Interactive Multimedia Systems for Technology-Enhanced Learning and Preservation

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Abstract

Interactive multimedia and human-computer interaction technologies are effecting and contributing towards a wide range of developments in all subject areas including contemporary performing arts. These include augmented instruments for interactive music performance, installation arts and technology-enhanced learning. Consequently, the preservation of interactive multimedia systems and performances is becoming important to ensure future re-performances as well as preserving the artistic style and heritage of the art form. This paper presents two interactive multimedia projects for technology-enhanced learning, and discusses their preservation issues with an approach that is currently being developed by the CASPAR EC IST project.

Keywords: Interactive Multimedia Performance, Technology-enhanced learning, Motion capture, sensor, multimodal, Digital Preservation, Ontologies.

1. Introduction

Interactive multimedia technologies and all forms of digital media are popularly used in contemporary performing arts, including musical compositions, installation arts, dance, etc. Typically, an Interactive Multimedia Performance (IMP) involves one or more performers who interact with a computer based multimedia system making use of multimedia content. This content may be prepared and generated in real-time and may include music, manipulated sound, animation, video, graphics, etc. The interactions between the performer(s) and the multimedia system can be done in a wide range of different approaches, such as body motions [1, 2], movements of traditional musical instruments, sounds generated by these instruments [3, 4] , tension of body muscle using bio-feedback [5], heart beats, sensors systems, and many others. These "signals" from performers are captured and processed by multimedia systems. Depending on specific performances, the "signals" will be mapped to multimedia content for generation using a mapping strategy (see Figure 1).

An example of an IMP process is the one adopted in the MvM (Music via Motion) interactive performance system, which produces music by capturing user motions [1, 6].

Interactive multimedia systems have been applied in a wide range of applications in this context. This paper presents two interactive multimedia systems that are designed for technology-enhanced learning for music performance (one for string instruments playing and one for conducting) and interactive multimedia performance, and consider their preservation issues and complexity.

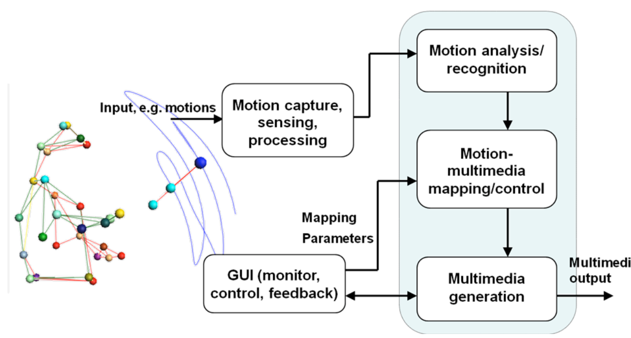

Figure 1: Interactive Multimedia Performance process

Generally, manipulating/recording multimedia content using computers is an essential part of a live interactive performance. Using simply performance outputs recorded in the form of audio and video media will not be sufficient for a proper analysis (e.g. for studying the effect of a particular performing gesture on the overall quality of the performance) or reconstruction of a performance at a later time. In this context, traditional music notation as an abstract representation of a performance is also not sufficient to store all the information and data required to reconstruct the performance. Therefore, in order to keep a performance alive through time, not only its output, but also the whole production process to create the output needs to be preserved.

The remaining paper is organized as follows. Section 2 presents two Interactive Multimedia Performance Systems that need to be preserved. Section 3 introduces the conceptual model of the CASPAR project and the tools that are used for the preservation of the IMP systems. Finally the paper is concluded in section 4 and the next steps of future work are outlined.

2. Interactive Multimedia Performance Systems (IMP)

2.1. 3D Augmented Mirror (AMIR)

The 3D Augmented Mirror (AMIR) [7, 8, 9] is an IMP system being developed in the context of the i-Maestro (www.i-maestro.org) project, for the analysis of gesture and posture in string practice training. String players often use mirrors to observe themselves practicing. More recently, video has also been used. However, this is generally not effective due to the inherent limitations of 2D perspective views of the media.

Playing an instrument is physical and requires careful coaching and training on the way a player positions himself/herself with the aim to provide the best/effective output with economical input, i.e. least physical effort. In many ways, this can be studied with respect to sport sciences to enhance performance and to reduce self inflicted injuries.

With the use of 3D Motion Capture technology, it is possible to enhance this practice by online and offline visualising of the instrument and the performer in a 3D environment together with precise and accurate motion analysis to offer a more informed environment to the user for further self-awareness, and computer assisted monitoring and analysis.

