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DIGITAL TECHNOLOGIES IN TEACHING CONDUCTING

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Abstract

The objective of this paper was to invent a digital technology, that could be used in a simple way in online conducting classes, throughout specialized education of students at universities. Transition to remote teaching due to Covid-19 pandemic has highlighted the gap in this field. This article presents a concept of using a specialised software, that is mapping in a 3D space and analysing the movement of human body in real time. The software combines two images provided by the cameras installed in a smartphone and a computer. Common presence of laptops and smartphones in human life makes it possible to omit the costs of buying specialised equipment. The technology was researched with professors and students involved, to verify: software stability, level of detail in the rendered movements of the virtual conductor after mapping the professors, understandability of the commands given to the students, students' performance in the tasks and the threshold above which the software was recognising moves of an individual as correct. Described software is constantly being developed and adapted to meet the needs of a new user, which may give future opportunities to use it also for other educational or non-educational purposes.

Keywords

Conducting, Teaching, Music, Education, Student

1. Introduction

Technology influences many aspects of life in our society, improving people's work, development and activity (Drozdowicz, 2022). The increased use of digital technologies in music, e.g., by composers and arrangers of electroacoustic and electronic music, points to them as promising methods for significant didactic improvement, if used correctly. Looking at widespread technological progress in music, compared to one specific category of musicians – symphonic and choir conductors – it would seem this group of artists has been, in a way, forgotten, or left behind, as far as teaching of the art of conducting in academic settings is concerned. The present paper endeavours to solve problems encountered by lecturers aiming to improve the training of conductors, as well as by young adepts striving to understand the art of conducting (Chang & Baer, 2021).

Additional factor of Covid-19 pandemic appearing in the world has led to the accumulation of several different issues concerning remote teaching of conducting. Previously there was no other digital tool that would help teaching or learning to conduct, would be simple to use, easily understood by professors and students, universally accessible for everybody, and containing a professional base of conducting moves, which are very distinctive for this profession, while still being personal for each individual. The inability to lead online classes during the pandemic, on a satisfying level for both sides was another thing that strongly influenced rapid development of discussed technology.

2. Literature Review

The literature introduces the related literature as well as theoretical framework and backgrounds of this study.

2.1. The Digital Baton

An electronic device called the digital baton, used for measuring movements when conducting, was a project initiated at the Massachusetts Institute of Technology laboratories in the early 1990s (Paradiso & Sparacino, 1997; Paradiso, 1999). The baton was constructed using built-in motion sensors, sending MIDI (Musical Instrument Digital Interface) signals to a computer.

MIDI is both a standard and a system commonly used in music. It contains a set of commands, an interface, and software allowing it to serve as a protocol for connecting computers and electronic instruments. As indicated above, the standard enables two-way communication and interpretation of signals between devices made by different producers. It does not define the quality of sound in the musical instruments being reproduced, but only delivers and receives digital data in the form of event messages (Rosiński, 2013; Huber, 2007; McGuire, 2014).

A computer fitted with the digital baton was also equipped with dedicated software, which interpreted motion and generated sound, enabling the whole device to create sound from movement (Baba et al., 2012). Apart from a teaching aid for conducting, it was also considered as an instrument in its own right, in the form of a MIDI controller used in sound design.

The digital technology available in the 1990s precluded significant miniaturisation of the electronic components used in the prototype. At that time, the device was an innovative proof of concept, but in practice, it proved unwieldy, large, heavy and additionally encumbered by cables connecting it to power and the computer. All of those drawbacks prevented the concept from further development (Marrin & Paradiso, 1997; Marrin & Picard, 1998).

2.2. Kinect

The *Kinect* motion sensor, which was made popular by games for the *Xbox* console, is also often used as a music controller, thanks to its ability to map the musician's motions (Sarasúa, 2013; Lim et al., 2012). When used for teaching conducting, the device records the movements of the conducting person through its internal cameras, using an analysis of pre-programmed motions, recognised in real time by its software (Hadjakos et al., 2013; Adams et al., 2014). *Kinect* then sends event messages about the motions to a computer or another digital device, serving as a MIDI controller interpreting input data.

Effective use of *Kinect* in teaching conducting relies on third-party software installed in the system. The software includes various digital instruments, which can mimic traditional instruments with an acceptable fidelity, and reproduce the sources of sound in three dimensions. Another feature needed in the software suite is a loudness interpreter, allowing for an appropriate timbre and articulation of virtual instrument-generated sound (based on loudness) when interpreting the motions of the conductor (Pejrolo & DeRosa, 2009).

The sensor's technical specifications and the quality of cameras used In *Kinect*, do not allow for detecting very minute and subtle movements of the conducting person (e.g., delicate finger motions). This device may also encounter problems with interpreting very complex motions, as well as with integrating different motions and interpreting them correctly in the context (and thus meaning) specific to a conductor's work (Mandanici & Sapir, 2012; Rosa-Pujazón et al., 2013). The number of programmes to be installed, and the question of their mutual compatibility, can multiply problems both pertaining to computer science and to music, which often elude solving. In addition, many programmes operating in real time are quite demanding on the computer and so require a device with very high specifications in order to be stable. Taking all of these difficulties under consideration, the author of the present paper decided to design and present an original system for high quality image capture and motion analysis, which creates a virtual figure of a conductor and generates advanced quality sound in real time, by using audio recordings especially made for this purpose.

