DANCE

D5.1 – Use Cases

Version	Edited by	Changes
0.2	UNIGE	First draft
0.3	KTH	Refinement section on sonification
0.4	UM	Refinement section on neuroscience
1.0	UNIGE	Integration and final check

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Introduction

This Deliverable reports the first version of Use Cases for which specific instances of the DANCE system will be integrated and evaluated. Such Use Cases take into consideration early feedback from blind and non-blind persons, dance artists (dancers and choreographers, including the famous choreographers Jacopo Godani, Sogi Gross, Virgilio Sieni), feasibility studies and proof-of-concepts in preliminary scientific experiments, and the public events SONAR+D (Barcelona) and STARTS Symposium (Brussels). The deliverable also specifies the technological requirements for WP2 and WP4. Preliminary experiments and a serious game (*MoveInTheDark*) to train users to learn interactive sonifications of their movement qualities include a 4-week Workshop at eNTERFACE 2015 (July-August 2015), and its testing in a public event at the Festival della Scienza (last week of October 2015 in Genoa).

The research described in this deliverable started from the analysis of the draft Use Cases described in the DoW, that stimulated feasibility studies, proof-of-concepts, preliminary experiments, and guidelines for the definition of movement qualities.

Section 1 presents start-up DANCE activities, and it sketches guidelines and early results towards the *DANCE Movement Qualities Repository*. Section 2 presents the Use Cases refined according to the feedback collected by these initial activities, including feedback from experts. In particular, a new Use Case based on the serious game *MoveInTheDark* is outlined.

Finally, section 3 defines the requirements for the technology platform and the experimental setups in the first iteration of the project.

The Appendix briefly describes an early table of movement qualities that are studied in the first phase of the project.

1. Startup DANCE activities

We formulated the guidelines and first hypotheses of movement qualities and of sonification models. Further, preliminary movement analysis, sonification, and neuro-imaging experiments with blind persons have been started, as described in the following sections.

1.1 Movement Qualities

We organized a number of Skype sessions and physical meetings with experts choreographers, including the following famous artists: Virgilio Sieni (http://www.sienidanza.it/, January and March 2015, planned meetings in September and October 2015), Sogi Gross (http://www.grossdancecompany.com/, January 2015), and, more recently Jacopo Godani. We organised a number of sessions with dancers at Casa Paganini-InfoMus (total of 8 dancers, including Federica Loredan, Roberta Messa, and Muriel Romero), and several sessions with the composer Pablo Palacio (http://www.pablopalacio.com/SONIC_DANCE.html). Future work includes multimodal recordings in collaboration with the choreographers mentioned above and the design and validation of interactive sonifications with the composer Andrea Cera.

Starting from literature on experimental psychology and HCI (e.g., Wallbott 1998; DeMejier et al 2001; Boone and Cunningham 1998; Camurri et al 2003), humanistic theories and the arts (e.g. Rudolf Laban's Theory of Effort), and from the meetings with above mentioned experts, we defined a first set of expressive movement qualities to be considered in the first part of the DANCE project, including smoothness, fluidity, weight (light/heavy), impulsiveness, Laban's Time dimension (sudden/sustained), symmetries, contraction/expansion, energy, synchronization, dynamics of relative directions of body parts (feet, hip, torso, shoulders, head). A preliminary table summarizing such features is whown in the Appendix. We hypothesized the definition of a common set capable to describe qualities of both individual and group movements: for example, synchronization can be at individual level (intra-personal synchronization of different body parts), as well as at group level (inter-personal synchronization of different individuals as parts of a group intended as a single organism); fluidity can refer to a set of body joints at individual level, or a set of measures of barycentres of dancers in a group.

We started the development of computational models and algorithms for the above mentioned qualities, starting from the existing state of the art within the consortium. A first feasibility study with dancers studied and analyzed a sample database of short "neutral" movements performed with different qualities. We developed a platform to obtain synchronized multimodal recordings based on the EyesWeb platform, and we collected a first sample of multimodal recordings consisting of motion capture, wireless accelerometers, respiration (via wireless audio microphones), and video data. This initial recording trial includes more than 100 segments of a few simple movements, focusing on single expressive movement qualities. Seven dancers participated to these recordings. Two of them (Roberta Messa and Muriel Romero) focused on individual movement qualities, 5 other dancers on group movements. Results from this feasibility study emerged in the preparation of the STARTS and SONAR+ events.

In parallel, we initiated a second feasibility study with the famous choreographer Virgilio Sieni (Head of Biennale Danza in Venezia, and founder of the CANGO Dance Company). After two preparatory meetings, we started a set of periodic visits to his dance company to analyze the creation and setup of specific dance projects (Atlante del Gesto), characterized by specific movement vocabulary by Virgilio Sieni, used with professional dancers, including a blind dancer, and amateur dancers. This work consists of a sort of ethnographic study, where research staff from UNIGE will participate as observers of dance rehearsals and will record videos showing the teaching and preparation of specific dance sections of "Atlante del Gesto". Two half-day sessions are planned in September 2015, in order to collect videos, and to start to analyze the expressive movement vocabulary of Virgilio Sieni.

