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# Following Orchestra Conductors: the IDEA Open Movement Dataset

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**ABSTRACT**

We report on a system that enables the synchronization of electroacoustic sounds with the conductor gestures. This system was specifically used in the context of the music composition 'IDEA', for instrumental ensemble and live electronics. After a series of experiments and testing, the system was used in two public performances with two different conductors. We describe in this paper the development and the implementation of the gesture following system and the data recording. In particular, the system requires the full-length recording of the conductor right hand movements with an inertial measurement unit. The patches and the dataset are made publicly available, along with

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the recording of other pieces collected during the preliminary experiments. We believe this material can be used to test other following systems, to study and learn conducting gestures, as well as for more general computational analysis of movements.

### CCS CONCEPTS

• **Applied computing** → **Performing arts; Sound and music computing;** • **Human-centered computing** → *Empirical studies in HCI*;

### KEYWORDS

gesture following; score following; orchestral conducting; gestural database

### ACM Reference Format:

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### INTRODUCTION

Since the pioneering work of Max Mathews' Radio Baton, several orchestral conducting studies and systems have been reported. Nevertheless, this type of gestures and movements is far from being comprehensively studied and computationally modeled. Yet, conducting gestures are particularly interesting for the movement and computing community since they can be seen exemplary in merging two elements: 1) formalized gestural beat patterns indicating the tempo, generally described as spatial patterns, and 2) expressive elements, altering the 'neutral' beat pattern, used to communicate key features of the musical interpretation to the musicians, such as dynamics and articulation[5]. Interestingly, the movement patterns have been found, at least in specific cases, to be very reproducible for a given conductor[15]. Such a personal 'gestural signature' can be considered as a learned style developed through practice, and can be compared, for a given piece, between different conductors. Also, the possible gestural variations of a professional conductor from early rehearsals to the performance is another interesting aspect to study.

Such intra- and inter-personal differences remain largely understudied quantitatively and there is currently a lack of available conducting dataset, as well as systems for real-time analysis of conducting gestures. The goal of this paper is precisely to report on a gesture-following system for orchestral conductor that has recently been used in two concerts, along with the recorded data that are made publicly available.

<sup>1</sup>commissioned by Time of Music festival and Ircam-Centre Pompidou, partly funded by the ULYSSES project of the European Commission (Creative Europe)

The image shows the first page of a musical score titled "IDEA". The title is in large, bold, black letters. Below the title, the subtitle "I Neural Network" is written in a smaller font. The score is in C major and 4/4 time, with a tempo of 90. The score is divided into two parts: a 7-measure section and a 6-measure section. The instruments listed include Flute, Clarinet, Bassoon, Trumpet, Trombone, Horn, Violin, Viola, Cello, Double Bass, and Electronics. The electronics part is notated at the bottom of the page with a series of rectangular blocks representing sound files and real-time transformations.

**Sidebar 1: First page of IDEA score**  
The electronics part is notated at the bottom of the page.

## Context and goal of the research

The reported research has been performed in the context of an orchestral piece commissioned to the composer Sampo Haapamäki entitled *IDEA*<sup>1</sup>. He then proposed to write a mixed acoustic-electronics piece requiring a precise temporal synchronization between the instrumental and the electroacoustic parts. The instrumental part was foreseen for a conducted ensemble of 12 musicians, with an electroacoustic part consisting in prepared sound files and real-time transformations of live instrumental sounds.

The composition process and electronic sound design was accompanied by a research phase to develop the system that could follow the movement of the conductor right hand to synchronously control the electronics part with the orchestra playing. Such a research was also motivated a larger research agenda on movement leaning (ELEMENT project <https://element-project.ircam.fr>), as well as to bring new possibilities to score following systems such as Antescofo[4].

The project was designed in three phases. First, the system, sensors and software, were adapted and tested with conductor students using musical pieces of the repertoire as test cases. Second, a series of recording sessions was set to evaluate the system with the conductor of the concert premiere. Third, a second sets of recording sessions were performed with another conductor and orchestra, for a second performance six months later. These three phases allowed us to record a complete motion dataset related to this musical piece.

## RELATED WORKS

### Orchestral Conducting System

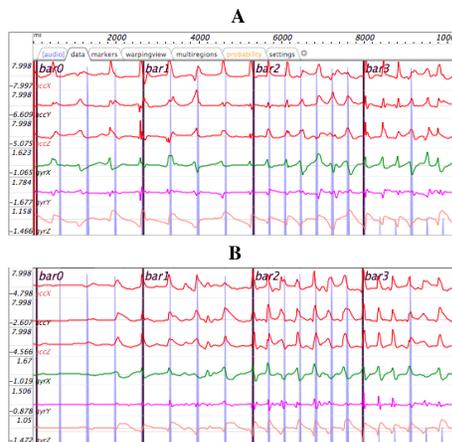
The use of interactive system for 'orchestral conducting' has been proposed since the beginning of electronic music. An overview of early systems can be found in [5], such as the works of Max Mathews with the Groove and Conductor programs as early as 1976. Other significant works can be cited such as the Bill Buxton's Conductor Follower in 1980, Morita et al. 1991 [10] or the Adaptive Conductor of Lee et al. in 1992.

Marrin-Nakra made significant contributions to the study of conducting [11] and in developing various public installation where the user gestures were used to drive audiovisual contents [12]. Eric Lee and Jan Borchers also developed conducting system for public installations [6, 7] (see also below). Pedagogical experiments with virtual conducting systems were performed at the music school 'Atelier des Feuillantines' by Fabrice Guédy in collaboration with IRCAM[2].

