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OntoCin: A Multimedia Ontology for the Semantic Indexation of Cinematographic Resources on the Web of Data

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ABSTRACT

The flood of Multimedia Resources on the Web of Data and offline platforms is a clear proof of the increase of such resources in day-to-day activities of modern society, especially web series, documentaries, fictions, etc. Multimedia Ontologies applied to film-related features entail to describe not only the film production process, but also their social and environmental inferences (with cultures, attractive sites, etc.). The insufficient insight of annotated features in existing ontologies affects retrieval accuracy on useful facts necessary in today's society. This paper presents a Multimedia Ontology for the co-construction and indexing of Cinematographic resources (OntoCin) on the Semantic Web, built on the Human Activity Theory (HAT) modelling approach and the Competency-based Questions Methodology which allowed to scope cinematographic knowledge. This ontology enables information retrieval by enhancing annotation and indexing of scenes, emotions, shooting places (touristic sites), film-users' preferences, socio-cultural knowledge and impressions on the Web of Data. We made some queries on the ontology and came out with results. This helped to set ground for a semantic wiki architecture that will facilitate the co-construction of multimedia resources based on this Multimedia Ontology.

1. INTRODUCTION

The volume of audio, video, and visual data circulating on the web is growing prodigiously, raising issues concerning the management of information based on the intrinsic nature of multimedia. These multimedia contents are produced and consumed by professionals as well as amateurs.

As a category of multimedia resources, cinematographic works comprise all on-screen visual elements, including, framing, composition, camera angles, film selection, and depth of field, colour, exposure, and filtration. Recent studies demonstrate a considerable qualitative and quantitative increase in film production in nearly all contexts, leading to a greater representation of cultural identities. Vectors of information and prescriptive analysis of film production reveal that about 25% of film viewers are influenced by the content available online [1].

Almost 24% of films are web-driven [2] and a majority of producers and consumers use the Internet to get more about cinematographic content. Therefore, access to such relevant content at a given time is a great matter of concern. Interconnecting semantic concepts and media data has become a way to bridge the divide between the Internet and the Web of data [3]. Semantic indexing of video contents has become a very important issue for data access and retrieval [4]. Unlike textual assets, media search is dependent on processes that either have cumbersome requirements for features comparison (e.g., color or texture) or rely on associated descriptors, selecting aspects of a frame or video and expressing them as text, or as concepts from a predefined vocabulary [5]. However, the content representation of Multimedia Ontologies also needs a large number of concepts in a taxonomical classification, concepts, roles and rules to be used for describing Cinematographic works [6].

Ontology represents a conceptualized organization of formal artifact, where the links between concepts are attributed a semantic nature and are rigorously formalistic [7]. By introducing a semantic web application, it enables the organization of data, enhances information retrieval, and automates indexing processes. The concept of socio-cultural knowledge encompasses all types of human knowledge, including objects that make up the physical world, as well as facts and events [8].

The film industry is firmly rooted in the process of cultural globalization; and the domination of America and France in the production and distribution sector greatly influences other cultures worldwide. The appraisal of cinema also depends on the cultural angle as described by Tcheuyap [9]. The history of African cinemas is hard to separate from that of decolonization [10]. First there were films of whites in Africa, later in the sixties, the new African states were confronted to the orientation of African cinema [11]. For example. In Algeria, we have prestigious films devoted to the War of Independence. Germany's films are mostly oriented towards war and crisis

[12].

However, the benefits of associating media with their semantic metadata are undoubtedly limited due to the lack of appropriate access methods, coupled with the glaring absence of a qualified query language specifically adapted to multimedia resources and fragments. A more specific annotation process taking into consideration factors such as infrastructure, language, emotions, activities, and communities could be important in the construction of multimedia content into the web of data.

The modelling of such concepts increases the indexing scheme of the web of data. For example, expelling a list of films played at a specific touristic site or popular places, the list of films in which a specific person has played a role, popular places in a film, and author of a particular music played in a film, etc. Therefore, a shared vocabulary within ontologies addressing cinematographic content and related semantic structures can enhance the collaborative construction and indexing of such knowledge.

In this paper we propose to build an ontology using a scrutinized process in order to address some specific film-related resources. The remaining part of this paper is divided into three sections. The first one presents related literature reviews on Multimedia Ontologies depicting cinematographic concepts. The second section describes the modelling process of our ontology based on the Engeström's Human Activity Theory with the reuse of related vocabularies to solve the interoperability issue. Finally, the last section presents how this ontology could be used based on some cases and open some important perspectives.