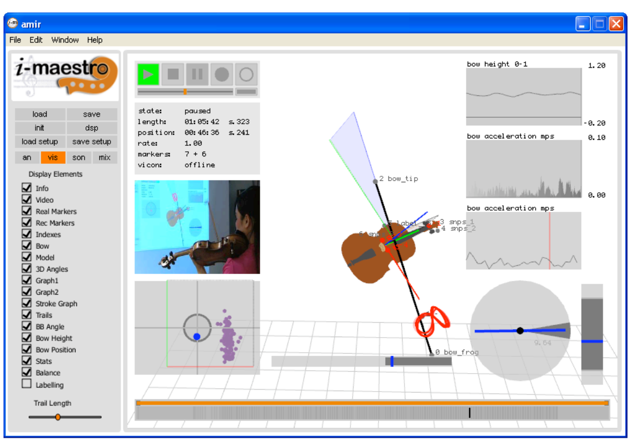

Figure 2: Graphical Interface of the 3D Augmented Mirror System

The 3D Augmented Mirror is designed to support the teaching and learning of bowing technique, by providing multimodal feedback based on real-time analysis of 3D motion capture data. Figure 2 shows a screenshot of the 3D Augmented Mirror interface, including synchronized video and motion capture data with 3D bowing trajectories.

When practicing using AMIR, a student can view the posture and gesture sequences (3D rendering of the recorded motion data) as prepared by the teacher, selecting viewpoints and studying the recording without the limitations of a normal 2D video. A student can also make use of the system to capture and study their own posture and gesture, or to compare them with some selected models.

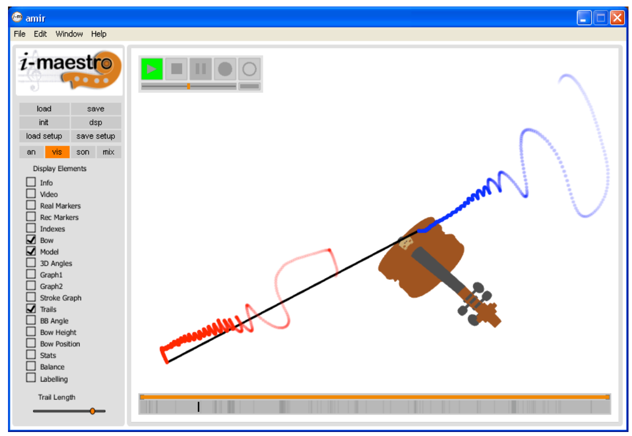

Figure 3: Gesture *signature* - tracing gesture for the analysis of composition.

It has been found that the AMIR multimodal recording which includes 3D motion data, audio, video and other optional sensor data (e.g. balance, etc) can be very useful to provide in-depth information beyond the classical audio visual recording for musicological analysis (see Figure 3). Preservation of the IMP system is of great importance in order to allow future re-performance. The multimodal recoding offers an additional level of detail for the preservation of musical gesture and performance that can be vital for the musicologist of the future. These contributions have resulted in our motivation for the preservation of the AMIR multimodal recordings.

2.2. ICSRiM Conducting Interface

The ICSRiM Conducting System is another IMP system developed for the tracking and analysis of a conductor's hand movements [10, 11]. Its aim is to help students learning and practicing conducting.

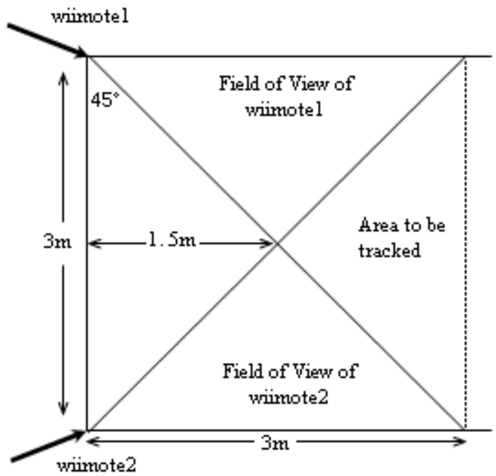

Figure 4: Wii-based 3D capture setup.

A portable motion capture system composed by multiple Nintendo Wiimotes is used to capture the conductor's gesture. The Nintendo Wiimote has several advantages as it combines both optical and sensor based motion tracking capabilities, it is portable, affordable and easily attainable. The captured data are analyzed and presented to the user in an entertaining as well as pedagogically informed manner highlighting important factors and offer helpful and informative monitoring for raising self awareness that can be used during a lesson or for self-practice. Figure 5 shows a screenshot of the Conducting System Interface with one of the four main visualization mode.

