WHOLODANCE

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Executive Summary

The following deliverable reflects the outcomes of the State of the Art (SoA) Survey which is held by Athena RC for the WhoLoDancE project[1] (Whole-body interaction Learning for Dance Education). The SoA Survey is one of the tools to achieve the objectives of the work package entitled: "WP1 Learning Models and Technical Requirements". The main objectives of this work package are: a) to deliver a user-oriented approach through understanding the domain of dance education in relation to ICT, b) to elicit the technical requirements of learning scenarios that will be innovative, but at the same time compliant with the contemporary approaches of dance teaching and learning, and c) to support the interdisciplinary collaboration for providing input to other work packages and the basis for the evaluation.

The first objective of this survey is to describe the main characteristics of dance teaching and learning, based on the recent advancement of dance education research and contemporary practices, as well as documenting the expertise coming from the dance partners within the consortium. The second main objective is to present relevant efforts and tools, summarizing their approach, the relevant technologies and methodologies used, as well as the context of experimentation and application.

Taking into account the lack of formal and fully described methodologies for each dance genre and context, this survey aims at selecting state-of-the-art approaches, needs and contexts, and serve as a basis for the rest of the project activities. The deliverable consists of two parts: a) Part A-Dance Learning Models and b) Dance and Technology State of the Art (SoA). Part A presents the recent advancements in dance education in relation to general contemporary learning approaches, and discusses the most significant of these models, as well as the potential benefits of the use of interactive technologies based on recent relevant literature. The second part presents the outcomes of recent research advancements in the design and development of tools to support dance teaching in learning through different technologies (Interactive whole-body experiences, Motion Capture, Virtual and Augmented Reality, Sonification, Annotation tools, Desktop and Mobile apps, etc). This presentation includes comments of the relation of these recent advancements to the main objectives of WhoLoDancE: 1) Investigate Body Knowledge, 2) Preserve Cultural Heritage, 3) Innovate the teaching of dance, 4) Revolutionize choreography, 5) Widen the access and practice of dance.

[1] http://www.wholodance.eu/

PART-A –Dance Learning Models

A.1 WhoLoDancE Objectives Dance Learning Characteristics

In the following section we describe the WhoLoDancE objectives in relation to dance learning characteristics. Previous efforts of analysing, archiving and representing the choreographing process in projects like "Thinking with the Body"[2] with Wayne McGregor, Synchronous Objects[3] with William Forsythe, Motion Bank[4] with the Forsythe Company and Daborah Hay, Siobhan Davies Replay[5] are the outcomes of close collaboration between cognitive psychologists, choreographers and technology experts and scientists. These efforts teach us two things: close collaboration of an interdisciplinary team is key and there are no one-to-fit-all codified techniques to teach and create dance movement. In addition, dance practice can vary in contexts from performative classic or contemporary art to intangible cultural heritage, and from social activity to somatic practice and a way of enhancing movement in general.

Most of the aforementioned efforts, come from contemporary choreography and are focused on the creative process of dance-making. Currently there is not one single repository of different teaching methods neither is there a repository of dance actions that would support the development of the teaching of dance. Dance learning and practice is by nature multimodal, time consuming, and presents a big diversity across dance genres and contexts. The WhoLoDancE investigates different dance genres use cases to develop a multimodal repository, as a proof-of concept, which will enable the usage of data analytics supporting the identification of effective teaching methods and practices showing commonalities and differences between them to support the future teaching of dance within a variety of contexts. An additional benefit of the project is that it may well encourage greater appreciation of different dance genres, providing access to the knowledge that underpins expert dance practices in a way that has hitherto not been possible.

WhoLoDancE will investigate and apply methodologies of personalization to create personalized scenarios for learning. Learning dance is a time-demanding, complex process which depends on the variety of techniques, context, student's needs etc. Several pedagogical approaches could be linked to this multimodal process, in order to deliver the needs of the particular (formal-informal) context and objectives of learning, the learning style of the student, and the preferences of the teacher, to achieve and assess the effectiveness of teaching. WhoLoDancE aims to construct dynamic Learning Scenarios in the forms of "stories" or paths of teaching. Under this perspective WhoLoDancE aims to respond to the users' different profiles (age, gender, level of expertise, dance genre and technique). Application scenarios will include formal and informal education providing tools that will be available both for public institutions as learning materials and group training in class or for private use in the form of entertaining educational games.

Dance is an experiential and often collective art form and the traditional way of learning is within a relational, embodied environment. In contrary to other subjects where learning is perceived as a process of transference of cognitive knowledge,iIn the case of dance, practice is the core of learning as transference of both cognitive and bodily knowledge and skills. Experiential learning is a process of constructing knowledge that involves a creative tension among the four learning modes that is responsive to contextual demands. This process is portrayed as an idealized learning cycle or spiral where the learner "touches all the bases"—experiencing, reflecting, thinking, and acting-in a recursive process that is responsive to the learning situation and what is being learned. Immediate or concrete experiences are the basis for

[2] http://wellcomecollection.org/thinking
[3] http://synchronousobjects.osu.edu/
[4] http://motionbank.org/
[5] http://www.siobhandaviesreplay.com/

observations and reflections. These reflections are assimilated and distilled into abstract concepts from which new implications for action can be drawn. These implications can be actively tested and serve as guides in creating new experiences [30].WhoLoDancE is not attempting to replace experience, but to enhance our 'experience of experience' – it aims to offer the learner (and teacher) with access to a resource that would not be possible within a local studio/institutional context, so provides access to new content and new learning modes.

WhoLoDancE learning tools will be designed upon the aforementioned principles of contemporary models of dance learning and teaching, focusing not only on learning steps by mimicry, but also on enhancing one's movement literacy, increasing the learners' ability to analyse her/his own movement, and enhancing one's movement skills, such as alignment, use of space, movement qualities, musicality etc. *Experiental Learning* Theory proposes that this idealized learning cycle will vary by individuals' learning style and learning context. Based on this, the learning environment of WhoLoDancE will provide the users with the ability to experiment on line with captured movement sequences and dance syllabi coming from a range of dance styles, through personalized paths of learning.

A2. Dance Learning and existing Learning Models

The aforementioned characteristics of Dance Learning, such as its experiential and practice oriented nature, multimodality, combining both cognitive and bodily process, and its diversity in relation to contexts, differentiates dance learning from any other subjects of "book" learning. In this section we will briefly present the relation of dance with relevant Learning Models and Theories.

It is good to notice however that dance operates within very different contexts across Europe. Some dance teaching takes place within schools, some at tertiary and higher level – some within Universities and some within Conservatoires/specialist vocational academies. Then there is the private sector (which follow their own and different syllabi), those taking dance within a recreational context and the continuing professional development accessed by professional dancers. When it comes to validation, the theoretical basis for categorising 'teaching styles' is likely to be drawn from a variety of texts, and of course might be related to the specific techniques or schools that are associated with particular dance genres, e.g., Vaganova [6] or RAD[7] school for classical ballet.

In WhoLoDancE, we are investigating learning models and approaches that are not limited only to one specific dance genres or schools. Our aim is to examine different examples of dance practices, coming from different use cases (contemporary, ballet, flamenco and Greek folk) in relation to more generic Learning models in order to design learning scenarios that will comply with specific needs for each of the use-cases within a unique framework which can be applied and extended to different styles of dance and allow cross fertilization of both movement vocabularies and also teaching approaches. The objective is to create a framework for storing movements and knowledge targeting the different practices through both within and across genre perspectives.

A3. Experiential Learning Theory and Dance

The Kolb Learning Style Inventory [37] is based on a theory of learning from experience that draws on the work of prominent 20th century scholars who gave experience a central role in their theories of human learning and development – notably William James, John Dewey, Kurt Lewin, Jean Piaget, Lev Vygotsky, Carl Jung, Paulo Freire, Carl Rogers and others. Experiential Learning Theory (ELT) defines learning as "the process whereby knowledge is created through the transformation of experience. The basis of the theory is

[6] http://vaganovaacademy.com/
[7] https://www.rad.org.uk/

that knowledge results from the combination of grasping and transforming experience"[30].From this Experiential Learning Theory (ELT) perspective, learners construct knowledge by experiencing, reflecting, thinking and acting. The ELT model portrays two dialectically related modes of grasping experience-Concrete Experience (CE) and Abstract Conceptualization (AC)-and two dialectically related modes of transforming experience-Reflective Observation (RO) and Active Experimentation (AE).

This analysis includes four distinct learning styles, which are based on a four-stage learning cycle-[30]. Kolb explains that different people naturally prefer a certain single different learning style. Various factors, such as social environment, educational experiences, or the basic cognitive structure of the individual, influence a person's preferred style.

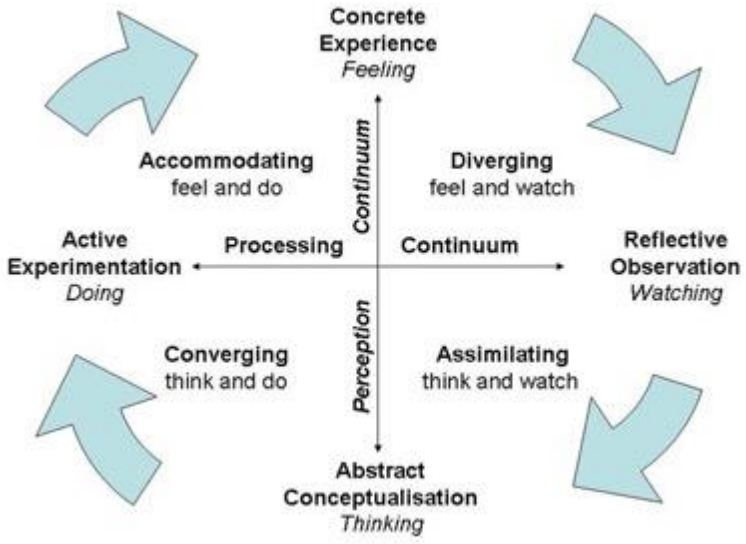


Figure 1- The Experiential Learning Cycle

Whatever influences the choice of style, according to Kolb, the learning style preference itself is actually the product of two pairs of variables, or two separate 'choices' that we make, which Kolb presented as lines of axis, each with 'conflicting' modes at either end: A typical presentation of Kolb's two continuums is that the east-west axis is called the *Processing Continuum* (how we approach a task), and the north-south axis is called the *Perception Continuum* (our emotional response, or how we think or feel about it). According to Kolb, each learning style represents a combination of two preferred styles resulting in the four Learning Styles: diverging, assimilating, and converging, accommodating [37].

Table 1 Kolb's Learning Styles in relation to Processing vs. Perceiving continuum

	Doing (Active Experimentation - AE)	Watching (Reflective Observation - RO)
Feeling (Concrete Experience - CE)	**Accommodating (CE/AE)**	**Diverging (CE/RO)**
Thinking (Abstract Conceptualization - AC)	**Converging (AC/AE)**	**Assimilating (AC/RO)**

Kolbe's Learning Styles Definitions:

Diverging (feeling and watching - CE/RO)

"These people are able to look at things from different perspectives. They are sensitive. They prefer to watch rather than do, tending to gather information and use imagination to solve problems. They are best at viewing concrete situations at several different viewpoints. Kolb called this style 'diverging' because these people perform better in situations that require ideas-generation, for example, brainstorming. People with a diverging learning style have broad cultural interests and like to gather information. They are interested in people, tend to be imaginative and emotional, and tend to be strong in the arts. People with the diverging style prefer to work in groups, to listen with an open mind and to receive personal feedback."

Assimilating (watching and thinking - AC/RO)

"The Assimilating learning preference is for a concise, logical approach. Ideas and concepts are more important than people. These people require good clear explanation rather than practical opportunity. They excel at understanding wide-ranging information and organizing it in a clear logical format. People with an assimilating learning style are less focused on people and more interested in ideas and abstract concepts. People with this style are more attracted to logically sound theories than approaches based on practical value. This learning style is important for effectiveness in information and science careers. In formal learning situations, people with this style prefer readings, lectures, exploring analytical models, and having time to think things through."

Converging (doing and thinking - AC/AE)

"People with a converging learning style can solve problems and will use their learning to find solutions to practical issues. They prefer technical tasks, and are less concerned with people and interpersonal aspects. People with a converging learning style are best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems. People with a converging learning style are more attracted to technical tasks and problems than social or interpersonal issues. A converging learning style enables specialist and technology abilities. People with a converging style like to experiment with new ideas, to simulate, and to work with practical applications."

Accommodating (doing and feeling - CE/AE)

"The Accommodating learning style is 'hands-on', and relies on intuition rather than logic. These people use other people's analysis, and prefer to take a practical, experiential approach. They are attracted to new challenges and experiences, and to carrying out plans. They commonly act on 'gut' instinct rather than logical analysis. People with an accommodating learning style will tend to rely on others for information than carry out their own analysis. This learning style is prevalent within the general population."

Transferring these definitions to the area of Dance Learning, one can be led to the following mistaken conclusion: Learners cannot perform both variables on a single axis at the same time (e.g. think and feel, or watch and do), however in the case of dance learning this is something very common, especially in some approaches of traditional dance teaching practices based on imitation (or mimicry).Within a good example of dance learning process we should find a balanced combination of all modes of transforming experience into bodily and cognitive knowledge.

- Concrete Experience (e.g., trying the sequence while it is shown by the teacher)
- Abstract Conceptualization (e.g., naming the sequence "step to the right, turn, then head, then quickly to the floor" but also ideas and concepts related to the sequence)
- Reflective Observation ("e.g., seeing the sequence done by the teachers, others or on video")
- Active Experimentation ("e.g., doing the sequence one more time, or trying new ways to do it")

Dance students and learners, even the ones in an intermediate to professional level, which WhoLoDancE is targeting, might belong to any one of the aforementioned Learning Styles, and thus might benefit from any of the aforementioned modes depending on their Learning Style.

Another superficial conclusion that might derive from the Learning Styles' definitions is that people have to follow specific carriers and activities to increase their chances to succeed in learning, e.g., only people who fall under the Accommodating (doing and feeling) Learning Style can become successful dance students and practitioners. At this point we should mention the notion of Learning Flexibility, i.e., a person's ability to fully use the learning cycle and modify her or his approach based on the context and subject of learning.

Learning Style, however, is not a fixed trait but is a dynamic state resulting from continual learning experiences. Although one may have a preferred Style of learning, learning flexibility implies the capability of also using non-preferred Styles; thus, moving around the nine Styles of the Learning Cycle to modify one's approach for the context [46] .

Not only dance students and movement practitioners should not be limited by their Learning Style, but some researches indicate that enhancing movement through dance classes can increase the students' ability to fully use the learning cycle and their learning ability in any subject. Peterson and DaCato [42] have explored how expanding one's movement repertoire and flexibility can increase Learning Flexibility. In their work the theoretical correspondence between the dialectic dimensions of the Experiential Learning Cycle and the dimensions of the Laban Movement Analysis system create an integrated typology of learning and movement styles that expands the description of learning style to include the movement affinities. Based on movement observations and interviews of over 200 adult learners descriptions of the movement patterns of each of the nine styles (Experiencing, Imagining, Reflecting, Analyzing, Thinking, Deciding, Acting, Initiating, Balancing) in the Kolb Learning Styles Inventory 4.0 (KLSI 4.0) [30] are given. As the study suggests, when learners have a preference for certain style and lack flexibility in other styles, they may have underutilized or undiscovered capabilities.

A4. The demonstration-reproduction model

The typical demonstration-reproduction (usually seen as mimicry) model for teaching dance technique is in some cases treated as a given and generally continues to be accepted without question, while number of writers in the field of dance research have in fact questioned the process of learning through imitation, considering it to be superficial or even alienating and criticized in some other cases. For the ones who use the typical demonstration-reproduction model, it would seem to be valued as a "traditional" tried and true teaching method, without having benefited from thorough and well-reasoned reflection. Harbonnier-Topin and Barbier [23] notice that "in the literature pertaining to education and training in contemporary dance there are a number of issues – not all of them explicit – relative to the question of the pedagogical model prevalent in the dance class. Some authors question the fundamental congruity of teaching technique at all in contemporary dance, others take exception to what they see as a dominant teaching model imported from the academic (ballet) heritage, still others warn us about the dangers of a conventional mode of teaching based on the representation of a model (the dance teacher) to be emulated." They also comment that the outcomes of research in five contemporary dance technique classes, as well as recent neuroscientific findings regarding the "mirror" system, have led us to observe that this type of interaction is in fact complex, diverse and has a strong biological basis.

Nevertheless, several testimonials of the students in the study of Harbonnier-Tobin [23] contradict the "surface" or superficial aspect of imitation mentioned above. An identical repetition by imitation, cannot in fact exist in class. Watching movement, we see not merely a body that executes the movement but rather an individual with his or her personal history. Each individual's background is quite unique, making identical reproduction absolutely impossible. ...We have seen that the teacher's communication constantly associates "doing" with "saying", therefore transmission is never simply imitative..." As the results of this study have shown there is a diversity of rationales that can be found within the traditional mode, including a variety of activities for the teacher (Presenting the sequence, Explaining the sequence, Questions, answers, Accompanying doing with saying, Evaluating doing, Observing students, Doing alone) and a variety of activities for the student (Doing with, Doing after, Watching without doing, Questions, answers, Doing alone-exercise, Doing alone-practice, Performing-displaying), which can be typically paired in a dance technique class as shown in [23], but also in a variety of combinations according to the individual's teacher goals and preference. "

Table 2 Typical pairing in the dance technique class

Teachers	Students
Presenting (doing and saying what to do)	Echoing-resonating
Explaining (doing and saying how to do it)	Echoing-resonating + performing alone
Presenting an action + reacting + observing	Echoing-resonating + reacting + performing alone
Managing the space	Preparing the performance + performing alone
Observing	Performing-displaying
Evaluating	Watching without doing

The same study have shown that more active the teachers were in "doing" and "saying", the more significant was the amount of time the students devoted to the self-activity of "Performing alone". At this

point we should however observe the following: 1) these activities and study are referring to contemporary dance technique class, not focusing on improvisation or creativity, 2) it would be interesting to examine what where the words used in accompanying "doing by saying" and if there were only action and biomechanical descriptions, or included metaphoric instructions introducing imagery, 3) the comment about "repetition does not actually existing" is really interesting and probably true: when the human teacher shows the sequence she at the same time conveys specific qualities through her body, her personality and of course the prosody of her voice in case of also "saying while doing". The student on the other hand observes this information through the mode of "watching" (or listening) without mirroring only the steps, but eventually mirroring also the qualities of the teachers' movement. The last point is very important when designing digital learning experiences. In the case of a computer –generated teacher or avatar exact repetition is possible from the teacher's side, and the risk of alienation is there. Moreover, what would be the "human" movement qualitative aspects that the avatar-teacher can transmit through mimicry to the student along with the shape of the movement is a good question. These set a big challenge for the design of a "virtual teacher", even if this "virtual teacher" is going to play a complementary role combined with the real teacher, class and practice experience.

Another point which seems important when adopting the "demonstration –reproduction" model level of expertise of the students and their familiarity with the movement vocabulary which is demonstrated is that Harbonnier-Tobin observed a clear difference among student's of different levels indicated by the "activities" observations as well as expressed in the student narratives.

Calvo-Merino et.al [11], have used functional magnetic resonance imaging (fMRI) in an experiment investigating whether, observing someone performing an action, our brains simulate making that action. The experiment studied differences in brain activity between watching an action that one has learned to do and an action that one has not, in order to assess whether the brain processes of action observation are modulated by the expertise and motor repertoire of the observer. Experts in classical ballet, experts in capoeira and inexpert control subjects viewed videos of ballet or capoeira actions. Comparing the brain activity when dancers watched their own dance style versus the other style therefore reveals the influence of motor expertise on action observation. The study has shown a clear effect of acquired motor skills on brain activity during action observation. The network of motor areas involved in preparation and execution of action was also activated by observation of actions. Crucially this activation was stronger when the subjects had the specific motor representation for the action they observed. The results also show that this 'mirror system' integrates observed actions of others with an individual's personal motor repertoire, and suggest that the human brain understands actions by motor simulation. In the study of Calvo-Merino et. al[11], while all the subjects saw the same actions, the mirror areas of their brains responded quite differently according to whether they could do the actions or not. We conclude that action observation evokes individual, acquired motor representations in the human mirror system. This activation of motor representations through mere observation could have important applications in enhancing skill learning and in motor rehabilitation.

The fact that although all the subjects in the study of Calvo-Merino [11] saw the same actions, the mirror areas of their brains responded quite differently according to whether they could do the actions or not, might also explain the observations in Harbonnier-Topin study: The more experienced the students are, the easier it is for them to learn through observation. The less advanced students preferred "Doing with", while the more advanced students more easily appreciated "Watching without doing". Nevertheless, it is also true that less experienced students do learn from the teacher's demonstration, but will struggle to memorise the movement and will experience greater difficulty reaching, if at all, the "performance-display" stage. We are quoting one the students sayings in Harbonnier's study[23] "… when I see him [her teacher] dancing, it is so fluid … but I do not think about fluidity when I should. I just think about stretching my legs,

pushing into the floor and keeping my balance". This quote emphasizes that are (at list) three different levels of imitation which are connected with the level of expertise of the student:

- imitate to memorize the sequence of actions, i.e., the form and structure of the movement sequence,
- imitate the technique, i.e. the biomechanical details in the performance e.g., how open should my arm be before turning,
- imitate the qualities of movement, e.g., fluidity.

Of course imitation is not perhaps the optimal way to enhance one's movement abilities like balance and perhaps not the ideal way for exploring the student's own movement qualities which can be improved through imagery and self-reflection, as we will see in the next sections.

A5. Imagery in Dance Practice

Mental imagery (varieties of which are sometimes colloquially referred to as "visualizing," "seeing in the mind's eye," "hearing in the head," "imagining the feel of," etc.) is a quasi-perceptual experience; it resembles perceptual experience, but occurs in the absence of the appropriate external stimuli. It is also generally understood to bear intentionality (i.e., mental images are always images of something or other), and thereby to function as a form of mental representation. Traditionally, visual mental imagery, the most discussed variety, was thought to be caused by the presence of picture-like representations (mental images) in the mind, soul, or brain, but this is no longer universally accepted [52].

There are seven types of imagery, each corresponding to a sense, feeling, or action:

- Visual imagery pertains to graphics, visual scenes, pictures, or the sense of sight.
- Auditory imagery pertains to sounds, noises, music, or the sense of hearing.
- Olfactory imagery pertains to odors, scents, or the sense of smell.
- Gustatory imagery pertains to flavors or the sense of taste.
- Tactile imagery pertains to physical textures or the sense of touch.
- Kinesthetic imagery pertains to movements or the sense of bodily motion.
- Organic imagery or subjective imagery, pertains to personal experiences of a character's body, including emotion and the senses of hunger, thirst, fatigue, and pain.

The use of visual, auditory, kinesthetic, and sometimes tactile imagery is very common in dance education, either through specific techniques which adopt imagery in the core of the pedagogy (like Skinner Releasing Technique [8]) [48], or through metaphoric instructions and definitions given through verbal descriptions to enhance the performance of a movement or sequence.

While movement creation is of strong interest to the choreographers such as Trisha Brown, William Forsythe, Wayne McGregor and Merce Cunningham, the use of other forms of mental imagery related to sensation, space, meaning and emotion is also widespread, as May, Jon, et al. [36] confirm. In common usage, mental imagery is often understood as mainly visual in nature, but we are all able to construct mental imagery in other sensory domains: imagining sounds, textures, tastes and smells. We can imagine movement, without actually executing it, and it would be expected that dancers would be especially well practiced at this form of mental imagery. Alongside sensory imagery, we can also construct more abstract mental representations, including emotional feelings, and highly conceptual thoughts [36].

The following instructions are part of the Notes to Teachers by D. Lewis for teaching Limon Technique, and present a very characteristic example of using a visual and kinesthetic imagery to improve the performance:

[8] http://www.skinnerreleasing.com/

> "In any exercise where the body passes from a side bend toward one side of the body through vertical to a side bend towards the other side, try using the image of rainbow arcing overhead. One of the colours is missing from the rainbow and there is a paintbrush filled with that colour on top of the dancer's head. As the body goes from one side to the other, the paint brush must paint the missing colour along the arc of the rainbow. This image helps to keep the top of the head stretching out into space so that the body makes a complete arc in the movement."

