Modeling the Video Game Environment: the VideOWL Ontology

Simone De Martino[1], Marianna Nicolosi-Asmundo[1], Stefano Angelo Rizzo[1] and Daniele Francesco Santamaria[1]

[1]*Department of Mathematics and Computer Science, University of Catania, Viale Andrea Doria 6 - 95125 - Catania, Italy*

Abstract

The paper presents an ontology that models the constitutional elements of video games, including agents and artefacts. It also addresses the ever-changing works of game programmers, who strive to exceed the limits derived from the classification mechanisms based on labels and title genres. With respect to the state-of-the-art, the ontology additionally permits to infer the categories of a game through the features of its dynamics and mechanics, such as the point of view (POV) or game-play elements. Furthermore, it encompasses programmers, final users, software programs, and devices in its ontological model. The ontology aims at advancing the mechanisms for understanding and classify games based on their features, ultimately offering new insights and opportunities in the field of game development. In this context, the ontology can be leveraged to represent any agent in the video-game domain such as players, bots, related actions and game strategies.

Keywords

Video game, digital art, OWL, ontology, Semantic Web

1. Introduction

We live today in an increasingly interconnected and fluid reality. Enclosing the world in arbitrary categories gradually is becoming progressively more challenging, as the need for certain products to be "outside the box" becomes more and more relevant. These goods have distinctive traits of different categories connected in an original way. Examples of this trend can be found in various fields: design [1], education [2], scientific research [3], as well as in computer software dedicated to entertainment such as video games [4]. These are emblematic of such reality, as human-made products without innovation will not survive the market due to a lack of appeal to the public. Recently, in fact, video games have experienced considerable development over time in terms of mechanics and typologies. Peculiar features of certain titles have come to influence entire genres.

The semantic web offers tools and techniques, such as ontologies, which are particularly suitable for representing and classifying video games according to their most relevant features. In light of these considerations, it is straightforward that video games are amenable to ontological

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simone.demartino@studium.unict.it (S. De Martino); marianna.nicolosiasmundo@unict.it (M. Nicolosi-Asmundo); stefano.rizzo@studium.unict.it (S. A. Rizzo); daniele.santamaria@unict.it (D. F. Santamaria)
https://www.dmi.unict.it/nicolosi/ (M. Nicolosi-Asmundo); https://www.dmi.unict.it/santamaria/ (D. F. Santamaria)

models. The peculiarity of the semantic web lies in its vision of the web, in which data is machine-readable and allows software agents to query and manipulate information. As such, web information carries explicit meaning, so it can be automatically processed and integrated by agents. The results in data can be accessed and modified on a global scale, thus resulting in increased coherence and dissemination of information. In addition, dedicated automated reasoners make it possible to infer and process implicit information within the data, thus leading to a deeper understanding of the domain.

While literature has provided valuable insights regarding the semantic representation of video games, we believe that an alternative approach should be adopted in order to connect game artefacts with the semantic web. The existing approaches can be heavily summarised as follows:

- some works revolve around organising preexisting information about a game, such as metadata;
- others focus on describing specific in-game instances for the purpose of identifying and correlating approaches, items, or characters across various media.

We present in this paper an OWL ontology called VideOWL [5] which aims to classify video games starting from their core features. This enables users to transcend the predefined categories imposed by marketing decisions, thus achieving a more comprehensive and nuanced categorisation of games. The primary goal of this ontology is to enhance the understanding and classification of games based on their intrinsic characteristics. It may ultimately offer new insights and opportunities for game analysis and design. It is intended for those who may benefit from keeping track of the video game industry with needs of a semantic insight. These may include:

a) market analysts that may need to keep track of a peculiar type of game, or that may need to elaborate data about producers as well as the proficiency of certain mechanics implemented by a product;

b) video game scholars or journalists that may require a semantic database of their domain of interest;

c) ontology specialists or scholars who may take inspiration from the framework to describe other ever-changing man-made domains, such as figurative arts or software products.