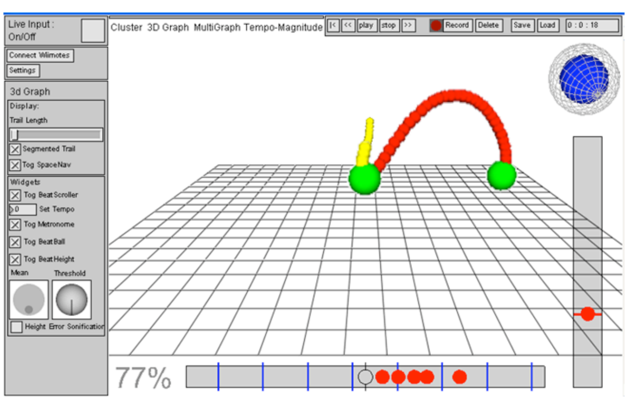

Figure 5: Graphical Interface of the ICSRiM Conducting System.

3. Preservation

Preserving the whole production process of an IMP is a challenging issue. In addition to the output multimedia contents, related digital contents such as mapping strategies, processing software and intermediate data created during the production process (e.g. data translated from "signals" captured) have to be preserved, together with all the configuration, setting of the software, changes (and time), etc. The most challenging problem is to preserve the knowledge about the logical and temporal relationships among individual components so that they can be properly assembled into a performance during the reconstruction process.

Another important aspect that needs to be preserved is also the comments and feedbacks that are generated from the users or performer during the production of an IMP and regard the quality of the performance and the used techniques. In the context of the CASPAR project, we have adopted an ontology-driven approach [13-15] that reuses and extends existing standards, such as the CIDOC Conceptual Reference Model (CIDOC-CRM) [16, 17] for the efficient preservation of an IMP.

3.1. Conceptual Model of CASPAR Preservation

The CASPAR framework is based on the full use of the OAIS (Open Archival Information System) Reference Model [18], which is an ISO standard. The OAIS conceptual model is shown in Figure 6. The Conceptual Model aims to provide an overall view of the way in which the project sees preservation working. Also the conceptual model helps to highlight the areas which can help to the formation of an interoperable and applicable structure that can support effectively the digital preservation across the different CASPAR domains.

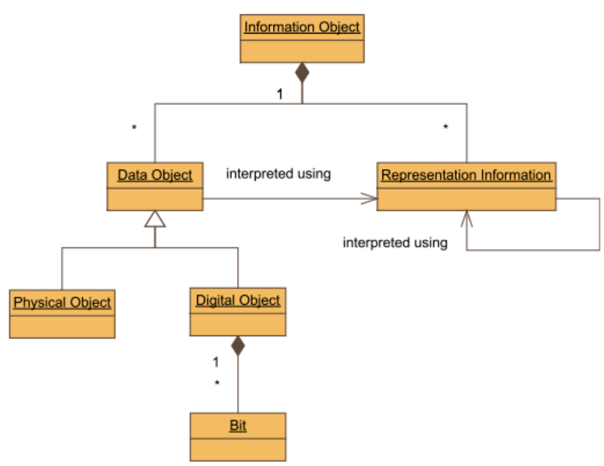

Figure 6: Basic concepts of OAIS Reference Model - Information Object [18]

The very basic concept defined in the OAIS Reference Model is Information Object. As illustrated in the UML diagram of Figure 6, an Information Object is composed of a Data Object and one or more layers of Representation Information. A Data Object can be a Physical Object (e.g. a painting) or a Digital Object (e.g. a JPEG image). Representation Information provides the necessary details for the interpretation of the bits contained within the digital object into meaningful information. For digital objects, representation information can be documentation about data formats and structures, the relationships amongst different data components. Representation information can also be software applications that are used to render or read the digital objects.

In addition, the Representation needs to be connected with the Knowledge base of the designated community. Ontology models offer the means for organizing and representing the semantics of this knowledge base.

3.2 The ICSRiM Archival System

The Archival System has been developed by the University of Leeds and it is used for the access, retrieval and preservation of different IMPs. The architecture of the Archival system is based on the OAIS conceptual model and on the CASPAR Framework. In addition, the Archival system integrates the appropriate CASPAR components (http://www.casparpreserves.eu/publications/software-releases/) as web services for the efficient preservation of the IMP.

