, specifies that to classify a game with a type of input the game must be digital. The input refers to the way the player interacts with the gaming platform to play the game, implying that it is being played a digital game.

```
1 Game =with_input=> Input :-
2   Game =is_available=> Available, (Available ==
   Digital_Offline; Available == Digital_Online).
```

Listing 6. Restriction related to the concept *Input*.

C. Creating Game Instances - LightBot: Code Hour

With the ontology consolidated, it is now possible to classify games accordingly. Although the ontology can be used only as a guide to classify a game, it is desirable and it is our intent to allow the creation of instances of the concept *Game*. Below in Listing 7 it is shown the example of an instance of *Game*, the classification of *LightBot* in the adopted syntax.

LightBot is a serious game for computing education that trains programming concepts and skills, like algorithm design and logical reasoning. This is a single player game where a series of levels have to be completed in sequence. Beyond being an educational game, this is also considered a puzzle, as the player has to determine a sequence of instructions to finish each level.

```
1 LightBot =iof=> Game[name='LightBot: Code Hour',
2   description='Lightbot is a mobile game for
3   learning software programming concepts.',
4   age_rating=3, storyline=null];
5 LightBot =is_available=> Digital_Offline;
6 LightBot =involves_character_choice=> Default;
7 LightBot =with_ending=> Singular;
8 LightBot =has_mode=> Casual;
9 LightBot =belongs_to_platform=> Mobile;
10 LightBot =belongs_to_genre=> Educational;
11 LightBot =belongs_to_genre=> Puzzle;
12 LightBot =with_input=> Touch;
13 LightBot =has_player_number=> Single_Player;
14 LightBot =has_perspective=> Third-Person;
15 LightBot =has_progression=> Level-Based;
16 LightBot =has_progression=> Linear;
```

Listing 7. Classification of the game *LightBot*.

V. CASE STUDIES

To validate the proposed ontology, in the next subsections three games are classified accordingly to OntoJogo. They were chosen because of their differences, in order to test the classification in a variety of games.

Furthermore, the ontology was also tested by five more experienced students (aside from our work team) from a Masters' degree in Computer Science Teaching, who considered OntoJogo easy to understand and effortlessly proposed classifications for games of their choice.

A. Chess

Chess is a classic, the original version comes with a board and 32 pieces. This is a two-player strategy game and one player wins when the adversary runs out of time or gets his king killed. There is also the possibility to play it against an artificial intelligence bot. The resulting classification of this game is illustrated in Listing 8.

```
1 Chess =iof=> Game[name='Chess', description='Chess
2   is a two-player board game played on a checkered
3   board, where the goal is to kill the king of
4   the opponent.', age_rating=3, storyline=null];
5 Chess =is_available=> Digital_Offline;
6 Chess =is_available=> Digital_Online;
7 Chess =is_available=> Non-Digital;
8 Chess =has_mode=> Competitive;
9 Chess =belongs_to_platform=> Mobile;
10 Chess =belongs_to_platform=> PC;
11 Chess =belongs_to_genre=> Board;
```

```
9 Chess =belongs_to_genre=> Strategy;
10 Chess =has_information=> Perfect;
11 Chess =with_input=> Mouse;
12 Chess =with_input=> Touch;
13 Chess =has_player_number=> Multiplayer;
14 Chess =has_player_number=> Single_Player;
```

Listing 8. Classification of the game *Chess*.

B. Minecraft

Minecraft is a sandbox game where the players can explore a pixelated 3D open world. The players have the liberty to create tools, build structures, and even cooperate with other players to evolve the world with minimal limitations. Classifying this game with the created ontology produces the instance displayed in Listing 9.

```
1 Minecraft =iof=> Game[name='Minecraft', description
2   ='Minecraft is a video game where the player
3   explores a blocky, pixelated, procedurally-
4   generated 3D world.', age_rating=7, storyline=
5   null];
6 Minecraft =is_available=> Digital_Offline;
7 Minecraft =is_available=> Digital_Online;
8 Minecraft =involves_character_choice=>
9   Customization;
10 Minecraft =with_ending=> Sandbox;
11 Minecraft =has_mode=> Casual;
12 Minecraft =has_mode=> Cooperative;
13 Minecraft =belongs_to_platform=> Console;
14 Minecraft =belongs_to_platform=> PC;
15 Minecraft =belongs_to_platform=> Portable_Console;
16 Minecraft =belongs_to_genre=> Action;
17 Minecraft =belongs_to_genre=> Adventure;
18 Minecraft =belongs_to_genre=> Survival;
19 Minecraft =with_input=> Controller;
20 Minecraft =with_input=> Keyboard;
21 Minecraft =with_input=> Mouse;
22 Minecraft =has_player_number=> Multiplayer;
23 Minecraft =has_player_number=> Single_Player;
24 Minecraft =has_perspective=> First-Person;
25 Minecraft =has_perspective=> Third-Person;
26 Minecraft =has_progression=> Open;
```

