A Labanotation Based Ontology for Representing Dance Movement

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Abstract. In this paper, we present a Knowledge Based System for describing and storing dances that takes advantage of the expressivity of Description Logics. We propose exploiting the tools of the Semantic Web Technologies in representing and archiving dance choreographies by developing a Dance Ontology in OWL-2. Description Logics allow us to express complex relations and inference rules for the domain of dance movement, while Reasoning capabilities make it easy to extract new knowledge from existing knowledge. Furthermore, we can search within the ontology based on the steps and movements of dances by writing SPARQL queries. The constructing elements of the ontology and their relationships to construct the dance model are based on the semantics of the Labanotation system, a widely applied language that uses symbols to denote dance choreographies.

Keywords: Semantic Web Technologies, Ontology, Description Logics, Dance Notation, Labanotation.

1 Introduction

Recently many significant systems have been developed to preserve cultural heritage through contemporary computer and web technologies. Nevertheless, only few of them have been dedicated to dance heritage preservation [11]. In this work, we develop an expressive, dance-style independent model to represent the kinesiology of dance and create a searchable knowledge base that enables us to search for specific movements in dance. Dance choreographies can be archived by the following methods [4], [20]: Motion Capture (MC), video recording, and dance notation (printed or computer-based). MC technology enables motion data to be stored easily, recording the physical aspects of movement (joint positions, velocity, acceleration), but usually requires specialized expensive systems. By using motion capture or video technology, we record a particular performance of specific dancers including personal style-even mistakes- rather than the choreography itself. In the case of MC, the problem of modeling and handling the motion data captured-which is usually expressed in markup languages [3]-still exists while video cannot be human or machine searchable unless they are annotated using semantics. On the other hand, dance notation systems provide a mean to theoretically study the choreography itself, rather than its specific performed versions. Some of the dance notation systems first appeared during 15th century and till now more than eighty have existed [10], although only few of them

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persisted through time, such as Feuillet, Benesh, Eshkol-Wachman and Labanotation. Introduced by dance artist and theorist, Rudolf von Laban in 1928, the Labanotation system, uses abstract symbols to describe movement, providing a well-structured language with rich vocabulary and clear semantics, based on Laban Movement Analysis (LMA). Labanotation usage for all types of dance style, theater plays, sports and gymnastics analysis and documentation in academic research, for more than 80 years, makes it one of the strongest notation. systems worldwide. In contrary to other systems, it captures not only the directional, but also the qualitative aspects of movement (Dynamics, Effort). In addition, LMA serves as useful foundation not only for designing dance documentation software but also for modeling human computer interaction based on movement and gestures [6][16],[19]. In this paper, we use the Labanotation System as the main guideline for -developing a Dance Ontology, transferring the semantics underlying symbols into concepts and relationships. This task proved to be quite challenging, as in many cases movements in Labanotation are not expressed by one and only symbol, but by a combination of more symbols and their placement on the Labanotation staff.

2 Related Work

Archiving dance can also be achieved using software applications that are based on notation systems. This field has a huge potential to reach, as it combines the established dance knowledge with new technologies. To what follows we present some of the most significant LMA-computer based systems, such as Labanotation graphic editors, e.g., LabanWriter [15], Labanatory [14], Calaban [2], and LED & LINTEL[8], which are used to create scores in digital form. Some of these editors have the ability to transform the digitally created scores into 3D animation e.g., LabanEditor [12], LabanDancer [21]. Nevertheless, the problem with the above software is that the user has to be able to produce the symbols of Labanotation, while only few dance practitioners and theorists can read and even fewer can write Labanotation scores. Based on LabanXML [18], Hatol [7] has developed a markup language (MOVEMENTXML) transferring the semantics of Labanotation symbols. Based on a similar idea, we create an ontology transferring the semantics of Labanotation into OWL entities, so that representations are both human (at least for the ones that are familiar with basic dance concepts) and machine-understandable. Moreover, in our work, the use of the ontology provides the ability to express complex relationships, restrictions, and rules about the concepts, creating hierarchies and graphs of movement entities and properties, and as a result provides a rich vocabulary for describing dance movements in different level of detail.

