

WHOLODANCE

Whole-Body Interaction Learning for Dance Education

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Executive Summary

The WhoLoDancE Work Package 5 is responsible for the overall data management infrastructure with the objective to collect, store, pre-process and manage the multimodal data acquired and integrate the various tools and components developed within the project.

This deliverable documents the outcomes of the tasks T5.4 *Integration and interoperability with external services, systems and applications*, T5.5 *Integration of EyesWeb platform* and T5.6 *Global integration within the WhoLoDancE data management platform*, summarizing the process and approaches of integrating to the platform the various components, modules and applications as described in the corresponding tasks.

At the moment, the various tools produced during the first period of the project are in different stages of completion and are gradually being integrated according to the needs defined by the envisioned user scenarios.

In this report we present the various tools (*Movement Library and Annotator*, *Blending Machine*, *Movement Sketching*, *Choreomorphy*, *Similarity Search*, and *Kinect-based tools*) through a lens of an integrated perspective, describing in detail the technical characteristics and interdependencies and propose a scheme for facilitating a variety of (web-based, low-end and high-end technology) digital learning experiences.

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1 Introduction

The project has produced so far a variety of tools and components in various stages of implementation, (more details can be found in the deliverable D3.6 *First Report on Software platform and libraries*). The Data Management platform has been completed to serve as the main repository where the rest of the applications can access the rich kinetic material produced within the project. The Movement Library serves as the main platform where advanced functionality is offered on the kinetic material, including visualization of the recorded motion capture movement, annotation and advanced search through the similarity search and movement sketching components. The Blending Machine is a desktop tool that allows experimentation with sequences of the kinetic material whereas the Choreomorphy tool can be used for improvisation through dancing with a virtual self, presented as different avatars. Finally, the Kinect-based learning tools offer concrete exercises for the dancer to improve specific qualities. At the moment, the various tools are in different stages of completion and are gradually being integrated according to the needs defined by the envisioned user scenarios.

The rest of this document presents, in Section 2, the plan for integrated access to the WhoLoDancE tools through the project website and, in Section 3, reports on the technical status of the integration. Section 4 presents each tool in detail, including their envisioned next steps.

2 Integration planning

The project has produced a variety of tools (back-end and front-end components) to support the different educational needs and scenarios as they have been identified through the interaction of the dancers' community. Towards the integrated version of the tools, we follow, with slight modifications, the flexible architecture which was already shown in D5.2 *Beta Prototype Testing and Validation Data Management Platform Report*, as shown in Figure 1.

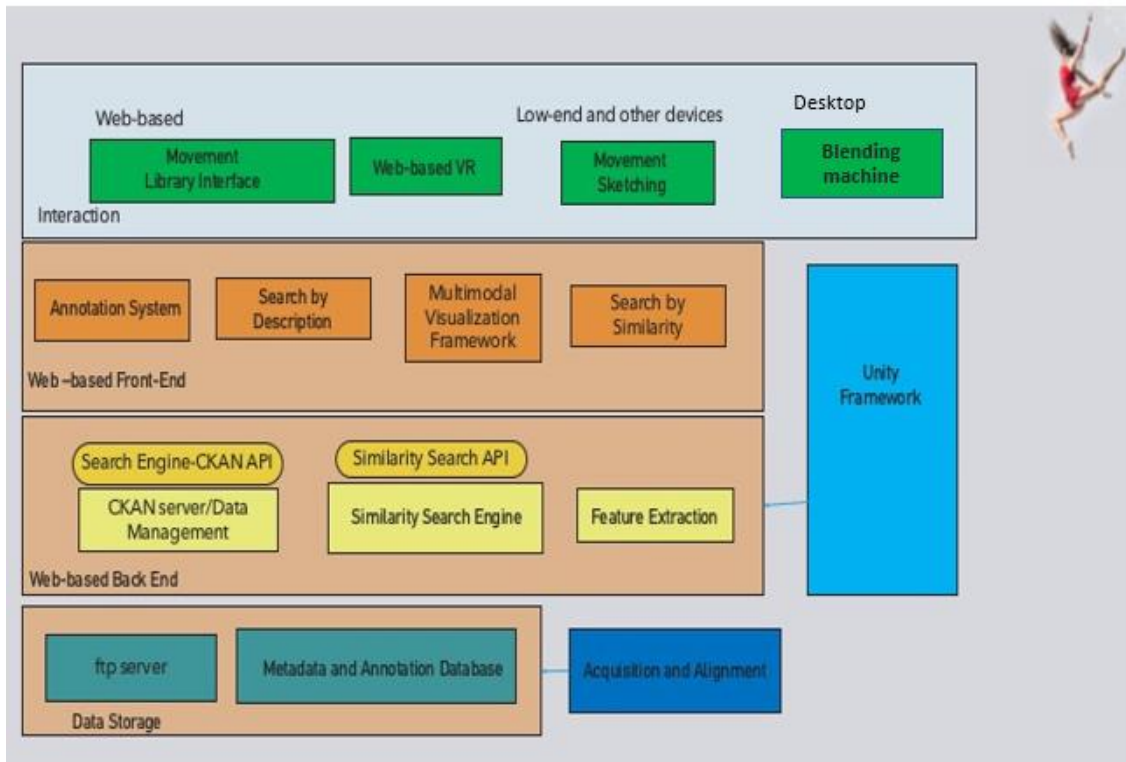


Figure 1. A conceptual map for the various components of WhoLoDancE tools and software towards an integrated, but flexible architecture.

As the schema implies, from the user's point of view, by the end of the project we envision to offer tools that provide three different user interaction experiences:

1. Web-based experiences that can be accessed through a URL using a PC, laptop or tablet, without the need for any special hardware.
2. Low-end technology experiences that can be either accessed through installing an app or through a link, and demand relatively affordable and portable devices such as Microsoft Kinect, Notch, low-cost headsets for VR, etc.
3. High-end technology experiences that can be demonstrated as a proof-of-concept in the lab or specific installations, using state-of-the-art technologies and hardware. This category of experiences demands the availability of specific hardware such as inertial or optical motion capture suit, and more precise and expensive Augmented and Virtual Reality devices.

In the following section, we present the tools which have been implemented so far by the various partners. We will distinguish them in two main categories: tools that are accessible through the web and tools that shall be downloaded and installed in the user's workstation.

1.1 Web-based tools

The web-based tools and components developed so far include the following:

WhoLoDancE Data Management Tool. The tool organizes the multimodal recording files, including motion capture, video, audio, text and synchronization files in the ftp server (repository) by grouping them into recordings. The tool also manages metadata information associated to the recordings. It also provides a useful API to access the stored data and metadata from other applications.

WhoLoDancE Movement Library. The main objective of the WhoLoDancE Movement Library (WML) application is to provide access to the WhoLoDancE repository, through an intuitive interface with browsing, searching, visualization and annotation functionalities for the multimodal recordings.

Similarity Search Tool. The Similarity Search Tool aims at supporting the users to browse WhoLoDancE repository by allowing them to start from a short excerpt of a motion capture recording (the *query* example) and search for the movements in the repository that are the most similar to it.

In Table 1, the web-based tools characteristics of the tools such as dependencies and hardware needed, OS compatibility and interaction of other tools are summarized.

Table 1. Summary of web-based tools characteristics

Tools	Server	Client	Dependencies and hardware needed	OS compatibility	Interaction with other tools
WhoLoDancE Data Management Tool	CKAN	Any web browser	None	All	Provides access to the WhoLoDancE motion capture, and multimodal repository of recordings
WhoLoDancE Movement Library	Apache Tomcat version 9	Any modern web browser supporting WebGL	PostgreSQL version 9, Java version 8, CKAN	All	Uses the WhoLoDancE Data Management Tool API to access the recordings repository and provides an interface for search, browse and annotate recordings
Similarity Search Tool		Any modern web browser supporting WebGL	Java SE, Ubuntu Linux 16.04, NGINX, PostgreSQL, Jenkins, OpenAPI (Swagger). Hardware needed: 32GB RAM, 10GB disk space, 8+ core server	All	Uses the WhoLoDancE Movement Library to access the motion capture recordings that are queried and visualized. An integration of the search system as a recommender is currently under integration

Desktop tools

The desktop tools and components developed so far include:

Blending Engine. The basic functionality of the software is the blending and composition of sequences of movements based on the mocap data that are already available in the library of movements.

Choreomorphy. Choreomorphy is a whole-body interaction interface that allows a user to visualize their movement in real time using motion capture technologies. The interface allows a user to change avatars and type of visualization in real time, in order to focus on specific aspects of their movement such as traces, trails, and volumetric space and improvise while seeing themselves as different avatars and shapes and interact with virtual objects.

Kinect-based learning tools. Kinect-based learning tasks are specially designed exercises that the user can go through to practice or understand a dance quality or movement. A Kinect sensor is used to capture the user's motion so that proper feedback can be obtained.

Movement Sketching. Movement sketching is a tool that allows dance practitioners, students, and professionals to create their own recordings of dance sequences (by performing them), and query the repository to find similar dance segments.

Table 2 summarizes the technical characteristics of the tools.