The strategy is to follow two parallel approaches in DANCE: in the former (bottom-up), we start from very basic, simple movements and will study movement qualities applied to such basic movements. In the latter (top down), we start from the vocabulary of famous and consolidated artists (the first will be Virgilio Sieni) in order to try to discover part of their expressive vocabulary.

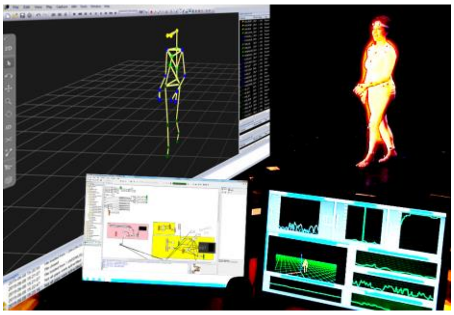


Figure 1. An excerpt from a synchronized multimodal recording session (Qualisys motion capture and accelerometers) to investigate the movement qualities to be considered in the project. Dancer Roberta Messa. April-May 2015

1.1.1 Requirements for the DANCE Movement Qualities Repository

An explorative study towards a *DANCE Movement Qualities Repository* identified the following typologies of movement:

a. Basic, elementary movements of an individual;
b. Basic, elementary movements of groups of individuals;
c. More complex movements in ecological scenarios, including the contribution of artists/choreographers, also grounded on artistic "Studio" dance works;

Basic movements

Very simple, basic movements, not evoking signs or language correlates, not stereotypical, used as carriers of different expressive qualities.

In general, movements can be performed and observed from different perspectives:

- *Space scale*: Kinesphere level: one finger, hand, arm, upper body, whole body, group (internal dynamics); General Space Level: whole body, a group of individuals as a single body, multiple groups;
- *Pathway*: Central Pathway (movement initiated from or passes through the center of the body), Peripheral Pathway (movement along the outer limits of the Kinesphere), Transverse Pathway (movement passing between the center of the body and the periphery of the Kinesphere);
- *Direction*: sagittal (depth), horizontal (side-side), vertical directions;
- *Inclination*: Flat inclinations (diagonals deflected by the side-side dimension, horizontal or lateral), Steep inclinations (diagonals deflected by the up-down vertical dimension), Suspended inclinations (diagonals deflected by the front-back sagittal dimension).
- *Level*: High Level (e.g., leaping and springing off the ground), Central or Middle Level (bodies leading with more sensuous movement), Deep or Low Level (earth-bound movements)

Examples of simple movements considered as "carriers" of our first set of movement qualities are the following:

Movement 1: SineWave & StraightBack air drawing

Draw on air (with a finger, a hand etc. depending on the Space scale) one period of a horizontal sinusoidal movement followed by a straight line to return back to the start position. Single movement or repetitive.

Movement 2: "Infinite shape air drawing", or "left-right loop"

Draw on air the symbol of "infinite". Repetitive.

Movement 3: Ellipsoid

Draw on air ellipsoid movements, with different Pathway, Direction, Inclination.

These three types of movements have the following characteristics:

- They are very simple and basic human movements, not requiring any particular skill
- They can be performed rhythmically, periodically;
- They can be performed with quite a large number of expressive qualities (sudden, fluid, rigid, contracted/expanded…)
- They can be scaled up/down in the space scale;
- They are typical "building bricks" of a large number of more complex movements: e.g. the movements of an orchestra conductor, the ancillary movements accompanying speech.
- We do not assume a fixed starting position, each movement can be performed starting from different initial postures, initial states, originating variations of the movement in terms of difficulty, equilibrium/balance, and of the above list of variables.

In the future we may consider also Laban's *choreutic (or space harmony) scales* as other examples of simple movements.

More complex movements in ecological scenarios

In parallel to the bottom-up approach described in the previous section, we defined a plan to approach the study and modeling of the concrete "expressive vocabulary" of famous choreographers. In this direction, more complex movements are explored in collaboration with choreographers, artists, and other experts. To this aim, a set of video recordings of rehearsals of Virgilio Sieni dance company will be recorded in Firenze, and a number of sessions with choreographers will be planned to obtain a corpus of multimodal recordings of their "expressive vocabulary". We propose an intensive collaboration with a few top-level choreographers in order to identify gesture vocabularies they use to teach expressive movement to dancers. Jacopo Godani and Virgilio Sieni are two candidates with whom we started this activity. Results from these activities will be available in D5.2 and may also result in public events.

1.1.2 Preliminary Recordings of Basic Individual movements

A first, simplified feasibility study was performed. The adopted protocol to record the movement qualities includes different phases. In the main phase, the dancer is instructed to repeat a predefined basic movement (e.g. the above mentioned ellipsoid of infinite shapes) using a requested expressive quality. To induce specific movement qualities, the dancer is instructed to imagine a particular event (e.g. being unexpectedly touched by a hot object, or floating in the water) while doing the assigned basic movement. Alternatively, the dancer is also asked to improvise freely to express the same expressive quality: this is used as a preparatory "warm-up" phase, as well as a "recovery" after a number of repetitions of the same basic movement.