Later on he reminds us that the image that will work for some students might not be effective for others:

> "Once the student has found and achieved the movement correctly, muscle memory should take over and the image will no longer be needed. One image will not always work for every student, so encourage them to come up with their own."[33]

Metaphors are very common in the practice of dancers which might be found in a way also in the terminology of traditional techniques, e.g., Fouette: one of the most famous turns in ballet means in French "to wipe", while the pas de chat jump means literally "step of the cat". Although this is not the best example of using imagery in dance, these connections suggest a very deep and old relation between dance and metaphors to transmit either a clearer shape or a quality for the movement.

Although usually imagery is related to improvisation, imagery can be a powerful tool to enhance one's technique. Franklin in his book Dance Imagery for Technique and Improvisation describes 583 imagery exercises', where the 314 can apply during technique classes to enhance the performance of dance students in particular tasks. One of these exercises to enhance whole-body sensation is really interesting as he actually uses an example of technology [18]:

> "Hologram: Holograms are three-dimensional photos created by laser beams. No matter how much you cut them up, you still see the whole image. Like a hologram, every part of your body expresses the total shape. Even your little toe, the toenail, and just a corner of the toenail all contain the total expression and cannot be separated from it"

Teresa Heiland [24] conducted intervention research using images created by Eric Franklin in his correspondent book [18] for their ability to support increased jump height and the relationship between dancer's perceptions and personal out- comes. Thirteen university dance majors served as participants, and performed 1rst position jumps for vertical height analysis while applying four imagery interventions: "whole body is a spring," "central axis is a rocket booster," "feet stretching into the sand," and "spinal curves lengthening and deepening." After various analyses, the 'rocket' and 'spring' images appeared to be particularly effective at improving jump height; both of these metaphorical images also happen to be whole body images. It seems then that metaphorical images may tend to generate whole body engagement, while anatomical (or biomechanical) images may tend to incite a more precise, local initiation of the motion. The outcomes of the research have shown that not all chosen images have improved jump height, as the 'sand' and 'spine' images produced only marginal improvements in jump height. Nevertheless, metaphorical, whole body images have produced the highest jumps, a fact which points to the need for images to incite the power needed for whole body integration. The hypothesis, that the 'spring' and 'rocket' images will cause fatigue more quickly than the others, was not supported; while a measureable fatigue effect existed, it had roughly the same value for all image types. Finally, Heiland notes that a preference for certain images was observed, however, the hypothesis, that participant experiences with images will correlate with jump height was not statistically supported.

Imagery or the notion that images in the mind can alter the physiology and neuromuscular behaviour of the body dates back at least to the nineteenth century. Mental imagery lies in the core of the some practices such as Butoh and Skinner Realising Technique (SRT)[48].

> "The pedagogy of images in the Skinner Releasing Technique serves as a structure of metaphors for kinesthetic experiences. Skill with image forming grows with practice. We (SRT teachers) select imagery carefully according to the student's level. The images at the basic level fall into two categories: specific and totality imagery. Specific imagery is concerned with segmented movement patterns, while totality imagery cultivates an overall state in which an integration of multidimensional awarenesses is realized. An example of a specific is the image of marionette stings at the knees. This image is designed to allow greater freedom in the hip socket. An example of a totality is the image of floating in a pool. Then the whole self merges with the pool -- the outer edges of the self becoming the outer edges of the pool. At times the specific string image is integrated within the pool totality. Students eventually can become so captured by the totality that their environment becomes real -- so real that the feeling state evoked by the image is experienced as another reality. These feeling states should not be confused with dramatic interpretations of the images. Rather, they are experienced more as an immersion or complete identification with the imagery. "Feeling state" is used in the sense that Suzanne Langer speaks of it. It denotes all that can be felt "from physical sensation, pain and comfort, excitement, repose, to the most complex emotions, intellectual tensions, or the steady feeling tones of a conscious human life."

Several renowned choreographers, such as Trisha Brown, William Forsythe, Wayne McGregor and Merce Cunningham have explored their performers' expressive range through developing and refining techniques for generating and structuring novel forms of movement. May, Jon, et al. [36] on the mental strategies underpinning the movement innovation techniques used by one of these choreographers, Wayne McGregor and his company Wayne McGregor| Random Dance. In particular, they have investigated how different forms of mental imagery are involved in movement creation, and how different task constraints can change the nature of the imagery that is used.

Here is one example of a McGregor task May, Jon, et al. [36]:

"First thing to do is in your mind create a very simple, literal freehand sketch or drawing – in your mind. Choose a beginning on that sketch and then describe it physically or draw it – the whole thing rather than just an element of the whole thing. So it has duration. The third part of this is to discard the geometry (of the object that you drew) and replace that with color. Then do another one."

A review by Overby [41] confirms that the history and research of dance imagery provides practitioners with evidence that dance images can positively impact motor learning and performance in beginning, intermediate and advanced dancers. In sum, research, dance teachers use imagery to teach; and existing research provides evidence that dance imagery is useful as a tool for motor skill learning in both teaching and performance settings. Kinesthetic (feeling) imagery appears to play an important role in skill development and performance. Metaphors, a common component of dance classes, appear to facilitate skill learning and performance.

At this point, we should say that although mental imagery is based on imagination, though mining visual, aura, tactile and kinesthetic "images" from previous experiences, David Kirsch [29] discusses the difference between perception, projection, and imagination and argues that marking as a form of projection is also a form of physical thinking. Marking refers to dancing a phrase in a less than complete manner. Marking is part of the practice of dance, pervasive in all phases of creation, practice, rehearsal, and reflection.

Kirsch provides the following definitions to differentiate perception from projection and imagination:

- When we perceive an object, our experience is that we are seeing an object that is really there; we feel it is what causes our perception.

- When we project onto an object, we experience ourselves intentionally augmenting the object; we feel we partially cause our experience.
- When we imagine an object, we feel as if we are the sole cause of our imagined experience.

A dancer creates a partial version of a phrase, attends to it while creating it, and because of processes like priming and projection, the dancer is able to understand something deeper about the phrase's structure than through imagination alone… Physical movement replaces mental computation. Instead of imagining transformations, they execute them externally. Marking is part of a distributed vehicle of thought with internal and external parts closely coupled.

A6. Different Practices and Learning Objectives

Dance learning can take place in informal settings as well as in formal dance education institutions. Systematic learning can be hard, demanding and also requires the development of critical, analytical skills on one's own movement and knowledge. Different techniques apply different learning objectives, teaching approaches, and often philosophies on movement depending on the dance genre, the level of the dancer in this particular dance style, age, goal, background, learning style.

The different teaching styles are usually adopted by specific practices, a fact that sometimes has to do with the tradition or culture in the dance genre rather than being a deliberate choice. Nevertheless, different teaching approaches can cultivate different motor, cognitive and creative skills. Dance teaching practices thus can vary depending on what they focus on:

- Movement form: the dance form consisting of specific shape of the body and actions which results with a time/space structure, i.e., particular sequence of actions and geometries of the body.
- Movement qualities: the dynamics and general feeling of the body rather than achieving particular form. Qualities refer to "how" the movement is executed, what are the dynamics of the movement. (e.g., Laban Movement Analysis Efforts)

It is true however that in most of the dance genres both structure and qualities are important although the focus may differ. Classical ballet for example, might have very specific positions, syllabus and terminology, and specific demanding technique, but qualities of movement are always part of good expressive performance. Learning the movement structure of a choreography is only one limited aspect of dance education. According to experiential learning: "all learning is re-learning", i.e., learning is best facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, more refined ideas. Based on this, which highlights the importance of cultivating transferability of skills through dance education rather learning a set of pre-defined sequences or "dances", we highlight the importance of Learning Objectives which seem to be part of integrated dance education, beyond dance genre. Whether the dance practice is more focused on learning specific sequences and forms, or movement qualities, there are some basic movement principles that a dancer of any genre deals with to a lesser of larger extent. In other words, movement principles refer to the concepts related to movement that any skilled dancer cannot go without developing and understanding e.g., directionality, symmetry, rhythmicality, balance, alignment, weight bearing vs. gesturing, stillness. In fact, a deep understanding and a competent application of Movement Principles (combined with a variety of movement qualities) is what makes the performance of a movement sequence a dance sequence and differentiates it from a gymnastic routine execution. In addition, movement principles should be 'tools', acquired skills for the students that allow them to develop transferable knowledge into new sequences and perhaps new styles or genres of dancing. One of the aims of WhoLoDancE is to define a set of movement principles, investigate how they are related with each of the four dance genres –use cases of WhoLoDancE and explore different ways to analyze, compare and transmit through the use of interactive technologies.

A6.1 Creativity vs. Tradition leading the practice

There is a need to emphasize the importance of creativity and improvisation ability along with memorization to grasp new given dance sequences, and cultivating embodied knowledge on the movement principles.

In contemporary dance, creativity and the ability to make not only new movement sequences, but also to explore new strategies in movement through improvisation is an important part of the dance practice. Dance learning as being in a constant dialogue with choreography and dance making it is impossible not to be influenced by the recent and contemporary approaches to movement. 'Wayne McGregor's approach to movement creation involves dancers making a wide range of embodied mental transformations. He asks his dancers to create movement in response to task instructions that require a great deal of mental imagery and decision making, and then observes the dancers' resulting movement, selecting and amplifying sections for potential re-use' [36]. Since, WhoLoDancE addresses intermediate to advanced and professional dancers aiming to enhance their continuous learning experiences, we have to consider choreographic and movement creation tasks as part of this educational process. Trisha Brown, William Forsythe, Wayne McGregor and Merce Cunningham are some of the famous choreographers who have approached movement creation both as a mental as well as a physical process which demands creativity, imagery ability, decision-making, as well as 'a problem solving' perspective. These practices and choreographic approaches nowadays are not unusual, if not inseparable tasks within a contemporary-improvisation dance class or rehearsal. This fact provides another strong argument on aiming to cover all four different modes of Kolb's experiential learning lifecycle including watching, doing, feeling and thinking as parts of a holistic dance learning approach.

Critien [13] reports on a study which had the purpose to identify and examine the methods that professional dancers use to engage fully into their work as artists. Improvisation ability was mentioned as one of the main key points. Dancers expressed that as they gained more experience they were more able to maintain the experience and expression of their performance even if something went wrong on stage. This could sometimes involve improvisation in order to deal with the unexpected event. This ability came through the experience of their professional work in companies, and they felt it was not addressed in their training. One dancer said:

> "I think, a lot of what they teach you at school is to carry on, in your robotic manner what you're meant to do, no matter what happens, and pretend that things don't happen and when you enter the professional world, you realise that no matter what's happening you should be able to improvise and bring that world into your world. "

To this point we should add that if there is one field where education and learning needs to be continuous this is the field of dance. There is no advanced or professional dancer who quits practicing, attending classes and seminars in daily or frequent basis if she/he wants to remain active. In the framework of the WhoLoDancE project, we are designing learning experiences that vary from an intermediate to advanced and professional level, thus we take into account the case of dance learning as part of professional continuous development. Another key point mentioned in the study Critien was the personal engaging factor [13]:

> "Most of the dancers spoke about the need to be self-aware and connected to the work that they are performing by finding a personal, engaging factor. Most dancers reported that this engaging factor would depend on the nature of the work, but the important thing was that they had a particular *intention* or goal that they were aware of while performing the piece, for example being aware of the origin of the movement that they are performing. As noted above, all

> the dancers spoke about being in a state of reflective automaticity while performing, which is achieved as a result of the preparation period where the focus is on practice."

One of use cases addressed by WhoLoDancE is Greek folk dance, a genre which has many more commonalities with tradition and cultural heritage education than with the practices already mentioned coming from contemporary dance. While in contemporary dance most of the practitioners and teachers, following the examples of leading choreographers encourage their students to create their own kinetic vocabularies, through reflection and generation of innovative paths, most of Greek folk dances are examples of chain and round dances with specific kinetic forms and structures. The leader dancer might improvise, though always within very specific boundaries:

> "The most widespread form of dance is the semicircular group dance. All the anonymous dancer, in the middle of the line, can do is to combine the generally simple variations of the basic dance motif. The folk dance is a popular art, and therefore a conservative art, which limits the personal creativity of the dancer, performer and, from this point of view, that of pure, original creation, we shall never find the folk dancer as a creator of new, integral movement patterns through which he can express ideas. The margins for personal creation are determined by the traditional folk art of his community. The term 'folk dance of a community' means movement patterns of the dance, which this community, after a long, slow process of transmitted oral tradition, has shaped and adopted as its choreographic expression. »

explains Amalia Markatzi, teacher and vice president of Lyceum of Greek Women[9]

> Another characteristic of this dance practice is its close relations to tradition as whole, including music, lyrics, history and contexts. "The music accompanying the selected dances, is one of the most important factors affecting the folk dancer and the improvisation will also be provided and has to be evaluated in parallel."

A6.2 WhoLoDancE and the Physical Education Learning Styles

Dance learning, depending on the context might require the development of both open and closed skills. When practicing in studio-or class specific sequences or choreographies the dancer performs in a highly predictable environment, and doesn't have to consider external, environmental changes and challenges (closed), while in improvisation, dancing with partner, or a group, or performing in front of the audience the dancer is challenged to move in an unpredictable environment (open). Also depending on the context the dancer can be internally paced, e.g., if he improvises alone or externally paced e.g., when have to follow the music or a dance partner. The last two examples (open vs. closed and internally vs. externally paced) inspire different learning scenarios for interactions.

For example, in contrary to some other sports and physical activities that rely solely on gross motor skills (running), most of dance techniques require mastering both *fine* i.e., using smaller muscles to achieve precision e.g., precise hand or finger movements, and *gross* motor skills, i.e., using larger muscle groups or parts of the body as a whole e.g., running, or jumping. Gesture based interaction, apart from conveying particular meaning, is based on *Discrete* motor skills, i.e., movement units that have clear start and ending point, whereas in physical activity in general and more specifically in dance discrete motor skill are only one option, e.g., doing a pirouette, among many. This is the case when one needs to master one specific move or step usually at early stages of learning. Dance, on the other hand depending again on the style and context is a combination of *Series* or *Sequential* and *Continuous* skill. For example, in choreography, a combination of specific motives (sequential) vs. dancing or improvising with no predefined, discrete movement units. Whilst unpredictability, fluency and freedom of movement are some principles in

[9] http://www.lykeionellinidon.gr/lyceumportal/default.aspx

contemporary dance, at the same time economy (meaning to move in an efficient, functional and simple, non-stylized manner) and efficiency, as well as clarity of movement are required as well.

In Table 3, we present a list of teaching styles described in literature [26][39]. Indeed, even though it is focused on general Physical Education, part of its theoretical basis is appropriate for dance teaching. It is important, at this stage, to bring up this other crucial issue of the design of learning scenarios later on in WhoLoDancE, but also in designing digital experiences for dance education. These other foundations are mandatory for the future design of the interaction and integration of rules for teaching-learning and "reproduction -production" processes.

WhoLoDancE addresses four different dance genres as use cases (ballet, contemporary, Greek folk and flamenco). Even if we focus on these four dance genres the diversity in both the kinetic vocabularies and the teaching methodologies is still wide and one of the biggest challenges is to find learning objectives that are common across genres. We aim for a systematic way of selecting characteristic video shots for Motion Capture and archiving in the repository, beyond the differences of the kinetic material. A focus group, with the participation of dance teachers of all genres, agreed that the following *Learning Principles* summarize the different teaching styles applied in different practices:

- **Mimesis**: imitation/copying: the teacher is teaching the student a specific movement or sequence of movements and the student follows the movement. This is a case where the learning is largely based on observational abilities of the students as they are asked to see and do;
- **Generative**: the teacher gives the student an exercise/phrase/sequence as a starting point to achieve technical and creative goals. In this case the student is allowed to generate new kinetic material, or alter things as long as he or she is consistent with the technical or creative goals;
- **Reflexive**: the student is given a movement task/image/to work with, improvising without trying to achieve a specific phrase/sequence and the teacher provides feedback. In this case the memorization ability of the student is challenged, as in contrary to the mimetic approach the student has to remember the sequence, rather than see and do, and at the same time is allowed to alter or generate new material, as in the generative approach;
- **Traditional also known as "command style teaching**": where the teacher makes all the decisions and the learner follows, while the teacher "commands" what the student must correct or change to achieve the good performance of the movement. The method requires precision and accuracy of performance.

Table 3-Teaching Styles in Physical Education and Dance

Teaching Style	Description (as defined in [26])	WhoLoDancE Comments
Command	The teacher breaks down the skills into parts and demonstrates the right way to perform the skill. Students try to move when and exactly how the teacher tells them. The teacher provides feedback and the students try to look like the teacher's model.	Mimesis (demonstration) and Traditional (command style)
Practice	The teacher makes several stations in the gym where students work on different parts of a skill or different skills. Students rotate around the stations and do the tasks at their own pace. The teacher moves around and helps students when needed.	Reflexive: the case where the teacher provides feedback after the student completes the task)
Reciprocal	Two students work together on a task that the teacher has designed. One student practices while the other student gives feedback to the partner. The students might use checklists to help them give good feedback to each other.	Reflexive: the case where the other student provides feedback after the student completes the task)
Self check	Students work alone on a task and check their own work. The teacher might give them a checklist so that the students can provide feedback to themselves while they learn the task.	Reflexive (the case where the student self-corrects herself after or while doing)
Inclusion	The teacher designs a learning task and there are several levels of difficulty. Students choose the level at which they want to work. Students can decide to make the task easier or harder by changing levels of the task to match their ability.	In WhoLoDancE we consider to design tasks in a variety of levels of difficulty.
Guided	The teacher asks students to discover a solution to a movement problem. The teacher asks students discovery a series of specific questions and the students try out their answers until they discover the right answer that the teacher wanted them to discover.	Generative : under this perspective the student is asked to generate new kinetic material as a 'solution to a problem'
Convergent	Students try to learn a skill or concept by using logical reasoning. The teacher asks a question and discovery students try to reason and think about different solutions. By critically thinking about the question and trying solutions, students can discover the single, right answer.	Generative: under this perspective the student is asked to generate new kinetic material initiated by a concept. This approach is common in contemporary improvisation. Note that in Kolb's Cycle Convergent= thinking and doing.
Divergent	The teacher asks students to solve a movement question. The students try to discover different movement production solutions to the teacher's question. There are multiple ways for the students to answer the question correctly.	Reflexive/Generative: there is no one right answer, it is more an invitation to experimentation. Note that in Kolb's Cycle Divergent= feeling and watching.

Learner's individual design program	The teacher picks the general subject matter, but the student makes most of the decisions about individual the learning experience. The student decides what will be learned within the teacher's guidelines, and designed then designs a personal learning program with consultation from the teacher.	For WhoLoDancE this appoach is not a different Learning Principle but an aspect to consider during the design of the Learning Scenarios (to what extend the system or the user makes choices about the next task)
Learner	The student decides what will be learned as well as how it will be learned. The teacher and student initiated set some basic criteria, but the student is responsible for all the decisions about how and what to learn. The teacher can help with information if the student needs it.	same as above.
Self- Teaching	The student decides everything about learning something new. They even decide if they want to involve teaching the teacher or not. The teacher accepts the student's decisions about learning.	same as above.

A7. Technology in Dance Learning: A potentially deep and essential relationship

A7.1 Dance and Interactive Technologies

As Calvert [9] states, of all the art forms, dance has probably been the slowest to adopt technology. In part, this reflects the reluctance of dancers and choreographers to let anything get between them and the live kinesthetic experience. But it also reflects the fact that useful tools have been slow to develop in a market with limited commercial opportunity. There are many examples of the use of all forms of multimedia in conjunction with live dance performances, as Calvert [9] explains. In some cases a pre-planned animation sequence or digital video with appropriate sound is played as a backdrop and live dancers interact with the preprogrammed display. A more technically challenging system is required when it senses the live dancers' movements and modifies the imagery and/or sound. Another situation arises when digital video, possibly with immersive or stereo display, links two distant locations for rehearsal and/or performance. All kinds of other variation are possible.

Today numerous examples of artistic dance groups integrate new technologies during performance and include interactive media in the core of their creative process. Augmenting Performances[10], a website curated by Fivos Kefalonitis, presents more than 100 examples of such performances, some of which we also present in part B section of this file.

In addition, many researchers have investigated the relation between movement qualities, a notion inspired from dance to analyze and develop whole –body and touch based interaction experiences. Currently the research areas of dance, music composition and movement analysis, visual and media arts and Human Computer Interaction seem to be in a cross-fertilization dialogue.

[10] http://www.augmentedperformance.com/

A7.2 Technology in Dance Education

In the following section we discuss, how these research and technological advancement can support the teaching and learning of dance in different educational contexts. Technology may not be the first thing to come to mind when thinking of dancing and choreography, but Marsha Barsky11, is one of dance educators who are changing that perception.“I integrate technology into all of my classes and have found exciting and novel approaches to using computer and video technology for studio classes,” she said. “It allows students to closely analyze their work in their own free time and offers them the possibility to make appropriate revisions to their choreographic assignments before the next class,” Barsky said. “Many responded very well and used it as a tool for learning. There can be a steep learning curve for technology like this, but all-in-all, everyone comes to appreciate the ability to record, upload, and receive feedback on their assignments. Barsky recognizes the challenges of integrating technology in the classroom and also understands the importance of technology in modern academia. She evaluates which form of technology is most effective and then reevaluates and rethinks her teaching methods on these bases. .

According to Barsky, through appropriate technologies, educators can have the opportunity to remodel their pedagogical approach, and when it’s done well, it’s possible to create a diverse learning environment suited to a host of different students.

Barsky, who directed the Vanderbilt dance program from 2003 to 2007 and joined the MTSU dance faculty in 2006, recognized that technology could be used to advance what she considers the most vital component for her class—the ability to offer meaningful, constructive feedback.

“It can be difficult to recreate the precise movement at issue for the discussion, and this need for precision—and the time limitations seemed to offer ideal platforms for the integration of media-based technology,” she adds.

Rosannne Spector (2005)[12] reports on an experiment in Stanford University where dancers from the Merce Cunningham Dance Company were recorded through Motion Capture sensors (put directly on their skin as shown in Figure 2).

Apart from the enthusiasm shown by the dancers who took part in the experiment, the quote of one of them highlights a good point about the impact of using technologies in the learning process. "I know what I think my body is doing. But is it really doing that? I don't really know, but I'd like to," The use of technologies like Motion Capture and biomechanical visualizations can support deep understanding of movement mechanism and provide objective date about one’s movement for self-evaluation and further reflection. “While movement is something humans do constantly without thinking, the members of this class are giving it a lot of thought: By analyzing movement from both scientific and aesthetic perspectives, they are trying to gain a deeper appreciation of why people move their muscles and bones in a particular fashion. The students evaluate golf swings, create a moving hand model, develop a standardized test for arm function and, in this particularly compelling example, probe the essence of a legendary choreographer's mode of expression. “When you actually quantify something artistic, even if it seems obvious, you often learn something," said Ladd, when asked before the final class presentation last week. "You often think you know how things work, but until you quantify it you don't know for sure." Eadweard Muybridge's 1878 stop-action photos of a trotting horse exemplify this—proving that for a moment the horse is suspended above the ground.”

[11] http://www.mtsunews.com/barsky-dance-technology/

[12] http://news.stanford.edu/news/2005/march16/med-mercer-031605.html

Figure 2-Jonah Bokaer, a dancer from the Merce Cunningham Dance Company, was adorned with sensors that allowed a computer to record the motions that he performed with Stanford senior Jessica Goldman.

Autard (2003) characterizes the connection between technology in dance pedagogy as essential, when it comes to support the memorization of dance form. She proposes that since dance form is abstract in that it exists only in the memory, teaching the concepts relating to form can be much enhanced by the use of technology. Risner and Anderson (2008) introduce the notion of "digital dance literacy" and describe the use of technologies in a pilot curriculum development project sought to design and implement a comprehensive technology curriculum for undergraduate dance students in bachelors degree programs in the US. According to them, technological advances and their creative applications in dance over the past decades (computer-mediated choreography, musical scores, and sound environments; interdisciplinary and mixed media; online rehearsal and performance) establish a new area of valuable knowledge which should be a part of a dance education curricula. They mention four developmental design problems which were confronted in this pilot project, including how to provide: (1) integrated delivery of technology in required, rather than elective dance coursework, throughout four-year undergraduate degree programs; (2) student-centered design and relevance, capitalising on students' own technology capital and interest; (3) balanced content in both creative application, as well as practical technological aspects; and (4) completion of digital e-portfolio in the undergraduate senior year".

