TempoWatch: a Wearable Music Control Interface for Dance Instructors

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ABSTRACT

We present TempoWatch, a wearable smartwatch-based interface designed to allow dance instructors to control music playback and tempo directly on their wrist via touch gestures using a circular watch display. Dance instructors have unique requirements with respect to music playback in their classes, in particular the ability to stay in position while controlling the playback, and to change speed via time-stretching. However, common stereo decks and mobile music player apps do not support these requirements well. We present the design and architecture of our system, and a qualitative evaluation performed with 9 semi-professional instructors in their own dance classes. Dance instructors were involved in this project from the very beginning to match the system and interface design to its prospective use cases. Results show that instructors are able to use TempoWatch productively after only a short learning phase.

CCS CONCEPTS

• **Applied computing** → **Performing arts**; • **Human- centered computing** → **Mobile devices**; *Gestural input*.

KEYWORDS

smartwatch, wearable, music, dance, instruction, teaching, control

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1 INTRODUCTION

During dance lessons, instructors often need to control the playback of dance music while simultaneously engaging the class by demonstrating, evaluating, and correcting the movements of the students. Depending on the current dance style and particularly skill level of the class, instructors might want to change the music selection or even playback speed on the fly. However, most current solutions for music playback in dance classrooms consist only of a standard stereo deck with CD and (optional) MP3 playback capability, and are therefore only rudimentarily suited to the specific requirements of a dance lesson. For example, any change of playback parameters (volume, tempo, track, pause) requires the instructor to walk to the control panel, thereby losing both their current pose and their focus on the students. Even if a regular infrared remote control is available, these devices are cumbersome to carry and aim, quickly wear down from heavy usage, or simply are lost. Also, only specialized and therefore more expensive decks offer the ability to control playback tempo, which is necessary to allow beginners to learn complex step sequences at a lower speed first before ramping up to the native speed of the music piece.

Figure 1: TempoWatch in use during dance lesson (left: wearable control interface on smartwatch; right: smartphone connected to stereo deck.)

To address these issues, we present TempoWatch, a wearable smartwatch-based interface which allows dance instructors to control all relevant playback parameters eyes-free directly on their wrist. TempoWatch consists of a regular Android app for the instructor's smartphone, which is connected to the stereo deck or amplifier in the classroom, and an additional Android Wear app to be installed on the smartwatch. Commands are sent via Bluetooth Low Energy (BTLE) and control playback of the music collection

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stored on the smartphone, including volume, track selection, pausing, and particularly time-stretching (tempo/playback speed).

With our prototype, we conducted a qualitative study with 9 dance instructors who used TempoWatch during their classes. Results from the study show that TempoWatch can be learned quickly, has a positive influence on the time spent for music management, and on the overall immersion level of the class. We conclude by discussing potential future extensions of TempoWatch as suggested by our test participants.

2 RELATED WORK

The combination of music and HCI is an extensively researched area, both for playback control and for music creation. As a representative example relating to control, Henze et al. [10] evaluated which free-hand gestures users found most intuitive for controlling music playback. Regarding music creation, the seminal Reactable [11] and related systems such as the Collaborative Music Composer [12] explore novel interfaces to perform and compose music, often with a focus on tabletop interfaces.

Related areas that have been a focus of research is music control for sports and other outdoor activities, e.g. as explored by Bauer and Kratschmar [3], interactive learning systems for instruments such as DrumGenius [17], or general eyes-free interaction methods on small devices [14, 20].

On the other hand, there is relatively little work focusing on the intersection of dance and computing. Most existing research looks at augmenting and supporting the dancers themselves: for example, BalletHero [8] takes its name from the popular GuitarHero series of rhythm games and presents an augmented textile which supports ballet training by visualizing the essential movements of the dancer. Charbonneau et al. [5] explore whether body-controlled rhythm games can be a substitute for an instructional video showing a human dancer. Trajkova et al. [19] explore design implications derived from observing ballet tutors and their students, and suggest using camera-based body tracking for individual feedback.

