MiLa: an Audiovisual Instrument for Learning the Curwen Hand Signs

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Abstract
We present a novel musical system for learning the Curwen-Kodaly hand signs, which stand for solfege syllables and pitches (*do*, *re*, *mi*, etc.). These hand postures comprise a system of musical notation typically used in sight-singing training to familiarize with patterns of musical tones. Therefore, what concerns us is music literacy as opposed to practice with any particular instrument. Our system uses a Leap motion sensor to recognize the hand signs and produce corresponding user-recorded sounds. For each hand sign, the system also displays a natural 3D scenery, which is intended to match the metaphorical nature of the tone and has a resemblance to the hand posture (e.g. *mi* is a steady or calm tone, so the hand sign is an open hand with palm downwards and the scenery is a calm but moving ocean).

Author Keywords
Embodied metaphors; musical instrument; posture recognition; music education; computer graphics.

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces; J.5 [Arts and humanities]: Performing arts (e.g., dance, music); K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI)

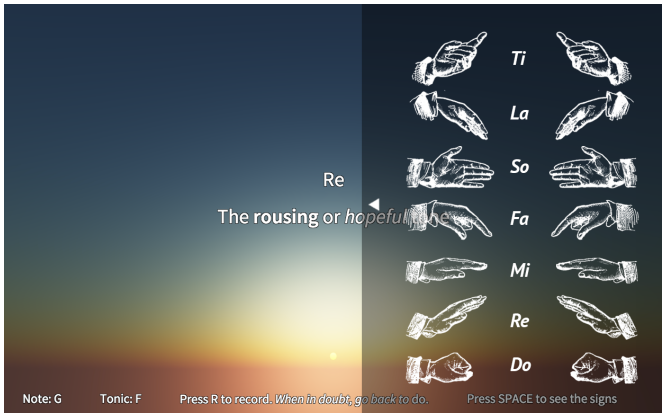


Figure 1. A reference to the hand signs can be displayed by pressing the spacebar.

Introduction

"Movable do solfege" is a system that associates syllables – *do*, *re*, *mi*, *fa*, *so*, *la*, *ti* – with the seven successive scale degrees of a major scale (e.g. *do* designates the "tonic" degree, or the starting note; *re* designates the "supertonic" degree, or the note a whole step up from *do*). It is the single most prevalent system for sight-singing training in the United States [4]. Its importance becomes clear if we consider, for instance, that given the task of sounding any two notes that are two whole steps away from each other, anyone experienced enough could fulfill it by singing *do* and *mi*.

Hence many students who have been in a music classroom will recognize a set of hand signs, first introduced by John Curwen in the 19th century [3] and popularized later by Zoltan Kodaly, which function as designators for solfege syllables. In vocal exercises that precede sight-singing, instructors signal tonal patterns to students (of all ages [7]), to which the students sing along on the syllables [6]. These tonal patterns are ones encountered in the sight-singing work that follows. The vertical position of the instructor's hands varies according to the height of each tone; this is crucial for patterns that include *do*s at different octaves.

As a system of musical notation, the hand signs can only be as effective as the ability of the student to read them. Our goal was to create a tangible learning system that could recognize and augment the hand signs with both visual and audio feedback, which would reinforce the associations between the hand signs and the syllables. The result is an instrument for music education that combines creative expression and learning.

As in the original conception of the Curwen hand signs, the input postures serve to evoke embodied metaphors that map the physical postures of the hand to the emotional and musical significance of the tones. In our system, the postures also embody mental images created by the accompanying 3D sceneries, which in turn hold similar emotional qualities with the postures (e.g. signaling *mi*, the steady or calm tone, presents the scene of a moving but calm ocean). Moreover, these sceneries have physical resemblances to the hand postures (e.g. the flatness of the hand posture for *mi* reflects the flat surface of the ocean.) Learning is facilitated by these displays, as our brain is adapted to efficiently capture such natural images [11].

Background

The Kodaly method and hand signs

A primary goal for music education in the classroom is music literacy [10]. In contrast with the Orff approach, which puts bodily experiences with tangible instruments first ("Feeling precedes intellectual understanding"), [13, page 3] the Kodaly method is an approach to music education that focuses on music literacy, and therefore devotes much effort to training sight-singing ability [6][8]. Toward this goal, the movable do solfege and the Curwen-Kodaly hand signs become vital components of the Kodaly method. Children who have been taught with the hand signs can identify intervals more quickly and accurately than those who have not [9], which increases sight singing proficiency. The hand signs save the student from the unnecessary mental effort that would be required by reading staff notation [6].

