Dance in the World of Data and Objects

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Abstract. In this paper, we discuss the challenges that we have faced and the solutions we have identified so far in our currently on-going effort to design and develop a Dance Information System for archiving traditional dance, one of the most significant realms of intangible cultural heritage. Our approach is based on Description Logics and aims at representing dance moves in a way that is both machine readable and human understandable to support semantic search and movement analysis. For this purpose, we are inspired by similar efforts on other cultural heritage artifacts and propose to use an ontology on dance moves (DanceOWL) that is based on the Labanotation concepts. We are thus able to represent dance movement as a synthesis of structures and sequences at different levels of conceptual abstraction, which serve the needs of different potential users, e.g., dance analysts, cultural anthropologists. We explain the rationale of this methodology, taking into account the state of the art and comparing it with similar efforts that are also in progress, outlining the similarities and differences in our respective objectives and perspectives. Finally, we describe the status of our effort and discuss the steps we intend to take next as we proceed towards the original goal.

Keywords: Intangible Heritage, Semantic Web Technologies, Ontology, Dance Analysis, Labanotation, Performing Arts.

1 Introduction

Currently in Europe, significant projects are aiming at developing and bringing cut-edge information technologies to the area of digitization, archiving and dissemination of Cultural Heritage, e.g., Europeana [16], eClap [14] building communities e.g., eCultValue [15], and enhancing experience, e.g., CHESS [34] by combining expertise from both technical and humanities/creativity fields. Nevertheless, in many European countries with rich tangible and intangible cultural heritage, –despite the various significant, sporadic efforts in collecting the different tangible expressions of dance (such as text descriptions, audio testimonies, images, etc.)–, the exploitation of computer and web technologies in archiving, preserving and promoting dance tradition using a systematic framework, is making its first steps. The Greek Dance Pandect [35], which provides a website where the user can search for text, images, bibliography about traditional dance of the different regions of Greece, makes a good example of these efforts. Thrace Research Program [36] is another Greek initiative for

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collecting, studying and promoting music and dance tradition. The records are available online through a relational database system, so the registered user can browse and search the material which includes videos, images, text information and interviews with locals, lyrics, music and Labanotation scores. In the cases mentioned above, the user may browse and search the material by name, dance genre, region, type of record (video, image, text), but in no case can search by the dance movement and its characteristics, e.g., “dance extracts that include many deep bents of the knees, or very small, quick steps in the same direction”. The idea is to develop a human understandable and machine searchable “language” to transform the knowledge that one can find in the “black box” of a Labanotation score or other formal notation score, into a comprehensive format so that the created annotation can serve as an input for further automated analysis, similarity search, and alignment with other informal or style specific vocabularies. To explain why the term “black box” was used above for the score we mention the following: 1) Labanotation scores are closed to non-experts of this language and 2) the exchange of such files is limited to specific formats. There is only one widely used editor to digitally produce scores (LabanWriter), which is available only for Mac OS exports files only in image or codified non-human readable ascii formats [27]. LabanXML [26, 29] and MOVEMENTXML [21] were two examples of efforts towards moving Labanotation to a more human readable format. As early as almost ten years before (2004), at the international conference for exploring research and programming potential for Labanotation [24] the need of an "interlingua" to enable communication among the different technologies that existed was discussed. A good question, however, is why the proposals to move towards a more human readable file format, or any other “interlingua” have never been applied or further investigated since then, although the Labanotation community still raises the topic of the need for “open formats” [10, 39].

2 Related Work

The great choreographer Merce Cunningham [30] was one of the first to use computers in the choreographing process. Since then many others have followed, like William Forsythe [33], and Wayne McGregor [9]. Currently many choreographers (Bud Blumenthal [5], Siobhan Davies [31], Emio Greco [18, 23], Deborah Hay [28]) are collaborating with technology research teams to support the investigation of pioneering methods for capturing and documenting dance. These collaborations with projects such as Siobhan Davies Replay [31], Inside Movement Knowledge [23], and Motion Bank [28] are aiming at designing tailored methods to capture the individual dancing vocabulary of each creator, and document his “idiosyncratic vocabulary”, to use a term used by the Transmedia Knowledge Base TKB project team [37], during a process which can lead to new cognitive paths on movement perception. Dance Digital Archive [8] is another web platform collecting and organising dance material. One of its goals is to provide the user with a kind of personal digital notebook for “scoring” choreographies” and give the opportunity to access this material for further inspiration. A very interesting point about this project is the development of tools which allow the user to select a specific part of an image which depicts a body shape or a pose and search for “similar” material by image processing. What is common and

