A Conceptual Framework for Creating and Analyzing Dance Learning Digital Content*

Katerina El Raheb
University of Athens & Athena
Research Center
Greece
kelraheb@di.uoa.gr

Sarah Whatley
Coventry University
UK
adx943@coventry.ac.uk

Antonio Camurri
University of Genoa
Italy
antonio.camurri@unige.it

ABSTRACT

As they are mainly based on bodily experiences and embodied knowledge, dance and movement practices present a great diversity and complexity across genre and context. Thus, developing a conceptual framework for archiving, managing, curating and analysing movement data, in order to develop re-usable datasets and algorithms for a variety of purposes, remains a challenge. In this work, based on relevant literature on movement representation and existing systems such as Laban Movement Analysis, as well as working with dance experts through workshops, focus groups, and interviews, we propose a conceptual framework for creating, and analysing dance learning content. The conceptual framework, has been developed within an interdisciplinary project, that brings together technology and human computer interaction researchers, computer science engineers, motion capture experts from industry and academia, as well as dance experts with background on four different dance genres: contemporary, ballet, Greek folk, and flamenco. The framework has been applied: a) as a guidance to systematically create a movement library with multimodal recordings for dance education, including four different dance genres, b) as the basis for developing controlled vocabularies of dance for manual and automated annotation, and c) as the conceptual framework to define the requirements for similarity search and feature extraction.

CCS CONCEPTS

Applied computing → Arts and humanities → Performing arts

KEYWORDS

Conceptual Framework, Movement descriptors, Movement Qualities, Dance Education

1 INTRODUCTION

Dance education and practice is multimodal and diverse by nature. Defining technical requirements for capturing, managing and analysing movement data to become useful learning content, as well as designing tools to provide meaningful learning experiences, to facilitate the need for a variety of dance genres might become a challenging and complex problem. Putting together such different cases such as contemporary dance, ballet, Greek folk and flamenco it is almost impossible to find one solution to fit all. The conceptual framework described in this work emerged as a contribute towards the necessity to find common concepts across dance genres which can lead to computational models, while still making sense for the dance practitioners of the different dance genres. The proposed conceptual framework serves as a common ground in investigating questions such as "what characterizes a movement sequence and a good performance of a student?", "what can be considered as similar in movement?" and "how we can tag these sequences to make them re-usable by dance practitioners?".

2 RELATED WORK

Most of the relevant efforts to represent body Movement, are based on the Laban Movement Analysis and the Labanotation system[20] for analysing and notating movement[8][21][24], and other notation systems such as Benesh [28] or Eskhol-Wachman [12]. Other attempts focus on providing semantic frameworks for annotating dance multimedia content of specific dance genres e.g., Indian dance [23][27]. Calvert[2] presents the shared interest across disciplines in the representation, analysis, composition and visualization of the movement of articulated structures in general and human bodies in particular. Ceusters and Smith[6], in their article explain the need to semantically represent movement in multimedia recordings, such as videos, for various purposes. De Beul et. al.[7] propose an approach for semantic annotation of movement in the videos that is based on ontology models and semantic concept classifiers based on the semantics of the Benesh Movement Notation (BMN)[28].