2.3. The Original System

The hardware and software system more specialised than *Kinect* (dedicated for the tasks required by conductors) presented here as original work, utilises electronic devices commonly found in the home to capture and interpret motion. The system's operation relies on software installed on a computer (laptop) and another program installed on a smartphone capable of video recording. The setup is simple: the conducting person stands in front of the computer's camera, while the smartphone camera is placed to the side, at an angle of 90 degrees to the direction the computer's camera is facing (cf. Fig. 1). The combined view of the two cameras enables the construction of a three-dimensional image of the conductor's figure (cf. Fig. 2).

Before the student attempts to conduct a given piece, the instructor should record their own figure for the piece and save it as a template in the software, to be compared to the motions of the trainees. Performing the piece by the instructor several times in different styles can create a sort of database of varied properties of the templates, allowing students to adopt various interpretations during their performances.

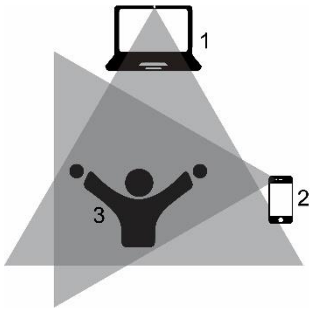

Figure 1: *Schema for Off-The-Shelf Equipment Setup in The System Analysing Movements of The Conductor: 1 – Computer Equipped with A Camera, 2 – Smartphone Equipped with A Video Camera, 3 – Conductor*

(Source: Own Research)

The system presented in Fig. 1 is fully automated, which means that if the laptop is equipped with a low-quality camera, or the desktop computer is not equipped with a camera, any external camera connected with a USB port can serve this purpose. In the case of the smartphone, the camera installed in the back of the device usually has much better parameters than the one mounted on the screen side (selfie camera). In both cases, the software allows for free configuring and re-routing signal from any camera, as required.

The new system of devices and software offers the following advantages for the work of the conductor:

- Precise and detailed movement analysis.
- Score display and scrolling based on the conductor's movements.
- Highlight line display, indicating the place in the score being replayed.
- Tracking lines display, indicating the motions of the conductor's hands (cf. Fig. 2).
- Point grid display, allowing the learner to notice any of their errors (cf. Fig. 2).
- Instructor template recording and learner movement analysis, based on a large number of varied, digitally generated 3D figures to choose from (cf. Fig. 2).
- Learner error history, allowing the instructor to quickly analyse and identify performance problems of the learner.
- Adaptive time-stretching of score replay, thanks to recordings prepared in a special audio system capable of real-time processing by phrase samplers (*variphrase*) (Brice, 2001), utilising a software-enabled time stretching function (significant changes in tempo, controlled by the conductor's movement, without a change in pitch) (Karrer et al., 2006; Juillerat & Hirsbrunner, 2017).

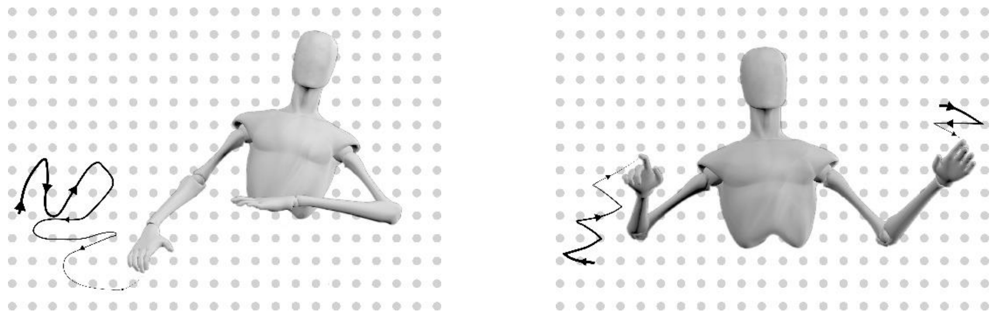

Figure 2: *Screen Captures from Blender 3D Programme, Generating A Real-Time Image of a Person's Body, Based on A Custom Application for Live Mapping of Body Position Relative to Cameras on A Laptop and A Smartphone*
(Source: Own Research)

Variphrase uses the function of compression or delay compensation (Russ, 2009), which enables lengthening or shortening of the sounds' duration (decreasing or increasing tempo) without a change in pitch (key). Additionally, an intentional change in the key of a piece recorded in this audio format does not influence the duration of individual notes, preserving the overall duration of the piece (Bello et al., 2005; Bonada, 2000; Cerra & Visconti, 2008; Lepri, 2016; Nagel & Walther, 2009).