Table 2. Summary of web-based tools characteristics

Tools	Dependencies	Hardware needed	OS compatibility	Interaction with other tools
Blending Engine		Standard PC. Advised a strong graphic card (from Nvidia 900 Series and up)	Microsoft Windows 7 and 10	
Choreomorphy (whole-body interaction)	Game Engine: Unity	Synertial Animate and Synertial Motion Capture System (or other motion capture system to be supported), router, internet connection	Windows desktop only	
Choreomorphy (desktop -PC)		Standard PC or laptop. Advised a strong graphic card	Windows, Mac, Linux – desktop only	
Kinect-based learning tools		MS Kinect V2		
Movement Sketching		PC, Motion capture system (Notches), internet connection, VR headset (Cardboard, HTC vive, Daydream) for VR interface.	Windows 8+ (main application), Android, iOS (VR displays)	Retrieves search results using the similarity search component

3 Tools description

This section presents the current status of development of the WhoLoDancE tools, focusing on functionalities, technical requirements and status of implementation and integration.

3.1 Web-based tools

3.1.1 WhoLoDancE Movement Library

The main objective of the WhoLoDancE Movement Library (WML) (Figure 2) application is to provide access to the WhoLoDancE repository, through an intuitive interface with browsing, searching, visualization and annotation functionalities for the multimodal recordings.

Making the motion capture data available to the dance practitioners is one of the most significant needs that have emerged during the WhoLoDancE project. Towards that direction, the development of the WML application aims to provide an effective and usable connection between users and the WhoLoDancE repository.

More specifically, the user can browse the recordings by dance genre (Figure 3), and search by using keywords (Figure 4) that are included as metadata associated to the recordings. A multimodal player has been developed, which allows the synchronized playback of a video alongside with the corresponding motion capture file (Figure 5). Moreover, not only do users have the opportunity to view the recordings but also to annotate them (Figure 8). Finally, a table and a timeline that operates as viewer for the annotations has been developed (Figure7).

Future work includes several new functionalities that will enhance the educational nature of the platform, as well as provide a more personalized experience, like personal channels and playlists. An overview of the approach can be found in the deliverable 6.3, while the final version will be described in future deliverables.