In previous work, El Raheb et. al. [8] have presented a Knowledge Based System for describing and storing dances that takes advantage of the expressivity of Description Logics. In a more recent work [11], based on choreological approaches for analysing the structure of dance they distinguish between the different abstraction levels in describing human movement. Based on this logic, the BalOnSe (Ballet Ontology for Annotating and Searching Video Performances) platform [9][10] is a web ontology- based application for annotating dance video performances, with archival and user management functionalities. Fileto et al [17] propose Baquara, an ontological framework for movement data that focuses on the description and semantic classification of motion trajectories. Golshani et. al. [22] propose a multimedia information system for automating the human process of comparison and analysis of human movement, with focus on dance movement. Last but not least, LMA has been used by Aristidou et. al. as the conceptual framework for analysing emotion in movement [1]. Fdili-Alaoui et. al. [13] investigate how LMA can be integrated as a method for observation in the design of movement-based computational systems, introducing also the issue of negotiating consensus amongst experts, even if they are trained and certified in LMA, while in a more recent work [14] they highlight the diversity of modalities and sensing systems needed to capture qualities, in a way human expert need and do in their practice. The need of an interdisciplinary, multimodal approach to describe and characterise movement in digital media such as videos was also investigated by the TKB project and the work of Fernandes et. al. [15][16]. Based on previous work in literature, and by extending existing frameworks such as LMA, we suggest a conceptual framework which emerged through an interdisciplinary dialogue amongst not only technologist and dance practitioners, but practitioners with completely different dance genre background and philosophy on movement, and dance practice. In a similar direction, Piana et al.[26] Glowinski et. al. [19] and Varni et. al. [28] propose computational models and software libraries to measure automatically expressive qualities and emotions from individual and group movements, in dance and for other applications including therapy and rehabilitation. The main aims of this framework were to create a common ground vocabulary for preparing and capturing dance movement sequences which reflect common educational objectives, and allow the re-use of these sequences in various context (teaching, learning, choreography, and research) In other words, the framework serves as a core indexical vocabulary for multimodal search of movements in a large movement archive; blending movements in the repository to obtain sequences useful for education; and possible applications beyond dance, e.g. the reduction of mocap sessions by reusing existing mocap fragments

3   HIGH LEVEL CONCEPTS IN DANCE TEACHING AND PRACTICE

The teaching, learning and practice of dance is multidimensional, reflecting the diversity of dance, which is an art form comprising numerous different dance genres, creative methods, pedagogical principles and learning contexts. Historically, dance has been taught, learnt and created within an embodied situation; the various actors involved are most often in direct physical relationship with each other. Dance has thus largely been taught and learnt through a teacher, facilitator or choreographer

providing direct information to the learner/dancer, which may be through physical demonstration, touch and verbal instruction or cueing (which may include technical information, imagery, tasks, etc.) The rise of digital technologies opens up new opportunities for augmenting the 'live learning environment' of the dancer through the development of tools that expand teaching and learning methods – and this is the focus of the work in the WhoLoDance EU project. By bringing together a consortium of experts in dance practice and teaching, and experts in computer science and engineering, motion capture and human movement science, one of the first tasks in WhoLoDance was to identify high level concepts and tasks in dance teaching and practice that would benefit from the integration of technology on human movement. A conceptual framework comprising Movement Principles, Movement Qualities and Actions was developed to provide the ground for identifying common properties of different dance genres and, at the same time, to determine the requirements for developing applications to support dance education.

Each dance genre is a complex movement system. WhoLoDance focuses on four different genres: ballet, contemporary, Greek folk, and Flamenco. A challenge is to explore the effectiveness of a shared conceptual framework broad enough to inform the same technology to support teaching. This selection is not intended to fully represent the field of dance and each dance genre is itself a broad category but limiting the scope whilst ensuring adequate breadth was necessary to explore and discover the challenges towards a shared conceptual framework.

The devising of the conceptual framework required the dance experts to share their experiences of teaching, learning and making dance, identifying established methods and imagining what could enhance and augment their practice. Methods covered a broad spectrum ranging from direct mimicking of the teacher/leader on one extreme to a more open task-based approach on the other. What emerged as important for the dance experts were tools that would enhance the 'live' exchange by revealing new insights to the teacher/learner about the movement being performed (at a micro level or at a macro structural level) or new information about the dancer's understanding of sensation and her own corporeality, and that would provide an equivalent experience of the 'live' environment when the dancer was practicing without the benefit of the teacher/leader present. These broad concerns informed the early dialogue with the scientific-technical experts and formed the foundation for establishing the main components of the framework: Movement Principles and Movement Qualities, which both have a relationship with a sub-component, Dance Actions. The Movement Principles have been used as concepts that can be seen in different dance genres. For example, in Greek Folk dances which are mainly chain and round or line dances, and suggest specific steps and form, rhythmical steps and footwork is a main aspect. Under this perspective the Movement principle of "weight bearing vs. gesturing" becomes a major aspect in this dance genre. At the same time, though through a completely different technique and form it is a major (though not the only) aspect also in Ballet and Flamenco. In addition, it is the core of Laban Movement Analysis and Labanotation System since it differentiates between the support on a body part (usually feet) vs. leg gesturing. In this case, the Movement Principle is suggested both by three dance genres -through specific form - and Laban systems. Contemporary dance experts on the other hand, have used a generative approach to create new movement material and exercises based on the