At this point, although dance learning is a "book" education subject that can be solely transmitted through typical e-learning or distant learning platforms, we should also consider this aspect. Online dance learning can share the same characteristics with online physical education. Daum et. al[14] explain that Online physical education (OLPE), on the other hand, both dance and physical education faces the same issues as other content areas taught online such as academic honesty, learner readiness and motivation, student retention, technology issues, etc. including the unique challenge of enhancing motor skills, movement principles and qualities. Buschner [8] documents some of the potential advantages and disadvantages of OLPE, which could also apply to online dance education. The advantages were: 1) students are motivated by technology, 2) benefits students who live in remote areas, 3) fits students were: 1) students are motivated by technology, 2) benefits s

Leijen et. al [32] have conducted a study to find out how dance students experienced learning in an international distance education program delivered in an e-learning format using a virtual learning

environment platform. In order to organize the students' experiences with the various learning assignments, the authors focused on three broad categories of learning tasks: individual writing assignments, collaborative assignments, and individual practical assignments. Data were collected from 42 students using a questionnaire and group interviews. Regarding the e-learning format, Leijen et. al [32] found that the most crucial factor for carrying out all learning assignments was the teacher's guidance and feedback on students' work. Regarding the learning platform, the authors found that in comparison to other learning tasks, carrying out practical assignments was the most limited with the available tool.

An article by Rachel James Clevenger[13], explains how using technology to teach dance and enhance intelligence through the approach of Chandler Vaccaro, Associate Professor of Dance at Rider University in New Jersey. A few years ago, Vaccaro was involved in a study with the New Jersey Department of Education that investigated whether dance education could be effectively delivered via technology. Using large split screens, an expert teacher was able to interact with the virtual bodies of the dancers. He could actually adjust their virtual bodies on the screen, so the dancers could see adjustments they needed to make. Vaccaro considered this the "most intense learning she'd experienced."
They started using recording and viewing devices, like iPads, "to record and watch movement phrases." Students would record the young ballet students, and then student-teachers would have them gather round the iPads to watch themselves on the devices.

Clabaugh explains, "They would respond with what they did well and what they would work on when the combination was repeated. This practice allowed them to evaluate themselves, a skill that is important to cultivate for all dancers." They also used iPads in the Choreography and Improvisation class, recording their own movement phases as they created them, so they could watch them and play "both the choreographer and the audience all in one go" which helped them "understand shape and space and how it is perceived by the audience."

Vacarro notes that she mentions Star Trek to her students often. Laughing, she recalls sitting down years ago to watch William Shatner's Captain Kirk and the then-futuristic technology. Now, though we aren't being beamed up quite yet, we are having face-to-face conversations on our phones and talking through Skype. She acknowledges this connection between art, imagination and technology. Her commitment to studying and applying concepts of neuroplasticity, and teaching students that "every part of the brain can grow," directs her pedagogy. "You can teach creativity through new experiences," she explains. Vacarro believes mindfulness is a critical component in learning, in that we can teach students to be more creative and imaginative by teaching them to be more mindful of what they are doing and why they are doing it. She sees technology, when used correctly, as a way to enhance this mindfulness.

Vacarro also explains that dance training can enhance intelligence. Because dancers are creating "visual art" and "creating moving sculpture," they are tapping into brain centers for logic and memory, fluid and coordinated movement, processing temporal location, and emotionality. Not only are they using "every single section of the brain all the time," she adds, but dancers may hold fifty or more full ballets in their minds for instant recall. In short, she explains, "Dance makes you smarter. Dancers are exceptionally intelligent people because they are making these connections all the time."

[13] http://www.pupnmag.com/article/detail/6263/using-technology-to-teach-dance-and-enhance-intelligence

PART-B: Dance and Technology SoA

Introduction

Whole-Body interaction methods have found a natural and straightforward application in dance as supporting tools both for choreography and learning. This section presents several of the most prominent approaches in this field. When designing Interactive tools for analyzing movement for creative, educational or other purposes, as Alaoui et al. [1] also states, the crucial point is how the link between the dancer's movement and the digital response is designed. In other words, within interactive tools the mappings between input and output modalities are crucial for generating expressive cause-effect relationships that allow for a rich exploration of movement. Alaoui et. al in this paper have categorized different compositional tools for movement which have been developed into four main categories: Reflective, Generative, Interactive and Annotating, and provide the following definitions [1]:

- Reflective Tools: As reflective tools, are described systems that apply various approaches to visualizing movement or structures including systems that reflect on shapes and structures of movement to enhance an audience's viewing skill set in the moment and one system abstracts performance and structural aspects of choreography to illustrate change over time in a single perspective. While the content of these systems are similar, they depict movement information to provide different perspectives and uses.

- Generative Tools: the term Generative Tools broadly is defined as, as tools that generate movement material either autonomously (through using an existing corpus of data) or manually (a tool that facilitates a human choreographer's creation of material). This category includes systems that focus on generative aspects of movement that support choreographic composition for humans, computation or video games.

- Interactive Tools: Interactive tools allow dancers to interact with a digital media that responds in real-time to their performance. The digital media can be designed for assisting choreography by facilitating improvisation or exploration of the creative process through behaving as the dancer's virtual partner.

- Annotating Tools: Annotating dance movement or structure during the rehearsal has a strong potential for assisting choreographic reflection. It allows choreographers to analyze, edit, play, and re-frame material in order to prototype it and craft it incrementally during the choreographic process. The choreographers also used the tool to provide detailed feedback on the performance for coaching purposes, as well as for documenting, annotating, reviewing and editing a choreography.

Although, Alaoui et.[1] are referring to tools that might have not been developed for the purpose of supporting learning, as the authors state, they can "enhance viewing skill". Reflecting on movement structures and qualities and viewing through different perspectives as described also in Part A of this document, can be considered an important part of a learning process.

In the following section we present examples of using technologies either for enhancing and supporting dance learning and teaching through whole-body interaction or desktop application, as well as some examples of using technologies in way that innovates the analysis and reflection of the movement. We categorize these example into the following categories: a) Virtual Experiences for Dance Learning, b) Annotation tools and desktop generative tools, c) Mobile Apps, d) Reflecting on movement, e) Augmented- and Virtual Spaces. At the end of the section we present a table overview of the technologies mentioning the main technologies used (Motion Capture, Kinect, Annotation technologies,etc), their type of experience (whole-body experience, VR, AR, desktop, mobile etc), the purpose (education, gaming, archival, artistic, online collaboration, etc) and the dance genre on which the example focuses.

Virtual Experiences for Dance Learning

1. SuperMirror - Interactive Tool for Education

Super Mirror[14] [35] is a Kinect-based system that combines the functionality of studio mirrors and prescriptive images to provide the user with instructional feedback in real-time.

Authors in [53] present a user study to evaluate Super Mirror performed on a working prototype of this system, which records ballet movements (also called positions and poses), captures live motion, and shows the difference between the two Figure 3. Ballet students were evaluated on eight ballet movements (plié, élevé, grand plié, batte- ment tendu (front, side and back), passé and développé) to measure the Super Mirror impact. The results show a potential for its use in ballet education but improvements of Super Mirror are needed to comply with the standardized subject matter expert's criteria.

[14] https://vimeo.com/36948847 and https://vimeo.com/33384199

Figure 3 Dancers performing a plié (left) and passé (right) using the Super Mirror

2. YouMove

YouMove [4][5] is a system for learning full body movements with a direct application in dance education. It allows users to record and learn physical movement sequences through a simple recording system that allows anyone to create and share training content. The training system uses recorded data to train the user using a large-scale augmented reality mirror (Figure 4). The system trains the user through a series of stages that gradually reduce the user's reliance on guidance and feedback.

YouMove is comprised of a Kinect-based recording system, and a corresponding training system. The recording system is designed to be easy to use, so anyone can capture movement sequences and annotate them for learning, without the need for complicated motion capture hardware or software. The training system uses the recorded video and 3D movement data to guide the trainee through a series of interactive stages. The training system augments a traditional 'ballet mirror' experience by using a half-silvered mirror with graphic overlays for guidance and feedback. The use of a mirror allows for zero latency, high fidelity feedback. Authors report that in a user study YouMove improves movement learning and short-term retention by a factor of 2 compared to traditional video demonstrations.

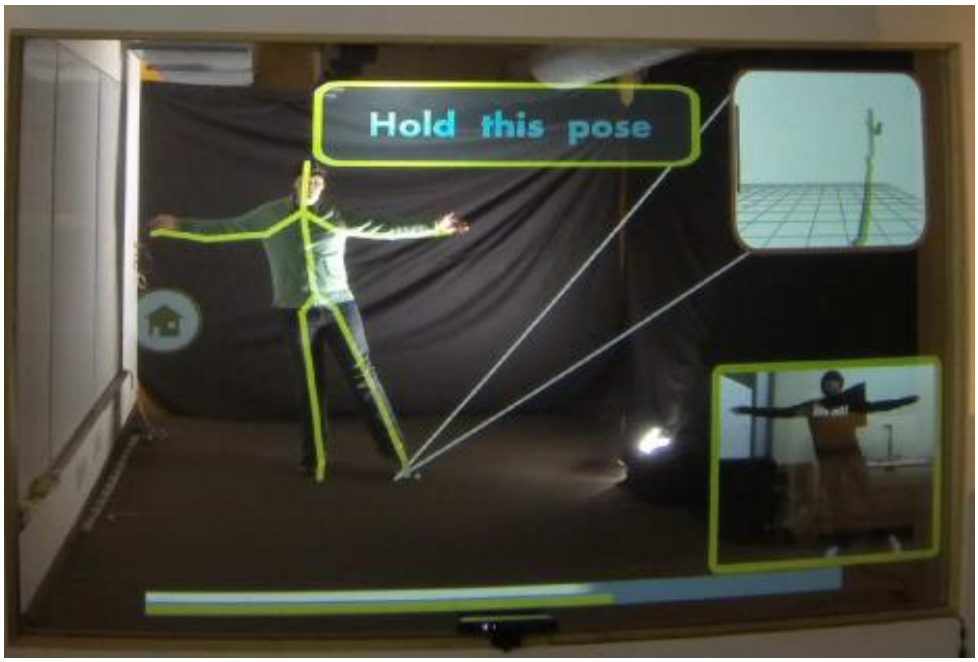


Figure 4 YouMove augmented reality mirror

Mirror-based augmented reality offers unique opportunities for interaction. The user's reflection can be used to directly activate on-screen components, allowing for direct manipulation of a 2D interface from 3D free-space. This reflection selection provides zero latency feedback on hand position, allowing quick positioning.

3. Motion Analysis for Folk Dance Evaluation

This work by Aristidou er al [6], introduces a motion analysis and comparison framework that is based on Laban Movement Analysis (LMA), used also in the context of teaching folk dances, and a prototype virtual reality simulator in which users can preview segments of folk dance performed by a 3D avatar (Figure 5) and repeat them. The prototype learning platform is built around the concept of students observing a virtual 3D teacher performing dance movements and repeating them. It uses quality motion captured folk dance data from a database, segmented into dance motion primitives, i.e. short sequences of distinct movements that usually last between 400 and 900 frames.

Figure 5 Samples from motion captured folk dances

During a dance learning session the user selects the dance she wants to learn and a 3D avatar (teacher) selects arbitrary dance motion primitives from the template motions and demonstrates it to the user (student). The user then physically performs the motion which is captured and passed to the motion analysis subsystem, via a full body motion capture system. The user's motion is analyzed and compared to the template motion and an evaluation of the user's performance is generated.

The users' performances are captured and subsequently compared to the folk dance template motions. The system then provides intuitive feedback about their performance, which is based on the four LMA components (BODY, EFFORT, SHAPE, SPACE) and provides both a quantitative and qualitative evaluation of the performance.

In contrast to other dance learning systems, the user is not explicitly provided with feedback on body parts that have been incorrect. According to the authors, beginners usually find it easier to learn the body posture (BODY) and steps (SPACE) of a dance, but may find it very difficult to reproduce the flow (EFFORT) and shape qualities (SHAPE) of a dance. Instead, the platform generates an evaluation based on the LMA categories (BODY, EFFORT, SHAPE, SPACE), which exactly point the student to the particular quality characteristic of his performance that needs improvement.

Furthermore, the learning platform allows the user to modify the sensitivity of the system when comparing the motion of the student to the template motions per LMA category. The four LMA categories are initially equally weighted (25% each). Users can manually adjust the weights to tilt the sensitivity toward one of the LMA components of the dance they would like to improve on. For instance, users that are comfortable with their body posture may reduce the decision threshold for the BODY and/or increase the threshold of the EFFORT to make the system more sensitive to mistakes in the fluidity of their motion. In addition, the system can be set to adaptively modify the difficulty of achieving a close match of the template motion. This follows the same principles of dynamic difficulty adjustment (DDA) in computer games, with an outlook of focusing the user's attention to spects of the motion he needs to improve on.

The approach of this system, both in terms of the LMA categorization and the learning approach, will be examined carefully in the context of WhoLoDancE.

4. A kinect-based skeleton tracking system for evaluating a dancer's performance

Alexiadis et al. [3] describe a prototype system that automatically evaluates dance performances against a gold-standard performance and provides visual feedback to the performer in a 3D virtual environment. The system acquires the motion of a performer via Kinect-based human skeleton tracking, making the approach viable for a large range of users, including home enthusiasts.

In such a scenario, a dance teacher is free to illustrate to online users choreography steps of their choice. After viewing the sequence at a later date, another online user (a student, for example) can attempt to mimic the steps, and obtain feedback from the system to help refine his/her dance moves. At any time, the teacher can alter the choreography or introduce extra steps when the student has reached a certain level of competency. As such, there is real online interaction between users.

Unlike traditional gaming scenarios, when the motion of a user must by kept in synch with a pre-recorded avatar that is displayed on screen, the technique described in this paper targets online interactive scenarios where dance choreographies can be set, altered, practiced and refined by users.

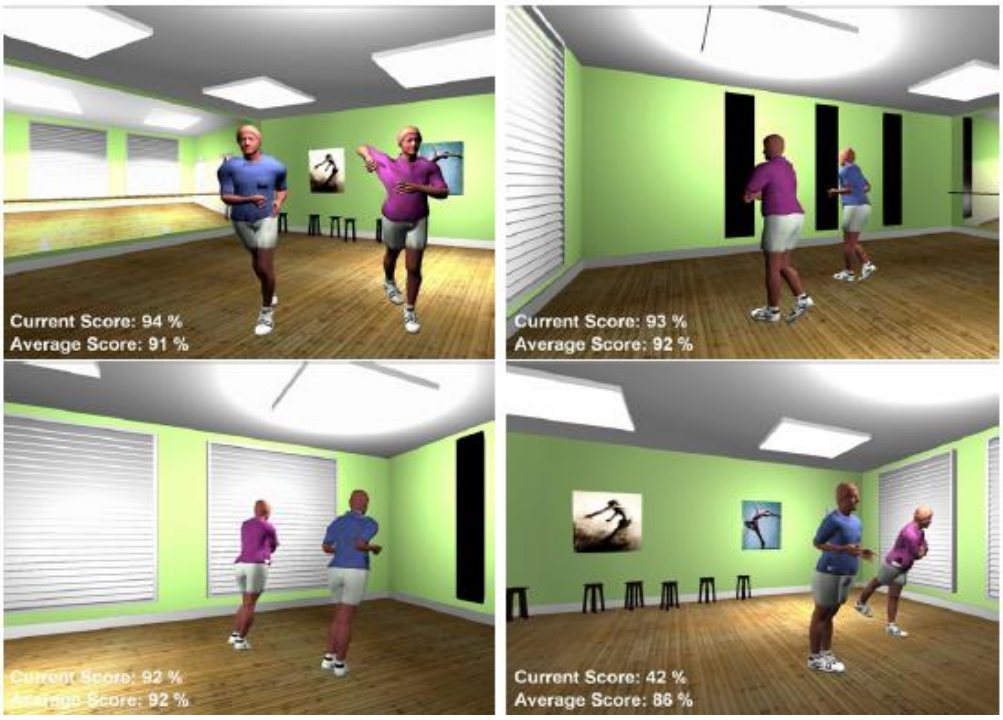


Figure 6 Visualization results from multiple angles and time sequences: how images with similar poses have good scores, but the dances diverges in the bottom right and is assigned a low score.

5. Just Follow Me - A prototype dance training support system with motion capture and mixed reality technologies

Training is usually regarded as one of the most natural application areas of virtual reality (VR). Just Follow Me (JFM) by Hachimura et. al [22], is a VR training system that uses an intuitive “ghost” metaphor and a first-person viewpoint for effective motion training. Using the ghost metaphor (GM), JFM visualizes the motion of the trainer in real time as a ghost (initially superimposed on the trainee) that emerges from one's own body. The trainee who observes the motion from the first-person viewpoint “follows” the ghostly master as closely as possible to learn the motion. The evaluation results show that JFM produces training

and transfer effects as good as—and, in certain situations, better than—in the real world. the authors believe that this is due to the more direct and correct transfer of proprioceptive information from the trainer to the trainee

A head-mounted display shows the professional dancer's motion overlapped with the body of the virtual character controlled by the user. The trainee can observe where his/ her body does not overlap with that of the professional dancer. In their system, the user needs to perform a motion and observes his/her avatar at the same time. This may affect the performance and require enough experience to identify mistakes.

6. A syntactical modeling and classification for performance evaluation of Bali traditional dance

Evaluation of dance element performance is a challenging problem particularly when the body-part motion is very articulated, i.e., involves large number of degrees of freedom (around 30). Heryadi et al [25]. present a linguistically motivated approach for dance gesture performance evaluation using skeleton tracking to robustly classify arbitrary dance gesture into one of predefined gesture classes and provide performance score in regards to the dance master's gesture. The gesture class in this study is a set of common gestures of Bali traditional dances. The dance gesture is represented as a set of skeleton feature descriptors that are extracted from images captured using Kinect depth sensor. A set of rules are learned from the training examples to capture the structure of the gesture motion using grammar inference method. The empiric results showed that elbow and foot of dance performer are the most discriminative features for representing dance gesture of Bali traditional dance

7. A multi-modal dance corpus for research into interaction between humans in virtual environments

Essid, Slim, et al (2013) [17] present a freely available, multimodal corpus for research into, amongst other areas, real-time realistic interaction between humans in online virtual environments.

The corpus has been created for the ACM Multimedia Grand Challenge 2011 by a partnership between the 3DLife Network of Excellence, a European Union funded research project that aims to integrate research that is currently conducted by leading European research groups in the field of Media Internet, and Huawei. Although the data corpus is tailored specifically for an online dance class application scenario, the data is free to download and used for any research and development purposes. This could include research into approaches for 3D signal processing, computer graphics, computer vision, human computer interaction and human factors. The data is free to download and use for any research and development purposes.

The specific corpus scenario focuses on an online dance class application scenario where students, with avatars driven by whatever 3D capture technology is locally available to them, can learn salsa dance choreographies with teacher guidance in an online virtual dance studio. As the dance corpus is focused on this scenario, it consists of student/teacher dance choreographies concurrently captured at two different sites using a variety of media modalities, including synchronized audio rigs, multiple cameras, wearable inertial measurement devices and depth sensors. In the corpus, each of the several dancers performs a number of fixed choreographies, which are graded according to a number of specific evaluation criteria. In addition, ground-truth dance choreography annotations are provided.

Ratings of the dancers' performances assigned to dancers by the teacher. 1 The dancers' ratings are given as an integer score between 1 and 5, 1 being poor and 5 excellent, across five evaluation axes:

- "Upper-body fluidity" evaluates the fluidity of the dancer's upper-body movements. "Lower-body fluidity" evaluates the fluidity of the dancer's upper-body movements.

- "Musical timing" evaluates the timing of the executed choreography movements/steps with respect to the music timing, the ideal timing being given in the choreography annotation files placed in the music/folder.
- "Body balance" evaluates the state of balance or quality of equilibrium of the dancer's body while he/she executes the choreography. "
- Choreography" evaluates the accuracy of the executed choreography; a rating of 5 is attributed to a dancer as soon as he/she accurately reproduces the sequence of steps of the choreography, quite independently from the quality of execution of each single figure.

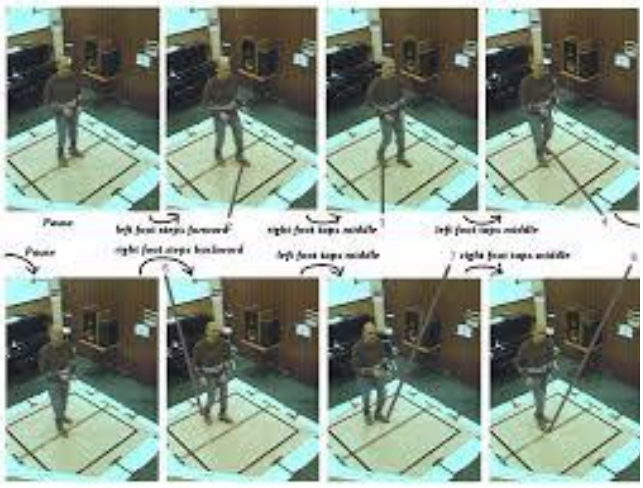


Figure 7-Basic steps for men recording

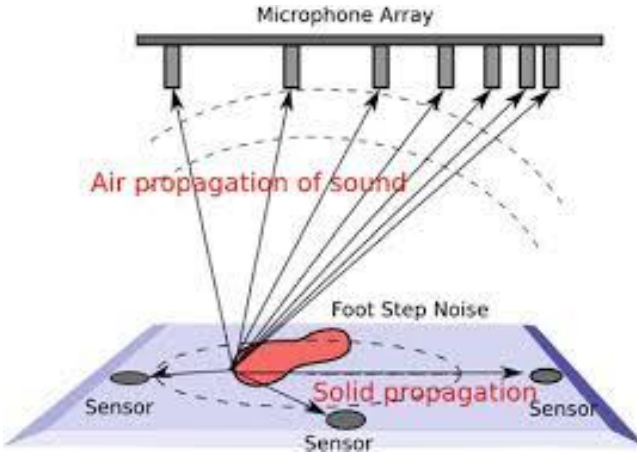


Figure 8-Sound propagation of the foot steps noise through the dancing board to the vibration sensors and through the air to the microphone array

8. Virtual reality and dance

Chen at al in [10] introduce a new dance training system based on motion capture and virtual reality (VR) technologies inspired by traditional approaches —imitating the teacher's movements and listening to the teacher's feedback. In the implemented prototype, a student can imitate the motion demonstrated by a virtual teacher projected on the wall screen. Meanwhile, the student's motions will be captured and analyzed by the system based on which feedback is given back to them (Figure 9).

Figure 9 Motion capture of the trainee and comparison with a VR avatar

The system provides three types of feedback to the students: 1) Intermediate Feedback which is shown in red (wrong) or yellow (correct) and appears while the students are dancing (Figure 10); 2) Score Report which shows scores for movement at each joint and appears after each performance; and 3) Slow Motion Replay which is shown in color of white (correct) to deep red (wrong) indicating the correctness and appears after the score report.

