



PROJECT PERIODIC REPORT

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¹ The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

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1. PUBLISHABLE SUMMARY

The MIROR (Musical Interaction Relying On Reflexion) project is co-funded by the European Commission under the 7th Framework Programme, Theme ICT-2009.4.2, Technology-enhanced learning. MIROR is a three-years project and started on September 1st, 2010. All information regarding MIROR is available through the MIROR Portal at <http://www.mirrorproject.eu>.

1.1. Concept

The MIROR Project deals with the development of an adaptive system for music learning and teaching based on the “reflexive interaction” paradigm. The system is developed in the context of early childhood music education. It acts as an advanced cognitive tutor, designed to promote specific cognitive abilities in the field of music improvisation, both in formal learning contexts (kindergartens, primary schools, music schools) and informal ones (at home, kinder centres, etc.). The reflexive interaction paradigm is based on the idea of letting users manipulate virtual copies of themselves, through specifically designed machine-learning software referred to as Interactive Reflexive Musical Systems (IRMS). By definition IRMS are able to learn and configure themselves according to their understanding of learner's behavior. In MIROR the IRMS paradigm is extended with the analysis and synthesis of multisensory expressive gesture to increase its impact on the musical pedagogy of young children, by developing new multimodal interfaces. The project is based on a spiral design approach involving coupled interactions between technical and psycho-pedagogical partners. MIROR integrates both psychological case-study experiments, aiming to investigate cognitive hypotheses concerning the mirroring behaviour and the learning efficacy of the platform, and validation studies aiming at developing the software in concrete educational settings. The project contributes to promoting the reflexive interaction paradigm not only in the field of music learning, but more generally as a new paradigm for establishing a synergy between learning and cognition in the context of child/machine interaction.

1.2. Objectives

The MIROR project aims primarily at developing the potential of IRMS for the benefit of *music education*. More precisely, MIROR's primary goal is to develop an adaptive and intuitive system for music education, based on the reflexive interaction paradigm. This includes:

The design and implementation of a platform, the **MIROR platform**, including the core technological modules needed to implement the reflexive interaction paradigm (e.g. modules for analysing the musical behaviour of learners, modules for analysing expressive full-body movement and gestures, modules for session and interaction management, and so on).

The design and implementation of three **MIROR prototypes** (Fig. 1), grounded on the MIROR platform, addressing different aspects of music education and exploiting different qualities of the reflexive interaction paradigm:

The **MIROR-Improvisation prototype** (MIROR-Impro), addressing music improvisation

The **MIROR-Composition prototype** (MIROR-Compo), addressing music composition

The **MIROR-Body Gesture prototype** (MIROR-Body Gesture), exploring how full-body movement and gesture can enhance music learning.