We obtained a preliminary set of recordings with the participation of two professional dancers (Roberta Messa and Muriel Romero). Two different setups were used (see Figure 2):

- Setup A: Qualisys motion capture system at 100 Hz and synchronized with the video (1280x720, 50fps). The mocap data contains 3D positions of twenty-six markers.-
- Setup B: 3D accelerometers of two smartphones placed on the arms and/or a leg; the data consists of the 3D acceleration, gyroscope, and gravity at 50 Hz and it is synchronized with the data obtained from Kinect 2 (2D and 3D coordinates of 25 markers, depth map, video and blob) at 30Hz.

Setup A Setup B

Figure 2. two different setups for the initial recording sessions.

So far, we collected nearly 1 hour 30 minutes of recordings:

- Dancer 1 (Setup A) - 88 segments, total duration 57 min and 15 sec.
- Dancer 1 (Setup B) - 14 segments, total duration 17 min and 31 sec.
- Dancer 2 (Setup B) - 14 segments, total duration is 12 min and 55 sec.

Each segment has a duration from a couple to 30 seconds.

1.1.3 Preliminary Recordings of Group Movements

A preliminary recording session of small groups (different couples of dancers) has been developed using *Contact Dance* improvisations as a specific sample explorative context. A duo *Contact Dance* is a multisensory activity, where vision and\or touch can be used to communicate between the dancers. Here, we aim to investigate whether the *quality of interpersonal expressive communication* depends on the type of sensory channel shared between the dancers. This is mainly related to Use Case 2 and Use Case 3 (see section 2) where we focus on the communication between dancers in the case of vision deprivation.

In more detail, in this preliminary experiment we studied how dancers mirror each other in a dance dialogue allowing them to communicate with each other in different conditions: vision and touch, only vision, only touch, no touch and no vision. The duo dance typically evolves either as an interaction in a form of a dialogue characterized by an alternation of leadership between the two dancers, or as a monologue with one dancer (the more expert) spontaneously playing a continuous leadership. Relevant features concerns the mirroring shape in space, i.e. the movement and position of dancers tend to be symmetric. In the time dimension, an important variable is the delay between movement initiation (in case of a leader) and movement response (follower). Our hypothesis is that the dance dialogue is influenced by the choice of the modality of sensory feedback. For example, the visual contact without touch may allow for an increased capability of mirroring of body shapes between dancers, but may slow down dancers reactivity to sudden changes of partner's. In the case touch only, the capability to mirror body shapes may result reduced, but touch may increase the reactivity to sudden changes in partner movement.
In this study we recorded professional dancers performing Contact Dance, with the above mentioned sensory constraints conditions.

Setup and procedure

The recordings were realized with the participation of 5 dancers with common background. We defined ten pairs, so each dancer had to dance with each one of the remaining 4 persons. Each pair of dancers performed in four different conditions (see Figure 3, pictures A, B, C and D, respectively):

- C1) No eye contact, no touch contact
- C2) No eye contact, only touch contact
- C3) Only eye contact, no touch contact
- C4) Both eye and touch contact

We recorded 40 trials. The duration of each recorded trial is less than 2 minutes. Dancers carried out the recording in total silence: no music/sonification was used. Consequently, the dancers might be able to hear each other's body sonic response (steps, respiration).
In more detail, each pair of dancers (D_i, D_j) was asked to perform the following task: D_i and D_j had to move like in front of a mirror, one in front of the other (moving as they were one the reflection of the other one, but they were not told who was the real body and who was the reflected image). They performed improvised movements. They were instructed to engage in a dance dialogue by mirroring each other while improvising, and to try to enhance as much as possible the communication of the intention and expressivity.

Description of the recordings

The data of both the dancers were captured with the Qualisys motion capture system at 100 Hz and synchronized with the video (1280x720, 50fps). The mocap data contains 3D positions of twenty-four markers for each dancer.

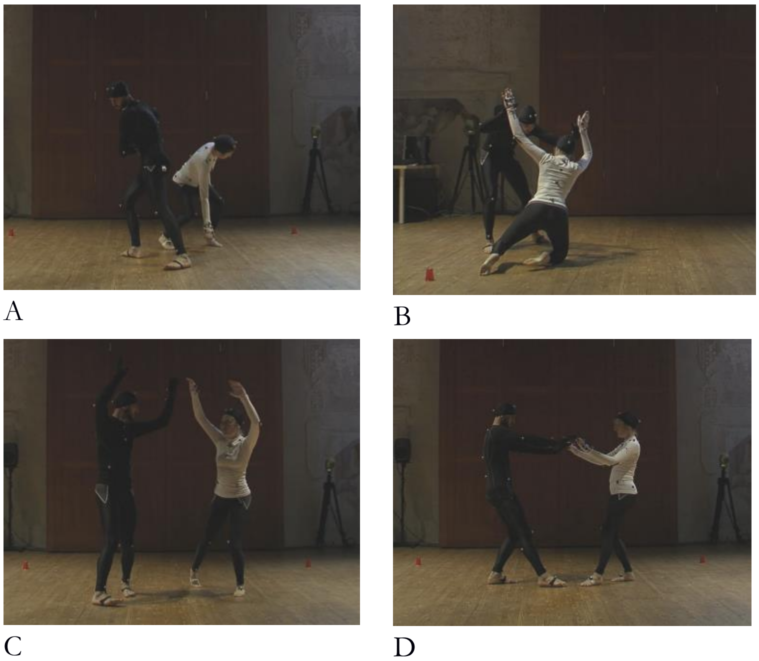


Figure 3. One couple of dancers in four different conditions: A) no eye contact, and no touch contact, B) No eye contact, and only touch C) only eye contact, and no touch contact, D) both eye and touch contact.