The ontology captures essential concepts and relationships of video game genres in a structured and formalised manner. These components can be potentially leveraged to analyse non-commentary walk-through videos from platforms like YouTube. This could involve extracting relevant data from the player's Heads-Us Display (HUD): the video content can be processed in order to obtain in-game statistics, visual cues, and contextual details. If a certain element is present in the game within a time-windows, then it becomes a game's feature. This is done in order to discriminate whether a feature is only temporary or intrinsic of the game. This information, combined with the defined concepts and relationships in the ontology made by a control group, is fed to the ontology for genre classification. By continuously learning and adapting to new games, the ontology can keep up pace with the ever-evolving video game industry. It could even retrospectively sort titles into the new categories, as this system allows to backtrack an ancestor of what could be perceived as a fresh genre. AI systems could adopt the ontology as an ontological framework for monitoring and researching the state of the art presented by video games through time. Thus, the ontology becomes a dynamic tool for tracking the evolution of video game genres. The question then arises on the type of data that the AI sorts into the VideOWL categories. The paper is organised as follows. Section 2 introduces the literature, while Section 3 presents the ontology also including some examples of utilisation in real contexts (Section 3.2). The paper concludes in Section 4 with final observations, depicting several directions for future work.

2. Related Works

MAS are mostly employed in video game industries to build games and virtual reality [6], and for analytic purposes [7]. These systems, however, do not rely on web ontologies. Nevertheless it is worth noting that several ontologies describing video games are available in literature.

The *Game Ontology Project* (GOP) [8] is a collaborative effort among game developers, researchers, and other stakeholders to create a comprehensive game ontology for game design, development, and analysis. The GOP describes game-plays through a hierarchy of classes and properties extracted from DBpedia. In particular, it aims to identify the structural elements of games and the relationships among them, establishing a framework for exploring, analysing, and understanding them.

The video game Ontology (VGO) [9] is one of the key outputs of the GOP project, providing a rich set of classes, properties, and relationships for describing game elements and enabling interoperability across different games. The ontology only considers a few small and open-source video games due to time and resource limitations of the companies involved in the project.

Another interesting project is the *Digital Game Ontology* [10], which well expresses the problem of the video game genre identification process. In fact, the authors present a first approach in order to develop an OWL ontology with the purpose of representing player activities and experiences gathered from play sessions. As far as we know, the project has been abandoned and the ontology is unavailable. Hence, a direct comparison with the work presented in this paper is unfeasible. By leveraging only the paper, the ontology is limited to collecting information on games from DBpedia and from game-play rules. These are extracted from a very short game-play event recorded.

There was also the *Game Metadata and Citation Project* (GAMECIP) and its projects [11], closed in 2017. This project aimed to provide a standardised vocabulary for the depiction of game artefacts and to facilitate their discovery and citation process.

These projects have provided valuable contributions for classifying video games and their relevant components. Their approaches, as stated, can be summarised as follows: (1) organising pre-existing information about a game, such as metadata; (b) describing specific in-game instances to identify and correlate approaches, items, or characters across different media.

It is important to note that all of them, however, use reasoning capabilities of the semantic web languages such as RDF Schema (RDFS) and the Web Ontology Language (OWL) fot the sole purpose of ensuring ontology consistency. This means, the reasoner is employed only to check the consistency of the ontologies. These do not actively apply the reasoning capabilities to infer video game genres based on their most relevant features. In fact, an ontology could make use of certain object properties to describe a "first-person shooter" or a "puzzle game". It could define an OWL class that corresponds to the overarching “game” category, to collect all the instances representing a game as individuals. Nevertheless, these actions constitute a rudimentary description that does not fully leverage the representational and reasoning capacities offered by the semantic web. We think the real potential lies in addressing semantic questions: asking whether a game is an action game or a racing game is a semantic question, one that could be rephrased as “what allows us to say that a game falls into a given category of games? Are there categories of game that depend on some features rather than others?”. These are questions of semantic nature that can be tackled using semantic web tools, provided that the considered application domain -namely the world of video games- is understood in a satisfactory way. After all, it is not a coincidence that nowadays semiologists speak more and more of video games as “texts” rather than simple “games”. The shift is due to their intrinsic and growing complexity in both the narrative and non-narrative devices implemented [12]. It is finally worth noting that previous research has explored various techniques for classifying video games, often relying on manual tagging of their features or hypothesising automatic taggers that make use of existing metadata. While these approaches have shown to be promising, they often require extensive human effort, domain expertise, or predefined frameworks for accurate categorisation.