3 Challenges and the Dance Ontology Approach

In the created ontology, we represent the most important concepts underlying the symbols of Labanotation, and we enrich the ontology with concepts and relationships to enhance the expressivity of the model. It is important to state that our goal is not to develop a Labanotation Ontology, but -a Dance Ontology based on the movement concepts of the Labanotation System. In what follows, we present the main advantages of a Labanotation-based ontology in addressing the main challenges of digital dance archiving:

- To preserve choreographies in an expressive searchable way, we need a strong theore-tical basis that allows us to describe the required elements of dance. In dance, we cannot predefine a limited set of specific movements, as the human body acts within the extremities of its movement range, creating innovative spatiotemporal entities and dynamics through endless combinations of possible positions, body parts relationships, rhythms, qualities and also face expressions .Thus naming the type of movement (*what*) and the main body parts (*who*), is not enough for describing dance. Timing (*when*) and quality (*how*) of movement are equally important. Based on the Labanotation System, our model captures all of the main parameters of dance movements: Time, Space, Dynamics, and Body Parts [9].
- Style in dance is one of the most difficult qualitative features to be captured [17], as it is associated with structural and qualitative features of the dance itself, as well as other parameters which are not directly related to the dance movement (e.g., social and historical context, music style, costumes) [13]. Aiming at developing a universal model which will be capable of describing a wide range of human movement independently of the contextual parameters of dance, we do not assume a particular style or technique. Instead, we develop the concepts that are required to describe the structural and qualitative stylistic features, as this is important when we need to compare similarities in dances of different eras and areas.
- In the need for a model to implement applications that can be used by non-experts in notation, we must use concepts rather than complicated combinations of symbols and organize these concepts in a higher level of detail. In our approach, we create a hierarchy/taxonomy of movements, by clustering them into abstract categories. This hierarchy supports the scalability of the system by giving the opportunity to search movements in different levels of detail e.g., search for arm gestures or specific dapping movement of extended fingers. As OWL is based on Description Logics, it allows us to express complex inference rules and relationships, enhancing the expressivity of the knowledge-base. Reasoning capabilities support reuse of entities, and allow the system itself to infer new knowledge from the stored dance knowledge, e.g., a gesture is a movement. To examine a detailed example, let's see the case of hop, a specific type of jump. In dance theory, we analyze a jump into three stages: preparation, elevation, and landing (in Labanotation three individual symbols -or group of sequential symbols are used) and we categorize jumps depending on preparation and landing and in particular, if the action is on both feet, on the same or on the other foot. We use the concept (Class Entity) "Hop" for jumps where preparation and landing is on the same foot. The hierarchy of this Class is as follows:

  Movement →Action→ Jump→Hop

  According to this analysis, the definition of concept "Hop" in Description Logics is the following:

  $$\text{Hop}\equiv\text{Jump} \sqcap ((\exists\ \text{hasPreparation.SupportOnLeft} \sqcap \exists\text{hasLanding.SupportOnLeft}) \sqcup (\exists\text{hasPreparation.SupportOnRight} \sqcap \exists\text{hasLanding.SupportOnRight})).$$

- By using OWL, we build a knowledge model that is extensible and can be further on integrated with related knowledge, i.e., origin, history and music of folk dances.
- Another challenge stems from the use of OWL itself and is related to the representation of timing and sequencing. We address this issue adopting a methodology similar

to the one applied for representing amino-acid sequences in proteins, using OWL [5]. In particular, each dance consists of temporal entities following one another, organized in staffs (kinetographs), phrases, and measures.