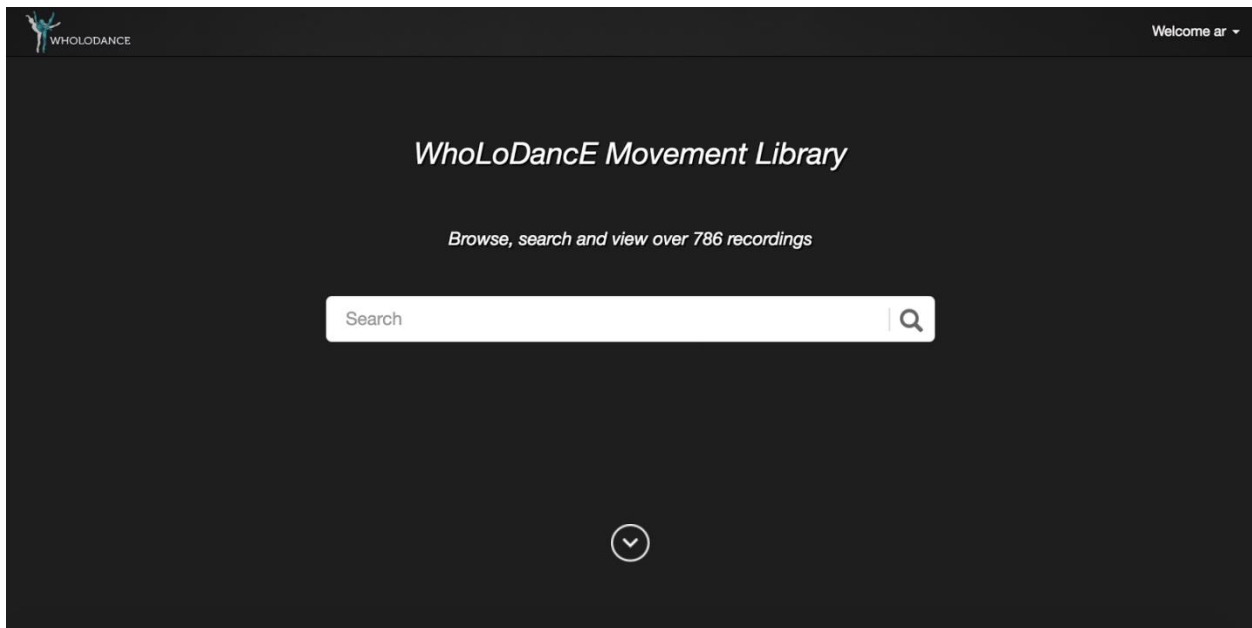


Figure 2. WhoLoDanceE Movement Library home page search

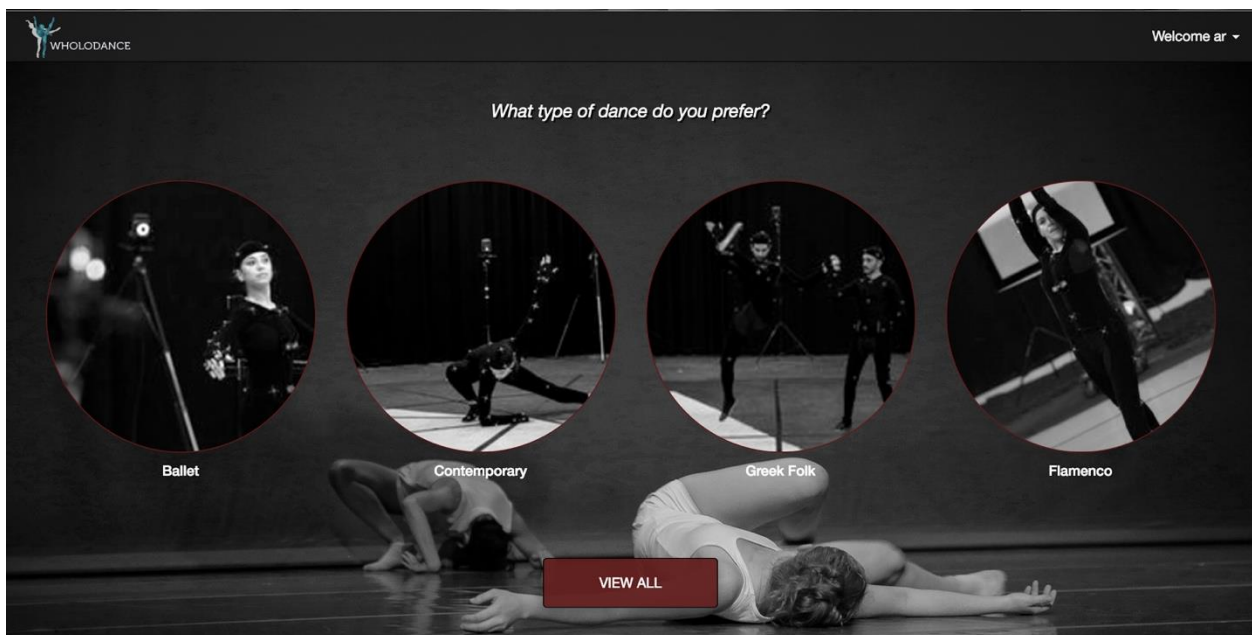


Figure 3. WhoLoDanceE Movement Library home page browse

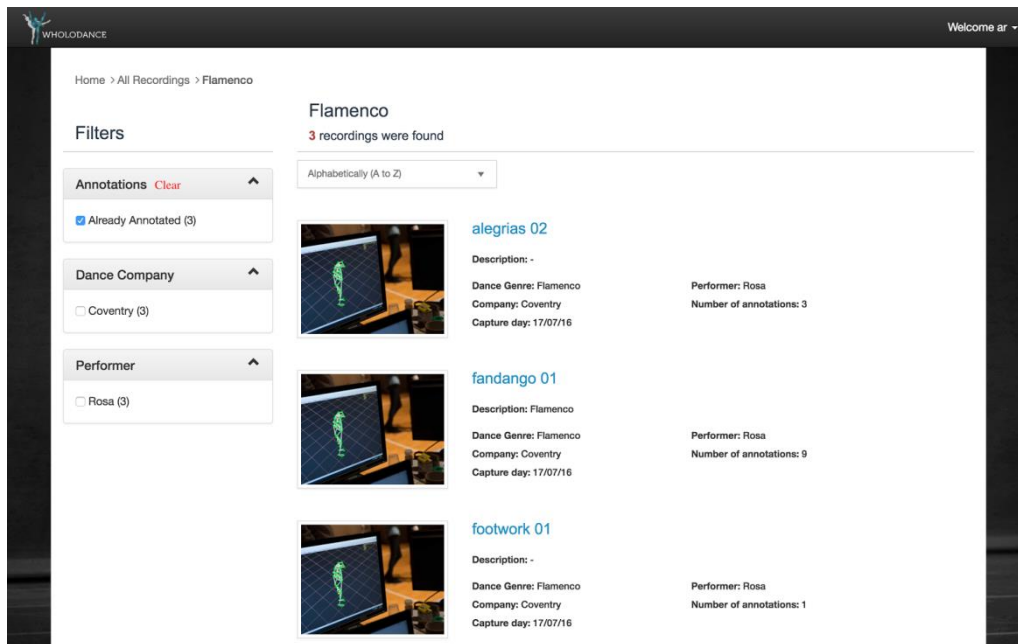


Figure 4. Search results page

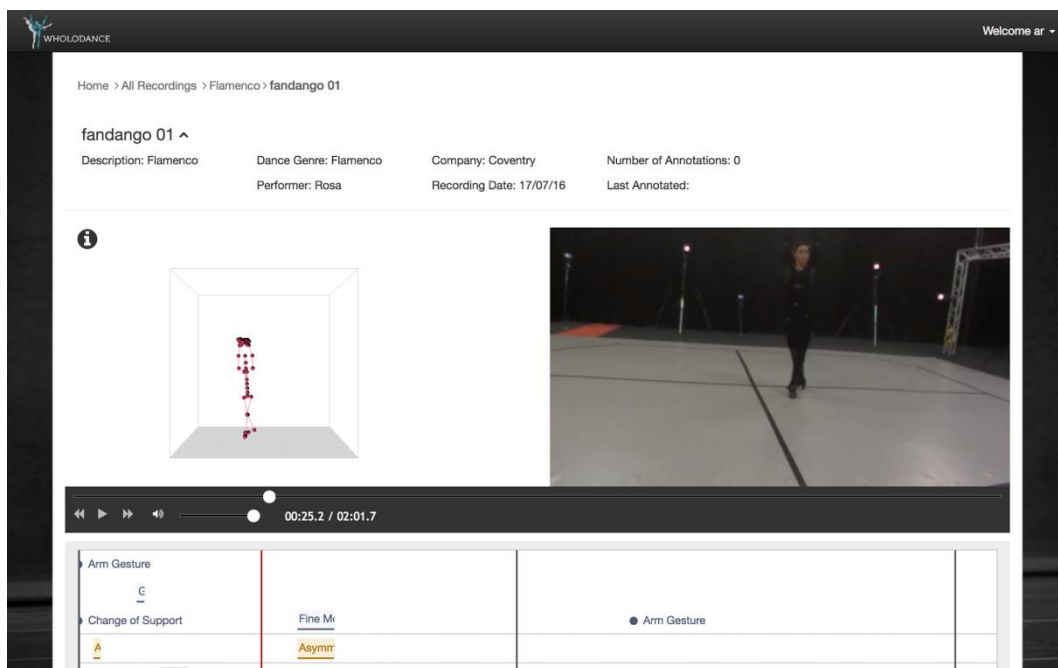


Figure 5. Viewer/player with the recording metadata

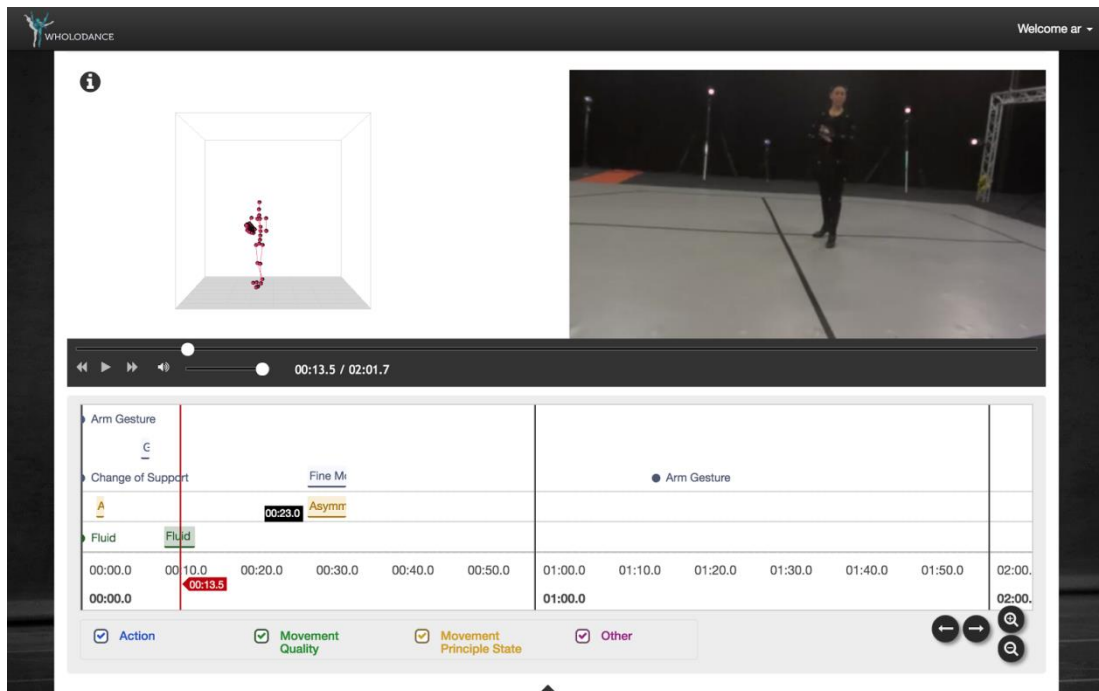


Figure 6. Viewer/player with the timeline

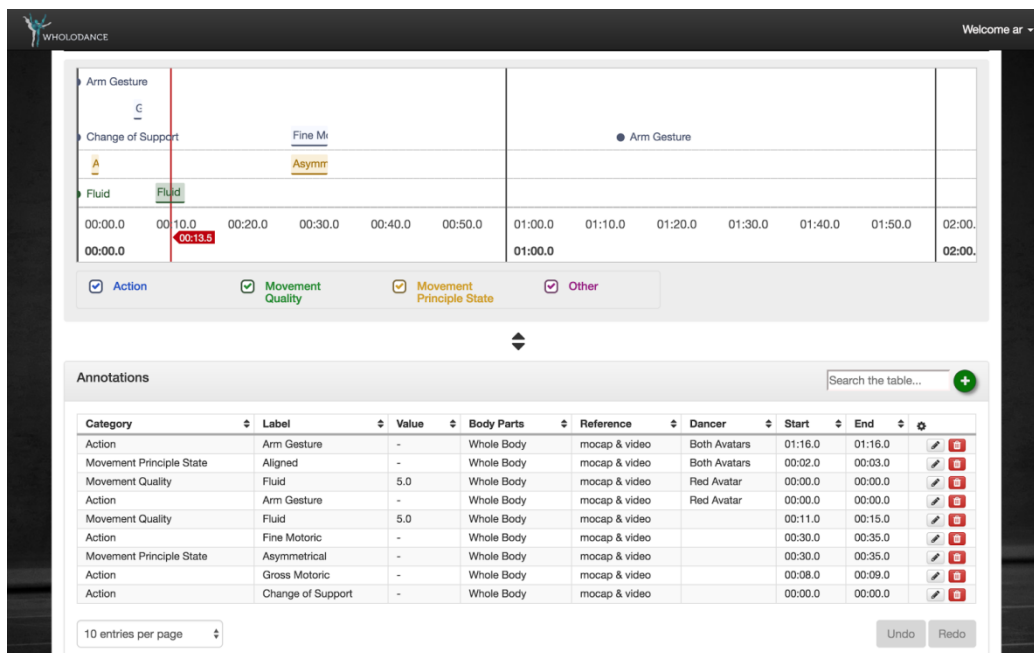
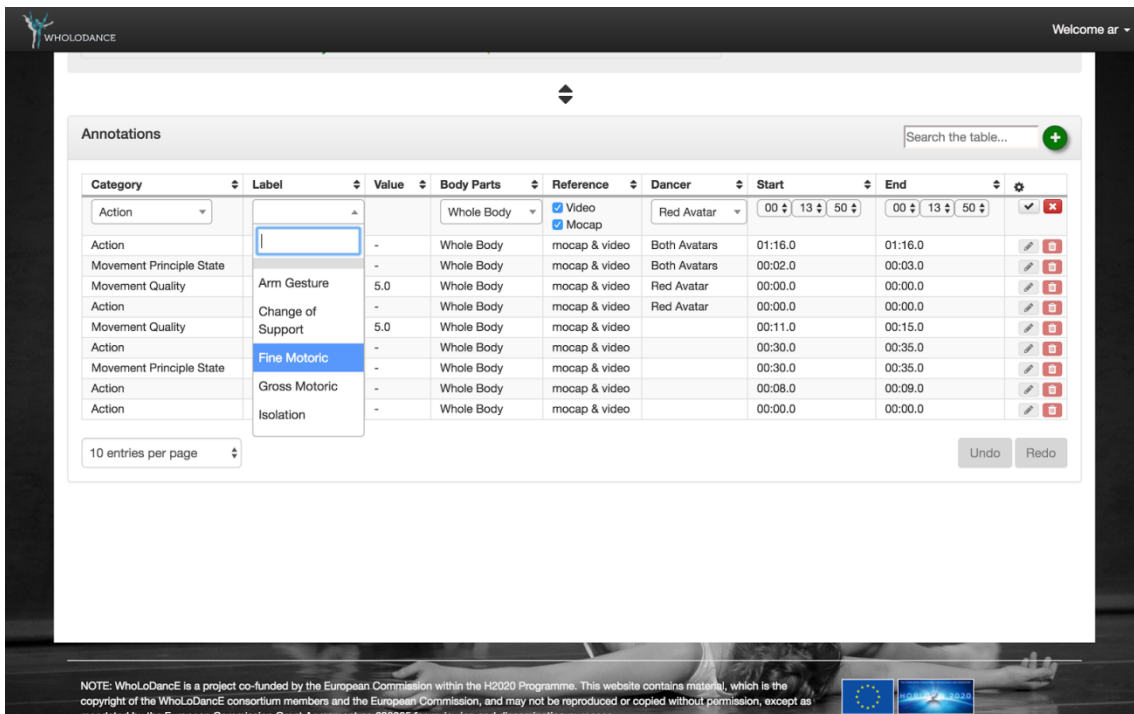