YouAreOffTheBeat [15] and ForroTrainer [6] are both systems designed to evaluate the matching accuracy between dance movement and music rhythm based on accelerometer data and give real-time feedback to the dance students. However, the authors also find that a purely algorithmic approach has noticeable differences to how professional instructors evaluate rhythm accuracy. An additional, smaller subset of related research looks at explicitly supporting dance performances, either by visualization of movements [4, 7] or by connecting remote dancers [21].

Regarding playback speed control, a common use case is software oriented towards DJs. As academic research in this area seems to be rare (with few exotic exceptions such as "Wearable DJ" [18]), we analyzed several existing iOS apps (djay [2], Cross DJ [13], Perfect Tempo [16], and Pacemaker [1]) with respect to their implementation of tempo control, and found several possible approaches. djay uses a dedicated dialog popup with a slider, while Cross DJ uses an always-visible speed slider on the screen border. Both variants borrow heavily from "traditional" mouse-based interfaces, and are therefore unlikely to be well suited for a smartwatch. Perfect Tempo does offer an Apple Watch interface, which however uses plain plus/minus buttons and is therefore not suited to eyes-free control. On the other hand, Pacemaker does not offer a dedicated wearable interface, but uses circular motion on a virtual turntable to increase (clockwise) or decrease (counter-clockwise) playback speed. As this variant is easily mappable to the limited screen space on a smartwatch, can be used eyes-free, and provides an additional tangible connection between motion and result, we selected this approach as inspiration for TempoWatch.

3 TEMPOWATCH

3.1 Context and Design Process

As mentioned before, a dance class presents a unique context which regular music player apps do not support well, even if they provide a wearable interface such as Perfect Tempo. One semi-professional dance instructor, who is also the first author of this work, was involved in the project from the beginning, and repeatedly tested the prototype in their own dance classes.

Based on their own domain knowledge and on informal discussions with other dance instructors, we focused on interaction which can be a) conducted eyes-free, b) requires only a minimal amount of fine motor control, and c) can be completed with at most two taps or a single gesture (with the exception of track selection).

The fundamental goal of our iterative development process was to create an interface which distracts both instructor and students as little as possible from the dance lesson itself, while still allowing unencumbered movement and quick reactions to the teaching situation for the instructor. Consequently, the main interface on the smartwatch offers only 3 major functions (see also figure 2):

- Pause/continue playback
- Adjust playback speed
- Track information

Note that volume control is not among the list of primary functions, as the amplifier is usually set up to provide a comfortable volume level for the whole room. If individual music pieces have a unsuitable volume level, this can still be adjusted via a secondary function as shown below in figure 4.

Figure 2: TempoWatch main interface with title and tempo indicators.

Figure 3: Scrolling gestures for controlling TempoWatch (left: increasing playback speed; right: track selection).

3.2 Interface

An overview of the main interface is shown in figure 2. Pause and continue are triggered by simply tapping in the center of the screen. A progress indicator (green arc in figure 2 right) shows how much of the current track has already been played, and will additionally switch to red color above 90% progress. Playback speed is controlled by the previously described circular touch motion in the outer ring, which is particularly well-suited to a round smartwatch screen. Track information is extracted from metadata tags in the current music file, focusing on dance genre and beats per minute (BPM) of the base recording. If the adjusted playback speed matches the recommended BPM for the dance genre (e.g. 84-90 BPM for slow waltz, 100-104 for Samba/Rumba, etc.), a green tickmark is displayed (cf. figure 2 right) as an additional memory aid. When the current speed is outside the respective range, a downward (too slow) or upward (too fast) arrow is shown instead (cf. figure 2 left). However, an instructor is free to intentionally slow down a particular piece below the recommended range, e.g. to help beginners deliberately place their steps, or to speed it up to challenge an advanced class.

Figure 4: TempoWatch track selection with current dance genre (left) and volume control (right).

Two additional functions, track selection and volume control, are available via buttons on the left and right side of the main interface. In the context of a dance class, these are less central than the primary functions discussed above, and have therefore been moved to a secondary interface tier.

The volume control interface supports dragging or directly touching the circular percentage indicator, and will automatically switch back to the main interface after a change has been made (cf. figure 4 right). The track selection screen shows a scrollable list of all songs belonging to the current genre along with important metadata, with the additional option to switch to a different genre via a secondary menu (cf. figure 4 left).