2. RELATED WORKS ON MULTIMEDIA ONTOLOGIES FOR THE WEB OF DATA

During the recent years a lot of research on annotation, indexing or retrieval of multimedia content on the Web provided important results. Most current approaches use Semantic Web technologies to enable efficient processing and understanding of metadata by computers [13-15].

Lemos and Souza [16] revealed important perspectives in the annotation and information retrieval of multimedia resources. To name some, we have search made by isolated and decontextualized words, which hinders greater visibility of the collection from the perspective of users and, consequently, search engines; lack of context in the media item; describe photos and videos related to text; conceptual ambiguity which concept is precisely speaking of. This work provides sufficient knowledge on the trend of multimedia ontologies and users appreciation of multimedia contents, but is less concerned with the characteristics of features and influences considered in the studied ontologies.

Table 1. Foundational multimedia ontologies synthesis [17]

No	Ontology	Type of Features Considered	Targeted Application	Semantic Level	Interoperability	Index Value
1	NinSuna ontology	HLF	Metadata Driven Media Delivery	Content-Based Semantics	YES	-
2	Ontology Based Video Annotation and Retrieval System	LLF	Transportation systems	Content-Based Semantics	NO	-
3	CCTV Ontology	HLF	TV and Camera Monitoring	Geometric	NO	-
4	MOM ontology	HLF	Games and Sports tools	Content-Based Semantics	NO	-
5	COMM	LLF & HLF	Audi-visual object retrieval systems	Geo-Spatial	NO	1.19
6	M3O	LLF & HLF	Web search	Content-Based Semantics	YES	1.23
7	Dynamic Pictorial Enriched Ontology	LLF	Video Soccer systems	Geo-Spatial	NO	-
8	LSCOM	LLF & HLF	Web search	Content-Based Semantics	NO	-
9	Media Resource Ontology	LLF & HLF	Web search	Content-Based Semantics	YES	1.56
10	POLISEMA MPEG-7 Video Annotator	HLF	Annotation tools	Content-Based Semantics	NO	-
11	MPEG-7 Rhizomik	HLF	Web search	Content-Based Semantics	YES, XML-OWL	-
12	Kanzaki Ontology	HLF	Web search	Content-Based Semantics	NO	-
13	VidOnto	HLF	Web search	Content-Based Semantics	NO	-
14	Large Annotation Ontology	HLF		Content-Based Semantics	NO	-
15	Film ontology	HLF	Web search	Content-Based Semantics	YES	-
16	Cinema Ontology	HLF	Annotation tools	Content-Based Semantics	NO	-
17	M3 Ontology	HLF	Web search	Content-Based Semantics	YES	0.95

Amaria et al. [17] proposed an interesting survey synthesising some multimedia ontologies. In this work, ontologies where evaluated based of five criteria namely: types of features (High Level Features, HLF or Low-Level Features, LLF, targeted application (domain of use), semantic level (content or context oriented), interoperability, and index value (as seen on Table 1).

Multimedia Ontologies discussed in its actual state needs more refinement to consider Cinematographic work features. An important study carried-out by the UNESCO Statistic branch (Institut de statistique de UNESCO, La Diversité des films long métrage. Fiche Information de ISU Numero 17.

Montreal: ISU, 2013) shows that language diversity, attractive sites, and many other concepts more and more influence cinematographic productions. For example: it revealed that almost 50% of films produced have a main language, which is the case of Morocco's film industry with 79% of its films in Arabic, 17% in French language and 4% in English language. On the other hand, Indian films do not have a main language in their films. 16% of their films are in Hindi, 15.3% in Telugu, 14.7% in Tamil, 11% in Kannada and 10% in Bengali, which makes India a more diversified film production industry. All these constraints are not included in research works on multimedia ontologies.

3. MODELLING OntoCin

3.1 Engeström human activities theorem

Practically, ontological engineering does not propose a standardized method or general methodology for building Ontologies. Most of existing approaches adopt an iterative and incremental cycle [18]. In our case, we used HAT based-methodology coupled with the top-down approach. We agree with Berger on the fact that "reality is socially constructed" [19]. The HAT provides a more realistic interaction between concepts of social identity.