Figure 7. Timeline and table of annotations



Annotations

Search the table... +

Category	Label	Value	Body Parts	Reference	Dancer	Start	End	
Action			Whole Body	<input checked="" type="checkbox"/> Video <input checked="" type="checkbox"/> Mocap	Red Avatar	00:00	01:16.0	<input checked="" type="checkbox"/>
Action		-	Whole Body	mocap & video	Both Avatars	01:16.0	01:16.0	<input type="checkbox"/>
Movement Principle State		-	Whole Body	mocap & video	Both Avatars	00:02.0	00:03.0	<input type="checkbox"/>
Movement Quality	Arm Gesture	5.0	Whole Body	mocap & video	Red Avatar	00:00.0	00:00.0	<input type="checkbox"/>
Action	Change of Support	-	Whole Body	mocap & video	Red Avatar	00:00.0	00:00.0	<input type="checkbox"/>
Movement Quality	Support	5.0	Whole Body	mocap & video		00:11.0	00:15.0	<input type="checkbox"/>
Action	Fine Motoric	-	Whole Body	mocap & video		00:30.0	00:35.0	<input type="checkbox"/>
Movement Principle State		-	Whole Body	mocap & video		00:30.0	00:35.0	<input type="checkbox"/>
Action	Gross Motoric	-	Whole Body	mocap & video		00:08.0	00:09.0	<input type="checkbox"/>
Action	Isolation	-	Whole Body	mocap & video		00:00.0	00:00.0	<input type="checkbox"/>

10 entries per page

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Figure 8. Table of annotations adding an annotation

Current status of implementation

With regard to the WhoLoDancE Movement Library implementation, a complete and fully functional first version has already been developed. The WML application provides an easy and quick access to the WhoLoDancE repository, as well as serves as a tool for searching based on related keywords in the metadata and annotations, browsing using a variety of filters, view, and annotating the recordings.

Users can search in the repository and browse it by dance genre. After searching or browsing, users are redirected in the search results page, in order to select the recordings of interest. Users will be informed for the total number of the results that was occurred from their keyword. Each recording is combined with several details, such as "Title", "Genre", "Performer" and "Date of recording". Filtering, sorting, and pagination are also supported.

Regarding the visualization of the recordings, a special player was developed. The player is responsible to synchronize the video and the mocap files that refer to the selected recording, offering the opportunity to simultaneously watch and handle both the mocap and the video.

Each recording that is stored in the WhoLoDancE repository can be annotated, in order to describe and characterize the dancers' motions. To facilitate viewing, adding, editing, and deleting annotations, a tabular and a timeline view were developed. Overall, the WML application intends to meet the users' expectations, by offering an effective and usable connection between users and WhoLoDancE repository, through a friendly and versatile interface.

Comments and recommendations provided useful feedback for improvements.

The second version of the WML application is in progress, including several new functionalities and interfaces. Through that direction, users will have the opportunity to create private profiles, save recordings of interest and create their own playlists.

Installation instructions

The platform is currently deployed for demonstration purposes in a project server. To install a new instance of the WhoLoDancE Movement Library platform, the following steps should be followed:

1. Install and configure Apache Tomcat
2. Install PostgreSQL
3. Set up and populate the database
4. Deploy the WhoLoDancE Movement Library web-application

3.1.2 Similarity Search Tool

The WhoLoDancE repository is composed of more than 2,000 recordings of movements, of which only a limited amount has been annotated so far, since the annotation process is a heavy cognitive task.

The Similarity Search Tool aims at providing an additional functionality for the users to browse and dig into the repository by allowing them to start from a short excerpt of a motion capture recording (the query example) and search for the movements in the repository that are the most similar to it. This tool is especially useful since it relies on a description of the movement that is automatically extracted and, therefore, does not require manual annotations.

More specifically, the similarity search is composed of two stages: the first, led by PoliMI, concerns the automatic extraction of features that are used as descriptors of the movement; the second, led by Peachnote, regards the retrieval, given a query, of the most similar movements according to the aforementioned descriptors. The former stage is performed offline, where all the performances are analyzed to extract the features, which are uploaded to and processed by the similarity search system. The latter stage is performed online, when a user selects an excerpt of the performance (Figure 9), the descriptors to be used in the similarity process, and the system retrieves a list of matching performances (Figure 10).

The performances are directly selected from the WhoLoDancE repository, and the information are obtained accessing the WhoLoDancE repository. A more comprehensive integration of the WhoLoDancE Movement Library with the similarity search is currently under design, which will include an automatic selection of recommended similar recordings for each viewed recording.

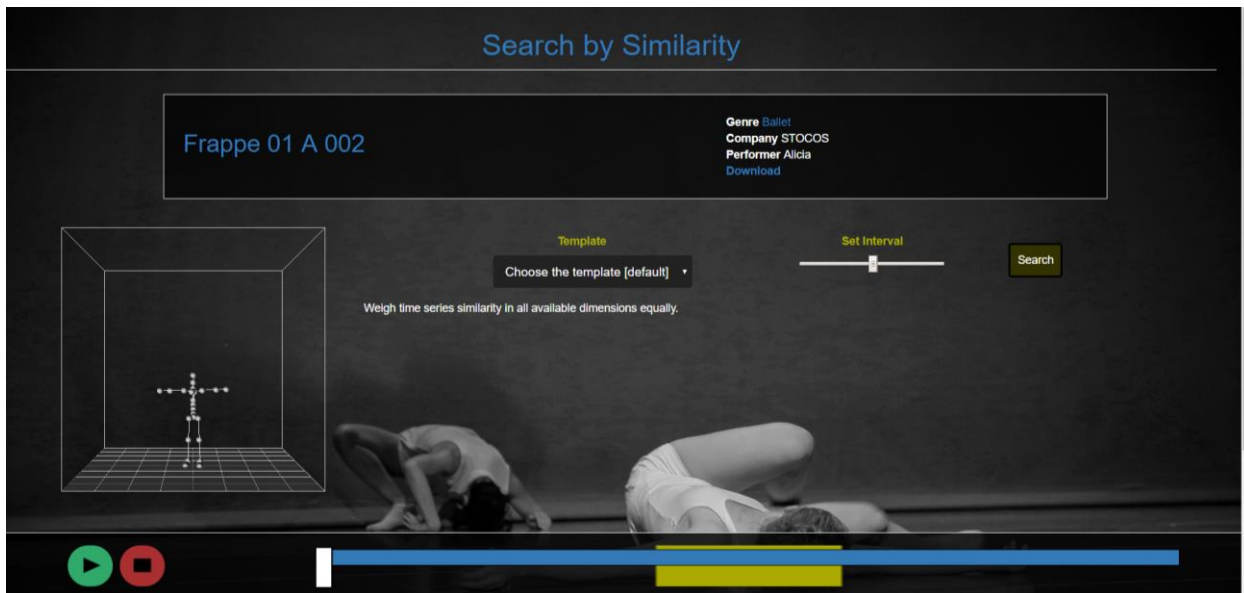


Figure 9. A performance is selected: the details are shown. The user can now select the template and the excerpt to consider for the similarity search



Figure 10. The results are shown. The player executes the query and the results' excerpts simultaneously, to improve comparability

3.2 Desktop tools

3.2.1 Blending machine

One of the results of the first year of the WhoLoDancE project is the development of a running prototype of the blending machine by Motek (Figure 11 and Figure 12). The basic functionality of the software is the blending and composition of sequences of movements based on the mocap data that are already available in the library of movements. The sequences are not only assembled in a linear (sequential) setup, where the combined movement segments appear in their original form, i.e., identical to the segments in the repository of movements, but also a parallel blending is possible, where the consecutive segments are a superposition of segments from the repository. This means that the blending machine allows the users to create new movements based on the ones that are already available. The user can, for instance, combine the lower body of a flamenco segment with the upper body of a traditional Greek dance segment and the head motions from ballet. The Blending machine provides a unique possibility for exploration of infinite movements. The model is broken down by body part (e.g., head, shoulders, hands, feet, etc.). Within each body part, a further breakdown can be accomplished. One of the technical issues in this approach is that the model in its current form does not fully take into account the biomechanical limits of the human body. This effectively means that a blending could lead to a sequence of movements that are technically impossible for humans. The tech partners of the projects are currently working to solve this issue. Another interesting feature of the blending machine is that it allows to group and view segments based on the movement qualities/principles that have been assigned to them during annotation. This can be of great assistance to the end users during choreographic composition.