principle, in order to capture, and store in Library, and add to it different qualities or details. In this way, the use of the Movement Principles, create a basis where instead of capturing, storing and searching named or recognized steps of a particular Greek dance, the library would allow the re-use and critical reflection on the different ways that movement principles can be interpreted, performed, annotated, and blended with other movements. Such an approach aims at allowing the end user, student, teacher, choreographer, or researcher not only to find commonalities and differences across dance genres but to explore the peculiarities in how each dance genre or performer might interpret the same common, high level concepts.

Movement Principles have been also thought as chapters to guide the design of the end-user learning experiences. While one of the main outcomes of the project is a movement library of captured dance sequences, which can be searched, annotated and visualized with different avatars and visualizations, the higher-level concepts provided a guide for both visualization and interaction. For example, independent of the dance genre, some avatars are more suitable for extending the discussion and conveying *fine motorics vs. gross motorics or* directionality of the body parts (Fig.1), while others seem more suitable for visualizing the *motion through space* and the volume of the body (Fig.2). In addition, the Movement Principles are used to organize and characterize the segments as most related to a particular objective of the teacher or a weakness of student and to also create a hierarchy of difficulty. For example, some movements require a higher level of understanding and performing Balance and Alignment than others.
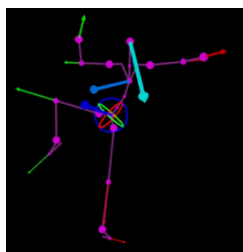

Figure 1. Avatar created inspired by Directionality

Figure 2. Avatars showing "Motion through space[1]

As the tools have developed, the Conceptual Model has revealed its value in offering a schema/taxonomy that can be adopted and adapted for a wide range of projects that are attempting to develop new tools for accessing, analyzing and evaluating various dance and movement systems.

4   THE CONCEPTUAL MODEL IN BRIEF

Based on relevant literature [4, 12, 22, 23], consortium expertise, and user's requirements as expressed through workshops, focus groups, interviews and questionnaires, we distinguish between two main aspects that are important in dance teaching:

- *Movement principles*: the main principles, skills that are related with dance teaching and can be seen as learning

objectives related to biomechanics (the use of space and time) of movement;
- *Movement qualities*: the dynamics and general feeling of the body qualities refer to "how" the movement is executed, what are the dynamics of the movement;
- *Dance Actions* are a sub-category that contribute to these main aspects, and consists of actions that draw from and expand on those proposed by Laban: Bending, Extending, Step, Turn, Jump, etc.

The Movement Principles emerged from the need to find a common language amongst the partners and to provide some parameters, given the diversity of dance practices and the many characteristics that determine the particular dance genres. The work focused on what linked all the dance genres and the underpinning concepts and principles that can be seen to be a feature of all dance genres, however emphasized. Not only did we need to find a common language for describing and discussing dance, we needed to find a framework that is transferable and meaningful to others working on devising structures and schema that will form a basis for analysis, for those working within the dance community as well as computational science experts. Decisions were made relatively quickly through agreement amongst the dance partners in the consortium who have expertise across the range of dance genres that feature in the project. Deciding on a finite list of Movement Principles (ten in total) was necessary to begin work on the project relatively quickly. Moreover, each Movement Principle could legitimately stimulate lengthy discussion about how the principle manifests in each dance genre and how individual interpretation, informed by experience, proclivity and language differences might influence understanding. The framework here played the role of thinking and creating commonalities across dance genre instead of working four completely isolated dance world conceptualizations. The idea behind this was what if we would extend this movement library with other dance genres? In that sense, the concepts were thought as also indexical vocabularies for enriching and finding movement in the created library. A typical Greek dance movement library would be organised by names of the dances, songs, regions, which is of course needed taking into account its cultural heritage nature and relation with tradition, however leaving way the aspect of movement, which will make it more accessible to users who are not familiar with Greek tradition. For example, a contemporary dancer with no flamenco or Greek folk dances, with no knowledge of the terminology of these dance genres, might find connections and inspirations through movement qualities or principles.