3. The VideOWL ontology

The VideOWL ontology classifies video games according to their distinct features, thus allowing to automatically infer, among other features, the genre of a title. The ontology delves deeper into the visual aspects of games and uncovers meaningful connections and patterns that extend beyond conventional categorisation. This, combined with the intrinsic bottom-up approach of the ontology, would make it really effective for leveraging reasoning through data-fed AI. A bottom-up approach refers to an ontology development approach that begins by constructing a knowledge representation system starting from specific instances or low-level concepts and incrementally building higher-level concepts and relationships.

In order to establish the fundamentals of the classification procedure, attention is directed towards the subsequent categories of entities and on their associated properties, namely:

a) single video games: titles are the sum of their narrative, mechanics, game-plays, Point Of Views (POWs), and contexts;

b) general features enclosed within a class employed to describe a video game, such as a distinctive narrative style or game-play mechanism;

c) sociological agents related to games;

d) a platform where games are released, thus permitting to recognise whether a game is platform-exclusive.

At the current version, the ontology consists of 100 classes, 31 object properties, 3 data-properties and 134 individuals. It does not largely rely on data-properties, on the contrary, there are many object-properties that are leveraged to reason on the individuals. The ontology has been developed on the Protégé editor [13] and classified using the Hermit reasoner [14] (version 1.4.3.456), even though consistency can be verified with any OWL 2-compliant reasoner such as Pellet [15].

3.1. Overview of VideOWL

The main features of VideOWL are introduced by means of 10 main classes which identify the corresponding macro-categories of the video game domain. All the classes defined in VideOWL are illustrated in Figure 1.

Figure 1: Class hierarchy of VideOWL

Agent. It includes all the entities involved in the development of a video game such as sociological actors within a game (*Fictional*), both playable (*Playable*) and non-playable (*NPC*), alter egos of real individuals within the game (*Pseudonym*).

Collection. It embraces the game series that meet the criteria of having at least two games within the collection. By organising games into collections, we establish a categorisation framework that distinguishes them from individual titles that lack direct correlations with other games.

Context. This class has been specifically designed to differentiate the various approaches that a video game may adopt towards our everyday life. At the current version of the ontology, it includes five sub-classes, namely *Familiar*, *Fantasy*, *Grotesque*, *Free*, and *Realistic*. These classes have been crafted to embrace inclusivity, acknowledging that human creativity transcends rigid boundaries. For instance, a game can seamlessly combine fantasy, familiarity, and grotesque elements, as exemplified by an imaginary scenario of a “management game where players oversee a human industrial factory producing magical potions for witches". Human imagination knows no inherent limits and may defy conventional categorisation, though it can be influenced by contingencies such as budgetary constraints and market dynamics. The domain-specific efforts invested in developing this ontology have been substantial. However, it remains an expandable framework, capable of accommodating new perspectives and features in the future, further enriching our understanding of video game contexts.

Game. This class describes an individual video game in its tangible form. As stated before, for a title to exist it requires some form of narrative, a developer, context, perspective, game-play, and mechanic. The game branches out through its sub-classes *Exclusive*, *Genre*, and *Multiplatform*. The class *Exclusive* specifies whether a title has been released on a single platform, whereas the *Multiplatform* refers to titles released on multiple gaming devices. Finally, the *Genre* class identifies the specific category of games related by similar game-play characteristics and includes genres such as *Action*, *ActionRPG*, *DynamicAdventure*, *Fighting* and so on.