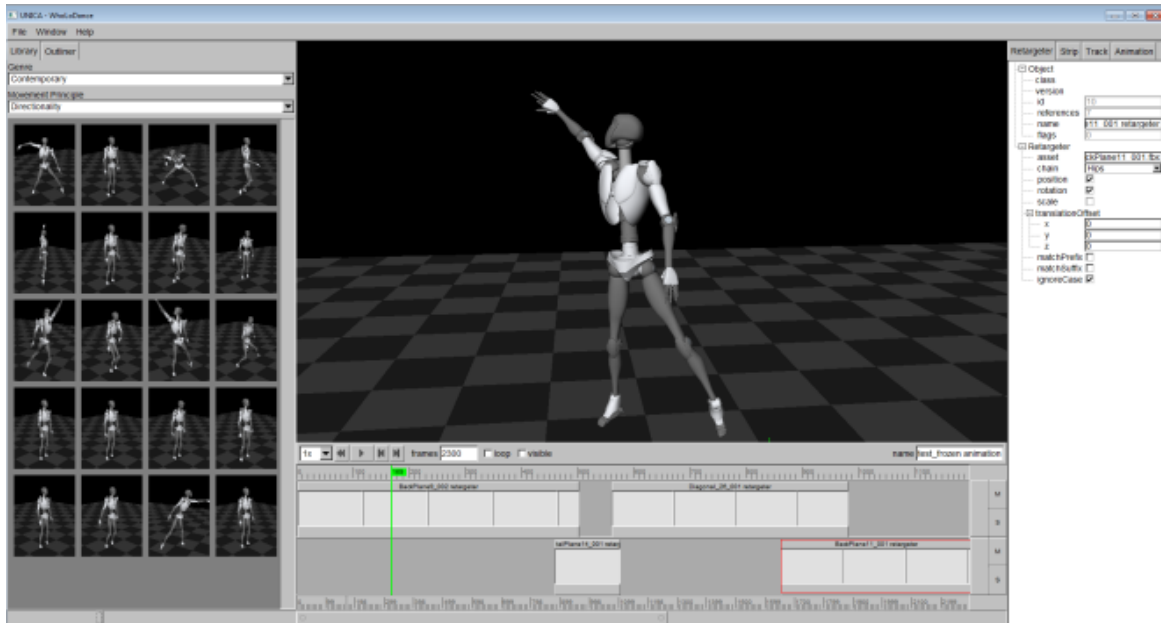


Figure 11. Description of the blending machine interface

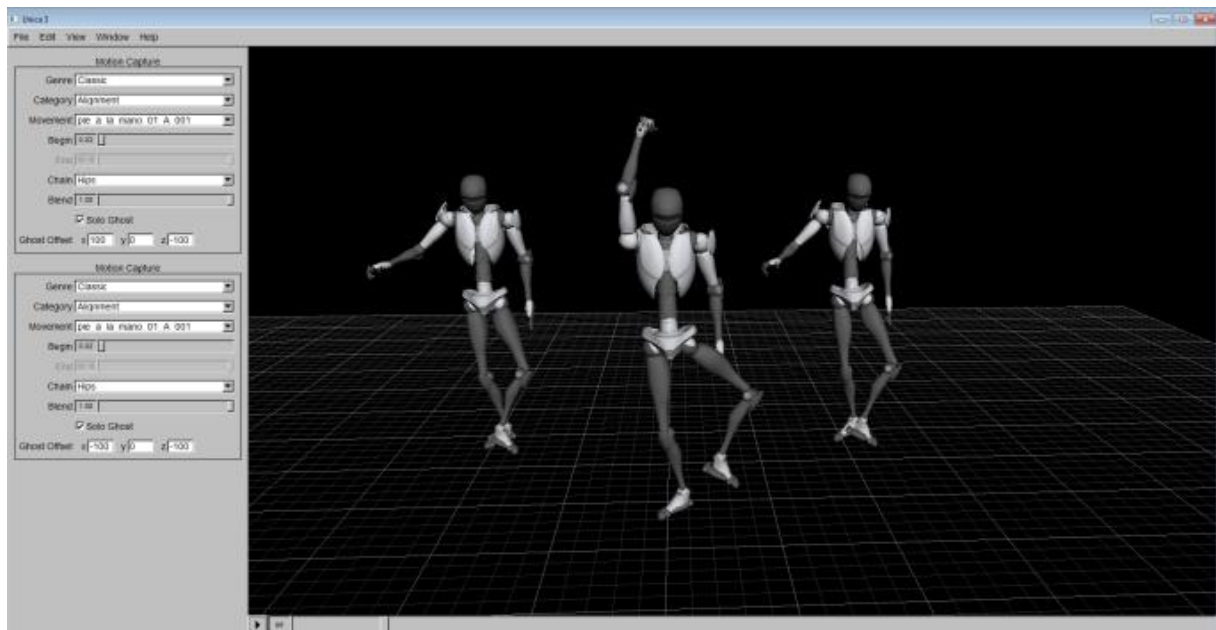


Figure 12. Description of the blending machine viewer interface

Current status of implementation

The functionalities available in the running prototype of the blending machine are briefly presented in Table 3.

Table 3. Functionalities of the blending machine prototype

New	Select this option to start a new blend.
Open	Allows the user to open a previously saved blending session from your hard drive.
Save	Saves user's current blending session to the hard drive. If a file name has not been previously defined, then the user is prompted for a new file name.
Save As	Saves user's current blending session to the hard drive. The user may select a pre-existing file name or create a new name for this session.
Play control properties	This option allows the user to customize his/her configuration to help optimize the blending experience. The users can play forward, backward, pause, jog and shuttle through the timeline.
Viewing area	The Viewing area (located in the left-hand side) is the area where the user can change general UNICA33 display settings.
Viewer Play Controls	The Viewer play controls (located below the Viewing area) allows the user to play, pause or stop a blending loop. This is useful if a single frame is to be focused on during the blending process.
Frame Slider	The Frame Slider (located to the right of the Viewer play controls) shows the frame id currently being viewed in the Viewing area. Frames can be individually selected by simply dragging this slider to the left or right.
Total Frame Count	The Total Frame Count (located to the right of the Frame Slider) shows the total number of frames in this blending sequence. The number shown here will vary depending on the sequence that is being blended.
Browsing Sources	By clicking on any of the " Source List Icons " the users are requesting from the server to add the selected source to the display list. If the user has already a source open (default head source) s/he will see a blend between the default and the new selected source. To view sources without any blending the user should make sure that he/she is viewing one source only. (i.e., remove the default source first.)
Status Bar	The status bar provides process information to the animator. Such items displayed here are: number of frames received from the UNICA3 repository, starting file paths, etc.

Blending Area	How does one make changes to the data in the blending process? This is done using sliders and blend types in the blending area. The user might change the values of each characteristic by clicking or dragging on the associated slider bar. As the user does so, s/he notices that the numerical value to the right adjusts accordingly. The lock checkbox, to the right of the slider and value display, holds the value of the slider. This is useful when the user does not want this value to be modified by any of the other characteristic value changes.
Blending Types	The blending type controls the amount of "leakage" of motion from the active (currently under editing) body part, to the rest of the body. Since all the sources are made from full body motion capture sequences, the amount and the path of the leakage will create different blends. By clicking on the leakage icon of the particular item that the user wants to modify, a pop-up window of leakage blend types appears. Simply click on the desired type to select.

The features to be implemented in the next period are: fast loading, multiple avatars and streaming capabilities.

Installation instructions

The tool comes as a stand-alone application; the user shall just download it and run the executable. A text file is provided to change some basic configurations.

3.2.2 Choreomorphy

Choreomorphy is a whole-body interaction interface (Figure 13) that allows a user to visualize their movement in real time using motion capture technologies. The interface allows a user to change avatars and different visualizations in real time, in order to focus on specific aspects of their movement such as traces, trails, and volumetric space (Figure 14 and Figure 15) and improvise while seeing themselves as different avatars and shapes and interact with virtual objects (Figure 16).

Choreomorphy consists of two versions: the standalone application which has been described above and the web-based that loads pre-recorded motion capture animations from the WhoLoDancE repository. It is planned to be integrated into the WhoLoDancE Movement Library for optimized viewing purposes.