Table 2. Mapping between poles of engeström model and cinema ontology concepts

Poles of Engeström Model	Cinematographic Fundamental Concepts
Artifact	Music
Subject	Person
Object	Image
Community	Locality
Rules	Media_tag
Division of labor	Event

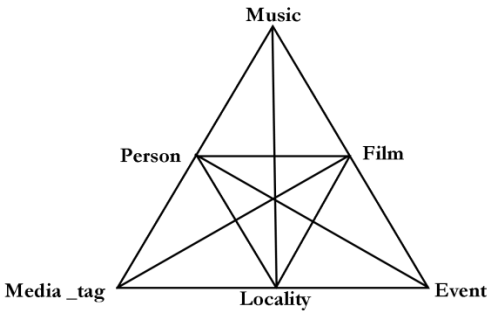

Figure 1. A mapped engeström model for cinematographic concepts

The realities in cinematographic works (as discussed earlier in this paper) helped depict societies and cultures around the world [20]. In the course of studying the CHAT, we derived a theoretical background to relate key cinematographic concepts, considering both the cinema context and Cinema scene views [21]. According to Ruckreim and Lompscher [22], "Yrjö Engeström is one of the most self-directed but certainly also one of the most interesting representatives of contemporary activity theory". In Table 2, we present an adaptation of the six poles of the Engeström's Model [23, 24] with regards to cinema resources, illustrated in Figure 1. The pertinence of these concepts is certified by the analysis of some experts in the field of study.

From the above film-related CHAT model, we suggested possible triads and Triples of the film domain (that is pair of concepts and the link between them) as seen on Table 2. Note that with multiple interactions between redundant relationships (due to reflexivity of relations), some triples have the same semantic meaning as seen on Table 3.

Table 3. Triads and triples for cinema foundational concepts

No	Triads	Triples
1	Person-Music-Locality	isAuthorOf(Person, Music), isRecordedAt(Music, locality), hasOrigin(Person, Locality)
2	Person-Film-Locality	isActorIn(Person, Film), isProducerOf(Person, Film) isDirectorOf(Person, Film), isProducedAt(Film, Locality), hasOrigin(Person, Locality)
3	Music-Locality-Film	hasGeneric(Film, Music), isRecordedAt(Music, Locality), isProducedAt(Film, Locality)
4	Music-Person-Film	isAuthorOf(Person, Music), isActorIn(Person, Film) isProducerOf(Person, Film), isDirectorOf(Person, Film) hasGeneric(Film, Music)
5	Person-Film-Media_tag	isActorIn(Person, Film), isProducerOf(Person, Film), isDirectorOf(Person, Film), isAvalaibleIn(Film, Media_tag), isPresentIn(Person, Media_tag)
6	Film-Locality-Media_tag	isProducedAt(Film, Locality), isfoundIn(Media_tag, Locality), isAvalaibleIn(Film, Media_tag)
7	Person-Locality-Media_tag	isfoundIn(Media_tag, Locality), hasOrigin(Person, Locality), isMemberOf(Person, Media_tag)
8	Person-Locality-Event	hasOrigin(Person, Locality), isAwardedIn(Person, Event), isOrganisedIn(Event, Locality)
9	Locality-Film-Event	wasRecompenceIn(Film, Event), isProducedAt(Film, Locality), isOrganisedIn(Event, Locality)
10	Person-Film-Event	isActorIn(Person,Film), isProducerOf(Person,Film) isDirectorOf(Person,Film), isAwardedIn(Person, Event) hasRecompenceIn(Film, Event)

From the refining process defined in the study [25], we then removed duplicates and redundant relationships to get consistent triads and the triples deduced from each triad as follows: isAuthorOf(Person, Music), hasGeneric(Film, Music), isRecordedAt(Music, locality), hasOrigin(Person, Locality), isAvalaibleIn(Film, Media_tag) isPresentIn(Person, Media_tag), isfoundIn(Media_tag, Locality), isAwardedIn(Person, Event), isOrganisedIn(Event, Locality), is Memberof(Person, Media_tag), hasRecompenceIn(Film, Event).

3.2 OntoCin concepts and relationships

The foundational upper-level concepts from the above mapping generated about sixteen (16) upper-level classes in our ontology and 22 low-level classes as seen in Figures 2 and 3 for the hierarchy of classes and some relationships between them.

3.2.1 Hierarchy of concepts

There exist many approaches to define the hierarchy of classes: top-down [26, 27], bottom-up [28, 29], hybrid approach [30]. The use of Engeström's model of the HAT allowed us to use the top-down Approach. The top-down development process begins with a definition of the most general concepts in the domain and continues with sub-concepts specialisation. Thereafter, to better define the hierarchy, we intended to think up before making specifications. Figure 2 shows the extract of a possible articulation between various levels of the concepts using OntoGraph tool available in the Protégé 5.0.