worth to mention in all of the above projects is the following, first, the notion of "score" or "notation" is used in a wider, less formal manner. Score in these cases is no longer a formal script to be read and interpreted in a specific way, but a collection of an individual's material and ideas selected during the creating process. In addition this kind of scores are open to many different interpretations if "read" by another dancer or choreographer. The second interesting common point is that they are not focused on specific technologies or methodologies that are pre-decided, instead, they combine different media and approaches according to the needs of the documentation itself.

Nevertheless, many dance analysts, anthropologists, or dance therapists still prefer formal archiving methodologies expressed in standard languages like Laban Movement Analysis, and Labanotation, which provide a common vocabulary that enables communication among researchers for comparative analysis. Motion capture technologies, on the other hand, can generate 3D animation with extreme accuracy and can capture the 3D dimensionality of the motion [32]. Nevertheless, MoCap is not appropriate to capture the movement of an onstage performer or a dancer in real-life environment. For example, it is not the same to have a professional dancer or a student to wear the equipment and recreate the local dance, instead of the local person, if we need to capture a traditional dance for ethnochorological research, as there will occur many differences in the movement style and quality of the dance that will be captured. This is where video in combination with Labanotation or other formal movement analysis is far more useful. Moreover the motion data that is produced is not reflecting any conceptual model about the movement in a way the movement creator or analyst can perceive. Numeric expressions, physics equations, and data about joint rotations and positions, are of no help, unless they are annotated or indexed using an upper level of conceptualization, to extract similarity and common knowledge about the dance [2, 32].

3 Dance OWL in the "Dance Data" Ecosystem

In addition, videos are still the main carrier of dance digital content. They can be annotated or processed through image recognition to extract information on dance movement [5]. Many digital files for Labanotation or other scores, and verbal descriptions of the movement are available worldwide in printed or digital formats in different databases or small digital libraries. Although the collaboration of dance creators, archivists and ICT experts is young, usually hard in communication and probably immature, it is also of no question that different forms of "dance data" (and metadata) is created every day.

While working in building and enhancing the DanceOWL, there was the need to locate this approach on the map of current "dance data" ecosystem where inputs for storing and processing techniques and possible outputs of the different forms is depicted (Fig.1). Fact is that although there are some standard "input-processing-output" schemas e.g., from Motion Capture to 3D animation, from notation to 3D animation [38] or from video recording to annotation and abstract visualization, the different forms in this map are mostly ad-hoc solutions which lack communication with each other. The DanceOWL approach is working on bridging one of these links: "from Labanotation Scores to the concepts of DanceOWL", by representing the