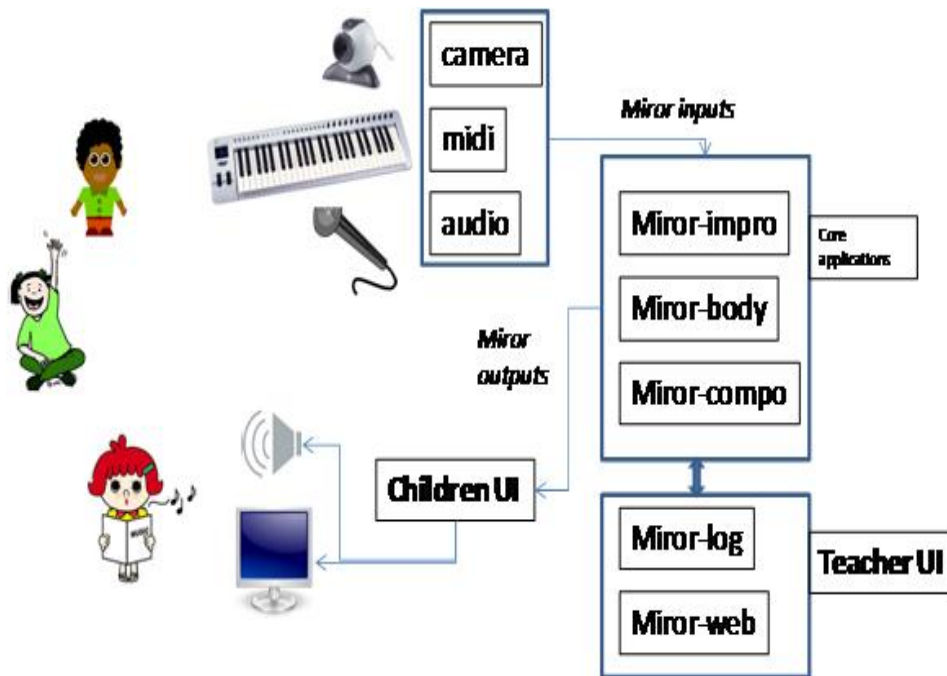


Fig. 1 – Overall architecture of the MIROR Platform

The **validation** of concrete pedagogical scenarios in which IRMS organise and stimulate the learning/teaching processes in the domains of music improvisation, composition, and body performance; the validation of the MIROR platform and prototypes in such scenarios.

The development of a detailed analysis aiming at assessing the impact of the reflexive interaction paradigm for both music learning and cognitive processes. The **theoretical framework of the reflexive interaction** will be investigated and implemented on the basis of the experimental results and on specific studies addressing the pedagogy of reflexive interaction.

The promotion of an **active approach to musical culture**, based on "music making" rather than on "music consuming". The promotion of the social-cultural perspective of music education and creativity, integrating embodiment to technology-enhanced learning.

1.3. Consortium

Alma Mater Studiorum - Università di Bologna (UNIBO), Italy – Coordinator.

Sony Europe Limited acting through Sony France Computer Science Laboratory (SONY FRANCE), France.

Università degli Studi di Genova (UNIGE), Italy.

Goeteborgs Universitet (UGOT), Sweden.

National and Kapodistrian University of Athens (NKUA), Greece.

1.4. Work performed and major results achieved so far

1.4.1 The First Year of the Project

The first year of the project was mainly devoted to the integration of background knowledge from partners, to the definition of the requirements for the MIROR platform and prototypes, and for their interfaces, to the development of the initial version of the MIROR platform and prototypes, to the performance of a first series of experiments in concrete pedagogical scenarios. Early results include the following:

- UNIBO, UGOT, NKUA, and UNEXE (psycho-pedagogical partners) investigated several **theoretical aspects** dealing with IRMS, both in the context of music education and cognitive sciences of music, and in the more general field of learning in an interactive scenario. A review of relevant literature was carried out and the theoretical background concerning the cognitive and creative processes, which are implicated in IRMS, was discussed. In particular the following topics were considered: the mirroring interaction; the theory of Flow in reflexive scenarios; the cognitive processes of music improvisation in children; the learning/teaching processes in reflexive and interactive scenario; music therapy and community music settings.

- The **initial version of the MIROR platform** was developed to provide the Consortium with running prototypes as soon as possible. SONY FRANCE and UNIGE (technological partners) carried out this work in close loop with the psycho-pedagogical partners who provided feedback on the outputs needed for the experiments, manipulation of musical parameters involved (rhythm, dynamics, texture, etc.), and development of specific settings, and with COMPEDIA who also provided feedback on exploitation issues. The following major results were achieved:

- New algorithmic solutions such as the novel musical sequence generation algorithm with constraint satisfaction scheme (SONY FRANCE) and the techniques for extraction and processing of movement and gesture features (UNIGE) were developed, successively tested, and integrated into the prototypes.
- Several core technological modules such as session management, session visualisation, music score display, and export functionalities were developed and integrated.
- Future integration abilities were addressed in particular by developing various independent software libraries, which will be used in MIROR prototypes through evolving but clearly defined APIs (Application Programming Interface).
- Hardware needs and compatibilities were studied and hardware selection was made.
- Tools for connecting the MIROR prototypes were investigated and an initial proof-of-concept of such a connection to generate musical outputs by gesture analysed in real time was developed and tested.