Gameplay. It is the root of a class hierarchy describing the various types of game-play styles and experiences that can be found in a game. Classes in the hierarchy either contain an individual with the same name to enable proper classification or include as elements several distinct instances of the same game-play mode.

Mechanic. This class describes the various game-play mechanics found in a video game. What separates mechanics from game-play is the fact that mechanics are independent of the adopted game-play style. It includes: the class *Choice*, whose instances are the mechanics that allow players to influence different aspects of the game world or story-line by making decisions; the class *ContextualInteraction*, that refers to the ability to interact with game elements based on well-defined contexts, such as proximity to the object with which the player wants to interact with; the class *PointAndClick*, that refers to a particular type of interaction with the game environment based solely on clicking specific elements with the cursor (either by mouse or joystick); lastly, the class *QTE*, which describes a unique mechanic that tests the player’s reflexes by requiring them to press a specific button at the right moment, widely known as *Quick-Time-Event* (*QTE*).

Narrative. This class describes the different categories that narrative elements within a video game can fall into. It includes as subclass: the class *Emergent*, that describes the narrative mode where the player’s choices and/or actions have a tangible impact on the structure or progression of the story-line; the class *Evocative*, which involves themes or elements within the game that reference brands or real-life aspects, triggering the player's existing knowledge from outside the game; the class *Framed*, that is related with the possibility of nesting multiple stories within a game, potentially with multiple protagonists, which then converge into a single complex narrative; and the class *Simple* that represents the classic linear narrative, where the story-line remains fixed and does not deviate from the original narrative intent (in short, classic single track storytelling).

Platform. It includes individual instances representing various hardware platforms used for playing video games, such as computers, game consoles or smartphones.

POV. The class *Point-Of-View* is used to describe the visual perspective through which the gaming experience is presented to the player. It includes as subclass: the class *Isometric*, that describes the visual perspectives consisting in a large portion of the game area, often with top-down views or where the character appears to be in scale with the game world; the class *Textual*, that includes games where the game-play is primarily presented as a text format rather than as a three-dimensional or two-dimensional environment. Finally, *POV* presents the class *Person standpoint* as its subclass, that further has, as subclasses, the classes *FirstPerson* and *ThirdPerson*. In the first-person perspective, the player sees the events of the game through the eyes of the playable character providing a high level of immersion, whereas in third-person perspective the playable character is visible within the field of view, typically with the viewpoint positioned behind the character's shoulders or torso.

The main object-properties of the ontology are depicted in Figure 2. In particular, we focus on the following ones:

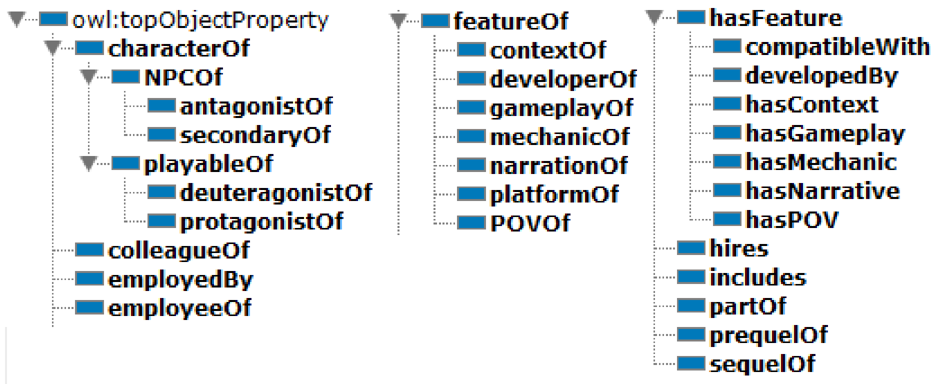

Figure 2: Object-property hierarchy of VideOWL

- *featureOf* encompasses everything that can be employed by an individual to describe its relationships with a specific game, certain actors, or platforms. It is defined as the inverse property of *hasFeature*.
- *contextOf* represents a specific context applied to a gaming experience. The inverse object-property is *hascontext*.