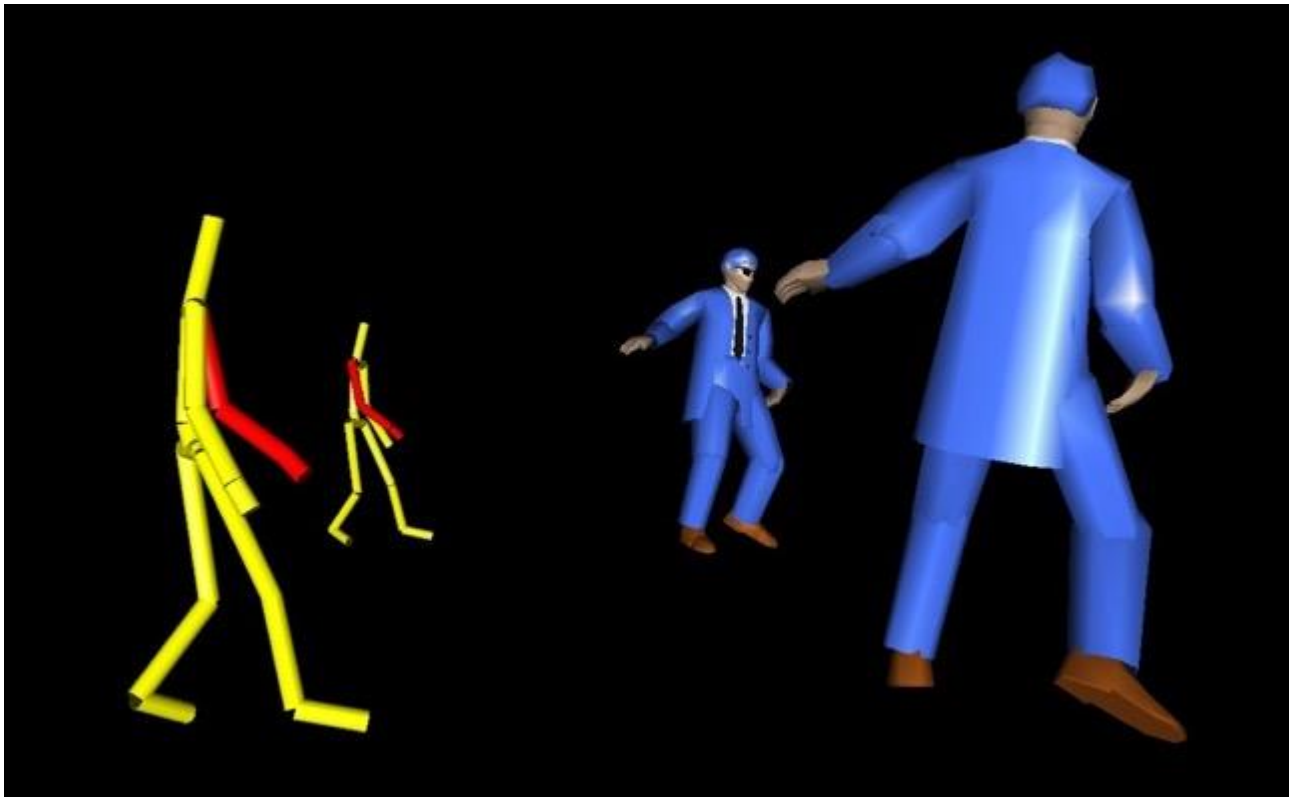


Figure 10 Intermediate feedback

The authors report that the system can successfully guide students to improve their skills. The subjects agreed that the system is interesting and can motivate them to learn.

9. A Dance Training System that Maps Self-Images onto an Instruction Video

The basic concept of this work [19]was to change the appearance of a dancer in an instruction video to that of the user to see how they would look like if they could perform so well. A motion training system that maps the user's image onto an instruction video was developed and evaluated.

Figure 11 Dance training system

Additionally, the authors developed a dance training system that increases user motivation by using a visual effect. This system vibrates the user's image by using image processing to emphasize the intensity of their movement.

10. Virtual K-pop dance teacher

A virtual dance teacher has been developed in [27] that can make learning famous K-Pop dances easier at home by precisely tracking 3-D body joints. The developers successfully created the precise 3-D tracking of 15 human body joints using big data of the human body and the relational information among human body joints.

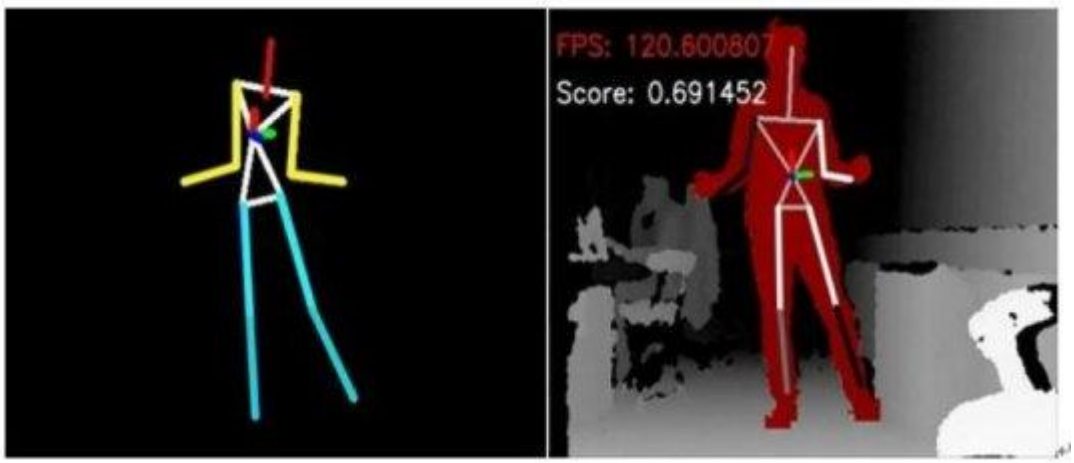


Figure 12 Virtual K-pop dance teacher

Daijin Kim and his team at POSTECH, South Korea, have developed a virtual dance teacher that can make learning famous K-Pop dances easier at home by precisely tracking 3D body joints. They developed the precise 3D tracking of 15 human body joints using big data of the human body and the relational information among human body joints and its tracking performance showed a 4.5 cm error on average among 15 human body joints. Dance movement of a dance teacher (left) and a dance learner (right). In the

right figure, body parts of the dance learner are represented with brighter sticks as they are those of the dance teacher.

They also developed a score monitoring method based on the similarity and represented how much each body part of a dance learner is deviated from the corresponding body part of a professional dancer. The brightness of each body part specifies the similarity of dance movements of each body part.

Kinect-based

11. Kinect Dance central

Figure 13 Kinect Dance Central

Dance Central[15] is a music rhythm game for the Xbox 360 that uses the Kinect motion peripheral. The game was developed by Harmonix and is a launch title for Kinect. In other words, Dance Central is a dance video game that features and tracks full-body dance moves. The designers put a lot of thought into both the moves and the teaching system, making it a pretty good educational tool.

Using a truly massive library of songs, each track features four unique routines that gradually introduce the required dance moves and build upon the previous move set to get even total non-dancers up to a level of coordination where they can gold star a Pro routine. There's also Cardio and Strength routines, for those after more of an aerobic workout, as well as an extra beginner and advanced level routine. Last but not least, it allows single players to pause a song at any time, slow down sections, and practice specific moves on a loop until they're mastered. Coupled with the game's remarkably accurate body tracking, this creates a true sense of skill progression and satisfaction.

Gameplay involves the player performing given dance moves which are tracked by Kinect and represented on the screen by one of eight in-game avatars. The game features over 650 different dance moves spanning over 90 dance routines, all created by professional choreographers. It is composed by the following five modes:

Perform It: The regular single-player gameplay mode, in which the objective is to complete these dance routines to earn a high score.

[15] http://www.xbox.com/en-US/games/dance-central

- Workout Mode: An extension to regular mode in which the number of calories burned are also tracked, along with the workout time.
- Dance Battle: Two players compete in a head-to head dance routine battle. The person with the highest score is the winner. In the rare event there is a tie in the score, the player who passed more moves wins.
- Challenge Mode: Once all songs (four or five) in each difficulty category have at least four stars on each one, a challenge based on the difficulty is unlocked. This mode increases the difficulty of the game by having portions of four or five songs combined into one, thus mixing up the dance moves. All challenges must be completed with four stars on each difficulty setting.
- Break it Down: A practice mode that allows beginners to learn more advanced dance moves in a step-by-step process.

It is important to note that this commercial tool, must be seen more like a game rather than a teaching tool or environment. Some of the critiques that Kinect Dance Central have received express skepticism and accuse these tools for a superficial approach which not compliant neither with the contemporary teaching approaches. "If you're a person who naturally has good rhythm, whether or not you have experience with dance, you can learn a lot from this game...Not saying that you can't learn if you don't have rhythm, but in our instant-gratification addicted society, you might not tough it out long enough to find out." 16 Although gamification can be part of learning process, it is important that a digital learning tool go deeper than learning the steps of specific choreographies

12. An Approach to Ballet Dance Training through MS Kinect and Visualization in a CAVE Virtual Reality Environment

Kyan et al in [31] propose a novel framework for the real-time capture, assessment, and visualization of ballet dance movements as performed by a student in an instructional, virtual reality (VR) setting. The acquisition of human movement data is facilitated by skeletal joint tracking captured using the Microsoft (MS) Kinect camera system, while instruction and performance evaluation are provided in the form of 3D visualizations and feedback through a CAVE virtual environment, in which the student is fully immersed.

[16] http://www.weirdworm.com/dance-central-for-the-kinect-learning-tool-or-humiliation-device/

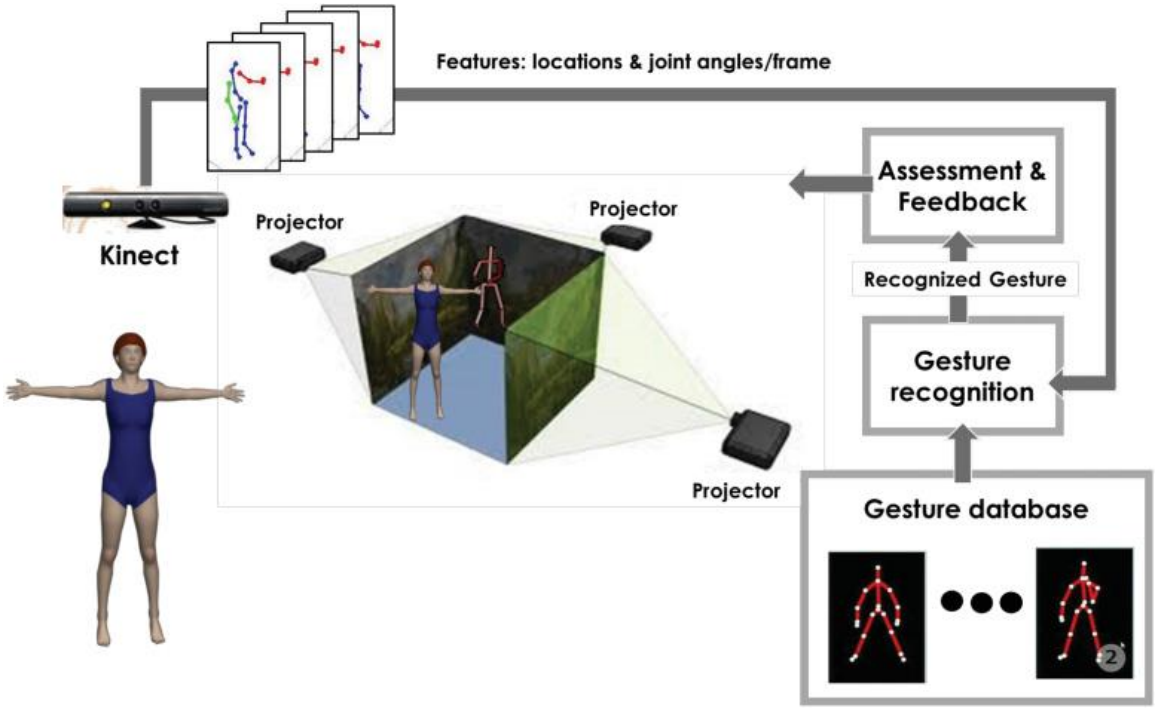


Figure 14-System architecture

Their work provides a biomechanical description of dance movements to inform dancers and dance instructors of the typical way to perform a standard movement and to explore the relationship between dance movements and injury. Using computational intelligence, they enable the system to recognize the student's dance gestures with a trajectory of postures over possible gestures. This computational intelligence is implemented in a fully immersive virtual reality system, the cave automatic virtual environment (CAVE). With an explicit model of a student's gestures, assuming a desired goal, the approach uses a trajectory of postures within a self-organizing spherical structure to predict the target gestures, given their actions. So the dance teaching problem is inverted into the problem of predicting the student's gestures. This is followed by an assessment of the student's performance and visual feedback in the CAVE, allowing high degrees of view and freedom of interaction.

Figure 15-CAVE environment for dance learning

The proposed framework is based on the unsupervised parsing of ballet dance movement into a structured posture space using the spherical self-organizing map (SSOM). A unique feature descriptor is proposed to more appropriately reflect the subtleties of ballet dance movements, which are represented as gesture trajectories through posture space on the SSOM. This recognition subsystem is used to identify the category of movement the student is attempting when prompted (by a virtual instructor) to perform a particular dance sequence. The dance sequence is then segmented and cross-referenced against a library of gestural components performed by the teacher. This facilitates alignment and score-based assessment of individual movements within the context of the dance sequence. An immersive interface enables the student to review his or her performance from a number of vantage points, each providing a unique perspective and spatial context suggestive of how the student might make improvements in training. An evaluation of the recognition and virtual feedback systems is presented.

13. Learning Hawaiian Hula Dance by Using Tablet Computer

The subjects of this study [56] were twelve high school students studying Hula Dance at a school Hula club. As seen in Figure 16 each hula dance of twelve students was measured by motion capture after each of them had danced to a compulsory tune alone and practiced to a certain extent. CG animation for practice based on the data measured by their motion captures was created. They are CG animations, which show a simplified skeleton of human beings as in the figure. This is a highly acclaimed expression method for dance learner's practice based on the past studies conducted by the authors. In this study, FBX Review, which is a CG animation viewer for tablet computer was used to view CG animation on it. A total of three types of CG animations and all seventeen animations were created: CG animation of the solo dance was created for twelve people respectively. CG animation for the group dance of three people was created for four groups respectively. CG animation for the dance of all twelve people was also created. Those CG animations were stored in five tablet computers. An i- Pad 2 (Apple, Inc.) was used as a tablet computer in this study. Those

tablet computers were used for about a one-month period of practice. Afterwards, the effectiveness of its use were surveyed for all twelve learners in a group interview. Moreover, in order to verify to what extent it was effective, the dances of the students were measured again by using motion capture. In addition, a club advisor was also separately interviewed concerning the changes in each student's dance.

Figure 16-Learning Hula from Tablet

The numerical results have shown enhancement in the motion of students, which are required for this style of dance, and help them improve their focus, attention and awareness on the related body parts.
The paper also discusses how the animation help them to focus on the movement rather than been distracted with other details that would catch their attention in a video or a mirror. Although the CG animation reproduces her own motion, it is not herself she is watching. Her own motions should be expressed accurately but a feeling of strangeness persists. However, this feeling of strangeness brings awareness: "why is CG animation different although I intended to dance (should have danced) in this way"? A learner can objectively view after processing into CG and objectivizing it. Thus, in an awareness of the difference between her own recognition and the CG motion, her own actual motion can be recognized. The advisor mentioned this issue and said, "Learners looked at other elements including face and did not look at elements I wanted them to look at although I gave instructions by using and showing videos and mirrors". It says it is hard for learners to recognize as there is such a thing as too much information. Utilization of motion capture may help learners view themselves with an "objective view". Moreover, it seems that it can be used to compare with a model and to "evaluate themselves objectively" reports Usui.

14. The WebDANCE and OpenDANCE projects

The WebDANCE [28]project and its continuation OpenDANCE [34][35] promotes the use of new technologies in dance education and in particular (a) the use of interactive multimedia technologies (e.g., video, 2D and 3D graphics, interactive images and text) for representing information about traditional dances (b) the use of the Internet as the learning medium. To this end WebDANCE aimed to develop a platform that would be used both as (a) a web-resource for teachers and (b) a web-based explorative learning environment for students in formal (school) and informal contexts.

In this model dance was perceived in a holistic manner and was defined as movement in its context i.e. both movement and cultural aspects were taken into account. Addressing just one of these was seen as potentially offering a very fragmented view of the dance experience. The conceptual model finally consisted of three major groups of concepts: concepts that focused either on the movement components of the dance, the dance's context, or both. When these concepts became part of the WebDANCE Curriculum, and they were translated into e-lessons that covered a number of different topics, as Figure 17 shows. The vast majority of students participating in the summative evaluation of WebDANCE enjoyed using the WebDANCE application and felt that it encouraged class participation. The WebDANCE project functioned as a pilot study with a European scope that aimed to experiment with the development of a web-based learning environment for traditional dances. The final tool included teaching units and 3D animation for two dances, Karsilamas from Greece and Valentine Morris from England, and was evaluated before (front-end), during (formative) and towards the end of the project (summative evaluation). Experience from the WebDANCE project has shown that (1) the same conceptualisation schema can potentially be used to document different European traditional dances, (2) web-based tools can be used to create attractive and functional dance resources, and (3) these tools can support the teaching of traditional dances to young people.

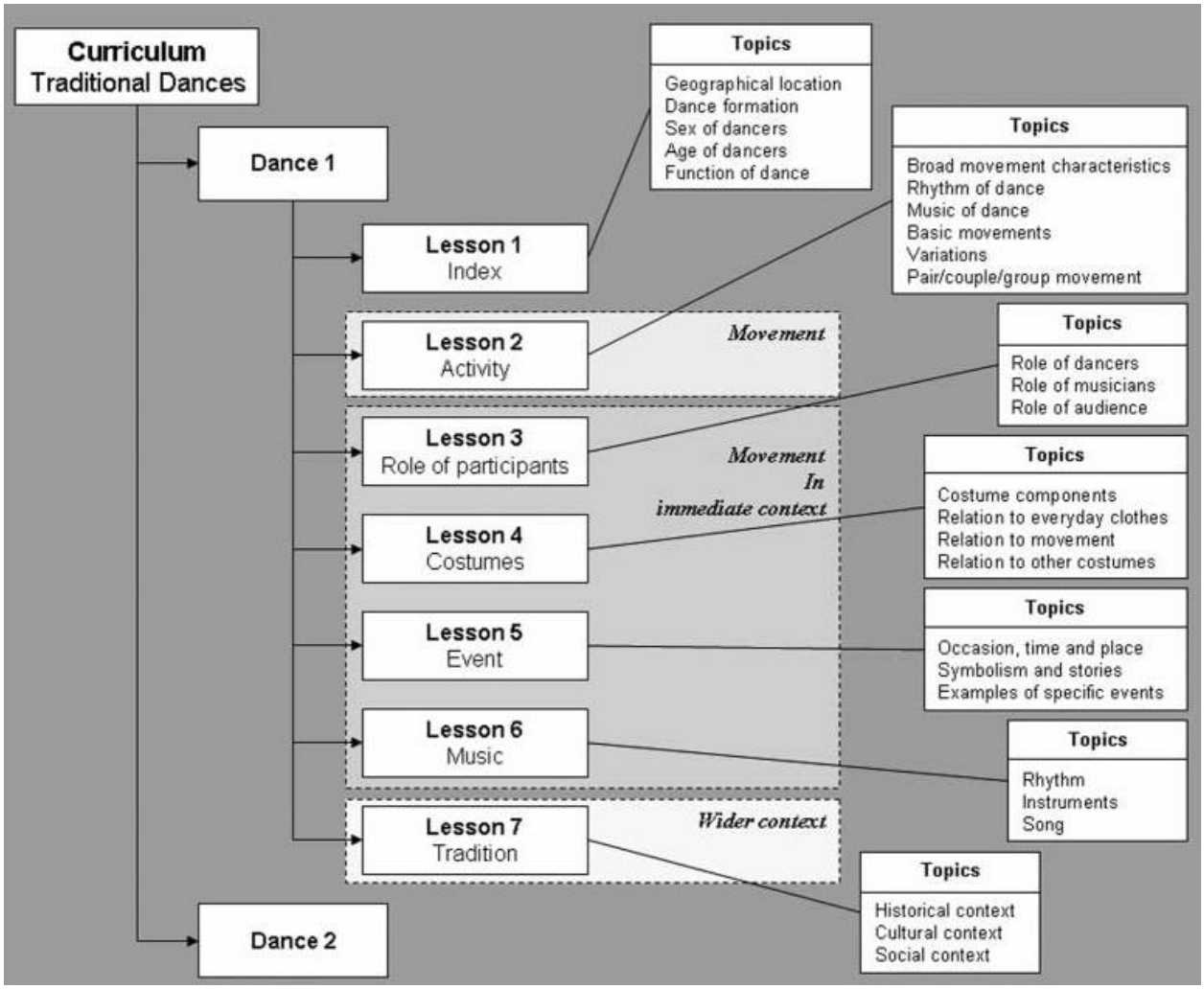


Figure 17 WebDANCE conceptual model

15. Whatever dance toolbox

Whatever Dance Toolbox[17] is a set of software tools designed for the analysis and development of dance and movement. Six tools included in the suite can help dancers and choreographers devise, develop and rehearse dance, but can also be used in dance education or by non-dancers to explore movement. The suite is a product of a long-standing collaboration between BADco[18] and German human-machine interface developer and artist Daniel Turing, and it reflects some of the mutual concerns with the dancer-computer interaction and choreographic thinking.

Using Whatever Dance Toolbox in rehearsal (Figure 18) dancers can manipulate the image of movement and work with an ”active mirror” to produce qualities that they cannot produce on their own. The body is placed inside a different relation to its environment, which, in turn, determines and changes its expressiveness.

Whatever Dance Toolbox is a tool that helps deconstruct basic dance material in real-time and approach it analytically. As most tools, it has its limitations, giving users feedback of the character of movement and its spatial and temporal composition as displayed in the modified 2D image that the tool generates. The temporally limited increments of movement reproduced by the Whatever Dance Toolbox – 10 seconds of movement replayed in delay or in reverse, for example – emphasize short phrases the dancer can focus on, creating new iterations, shifting and dividing the attention of the performer, enabling montage in place of composition of movement.

Figure 18 Whatever Dance Toolbox in Action

[17] https://badco.hr/works/whatever-toolbox/

[18] https://badco.hr/badco/

Tools employ visual analysis, tasks and temporally manipulated reproduction of captured images to allow dancers and choreographers to study and complexify their movement and composition. The machine-factor generates an organization of choreographic elements different and alien to what other choreographic methodologies can produce.

It employs several tools to achieve this objective. “Matching positions”, for example, is a task-based tool and is widely applicable in the work of both dancers and non-dancers. It is seemingly simple: one or more persons have to seek a body position so that the individual’s onscreen shape or the collective onscreen silhouette matches the angle or point given as a task. As you complete a task, you move on to the next one. However, in order to accomplish a task you will have to explore different positions, levels of space, spatial composition, and general spatial dynamics. It is a tool that encourages non-dancers to overcome their inhibition of moving and to progressively acquire awareness of decisions they make with their bodies, of positions and space, of relations they establish to other bodies. Dancers can use it to generate new positions and increase the spatial dynamics of their choreography

When starting Matching Positions and entering in front of the camera, on the black screen space the user will see a white shape representing the silhouette of her body. The onscreen shape is framed by a white rectangle called extrema that will change its position and extension as the onscreen shape is changing. If there is more than one body in front of the camera the computer will interpret their silhouettes as composing a “many-in-one” shape (Figure 19).