- The **initial versions of the three MIROR prototypes** were developed (SONY FRANCE and UNIGE) and provided to the psycho-pedagogical partners for early feedback. In particular:

- SONY FRANCE developed the initial MIROR-Impro prototype. Its focus is the basic musical level (notes, clusters, and sequences thereof). Since the early stages of the project eleven different versions were delivered to the consortium, and many new features, bug fixes, and comments, in particular concerning the user interface, were progressively integrated, including a session management tool to record, save, retrieve, and visualise the musical information exchanged during each session in an easy way.
- SONY FRANCE developed the initial MIROR-Compo prototype. MIROR-Compo grounds on MIROR-Impro and aims at teaching children how to reflect on a larger scale than the basic musical level.
- UNIGE developed the initial version of the MIROR-Body Gesture prototype. This prototype mainly enables children to perform exploration of sound and of musical concepts by means of their body movements and gestures. The framework integrates customisable exercises, with different levels of complexity, spanning over different dimensions of sound and over different music concepts.
- SONY FRANCE and UNIGE developed the initial versions of the interfaces for the MIROR prototypes, with particular reference to the MIROR-Impro prototype (Fig. 2). Following the feedback by the Consortium, COMPEDIA developed a mock-up for an improved version of the teacher interface for the MIROR-Impro prototype (Fig. 3).