- *gameplayOf* signifies when a particular game-play type has been incorporated into a game. Its inverse is *hasGameplay*.
- *mechanicOf* denotes when a specific game mechanic is implemented in a title. The inverse object-property is *hasMechanic*.
- *narrationOf* indicates the adoption of a narrative story-line in a video game. The inverse object-property is *hasNarrative*.
- *platformOf* signifies when a device can successfully run the game. The inverse object-property is *compatibleWith*.
- *POVOf* represents the utilisation of a particular point of view to visualise the game. It is defined as the inverse property of *hasPOV*.
- *developerOf* signifies that a real person (a subcategory of type-3 individuals) has developed a specific title (type-1 individual). It is defined as the inverse property of *developedBy*.

We have devised a classification system that enables the reasoner to infer the genre of games based on their distinctive characteristics. We start with the assumption that a game's genre is typically identified from characteristic traits that define the genre itself. This is the reason why the class *Genre* and all of its subclasses, are subclasses of the class *Game* as well. If a game is associated with certain specific characteristics, the reasoner classifies it as an instance of the classes characterised by the mentioned features. The genres, in this context, manifest themselves as the intersection of diverse components. These fall within purpose-built classes tailored to facilitate classification, and among these classes we include *Narrative*, *Mechanic*, *Gameplay*, *POV*, and *Context*. By incorporating these components, the classification system offers a framework for inferring the genre of games in a rigorous and systematic manner. Moreover, the classification system also exhibits an inherent openness to accommodate emerging genres. By design, the system allows for the seamless integration of additional classes, thereby enabling and facilitating the inclusion of novel categories that may arise (or just be expanded) in the future. This approach may also allow us to see how well traditional categories of games fall into new ones. Such features bolster the longevity and adaptability of the ontology, enabling it to remain at the forefront of genre classification in the ever-evolving landscape of video games.

The VideOWL ontology permits to answer at least to the following types of competency questions:

1. Retrieve all games that exhibit a distinct narrative.
2. Find all the titles in the *Sandbox* genre, defined as games with emergent narrative and creative game-play.
3. All the developers of a certain title.
4. All the titles of a saga.
5. All PC-compatible titles.

6. How many platforms are supported for each title.
7. All the *exclusives*, namely all the titles that came out only for a single platform.
8. All games of a certain genre with their income.

For instance, the competency question 1. is implemented by the following SPARQL query:

Query 1 The query for the competency question 1.

```
SELECT DISTINCT ?Game
WHERE {
?Game unt:hasNarrative ?Narration.
?Game unt:hasGameplay ?Gameplay.
FILTER (?Narration = unt:simple) }
```

while competency question 2. by the following one:

Query 2 The query for the competency question 2.

```
SELECT DISTINCT ?Game
WHERE {
?Game unt:hasNarrative ?Narration.
?Game unt:hasGameplay ?Gameplay.
FILTER (?Narration = unt:emergent).
FILTER (?Gameplay = unt:creation_based) }
```

SPARQL queries for the considered competency questions can be found in [5].

3.2. Reasoning example in VideOWL

The ontology permits to infer the genre of a game using the Hermit reasoner. We can assume in general that a game is identified within its genre through characteristic features that define it. In light of that observation, the ontology defines each game genre as the intersection of the classes *Narrative*, *Mechanics*, *Gameplay*, *POV*, and *Context*. As an example, Figure 3 depicts the class *FPSRealistic*, subclass of the class *Genre*.

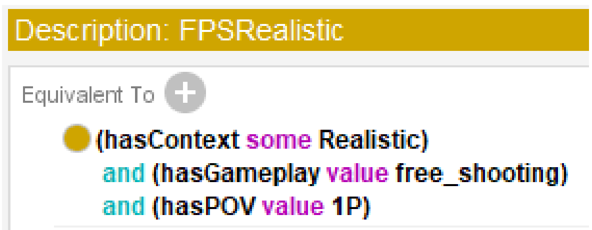

Figure 3: Definition of the class *FPSRealistic*.