Synchronization of Expressive qualities

Synchronization of movements in a group of dancers, and more in general the affective and temporal entrainment, is an important quality we face in DANCE. Use Case 2 and Use Case 3 explore the sonification of entrainment of groups of dancers, in terms of synchronization of expressive qualities (e.g., fluidity or impulsivity).

We recorded 10 trials to explore this research direction. Each trial was about 1 min 30s to 2 minutes.

In these recordings, two dancers performed a synchronized predefined sequence of movements. They were asked, however, to change progressively the quality of movement, from lower to higher energy (or vice-versa) during the performance. Thus, the dancers had to put special emphasis to motion expressivity and search for a mutual implicit agreement about its progression.

1.2 Sonification

1.2.1 Indentification of sound models for the representation of body movement qualities: Experimenting with interactive sonification of children free movements

We started to test a set of sound synthesis models that we expect to be best in reacting to body movements and in portraying their qualities. We hypothesized that through evaluation we will identify sound models that implement effective mappings between body movement features (from low to high level) and sound parameters for communicating movement qualities through sound.

During the reporting period we have being designing an experiment involving children aged between 4 and 6 years. We chose children for this first experiment since we wanted to have spontaneous reactions from users to our sound models, since children usually show fewer inhibitions than adults and it has been shown that they spontaneously move to sound[1],[2]. The main idea with the experiment was to test if the quality of children's motion would vary when the sound generated by their own movements had different acoustical characteristics corresponding to smooth or jerky sounds. In particular we created three filtered noise models which range from very fluid (wind-like) sounds to very jerky (choppy, clicking) sounds. The sound models were implemented in Max/MSP and can be connected to an input device using OSC. The input parameters are velocity and acceleration. Velocity is mapped to loudness and frequency, acceleration is mapped to q-factor. This mappings have been used in previous studies, and follow the logic of ecological perception[3]. Sounds with rich spectral content have been shown to be more appealing to children with disabilities than other sounds[4]. Sound of speed and acceleration can be ecologically represented using simplified sound models reminding of the sound of wind, as for examples used in the sonification of rowing actions[5].

We placed a so-called rigid body on the head of each child. In this way we could get velocity and acceleration of each child moving in a 5x5 meters room equipped with a motion capture system (Optitrack[6]). Sounds were generated from 4 or 5 different children moving freely while at the same time generating spatialized sound (there are 4 to 5 sound sources in a 8-channel audio system).

In a factorial design we let the children moving with all the three sound models that were ordered in all possible combinations for avoiding order effect. Children participated to the whole experiment twice (1 session in the morning and 1 in the afternoon). In total 21 children participated to the test. On the day after the experiment, children were asked to make spontaneous drawings while listening to the recordings of the sounds generated by them.

1 Zentner, Marcel & Eerola, Tuomas (2010). Rhythmic Engagement with Music in Infancy. *Proceedings of the National Academy of Sciences of the United States of America* 107(13): 5768–5773.

2 Källblad, A., Friberg, A., Svensson, K., & Sjöstedt Edelholm, E. (2008). Hoppsa Universum – An interactive dance installation for children. *In Proceedings of New Interfaces for Musical Expression - NIME, Genova, 2008.*

3 Gaël Dubus and Roberto Bresin (2013) A Systematic Review of Mapping Strategies for the Sonification of Physical Quantities, PLoS ONE, ISSN: 1932-6203, Vol. 8, No. 12.

4 Kjetil Hansen, Christina Dravins and Roberto Bresin (2012) Active Listening and Expressive Communication for Children with Hearing Loss Using Getatable Environments for Creativity, Journal of New Music Research, ISSN: 0929-8215, Vol. 41, No. 4, pp. 365-375.

5 Gaël Dubus and Roberto Bresin (2015) Exploration and evaluation of a system for interactive sonification of elite rowing, Sports Engineering, ISSN: 1369-7072, Vol. 18, No. 1, pp. 29-41, Springer London.

6 http://www.optitrack.com

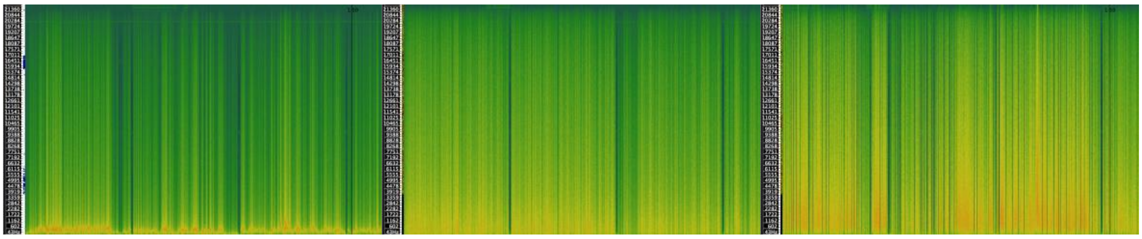


Figure 4. Spectrogram of 2 minutes of sounds generated by children motion with the three sound models. Left panel: very fluid sound (wind-like); Center Panel: somehow jerky sounds; Right Panel: very jerky sounds (choppy, clicking)

Figure 5. Drawings by one child for each of the three sounds reproduced in Figure 4 (the drawings correspond to the sounds in the same order as in Figure 1).