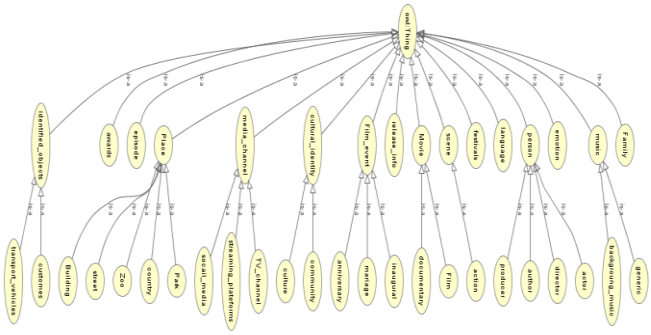

Figure 2. Hierarchy of concepts of OntoCin

3.2.2 Relationships

Relationship in ontology specifies how objects are interrelated [31] by determining the domain and range of the relation. Lazarre et al. [32], Hovy [33], Atkinson et al. [34] gave more details on modularisation and constraints necessary when building ontologies. With protégé 5.0, we used the VOWL tool to have a better view of the different concepts, their data properties and relationships between the concepts (see Figure 3).

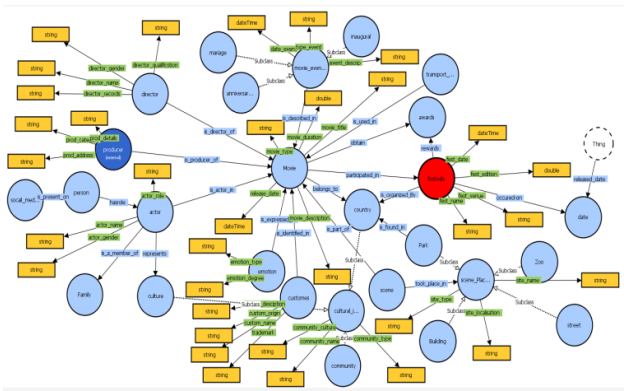

Figure 3. OntoCin concepts and relationships

4. SEMANTIC INTEROPERABILITY

The semantic interoperability refers to the ability of different systems to exchange and understand data and information in a meaningful way, even if they are built on different platforms. This involves the use of common vocabularies, ontologies, and standard to ensure that data can be interpreted correctly, enabling efficient data sharing and collaboration across the domain on the web of data [35]. To ensure interoperability, we aligned some concepts of our model with those on the Linked Open Vocabulary. If it happens that one of our concepts had and existing syntax and/or semantic definition on the LOV, we simply link its URI on our Ontology.

4.1 Alignment of concepts

For a semantic web, alignment is a solution to the interoperability problem between heterogeneous ontologies developed and helps not to recreate what exists but improve it. OntoCin vocabulary reuses some concepts of related ontologies, of which some are presented in Table 4.

Table 4. OntoCin concepts alignment

OntoCin Concepts	Mapped Concept	URI
Person	Person	http://xmlns.com/foaf/0.1/Person
Festival	FilmFestival	http://dbpedia.org/ontology/FilmFestival
Author	Author	http://www.ontotext.com/proton/protonext#authorOf
Film	Film	http://dbpedia.org/ontology/Film
Media_tag	OnlineAccount	foaf:accountServiceHomepage
Locality	Geo	http://www.w3.org/2003/01/geo/wgs84_pos#
Director	Film Director	http://dbpedia.org/ontology/MovieDirector

4.2 Performance evaluation

Measuring the accuracy, comprehensiveness, and practicality of an ontology is crucially important in the phase of ontology performance evaluation, correctness; it examines how well functional components designed and assesses the language expressiveness and competency-based questions checking, with the aid of domain experts. Comprehensiveness studies the extent to which designed criteria align with use cases and requirements specifications, while also identifying necessary semantic components for concepts are already defined in an existing vocabulary. We mostly used the LOV Web of Data platform. We evaluated using competency-based questions and challenge tests performed against use cases, with interrogation tools and reasoners used to improve performance.

4.2.1 Populating

For tailoring our ontology, we used the "Protégé 5.5" ontology development tool, a platform of ontology implementation and management [36]. Population of OntoCin was done using datasets from the 95th edition of the Academy of Motion Picture Arts and Sciences (AMPAS), which honours films released in 2022 [37], the FESPACO use cases data and other famous film acknowledged agencies [1] according to the "collaboration personas" approach. The manual selection of some real dataset on films permitted us to query our ontology and get some results presented in the paragraph below.