4 The Dance Ontology Classes

The main classes of the created Dance Ontology model are the following:

- **Dance:** refers to the abstract concept of dance categories, and not the choreography. Examples of Dance subclasses are Solo, Group, Round, Folk Dance, Greek Folk, Dance etc. Instances of this class are Waltz, Calamatianos, Zonaradikos etc. In ontology engineering, expressing a concept as a subclass or an individual usually, is not a one solution problem, rather than a decision which relies on the general context of described domain. For example, Zonaradikos could be an individual of the ontology if we expect to have only one type of Zonaradikos, but it should be a class if we consider it a category of Dance which has many versions. The intention of this extendable hierarchy, which can be further associated with other concepts e.g., *"Zonaradikos hasOrigin Thrace and Thrace isPartOf Greece",* is rather indicative and serves to organize general dance knowledge, but it does not reflect a specific study on styles, genres, and dance classification.
- **Movement:** the subclasses of this class and their associated properties form the core schema for the dance movement analysis. Subclasses of Movement 1) can either have a one- to-one relationship to Labanotation symbols e.g. Contraction, Extention, Step, Support, Gesture, Relationship, Turn and specialization of them, e.g., Bend, Arm Gesture, Limb Rotation, Forward Step, or 2) more complex Actions and Positions e.g., Double Step, Feet Parallel, Jump, Stamp that are expressed by a combination of symbols. In the knowledge base, the individuals of Movement class, the movement instances, represent the building blocks of the "scored" choreographies. These building blocks usually can be subclasses of more than one class movement, e.g., *"AG1 isa ArmGesture and isa LimbRotation"*. In addition, some of the movements classes are defined through DL rule expressions (as Equivalences or Subclasses) e.g.,

  $$Clap \sqsubseteq Action \sqcap Touch \sqcap (\exists isActedBy.Hand) \sqcap (\exists hasDynamics.StrongAccent)$$

  In fact, we represent only the basic rules; however, it is not effective to exclusively express all possible rules for all possible movements and postures of all dance techniques, and styles, if this would ever be feasible. In addition, OWL tools have some performance issues when using too many complex rules, and the reasoner system responds too slowly. Our goal is to include in the model the required dance parameters of space, time, dynamics and body parts considering them the different "degrees of freedom" of the complex "system of the moving human body". Thus we do not define classes of default movements, only general types of movements e.g., a Turn class describes an abstract action of turning, however, different versions of turns are represented by different instances of the Turn class, which have specific properties (direction, degree, level, and axis) and optionally consist of other instances of simultaneous movements and sequential stages describing the details (e.g. legs and arms positions or gestures during the turn).

- **MovementChar:** this class includes the space and dynamic parameters e.g., Direction, Size, Accent, Effort etc. that are needed to characterize the Movements instances using object properties e.g., *"S1 hasDirection Forward"*.
- **Stage Object:** refers to any human or inanimate object that may occur on a (real or imaginary) dance stage and has as subclasses the Performers and their Body Parts, Groups of Performers, Costumes, Stage Parts, Stage Areas, e.g., Floor , Stage Points, and Corners e.g., FLCorner.
- **ScoreElement:** this class and its subclasses represent the kinetograph and the staffs that are used in Labanotation to score a specific dance- movement analysis. A Dance instance e.g., Calamatianos has one or more instances of Score and each Score has one or more Staff (we need only one staff for a group dance where all performers do the same choreography or a solo dance). Each Staff contains Phrases, Measures, Temporal Entities, Start Positions and finally movements. Each Measure individual has properties such as Meter e.g., 3/4 , Tempo and Unit e.g., ♩=120

5 Human Body Representation

In contrast to many human body computer models for analyzing movement which use a skeleton model or a stick figure description [3], Labanotation offers a wide variety of symbols referring to different parts, joints, areas, surfaces, and other details of a "flesh and bone" body (e.g., eyes, tips of finger). Also note that Labanotation system may be used to describe the same movement shape (at least for the untrained observer), in many different ways, e.g., tilting the head (joint) backwards and moving face (surface) up may produce a similar shape, but the emphasis on different body part may define a difference in dance style, and demand a different "feeling" on the body of the performer [1]. In addition, a specific usage of body parts in the description, help us recognize familiar movements in a specific technique. For example, a ballet-technique right leg "passé" or "retire" is usually notated as "upper leg has direction right side and has level middle and lower leg has direction left side and level middle" rather than "right leg has direction on place and level low it is contracted 3 or 4 degrees", although the two description produce a very similar shape.