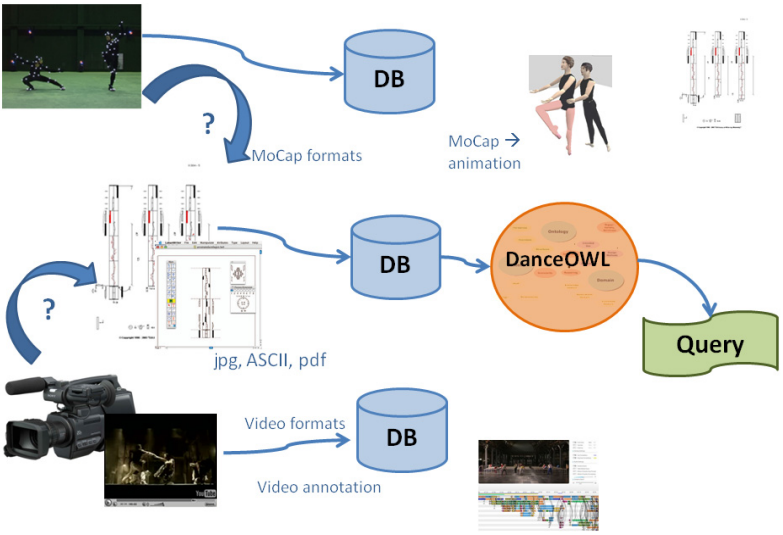

Fig. 1. The Dance Data Ecosystem

semantics of these symbols, to make this description of the movement, its characteristics and synchronization readable and searchable. At this point the user interface is not designed yet, but one can search by quering (using SPARQL) the ontology and experimental knowledge base, by posing questions like "Give me all dance expressions or extracts that are originated from Kastanies village and include a crossed arms hand grasp, or very small light steps".

4 Ontology Based Data Modeling

Usually in other cases of IT solutions for Cultural Heritage or Digital Libraries, ontologies, as formal conseptualisation of a specific domain seems to give the answer to the different syntactic and semantic interoperability issues. Ceusters & Smith [6] state that ontology engineering can play a great role in making digital dance knowledge accessible, searchable and meaningful. As they consider videos to be the main form of "dance data", they propose to have two ontologies: the first describing real world phenomena relevant for the domain of dancing and the second covering how these phenomena are exhibited in videos through image and sounds. This statement enforces the argument to distinguish between the act of dancing, the performance and the recording media, as when annotating a video about a dance we do not describe the dance we describe the video that records the dance. The creator of the file is the creator of the digitized or born digital media, but is not the creator of the dance or the movement.

In addition, the question that is going to be discussed later on is the following: can we say that any kind of these "data" is indeed a digital form of the dance itself, or all

these are nothing but data related to dance? If the answer is the latter, and dance does not exist in any physical (or digital) form once the performance of it is over, maybe we should compromise with the idea that in the case human movement the best we can archive are metadata and related objects, and not the dance itself as a digital object.

As described above one of the aimed functionalities of the Knowledge Base is to query similar movement elements, motives or more complicated units within the different scores, but before searching for "similar" things we need to define what these things are. Of course this stands for any conceptual representation, but dance as been intangible has its own peculiarities. We stressed above on the importance of building bridges between one description, representation of dance to another, but this process is highly challenging, as we are not only translating from one language to another e.g., Labanotation to OWL, but in addition the referent is intangible, is movement.

In all kind of representations, we have the semantic triangle which was introduced by Ogden & Richards (1923) and depicts the relation of the Concept (Reference or Thought), the Object or Referent and the Symbol (Word or Lexeme in Linguistics, or Sign) and here is the tricky point when using any kind of language to describe dance: the object is not an object, is dancing, an act which after the performance, the end of dancing, is not there anymore. In Fig. 2.the relation between an extract of the Labanotation score is shown, in particular we have a Jump with preparation on both feet apart in low level, touch of both feet in low level in the air, and landing in both feet apart in low level, so in this case the reader interprets this as a "Jump" a concept referred to the "object" the act of jumping in this particular way. Here we need to stress that the concept "Jump" is not the word "Jump" itself (words are symbols as well), but is the concept, a general class of "jumping moves" one brings in mind when using the word jump or reads related score. If we take into account the different interpretation one can give to concepts, the use of words might be confusing, although unavoidable. For example S. Fdili Alaoui [18] uses the term "jumping" metaphorically to express one specific quality of movement in Emio Greco's dancing vocabulary. Therefore we have same word, but different concept.