Noting that there are existing taxonomies of dance movement that have been drawn upon in the teaching and learning of dance, such as that developed by the movement teacher, theorist and artist Rudolf Laban (1879 – 1958) and his successors, forming Laban Movement Analysis (LMA), the consortium was wary of 'reinventing wheels' and thus looked to Laban's schema as a reference point. Valuable though LMA is for dance and movement analysis in a broad sense, (which focuses on the analysis of Body, Effort, Shape and Space), we needed a more distilled conceptual framework that would be sufficiently broad to encompass different dance genres, hold relevance for different teaching and learning
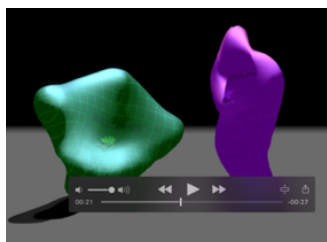
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[1] motekentertainment.com

methods and would provide the base structure from which could be developed a related schema of dance qualities and dance actions. LMA is also not widely used within the dance user community, due in part to it being a Western-centric system so is not 'genre neutral' as is sometimes assumed so has limitations as it currently stands. Furthermore, the framework needed to be sufficiently focused to support the development of different digital applications. Nevertheless, as we later explain, the proposed conceptual framework, do not contradict or aim to substitute systematic models such as LMA, but to include concepts which are more targeted to the creation, and re-use of motion capture sequences for both educational and other contexts. It is true, that LMA extends dance genres, although not all dance practitioners, are familiar with this terminology and discourse or actually using it in their everyday practice. The ten Movement Principles that were agreed at the start of the project and have formed a foundation for the conceptual framework are:

Symmetry: the ability to perform with both right and left side of the body, arm or leg the exact same movement, simultaneously or sequentially, both in position and in motion. As for the other principles, it also includes the opposite, the capacity to play with asymmetry and isometry.

Directionality: the awareness of body orientation in space. Usually this is derived from the position of hips and torso, but interesting postures might derive from various directions of each body part in relation to a specific space, e.g., the audience, camera or studio.

Balance: the ability to stand and move in balance, but also out of balance, depending on whether the line of gravity falls within the line of your supporting limb(s), or not. It relies on the awareness of the different vector forces on your body.

Alignment – posture stability: the awareness of the geometry of the body (e.g., the sagittal, horizontal, vertical axes) and planes, and how the relation of different body parts and joints create "lines" in the body shape.

Weight bearing vs gesturing: this principle concerns the capacity to distinguish between movements implying bearing weights (e.g., weight transference, stepping) and gestures which simply involve an analogous intention/expression.

Gross vs fine motoric/isolation/articulation: the ability to distinguish small movements executed by specific body parts (e.g., hand, hip, shoulder) without moving the rest of the body, from those moving larger parts of the body as a whole.

Coordination: one of the most important skills in every kind of dancing, it represents the ability to synchronise (or not) different parts of the body, that can move in the same or separate tempos.

Motion through space: the capacity of progressing through space, towards particular directions, paths etc., versus dancing on the spot. Also, the use of body as a moving point in space, or as a continuously changing moving volume.

Rhythm and phrasing: the ability to move in particular (predefined or improvised) rhythms. This principle also implies how the dancer's movement is related (or not) to the music and its rhythmical aspects (tempo, time signature, rhythmic patterns etc.).

Stillness: while movement seems to be the essence of dance, a dancer needs to improve her/his ability to remain still, either if it is part of a choreography or interpretation of rhythmical pauses, or an exercise for balance and isolation of body parts. Stillness is related to 'presence'; the ability for the dancer to be bodily aware

and has been investigated in previous interdisciplinary work, both from the artistic, experiential [18], as well as computational perspective [5].