Adding body details to our model allows us to be more specific in description, and be able to compare details later on, in movement search. In our ontology the Performer class has Body Parts, and the Body Part class has the following subclasses:

- Body Joint: e.g., Elbow, Wrist, Ankle, Knee.
- Body Area: e.g., Torso, Chest, Pelvis, Waist.
- Limb: e.g., Arm, Leg, Upper Arm, Lower Leg.
- Surface: e.g., Face, Back, Palm.
- ArmPart: e.g., Elbow, Shoulder, Upper Arm, Hand, Right Hand.
- LegPart: e.g., Leg, Left Foot, Hip, Right Knee, Both Legs.
- BodySide e.g., Right Side (Right Hand, Right Leg), Left Side.

Some body parts are subclasses of more than one class e.g., a Right Arm is a Right Side part, an Arm Part and a Limb Part, this complex hierarchy serves again to search in different level of detail, by actually clustering body parts in many different ways.

In Labanotation a single body is represented by a staff and its columns and different bodies by different staffs. In our model, we have Performers class individuals, related to the respective Staff to represent group dances where each individual has his own choreography.

6 Interpreting Labanotation into OWL

In the process of transferring the semantics underlying the Labanotation symbols to the ontology, the translation into words and phrases of natural language was unavoidable, which is no surprise, as Labanotation is actually a (symbolic) language [7] [9]. Nevertheless, following the general rules of translating physical language into OWL was not always a straightforward task, considering the spatiotemporal nature of movement and all the related philosophical questions expressed on representing processes and change. Ontology engineering recommends translating names into Entities (Classes and Individuals), verbs into Properties and names or adverbs into Values (e.g. Arm1 moves High). To simply use triplets such as "Hand1 Touches Face2" to represent Relationships of Labanotation (expressed with bows, hooks, or pins), would mean that Hand1 touches Face2 forever! To address this, we express a touch as follows:

- R1 isa Touch (subclass of Relationship)
- R1 hasActiveMember (subproperty of isActing and hasMember) Hand1
- R1 hasPassiveMember (subproperty of hasMember) Face2.

In our case, where we don't actually talk about body parts moving but about entities of movements, N-ary relationships are represented between each building block of movement , all of its characteristics (BodyParts, Direction, Level, Effort etc.) and also among movements (M1 hasNext M2, A1 hasMov M1). Each instance of Movement is characterized by the following:

- The type of Movement (e.g., Contraction, Relationship, Step, Turn, WeightTrasfer, LevelChange, Location, Space Facing)
- The object properties describing Space e.g., *hasDirection, hasLevel, hasSize*
- The object properties describing Dynamics e.g., *hasAccent, hasDynamic, hasEffort*
- The body parts involving in the movement action or position), e.g., *isActedBy, hasMember*
- The simplest movements that can be analyzed e.g., a Double Step consists of three small, quick steps, thus *hasMov S1, S2, S3.*

Also note that OWL is an Open World Assumption language, which means that we expect knowledge to be incomplete. In our case, we do not expect to have values for all the above properties, but we add properties and values only if we have specific information about this aspect of movement. Not giving values to properties could either mean two things: 1) no specific knowledge is available about this aspect of movement, or 2) it is considered insignificant detail, e.g., we don't describe finger positions, or even palm direction in all arm gestures unless this is part of the choreography. Usually, we assume a "standard/normal" position for the rest parts of the body, for example, in a Step, unless the head takes part in the choreography doing an "important or different from usual move", we do not notate anything about the head, thus it is assumed that the head follows the standard position (place-high).

One of the strong advantages of Labanotation is that, in the typed score, the reader has the whole image of the choreography, so the trained eye can catch familiar "word movements" [9] and then focus on the details. In the Dance Ontology approach we represent these different levels of details by the encapsulation of the analysis which consists of a sequence or a combination of Movement individuals, inside the main movement instance. For example, the Labanotation score, in Figure1, represents a jump (J1) with specific details in each of its 3 stages: preparation (P1), elevation (E1), and landing (P2). Next to the figure, we analyze this example as expressed in ontology.

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

$$SimpleJump \equiv Jump \sqcap ((\exists hasPreparation.SupportOnBothLegs \sqcap \exists hasLanding.SupportOnBothLegs))$$

In addition the following hierarchy occurs for the object properties *hasMov* → *hasJumpStage*→ *hasPreparation, hasElevation, hasLanding* and hasMov is a transitive property, which means that *if a hasPreparation b, then a hasMov b and if a hasMov b, and b hasMov c then a hasMov c,* so the new knowledge that results from Reasoning is that J1 isa SimpleJump *and* hasMov P1, E1, P2, S1, S2, R1, LG1.