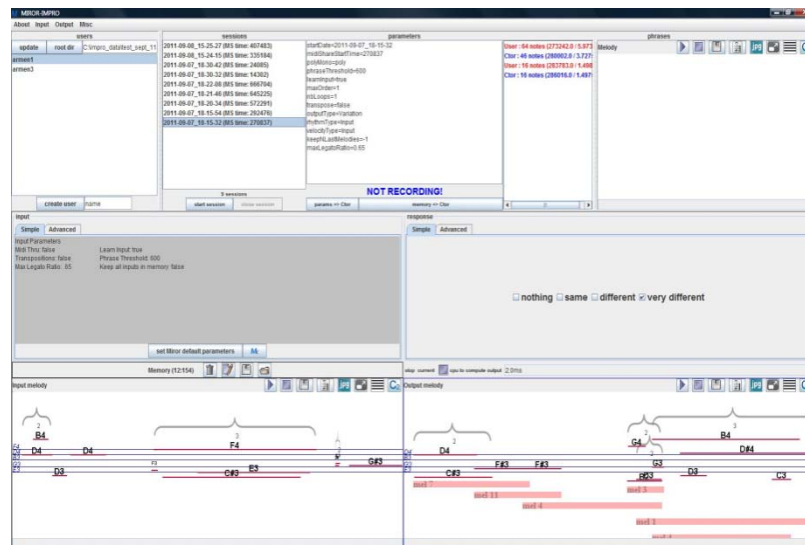


Fig. 2 - Initial version of the MIROR-Impro interface

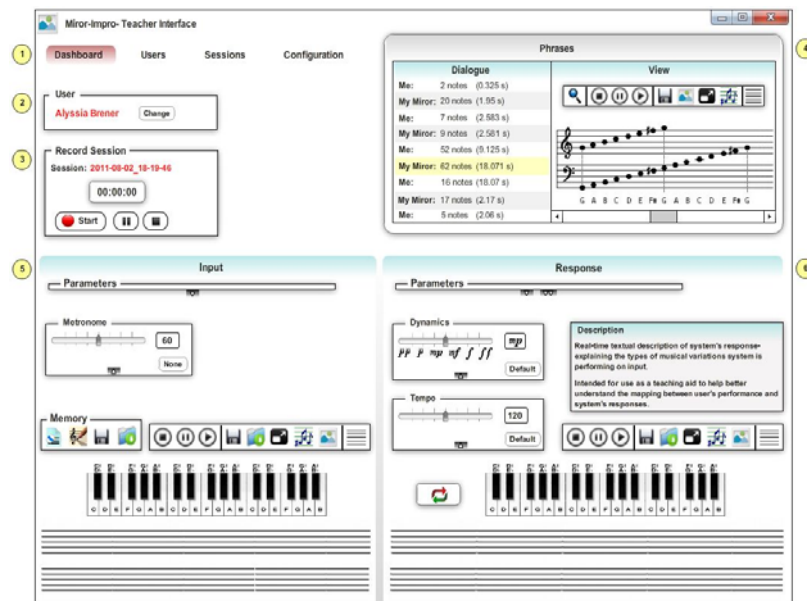


Fig. 3– MIROR-Impro Sample of the new suggested UI design

- **Experiments with children:** UNIBO, UNEXE, UGOT, and NKUA prepared and carried out experiments with children and the MIROR-Impro prototype. From September 2010 to April 2011 the psycho-pedagogical partners planned, in strict collaboration with the other Partners SONY FRANCE, UNIGE, and COMPEDIA, two protocols and several exploratory studies to be carried out with children in kindergarten and primary schools. In April-August 2011 the experiments and further minor exploratory studies were performed in Athens (NKUA), Bologna (UNIBO), Gothenburg (UGOT), and Birmingham (UNEXE). Almost 100 children were involved in the experiments. Initial considerations can be made as follows:

- The collected archives represent a rich data collection.
- The results obtained so far show that the MIROR-Impro prototype works and can have a positive effect on the level of Flow of the child while improvising, providing a reach interaction context.
- The results indicate several suggestions in order to further improve the system, the interface, the equipment and the setting, and suggest new experimental hypotheses to be tested.
- The results suggest new interesting experimental ideas to be implemented with the next versions of MIROR-Impro and with the recent MIROR-Compo prototype.
- The results raise interesting theoretical aspects concerning perceptual and cognitive issues on the reflexive scenario with young children, music perception and music analysis, music therapy, and different socio-pedagogical contexts.
- An overview of the data and results partners collected underlines how carrying out different protocols in a range of contexts is positive and enriching for the project.
- During months 9-12, starting from the results of the experiments carried out with MIROR-Impro and analysing the literature about composition with children, the Consortium started the preparation of the experiments with MIROR-Compo and MIROR-Body Gesture that were delivered at the end of August 2011. Experiments will be carried out in Year 2.
- The Consortium organised **two workshops** (Paris, November 2010; Gothenburg, March 2011) to work on experimental designs, requirements of the platform and

prototypes, hardware and technical equipment. The goal was to transfer the results of user testing to the prototype implementation and vice versa.

- The **MIROR website** has been delivered on Month 3 (UNIBO) (www.mirrorproject.eu).

- The **logo of the project** was created by UNIBO on the basis of a writing made by a child of 5 years old who was asked to write the word MIROR on a yellow and a red line (as from the medieval musical score). In spontaneous way, the child wrote the last letter "R" in reverse, and giving the idea of mirroring effect and of the reflexive paradigm.



- **Secured video sharing service** was enabled by COMPEDIA and is used for both sharing videos and comments among researchers. It also includes a sub-set of approved videos for demonstration and exploitation purposes.

- The project was **disseminated** to the scientific community through presentations at conferences. Initial results of research were published or submitted for publication. A special issue of the journal *Musicae Scientiae* on MIROR topics is planned for publication at the end of the project.