It is important to clarify that the Movement Principles are seen as different "chapters" of teaching within the Learning Scenarios and serve to organize the process of producing and organizing the teaching content. For this reason, they do not necessarily represent directly measurable properties of movement, but rather higher level complex concepts (in some cases amodal) which are further analyzed into lower level features and specific definitions in this document.

On the other hand, recent research [5][19][28][26]and results from the DANCE EU H2020 ICT Project (dance.dibris.unige.it) led to novel computational models and software libraries to model and measure automatically mid- and high-level movement qualities, including the Movement Principles here described, and their *analysis variables* such as *saliency* and *predictability* [25]. See [5] for an overview of the proposed movement qualities.

The possibility to measure automatically Movement Principles, and in general movement qualities, and their context can be an important contribution to the teaching process, by supporting the evolution, "narrative structure" of the teaching per course, where the same principle may have different importance and meaning according to the preceding and subsequent evolution of movement.

5 METHODOLOGY AND ITERATIVE EVALUATION

Devising the conceptual model seemed to work for the consortium members, even when it exposed some interesting conversations between different dance experts because of different emphases in the practice. For example, whilst contemporary and ballet dance is a practice that is familiar with the discourse of movement qualities, Greek folk dance does not ordinarily discuss movement qualities, developing expertise through practicing complex stepping patterns, working as an ensemble or in couples, and moving in close relation with the musicians. Similarly, flamenco is developed on particular expressive properties, often rooted in particular narratives or, as with Greek folk dance, regional variations. The breadth of experience amongst the dance partners enriched the conceptual framework but it was necessary to test our thinking within a much broader dance practitioner community, to check on the validity of the framework and expand (or limit) where necessary. The first round of this iterative approach included a questionnaire to all dance partners including the following sections:

1. Questions to dance experts of all dance genres
   - Define a set of movements/movement sequences that are connected with the movement principle.
   - How important is this principle for your dance genre-style?
   - Give two examples-learning scenarios of teaching the particular principle.
2. Questions to technical partners
   - Do you see the connection between the movement principle, and the low-level features we should capture analyse? Is there a challenge/obstacle?
   - Is there any related work in your institution in capturing-analysing this particular movement principle?

A series of online surveys, questionnaires, workshops and interviews were delivered by consortium members to elicit further thoughts based on the experience of dance and technology experts. In particular, two online surveys including 38 and 71 responses respectively have been received, 48 extended questionnaires, 19 interviews and two participatory workshops with 31 and 35 participants have been held.

We targeted dance teachers within private schools, in conservatoires, and those in further and higher education across a broad geographical area, as well as dance practitioners representing a broad spectrum of dance forms. We also surveyed the experience of technology experts who have had a track record of working with dance and dancers. Initial surveys provided valuable data about working practices and expectations for how technology can enhance the teaching, learning and making of dance. The majority of the responses endorsed the schema we had devised, confirming that the conceptual framework was widely recognized by the wider dance community.

All of the interviewees recognized the movement principles and were able to identify some that resonated more with their practice than others. For example, directionality, co-ordination, motion through space and alignment were important for teaching for some participants. When performing, two participants shared that they would think about the same principles as when they teach, indicating that these principles are foundational knowledge and personal to their practice. Each interviewee appeared comfortable with the principles as presented, suggesting that the movement principles identified and categorized within the project were appropriate and meaningful for the dance practitioners.
We were thus able to conclude that the movement principles are widely recognized as a useful foundation to most dance practices. During two participatory workshops (Fig.3 and Fig.4), participants have worked in groups to provide examples of matching dance genre, movement principles with particular tools of the projects, prototype visualizations and interactions.

Figure 3. Participatory workshop in Athens

Figure 4. Participatory workshop in Thessaloniki

When asked about the integration of digital tools, the overriding responses asked that technology should be portable, accessible and affordable. Many dance practitioners were excited about the possibility of digital tools that would enable them to analyse, record and reconstruct dance movement in 'smarter' ways. Dance teachers looked forward to tools that would provide access to dance content that would support students when working independently and would encourage more reflexivity in learning.