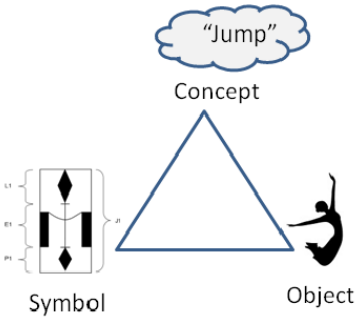

Fig. 2. The Labanotation triangle of meaning

We address this challenge by basing our model on the Labanotation system and its terminology, writing rules in Description Logics, otherwise a concept (or a Class in a an owl ontology) is not of clear "meaning". Even if we humans can understand the difference from the context, a machine cannot. For example, in DanceOWL the hierarchy of a Hop is as follows: *Movement hasSubClass Action, Action hasSubClassJump, Jump hasSubClassHop*

The definition of concept "Hop", in Description Logics, is the following

$$Hop \equiv Jump \sqcap ((\exists hasPreparation.SupportOnLeft \sqcap \exists hasLanding.SupportOnLeft) \sqcup (\exists hasPreparation.SupportOnRight \sqcap \exists hasLanding.SupportOnRight)).$$ [17]

So in DanceOWL, a Jump and its subclasses have specific semantics for the machine, which is also open to integration with other kind of vocabularies, if we of course formally describe their "meaning" in the same language. Coming back, however to the semantic triangle, no matter how well defined the concept will be, the object itself, i.e., the movement performed in the real world can vary if performed by different people, or even by the same person in different circumstances. We are aware of the fact that no matter how much detail one can add to a Labanotation score what he gets might be a detailed useful representation, but this is still a script [3, 13] about the choreography. It is not the performance, but only a description or a prescription of it. In addition, no matter how formal or consistent one wants to be in a translation, there is no guarantee that in the semantic triangle of these two languages changing from one symbol to another won't cause a small shift and that the alignment will be perfect, especially now that is about something that is difficult to talk about. Therefore I quote Z. Brown's comment [10] on Labanotation: "It's not a technically rigorous system. A lot of the ideas expressible in notation rely on subtle poetic interpretations. Often the meaning of a piece of notation can only be understood by asking, "what might the author have meant when they wrote this?". Well, this is true. This is why this translation is very challenging. On the other hand the goal of interpreting Labanotation into XML, RDF, OWL or any other semantic computer language is not to substitute the work of notators, and dance experts [3, 39], is to create tools that enhance and enable the communication between one form of digital dance descriptions and another [10]. Semantics about dance and human movement is not the meaning of the dance or the movement, is simply to add common knowledge on data that otherwise is not searchable or usable. It might be useful for a dance student to search for a specific dance motif, e.g., "right turn, fall, then jump" which is available in different dance extracts, although this "similarity, on the motif level does not mean that all the above dance extracts are the "same" or "similar". If one wants to go deeper in the similarity of these dance extracts he has to go for the context and the provenance of these dance extracts.

5 Modeling Dance: Existing Schemas for Performing Arts

At this point, we briefly discuss existing Cultural Heritage models, and their possible application in the field of Dance. Although the following models are created for Museum and Libraries, we examine these schemas as a Library shares the objective of

our Knowledge Base to help user to *find*, *identify* and *obtain* [11] things. The CIDOC Conceptual Reference Model (CRM) [7] provides definitions and a formal structure to enhance interoperability between different data and metadata models in cultural heritage documentation. The FRBR model (Functional Requirements for Bibliographic Records) was designed as an entity-relationship model by a study group appointed by the International Federation ofLibrary Associations and Institutions (IFLA). The IFLA model distinguishes four level of abstraction from ideational content to the physical (or digital) item: The *Work*, the *Expression*, *Manifestation* and *Item*. Nevertheless, in the case of dance the realized and embodied "object" is the last thing one can have in hand: it is not an object such as a book or a file, it's an event. Here there is a kind of paradox when we try to apply this model on Dance, stemming of the fact that Manifestation is defined as "The physical embodiment of an Expression of a Work" [19]. If we want to be semantically correct, the embodiment of an Expression of a dance Work is the dancing process itself, the ephemeral phenomenon which happens in a specific time and place incorporated by the performers. The embodiment of an Expression of a Dance Work is not the prescription, neither the description, or the digital object that is created by the recording of using video, motion capture or other media.