1.4.2 The Second Year of the Project

The second year of the project was mainly devoted to a deeper definition of the theoretical framework of the reflexive interaction paradigm in the field of childhood technology-enhanced learning, to the performance of experiments with particular attention to the children and teacher interaction with the platform in concrete pedagogical scenarios, to the methodological implementation of quantitative and qualitative research supported by a "mixed method" approach, to the refinement of the requirements for the MIROR platform and prototypes and for their interfaces, to the implementation of the spiral process of specification leading to the development of the second version of the MIROR platform and prototypes. The second year was mostly devoted to the implementation of MIROR-Compo and MIROR-Body Gesture , and to the integration of the three MIROR components. Exploratory studies on composition and embodiment were realised with MIROR-Compo and MIROR-Body Gesture. Finally, the Consortium designed and implemented studies addressing usability and user experience aspects with the MIROR platform and related components (Impro, Compo, and Body Gesture) to be carried out in the 3rd year of Project. The initial step for market analysis was implemented and a Survey has been launched aiming at identifying and evaluating the demand for the MIROR platform among different segments and users. Results include the following:

- **The theoretical framework of reflexive interaction paradigm** has been deeper defined. In particular the theoretical framework focuses on reflexive interaction, including also children developmental models in improvisation, composition, and body gesture. The theoretical

framework of the reflexive interaction paradigm has been developed from a systematic perspective. It starts from the theoretical and technical background of the IRMS and follows with an attempt to explain the human behaviours involved in the reflexive interaction, starting from the behaviours observed in children interacting with the Continuator, the first prototype of IRMS. These highlighted elements have been proposed to support the fundamental hypothesis of the MIROR Project, that reflexive interaction enhances teaching/learning processes and musical creativity, placing the theoretical basis for a pedagogy of reflexive interaction and for exploiting IRMS in the field of technology-enhanced learning and therapeutic/rehabilitative actions. Starting from IRMS and the experience with children, some fundamental requirements have been identified in order to implement new interactive reflexive musical systems. The background on children's improvisation, composition, and dance education is considered, and related to the reflexive interaction.

- **Performance of experiments** with particular attention to children and teacher interaction with the platform in concrete pedagogical scenarios and methodological implementation of quantitative and qualitative research supported by a “mixed method” approach. Several exploratory and experimental studies have been carried out by UNIBO, NKUA, UGOT and UNEXE with MIROR-Impro, MIROR-Compo, and MIROR Body Gesture prototypes. Results with MIROR-Impro support the hypotheses that reflexive interaction and MIROR-Impro enhance children's Flow emotional state, several kinds of listening conducts and behaviours enhancing music learning and creativity. The results indicate that children's ability to improvise in dialogue with a computer is dependent on their previous experience and cultural tools already appropriated through participation in other musical settings. Computational music analysis showed repeated patterns that children use when they play the keyboard and that seem indicative of specific gestures that children use when they play. Three levels of interaction with MIROR-Impro were observed and difference between girl/boys and 4-and 8 years old were observed as well. The experiments with MIROR-Compo raised interesting reflections about children music composition and suggest that the system acts as a “musical scaffolding” (the “actions” system) that allows children to develop the ability to create new ways to combine the actions each other, i.e. to “compose” music. The results of the studies in therapeutic settings showed that there is a clear enjoyment of the sessions with the system, proving that this is an appropriate and fun tool to use for therapeutic purposes. The experiments with MIROR-Body Gesture drafted the methodological process of designing MIROR-Body Gesture, focusing on the new issue of reflexive interaction in the body gesture system, designed the pedagogical framework of MIROR-Body Gesture, collected several pedagogical scenarios, and deeply analysed the Laban' Effort Weight boundaries (heavy/light) in children movement and music performance. Researchers had the occasion to share ideas and pedagogical issues with the teachers of the primary and kindergarten schools about the ecological setting for the experiments and the activities of training teachers.

- **Refinement of the requirements and implementation of the spiral process of specification** for the MIROR platform and related components, and for their interfaces. During project year 2 two workshops have been carried out. Different psychological tests among the psycho-pedagogical-partners have contributed to the development of new and improved versions of the MIROR platform by SONY and UNIGE. The spiral process between user testing and MIROR prototypes design and implementation has transferred the results of user testing to prototype implementation. Psycho-pedagogical partners provided feedback to technological partners, including lists of recommendations.