3.3 Implementation

We developed and tested our system on a Nexus 5 smartphone and a Huawei Watch (1st gen.) with a circular display, both running Android 7.1. TempoWatch consists of a regular Android app to be installed on the instructor's personal smartphone, and a companion Android Wear app which is automatically installed on any linked smartwatch. In a typical usage scenario, the smartphone is connected to a stereo deck or amplifier in the dance room via audio cable, while the watch is worn by the instructor and uses a BTLE connection to send commands to the smartphone. The music collection is stored on the smartphone and uses Android's built-in MediaPlayer component for playback and timestretching functionality.

4 EVALUATION

To provide early feedback on the design of our system, a dance instructor in person of the first author was regularly involved during the development phase and tested the prototype repeatedly in their own classes. For example, during an early test, the need for a progress indicator was discovered and the corresponding functionality implemented in the next iteration.

4.1 Participants

After the initial development phase was concluded, we performed a qualitative expert evaluation with 9 additional semi-professional dance instructors from local dance schools (see table 1 for demographical details). Their primary professional background varied widely and included carpenters, medical students, schoolteachers, software developers, or pharmacists. Their average age was 33.1 years, with 4 female and 5 male instructors participating in our study. Our prototype was used during five dance lessons of 90 - 120 minutes duration; for four instructors, scheduling conflicts prevented them from testing the prototype during their class sessions and we performed a free exploration instead in which we asked them to imagine leading a dance class using TempoWatch. In all cases, one of the authors was present to answer questions about the prototype and observe the evaluation.

4.2 Procedure

The tests were conducted in dance rooms of the respective dance schools, mostly equipped with hardwood floors and mirrored walls (see figure 5 for an example). The rooms had a size of about 100 m^2 each, and the class sessions with dance students had between 4 and 10 dancing couples present. Due to the dimensions of the rooms and the number of students present, who can be expected to carry their own smartphones with them, we were also interested in evaluating

Table 1: Demographics and background of dance instructors who tested TempoWatch.

Gender	Age	Profession	Venue	Location	Genre	Class duration
f.	22	medical student	Thüringer Tanzakademie	Weimar	Ballroom/Latin	120 min
m.	41	computer scientist	Tanzwerkstatt	Weimar	Salsa	90 min
m.	38	schoolteacher	Sporthalle Parkschule	Weimar	Ballroom/Latin	90 min
m.	51	software developer	Projekt Eins	Weimar	Salsa	-
f.	27	dance instructor	ADTV Tanzschule Näder	Jena	Ballroom/Latin	90 min
f.	21	carpenter	Thüringer Tanzakademie	Weimar	Ballroom/Latin	-
m.	35	freelance developer	Projekt Eins	Weimar	Salsa	-
m.	45	pharmacist	Tanzwerkstatt	Weimar	Ballroom/Latin	-
f.	18	high-school student	Tanzwerkstatt	Weimar	Ballroom/Latin	90 min

the quality of the wireless BTLE connection between watch and smartphone. We prepared a music playlist with 154 tracks from various genres (e.g. salsa, slow waltz, rumba) and speeds, taking care that correct metadata regarding speed (BPM) and dance style was present in each track.

In each test, we first introduced the participants to the system and provided them with short test tasks (launch app, start/pause, change speed, select track, change volume) for about 5 minutes to cover the main functions of TempoWatch. Afterwards, the participants used the system during their dance class (or performed a free exploration, when scheduling issues prevented testing during a class session). We then concluded with a semi-structured post-study interview covering suggestions for improvement and free comments. We decided against collecting quantitative data using tools such as Likert scale questionnaires, as this data would only have limited value due to relatively small sample size and a strong novelty bias.

5 RESULTS

In total, our prototype was used for over eight hours in real-world conditions by five real-world users, with four additional shorter exploratory sessions. Even though a longitudinal evaluation across multiple subsequent dance classes with the same instructor would likely reveal additional insights, this is currently not possible due to schools being closed during the COVID-19 pandemic. We are planning to conduct additional evaluations after dance schools reopen in the future.