The architecture of the Archival system is shown in Figure 7. It has been designed in order to support the preservation of different types of IMPs. Thus, it can be used for both the 3D Augmented Mirror and the Conducting System.

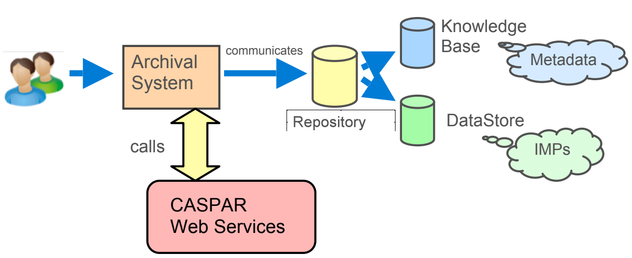

Figure 7: The Architecture of the ICSRiM Archival System.

The archival system provides a web interface and its backend communicates with a Repository containing the IMPs and the necessary metadata for preserving the IMPs. Before the ingestion of an IMP, it is necessary to create its description based on the CIDOC-CRM and FRBRoo ontologies. This information is generated in RDF/XML format with the use of the CASPAR Cyclops tool (http://www.utc.fr/caspar/wiki/pmwiki.php?n=Main.Proto). The Cyclops tool is used to capture appropriate Representation Information from a high level in order to enhance virtualization and future re-use of the IMP. It also offers the ability of adding comments and annotations concerning any concept of the IMP. Figure 8 shows the Graphical interface of the Cyclops tool and how it is used to create an IMP description. The tool provides a palette for creating the description of an IMP as a graph in the drawing area.

The concepts of the diagram that is shown in Figure 8 can be mapped to the concepts of the used ontology model**Erreur ! Source du renvoi introuvable.**. However, the usable interface of the tool hides the complexity of the system from the user. It uses a simple high level language (concepts, relations, and types) which is based on the terminology of the domain and does not require any ontology expertise to create the instantiation. The Cyclops canvas offers a graphical representation of the life cycle to make its understanding easier. Cyclops is a Web application. It is open source and it uses the following technologies: XUL, JavaScript, SVG, HTML, CSS, XML, PHP, MySQL. Cyclops can be used as an integrated component of the CASPAR system, and also as a standalone tool.

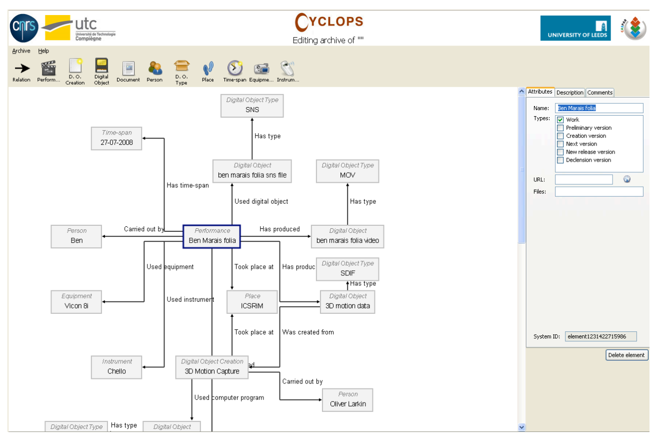

Figure 8: Part of the IMP instantiation created with the Cyclops tool.

The retrieval of an IMP is based on queries that are applied on the Knowledge Base. In particular, the Web Archival calls the FindingAids services, which task is to perform RQL queries on the Representation Information Objects and return the results to the user. Every Representation Information object is linked to a corresponding dataset of an IMP stored in the Repository. Therefore, the user will be able to retrieve the IMP files s/he is interested in and their description.

4. Conclusions and Future Work

The paper presented the CASPAR Conceptual model and the tools that are used for the preservation of interactive multimedia performances. The approach of the project considers ontologies as a semantic knowledge base containing the necessary metadata for the preservation of IMPs.

The design of the system offers flexibility in preserving multiple IMP systems. In addition, the preservation of the IMP Systems could enhance the learning procedure as it provides ways of capturing feedbacks and comments on the quality of the IMP. It also helps to preserve the intangible heritage that an IMP reflects.

We are currently working on the deployment of the CASPAR components within the Archival System. In particular, we are integrating software tools such as the Semantic Web Knowledge Middleware [19], for performing Information Retrieval tasks that will facilitate the exploitation of our knowledge base.

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