We are currently analysing the results from the experiments. By visual inspection it emerges that children changed the quality of their body motion when generating different sounds, e.g. while in control of different sound models, and that they made different drawing reflecting the acoustic characteristics of the generated sounds (see Figure 5).

The three sound models used in the experiment with children will also be used in projects during eNTERFACE 2015 for the interactive sonification of body motion qualities analysed by means of accelerometers and cameras (i.e. Kinect).

We have also started the development of a workbench for the design of interactive sonification of body movement features. The workbench will be equipped with different sound models that will be chosen from case to case depending on the mapping to be implemented and tested. Special care will be given to aesthetic qualities of the sonifications, therefore more complex sound models of those used in the experiment with children will be selected.

The sound models resulting from this experiment, and their future refinements, will be used for the sonic representation of body movement qualities in each of the Use Cases presented in the following section. The sound models will be possible to be used both as an audification of user movements (i.e. direct translation into sound of user movement data) and for the sonification of high-level qualities of body movements such as fluidity and jerkiness.

1.2.2 Interactive sonification of movement qualities and experiments at SONAR+D and STARTS Symposium

A set of sonification models were developed in collaboration with the composer Pablo Palacio, for the following movement qualities: fluid, light/heavy, fall/loss of balance.

Short demos and proof-of-concepts on real-time analysis and interactive sonification of these expressive qualities were presented at SONAR+D in Barcelona and at the STARTS Symposium in Brussels.

Such early demos and proof of concepts were developed in the freely available platform EyesWeb (http://www.infomus.org/eyesweb_eng.php).

Videos of such demos are available in the DANCE web site (dance.dibris.unige.it).

2. Use Cases refinements

The following use cases are developed starting from the use cases proposed in the DoW, following the feedback obtained by the work in the first months of the project, including various meetings with dancers and choreographers, the preliminary experiments and feasibility studies, and the two public events SONAR+D and STARTS.
A new Use Case is proposed: the serious game scenario *Move In The Dark*, to explore and evaluate movement qualities and sonifications.

2.1 Use Case 1 – What do you see, when "hearing" a dance ? (Individual UC)

A user is temporarily deprived of vision. She learns to recognize (her own as well as others') movement qualities only by the auditory channel: following one of the main DANCE guidelines, sensory deprivation is here a mean to amplify user's capabilities and sensibility in recognizing individual movement qualities by means of the auditory modality.
This UC is structured in two steps:

1. *Exploratory training to hear her movement qualities*: The user (normal sighted and blindfolded) performs a series of sessions with the DANCE interactive system enabling the experience in real-time of interactive sonification of her movement. In this way, the user learns which and how her qualities of movement are translated into sound, and comprehends how to exploit such an inner vision, induced by sound, of the movement qualities (e.g., fluidity, impulsivity, weight, suddenness). The definition of the set of qualities is one of the main research challenges of the project, as well as the definition of the interactive sonification models.
2. *Hearing the dance*: The user, once learned and familiarized with the mechanisms of interactive sonification of her own movement qualities (i.e., amplification of her sensibility to movement qualities by means of her auditory channel), becomes capable to recognize her and other person movement qualities just by listening to the corresponding interactive sonification.

This Use Case is grounded on the Living List of Movement Qualities (Appendix 1).

2.2 Use Case 2 – What do you see, when "hearing" a dance ensemble? (Social UC)

We assume that the user is trained by the experience in UC1. The user (blindfolded or blind) listens to the sonification of the qualities of a group of dancers. Analogously with UC1, sensory deprivation is a means to amplify user's capabilities and sensibility in recognizing, this time, the movement qualities of a group.
A starting hypothesis is that a set of individual movement qualities (see Appendix 1) can be adopted also at group level, as generalizations of the corresponding individual qualities. For example, *intra-personal synchronization* of different joints of the body can correspond to the *inter-personal synchronization* in an ensemble considered as a whole single body. This means that a user may hear the dance of an ensemble in terms of the qualities learned on her own body. This concept and the taxonomy and conceptual model of the movement qualities will be subject of continuous refinements in the project.

2.3 Use Case 3 – DANCE Serious Games

This UC supports the training and validation of interactive sonifications in UC1 and UC2, and it is at the same time an interesting example of exploitation of DANCE project research results in the field of serious games.
The objective is twofold: (i) to design a family of serious games to teach users "to hear dance", i.e. to understand movement qualities in terms of interactive sonification; (ii) to develop a scalable and flexible system based on the EyesWeb software platform to support the development of a number of serious games useful to validate and compare interactive sonifications and qualities of movements.
The basic concept of serious game is for two or more users, and starts from a repository of (i) interactive sonification models (ISMs), (ii) movement qualities (MQs), and (iii) audio recordings of sonifications (RSs) of a repository of short dance sequences. The serious game is a competition between two or more users. Users are blindfolded to increase the sensitivity of each user on the auditory channel, and to avoid imitation of the other players. They listen to the same selected recording of an interactive sonification of one or more movement qualities, and are asked to move in such a way to match the qualities they perceive in the sound they are listening. The same movements qualities that