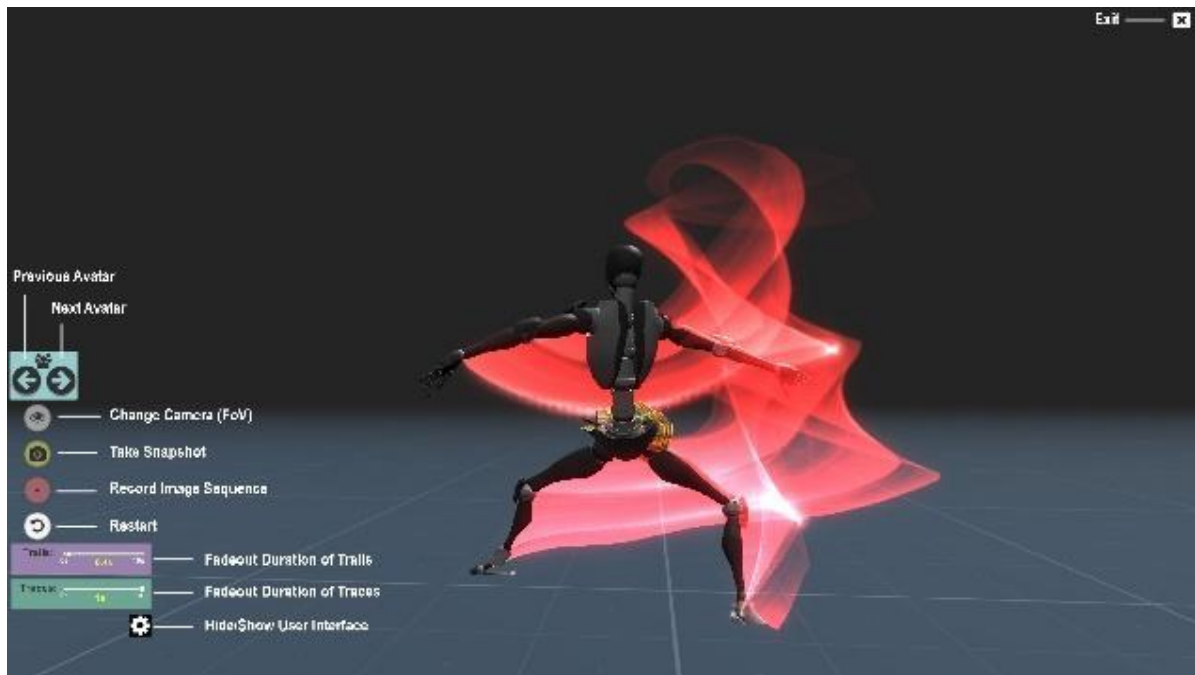


Figure 13. Basic interface

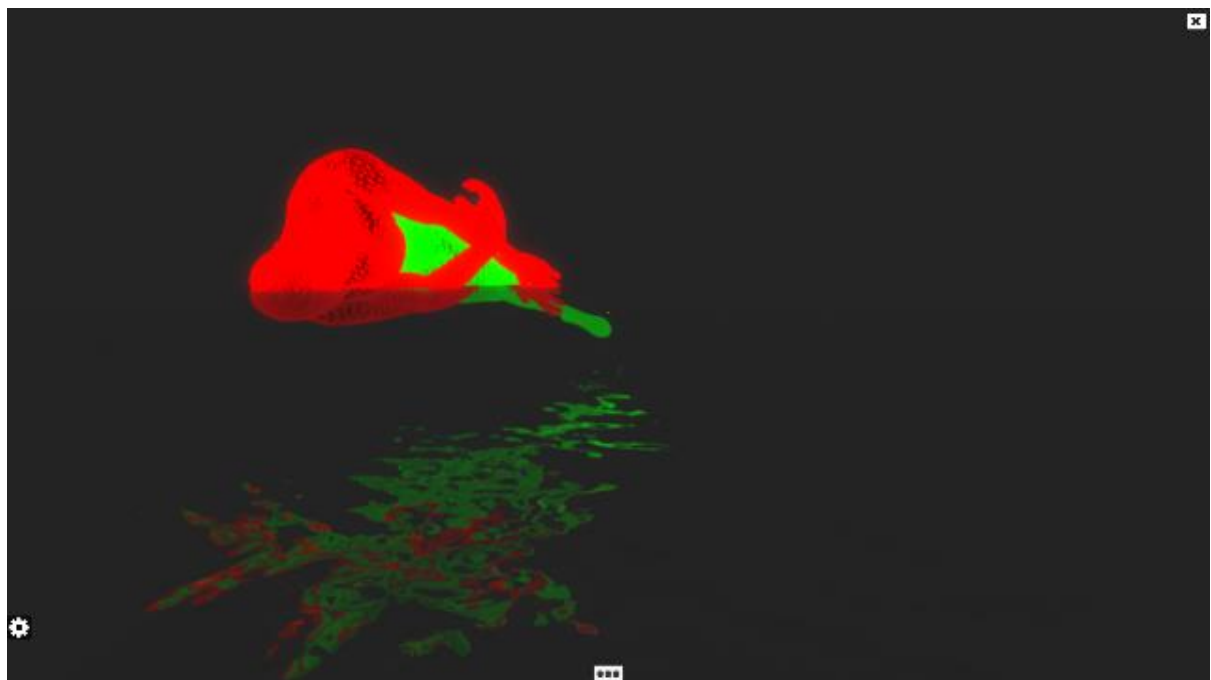


Figure 14. Water scene

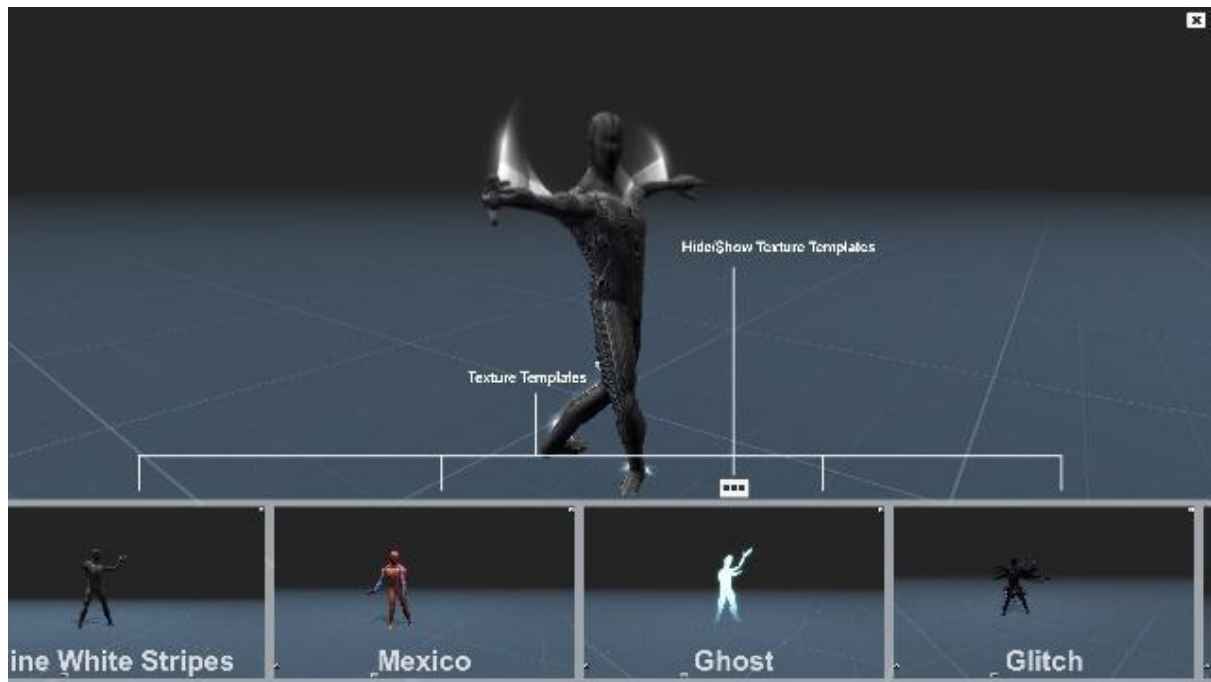


Figure 15. Texture template menu

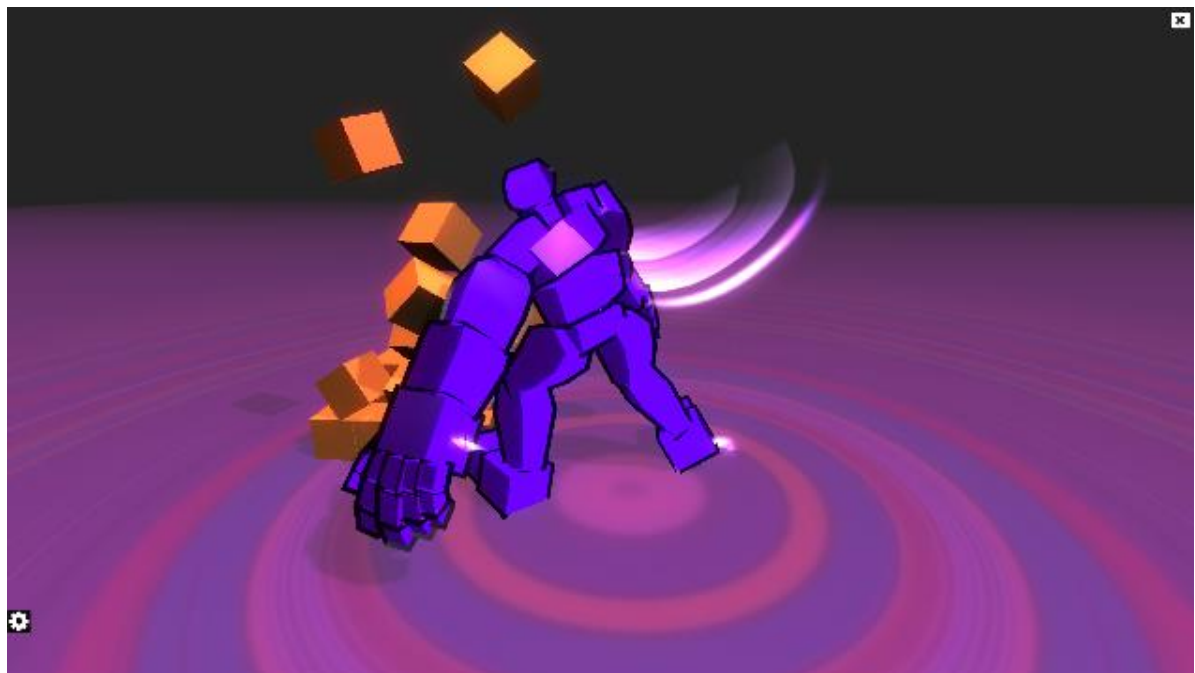


Figure 16. Interaction with virtual objects

Minimum Specs (1080+ p, 60+ fps)