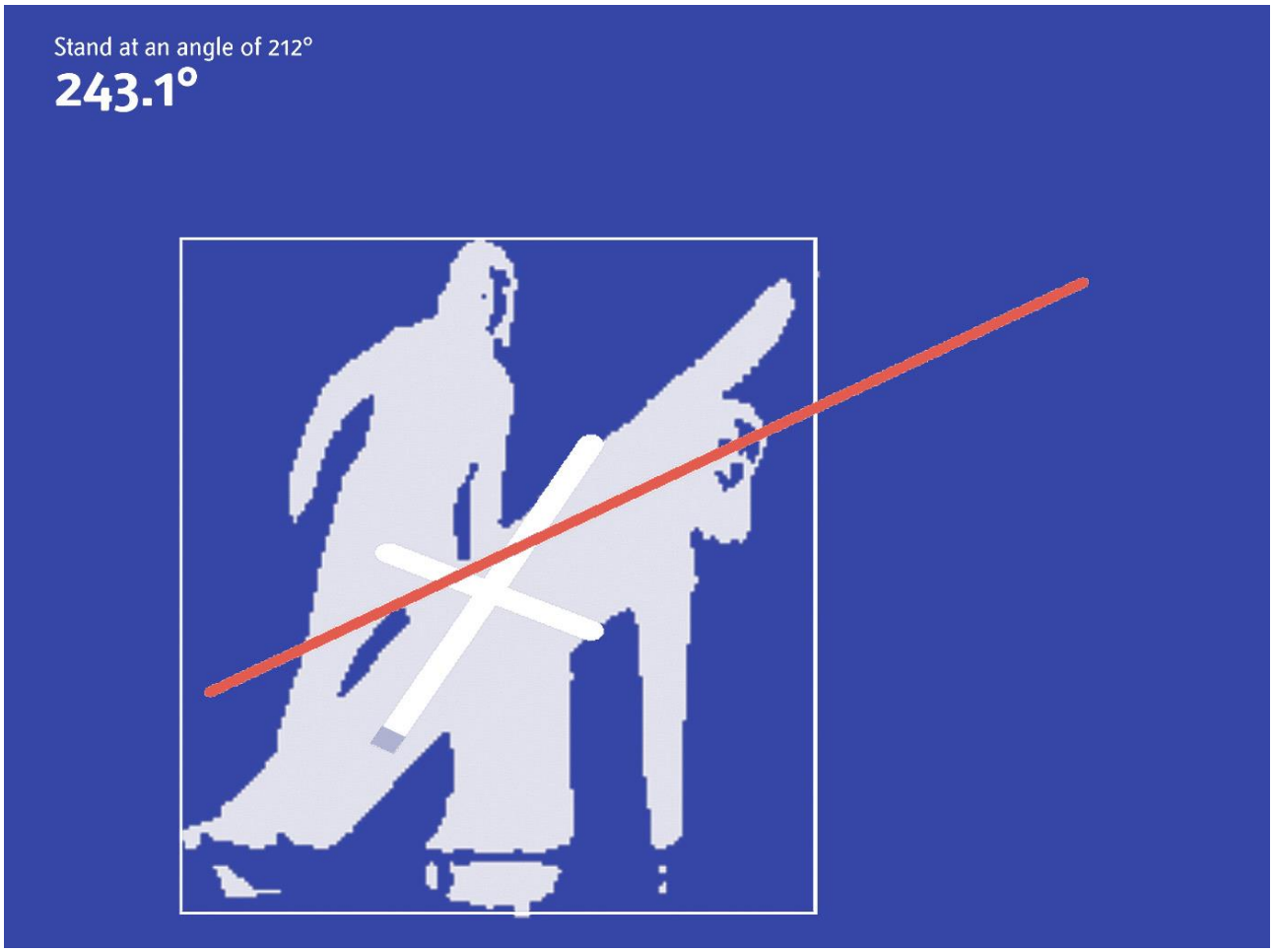


Figure 19 Whatever Dance Toolbox: Representation of the users on screen

Other tools include:

- "Inertia": Inertia is a variation of the Matching Positions tool, but it is not task-based. Its primary purpose is to visualize and measure the dynamics of movement.
- "Cage": Cage is a variation of the Matching Positions tool. Its primary purpose is to allow dancers and non-dancers to work with the spatial organizations, containment and composition of movement as seen through a camera lens.
- "Delay and reverse": This tool performs simple temporal transformations of the captured image. It has two functions: delay function and reverse function.
- "Capture and replay": An interactive mirror that you can use it to capture up to 30 seconds of images that you can then choose to reproduce in various ways: simple replay, replay in reverse and in slow motion
- "Appear and disappear": the more static parts of the image remain in focus while all quick movements become blurred (Figure 20).

Figure 20 "Appear-disappear" tool

WhoLoDancE can explore the suitability and applicability of these tools in the context of its envisioned learning scenarios.

Annotation tools and Desktop Generative Tools

Sketching and doodling are two techniques commonly used by choreographers to design a dance sequence. These sketches usually represent the trajectory of the dancer in the scene. A set of annotations can be used to differentiate the various dance movements. In order to have more control over the choreographed

dance, a 3D animation is preferable. During the past decade, evolution of sketch-based interfaces has provided 3D interaction techniques for modelling and animation. Long traditions of mouse-keyboard-menu-based techniques are now taking more intuitive forms. However, there is no significant effort on creating a sketch-based solution for dance choreography [38] .

16. BalOnSe

BalOnSe (Ballet Ontology for Annotating and Searching Video performances) is a web application created in order to help individuals or teams keep better track of the content of a set of videos, by the University of Athens [16]. More specifically, BalOnSe is an ontology-based web interface that allows the user to annotate classical ballet videos, with a hierarchical domain specific vocabulary and provides an archival system for videos of dance. The interface integrates a hierarchical vocabulary based on classical ballet syllabus terminology (Ballet.owl) implemented as an OWL-2 ontology. With BalOnSe the user has the opportunity for searching and browsing of the multimedia content using metadata (title, dancer featured, etc.), and also implements the functionality of "searching by movement concepts", for example filtering the videos that are associated with particular required terms of the vocabulary, based on previous submitted annotations. Finally, the application has been developed using mainly open-source technologies aiming at a sustainable, reusable and extensible system.

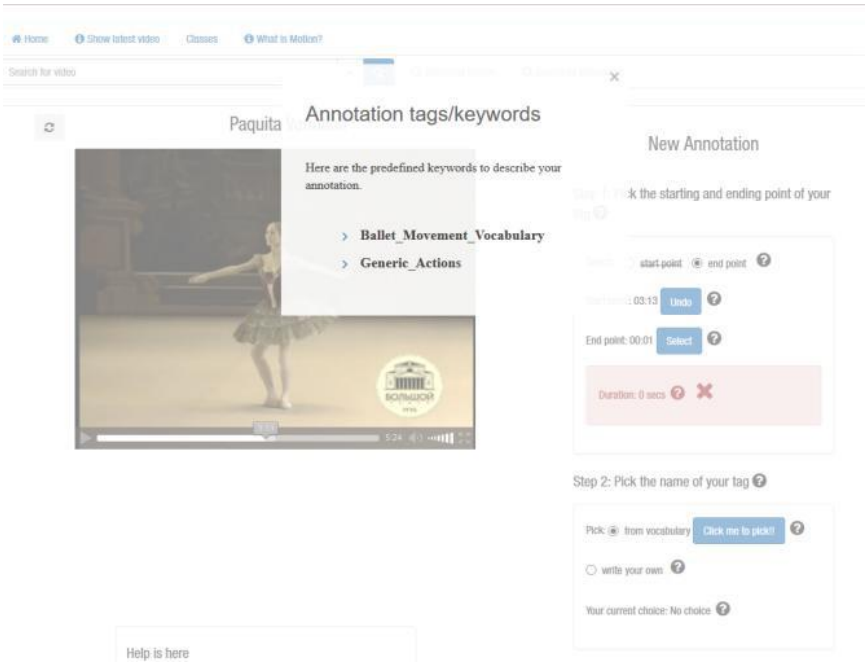


Figure 21-A screenshot of the add new annotation functionality

Providing a usable interface BalOnSe application can serve a variety of users and dance amateurs who may be less familiar with the ballet genre. The system's design is focused on the following features:

- Web-based interface for users with varying degrees of technological expertise.
- An archival system of videos for both the metadata and the annotations
- Context-related video navigational tools with semantic reasoning and search functionality
- Domain specific organized vocabulary

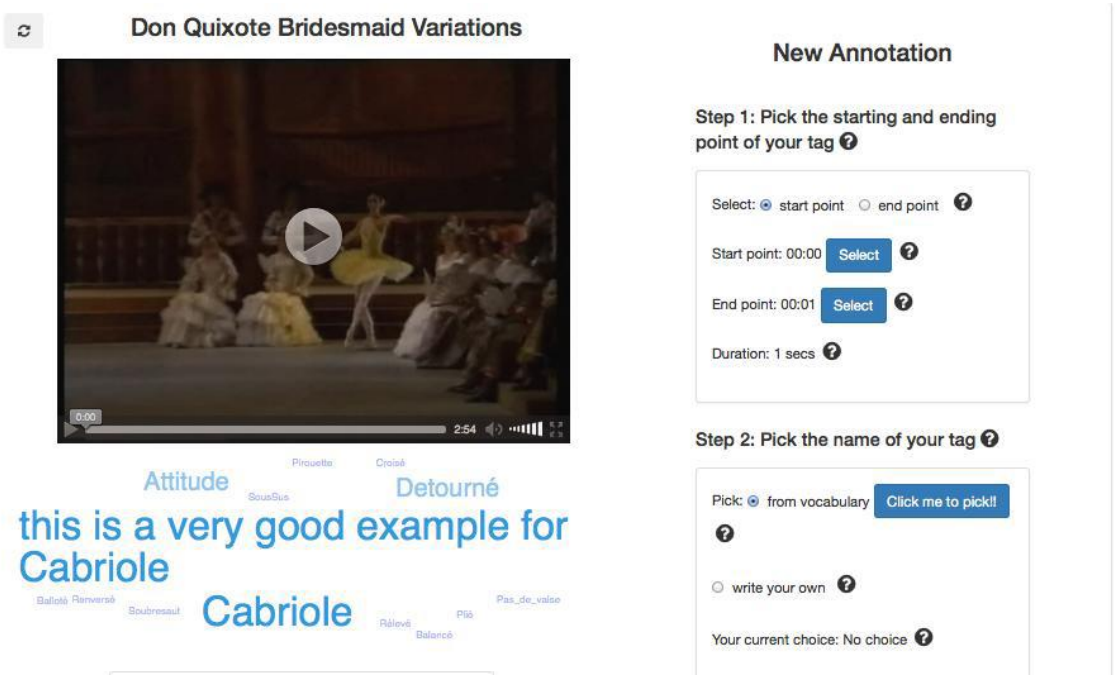


Figure 22-Screenshot of tag cloud based on previous annotation

17. Dance Traces

The D-TRACES Project (Dance teaching resource and collaborative engagement spaces)[19] set out to exploit a unique and significant digital dance resource, the Siobhan Davies digital archive; Siobhan Davies RePlay[20], which launched in June 2009 following 30 months of development by researchers at Coventry University, supported by the Siobhan Davies Dance company and funded by the Arts and Humanities Research Council (AHRC). The archive currently contains more than 5000 core assets including moving image, still image, text-based materials (marketing materials, journal articles, notations, scholarly writings) ranging from personal recollections, sketches and drafts to records of the performances themselves, some of which have not been in the public domain before (rehearsal „scratch tapes", draft designs, artist notes etc). A „scrapbook" feature enables users to create their own collections of archive content. Research outcomes have been disseminated widely via publications, conferences and research meetings both in the UK and overseas, and the archive is frequently cited within archive forums.

Since launching the digital archive it has received informal feedback from users about the ways in which they are using the archive within teaching, research and creative practice, which is primarily to discover dance content for analysis and appreciation.

A key aim of the D-TRACES project was to further exploit RePlay as a teaching, learning and research tool within the dance curriculum at Coventry University. The archive offers users access to different methods for documenting, collecting, organising and curating performance materials, and an innovative model for individuals to develop their own collections online, particularly when working with a range of non-print based material. But despite the archive's accessibility, dance students and staff do not make full use of the archive, or other digital dance resources, and have not explored the way in which they offer methods to facilitate a process of self-archiving. The D-TRACES project set out to resolve this problem by embedding the archive within the Personal Development Planning (PDP) element of the undergraduate dance curriculum at Coventry University, to encourage more engagement with the archive and to open up more opportunities to embed the archive within the curriculum.

[19] https://dancetraces.wordpress.com/
[20] www.siobhandaviesreplay.com

18. DancePro

The Coventry Center for Dance Research (C-Dare)[21], in the context of ESpace[22], which examines the creative reuse of cultural heritage across a range of art and media forms has created two digital tools to facilitate and encourage creative engagement with digital dance content.

DancePro[23] is a digital annotation tool, which allows users to inscribe on top of live streamed and recorded footage. It is designed for use during and after the creative process, allowing artists to notate their work and draw attention to key features. The tool allows for aspects of choreographic thinking to be communicated across disciplines and has great potential for use in educational contexts.

It focuses on the needs of researchers and dance experts (e.g. dance artists, choreographers) for more powerful tools for accessing dance content and creating extensive metadata. The tool allows the user to record and annotate videos in real-time or to annotate previously recorded videos; it allows several types and modes of annotations and is designed to support the creative and compositional processes of professional choreographers and dancers. It can also have an analytic and scholarly use. DancePro can also be of use in any other domain related to the performance of the human body.

Figure 23 DancePro

19. Dance Spaces

Dance Spaces[24] is an online portal that allows users to search, collate and organise dance content. It facilitates the development of virtual exhibitions, specialist educational resources, and expansive collections of online and personal content. Dance Spaces focuses on the needs of the dance enthusiasts and pre-professionals who want to share and explore content about a particular dance aspect.

[21] http://www.coventry.ac.uk/research/areas-of-research/centre-for-dance-research/
[22] http://www.europeana-space.eu/
[23] http://www.europeana-space.eu/dancepro/

[24] http://www.europeana-space.eu/dancespaces/

As such, Dance Spaces targets leisure, teaching and learning at the same time. Dance Spaces is to be used by the general public, dance learners and educators, those who participate in dance as a social and/or recreational activity, dance audiences/viewers and tourists, dance clubs and those taking dance classes for sports and fitness.

20. LabanDancer

To begin with, LabanDancer is a tool, created for animating Labanotation. Labanotation is a symbolic system for notating dance and choreography. So, the LabanDancer system has been developed in order to translate Labanotation [21] scores that have been recorded in the LabanWriter editor[25] into 3d human figure animations.
At this point, it is necessary to be given, some more specific information about LabaWriter and LabanDancer. LabanWriter application is a Macintosh based 2D graphics editor, specialized for creating Labanotation scores. Using LabanWriter, the user can create one or more staves on the LabanWriter virtual page, and select from a palette of Labanotation symbols. The symbols are placed on a staff in the column representing the appropriate body part. The duration of direction and turn symbols is indicated by their vertical length which can be stretched or squeezed by the user. Modifier symbols are placed in proximity to the main symbols or columns that they modify. The Labanotation symbols used in LabanWriter are treated as 2D graphical objects. Regarding the Labanotation score, it can be printed by LabanWriter, or stored as a 2D raster image in one of three popular graphic file formats (PNG, PICT or JPEG). This graphics file is used by the Windows version of LabanDancer as a means of displaying the score.
LabanDancer uses as an input, the digital score from the LabanWriter application for composition and editing of Labanotation. In developing this new interpretation system developers have sought out general techniques that handle the great majority of movement situations correctly and recognize the context for the movement.

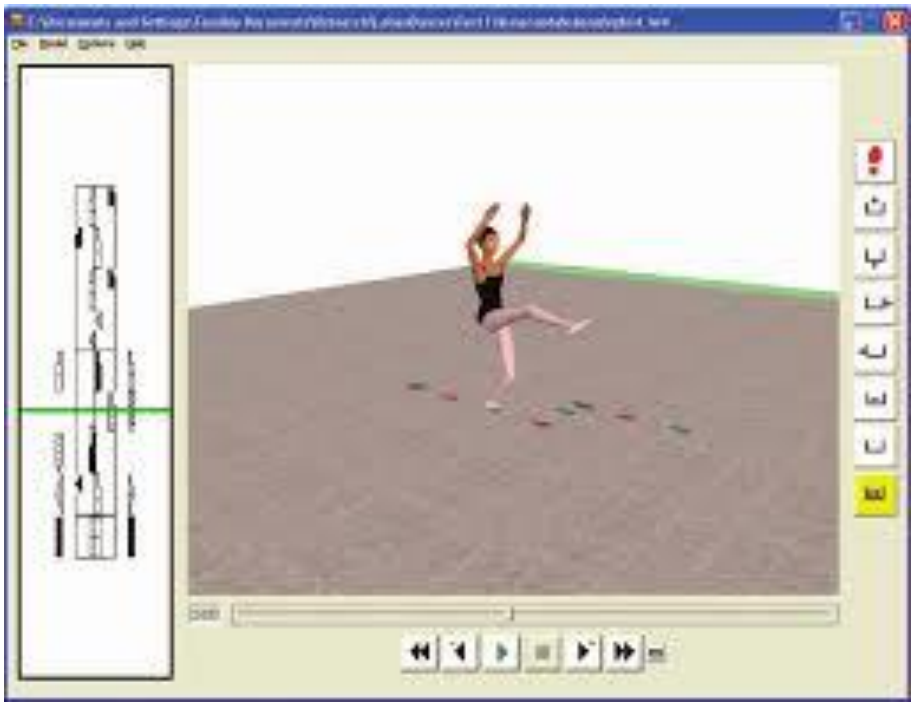


Figure 24-LabanDancer

[25] https://dance.osu.edu/research/dnb/laban-writer

21. LifeForms

LifeForms[26][9], developed by Calvert et al , is a tool for creating and planning human movement in dance and choreography. In dance education, LifeForms is widely recognized as the first readily available software for dance educators. It opened up possibilities of dance unbound by the physical body and the forces of gravity. On-line college-level courses have been developed for its instruction. Like Cunningham, enthusiastic educators have found ways to adapt the software to meet the needs and interests of younger students, allowing them to express themselves with computer choreography.

In 1991, the founders of Credo Interactive—the developer of Life Forms, a software package for planning human movement—began to work with Merce Cunningham and other choreographers to explore this approach. The result was the evolution of Life Forms into a tool known as Life Forms Dance and now as DanceForms[27]. This tool lets the choreographer try out ideas before ever meeting with live dancers. None of DanceForms' features would surprise those working in human figure animation; however, it's customized for dance. Similar features exist in Curious Labs' Poser[28], Alias' Motion Builder[29] and in general-purpose animation systems such as Alias' Maya and Discreet's 3ds max. However, most of those applications are opaque to the typical dance choreographer or dance teacher. The updated interface of DanceForms offers dance-friendly terminology and familiar to the dance domain users. The Studio window can be used to pose the character. The Stage is used to play back the results. The Score window can chronicle the details of the motion step by step. And finally, the user can see the finished product with colors, textures and even music in the Performance window.

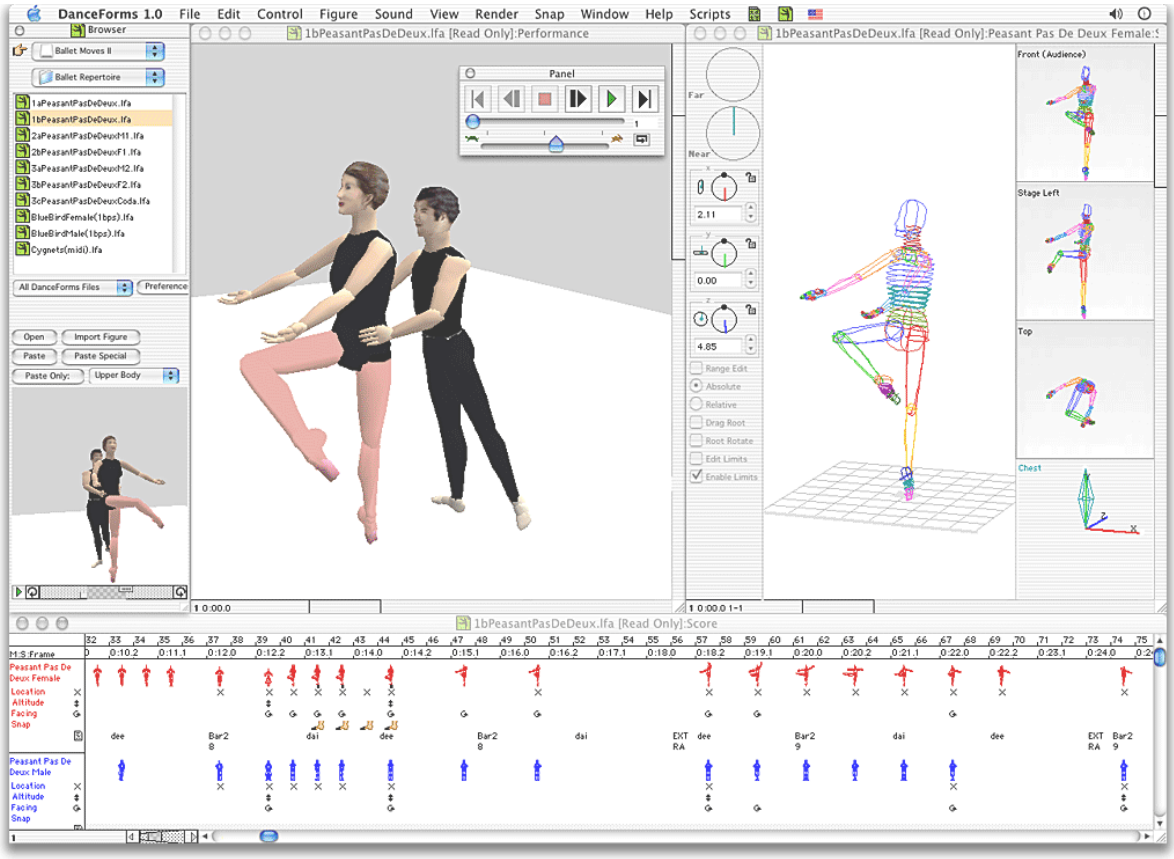


Figure 25 Dance Forms

[26] http://www.credo-interactive.com/products/lifeforms/
[27] http://www.danceforms.com
[28] http://my.smithmicro.com/poser-3d-animation-software.html
[29] http://www.autodesk.com/products/motionbuilder/overview

There are two main version tools:
Life Forms Studio 5 - **Character animation software**
Life Forms 5 software is a character-animation package that offers the opportunity to create animations based on default models or edit motion capture or key-framed character animations from almost any source.
Life Forms has advanced importing/exporting capabilities that support interchange with a wide variety of 3D animation and modelling applications including: Maya, 3D Studio Max, Lightwave, Poser, Inspire 3D, Electric-Image, Cinema 4D, Bio-Vision BVH, Acclaim, and Unity3D.

Dance Forms 2 - choreography software with Ballet Moves II
From the legacy of Life Forms animation software, Credo provides a choreography software designed with dance teachers and choreographers. Dance Forms 2 help the user to visualize and chronicle dance steps or entire routines in a 3D environment. For choreography, interdisciplinary arts and dance technology applications.
Concluding Dance Forms 2 the user could:

- Sketch out choreographic ideas using an assortment of poseable dance figures.
- Experiment by mixing, matching, and blending sequences from Dance Forms' existing libraries and palettes of dance movement.
- Animate single figures, or large groups.
- Use innovative features in order to create three dimensional figures.

22. PM2GO: dance annotation tool

Piecemaker[30] is a multi-user application (app) initiated as a research project by David Kern to support the organisation and recall of materials created in The Forsythe Company rehearsal studio. PM2GO is an easy-to-install and intuitive-to-use adaption of this app for use in dance creation and education. It is available for free download as one of the research results of the first phase of Motion Bank[31].
The tool supports:

- Video annotation with text
- Live annotation
- Text editing
- Cue editing
- Colour categorization
- Export and import projects
- Asynchronous annotations of collaborating authors.

[30] http://motionbank.org/en/event/pm2go-easy-use-video-annotation-tool

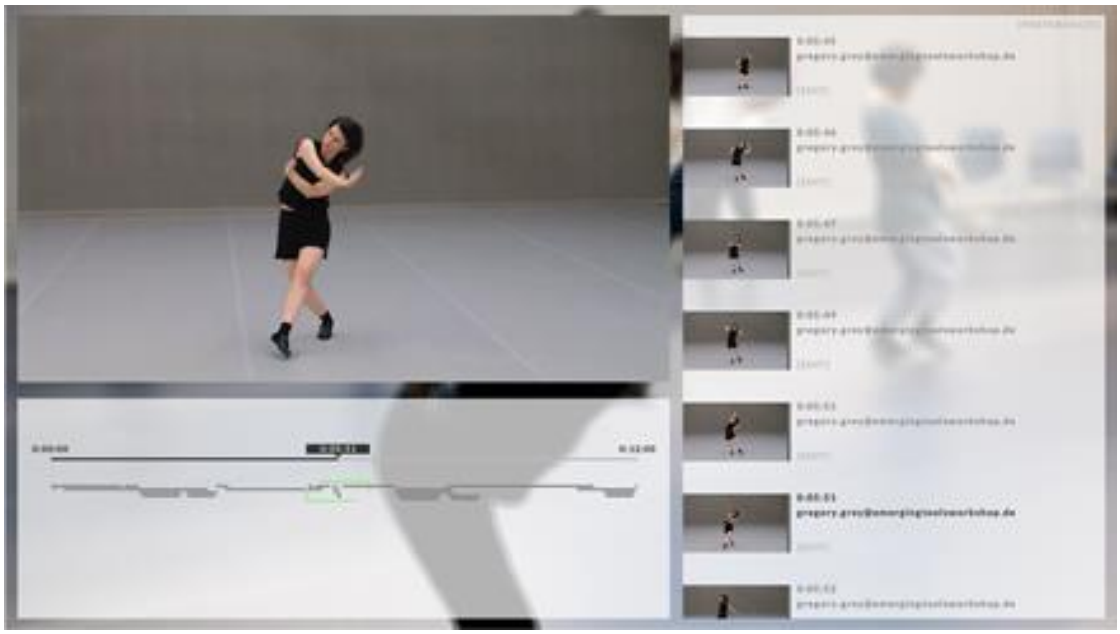


Figure 26 PM2GO

23. Sketch based dance choreography

Sketch based dance choreography by Moghaddam et al [38] is a sketch-based approach to assist dance choreographers authoring dance motions in a 3D environment. The proposed approach allows a choreographer to storyboard a dance using stick figure sketches of a dancer. It also helps to draw the trace of a 3D avatar to direct it in the same way choreographer intends. Inspired by traditional choreography, a set of simple annotations is introduced for ballet. These annotations help to retrieve and blend ballet `mini-motions' in order to create a synthesized dance. To build the mini-motions, several ballet movements in a MoCap database are analyzed and processed.