Remote surveying led to a series of focus groups and user-board sessions to deepen the discussion with representatives from major dance companies, dance houses, journalists and other stakeholders to gain further feedback and direction for developing the tools. The answers have been given both through text and verbal descriptions, as well as through particular life examples which have been recorded and uploaded on a dedicated vimeo channel[2].

The outcomes of the validity checking were tested further within the early phase of videoing selected, typical movement 'sequences' from each dance genre that embodied particular movement principles. The videos were made to generate a large repository of movement sequences, from which selections were made for the motion capture phase. The data that emerged has been the basis for subsequent analysis, informing the development of the tools and applications.

6 THE CONCEPTUAL MODEL IN DETAIL

6. 1 Symmetry

Symmetry is defined as the use of the two sides of the body (right vs. left side, arm, leg) etc., both in position and while moving (Fig.5 and Fig.6) . It is the ability to do the same thing simultaneously or sequentially using both sides. For example, in natural continuous walking, there is not one moment that the body is in a completely symmetrical pose, but each step is sequentially symmetrical to the other. This is actually an example of mirroring one pose or a motion. Each Movement Principle includes also the opposite. Playing with asymmetry and isometry is included in this principle. An extension of the Symmetry principle including Dynamic Symmetry, as well as other movement principles, is included in the EyesWeb software library for the automatic analysis of movement qualities[25][4]that has been experimented in WhoLoDance also in a dance performance by Stocos (Muriel Romero and Pablo Palacio). The use of the two sides of the body in different combinations had been the basis of different movement analysis and notation systems. The body has an ideational division, by way of the spine, into two halves, the right and the left [20].

Figure 5. Symmetrical pose
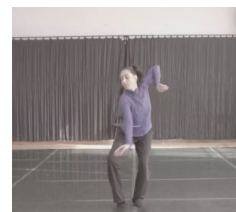
Figure 6. Asymmetrical pose

To define symmetry, we need to define an axis reference. The human body is (almost symmetrical) to the vertical axis and the most common way to define a pose as symmetrical is if the limbs are symmetrical (Left and Right Arm in the same direction, level,

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bend or extended equally, rotated equally). The following list includes the concepts which have been used to prepare and organize the movement sequences which were related with the Symmetry Movement Principle: On Spot vs. Travelling, Symmetry in time vs. Shape symmetry (in a pose), Asymmetry, Isometry, Sagittal and Horizontal Symmetry, Symmetry and travelling.

6. 2 Directionality

Directionality is defined as the awareness of body orientation in space. Usually it is derived from the position of hips and torso, but interesting postures might derive from the various directions of each body part in relation to a space, e.g., the audience, the camera, the studio. The awareness happens when we relate what we do to a reference formal system; the difference of just dancing a variation, or dancing it being conscious of its relations to the planes, axis or points of the cube.

In other words, this Movement Principle or learning objective, is about the ability of a dancer to orient and direct the different parts of his body to specific directions, both while being a) on spot or in a pose, and b) while moving. If we are talking about specific forms or shapes that are required from the dancer in a dance genre, directionality, as a learning objective or skill is essential. For example, if the choreography requires that the head is directed towards the High Diagonal Left Corner, then this should be the case.

This principle actually can help create a checklist for the dance learner, to check his relation to personal space and peripheral space, in other words, orientation. Orientation refers to where the dancer is heading to as a whole, while moving across space or on spot, where the dancer is facing, and where is the dancer "front". The orientation of the body is usually felt as being established by the pelvis, and torso. The learner might ask:

What is the orientation of the body in space (en face, diagonal, - facing the audience-camera, profile, etc)? Are there directions to which the different points of the body are pointing (e.g., elbow backwards)? What are the directions to which the different surfaces of the body are pointing? e.g., torso to the forward right diagonal. How might the geometry of the body (Shape) be accessed by checking where different body parts are directed while they move; what are their trajectories? Do they have the right starting and ending point? Is the trajectory the right one (line, curve, a specific shape)?