- **MIROR Libraries:** The second year was mostly devoted to the implementation of MIROR-Compo and MIROR-Body Gesture, and to the integration of the three MIROR components. This includes the development of the final version of the core technological modules on which the MIROR prototypes are grounded on and of the support modules for connecting the MIROR Prototypes between them. SONY and UNIGE conducted this work in close loop with psycho-pedagogical partners who provided feedback on the types of system output needed for the experiments, manipulation of musical parameters involved (rhythm, dynamics, texture, etc.), and development of specific settings, and with COMPEDIA who also provided feedback on exploitation issues. The following major objectives were achieved:

- Algorithmic solutions such as the novel musical sequence generation algorithm with constraint satisfaction scheme (SONY) were improved and adapted to the context of MIROR-Compo prototype
- New and extended techniques for analysis of expressive qualities of movement and gesture (UNIGE): in particular, the framework of Laban's Theory of Effort was addressed (Space, Time, and Weight) and machine-learning techniques were developed for analysis of Laban's quality on a selected gesture vocabulary. Recognition is grounded on techniques for extracting 3D features from movement trajectories provided by the Kinect sensor. Features developed in MIROR and added to the EyesWeb XMI libraries include, for example, 3D curvature and sphericity.
- Various core technological modules such as session management, session visualisation, music score display, tagging and export functionalities were extended and adapted to MIROR-Compo prototype
- Integration of MIROR-Impro and MIROR-Body Gesture prototypes has been further investigated.

- **MIROR prototypes** (Impro, Compo, and Body Gesture) Major achievements in the reporting period are summarised as follows:

- Developed the final MIROR-Impro prototype (SONY FRANCE). Intensive specification and development was conducted during year 2 (10 versions along Year 2). The prototype was evaluated with experiments;
- Developed the final MIROR-Compo prototype (SONY FRANCE). Intensive specification and development was conducted during year 2 (10 versions along Year 2). The prototype was evaluated with experiments;
- Developed the second version of the MIROR-Body Gesture prototype (UNIGE). Intensive specification and development was carried out during year 2. The prototype is being evaluated with experiments.

- The Consortium planned **studies addressing usability and user-experience** to be carried out in the 3rd year of Project with the MIROR platform and related components (Impro, Compo, and Body Gesture), that is, studies that address the particular relationships of the child with technology on the one hand, and the experience of the child on the other hand. The results of these studies should lead to a clear and explicit list of recommendations that

are useful for further technological development. Further validations of the interfaces are being discussed (video observation, experience with small group of teachers).

- **The initial step of market analysis** was implemented and a Survey has been launched by Compedia in collaboration with the other Partners aiming at identifying and evaluating the demand for the MIROR platform among different segments and users.

- **Dissemination of results:** This includes (i) update of the project website, (ii) giving the project visibility with respect to the scientific community, the stakeholders, and the general public, (iii) publishing results from the project, (iv), creation of the MIROR newsletter.

1.5. Expected final results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far)

The expected final results of the project are a fully functional MIROR platform and prototypes, assessed with experiments with children and grounded on solid theoretical bases. Impact is expected on education and learning, starting from music education, but possibly extending to other fields. Moreover, MIROR aims to:

- Develop a detailed analysis aiming at assessing the impact of the reflexive interaction paradigm for both music learning and general cognitive/learning processes.
- Promote an active approach to musical culture, based on "music-making" concept, rather than "music-consuming"; promoting the use of the MIROR platform in children and adults, enabling a wider access to music by experts as well as non experts, and enhancing the diffusion of music culture in EU society through experiments with the MIROR platform in several European countries, producing an User Guide and a Teachers' Guide.

1.6. The address of the project public website

Relevant information and updates about the MIROR activity can be found at the project URL: www.mirrorproject.eu