A multimodal corpus for technology-enhanced learning of violin playing

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ABSTRACT

Learning to play a musical instrument is a difficult task, mostly based on the master-apprentice model. Technologies are rarely employed and are usually restricted to audio and video recording and playback. Nevertheless, multimodal interactive systems can complement actual learning and teaching practice, by offering students guidance during self-study and by helping teachers and students to focus on details that would be otherwise difficult to appreciate from usual audiovisual recordings. This paper introduces a multimodal corpus consisting of the recordings of expert models of success, provided by four professional violin performers. The corpus is publicly available on the repoVizz platform, and includes synchronized audio, video, motion capture, and physiological (EMG) data. It represents the reference archive for the EU-H2020-ICT Project TELMI, an international research project investigating how we learn musical instruments from a pedagogical and scientific perspective and how to develop new interactive, assistive, self-learning, augmented-feedback, and social-aware systems to support musical instrument learning and teaching.

CCS CONCEPTS

• **Applied computing** → **Sound and music computing; Computer-assisted instruction; Interactive learning environments;**

KEYWORDS

Multimodal corpora, multimodal interactive systems, technology-enhanced learning, music performance.

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1 INTRODUCTION

Learning to play a musical instrument is mostly based on the master-apprentice model. In this difficult task, student's interaction with teachers is often restricted to short and punctual contacts followed by long periods of self-study resulting in high abandonment rates. Technologies are rarely employed and are usually restricted to audio and video recording and playback. The EU-H2020-ICT TELMI Project¹ takes the violin as a case-study to investigate how we learn musical instruments from a pedagogical and scientific perspective and to develop new interactive, assistive, self-learning, augmented-feedback, and social-aware systems to support musical instrument learning and teaching.

In this framework, this paper introduces the recordings of expert models of success, provided by four professional

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¹<http://telmi.upf.edu/>

violin performers and teachers between December 2016 and January 2017. Recordings are collected in a publicly available reference archive and consist of synchronized audio, video, motion capture, and physiological (EMG) data. The multimodal corpus is currently used for research, technological, and educational purposes, including developing feature computation and analysis techniques, modeling and automatically measuring the technical quality of a violin performance, comparing students with masters to provide ways of improving students' technique, designing feedback for students, and providing students with reference examples of performances. The final goal is to develop a multimodal interactive system for technology-enhanced learning of violin playing, capable of analyzing violin performances both in real-time and off-line and of providing teachers and students with interactive feedback. The system can complement actual learning and teaching practice, by offering guidance during self-study and by helping teachers and students to focus on details that would be otherwise difficult to appreciate from usual audiovisual recordings.

The paper is organized as follows: the next section introduces some related work; then, the collected data corpus is described; finally, future developments are sketched.

2 RELATED WORK

Several online resources are available on the Internet including data corpora concerning music in general and music performance in particular. Resources include repositories of audio samples (e.g., Freesound²), repositories of music pieces such as for example Free Music Archive³, Jamendo Music⁴, and the medleyDB dataset [2], and repositories created on-purpose for specific research challenges, e.g., the datasets used in the tasks of the Music Information Retrieval Evaluation eXchange (MIREX)⁵ and in the Emotion in Music task in MediaEval [7][1]. These corpora, however, only contain audio data and are therefore unsuitable for a deeper analysis of music performance, taking also into account e.g., the performer's posture and movement. To this aim, corpora including data from multiple sources e.g., motion capture, audio, and video were collected. The Bowstroke Database [9], for example, contains calibrated gesture and audio data corresponding to various violin bowstrokes. A subset of the database includes video and motion capture data as well. Other relevant examples are the ENSTDrams dataset [4], a rich collection of annotated audiovisual recordings of drum performances for automatic drum transcription and processing, the motion capture database of music performances

collected at University of Oslo⁶, the corpora collected in the framework of the Interpersonal Entrainment in Music Performance (IEMP) project at Durham University⁷, and the Quartet Dataset [5], a multimodal music performance dataset focusing on the string quartet ensemble originally aimed at studying the interdependence between the members of the quartet and at modeling ensemble expressive performance. The latter dataset is made available through repoVizz⁸, an online platform for open access to collections of time-aligned multimodal datastreams, containing several archives of music performance data.

With respect to existing corpora, the one described in this paper has the special purpose to be recorded in view of the development of a multimodal interactive system for technology-enhanced learning of violin playing. As such, it is not oriented to a specific research task (e.g., emotion recognition) or to the performance of particular music pieces. Rather, it is organized in a structured collection of exercises, following a precise learning path. Moreover, it collects data for several rich sources, including motion capture, audio, video, and physiological sensors.