- *J1 isa Jump*
  - *hasPreparation P1*
  - *hasElevation E1*
  - *hasLanding P2*
- *P1 isa Position*
  - *hasMov(hasSup) S1*
- *S1 isa SupportOnBoth*
  - *isa FeetApart*
  - *hasLevel Low*
- *E1 isa Elevation*
  - *hasMov (hasLegG) LG1*
  - *hasMov R2*
- *LG1 actedBy RightLeg1 and LeftLeg1*
  - *hasLevel Low*
  - *hasDirection OnPlace*
- *R2 isaTouch*
  - *hasMember RightLeg1*
  - *hasMember LeftLeg1*
- *L1 isaPosition*
  - *hasMov(hasSup) S2*
- *S2 isa SupportOnBoth*
  - *isa FeetApart*
  - *hasLevel Low*

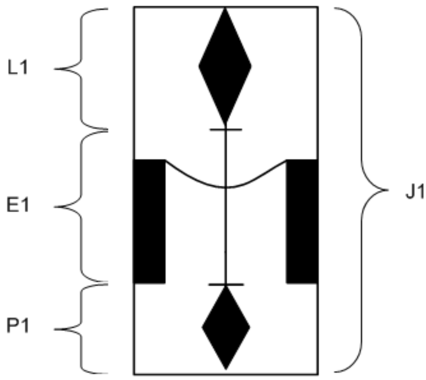

Fig. 1. Jump from an open position to an open position and a touch during the lift

7 Storing a Choreography–Where Is Time?

Labanotation scores are read bottom to top, and the duration of each movement is realized by the length of the symbol. Whatever is in parallel is simultaneous, while the sequence of symbols indicates the sequence of movements. Timing can be free or measured (in measures, counts/beats or subdivisions of beats) and usually a metronome indication is included to indicate the tempo. In the Dance Ontology, we need to represent all this information, without applying a tight schema, which would reduce the flexibility. The goal is to represent time and sequence in such manner that if we want to represent effectively both untimed sequences of movements and measured staff, without being inconsistent and thus be able to somehow compare these two representations. The second question is if the time units that we use, whether they are measures, beats or subdivisions, indicate the start and duration of movement entities. The answer is no, at least no rule can be applied for all cases, and this is why we should be able to represent independently movement entities (that are represented by a group or a sequence of symbols) and rhythmical units such as phrases, measures, beats, and temporal entities that indicate the rhythmic motives. For example, if we say that the measure consists of four beats, this does not mean that we have four instances of movements, one for each beat, bur each movement starts whenever something changes in movement itself (a new Relationship, Position, Direction, Effort etc.) and has its own duration. Nevertheless, we assume that in all cases, staffs are divided into measures, represented by Measure individuals and have tempo and meter. Example:

- *Measure 1 isa Measure*
  - *isContentOf Staff1*
  - *hasBeatUnit quaver (=eighth)*
  - *hasTempo 120*
  - *hasMeter 5/8*

Where: *hasBeatUnit* is an ObjectProperty having Measure as domain and Beat as range, *hasTempo* and *hasMeter* is a Datatype Property having Measure as domain and a string as range. Then the Measure is devided into Temporal Entities which have duration (*hasDuration* is an Object Property with Beat as range). These Temporal Entities may have longer, smaller or equal duration of beats and represent the dance count. Movements on the other hand have their own duration (hasDuration) which may be longer or smaller than these Temporal Entities. In this way we have the sequence of counts (Temporal Entities), but without restricting the duration of the Movements. For example in a ¾ waltz triplet where the count is 1,2,3 the feet make 3 steps (one for each beat), but the arm movement may last 2, or 3 counts.