The FRBRoo [20] is a formal ontology intended to capture and represent the underlying semantics of bibliographic information and to facilitate the integration, mediation, and interchange of bibliographic and museum information. FBRoo is the outcome of FRBR/CIDOC CRM Harmonisation. In 2008 M. Doerr and C.Bekiari [11], presented an FRBRoo for perforiming arts. FRBRoo declares therefore three classes: F20 Performance Work, F25 Performance Plan, and F31 Performance, interrelated as follows: F20 Performance Work R12 is realized in (realizes) F25 Performance Plan, and F31 Performance R25 performed (was performed in) F25 Performance Plan. In the case of theater as a form of performing art there is also the need to differentiate between Performance-Work e.g., Shakespeare's Hamlet, the Production and the Individual Performance, as C. Doty [12] states. Nevertheless, in the case of theater, especially if we talk about a famous classic written play, the script exists before any Performance Production or any Individual Performance in physical or digital forms (book, pdf, etc.). This is not the case with dance, which although it might have been documented using notation, usually one does not expect to have the movement of the Dance Work "written". Moreover, in most of the cases the Labanotation or other scores are created after or during the performance for documentation and archiving purposes. So score is rather a description not a prescription, which means that a score is more like a recording (F21Recording Work) rather than a script (F25 Performance Plan) [11]. Of course, any score which have been created as a F21 Recording Score can also serves later on as a F25 Performance Plan in performance reproduction from the score. In addition, the above discussion is meaningful in the case we are talking about *Dance Work(s)* e.g., Swan Lake where dance is considered a form of Performing Art, a subcategory of Performance Work, Nevertheless, another critical question is if the above vocabulary is appropriate to describe dance as a social phenomenon or a physical form of entertainment, therefore use these vocabularies to describe folklore, traditional or social and popular forms of

dance. In common language usually we use simply the word “dances” to describe the different types of dance which have specific name e.g., jig, or mambo and specific “steps and variations”, referring to specific Dance Types, or Dance Genres. Later on we will discuss the relation between the notion of “dances” with *Dance Type* and *Dance Record*, as represented in DanceOWL.

6 DanceOWL: The Dance Ontology

The DanceOWL is based on the concepts of Labanotation [22]. It is built to provide an expressive machine understandable schema to arrange formal and common knowledge about dance movement. The concepts of Labanotation about movement are used to translate original Labanotation scores into DanceOWL *Scores* to make them accessible, searchable and subject to further analysis and complex computational processing. The open world assumption of Description Logics fits perfectly to the domain of dance description, as our aim is not to provide a close template to define what dance is, but to build a core data model about the movement that is open to possible integration for different applications, e.g., video annotation, motion capture indexing or wikis enrichment for educational purposes

The ontology was engineered using OWL-2, within Protégé 4.1 which supports SHOIQ(D) expressivity, combined with Pellet reasoner which is capable for Sound and Complete Reasoning. SPARQL queries where executed within Eclipse framework for JAVA using JENA API. The current edition of DanceOWL, which is in progress and subject to continuous enhancements, consists of ~350concepts and rules, ~100 relationships , ~720 individuals (experimental data) and 4000 axioms.

The advantages of this approach are the following:

- *Reasoning & expression of complex rules*: As OWL is based on Description Logics, it provides a formal language to express complex inference rules and relationships, enhancing the expressivity of the knowledge-base. Reasoning capabilities support reuse of entities, and allow the system to infer new knowledge from the stored dance knowledge, e.g., a gesture is a movement, as being a subclass of the first.
- *Extensibility*: By using OWL, the knowledge model which is extensible and easy to be integrated with related knowledge, i.e., origin, history and music .
- *Searchability*: The Knowledge Base can easily searched by SPARQL queries or browsing within Protégé.
- *Movement Hierarchies:* The ontology allows to express movement categorisation , either by *Extension*, i.e., Step1 and Step2 isa Step Forward, or by *Intention* i.e., *Step*≡*Step* ⊓ ((∃ *hasDirection.Forward*) , therefore any Step which satisfies this condition is a StepForward.
- *Temporal Modeling*: In the DanceOWL time is represented in a similar way with Labanotation as it is expressed in measures, and beats. Movements are modeled as intervals and the synchronization of them is expressed with properties like

"hasNext", "isSimultaneous", ismetby" based on Allen's temporal relations of intervals [1].