3 DATA CORPUS

Participants

Four internationally renowned professional violin players were recruited for recording the corpus. Madeleine Mitchell is Professor at the Royal College of Music in London. She is a violin soloist, chamber musician, dedicated teacher, and artistic director. She has performed in some 50 countries and made many recordings and broadcast. John Haspel Gilbert is Professor of Violin at the Texas Tech University School of Music in Lubbock, Texas. He is the recipient of the 2015 TexASTA Phyllis Young Outstanding Studio Teacher Award, the TTTU President's Award for Excellence in Teaching, and served as concertmaster of the Lubbock Symphony Orchestra for 13 seasons. Eulalie Charland is an instrumental teacher at the University of Chichester and a chamber music coach at the Guildhall School of Music and Drama. She is an accomplished violinist, with an international performance and teaching profile. Berent Korfker is Professor at the Royal College of Music in London and the Yehudi Menuhin School in Surrey. He has performed concertos with major orchestras worldwide and has made solo recital broadcasts in the USA, France, and the Netherlands.

Material

Material consisted of 41 exercises concerning:

²<http://freesound.org/>

³<http://freemusicarchive.org/>

⁴<http://jamendo.com/>

⁵http://www.music-ir.org/mirex/wiki/MIREX_HOME

⁶<http://www.uio.no/english/research/groups/fourms/downloads/motion-capture/>

⁷<https://musicscience.net/projects/iemp/>

⁸<https://repovizz.upf.edu/repo/Home>

- *Handling the instrument*: posture, holding the violin, holding the bow;
- *Techniques of the right hand*: bow control, bow direction, bow changes, bow tilt, bow speed, bow weight, bow contact point, string crossing;
- *Techniques of the left hand*: articulation, intonation, shifts, double stops, vibrato, trill.
- *Articulation*: détaché, legato, martelé, pizzicato, sautillé, spiccato, staccato, ricochet.

Exercises were selected under the guidance of professional violinist Madeleine Mitchell – who also participated in the recordings – and supported through consultation with performing, teaching, and student violinists. The exercises take three forms: (1) those sourced from standard published catalogs of exercises, including those of Schradieck, Ševčík, and Kreutzer; (2) those sourced or adapted from the Associated Board of the Royal Schools of Music (ABRSM) examination syllabus; and (3) customized exercises developed by Madeleine Mitchell to address specific techniques with a particular focus on the capabilities offered by non-notated feedback (e.g., the bowing exercises). The use of both custom and pre-existing exercises was deliberate. The bespoke pieces are intended to capitalize on the unique possibilities offered by audio, video, and motion-capture feedback, while the published sources draw on centuries of pedagogical insight and tradition to give students and teachers a common frame of reference.

Set-up

Recordings consisted of motion capture data (performer, violin, and bow), instrument and ambient audio, video (frontal and lateral view), and data from physiological sensors (EMG as captured by Myo sensors⁹). Equipment included:

- A 13-cameras Qualysis motion capture system;
- Two video cameras JVC GY-HD251 (720p, 50 fps);
- One Kinect v.2, capturing both live video and depth-map;
- One pick-up Fishman PRO-V20-0VI connected via radio (AKG UHF wireless system PT40-SR40) mounted on the violin;
- Two Neumann KM184 microphones for ambient audio;
- Two Myo sensor for EMG data.

Figure 1 shows a top and a frontal view of the environment for the recordings and displays where equipment was located. Recordings were carried out at the Casa Paganini-InfoMus research center of DIBRIS-University of Genova, Italy.

The violin was endowed with 6 small lightweight reference reflective markers and with a pick-up microphone. A 6DOF rigid body was defined to track the violin in the local systems of coordinates. Virtual markers were used for

Figure 1: Top (a) and frontal (b) view of the set-up. Colors show the locations where the video cameras of the motion capture system, the video cameras for video recordings, the microphones for ambient audio recordings, and the Kinect sensor were positioned.

the violin strings. These are markers that are placed at each string-end during the calibration phase. Then markers are removed for the performance, as they would be very intrusive. During the actual tracking, virtual markers are reconstructed from the reference markers. After the first recording session with Madeleine Mitchell, the same violin was used for the next three performers. This choice had a twofold benefit: (i) it reduced the variability introduced by using different music instruments (i.e., it reduced the number of variables to take into account), and (ii) it enabled speeding-up the recordings, since the violin could be prepared in advance by putting motion capture markers and the pick-up microphone in appropriate positions on its surface. Some time was needed for the players to get acquainted with the new instrument. The players, however, are all professionals. Figure 2 shows where the reflective markers, the virtual markers, and the pick-up microphone were positioned on the violin.