This approach claims to be an intuitive method for motion control and its ease of use for non-experts, which allows choreographers to convey their ideas using an animation sequence and watch dance motions from different angles helps to exactly plan the scene.

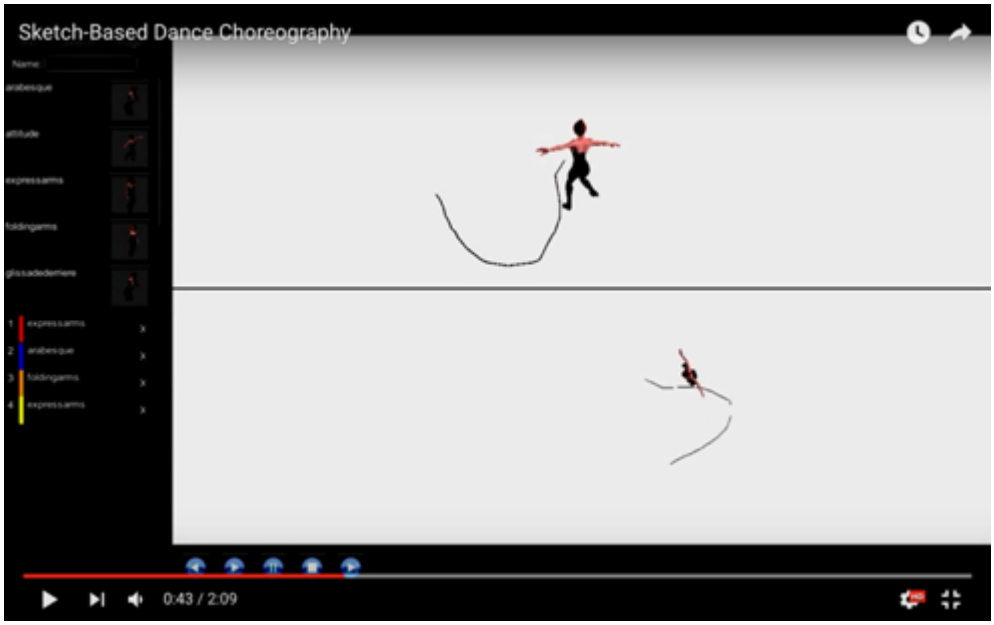


Figure 27 Sketch Based Dance Choreography

24. ReEnact - Sketch based choreography

ReEnact [50] is a prototype system for searching dance video content directly, using free-hand sketches of human pose – the essential element of choreography. Moreover, it enables the synthesis of novel choreographic video sequences from a sequence (or 'storyboard') of such sketches. The novel choreography is composed using fragments of original archive footage seamlessly combined to match the intention expressed in the sketched storyboard. The system accepts a free-hand drawing of a stick-man in the desired pose as input, and searches through footage to retrieve frames containing similar poses. This is a challenging task, as archival dance footage is frequently low fidelity with poor definition and contrast bleaching due to transfers between analogue media over the years. Such footage has been shown to frustrate the automated parsing of an explicit estimate of pose or labelling of limbs using state of the art techniques.

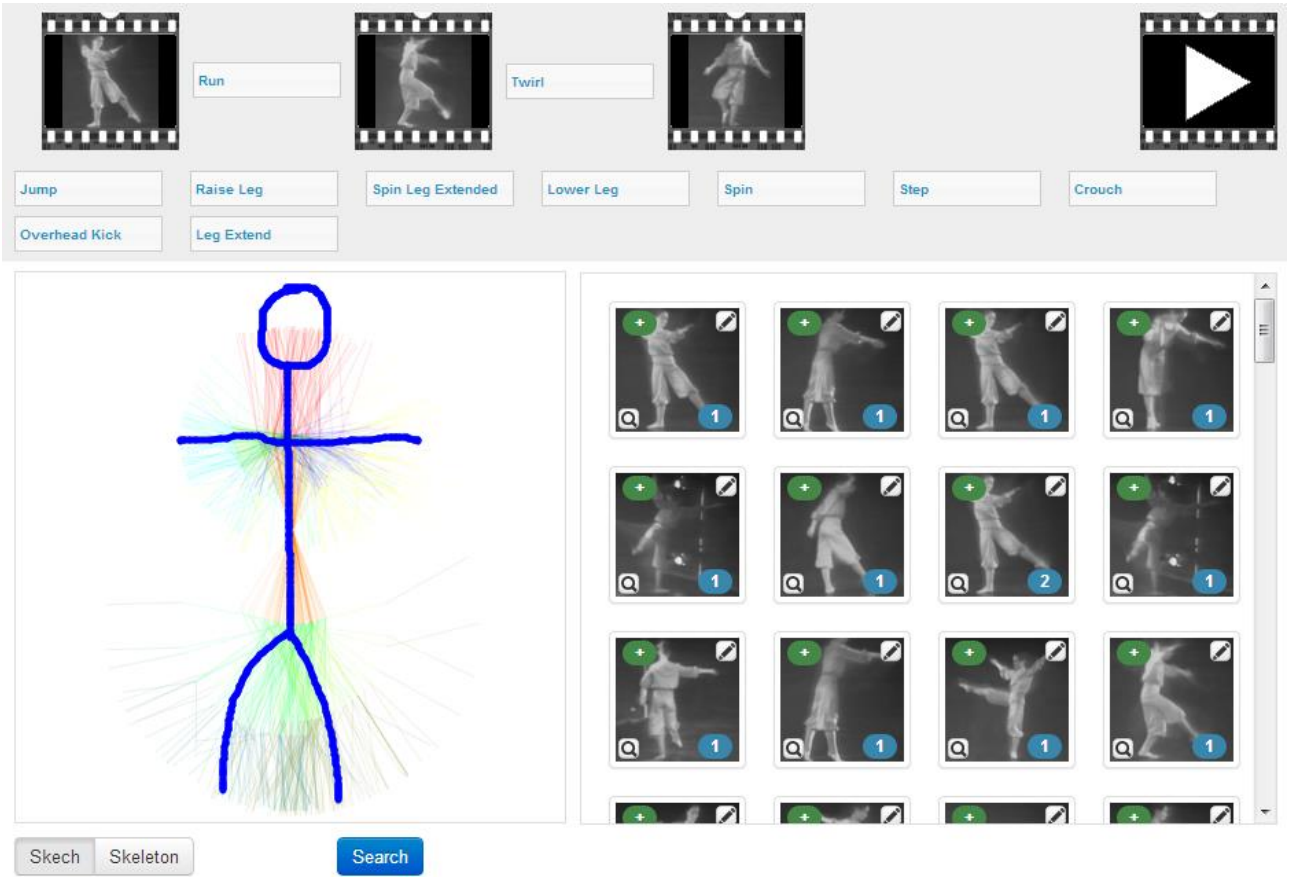


Figure 28 Pose retrieval and choreography creation interface

25. Web3D composer

The paper of Umino et. al [55] reports on 'Web3D dance composer' for ballet e-learning. Elementary *petit allegro* ballet steps were enumerated in collaboration with ballet teachers, digitally acquired through 3D motion capture systems, and categorised into families and sub-families. Digital data was manipulated into virtual reality modelling language (VRML) and fit to an animated dancer. Movements were segmented and stored in the motion data archive to be freely combinable in sequences by an algorithm for automatic generation of *enchaînement* conforming to principles of balletic aesthetics. An online interface was created containing controls for automatic composition and the 3D display. The goal in the initial stage of this research was to develop an online automatic composing system which can generate dance movement sequences according to algorithms which define particular laws of sequencing. The automatic composing system functions within a 3D environment with animations assembled out of a library of 3D motion captured dance movements. This is intended as a study resource for teachers and students as well as

researchers in biomechanical functions. In order to present a viable learning environment, as the authors state, it was decided that the system for dance e-learning should include the following features:

(1) Dynamic simulations of dance;
(2) Organic, realistic representations of human motion;
(3) Viewable in full 3D perspectives;
(4) Available access on the Internet;
(5) User editable and interactive (choices);
(6) Include motion data archive of dance steps; and
(7) Include possibilities for composition or choreography.

The last criterion means that the system displays not only steps and movements, but demonstrates how to combine these in sequences. The system 'Web3D Dance Composer' was developed according to these seven criteria, focusing on e-learning for classical ballet (Soga et al. 2002, 2003, 2004, 2006). Figure 29 shows the user interface of the whole system which is outlined later.

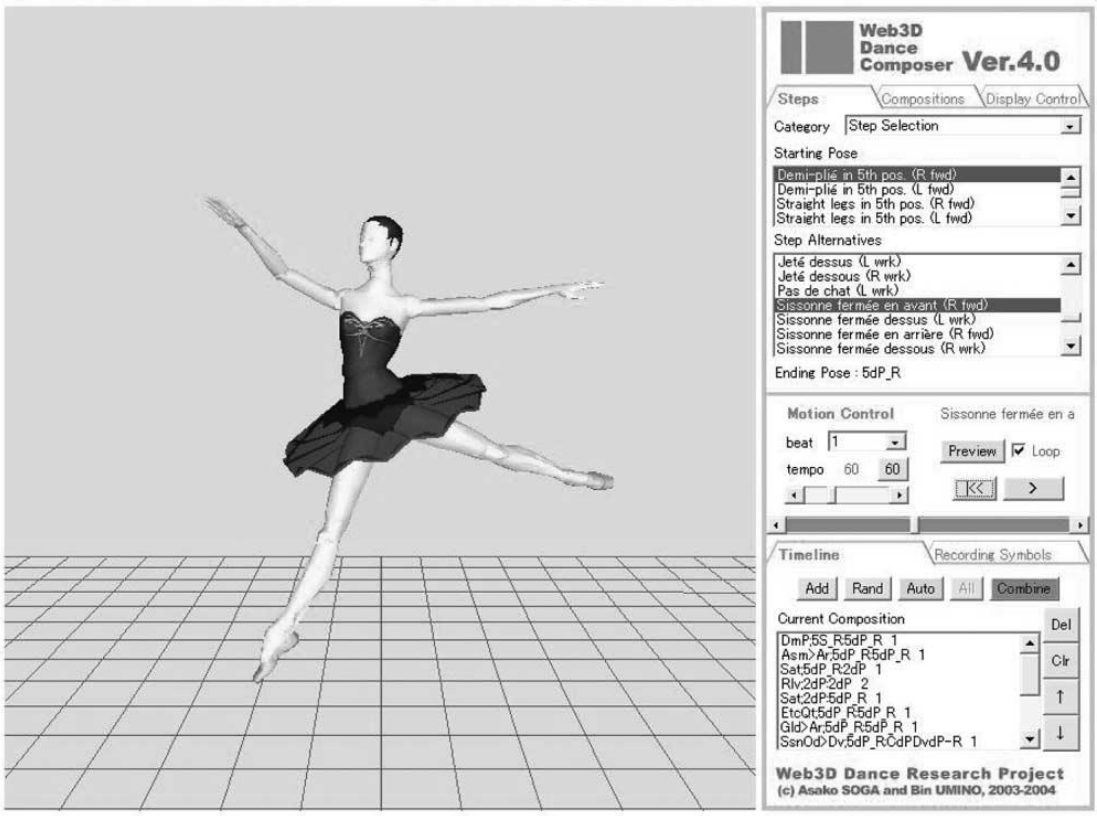


Figure 29-Web3D interface

In an assessment of the system by expert ballet teachers only 8% of automatically generated *enchaînements* were inappropriate for ballet lessons, with 65% appropriate for elementary level and 75% rated as danceable by elementary level students. Interviews revealed that the system provided a creative resource for new *enchaînements* usable in ballet education by teachers and students.

Mobile Apps

26. Bounden Gameplay

For a more artistic take on mobile gaming, there's Bounden. It's an accelerometer-based game that forces you to get up and move. Using a phone (or small tablet), you and a friend each hold one end of the phone, then start moving and grooving to get the crosshairs to pass through a series of rings. Before you know it,

Bounden tricks you into dancing (no matter how uncoordinated you may be). It's a unique experience on mobile, and it only works with with two players. Game Oven's whimsical dancing game for two players, with choreography by the Dutch National Ballet. Twist and twirl elegantly, or get entangled with a friend. Get Bounden here: http://gameovenstudios.com/link/bounden
https://www.youtube.com/watch?v=aKC20iebhXg

Figure 30-Boundain Gameplay

27. Sonolope app.

Sonolope[32] is a downloadable mobile application for smart-phones and smar-watches that enables the user to create three-dimensional soundescapes while moving. The performer (user) hold the device, or have strapped to her body somewhere, your smart-phone or smart-watch .and when the user moves a specific sound linked to the device is produced: this could be a piano, a synthesised, a set of samples, or any other kind of sound. The sounds move around the room in three dimensions and respond to the performer's movements with changes in pitch, volume and duration. The quicker the performer moves the phone the louder the sound will be. The longer the performer moves the device it for the longer the sound will sustain. All of the user's smart-phones or smart-watches connect to a master device which actually produces the sounds and connects to the speakers in the room.

This is an example of sonifying movement through a mobile device. The effect is that the user feeks directly connected to a sound and after a few minutes practice the user should be able to easily control how your sound behaves. Sonolope has been developed by Simon East at Curvor and Dr. Maria Kapsali from the School of Performance and Cultural Industries at Leeds University. It has been presented in artistic and research contexts.

[32] http://www.sonolope.com

Figure 31 Sonolop interface and its use

Reflecting on Movement

28. Improvisation Technologies by William Forsythe

Improvisation Technologies: A Tool for the Analytical Dance Eye was developed by Volker Kuchelmeister in collaboration with American born choreographer William Forsythe as a "digital dance school" in the form of an interactive computer installation. It consists of over a hundred video lectures in which Forsythe demonstrates and comments on the essential principles of his motional language, where film, audio, animation and CGI express the choreographer's meaning in an immersive, 4D experience. Forsythe's video lectures are augmented with computer generated and animated shapes, forms and figures to illustrate the choreographer's improvisation techniques and theoretical principles. References to moments in actual stage performances and demonstrations from Frankfurt Ballet company dancers, improvising on the theory lecture themes, close the circle reaching from theory to practice. This conceptual framework proved very effective as a didactic tool. Described by Johannes Birringer as a “'school of perception' that ingeniously links theory and practice to place the user in the studio and make familiar the large palette of terms and organizational metaphors employed in Forsythe's 'initiations' for movement."

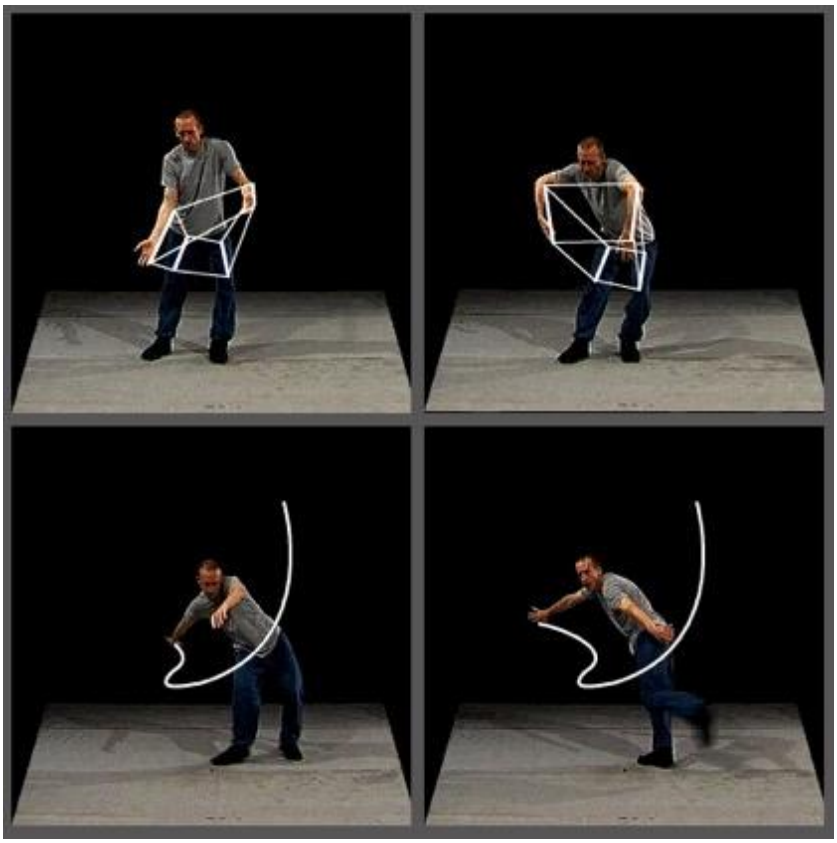


Figure 32-Improvisation Technologies

29. EyesWeb Platform

EyesWeb is a tool that has been developed by Lab. InfoMus - DIST - University of Genoa, in order to create interactive digital multimedia applications. More specifically, it is an open software research platform for the design and development of real-time multimodal systems and interfaces. The tool enables the possibility to form digital sound and images real-time, through use of various Human-Computer Interactions. Object Identification, Segmentation and Recognition, Face Recognition, Gesture Recognition and Motion Tracking are some of its features. Its development is based on the Intel OpenCV (Open Source Computer Vision Library). The Intel OpenCV is a collection of program code (C functions, few C++ classes and popular algorithms) obtained and contributed by researchers all over the world. EyesWeb can support a wide number of input devices as for example motion capture systems, various types of professional and low cost video cameras, game interfaces (e.g., Kinect, Wii), multichannel audio input (e.g. microphones) and analog inputs (e.g. for physiological signals). Furthermore, EyesWeb supports a sufficient number of outputs as multichannel audio, video, analog devices and robotic platforms. We should also mention that various standards are supported, including OSC, MIDI, FreeFrame and VST plugins, ASIO, Motion Capture standards and systems (Qualisys) and Matlab. Finally EyesWeb supports real-time synchronized recordings of multimodal channels, and includes a number of software libraries, including the Non-Verbal Expressive Gesture Analysis and the Non-Verbal Social Signals Analysis libs. Users can use the EyesWeb's libs in their projects but they can also develop their own libs using the EyesWeb development environment.

The EyesWeb software platform has been adopted in EU projects in the 5th, 6th and 7th Framework Programme (ICT), and by thousands of users worldwide for scientific research, education, and industry applications. For example, EyesWeb was selected by INTEL in 2008 for their hardware for "independent living", and was adopted at the New York University Summer Program on "Music, dance and new technologies" (2004 - 2006).

EyesWeb is used in the framework of DANCE[33], a H2020 project which aims at understanding the meaning of "closing the eyes", the perception of expressiveness and entrainment in dance, the participation to the emotion conveyed by a sequence of movements in space, the understanding of the non-verbal language of bodies that communicate, imagining and questioning concrete ways *to listen to a choreography, feel a ballet*. An example of early results from the DANCE project were presented at the SONAR+ Festival in Barcelona in June 2015 (see Figure 33), showing how the EyesWeb helps the development of interactive sonifications of movement qualities such as "fluidity" and "impulsivity."

Figure 33- the booth of the European Horizon 2020 ICT Project DANCE at SONAR+, Barcelona, in June 2015

Short DANCE demos and proof-of-concepts on real-time analysis and interactive sonification of expressive qualities of human movement were developed by the Casa Paganini-InfoMus Research Centre in collaboration with the composer Pablo Palacio and dancers Muriel Romero, Roberta Messa, and Sabrina Ribes. The demo measures movement qualities using the accelerometers and gyros on two smartphones worn on the dancer's right wrist and left ankle. This initiative was organized by the European Commission Project Officer Ralph Dum in the framework of the European Commission Science, Technology and the Arts (Starts) program.

Another example, is the artistic performance tanGO[34] - Touching Music in Figure 34. In that one, it is possible to see the techniques for analyzing entrainment (that is, temporal and affective synchronization between individuals) and leadership from movement signals captured by mobile devices that were exploited to let four dancers and their audience reconstruct a tango. Dancers' quality of movement and nonverbal social signals were used to mold and control the different musical parts of a tango piece.

[33] http://dance.dibris.unige.it/

[34] https://www.youtube.com/watch?v=DckQ5XI_B0s&ab_channel=CasaPaganiniInfoMus

Figure 34 tanGO project

Intrapersonal synchronization of limb movements is a relevant feature for assessing coordination of motoric behavior and can also distinguish between full-body movements performed with different expressive qualities, namely rigidity, fluidity, and impulsivity. For this purpose, University of Genoa, Alborno et. al [2] has collected a dataset of movements that have been performed by professional dancers, and annotated the perceived movement qualities with the help of a group of experts in expressive movement analysis. With their work they present an approach to dance movement analysis where a set of distinct dance performances are analyzed and classified according to their movement qualities. They propose a method, in order to distinguish between different movement's qualities using a multilayered framework approach, in which low-level features (e.g., single joint velocity) are used to compute high level features (such as fluidity, or emotion). With this way they achieve to demonstrate that intra-personal synchronization (i.e., the level of synchronization of the joints composing the kinematic chains of a single person) can help to automatically distinguish movements displaying following expressive qualities: *Fluidity*, *Rigidity*, and *Impulsivity*.

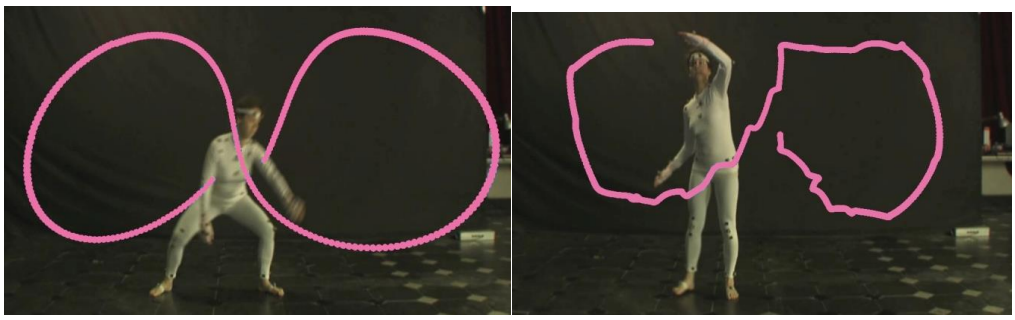


Figure 35-Execution of a simple movement, with different movement qualities: a) fluid; b) rigid

Their work is part of the more general framework of the EU ICT H2020 SHINE Project1, aiming at developing techniques and models for human body movement quality analysis, with a focus on the expressive component of non-verbal communication. The perspective is on how movement qualities are perceived by an external observer.

In a relevant work by Piana et. al [44] is presented a framework and an experimental approach to investigate human body movement qualities in HCI. They first define a candidate movement quality conceptually, with contribute of experts in the field. Next, they collect a dataset of performances and they evaluate the perception of the chosen quality. Finally, they propose a computational model to detect the presence of the quality in a movement segment and they compare the outcomes of the model with the evaluation results. In the proposed on-going work, they apply this approach to a specific quality of movement: Fluidity. The proposed methods and models may have several applications, e.g., in emotion detection from full-body movement, interactive training of motor skills, rehabilitation.

Their research is part of the more general scenario of modeling human body movement quality, and in particular its expressive components in non-verbal communication. They are mainly focused on how movement qualities are perceived by an external observer. Their approach takes into account human perception of a professional performance. They proposed a new definition of full-body movement Fluidity based on the perceptive evaluation of professional dancers' performance. Finally, they proposed an algorithm based on Mass-Spring-Damper model to detect the presence Fluidity in movements.