The class *Genre* and all the related subclasses are also defined as subclasses of the class *Game*. As an example, we consider the case of the video game Call Of Duty,[1] introduced by way of the

[1] https://www.callofduty.com/it/

OWL individual *CALL_OF_DUTY*. As Figure 4 shows, the ontology defines *CALL_OF_DUTY* as an individual associated with

a) *1P*, instance of the *POV* class,

b) *pc_gaming*, instance of the *Platform* class;

c) *simple*, instance of the class *Narrative*;

d) *historical*, instance of the class *Context*;

e) both *free_shooting* and *PVP*, instances of the class *Gameplay*.

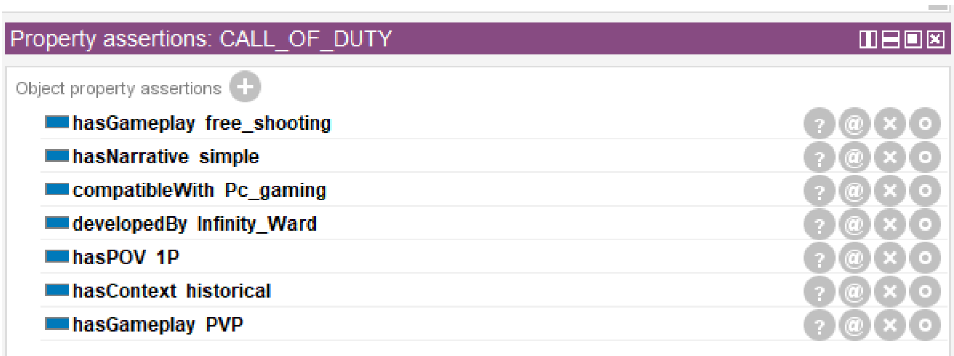

Figure 4: The property assertions of the game *Call of Duty*

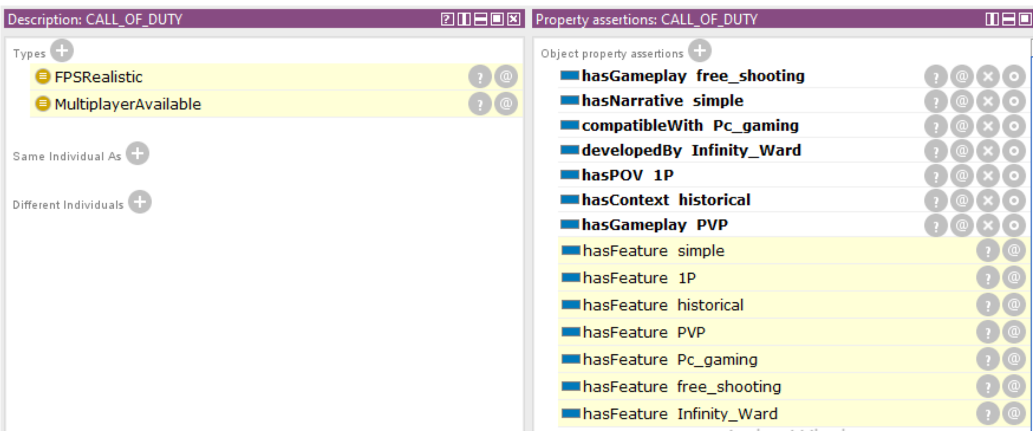

Figure 5: The inferences for the game *Call of Duty*

By means of the definition in Figure 3, the reasoner infers correctly that the game "Call of Duty" belongs to the class *FPS_realistic*. This happens as it is existentially related to a realistic context -*historical* in this case- and specific values (namely, *free_shooting* and *1P*). This is illustrated in Figure 5. Moreover, the reasoning system can proficiently capture inferences pertaining to characters. It can also handle the relationships within sequences of games and the games constituting them: this includes those that serve as prequels and/or sequels. In such cases, transitive properties are used, while elsewhere symmetries are employed, as exemplified by the *colleagueOf* property, which establishes relationships between colleagues. These types of relationships can be easily accessed and further explored through SPARQL queries, thus allowing for more in-depth analysis and investigation. The *Call of Duty* example has been provided as a proof of concept. However, we feel that the real power in this methodology lies in the power to exceed classical labels, as the inferences obtained serve as a means to enhance our understanding of the nature and characteristics of the game at hand. The landscape of video games has transcended traditional classifications, rendering conventional labelling systems increasingly inadequate. The evolution of this medium has led to the emergence of diverse and hybrid genres that defy easy categorisation. The progressive dissolution or amalgamation of genre constraints has resulted in an enriching and complex gaming experience for players. This fosters a more inclusive and dynamic gaming industry that accommodates a wide spectrum of tastes and preferences. In light of these developments, the game *PowerWash Simulator*[2] is an exemplar case wherein semantic systems enable accurate classification that traditional non-semantic searches may overlook. Despite exhibiting mechanics resembling those of a