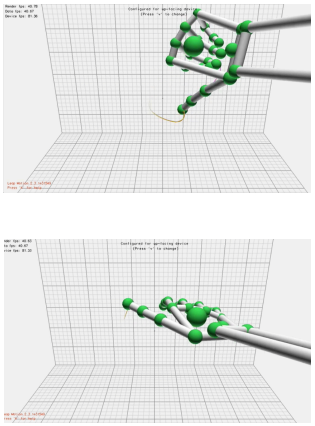


Figure 1. Vertical transitions between two sceneries reflect how we understand pitch in terms of physical height. The corresponding hand signs as recognized by the Leap motion sensor are visualized on the left.

Embodied metaphors

The Curwen-Kodaly hand signs are designed such that each embodies the mental effect of the signified tone, which is palpable when the tone is sounded "slowly - when the ear is filled with the key, and when the effect is not modified by harmony." For example, *mi* is designated with "the open hand with the palm downwards," and its mental effect is "steady or calm" [3, page ix]. In tangible interaction, embodied metaphors are often chosen as the foundation for designs that map bodily movement into interactions with an abstract domain (e.g. [1]). Here we are building on existing hand signs that were created specifically with this purpose in mind.

Implementation

We implemented our system using HTML5 and JavaScript. The application consists of a sequence of sections each displaying a solfege syllable, a mental effect, and a 3D scenery, as listed in Table 1. The sections are arranged vertically so that transitions from one degree to another reinforce our understanding of pitch through height metaphors (Figure 2). The scenery is rendered with WebGL via Three.js [2].

A section is moved into view when a Leap motion sensor [5] recognizes a hand posture as a designator for the section. The Leap motion sensor outputs data pertaining to the directions of the hand and each fingertip, the normal vector to the palm, the velocity of hand movement, and the strength of a grip, among other things. The hand signs are recognized through constraints on this information, which causes a transition between sections when the hand is still for some time. The low *do* is distinct from the high *do* only by the height of the hand. After a transition occurs and

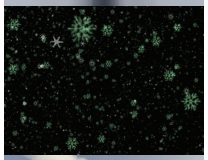
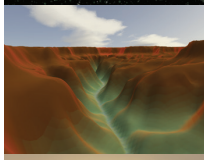
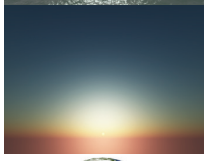
Name	Degree	Function	Mental Effect	Signs (try them!)	Sign Description	3D Scenery	Scenery Description
Ti	7th	Leading	Piercing or sensitive		Hand pointing upwards with the index finger		Sun rays piercing through branches
La	6th	Submediant	Sad or weeping		Hand hanging down from the wrist		A snowy evening
So	5th	Dominant	Grand or bright		Open hand directed forwards, thumb upwards		The Grand Canyon
Fa	4th	Subdominant	Desolate or awe-inspiring		Hand firmly pointing downwards		Above the clouds at sundown
Mi	3rd	Mediant	Steady or calm		Open hand with palm downwards		A calm but moving ocean
Re	2nd	Supertonic	Rousing or hopeful		Open hand directed upwards, showing the palm		Sunrise
Do	1st	Tonic (upon which above pitches are referenced)	Strong or firm		Closed hand with palm downwards		The rotating Earth (on which above sceneries take place)

Table 1. The seven scale degrees of a major scale and their musical attributes, signs, and 3D sceneries. The "mental effects" and signs are from [3]. The signs are viewed from the left side of the hand. The reader is encouraged to make the hand signs in front of the chest to perceive the mental effects they embody and to notice how their shapes resemble the sceneries.

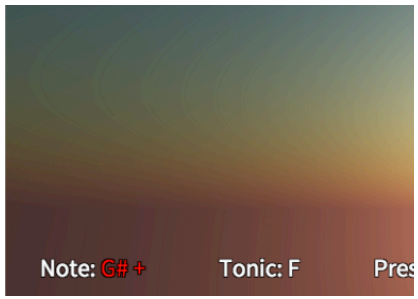


Figure 3. Recordings at *do* and *re* are at wrong pitches. The sound at *do* is in pitch class F. The sound at *re* is in class G#, a whole step and a half higher than the sound at *do*. This sound is sharper than it should be in reference to *do*, hence the plus sign.

the corresponding scenery is displayed, an associated sound is played if the user previously recorded it. To assist new learners, MiLa will display a reference set of hand signs when the user presses the spacebar (Figure 1).