Listing 9. Classification of the game *Minecraft*.

C. Pokémon (Main Series)

Pokémon is a role-playing game where the player controls the main character that lives in the *Pokémon* world. The game revolves around catching and training *pokémon*s that later can be used to fight other trainers. The game is mostly casual, although there are elements added for a more competitive environment. This game is classified as illustrated in Listing 10.

```
1 Pokemon =iof=> Game[name='Pokemon', description='
2   Pokemon is a game that involves catching
3   imaginary creatures and training them to fight
4   each other.', age_rating=7, storyline='fiction
5   '];
6 Pokemon =is_available=> Digital_Offline;
7 Pokemon =is_available=> Digital_Online;
8 Pokemon =involves_character_choice=> Default;
9 Pokemon =with_ending=> Singular;
10 Pokemon =has_mode=> Casual;
11 Pokemon =has_mode=> Competitive;
12 Pokemon =belongs_to_platform=> Portable_Console;
13 Pokemon =belongs_to_genre=> Role-Playing;
14 Pokemon =belongs_to_genre=> Strategy;
15 Pokemon =with_input=> Controller;
```

```

12 Pokemon =has_player_number=> Single_Player;
13 Pokemon =has_perspective=> Third-Person;
14 Pokemon =has_progression=> Linear;
15 Pokemon =has_story=> Plot-Driven;

```

Listing 10. Classification of the game *Pokémon*.

VI. CONCLUSION

Along the paper we have discussed the development of an ontology that describes the games' domain. The idea behind that exercise, which led us to write and propose OntoJogo, was to identify the main concepts that are related to and effectively help on defining the concept *Game*. We elected a set of twelve generic concepts or classes that in our opinion better cover the different perspectives. With this, we can characterize a digital or non-digital game² in all contexts where games are used to educate people in methodical and strategic reasoning.

We believe that the resulting ontology is more advantageous than the ones introduced in Section III in cases that hold the necessity to classify games according to a player perspective, namely when it is being evaluated the effects of a game in the player. GOP [20] and GCM [22] are ontologies with classifications that focus more on the design of the game, presenting concepts that are not as easily connected to the player as the ones in OntoJogo. Furthermore, OntoJogo is more inclusive than the ontology presented on [21], as it allows to classify both digital and non-digital games and covers more categories of a game. Lastly, our ontology is more generic than the one on [7], which focus only on digital educational games, having most of the concepts also related to education.

The ontology introduced in the paper aims to facilitate the study on the suitability of a game to a user (an apprentice or trainee) in a specific working context. We will test it under an academic project for researching methods to train computational thinking to improve the effectiveness of computer programming teachers. But we argue that the contribution presented in this paper is broader than that and can be useful in other domains of game-based activities.

The outcomes of a first small experiment partially reported in Section V, involving five Master Students, are promising in the sense that: (1) the ontology was easily understood; (2) the classes and instances provided by OntoJogo were expressive enough to classify all kinds of games freely chosen by each participant; (3) the time and effort required to classify each of the games were negligible. The main lesson learned out from that experiment was the need to classify separately the digital and the non-digital versions of a game. We noticed that, in most cases, it is considerably different when a game is created to be unplugged and after some time implemented in a plugged version or when it is designed from scratch to be plugged.

As future work, we intend to classify a bigger diversity of games to continuously test OntoJogo, as well as do a deeper analysis on the differences between digital and non-digital games, that may result in new concepts and changes on the ontology restrictions.

²Also designated as *plugged* or *unplugged* game.

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