non-violent first-person shooter (FPS) with elements such as multiple weapons (the pressure washers), ammunition (the different kinds of soap) and a persistent presence of a weapon on the screen, the title's classification according to conventional search criteria is only a "job simulator", as if the two categories were mutually exclusive. Thus, the implementation of a semantic system may empower users to discover and explore FPS games with non-violent game-play, thereby accommodating a more comprehensive range of preferences. Another example is that of *Greedventory*[3]: although this title is an action Point-and-Click game based on quick-time events and the context of such games is often associated with adventures, it is often labelled only as an action game, without considering its nature of Point-and-Click game.

Another complex scenario concerns the MetroidVania, namely, a sub genre of action-adventure video games, characterised by nonlinear exploration, interconnected level design, and a reliance on player character progression to access previously inaccessible areas. The term itself is a portmanteau of two influential franchises within this sub-genre, namely *Metroid* and *Castlevania*. With respect to the FPS genre where players experience the game from a first-person perspective and primarily focus on combat encounters, Metroidvania games offer a distinct experience: players typically assume the control of a character embarking on a journey through expansive, intricate and often labyrinthine worlds. Combat, when present, takes on a secondary role compared to eventual boss battles. In this type of games, progression is facilitated by acquiring new abilities, tools, or upgrades, which grant access to previously locked regions or to unlock new gameplay possibilities. This creates a sense of exploration and discovery as players gradually uncover the game world's secrets while advancing the narrative. As such, key elements of Metroidvania games include backtracking (namely the need to go back to previously locked areas), and environmental puzzles. As a result, the genre of the game is defined in VideOWL as follows: a Metroidvania game has Open-World and Puzzle gameplay, Inventory mechanics and

[2]https://powerwash-simulator.square-enix-games.com/en-us/
[3]https://store.steampowered.com/app/1895820/Greedventory/

an Isometric Point-of-View (see Fig. 6).

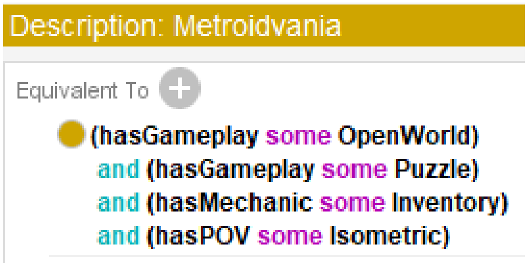

Figure 6: Definition of the class *Metroidvania*

Leveraging the VideOWL approach of breaking down a genre in its peculiar features, we are able to present the instance of Hollow Knight[4], a game that very well embodies the non-linearity of progress that defines the genre, promoting a sense of agency and discovery, as illustrated in Figure 7.