Processor	Dual Core 2.60 GHz (Intel i5 4 th Gen or equivalent AMD)
RAM	500MB
Dedicated GPU	NVIDIA GTX500 or AMD HD6000 series
Hard Drive	250 MB

Current status of implementation

The Choreomorphy completed features include:

- Avatar Library including a variety of 3D models
- Basic Interface for configuring the experience real time
- Camera Library for different views (3rd and 1st person and cinematic)
- Visualization of movement trails
- Visualization of movement traces
- Interaction with virtual objects
- Texture Template Menu
- Scene Library including a variety of 3D environments
- Remote Control
- WebGL

The following features are in progress:

- Pre-recorded animations from repository
- Web-based version and integration to WML
- Work has started for the integration of Choreomorphy into the Unity communication infrastructure delivered by Motek

Currently, Choreomorphy is implemented using the Synertial motion capture system. Thus, to enable the computer to acquire the motion data from the suit, a connection must be established in a LAN. Also, when the suit and the computer are connected, it is essential to use the Synertial Animate software that operates as a bridge between the suit and Choreomorphy for the motion data transfer. The current version of Choreomorphy uses synertial motion capture system, but it can be adaptable to other motion capture systems.

Installation instructions

These instructions take as a given that the Synertial Motion Capture is used for the session.

1. The user wears the Synertial motion capture suit.
2. Connect the suit with the computer through a LAN.
3. Calibrate the suit.
4. Launch Choreomorphy.

The following generic installation instructions apply for any motion capture system:

1. The user wears the motion capture suit.
2. Configure a local connection between the suit and the computer where Choreomorphy will be launched.

3. Calibrate Suit.
4. Launch Choreomorphy

3.2.3 Kinect-based learning tasks

Kinect-based learning tasks are exercises that help users practicing or understanding a dance quality or movement (Figure 18). A Kinect sensor is used to capture the user's motion so that proper feedback can be obtained. According to each task, feedback that helps the user improve themselves is provided.

Through a combination with Choreomorphy the tool can also be used for improvisation and experimentation (Figure 17).

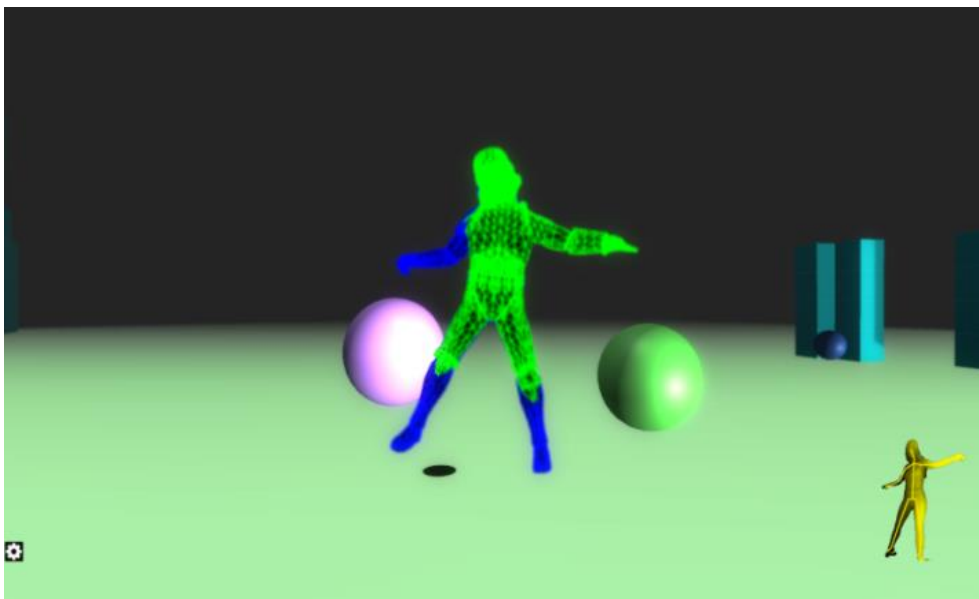


Figure 17. Kinect version of Choreomorphy

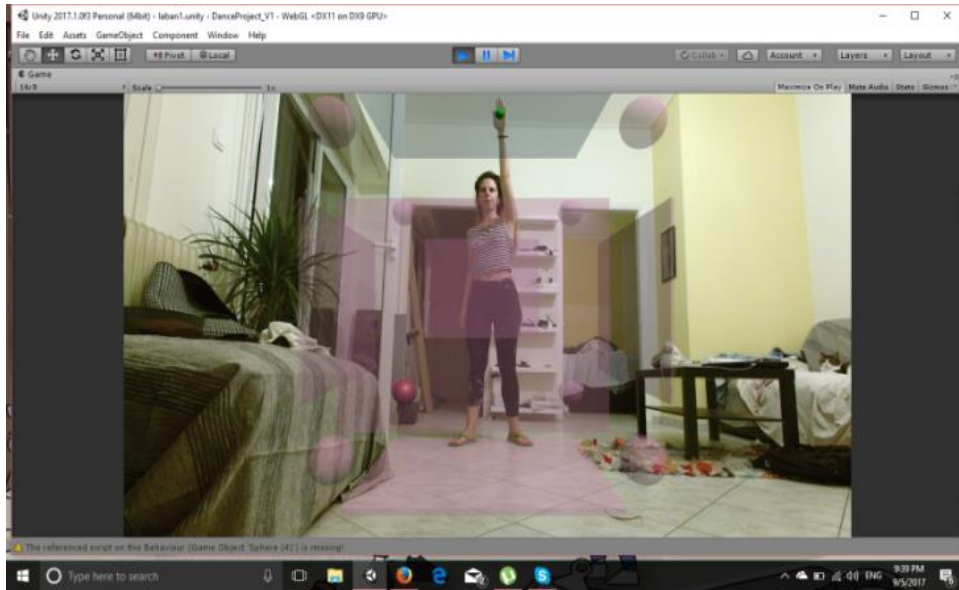


Figure 18. Directionality –cube practice

Current status of implementation

The tool is ready as a Unity based desktop application. It is currently under investigation whether a web-based version of the tool can be provided.

Installation instructions

Not available yet.

3.2.4 Movement Sketching

Movement sketching is a tool that allows dance practitioners, students, and professionals to create their own recordings of dance sequences (by performing them), and query the repository in order to find similar dance segments (Figure 19). This allows the users to compare, correct and integrate their interpretation and the ones of professionals and teachers. It makes use of the similarity search engine provided by Peachnote to query and get recordings that are similar to the ones performed by users.

Users can record movements using low-end motion capture systems (e.g., Notch Sensors) and query the system to get similar movements in terms of movement and movement qualities. The tool is (at the moment) a standalone application that runs on a PC.