originated the sonification they are listening are measured from each user and are compared with those in the original recordings. Each player receives points from the system according to the distance (by means of a given metrics) of the measured user's movement quality from the qualities of the sonification. The player that best approximates the movement qualities of the listened sonification wins the game.
This use case is also an instrument to validate interactive sonifications released during the DANCE project, and represents a useful tool for investigating the perception of movement qualities when translated into sonic material.
The game will be designed as a modular software platform in order to validate an open, extendable repository of interactive sonifications models on the set of DANCE movement qualities and DANCE movement repository.
Another extension of this serious game concerns the cooperation of users, to study and exploit social features (e.g., collaboration, cohesion, entrainment, leadership), where users are measured in their social movement qualities, and sonifications are related to social features of groups. An example of a case study related to collaborative features is the following: groups of users are asked to give the same interpretation of the sounds in a joint way, i.e. the group should move as a whole to express the listened qualities. In order to measure the degree of collaboration, modules to estimate real-time synchronization between user's movements will be added to the system.
A first prototype of this Use Case for two competing users, in the individual movement version, will be developed during the eNTERFACE 2015 Intl Workshop and validated at the Festival of Science 2015.

2.4 Use Case 4 – Can you play my dance? (Art / Creativity UC)

This UC is here only sketched, and will be refined at Month 18, following the evaluation phase of UC1, UC2, UC3, and after further multimodal recordings and analysis with choreographers and dancers.
There is no unique way to sonify movement qualities: context, application, user types are only few of the variables involved. Together with music composers (Pablo Palacio, Andrea Cera) and choreographers we'll define artistic scenarios as a means to fertilize the scientific research.
In this UC, standard interactive sonification techniques will be extended by active experience of music (active listening). An example of instance of this UC that will be proposed to the artists collaborating in the project is the folllowing:

- Step 1: A blind person enters the theatre, where a dance performance is taking place on the stage
- Step 2: She starts an app on her smartphone and wears her headphones
- Step 3: The blind person can now hear the dance of the performers (their movement quality, emotional intention, interaction among performers) as a real time modulation of the music on which the performers are dancing

Another instance will concern the study of the expressive vocabulary of a famous choreographers (preliminary agreements have been started with Virgilio Sieni (Director of Biennale Danza, Venice), and to exploit this vocabulary in public performances where the real-time analysis of the vocabulary on professional and/or non expert dancers (e.g., members of the audience).

2.5 Use Case 5 – Ease physically demanding body movements

The methods developed in DANCE will be transported to situations where training of body movements is more difficult or more painful than normal. Two specific examples illustrate this. One case is that of dancers or actors that need to go through long straining rehearsing sessions. Dance is often organised in repeated movement patterns. In this use case, the project will test whether the feeling of fatigue in repetitive dance movements can be reduced when listening to the sonification of one's own body motion (Hoffmann, Torregrosa, Bardy, 2012 PlosOne). Achieving this should result in a higher level of enjoyment of dancing for both blind and sighted people. Collaboration of partners with performing artists has already revealed this to be an important application for training. Another example is found in the context of physical exercise. It is well-known since antiquity that singing alleviates the fatigue of performing a repetitive labour. In a recent study, participants training with fitness machines reported that they felt less exhausted when they performed their workout while listening to music generated from their own movements (Fritz et al. 2013). Methods developed in DANCE will be also used in the sonification of wheelchair movements in sports, for helping athletes to better perform and understand their actions.

3. Definition of the requirements for the technology platform and experimental setups

3.1 Sensors for expressive feature extraction (WP2)

- MoCap
  - Qualisys[1] – Installed at Casa Paganini – Infomus research center
  - Optitrack[2] – Installed at KTH
- Biometric
  - Breath sensor
  - EMG sensor
  - ECG sensor
- Audio
  - Microphones
- Inertial (XOSC and mobiles)
  - Accelerometers
  - Gyroscopes
  - Compass
- Video
  - RGB Cameras
  - Infrared Cameras
  - Kinect for Windows

3.2 Platform (WP4)

DANCE platform is based on EyesWeb[3] software architecture in order to integrate, synchronize and record data coming from the sensors listed in the previous section and to evaluate expressive features in real time.
We start from the platform developed in the European Project SIEMPRE[4] for the synchronization of multimodal streams. In this project we extend this platform to support Optitrack's exported files, XOSC[5] inertial sensors, new smartphones and Kinect for Windows.
A scheme of the overall architecture is shown in Figure 6.

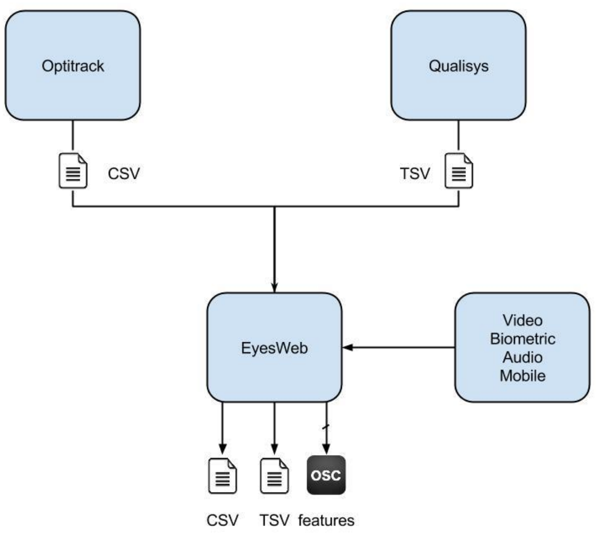


Figure 6. DANCE platform architecture.