- *Human Body Representation:* Based on the rich vocabulary and number of symbols that Labanotation offers a part of the ontology is dedicated to represent the Human Body and the relations between the various parts and perspectives i.e., joints, surfaces, points, areas.
- *Human Readability:* The terms that are used to describe the movements and their characteristics are simple words, based on the literature of Labanotation system. Although, someone can claim that someone has to be familiar with Laban Movement Analysis to fully comprehend the meaning of these terms, it is far more readable than an ascii file, or any other numeric expressions created by Motion Capture. Moreover, Laban Movement Analysis is an established system used worldwide since the 20's, supporting communications among movement analysts.

7 Modeling Movement: Linguistic Approaches

As also explained in detail in [17] the ontology expresses movement by Labanotation characteristics: Space (e.g., Level, Direction, Size), Time (e.g., ST01 hasNext ST02, ST01isDuring AG, ST01hasDuration Quaver), Body (e.g., Right Elbow, Upper Left Leg), Dynamics (e.g., Strong Accent, Tremolo), Effort (e.g., Flick, Float) and Type (e.g., Support, Turn, Relationship, Contraction). Nevertheless, when we talk about movement as spatiotemporal entity, or a specific activity, what's the "segment" we refer to? To this point we will introduce the dance- language analogy as it was presented by A.Kaeppler [25]. This analogy is in the terms that we can use the linguistic morphology analysis tools to study dance structures of a specific area or group of people, i.e., a dance genre's movement vocabulary. (Table 1)

What it is important in this segmentation technique of movement is that is based on what "makes sense" in a particular dance genre. For example if we consider Ballet a dance genre, one does not expect to find kinemata, i.e., movements of the pelvis in the scores of this genre, as they are not part of its movement vocabulary. This point brings to light the fact that dance segmentation is related to the knowledge of a specific language. For example, a ballet dancer can easily select a "pas de chat" on a Labanotation score and classify the symbols into a larger unit, because the "pas de chat" movement (or morphokine) makes sense to his dancing language. To this point, the DanceOWL serves as a dance genre independent "language" to describe the small simple movements and characteristics (at the level of elements or kinemata) in a way a score can do. Once the knowledge of the score, is inserted to the ontology, having the sequence and synchronization of these small movements, this knowledge can be subject to further analysis, by more complex temporal queries and aggregations. Nevertheless this analysis and search for larger movement units requires specific dance genre knowledge. Our future work includes the addition this kind of knowledge, starting with Greek dance expressions from Thrace.

Table 1. -Dance Language analogy

Language	*Kaeppler*	*IFMC*
Phoneme	Kineme	Element
Morpheme	Morphokine	Cell
Word	Motif	Motif
Language Clause		
Sentence	Phrase	Phrase
Larger Grammatical Unit	Larger Grammatical Phrases	MacroStructures
language or Language Genre	Dance Genre	Dance Type

In relation to Kaeppler's linguistic model, we would like to add, that the word *Dance* is not referring to dance as an art form in general, but to "a dance", a dancing language, genre or type which is danced in a studied area and era. This distinction between the notion of *Dance* as a general human cultural, physical and artistic phenomenon and dance genres (or "dances" in common language) is analogous to the distinction between *Language*, the general human capacity for acquiring and using complex systems of communication, and language(s) which is any specific example of such a system.