More recently, a project called 'Augmented conductor' was developed in collaboration with the composer Alexander Schubert [9]. Sarasua and colleagues made several studies on conducting gestures, and in applying various machine learning techniques [14–17]. Lee proposed to use deep leaning to conducting data [8]. Finally, we note that several projects were developed as installations for a



**Sidebar 2: RIoT sensor with a detached IMU sensor.**



**Sidebar 3: Conducting gestures**

First 4 bars of IDEA, as recorded by the gesture follower interface. The first 6 data are 3D accelerometers and 3D gyroscope (A: Conductor 1. B: Conductor 2).

general public such as the installation at the Mendelssohn Museum in Leipzig , or the interactive installation for children ‘You’re the conductor’ (Boston, 2003-2008, Kohl Children’s Museum of Chicago 2013-present) or Virtual Maestro (2007-2008) using the Wiimote.

### Synchronization Systems: Score and Gesture Following

Since the pioneering work of Dannenberg and Vercoe in 1984, the research on automatic musical accompaniment has been an intense field of research and development.

Seminal works has been performed in this domain by Miller Puckette between 1986 and 1995, in collaboration with the composer Philippe Manoury. Later, score following algorithms has been developed using statistical models (Hidden Markov Models)[13]. In particular, the score following system Antescofo[4] integrated tempo estimation and anticipation strategies to further improve the tracking accuracy and the human-machine synchronisation.

Branching out of the work in score following using statistical models, a gesture following system has been developed to work with continuous data, using gestural data or sound descriptors [3]. In particular, this system makes use of a Markov model built from a single recording (and a set of parameters adjustable manually by the users). These statistical methods developed for gesture following has been successfully used to follow musical gestures detected by motion sensors, as in *StreicherKreis*, a string quartet written in 2008 by Florence Baschet[1]. The same system was also used to follow the orchestra of the piece ‘La Muette’ based on sound descriptors (also by Florence Baschet).

### EXPERIMENTAL SYSTEMS AND MEASUREMENTS

We focused in this project on sensing ‘time-beating’ gestures of the right hand. This requires to use a sufficiently high sampling rate to track the movements. As, the system had to be used in concert setting with a fast installation procedure, we opted for a wireless Inertial Measurement Unit that could be attached to the right hand, whether the conductor use a baton or not (RIoT sensor <http://ismm.ircam.fr/riot/> and <https://bitalino.com/en/r-iot-kit>). The main unit with the WiFi emitter and battery is attached to the wrist, and the IMU is attached to the top of the hand. After several tests with different conductors, the system was found acceptable (could be hold for several hours without discomfort) and not perturbing the gestures.

All the electronic music of IDEA is controlled using Max (*Cycling’74*). The conductor gesture data is transmitted using OSC to the computer running the gesture following patch, using the *gf* Max external object of the *MuBu* package (<https://forumnet.ircam.fr/product/mubu-en/> and <https://cycling74.com/packages/>). For recording, an additional computer was used (connected through OSC) to record synchronously video, sound and data (also using Max with the MuBu package).

Several strategies were tested to optimize the synchronization, involving the conductors in the evaluation process on perceived precision, musicality fluidity and tempo coherence. We finally chose

to implement a tempo estimation at the bar level: the gesture follower, analyzing continuously the data stream, sent a synchronization signal to the score following Antescofo at the beginning of every bar, which is then responsible for the scheduling of the events inside the bar timespan.

## MOVEMENT DATASET

### File formats

All the gestural data collected are stored as CSV text files, as well as as MuBu binary files (compatible with the Sound Description Interchange Format, cf <http://sdif.sourceforge.net>).

### GitHub repository

The database is available on github (<https://forum.ircam.fr/projects/detail/idea-project-conducting-gestures-dataset/>), where Max patches and python code utilities are available to read and visualize the data. The database contains recorded gestures and videos of conductors students conducting excerpts of Beethoven 2nd Symphony (studio gesture recording and rehearsal situation). Several versions of the recorded gestures of two conductor of the IDEA composition (28 minute contemporary music piece)

## Recording Sessions and Concert Performances

We conducted several recording sessions with different conductors with or without audio metronome (clic tracks). Experiments were performed without instrumentalists with three advanced conducting students, with a well-known excerpt from the repertoire (Beethoven's 2nd symphony) and a 2-minute excerpt of *IDEA*. We also had additional sessions in rehearsal situations with a full symphonic orchestra, in order to study movement variations implied by the interaction between the conductor and the musicians. Finally, we recorded the conductor gesture in studio before the first rehearsal with the orchestra (for each conductor).

The piece was premiered during the festival 'Time of Music' in Vitasari (Finland) the 5/7/2018 by the International Contemporary Ensemble conducted by Christian Karlsen. The piece has been performed a second time in Paris by the French ensemble Court Circuit conducted by Jean Deroyer during the French Radio festival Presences the 13/2/2019. At this occasion we record again the integrality of the conductor gesture. At the end, we have perfectly aligned data of two different conductors performing the integrality of a 30 minutes contemporary piece.

## DISCUSSIONS AND CONCLUSIONS

We were thus able to test and evaluate the system performance in real musical situations (rehearsals and in concert). The synchronization strategy described above was found adequate in the context of a challenging contemporary piece. Other strategies (looser or tighter) can be used, depending on the musical context. As expected, we found that every conductor has a specific, idiosyncratic personal way to conduct a given orchestral piece orchestra. Therefore, one of the main constraints of the gesture follower system we used is the necessity of recording the whole piece for each conductor. Our next goal is to generalize this system to be able to simplify the learning process. We believe that the data collected in this project can serve to quantitatively compare such idiomatic gestures and could be useful for several other type of movement analysis.

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