To what follows we give a detailed example of a Greek folk dance that shows the relation of rhythm and movement instances and our approach. Usually dance practitioners use the term "step" to refer to a more complex group of movements e.g., a Double Step, or a skimming Skip, or a Step-Close sequence, but in our ontology a Step has a very specific meaning (means a unique Weight Transfer and a Support Change from one Foot to the other with specific direction). In addition, in the Greek Folk, as in many other dances, the "steps" are always associated with the rhythmic motif of the music. When teaching the different versions of Tsamikos dance e.g., the one with "16 steps", we actually don't count neither 16 "movement instances" (as in "step 1"a double step occurs and is actually a sequence of three Steps), neither we count 16 beats, (as the 16 “steps” actually represent a rhythmic –dance phrase which consists of 8 measures having ¾ meter, and the rhythmic motif “ slow (2/4) – fast (1/4), slow (2/4) – fast (1/4) etc”, so step1, 3, 5,7 etc have double duration of step 2, 4, 6 etc.).

So in our approach, trying to add this knowledge but without affecting the philosophy of our model, we divided the Dance Score in Phrases, Measures and in Temporal Entities, which have different duration and correspond to the dance “steps” rhythm. In this case, we have two types of sequences and durations: one between Temporal Entities, and one between the movements. Below, along with Fig. 2, a detailed analysis of our system is presented . Please note that the Labanotation symbols here have no specific meaning in terms of movement type and direction (shape) or level (color) but only in terms of sequence and duration (length).

In the example, note that temporal relationships, e.g., hasNext are expressed both between Temporal Entities and Measures, but also between Movements, as temporal knowledge of these two classes is supplementary.

- *TsamikosStaff is a Staff*
  - *hasContent Meas1, Meas2, Meas3*
- *Meas1 hasNext Meas2*
  - *hasContent TS1, TS2*
  - *hasMeter ¾*
  - *hasBeats 3*
  - *hasBeatUnit crotchet (quarter note)*
- *Meas2 hasNext Meas3*
- *TS1 hasNext TS2*
  - *hasDuration minim (quarter note)*
  - *hasMov DS*
- *TS2 hasDuration “crotchet (quarter note)”*
  - *hasMov S4*
- *DS isa DoubleStep and hasMov S1, S2, S3*
- *S1, S2, S3 isa Step*
- *S1 hasNext S2*
- *S3 hasNext S3*

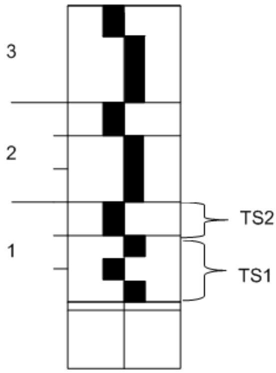

Fig. 2. The 3 first measures of “Tsamikos” Greek dance where each measure has 2 temporal entities of different duration

The idea is that a group of movements, within the same Temporal Entity, does not necessarily form a new “movement instance”, while sequences or group of movements in different sequential Temporal Entities may (but again not necessarily) form a unique “movement instance”, i.e., a movement entity that can be stand alone and can be represented by Movement subclasses (e.g., a Double Step, a Jump, a Skip).

8 Implementation and Search

The ontology includes about 300 classes, 500 individuals and 80 properties and is developed using Protégé 4.1.0. This version of the software supports OWL-2 with SHOIQ(D) expressivity, and Pellet reasoner. Note here that although the general idea is that the classes and properties provide the schema whereas individuals represent the specific entities of scored dances, however, this is not always the case as many movement characteristics are also defined as individuals (e.g., Forward, Right and so on are individuals of the class Direction although directions are part of the "schema", i.e., the model description and not the "data".

First, in the ontology we analyzed and stored seven Greek folk dances: Baytouska, Calamatianos, Chaniotis, Fissouni, Syrtos, Tsamikos, Zonaradikos, that are originated from different areas, creating a pilot knowledge base, however, the sample at this stage is very small to enable any comparative conclusions and evaluation of the model itself. Nevertheless, this pilot knowledge base is considered a first step to evaluate and plan the appropriate process of building the dance repository. At this stage the experiment was to explore how straightforward is to use the system developed to analyze dances not by reading the Labanotation scores, but by following simple description using a Greek dance teacher's book. What came as a conclusion from this process is that, however strong is the theory that the dance model is based on it will not reach its potential, unless the data acquisition is based on the same theory and expressed in a similar language. Developing a model language for dance description does not address the challenge of analyzing and documenting the dance.