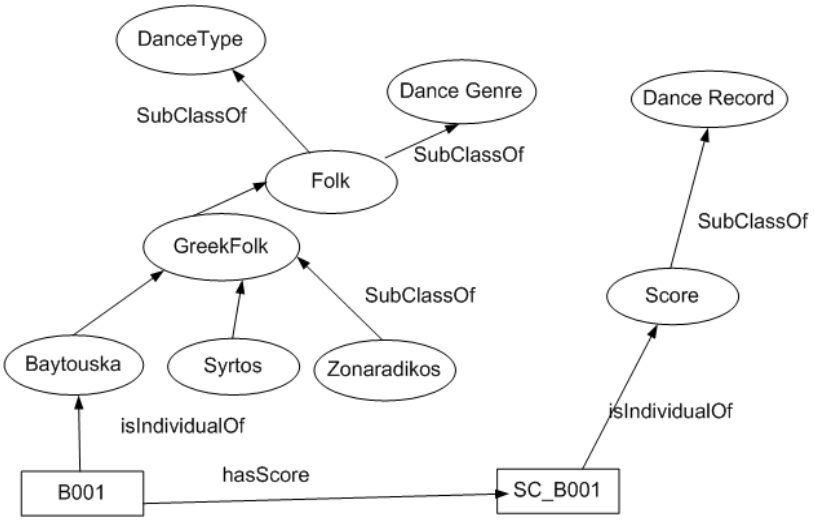

Fig. 3. Dance Type and Dance Record

Ceusters & Smith [6] state that if we want to "represent" dancing, we must have a good insight of what dancing is. In our previous paper [17] we presented a simple hierarchy under the notion "Dance". In fact what we were referring to with the word Dance was the Dance Type (IFMC) or the Dance Genre (A. Kaeppler) [25]. In the latest version of DanceOWL, the instances of this Dance Type Class are particular

dance “expressions” of a very specific dance type which are scored, e.g., D001D isa (individualOf) GreekFolk as it was performed, recorded and scored at a very specific time and place, by specific people.

In the latest version of DanceOWL, Dance Genre or Dance Type is referring to the type of dance e.g., Ballet, Contemporary, Folk, Traditional, Greek Folk, etc. The subclasses of the Greek Folk help us represent a simple hierarchy. Example: "B001" is an (individualOf) Baytouska, Baytouska isa (SubClassOf) GreekFolk, GreekFolk isa (SubClassOf) Folk, Folk isa (SubClassOf) DanceType. In addition Folk hasOrigin some Region, and B001 hasScore SCB001 which is individualOf Score, which is SubClass of DanceRecord. So in this way: 1) we make clear that a scored extract e.g., B001 is not the dance type itself, but only one of many individuals of this dance type, an “expression” of it recorded in a specific place and time, and 2) we differentiate between the dance expression itself and the score which in this case is a type of Dance Record.

At this stage we are evaluating the ontology and experimenting with scores, from the repository of Thrace Dance. The interpretation of the scores is added manually according to the specifications –relations to Labanotation. These Labanotation scores are outcomes of anthropological onsite research and have been created onsite, after interviewing the local dancers. They represent different dance expressions of specific dance types and genres of Greek folk, e.g., the “Zonaradikos” dance. It is very important to test with such different expressions in order to later on find the similarities by comparing small amounts of dance reality provided that it is described in the same language (i.e., Labanotation) and by the same team with the same goals (in these case Thrace’s researchers).. The strength of a documentation tool lies on its ability to represent dance knowledge as it is coming from the creators of the movement or the analysts and not to provide a template on what a dance should be.

8 Conclusion

Since the nature of dance, either as a performing art form, a cultural, social phenomenon, or an entertainment physical activity, is an ephemeral event that exists once it is embodied by the dancers, we can only have tangible items which are related to the dance such as videos, descriptions, printed images, used objects and costumes scores and scripts about the movement in different forms. Nevertheless, “dance data”, including movement descriptions in a variety of forms and granularities are living and growing everyday in the web of things and objects, and recent research assesses the need for data models that are based on formal notation or other scripts, to exploit theoretical and practical dance knowledge. There is high need to organize data and make this knowledge accessible for further computational automated analysis and a basis for building user interfaces and tools for educational purposes [4], research or creative applications.

Having in mind that all notation are partial descriptions and that the different forms of movement descriptions are complementary, we took advantage of the semantic web technologies, to build an extensible data model that can be easily related to other similar models e.g., idiosyncratic vocabularies or history of the dance.

The contribution of this work is making movements of choreographies and dance extracts searchable in different granularities, in a machine understandable way while using terms that have meaning for the user. By developing a core model, based on a formal language such as Labanotation, we are aiming at putting another piece in the puzzle of dance knowledge which is available online in various forms. We envision a future where the dance related knowledge will be interlinked, machine understandable, human accessible and searchable by all users.

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