30. Neural Narratives

INSTITUTO STOCOS[35] is a project focused on the analysis and development of the interaction between body and sonic gesture. The trilogy Acusmatrix, Catexis, Stocos and the Neural Narratives series () constitute some of the outcomes of this investigation. In this series of pieces the dancer's activity evolve in a three dimensional sound space interacting with sonic objects that are successively transformed according to their trajectory and dynamic morphology. These works integrate in a performative context abstractions taken from other disciplines such as artificial intelligence, biology, mathematics or experimental psychology. In this new piece Muriel Romero and Pablo Palacio collaborate with media artist and artificial intelligence researcher Daniel Bisig.

The project "Neural Narratives" experiments with interactive simulation-based approaches that allow a dancer to alter and extend his or her bodily presence and movement possibilities. The project has emerged from the practical and creation focused context of two dance productions entitled "Neural narratives1: Phantom Limb[36] and Neural narratives2: Polytopya"[37]. Phantom Limb is the first part of this Neural Narratives series of works in which they have experimented with body extensions that offer the possibility to expand human movement into multimodal augmented gestures. In February 2015, the second part of this project Neural Narratives2: Polytopya was premiered in Barcelona at Mercat de les Flors at the IDN festival. For both productions, the chosen approach is based on the simulation of artificial body structures whose morphological and behavioral properties are tightly interrelated with the dancer's body and movements. These structures take on the role of virtual extensions of the dancer's body that respond to his or her activities via a combination of reactive and proactive behaviors. The reactive behaviors are based on a physical coupling between the dancer's body and a simulated mass-spring system [MSS] that

[35] http://www.stocos.com/
[36] http://www.stocos.com/PHANTOM_LIMB_eng.html
[37] http://www.stocos.com/POLYTOPYA_eng.html

mechanically perpetuates the dancer's gestures. The pro-active behaviors spontaneously emerge from the internal dynamics of a simulated artificial neural network [ANN].

Figure 36-Artificial body extensions in the Neural Narratives project.

The two photographs in Figure 37 show a stage situation in which a visual rendering of the virtual body extensions is projected on a transparent screen that hangs in front of a dancer. The photograph on the left shows a body structure that is attached to multiple joints of a dancer. The photograph on the right shows a body structure whose morphology has fractured and become partially dissociated from the dancer's body

The Neural Narratives project has led to the development of simulation, visualization and sonification tools that allow the creation of virtual body structures whose morphology, behavior and appearance are closely connected to a dancer's bodily presence and activities. Through that process they have managed to convey an understanding of the motivation and particular approach for designing artificial systems that operate via their simulation-based underpinning and audiovisual rendering as morphological, behavioral and audiovisual extensions of the dancer's bodily presence and activities. They placed a strong emphasis on a contextualization and discussion of the most pertinent issues that have arisen during the realization of and reflection about the Neural Narratives project: the issues of embodiment, agency, and creativity.

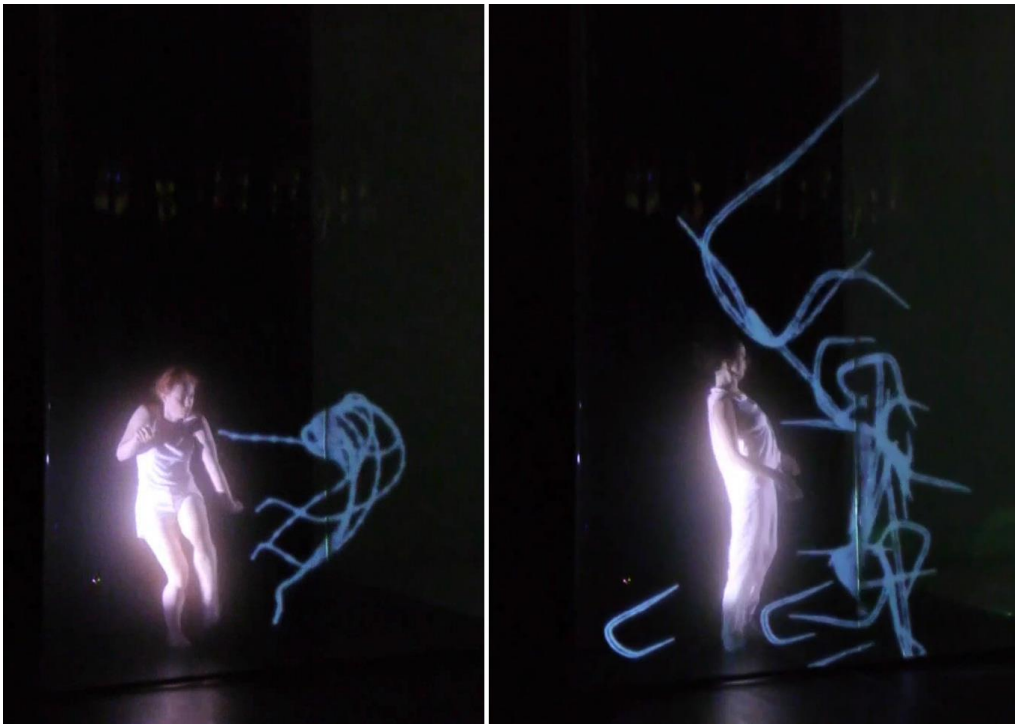


Figure 37-Visual Presence of Body Extensions on Stage.

Stocos combines stochastic processes and artificial intelligence based simulations in order to create behavioral dependencies and aesthetic relationships between dancers, simulated entities, music, visuals and light. As a result, the stage becomes a responsive environment and its visual and acoustic properties emerge from the mutual interactions between the dancers, stochastic sound synthesis and swarm simulations.

Figure 38 Rain Scene. The swarm simulation behaves similar to rain that is perturbed

More specifically, Stocos creates a three-dimensional space in which natural and artificial entities coexist, interrelate and overlap. It relies on stochastic processes and swarm simulations for the creation of dance movements, musical compositions and visual imagery. Throughout the performance, a dense network of mutual interactions among algorithms, dance, music and visuals establishes coherence, simultaneity and presence in the behavioral and aesthetic characteristics of the piece.

Figure 39-Contours Scene. The swarm creates afterimages of the dancers' body postures.

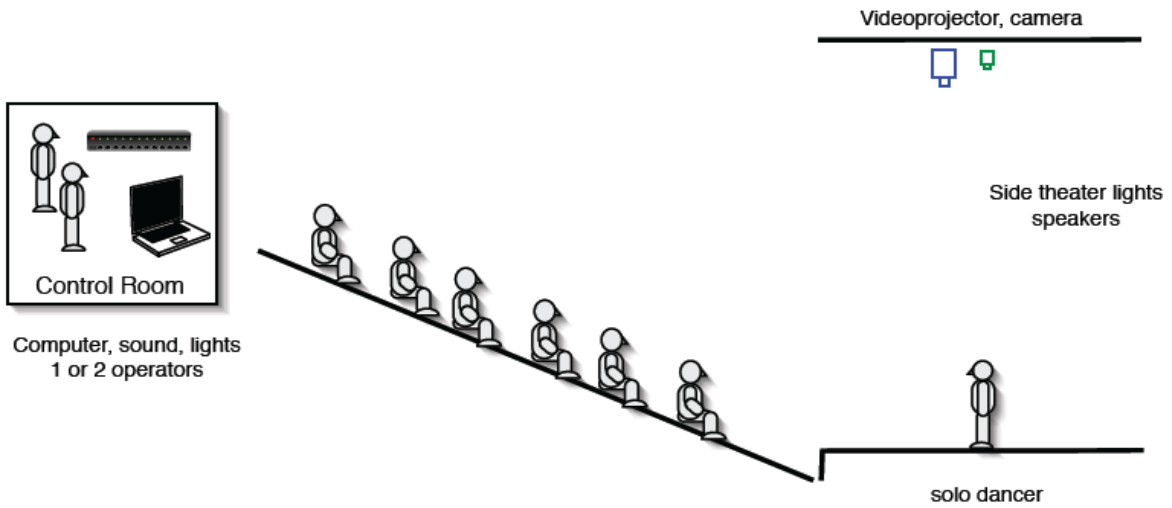
The musical composition is based on the stochastic processes of brownian motion, a method that was initially devised by Iannis Xenakis. Stocos develops an extension of this approach using swarm simulations. These processes also define some of the dancer's movement sequences and they affect the swarm based live imagery. The spatial movements of the music are achieved via an octaphonic speaker ring that surrounds both the stage and audience space. The video imagery is life generated and renders the spatial movements of various interactive swarm simulations that have been specifically developed for the piece. The imagery is projected seamlessly on the back of the stage, the stage floor and the dancers' bodies in an attempt to create a behavioral and visual continuity between the natural properties of the space, its inhabitants and the simulated entities. The characteristics of these responsive visuals continually changes from a dynamic property of the entire space to that of autonomous virtual dancers improvising on stage up to that of a artificial skin that covers the dancer's bodies. The dance performance combines pre-choreographed and improvised sequences for two human dancers and virtual dancers. The dancer's abstract gestures explore the network of mutual dependencies and causalities that relate them to the musical and visual activities on stage. The choreography reflects the properties of the hybrid ecosystem, that responds favorable or antagonistic but never neutral to the activities of its inhabitants.

31. Gameplay

Interactive Performance/creative

Gameplay[38] is a project made in close collaboration with artist-programmer Antoine Schmitt and dancer Benjamin-Aliot Pagès. (Eight minute video excerpts can be found in http://vimeo.com/6847557)

Gameplay transposes the language and technology of video games to a choreographic environment where the dancer is confronted with challenges paralleling the notion of the physical test present in many rites of passage. A performance in which a dancer is confronted with a visual and sonic semi- autonomous environment sensitive to her/his presence. The solo dancer dances on stage on white floor (Figure 40), inside and around image projected on the floor by a ceiling- suspended video projector. Surveillance camera on ceiling sees dancer and sends image to computer in control room (video composite). Computer analyses dancer position, and generates image and sound. Image is sent to video projector (SVGA). Sound is sent to stereo sound system. Dancer is lit by side lights. One or two company operators in control room pilot lights, computer and sound.



[38] http://www.k-danse.net/en/gameplay-en

Figure 40 Techincal installation of Gameplay in space

Figure 41 Gameplay

For this project, distinct dance connected principles were used for both the choreography, the shapes and dynamics of the visual-sonic entities and their respective programming, with which the dancer is dialoguing in real time. The performer must constantly adapt him/herself to the unexpected moves of the projected entity, depending on the level of pre-programmed semi-autonomy.

In the context of the WhoLoDancE project a similar approach could be considered so that the system proposes a simple, changing and efficient learning scenario through a dynamic programmed interaction. The user is somehow "invited" to move in a certain way in order to achieve tasks, and to experience physically rewarding constraints, depending on the computed and choreographed rules. This applies to any dance training level of expertise.

32. Para_site

Interactive Performance/creative

Para_site[39] is a project made by K. Danse (choreographers Jean-Marc Matos & Anne Holst) in close collaboration with artist-programmer Ivan Chabanaud and dancer Yuko Yamada. (Four minute video excerpts can be found in http://vimeo.com/7224249).

[39] http://www.k-danse.net/en/gameplay-en

Figure 42 Para_site

Set in a performative context, as the power of the dancer in the space increases (higher level of energy, more dynamics and extended limbs), the power of the body is reduced by a strategic partitioning of time, space and movement, so that the environment responds with more aggressive visuals and sounds. The artificial intelligence of the environment (software designed with imbedded inspired neural networks) "learns" from the user. Only through breathing the dancer is able to control and put on halt, momentarily, the feed-back provided by the environment (set as a suspended circle of 7 screens).
This performance explores in a new way, and within a multi screen scenography, various body sensors for real time treatment of image and sound and for interaction with 3D objects.
Physiological sensors (measuring the breathing) are also used. Algorithms based on "neuronal networks" are integrated in order to provide the system with learning capacities.
In this setup images and sounds "control" the dancer.

In the Wholodance context such an approach to make the setup capable of providing feed back onto the user would enhance the richness of the interaction between the dancer and an avatar, visually and musically represented in the running environment.

33. Echo Room

Interactive Performance/creative
Echo Room[40] is a project made by K. Danse (choreographers Jean-Marc Matos & Anne Holst) in close collaboration with a team of programmers and multimedia artists. (Five minute video excerpts can be found in http://vimeo.com/6598010).

[40] http://www.k-danse.net/en/gameplay-en

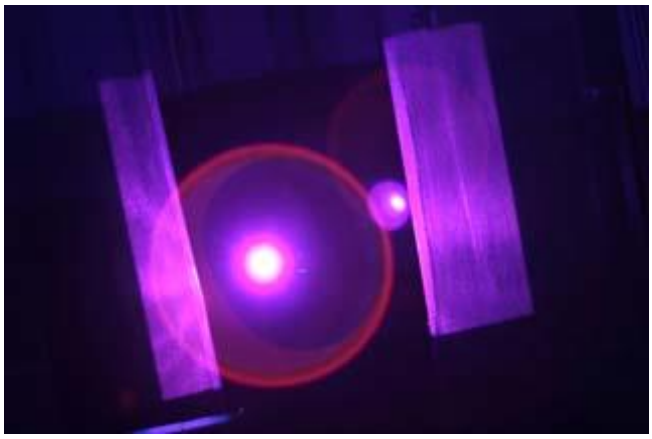


Figure 43 Echo Room

Echo Room deals with the simultaneous perception of various body states embodied in a man-woman relationship through the use of physiological sensors. It questions the relationship between movement, physiology and psychological structures through a danced duo to be experienced by the audience in three spaces. Each space emphasizes either the live dance; the physiological reactions-interactions of the dancers through sound, shape and color; or the mental space of the dancers through reactive sound and video. This is achieved by treating information collected by sensors attached to the dancers which measure their physiological reactions: muscular tension, breathing, and heartbeat which allows for another real-symbolic-past-future space/time interpretation of the dance that we see unfolding before us.
This project reflects on the possibilities of translating body states associated to movement qualities into a diversity of visual and sonic media to be perceived on different levels by the user.
The Wholodance projects tackles also the issues of quality of movement and potentially the possibility of providing the user with immediate feedback through the use of physiological sensors.

34. Tactile Sensations

Interactive Performance/creative
Tactile Sensations[41] is a project about augmented tactility made by K. Danse (choreographers Jean-Marc Matos & Anne Holst) in close collaboration with artists Scenocosme. (Nine minute video excerpts can be found in http://vimeo.com/25120631).

[41] http://www.k-danse.net/en/gameplay-en

Figure 44 Tactile Sensations

Tactile Sensations set in a performative context is a dance performance that investigates the meaning and intimacy of touch and its social construction: the connection to memory and human attachment, emotion, desire, rejection. How and why do people touch each other? How is touch initiated between people? What is the meaning of touch? This performance stages the sensitive relationship between 2 people. The overall theme is enhanced by the interactive experience of producing and altering the sound and lights via the digital treatment of data coming from the contact between two bodies. The exchange happens when the two dancers touch each. This investigation of touch within the performance is augmented and made more clearly perceptible to the audience by adding the aural and visual sense in that each moment of touch (dancer-dancer) – according to the various meanings of the touch graded according to which part of the dancers body touches or is touched – produces a specific sound and variations in lights. This augmentation of the sense of touch by associating sound and light thus induces, enhances and stimulates the senses and makes the audience acutely aware of the multiple meanings of bodily human interaction which in daily life nowadays are often suppressed, subconscious or ignored.

As a possible use in teaching-learning contexts the immediate translation into sound and light of the quality of touch could be quite useful for sessions dedicated at this particular and important aspect in dance composition.

35. Metaphorá

Interactive Performance/creative

Metaphorá[42] is a project made by K. Danse (choreographers Jean-Marc Matos & Anne Holst) in close collaboration with artists 1minute69. (Three minute video excerpts can be found in http://vimeo.com/172286193)

Figure 45 Metaphorá

Set in a performative context as an interactive, immersive installation, with choreographic performance, and audience physical participation, it is a unique environment as a shared experience for choreography, sensitive bodies and a community of audience members.

[42] http://www.k-danse.net/en/gameplay-en

The dialog with a semi autonomous avatar, as a distributed sonic and visual double, with both the dance and the generative visual entities being based on the concept of a body made of multiple articulated internal links, takes place inside of a circular environment which offers the user a global immersive physical experience.Another possible interesting direction for Wholodance.

36. Designing For Movement: Evaluating Computational Models using LMA Effort Qualities

While single-accelerometers are common consumer embedded sensors, their use in representing movement data as an intelligent resource remains scarce. Accelerometers have been used in movement recognition systems, but rarely to assess expressive qualities of movement. EFFORTDETECT [47] is a prototype wearable system for the real-time detection and classification of movement quality using acceleration data. EFFORTDETECT uses data from a single wearable accelerometer. Although acceleration can be derived from positional data, collecting acceleration data is a more natural fit to motion dynamics and thus movement qualities using recognition than capturing positional information. More generally, LMA analyses human movement as the process of change, any change of Body Effort Shape or Space, rather than the positions within the trajectories traced by a movement.

Figure 42 Wearable accelerometer

The system applies Laban Movement Analysis (LMA) to recognize Laban Effort qualities from acceleration input using a Machine Learning software that generates classifications in real time. Existing LMA-recognition systems rely on motion capture data and video data, and can only be deployed in controlled settings. The single-accelerometer system is portable and can be used under a wide range of environmental conditions.

In the fields of human movement analysis, artistic visualization, and interactive dance performance, EffortDetect has also been used in the EMVIZ visualization system[43] (shown in Figure 43) to explore visual metaphors by mapping movement qualities, in the form of Laban BEAs to parameterized abstract visualizations. The motivation for this project comes from the interest and expertise about human movement in the field of contemporary dance performance and artistic visualization. The visualization system places attention on aesthetics, provides real-time response through models from expertise-based knowledge on properties of movement. EMVIZ uses metaphoric mappings that rely on artistic interpretation of human movement qualities to generate visual forms, and illustrate the creative design process for communicating expert knowledge around movement. EMVIZ was used in an interactive art installation during which the audience provided critical feedback regarding their response to the aesthetic and communicative properties of the visualizations.

There is a direct relevance of this approach with WhoLoDancE, which wishes to research the use of alternative technologies for motion capture of the dancer in different settings and price ranges. The accelerometers are a promising technology to take into account in this context, along with the visualization approaches of EMVIZ.

[43] http://metacreation.net/index.php?s=projects#top

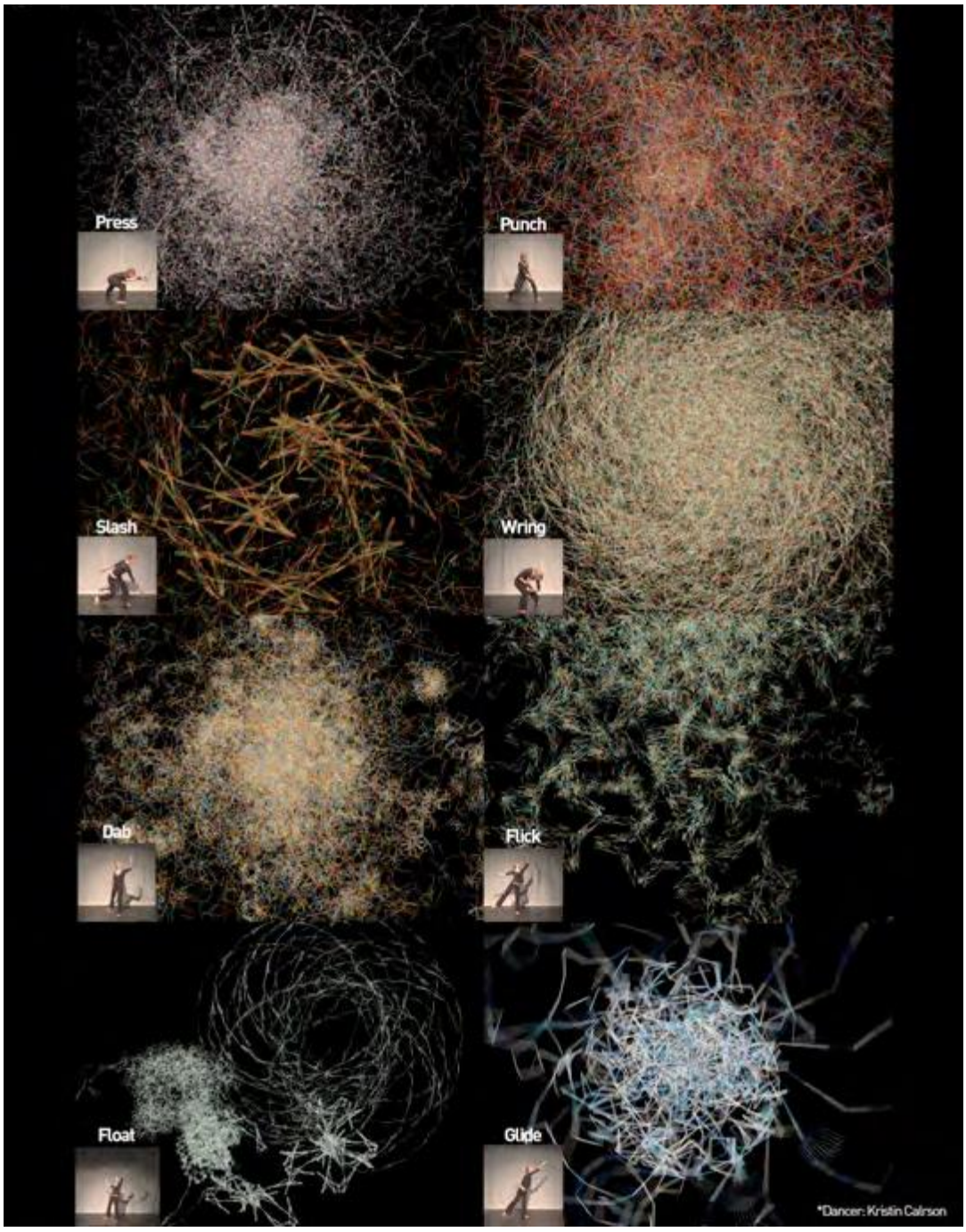


Figure 43 EMVIZ visual metaphors mapping Laban BEA to parameterized abstract visualizations

37. Synchronous Objects-One flat Thing

Synchronous Objects [44] for the choreography of William Forsythe One Flat Thing, reproduced is an interactive screen-based work developed by The Ohio State University's Advanced Computing Center for the Arts and Design and the Department of Dance in collaboration with renowned choreographer William Forsythe. Pivoting on Forsythe's masterwork of visual complexity, One Flat Thing, reproduced, the Synchronous Objects project seeks to enrich cross-disciplinary investigation and creativity by revealing deep structures of choreographic thinking through a vivid collection of information objects in the form of 3D computer animation, annotation, and interactive graphics.

[44] http://synchronousobjects.osu.edu/

Figure 44 Synchronous Objects visualisations of motion for "One Flat Thing"

So in 2009, the intercultural and interdisciplinary team of Norah Zuniga Shaw, William Forsythe and Maria Palazzi, published the screen-based work titled *Synchronous Objects for One Flat Thing, reproduced. U*sing dance as a starting point for visualizing thought, the team data-mined the choreography of William Forsythe. The deep dive unearthed alignments, cues and themes that are repeated and fragmented and recombined.

In *One Flat Thing, reproduced*, there are multiple performers dancing around and interacting with multiple tables (the flat thing, reproduced several times) and each other. To capture data of the dance, the team used video of a performance and interviews with the dancers. The interviews capture data about cues given and received during the dance and the flow of interactions that result. The video shows visual patterns, for instance an arc created by arms and then by a head, then again by feet, emerges as one motion at different times in different directions by different bodies. The similarity is the arc, the complexity brought by changing times, body parts, directions, etc. This teasing out of a complex structure is how a simple aesthetically pleasing movement becomes a complex ecosystem that can be examined for deeper understanding of relationships and visual counterpoint.

The results—the ecosystem of this dance—are shown in a fluid, discovery-based website which can be explored by both novice and expert. The data are showcased as alignment annotations, cue visualization, concept threads, movement densities, 3D alignment forms, motion volumes and performance architectures, among other visualizations. Essentially, the data flows from dance to data to visual objects also in motion.