Qualisys, used by Infomus, and Optitrack, used by KTH, are different Motion capture systems. Each one supports its own file format to export captured data. EyesWeb allows working with both formats, converting from one to the other. This is needed to perform analisys on data captured by both system.

We use EyesWeb to evaluate features from both saved and real time data coming from sensors, and to send the computed features to external software, i.e., sonification systems, analisys and evaluation tools.
We will investigate the possibility to support the real time protocol communication between EyesWeb and Optitrack using the NatNet SDK.
Platform References:
1 http://www.qualisys.com/
2 http://www.optitrack.com/
3 http://www.infomus.org/eyesweb_eng.php
4 http://www.infomus.org/siempre/
5 http://www.x-io.co.uk/products/x-osc/

Appendix 1 – First draft scheme of movement qualities

In DANCE, we work like in a translation process of a poem from one language to another: there is always a loss: for example, we lose in at least one of the following two aspects: the "sound" of the poem, the "meaning" of the text of the poem. In DANCE we aim (1) to "translate" from vision to hearing, and (2) to focus on qualities and not on typologies of movement. That is, we are not interested in specific gestures or movement directions *per se*: our focus is on the expressive quality. For example, a hand movement direction to the left or to the right may be irrelevant, instead the level of fluidity or impulsiveness of such movement might be relevant. An example of a successful DANCE experiment is the case of a blind person that perceives two different movements sharing the same expressive quality as the same expression. Let us consider the example of movement "Knocking at a door"[7]. We do not want to translate for the blind person the functional action "knocking at a door", but the intention that is behind (e.g., the emotion guiding the lover knocking at the door of his/her beloved). Furthermore, DANCE aims at giving to a normal seeing person the understanding of what is behind (or beyond) the functional movement of knocking.

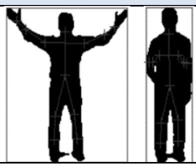
The expressive features proposed in this Appendix are a first, starting list of features and qualities that will be continuously revised along the project. It may depend on both the choreography (the "score") and the interpretation of the dancers. It is usually difficult to distinguish the difference between functional and ancillary movements (see e.g. Wanderley et al 2000), since functional movements are used by the choreographer also as a means of expression, not in their original function.

Hypothesis: a subset of qualities are applicable to three main levels: a part of the body (e.g. an arm), at full body (individual level), and group level (a group as a single organism, a single body). This hypothesis will be evaluated along the project in the development of Use Case 1 (Individual) and Use Case 2 (Group).

The proposed initial set of features and qualities should have the expressive power to describe the typical qualities of the movement of blind persons (e.g., rigidity, oscillations, and postural asymmetries) as well as of experts in movement such as dancers or sportsmen (e.g. martial arts experts).

Our objective is to develop software tools that measure, possibly in real-time, these qualities. It is important to note that the comparative use of these measurements should be evaluated carefully: for example, a quality expressed by a blind person and the same quality expressed by a seeing person might be different in terms of measured expressive features: in general, a mapping is necessary to equalize/rescale the meaning of an expressive feature to make it comparable among different individuals with different movement and expressive skills.

Movement Qualities – version June 2015

ID	Name	Description
Low-Level Features		
1	Kinematics (position, speed, acceleration)	Positional data (e.g., 3D joints position, barycentre position) obtained from Mocap, videocameras, accelerometers.
2	Motion Index/Quantity Of Motion (QoM)	Area of the difference of the silhouettes' area computed on consecutive frames
3	Kinetic Energy	The energy of a cloud of 3D moving joints, possibly weighted by their masses, using weights from biometric tables
4	Entropy(feature)	Sample Entropy, Multi-Scale Entropy applied to a low-level feature
5	Bounding Space / ConvexHull	The minimum volume (3D) or polygon (2D) surrounding the input cloud of points or the silhouette
6	Smoothness	A joint moving according to the specific laws from biomechanics defining smoothness.
Mid-Level Features		
7	Contraction/Expansion, Introvert/Extrovert	 A measure of how much the body is moving from its barycentre to the external space and vice-versa. extrovert/introvert movements. It can be a 3D or 2D measure: based on a cloud of 3D points, on a body silhouette (body image blob), or accelerometers data.
8	Symmetry	How much a cloud of points is symmetric with respect to a point, axis, plane, e.g. the vertical plane
9	Balance, Change of Weight between Feet	(static measure) Measure of the projection to the floor of the barycentre of the body in the area defined by the feet; (dynamic measure) ratio between acceleration of the barycentre of the head and the barycentre of the body.
10	Sudden/Sustained	A movement exhibiting a rapid change of velocity (i.e., increase or decrease)