5.1 Observations

A common observation during all evaluations was that test participants were so used to having to walk to the stereo deck for controlling music that they generally still started doing so during the first 30 minutes of the test before stopping and realizing that TempoWatch made this unnecessary. After about 30 minutes, this behaviour gradually stopped as instructors became used to the wearable interface.

For the dance students, using TempoWatch resulted in an increased presence of the instructor as no interruptions for music management were necessary anymore. This was confirmed by the instructors' self-reflected comments after the class sessions as well as by anecdotal comments from students. For example, the instructor was now able to focus on a student couple and briefly pause

Figure 5: Example of dance classroom used for salsa class during evaluation (© 2020 Tanzwerkstatt Weimar)

the music to explain a step sequence while immediately resuming playback afterwards. In addition, we also observed that instructors would sometimes keep the non-dominant hand with the watch engaged with a participant (e.g. on their shoulder) while only briefly releasing the dominant hand for music control and immediately resuming "hands-on" instruction afterwards.

In cases where it was necessary to address the whole course, e.g. during a "rueda de casino" in a salsa course which the instructor also actively participates in, test participants regularly used the remote control feature to briefly reduce the music volume while giving instructions, and raise it back to normal volume right away.

5.2 Stability

Despite the large and crowded rooms with multiple other devices present, we did not observe any issues with wireless link quality during testing. All commands issued on the watch were executed by the playback system on the smartphone without noticeable delay, and none of our test participants commented on any connection issues or lag.

We observed only a single issue related to heavily slowing down a track right after starting playback. Apparently due to internal

buffering, the slowdown is only audible with a delay of some seconds in this specific case. However, this issue did not negatively influence any of the test sessions. We estimate the current battery runtime of the system to be 4 hours, which is sufficient to cover two full dance lessons without recharging.

5.3 Suggested Improvements

Regarding suggestions for improvement, there are two topics that were mentioned by three or more test participants each, and which we therefore consider to be generally useful additions:

(1) Autoplay/Playlist (5 instructors each). Our current prototype stops after each song and requires the user to actively select and start the next track from an alphabetically-sorted list of songs with the current genre. For smoother flow during a class session, instructors would like to be able to prepare a playlist with songs from the same genre on their smartphone beforehand and have the system automatically play all items in the list in sequence.
(2) Duration of title (3 instructors each). For better short-term planning during an ongoing class session, three instructors mentioned that a quick-glance overview over the current song's total duration and elapsed time would be helpful.

Additional suggestions which were mentioned by individual instructors included font size of the interface, visual feedback of touch buttons, current track indicator in list, volume normalization, or a reset option for the playback speed.

6 DISCUSSION & FUTURE WORK

One limitation of our evaluation was that we provided a default set of tracks for all instructors that covered common dance styles, but may have contained unfamiliar music. Nevertheless, based on the results of our evaluation, we conclude that dance instructors from a wide variety of backgrounds are able to use TempoWatch productively in their classes after only a brief training session. Our system proved to be reliable during testing, and instructors provided various suggestions for UI improvements, commonly mentioning a playlist/autoplay feature and a duration/elapsed indicator.

Based on our observations during the evaluation, we will also consider introducing a one-touch button to temporarily reduce the music volume while held down for brief instructions to the whole class, even though none of the participants suggested this extension directly. Other minor extensions (e.g. current track indicator) will also be taken into consideration when implementing the major requested features (custom playlists, duration/elapsed indicator). For longer playlists, we will consider advanced scrolling techniques for small screens such as BinarySwipes [9].

Moreover, we plan to explore other use cases in the future. For example, athletes listening to music while working out or running might also benefit from easily accessibly tempo control to adjust the playback speed to match their workout. In addition, musicians learning a new instrument could potentially also use our approach to practice a specific music piece at lower speed and gradually increase the tempo with increasing skill.

7 CONCLUSION

In this paper, we presented TempoWatch, a novel wearable interface designed for dance instructors. We tested TempoWatch with a total of 9 dance instructors, also during live dance classes, and found that TempoWatch was able to support the instructors as intended after only a short learning period. Suggestions for improvements from the test participants will be integrated into future versions of our system.

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