This short list, which can be enriched with more details, creates the need to define the following:

- Space (inner and outer)
- System of reference (defining location/position and orientation)
- Axis and Planes (Transverse Vertical, and Sagittal)
- Directions - 9 (Forward, Backward, Diagonal Right Forward, Diagonal Left Forward, Diagonal Right Backwards, Diagonal Left Backwards, Right, Left, Place) x 3Level (High, Middle, Low) =27 directions
- Body Parts in terms of joints (points e.g., elbow), lines (e.g., line of the upper arm), surfaces (e.g., chest or palm).
- The cube and the Planes of the Cube (Frontal, Right Side, Left Side, Back, Ceiling, Floor)
- Trajectories and paths

Directionality in relation to body parts, has three main aspects:
1. Positioning of the body parts: This refers to what is the direction that the body parts are "looking at", in a still position or pose (neither the body as a whole or the different body parts are moving). These body parts can be: a) joints (e.g., knee, elbow), b) surfaces (e.g., palm, face, front of the chest), c) bigger body areas or volumes (e.g. chest, rib cage, pelvis).
2. Trajectories of body parts (on spot): This refers to what are the trajectories of the different body parts, while being on spot. For example, gestures of arms and legs while being on spot.
3. Trajectories of body parts (travelling): This refers to what are the trajectories of the different body parts, while the body is travelling through space as a whole. For example, gestures of arms and legs combined with walking through space.

6.3 Balance

Balance relates to the ability to stand and move in balance, but also out of balance, depending on whether the line of gravity falls within the line of the dancer's supporting limb(s) or not. The awareness of the different vector forces on the body. There are two main possible states as shown in the figures a)Being in Balance (the center of weight is within the support, as shown in Fig. 7), b) Off Balance (Fig.8)

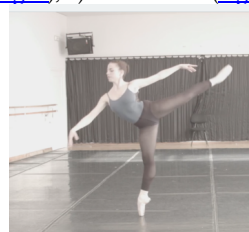**Figure 7. Arabesque in balance**

Figure 8. Arabesque off balance

6.4 Alignment

Contrary to Directionality which refers to the body relationship of the body with the outer space, Alignment refers to the virtual lines of the various body parts and points while standing or moving. The following list includes the concepts which have been used to prepare and organize the movement sequences: Alignment between different body parts, horizontal, vertical and sagittal, alignment, using the 3 planes of the body, alignment in free movement, alignment while moving on spot, creating and virtual lines between two different body parts e.g. chin and shoulders, elbow and hand, alignment and balance, virtual sliding lines, virtual stretching lines, virtual matching lines and virtual rotating lines. Virtual lines in particular are a clear example, of how a generic principle lead to particular visual imagery which eventually can be translated into a virtual digital experience. 6.5 Weight bearing vs. Gesturing

This principle is about the difference between movement that is concerned with bearing weight (weight transference, stepping, handstands, etc.) and movement (gesture) that is not bearing weight, but which has intention/expression. It is about the

difference of using a body part as weight bearing part, or a free moving gesturing part" transfer of weight, changes of support.

6.6 Gross vs fine motoric/isolation/articulation:

Two core concepts have been used to prepare and organize the movement sequences which were related with the Gross vs. Fine Motorics Movement Principle: Isolation of different body parts and isolation of upper vs. lower body.

6.7 Coordination

Coordination is one of the most important skills practiced in every kind of dancing, which is about the ability to synchronize or not different parts of the body that can move together or independently. The following list includes the concepts which have been used to prepare and organize the movement sequences which were related with the Coordination Movement Principle.

6.8 Motion through space

Motion through space is about progressing through space or towards particular directions, paths etc, in contrast to dancing on the spot. It also refers to the body as a moving point in space, or as a continuously changing moving volume. This principle also includes sub-concepts such as Trajectories, Shapes (angular, spiral, curved, serratic), Undulating vs. straight lines.

6.9 Rhythm and Phrasing

This principle refers to the ability to move in particular (predefined or improvised) rhythms. It is also about how the dancer's movement is related or not to any accompanying sound/music and its rhythmical aspects (tempo, time signature, rhythmic patterns etc.).

6.10 Stillness

While movement seems to be the essence of dance, a dancer needs to improve her/his ability to remain still, whether this is a part of a choreography or interpretation of rhythmical pauses, and exercise for balance and isolation of body parts. Stillness is usually connected to the notion of being present and has been investigated in previous interdisciplinary work, both in artistic [18] and computational context[4].