7 Pollick, Frank E., et al. "Perceiving affect from arm movement." Cognition 82.2 (2001): B51-B61.

11	Impulsive	An impulsive movement is sudden and not prepared (e.g. by antagonists muscles)
12	Light/Heavy	The degree of influence the gravity force has on a cloud of moving points
13	Fluid	A set of joint moving smooth, and coordinated (e.g. movements in a propagation wave).
14	Repetitiveness	Movement exhibits repetitive or oscillating patterns
15	Cohesion/fragmentation	Tendency of a cloud of points to move as a single entity in a direction
16	Leading joints, Origins of movement	Which joint originate or leads/guides the other points of the body during a movement
17	Synchronization	Coordination of moving points to operate a body at the unison
18	Still, Suspension	Analogous to the Pause in Music: stillness in movement does not mean lack of movement: minimal movements induced from both the body (respiration, blood circulation), emotions, and attention are always present. A suspension is characterized by an array of micro-features of movements explaining the quality of the stillness/suspension (e.g., where main micro-movements occur, translations, rotations, oscillations, changes of weight between feet etc.).
High-Level Features		
19	Predictability/expectancy	How much user's movement is predictable. This is based on physical models of the movement (mental model simulations).
20	Hesitating / Intentional (Directness)	When intention is clear, movement is performed to directly reach the target/goal position, that is, top reach the target/goal position with the least effort possible
21	Postural Tension, Multi-Layer planes directions	A vector describing the angles between adjacent orthogonals of different body lines: feet, hip, trunk, shoulders, head (See for example classical paintings or sculptures, e.g., the *Discobolus*, where such angles express the posture dynamics in terms of energy loaded in the transversal muscles ready to be released into movement)
22	Attraction / Repulsion	The degree of influence an external popint in space has on a cloud of moving points (e.g., like a magnet attracting or repulsing)
23	Equilibrium / Tendency to Fall	The condition of a cloud of points in which all the influencing forces between points are balanced/unbalanced.
24	Entrainment	Entrainment has a temporal and an affective component (Phillips-Silver and Keller 2012): we propose a model based on temporal synchronization of expressive features.
25	Emotion	e.g. Scherer's Eclectic Emotion, Music Emotions. Dimensional models (eg, PAD) Emotional states can be detected from simple movement features, see for example our work (Glowinski et al 2011, IEEE Trans Affective Computing; Piana et al., 2016, ACM Trans TiiS).

Appendix 2 – Public events to collect users and experts feedback

The DANCE project participated to the SONAR+D and STARTS symposiums in Barcelona and Bozar (Brussels) in June 2015. During the two public events, demos on real-time analysis and interactive sonification of full-body human movement expressive qualities have been presented. Sonification was based on processing of sound spaces and ways of using affective music content in relation to the quality of gestures. The demos have been developed by UNIGE, in collaboration with the composer Pablo Palacio and dancers Muriel Romero and Roberta Messa. Demos at the stand of the European Commission were kindly supported by the dancer Sabrina Ribes. A further demo, iLabelMusic, was shown on an early example of creative commercial exploitation of DANCE concepts and technology, designed and developed by University of Genoa in collaboration with Rotas.

Stands visitors were first introduced to the main DANCE research dimensions:

1. *Inclusion and rehabilitation.* Interactive sonification and *musicalization* of choreutic movement (processing of sound spaces and ways of using affective music content in relation to the quality of gestures) investigates forms of sensory substitution: *to see through listening*. Testing new perceptual experiences of body movement in the dark implies the possibility of rapprochement and sharing (of spaces and emotions) between visually impaired and sighted people.
2. *Scientific and technological research.* Neuroscience studies on brain plasticity in sensory substitution at University of Maastricht will be combined with studies at Casa Paganini-InfoMus on technologies capable of *seeing* emotional qualities and social indicators of movement, interpreting them as techniques for searching data in digital archives (e.g. sound, music, visual archives), and with research on interactive sonification at KTH.
3. *Artistic research and production.* The choreography itself creates the music: dance can be conceived as musical composition (or re-composition, interpretation), changing its traditional dimension into an eminently or exclusively listening experience: Gesture, as an aesthetic object, is experienced as a sounding object.

Then, visitors could directly experience the following DANCE demos and proof-of-concepts:

- Real-time analysis and interactive sonification of expressive qualities of full-body human movement, developed by University of Genoa (Casa Paganini – InfoMus Research Centre, www.casapaganini.org), in collaboration with the composer Pablo Palacio (http://www.pablopalacio.com/ABOUT.html) and dancers Muriel Romero and Roberta Messa. Demos at the stand will be kindly supported by the dancer Sabrina Ribes.
- *iLabelMusic* demo: an early example of creative commercial exploitation of DANCE concepts and technology, presented by University of Genoa in collaboration with Rotas (www.rotas.com).

Demos and proof of concepts are developed using the freely available EyesWeb software platform: http://www.infomus.org/eyesweb_eng.php
Videos of the demos are available on the DANCE website: http://dance.dibris.unige.it/

Appendix 3 – Impulsivity and Suddenness movement qualities

Paper "Automated detection of impulsive movements in HCI", ACM CHItaly 2015 Conference, Rome, September 2015, available in the repository of the DANCE project at http://dance.dibris.unige.it.