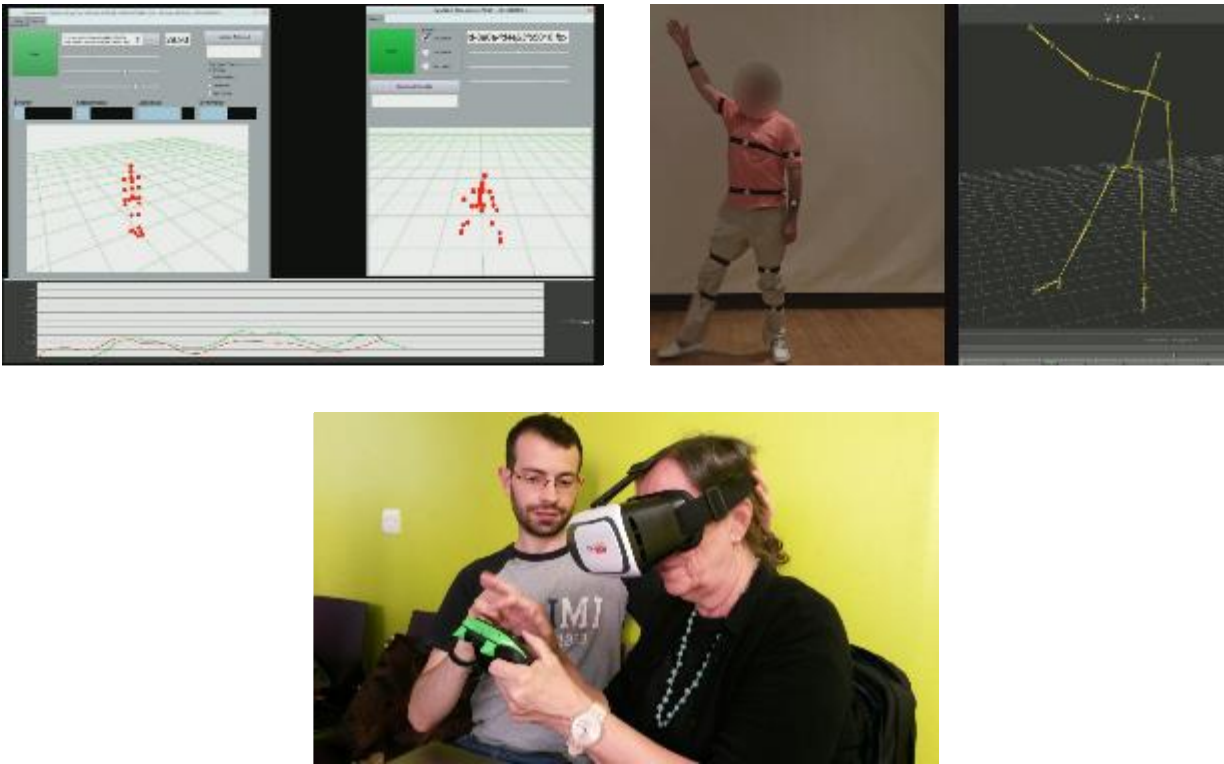


Figure 19. The Movement Sketching tool

Current status of implementation

Completed features:

- first version of the analysis and extraction of features from recorded and live performances
- Similar movements retrieval from repository using similarity Engine
- VR display using google cardboard

Future work:

- Refinements on the extracted features
- More VR displays
- Integration un unity framework

Installation instructions

The installation may require internet connection.

The application depends on EyesWeb XMI, that must be installed on the machine:

- Download and install the main EyesWeb XMI Package from here:
ftp://ftp.infomus.org/Evaluate/EyesWeb/XMI/Nightly/trunk/EyesWeb_XMI_setup_5.7.2.0.exe
- Download and install the EyesWeb XMI python Package from here:
ftp://ftp.infomus.org/Evaluate/EyesWeb/XMI/Nightly/trunk/EyesWeb_XMI_python_setup_5.7.2.0.exe
- Download and install the sketching tool from here:
ftp://ftp.infomus.org/Evaluate/EyesWeb/Projects/WHOLODANCE/Eyesweb_XMI_movement_sketching_setup_5.7.2.0.exe

Dependencies from other tools/systems

Depending on the capture device (i.e., Notches sensors) the system requires the appropriate drivers / applications to be installed on the PC/handled devices.

4 Integrated Vision

4.1 Access through the WhoLoDancE website

Once the tools are completed as a beta or final version, they will be made available through the project website, so that they are presented and framed within the project objectives. Figures 20 and 21 are alternative designs of the tool presentation page.

The main idea is that all tools that are targeted to the end users will have their own description in the web page. At later stages of integration this presentation will be updated accordingly.

Tools that will not be openly accessible will be made available under authorization so that they can be directly accessible for demonstration purposes when needed.

For each tool, whether web-based or desktop, a separate web page will be created that will include the following (not necessarily in this order):

- Introduction to the tool (what it is, what it does)
- A link to the tool (on wholodance.eu or other location)
- Some usage examples with screenshots.
- A video, if available
- Usage manual, if available

In the case of desktop tools, additional information is needed, including:

- Instructions on how to install
- A contact for obtaining a license (if applicable)
- A contact to whom the tool can be asked for, if a download URL is not available

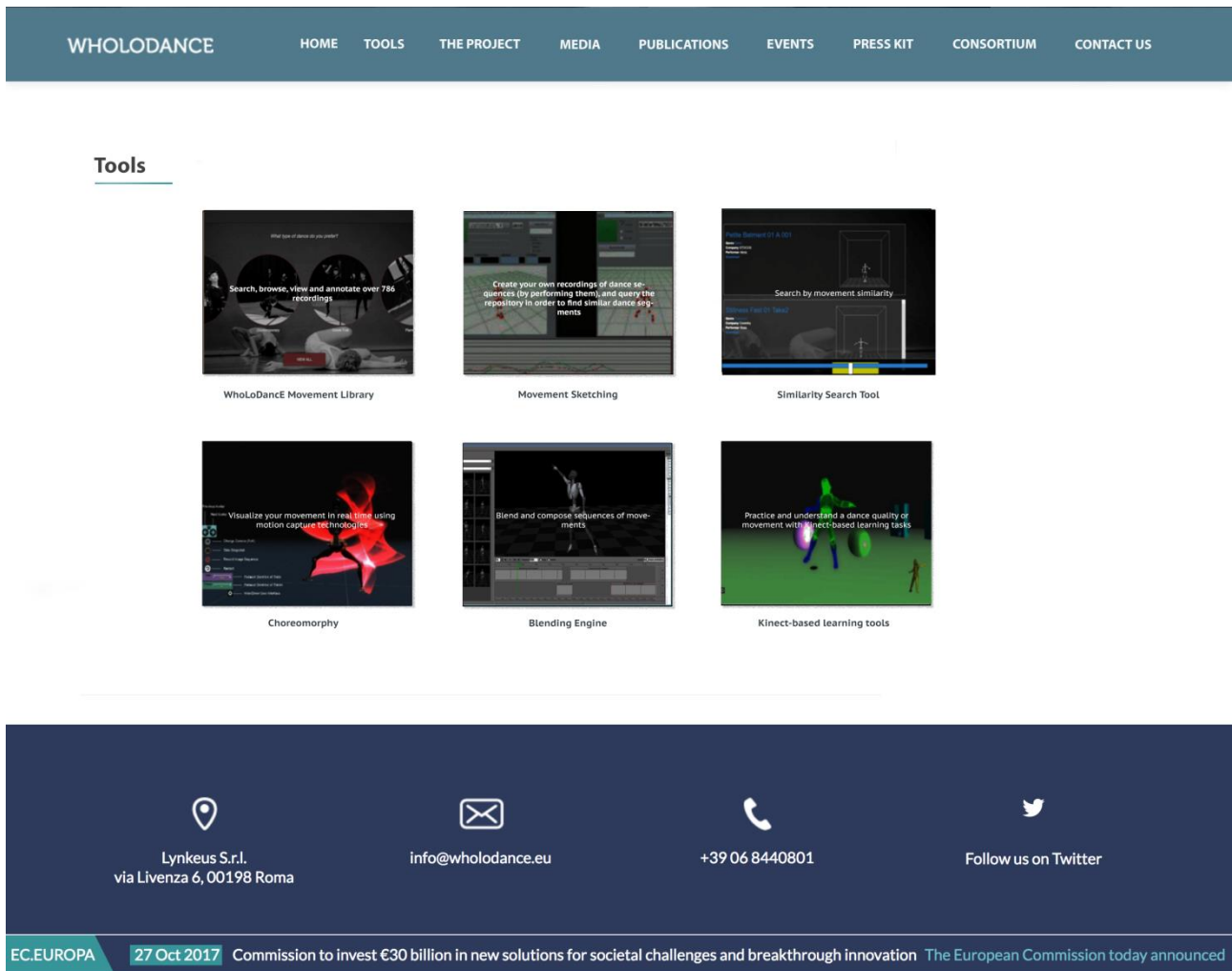


Figure 20. Mock-up for the integrated access to the WhoLoDancE tools in the website



Tools

- WhoLoDance Movement Library**: Search, browse, view and annotate over 786 recordings.
- Kinect-based learning tools**: Practice and understand a dance quality or movement with Kinect-based learning tasks.
- Similarity Search Tool**: Search by movement similarity.
- Choreomorphy**: Visualize your movement in real time using motion capture technologies.
- Movement Sketching**: Create your own knowledge of dance sequences by performing tasks and saving the resulting video to find other dance segments.
- Blending Engine**: Blend and compose sequences of movements.

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Figure 21. Alternative mock-up for the integrated access to the WhoLoDance tools in the website

4.2 Integrated web-based platform

Currently the WML front-end and the web-based Choreomorphy version have been integrated in the platform (Figure 22).

In the following period of the project, we are planning to integrate the available web-based tools into one platform for accessing the movement recordings, browse them by dance genres and other metadata, annotate, search among them in different ways (key words and tags, semantic search, similarity search and movement sketching) and visualize them using the web-based version of Choreomorphy for standard pc or laptop.



Figure 22. Integrated view of WhoLoDancE web based tools