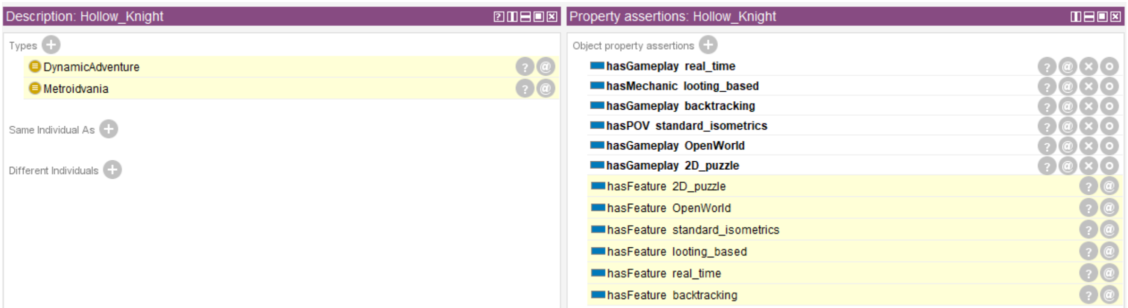

Figure 7: The inference of the game *Hollow Knight*

It is worth noticing that the individual representing the game has been concurrently categorised within the “dynamic adventure" genre due to the inclusion of the real time combat related elements.

4. Conclusions and future work

While our current work has the potential to significantly contribute to the development of a OWL ontology for describing the video games environment, we are investigating how AI systems could utilise the ontology. For instance, by training to recognise patterns within the player’s HUD (Heads-Up Display)[5] data, the AI system could be able to analyse non-commentary walk-through videos from platforms like YouTube. It would extract relevant data from the player’s HUD, including the in-game statistics, visual cues, and context details. In this context, the behaviouristic

[4]https://www.hollowknight.com/
[5]The HUD is the part of the graphic user interface managing how information is visually relayed to the player.

approach of the OASIS 2 ontology [16, 17, 18] can be leveraged to represent any agent in the VideOWL ontology such as players, NPCs, and related actions, and game strategies. The latter, in particular, can be ontologically formalised through OASIS 2 in order to build more smart and effective bots, both to assist and to play against the human player. A similar approach has been successfully applied to blockchains and, in particular, to Ethereum [19, 20, 21], while applications to cognitive IoT agents [22, 23], to cybersecurity [24], and to the representation of the Hyperledger Fabric blockchain [25] are in progress .

Previous researches have explored various techniques for video game genre classification with manual tagging of its features or hypothesising automatic taggers that make use of existing metadata. While these approaches appeared to be promising, they often require extensive human effort, domain expertise, or predefined frameworks for accurate categorisation. Our approach could address these limitations by employing an AI system trained to recognise patterns within the player's HUD data, which serves as a rich source of information for genre inference, as the HUD conveys information about the game to the player beyond its internal game-play, making it a useful filter. This similarity in HUD usage across genres allows for effective classification despite differences in each title.

The ontology holds significant potentiality for enhancing the verification process of the *Pan-European Game Information* (PEGI) classification for video games. It is a standardised age-rating system used throughout Europe to inform consumers about the content and suitability of video games for various age groups, with the goal of protecting minors from potentially harmful or inappropriate game experiences. By leveraging the rich knowledge representation and reasoning capabilities provided by the ontology, coupled with the AI system's ability to analyse complex game elements, the accuracy and efficiency of PEGI classification assessments could be greatly improved. This advancement can assist regulatory bodies, game developers, and consumers in ensuring appropriate age ratings, promoting responsible gaming, and facilitating informed decision-making regarding the suitability of video games for different audiences. Similar type of aid could be used by the *Entertainment Software Rating Board* (ESRB), the rating system employed in USA, Canada, and Mexico. Such rating systems range from "Early Childhood" to "Adults Only", trying to balance the creative expression inherent in video games with the need to protect vulnerable audiences from potentially inappropriate content. We think that our work has an high scalability factor, with enormous potential for semantic market analysis in light of suitable extensions. Finally, we plan to extend the ontology, translating it in the description logic introduced in [26, 27, 28]. This will allow us to make further useful inferences to better understand the nature of video games.

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