The purpose for using such a system in teaching conducting is to create a set of templates and gestures associated with a given musical piece. The instructor performs at least one correct conducting of the piece, while recording their movements as the piece is replayed during the class. Subsequently, students practice conducting the piece at home with the system being discussed, which gives them the opportunity to compare their own movements with the template prepared by the instructor. If the movements made by the student are incorrect, i.e. do not match the template, the program stops the music, and highlights in red the gestures requiring correction. The software can also precisely guide the positioning of the body, arm, hand, and fingers, by using 'slow motion' function while replaying the template, allowing the student to follow and recreate it.

The system possesses a function, whose working name is 'humaniser', allowing for certain departures from the template by the participants of conducting class. This function, enabled and calibrated by the lecturer or the students, allows for individuality of the learners' motions, so that they do not become mere copies of the instructor. It is possible to specify what types of gestures, movements and departures from the norm would be accepted by the teacher and marked as correct by the system, by adjusting a percentage value on the tolerance of departure.

3. Methodology

The aim of the study was to examine the relevance of using digital technologies to teach conducting. To do that, 3 voluntary professors were selected from the faculty to take part in a recording session – mapping the conductor's body while conducting various musical pieces. These individuals leaded the groups in the academic conducting classes. Each pedagogue chose 3 most difficult pieces, that according to them are the most problematic ones for students during stationary education. The most important thing was the desire of making the learning process easier for students by using the software connecting a smartphone with a laptop, during home practice.

3.1. Recording Session

In total, 9 different 4-voice mixed choir pieces were recorded. Each professor was recorded twice. First time, performing strictly defined technical moves, fully synchronised with played audio recording and with the score. The second take was an interpretation of the piece (also synchronised with audio), saved as the extended conducting moves. The next step was to import 2 recordings into the computer memory: strictly technical one and the extended performance consisting of new moves – a free interpretation, within the scope of correct conducting technique. The recording session resulted in 18 video recordings.

3.2. Research Subjects

Each conducting group consisted of 6 students, and every professor randomly chose 3 students from his class to be in a research group using the digital technology during home practice, while the other 3 students didn't participate in the experiment and were treated as a control group. In total, research and control groups consisted of 9 students each.

3.3. Experiment 1

In this experiment, the research group, despite participating in conventional classes involving the professor, had to additionally practice selected pieces at home in front of the camera of the computer system, which overlayed student's image on top of previously mapped professor's image. By doing this kind of activity, students were able to correct their moves in real time by comparing them with an example recording. It was stipulated, that students should not practice more with the software than in a conventional way, without it. The control group's practice routine stayed unchanged.

3.4. Experiment 1 Results

The research group typically mastered every new piece in about 2-3 weeks, while in the control group, average time needed to master one piece was around 4-6 weeks – approximately twice as much. The professors confirmed, that each person taking part in the experiment was learning significantly faster than before, making it possible to extend the didactic process on the university by new elements, whereas there was not enough time for that with a conventional way of teaching. Each professor clearly communicated, that the effects of using this new learning method are already visible after only one week of student's work.

3.5. Experiment 2

In described experiment, every student from both groups had to choose one musical piece to work on entirely by themselves, without any professor's help. After a few weeks, each student had to conduct the piece in the presence of his professor evaluating the progress made and noting the mistakes.

3.6. Experiment 2 Results

In the case of the research group making use of digital technologies, the level of piece's mastery reached about 70-80% after 4 weeks. For the individuals not having access to the software described earlier, this level reached 30-40% after approximately 6 weeks of work.

4. Conclusions

Presented results prove the utility and validity of using own educational software during the conducting classes on universities. Thanks to the technological development, devices such as smartphone and a computer are becoming a medium cheaper and commonly available for a big number of people.

Future studies could cover much larger research group, and verified recordings of professional users of discussed software could be used to build a big database with free online access for everyone in the world. The scope of future research can be extended by examining the utility of this software in other musical, performative, dance or even non-artistic specialities. In case of young users, major limitation and at the same time danger could be a desire to perfectly imitate the "virtual teacher", which might result in becoming an exact copy of the recorded person. Hence the importance of interpretation and artistic individuality aspects which should only be stimulated by described software. This "virtual teacher" cannot replace the real professor, its objective is to help with faster and more effective development of user's competences by real time comparison of his moves with an example recorded and mapped earlier.

The system presented herein enables going beyond the schematic teaching of conducting. It is not uncommon for a student conductor, practising with accompaniment or with the lecturer, to borrow the character of their performance, which can become ingrained in the young person's conducting habits. In addition, conducting adepts, while studying at home on recorded pieces downloaded from the internet, can become accustomed to a given performance (e.g., its tempo, articulation, and dynamics), and surrender their own interpretation to the recording. The present system allows what was impossible so far, namely, presenting a personal vision of varying musical phrases, dependent on the movements of the conductor. From the conductor's point of view, the system enables individual performance and interpretation of musical pieces originating in various periods, genres, and styles, while additionally facilitating and accelerating the work of instructors in academic settings, as well as that of students practising and developing their skills at home.

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