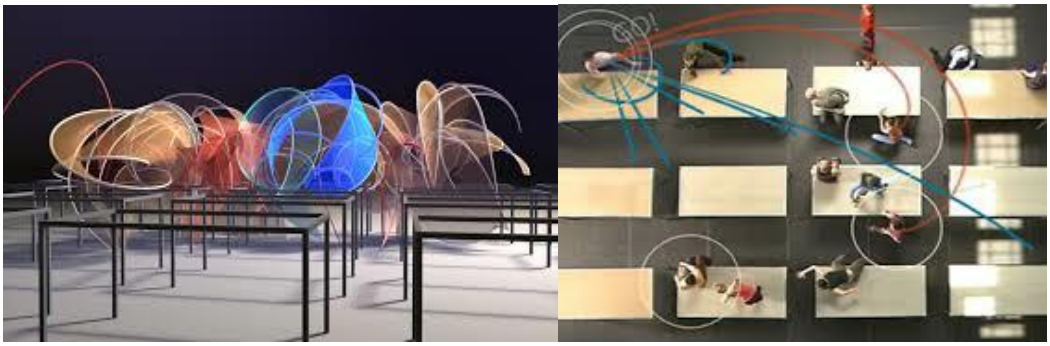


Figure 45 Synchronous objects

To sum up, Synchronous Objects for One Flat Thing not only exposes a detailed quasi-scientific approach to the art of dance, but it also emphasizes the benefits of data visualization in the understanding of a fundamental form of human expression. Aiming to create a large set of data visualization tools for understanding and analyzing the interlocking systems of organization in the choreography of William Forsythe's "One Flat Thing, reproduced". These systems were quantified through the collection of data and transformed into a series of objects - synchronous objects - that work in harmony to explore those choreographic structures, reveal their patterns, and re-imagine what else they might look like.

Augmented -Virtual Spaces and Dance

38. A ballet from the inside

“A ballet from the inside” aims to create a virtual performance of a contemporary dance where users can embed themselves into the piece and watch from every point of view as the dancers evolve, as if they were themselves actors on stage. Research and motion capture prototype for this work was done by Cie Gilles Jobin in Geneva. The choreography is by Gilles Jobin, the dancers are Gilles Jobin and Susana Panades Diaz, and the music is by Franz Treichler. The work is in a virtual space that can only be seen with VR googles. The dancers that the visitors are seeing in the VR environment are animations driven by Motion Capture data from Gilles and Susana. The visitors are been tracked by the whole mocap camera system in real time. So the visitors move in the space as if they are in the VR space rendered in realtime with the dance happening in the center.[45]

Figure 46-"a ballet from the inside"

[45] http://www.dance-tech.net/video/a-ballet-from-the-inside-real-virtuality-experience?xg_source=activity

39.Ballet Pixelle

Ballet Pixelle[46] uses new technology to take the art form into a unique environment to new and existing spectators. The first and only of its kind, the company performs in and takes advantage of a 3D Internet virtual world called Second Life®.[47] The company creatively utilizes unique aspects of the virtual reality, e.g., transforming from human into animal or dragon or growing old on stage. The ballet uses a new breed of dancers and a new classical ballet vocabulary created to take advantage of the innovative medium. By performing in an Internet virtual space, it breaks geographical boundaries and time zones, and it allows new spectators, such as disabled individuals, to enjoy a ballet performance that they may not have experienced otherwise.

Ballet Pixelle® performs original ballets choreographed by Inarra Saarinen to music created for each ballet by professional First Life composers. Performances are one or two times a week at Ballet Pixelle's theatre. In addition to the performance schedule, each ballet requires several weeks of rehearsal. Ballet Pixelle crew, counting more than 25 people, work collaboratively to design, build, and script sets, props, and costumes.

These avatars are real people from around the globe – Japan, Canada, Portugal, England, and California, Colorado, Florida, Hawaii, Illinois, Massachusetts, Michigan, Pennsylvania, and Washington, DC – they come together to captivate audiences. Many are Real Life professional and amateur dancers and not just in ballet but in others such as Irish Dance. Poseballs, scripted animations, or synchronization devices are not used in Ballet Pixelle® performances. Dancers move independently, enacting steps and gestures coordinated with the rest of the cast and to the music. Technically, Inarra Saarinen used Avimator, Qavimator, Poser and others to create the animations. She began with some ballet animations and created quite a number over the course of the choreography. All in all, I now have approximately 250 original animations. The main difference between dance animations at clubs in Second Life and these ballet animations is that 100% of the ballet animations do not loop and run under the precise control (SL willing) of the dancer. The animations are put into gestures, which Inarra Saarinen makes akin to musical phrases in ballet. This way the choreographer and dancers and composer are able to work in a normal real (or First Life, to use Second's life terminology) style. The gestures also allow very precise timing between animations (in tenth of seconds but, alas, not counting lag) and compound animations. That is, in a gesture if you do not add a "wait" step the two animations happen at the same time. The dancers map the gestures to function keys or use chat "/gesture_name" to activate the phrase. It is up to the dancers to rehearse and time the execution of each gesture in order. During these times, I have tried working with both off-the-shelf and custom HUDs, but neither of them gave me all of the functionality that I needed. There were added lags in a HUD, for example, even though having buttons might have been convenient for the dancers.

[46] http://balletpixelle.org.

[47] http://secondlife.com/

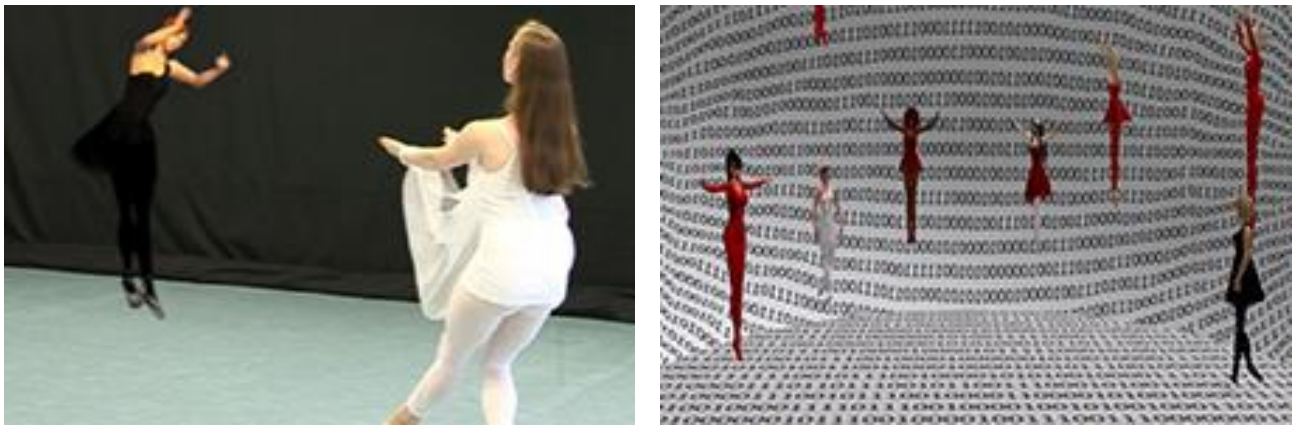


Figure 47-Avatara ballet by Ballet Pixel

Ballet Pixelle have produced more than 15 ballet An excellent example is Avatara in which Ava, the Real Life dancer Hiroko Kimono (Tokyo), dances pas de deux with Tara, the Second Life dancer Amelie Dibou (Washington, D.C.). Then in Act II Ava joins Tara in the virtual world to dance together as humans, butterflies, metal aliens, and more. One of the funniest animations folds the dancers up into human suitcases.

40. Man A

'MAN A' is one of the latest work of the London-based artistic collaborative Gibson/Martelli[48] by dance and visual artist Ruth Gibson & artist Bruno Martelli, which create installations and performance spaces using computer games, virtual reality, print and video technology. Their practice is an investigation into the body and landscape, the notion of space and simulacra and the sublime. MAN-A takes military Dazzle Camouflage as point of departure. Unlike traditional camouflage which operates on the principle of concealment, dazzle camo uses complex arrangements of high-contrast, interrupted patterns of geometric shapes intended to confuse the calculation of a ship's range, speed and bearing in an enemy's optical gunnery rangefinder.

Gibson/Martelli's installation brings this thoroughly modern aesthetic into a contemporary framework by exploiting its monochromatic, geometric patterns as the de facto standard for machine reading, akin to a barcode or QR pattern. This appropriation takes the form of a custom 'augmented reality' mobile application created by Martelli, in which the device's camera 'recognizes' the pattern and superimposes three-dimensional imagery into the live- camera view.

[48] http://www.gibsonmartelli.com/

Figure 48-MAN-A app

The superimposed imagery occupies the screen of the viewer's mobile device, atop its live- camera digital representation of the space, which is filled with re-presentations of dazzle camouflage - which was itself designed with optical representation in mind. This multiple layering of imagery foregrounds the simulacra nature of the experience, highlighting the ways in which images and technologies produce both each other and the viewing subject simultaneously.

Figure 49-Man-A by Gibson Martelli AR -view

Furthermore, the artist's purposeful 'glitch' in this chain of representation becomes apparent; what was once a pattern intended to obfuscate in the analog era becomes one able to reveal and expand upon the image in the digital era, by way of image-recognition and augmentation.

The specific nature of these augmentations is crucial. In presenting stylized humanoid forms whose movements are derived from 3D motion-captured contemporary dance performances, Gibson/Martelli reintegrate embodied perception into a process that otherwise privileges the visual and cerebral almost exclusively. The performers who lent their motion-captured presence to the installation are all experts in the Skinner Releasing Technique model of contemporary dance, which holds as its core premise that all humans are endowed with a natural, animal-like grace that can be tapped by the combination of technical movement principles with poetic images and spontaneity. It is from this principle of natural force and energy - referred to as mana in Pacific Island cultures - that MAN A takes its name.

Figure 50-"Big Bob" explores the relationship between movement and virtual reality

Big Bob[49] is the central work of MAN A at the Jaffe-Friede Gallery. Their exhibition is made up of a giant reclining sculpture, known as "Big Bob," a piece of art mounted on a wall that represents the movement and flaws of motion capture, and three phone applications that allow viewers to see alternate reality figures that move along "Big Bob." Gibson and Martelli said they wanted to explore the idea of intersections of reality and the interplay between audience and art.

[49] http://www.gibsonmartelli.com/BigBob1.html

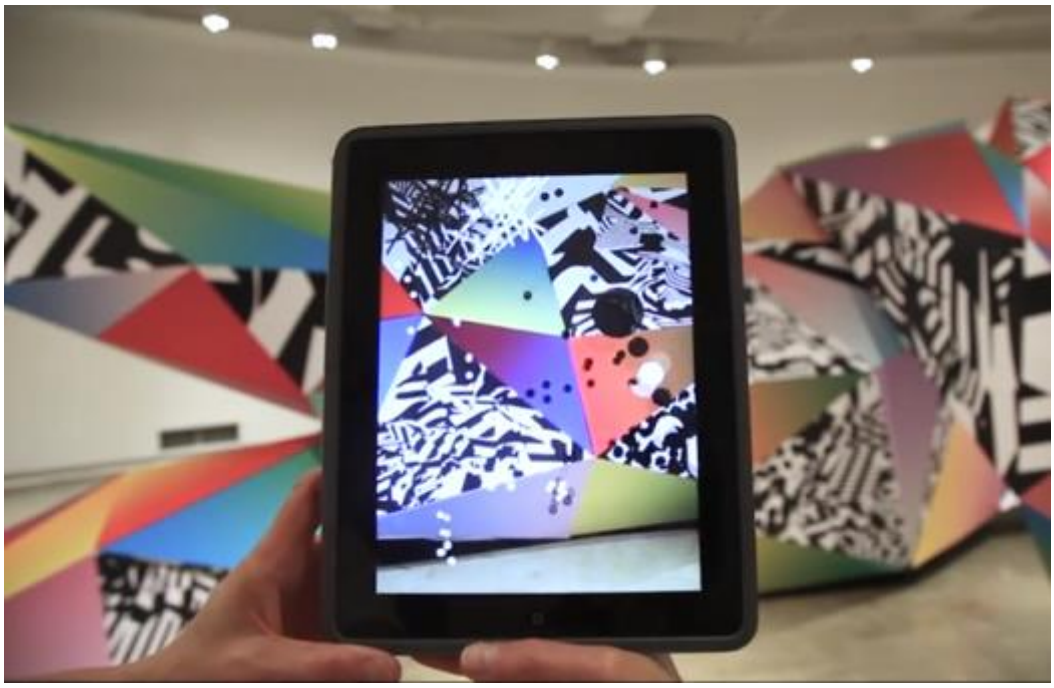


Figure 51-Big Bob app

The applications they developed for the exhibit will help the viewer enter the virtual world. Among the three apps developed for "MAN A" are the iPhone and Android apps "MAN A" and "MAN A VR", which add the virtual characters into the exhibit space and use special Google headsets to create a virtual reality, respectively. Joining then is the Android-only "RAGTIME VR", an app that creates a virtual reality within the exhibition.
Artists Gibson/Martelli reimagine 'dazzle' camouflage as tribal markings for invisible performers, moving within an installation, activated by a special App.

- 'MAN A'[50] takes as its starting point the relationship between man & his environment, exploring the use of camouflage, war paint & tattoos - seen through the prism of neo-tribalism. The subject is hidden in plain sight, the pattern used to confound the eye rather than conceal, to give power to the wearer rather than diminish them.During WWI artist Norman Wilkinson invented a type of ship camouflage consisting of complex intersecting geometric patterning designed to confuse the enemy. Dazzle camouflage & machine readable markers (Barcodes, Augmented Reality, QR codes) are two opposing ways in which information can be encoded on a surface, one used in wartime for concealment, the other in peacetime as a tracking marker or bearer of information.
- MAN A VR[51] is a site-specific installation featuring vinyl wall-prints referencing military dazzle-camouflage, sculptural objects and motion captured contemporary dance performance activated by a custom augmented-reality mobile application by the British electronic-arts duo Gibson / Martelli. This app is designed for the Google Cardboard VR glasses.
- The virtual reality figures that move on "Big Bob,[52]" which the audience can see through the apps, are motion captures of performers dancing and moving around. The third part of the exhibit, the mounted piece, is a printed visualization of the parts of the roll that the motion capture system was unable to capture, Gibson said. In the piece, each sensor placed on the dancer's body is represented by a color, and the motions that could not be picked up are represented by yellow, creating a grid of various colors mixed with random swatches of bright yellow.

[50] https://play.google.com/store/apps/details?id=com.gibsonmartelli.MANA14
[51] https://play.google.com/store/apps/details?id=com.gibsonmartelli.VR&hl=en
[52] https://vimeo.com/145684603

41. Capturing Stillness Project

Capturing Stillness[53] is another example of Gibson's and Martelli's work. It uses performance capture and computer game worlds to create transformative experiences derived from Skinner Releasing Dance Technique and its poetics. The study questions the relationships that arise between the poetic imagery cited in the pedagogy aligned with motion analysis, visualization techniques and digital technologies & how these findings in combination with SRT principles can permeate the development of kinesthetic Human Computer Interfaces for mobile devices and large scale projected real-time 3D environments.

Gibson / Martelli performance captured 16 dancers from across the globe in the *Bugatti Lab* at Coventry University and *motion.lab* at Deakin University, Melbourne. Visualizations of the movement data are incorporated into a series of new Augmented Reality and Stereoscopic Virtual Environments for CAVE & Oculus Rift.

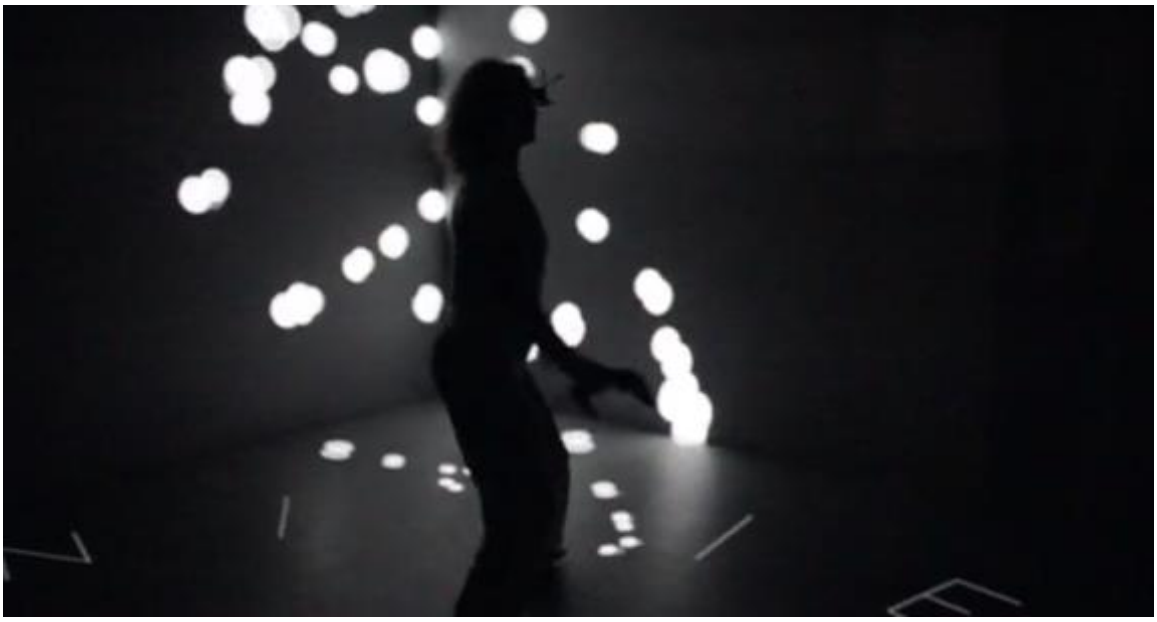


*Figure 52-*Spots&Dots *2013 CAVE installation/performance with real-time performance capture, Christie Digital*

As the first study of its kind to interrogate Skinner Realising Technique[54] (SRT) dance practice in the field of motion capture and interactive virtual environments, the project resulted in exhibitions, conference contributions, multimedia publications, didactic materials and various other events and public engagement activitie. It consists an interesting a example adopting state of the art interactive technologies to transfer the approach of a somatic and pedagogical approach which relies on the use of imagery. In WhoLoDancE we are investigating the connections between optimal imagery examples for reflection in dance pedagogy and virtual visualizations.

[53] http://www.gibsonmartelli.com/CapturingStillness.html
[54] http://www.skinnerreleasing.com/

Overview table

Table 4 presents an overview of the technologies related to dance education identified in the remaining of this section. The rest of the section presents a brief description of these technologies and tools. In this context it should be noted that in Table 4 we use the term Education from a very wide perspective; some of the works use the term "training", "teaching", "learning" in different formal and informal contexts which vary from applications which have been tested within formal education of dance to applications developed in a gamified, edutainment, "teach-your-self" context. It is important also to note that some of these tools focus on technological research while others are the result of co-design and collaboration between technologists, dance educators, choreographers and practitioners and artists. The table provides the following information:

- Technologies used (Motion Capture, Kinect, Annotation technologies,etc)
- Type of experience (whole-body experience, VR, AR, desktop, mobile etc)
- Purpose (education, gaming, archival, artistic, online collaboration, etc)
- dance genre on which the example focuses.

Table 4 An overview of technologies directly or indirectly related to Dance Education

No	Title of Tool or Paper	Technologies	Type	Purpose	Dance Genre
1	Super Mirror	Kinect	Screen	Education	Ballet
2	YouMove	Kinect	Whole-body Interaction, Half-silvered mirror with graphic overlays	Education	Any/Not reported
3	Motion analysis for fold dance education (Aristidis et. Al)	Motion capture, 3D animation, LMA analysis	Screen,	Education	Greek Folk
4	A kinect-based skeleton tracking system for evaluating a dancer's performance (Alexiadis et al)	Kinect, 3D animation	Whole-body Interaction, Screen,	Education	Salsa
5	Just Follow Me: A prototype dance training support system with motion capture and mixed reality technologies (Hachimura et al)	Motion capture	Whole-body Interaction, Head-mounted display	Education	Any/Not reported
6	A syntactical modeling and classification for performance evaluation of Bali traditional dance (Heryadi et al)	Kinect	Whole-body Interaction	Education	Bali folk dance
7	A multi-modal dance corpus for research into interaction between humans in virtual environments (Essid et al)	Motion capture	mixed reality	Education	Salsa
8	Virtual Reality and Dance (Chen et.al)	Motion Capture	VR	Education	
9	A dance training system that maps self-images onto an Instruction video	Motion Capture	AR, Whole-body Interaction	Education	Any/not reported
10	Virtual K-pop dance teacher	Motion Capture	Whole body Interaction	Education	K(orean)-pop

11	Kinect dance central	Kinect	Whole body interaction	Education, Gaming	Pop choreographies
12	An approach to ballet dance training through kinect and visualization in a CAVE	Kinect	VR	Education	Ballet
13	Learning Hawaiian Hula Dance by Using Tablet Computer (Usui et. al 2015)	CG animation	CG animation on screen tablet	Education	Hawaian Hula
14	WebDANCE/OpenDANCE	3D animation, e-learning technologies	Screen	Education	Greek and other folk dances
15	Whatever Dance Toolbox	FireWire enabled video camera	Screen/2D projection	use in dance studio, choreography, partly educational	any
16	BalOnSe	archival, ontologies, text-based annotation	Screeen	Annotation, archival, online collaboration,	ballet
17	DanceTraces	archival, text based annotation	Screen	Annotation Education online collaboration	contemporary
18	DancePro and Dance Spaces	text and sketch based annotation	Screen	Annotation online collaboration	contemporary
19	Dance Spaces	annotation on videos	Screen	archival, Choreography	contemporary
20	LabanDancer	Notation to 3D	Screen	Choreography	any
21	LifeForms	3D animation libraries	Screen	Choreographr y	ballet, contemporary, any
22	PM2GO	text based on annotation	Screen	choreography , online collaboration	
23	Sketch based dance choreography	sketch bases annotation	Screen	Choreography	
24	ReEnact Sketch based Choreography	videos, Storyboarding choreographies on screen	Screen	Choreography	
25	Web3D	3D, VRML	Desktop,	Education	ballet

			Screen		
26	Bounden Gameplay app.	Mobile app.	Mobile experience, Whole-body Interaction,	use in dance studio	dancing with partner (turning),any
27	Sonolope app.	Mobile app. sonification	Mobile experience, Whole-body Interaction, sound	Improvisation Performance,	Improvisation, any
28	Improvisation Technologies by W.Forsythe	Augmented visualizations videos	Screen	Choreography, (Reflection)	contemporary
29	EyesWeb Platform	Sonification, Visualization, Movement Qualities Analysis, Motion Capture	Whole-body Interaction	Artistic Experimentation, Research	contemporary
30	Neural Narratives	Sonification, Visualizations (simulation-extentionf on body gestures) Motion Capture	Whole-body Interaction	Artistic Installation and Experimentation, Choreography	contemporary
31	Gameplay	Camera suspension system and infrared Webcam Video projector (3000 lumen minimum)	Whole-body Interaction	Artistic Installation and Experimentation, Choreography	contemporary
32	Para_site	Body sensors and breathing sensor One video projector mapped on 7 screens	Whole-body Interaction	Artistic Installation and Experimentation, Choreography	contemporary
33	Echo Room	Physiological sensors 3 rooms	Whole-body Interaction	Artistic Installation and Experimentation,	contemporary

				Choreography	
34	Tactile Sensations	Tactile wireless sensors Tactile circular customized dance floor	Whole-body Interaction	Artistic Installation and Experimentation, Choreography	contemporary
35	Metaphorá	Tracking overhead camera Mapping with 3 video projectors	Whole-body Interaction	Artistic Installation and Experimentation, Choreography	contemporary
36	Designing for Movement: Evaluating Computational Models using LMA	Movement Qualities Analysis, LMA Analysis, VIsualizations	Whole-body Interaction	Artistic Installation and Experimentation,	contemporary
37	Synchronous Objects	Augmented Visualizations, 3D display		Choreography, Artistic Installation and Experimentation	contemporary
38	A ballet from the inside	Motion Capture, 3D animation	VR	Artistic Installation and Experimentation	contemporary
39	Ballet Pixelle	Motion Capture -3D animation	Screen	Virtual Choreography	contemporary, ballet
40	Man A	apps, Motion Capture, Visualizations	AR, VR	Artistic Installation and Experimentation	contemporary
41	Capturing Stillness	Motion Capture, Visualizations,	VR	Artistic Installation and Experimentation	contemporary, Skinner Releasing Technique

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