7 MOVEMENT QUALITIES: EXPRESSIVITY IN DANCE EDUCATION

Although the mapping between a specific way of moving and a particular emotion is not only difficult to achieve, it is also out of the scope of dance learning in most genres and practices. However, exploring different ways to perform a particular movement, and experiment with different qualities is an essential part in dance education. Understanding these different qualities and being able not only to execute steps and specific movements but perform these movements in more than one way in order to express an emotion or feeling state is often part of a dancer's education. In our work, focusing on investigating bodily knowledge and enhancing creativity in dance in an educational and training context, we consider the following framework:

1. We use as basis the definition of Movement Qualities as explained by Camurri et.al [3][4]. For this reason, we dedicated a

number of recording sessions, focusing mainly of Movement Qualities (21st-23rd of March 2016 in Genoa) where the dance partners, with background in contemporary practices, improvisation, choreography and movement composition rehearsed sequences in order to improvise with the focus on specific Movement Qualities.

2. We consider the framework of Laban Movement Analysis (LMA) and its Effort-Shape components, which analyses the qualitative aspects of movement, rather than the form of it. Part of the extended list of Movement Qualities which is described in the conceptual framework of Camurri et. al [4], is based on LMA, since it is the most acceptable systematic model for analysing the qualitative aspects of dance by dance scholars, movement analysts, and movement computing experts, though it is not widely used by dance practitioners and dance teachers.

3. We distinguish between the a) perceived expressivity, b) calculated expressivity, c) indented expressivity and work on narrowing the gap between these three perspectives, through hybrid techniques of analysis, including automatic and manual annotations of experts, and focus groups for enriching and validating the results as well as the theoretical framework.

4. We accept the fact that perceived expressivity depends on or can be enforced by various modalities such as music, visual metaphors, and therefore we explore the ways the digital representations can enhance the understanding of expressive aspects within the learning scenarios. For that purpose, we have set some experiments for studying how the different avatars and visual metaphors can affect the quality of movement, expressivity, and creativity of contemporary dancers while they improvise. Although the number of the participants in early tests didn't allow for clear conclusions, all participants admitted that their movement in terms of expressivity was highly affected by the different avatars and visual metaphors.

5. Other than the conceptual and computational frameworks discussed in the literature (such as the one proposed by Camurri et. al [4]), for Movement Qualities there is no unique, universal vocabulary which is accepted by all dance practitioners and perceived or interpreted in the same exact way. During this research, we have focused the analysis of the recordings against a specific shortlist which consists mainly of Laban concepts (Fluid, Rigid, Fragmented, Sustained, Sudden, Heavy, Light, Direct, Indirect). By proposing this smaller subset of Movement Qualities and focusing on its analysis, we aim at identifying the commonalities and differences which exist in the interpretations of these quality -concepts, starting from our particular expert groups and focusing on four dance genres: contemporary, ballet, Greek folk and flamenco.

8 FRAMEWORK DEPLOYMENT

These concepts are applied through the interfaces, and applications, and serve as a core conceptualization for

- Enrichment of metadata schema for managing and searching
- Creating re-usable motion capture data for various purposes (across dance genre, non-verbal communication, dance-theatre, sports etc)
- A guideline to create digital dance learning content beyond dance genre and Motion Capture Pipeline scheduling.
- An indexical controlled vocabulary for manual annotation

- Annotation schema for search based on movement characteristics
- A conceptual framework for the High-Level Feature extraction, Similarity Search and Segmentation

9 CONCLUSIONS

In summary, as an interdisciplinary collective of dance and computational science experts, we have devised a framework that allows for a cross-genre analysis of dance practices, providing the necessary conceptual categories to assist in the building of tools to support the teaching and learning of dance. These categories include Movement Principles and Movement Qualities, which when examined in close detail, generate sub-categories that facilitate micro-level analyses that identify common features and distinguishing properties of different dance genres. The research is an initial step towards more general and integrated modelling of dance movements.

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