The bow was also endowed with lightweight reflective markers and a 6DOF rigid body was defined to track it (see figure 3). The same bow (prepared in advance) was used with John H. Gilbert and with Eulalie Charland, whereas Berent Korfker preferred to use his own bow. Both the violin and

⁹<http://www.myo.com/>

Figure 2: Preparation of the violin. Reflective markers and a pick up microphone are placed on the surface of the violin. Moreover, virtual markers are used.

Figure 3: Positions of the reflective markers on the bow.

the bow were kindly provided by Alberto Giordano an internationally renowned luthier, conservator of the Cannone, the violin owned by Niccolò Paganini.

Markers on the body of the player were placed as follows: right and left front head, right and left back head, head top, C7 spine, spine fifth thoracic vertebra, spine tenth thoracic vertebra, left and right shoulder, left and right scapula, left and right knee (inner and outer side), right and left pelvic bone back, sacrum bone, right and left toe, right and left elbow (inner and outer side), right and left wrist (inner and outer side), right and left palm index finger, right and left palm pinky finger. A motion capture suit of appropriate size was used. Moreover, two Myo bracelet were placed on the left and right forearms.

The EyesWeb XMI platform¹⁰[3][8] was used for synchronized data recording and play back. Synchronization is based on SMPTE time-stamps. Kinect and Myo data were synchronized by EyesWeb XMI using proprietary time-stamps.

Procedure

A document was prepared in advance and shared with each of the participants to explain the requirements for the recording, e.g., the need to wear a motion capture suit and the physiological sensors as well as the need to play a violin prepared with markers. Upon arrival at the location of the recordings, after initial welcoming and further explanation of the purpose and procedure of the recordings, each participant was dressed with a motion capture suit of appropriate size and was given time to get used to play in the required conditions. At the same time or immediately before starting the recording session, the motion capture system was calibrated and a recording test was performed to check whether all the required equipment was working properly. During the recording session, the player was free to play the exercises in the order s/he preferred. The player could replay each exercise how many times s/he wanted, until s/he was satisfied with the performance. Players were also given the opportunity to check the recordings after the session and to record again the exercises they were not satisfied with. The players were informed of the purpose of the recording and signed a consent form.

Results

The recorded material was post-processed and uploaded in the repoVizz repository, where it is publicly available. Figure 4 shows a sample item of the corpus in the repoVizz web interface. EyesWeb Mobile interfaces were also developed for preview and play back of downloaded data (see Figure 5).

Data is currently being analyzed to extract audio and movement features. Concerning the latter, computed features include kinematics (velocity, acceleration, jerk, curvature of relevant trajectories such as hands and head, rangles between bones, kinetic energy) and higher level features, such as openness, lightness, sway, tension, suddenness, coordination. An ongoing work consists, for example, in analyzing regularity of movement signals and movement coordination (intended as intra-personal synchronization). In this framework, figure 6 shows an application of Recurrence Quantification Analysis [6] to the kinetic energy of the right wrist. Recurrence rates of signals captured from players having a different level of skill can be compared, e.g., as a contribute for assessing the technical quality of the music performance.

4 CONCLUSION AND FUTURE WORK

This paper presented a multimodal corpus of violin performances. These consist of 41 exercises performed by 4 internationally renowned professional violin players. In the near future, the corpus is going to be extended in two major directions. First, further recordings exploiting the Qualysis motion capture system will be carried out. These recordings

¹⁰www.infomus.org

Figure 4: A sample item of the corpus in the repoVizz web interface.

Figure 5: An EyesWeb Mobile interface for preview and playback of the data.

will be performed by other professional players as well as highly and medium skilled amateur players and conservatory students. The purpose is to quantify and model the technical quality of the recorded performances, and to compare technical quality between performances by experts and performances by amateurs and students having different levels of skill. Secondly, further recordings will be made by using low-cost technologies (e.g., Kinect and/or other low-cost sensor systems). The purpose is to port technologies to more affordable devices, available to both students and schools.

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Figure 6: Recurrence Quantification Analysis applied to kinetic energy of the right wrist. In the bottom, recurrence plot and probabilities of recurrence of the signal in the top.

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