4.2.2 SPARQL queries for indexing of content

The expressive power of a query language is of paramount importance in assessing its efficiency. This is done by evaluating the queries that a user executes and the complexity and evaluation of these queries that we can really grasp the essential issues to take into account when designing a query language [38, 39]. For this, SPARQL, the query language for

RDF, recently achieved W3C recommendation status, demonstrating its official recognition and significant relevance [40-42].

The Protégé environment provides a query endpoint (SPARQL) [43, 44]. It helps to build queries on OWL graph of OntoCin. In this environment, predicates are used for example to help us verify disjoint, equivalent of properties. We focused on various film concepts with regards to content-based and context-based properties such as actors, scene production places, socio-cultural factors, festivals or events, etc.

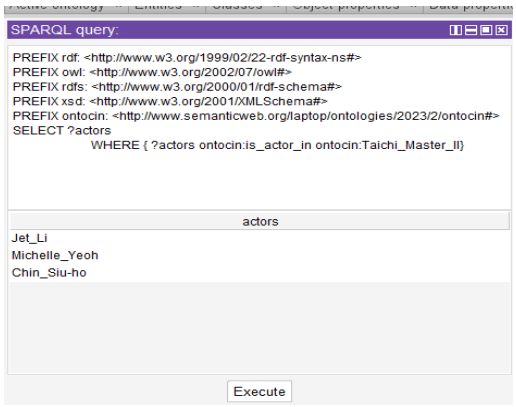

Figure 4. List of actors who played in the film titled "Tai chi Master II

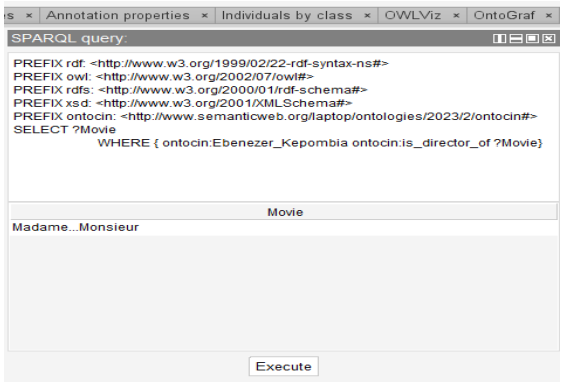

Figure 5. List of films directed by Ebenezer Kepombia

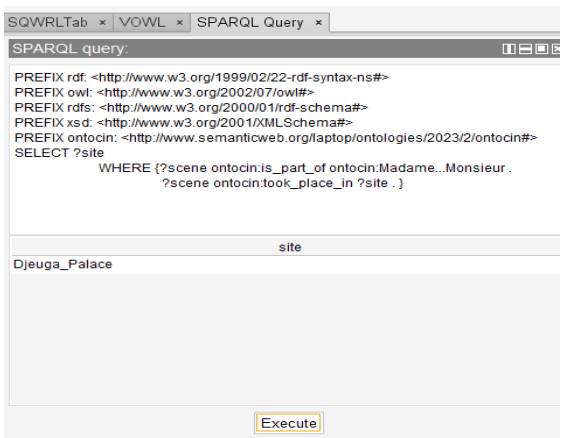

Figure 6. List of famous sites present in the film "Madame Monsieur"

Depending on the Competency-based Questions methodology, OntoCin enables users to search for information such as: names of people who played in a given film; touristic sites that were used in a particular film; list of films in which "Robert Gates" was played for example; list of films in which fear and sorrow are felt, list of African films, etc. Three of these SPARQL queries were executed on test data using the platform Protégé 5.5 (as shown on Figures 4, 5 and 6).

5. CONCLUSIONS

We proposed a modelling approach of multimedia ontology, rooted on the Engeström Human Activity Theory to pinpoint Context-based ontology concepts with their relationships and Competency-Based Questions for the user's experience. To mend interoperability, we aligned on the Linked Open Vocabulary, then populated our ontology with data from the FESPACO dataset and applied SPARQL queries, evaluated its response to user's questions on three sample questions.

Nevertheless, further studies can help building architecture for a collaborative wiki semantic platform for a recommendation system. This collaborative wiki platform could benefit from an ontology-based indexation of film related resources. We also believe that a modularised model of this ontology will facilitate reuse and interoperability of multimedia ontologies, and that the application of fuzzy logic on measurable properties could ameliorate the ontological annotation process of cinema Contents.

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