The second part of the experiments included search of the ontology using SPARQL queries executed within Eclipse framework for JAVA using Jena API and Pellet reasoner. This allows us to search for small sequences of movements with specific characteristics. For example the following query returns the movement individuals that consist of three movements in row and the name of the dance which include them:

```
SELECT DISTINCT ?a ?d WHERE {
?m1 rdf:type  dnc:StepWithRight.
?m2 rdf:type  dnc:StepWithLeft.
?m3 rdf:type  dnc:StepWithRight.
?m1 dnc:hasNext ?m2.?m2 dnc:hasNext ?m3.?m1 dnc:isOn ?a.
?m2 dnc:isOn ?a.?m3 dnc:isOn ?a.?m1 dnc:isContentOf ?t.
?m2 dnc:isContentOf ?t.?m3 dnc:isContentOf ?t.
?t dnc:isScoreOf ?d.?a rdf:type dnc:Movement}
ORDER BY (?a)
```

9 Limitations and Future Work

One of the weaknesses of our approach is that by using concepts and entities instead of symbols on paper (or on a screen), is that we can hardly represent complex shapes that cannot be described in words and thus concepts. In the following example we describe a starting position in space and a simple circular path, but what if the path follows a more complex shape (e.g., non-symmetrical spiral)?

- P1 isa Circular Path
  - hasTurnDirection Clockwise
  - hasTurnDegree ¼
- L1 isa Location (Relationship)
  - hasActive Performer1
  - hasPassive BLCorner

- SF1 isa SpaceFacing (Relatioship)
  - has Active Performer1
  - hasPassive FRCorner

The same stands for complicated Floor Patterns especially when many performers take place. Another limitation which stems from the fact that we lose the whole image of a printed score is that, if we search for specific movements we can't always guess the shape resulted unless we know what is done in the previous movement. For example, if we search for movement instances where the "elbow is middle, right side", we will get "frames" where the elbow is in the required direction and level, but the whole arm shape is different depending on the previous level and direction of the whole arm. Moreover, in each "frame, whether it is an action, position or temporal entity, we do not describe the shape of all body parts, but only of the parts that move/ change position. In Labanotation, it is assumed that the "inactive" parts hold in a "normal/standard" position according to the context or dance style. Respectively, if we want to have the whole picture of the body shape we have to go back to previous frames, or even try to guess the "normal" position according to the context of dance, an aspect which is not taken into account in our model.

Another challenging issue is raised from the fact that, even if we use the simplest words to describe movements, an essential sense of analyzing movement is required to interpret the description into the imaginary movement. For example, the normal place for the chest-rib cage area is not middle-forward as one would easily say (thinking of the rib cage as the front surface of chest), but high on place, following the rule of Labanotation that direction is measured from the "free end" of the body part in relation to the "basis" of the joint which produces the movement). Thus a description of a chest movement/position forward middle means a forward down tilt of the rib cage. To overcome this issue, we are in the process of creating a detailed dictionary which would accompany our system explaining in detail each class and property along with pictured symbols of Labanotation and paradigms. In this paper, we present a "language": a model for the Dance Representation, but this model cannot substitute the process of the analysis which requires many work –hours of experts such as choreologists, and notators.

The work outlined in this paper is only the beginning in a longer-term effort to create a universal dance repository with advanced storage, indexing, search, and analysis capabilities. Our future work will be more focused on adding "data" from existing Labanotation scores and experiment on them to implement more usable ways in searching movement instances, sequences, and patterns. This "data migration" will be held under the supervision of dance theorists and practitioners that we have contacted already. Additionally, our plans for future work include enhancement and extension of the dance ontology, as we are in continuous discussion with dance practitioners. So far we are working with a dancer/dance teacher and an experienced ethnochorologist, and we plan to get feedback from more practitioners during the future development phases of applications. These future experiments will also include the description of more challenging score examples from different dance styles, as scores of a specific dance style may not provide the variety of movement examples need to evaluate and extend the model.

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