Tuning

The user has the freedom to choose at which pitch the tonic will be positioned. In order to associate a new sound with a section, the user presses the record key and sounds a note. Any musical instrument could be used, including voice. Displayed on the bottom left of each section is the name of the pitch class of the recordings associated with *do* and the current scale degree (Figure 3). This information is calculated via a pitch detection algorithm that relies on autocorrelation of the sound signals [14]. If the pitch class does not match up with the scale degree, the font color on the note name turns red. In addition, a plus sign is added if the pitch is sharp and a minus sign if flat.

Evaluation

To evaluate our system we conducted testing sessions with five (three male, two female) undergraduate students and staff at a research university. The goal of our study was to observe whether or not the participants, given a simple curriculum, could easily learn the Curwen-Kodaly hand signs using the system. We were also curious how users would utilize MiLa's audio and visual feedback to help with the learning process.

Procedure

The study was conducted in a music practice room equipped with a piano. Participants did not know the hand signs; two of them had never used the hand signs, and the other three had last used them only before the age of six. Although some of them had previous experience with musical instruments, none of them were active musicians. They were first briefed on the purpose of the system, and were told that their goal was to learn the hand signs to perform a simple composition with MiLa.

They were then told to explore freely with the instrument. After five minutes, they were told to attempt go from the low *do* to the high *do* in succession, without mistake (*sequential recall)*. When they were successful, they were presented with the notes for singing exercise 134 from [3] (a German chorale titled *Praise to God)*, which was composed of a well-rounded mixture of 60 notes (*mixed recall)*. Finally, they were asked follow-up questions about how they felt during the experience and what memorization techniques they might have used.

Results

In the free exploration stage one participant, upon discovering that the low *do* was distinct from the high *do*, went on to excitedly figure out the melody to *Over the Rainbow* (a song that begins with an octave) on the piano, and practiced playing it with our instrument. In other cases, participants first attempted to master *do, re,* and *mi*. Upon success they gradually added the next four notes, and finally proceeded to recite the full scale in succession.

The participants performed extremely well in the recall tasks. Every user was able to produce the hand signs in succession by their fourth attempt at a sequential recall. By the end of the mixed recall task, they were

able to produce the hand signs with 100% accuracy (response time was not limited).

Everyone commented that the experience was "fun" or "cool," and that they wanted to continue messing around with the tool (some did). They spoke of the natural sceneries being aesthetically pleasing, and even "soothing… therapeutic." One participant spoke of being left feeling "powerful" because hands could generate sounds without the assistance of mechanical actions. These results look very promising. They point toward the possibility that our tool can indeed afford creative exploration and learning through active engagement.

Some participants said that they utilized either the scenes or the mental effects to help recall when they were stuck. They agreed that the most memorable scenes were those for *mi* (ocean) and *so* (Grand Canyon). The least memorable were *fa* and *ti*, each of which only one user could recall the scene and mental effect for when told to. Although some of the visual and verbal content might then be superfluous, participants agreed they were not distractions that would disengage them from the task at hand [12], and as stated earlier they simply enjoyed the visual experience.

Conclusion & Future Work

We presented an audiovisual instrument with the goal of helping students improve their ability to read tonal patterns dictated with the Curwen-Kodaly hand signs. As a tangible instrument for music literacy, we believe that MiLa could be an exciting and important supplement to the music classroom.

We are working on several improvements to the system. MiLa struggled at times to recognize the hand sign for *ti*, as it is very similar to *do* from the perspective of the Leap motion sensor. We are experimenting with different positions for the Leap sensor to improve recognition reliability. Displaying the Leap hand visualizer would also provide an excellent additional feedback so the user knows whether a problem was due to a mistake or to a sensor error. And although the posture recognition was sufficient for a sample of adult participants with fairly steady hands, usability for children might require a system that can more easily classify hand signs. Finally, we are considering educational extensions such as a built-in tutor where the user is given a series of hand signs, and would pass if they sang the right notes as captured by our pitch detection algorithm.

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