An Environment for Gestural Interaction with 3D Virtual Musical Instruments as an Educational Tool

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Outline / Contributions

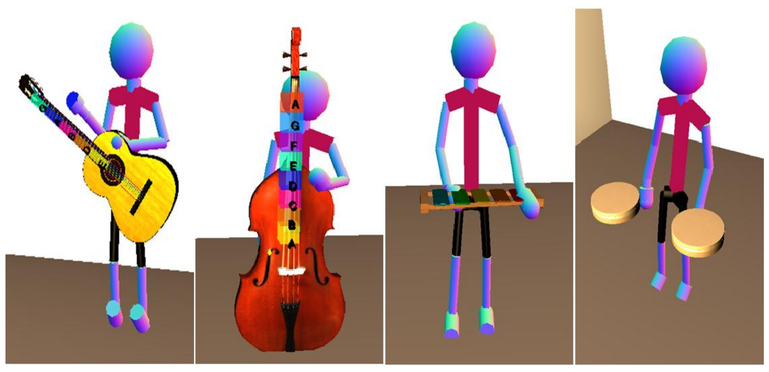
• Presentation of an online system for interaction with virtual musical instruments.
• The system can deploy either a **Microsoft Kinect** or a **Leap Motion** sensor in order to facilitate user interaction with the instruments.
• The interactions are realized through **hand gestures** of the performers.
• A pilot study was carried out, gauging potential usage of the system in musical education applications, that involved keeping specific rhythm patterns.
• Encouraging results with regards to the effect of the audiovisual feedback that our system provides.

STEAM Pedagogy -The iMuSciCA Project

• **STEAM** education: Integration of Artistic activities in traditional STEM (Science/ Technology/ Engineering/ Mathematics).
• The **iMuSciCA** project is grounded in the need for STEAM pedagogy, with the following goals:
➢ Research on **innovative enabling technologies** in order to support STEM learning through musical activities.
➢ Development of a set of **practical activities** that combine musical interactions with acquisition of STEM knowledge skills.
➢ Development of **multimodal interfaces** that facilitate student participation in musical activities.

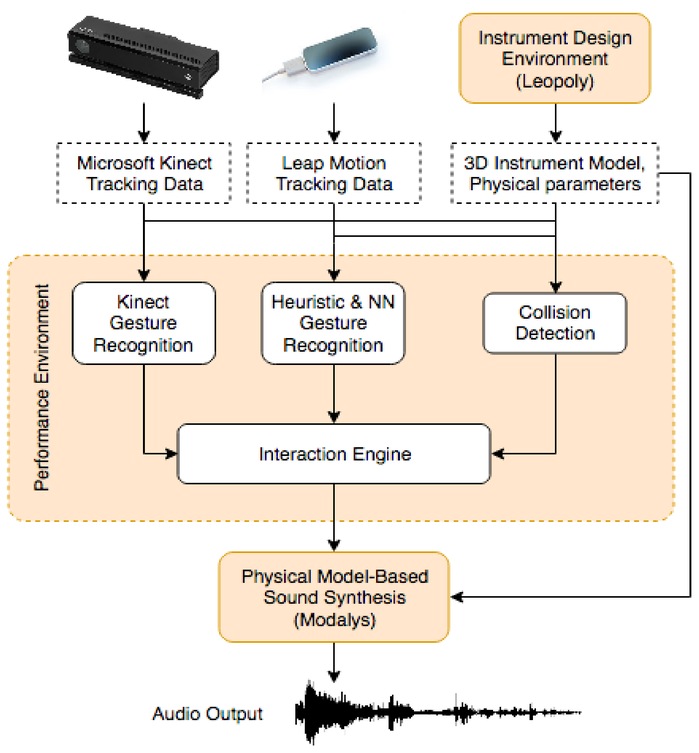
Interactions Involving Microsoft Kinect

When using Microsoft Kinect as a sensor, a skeletonized avatar of the user appears in the computer screen, along with the selected instrument, that is mounted on the body.



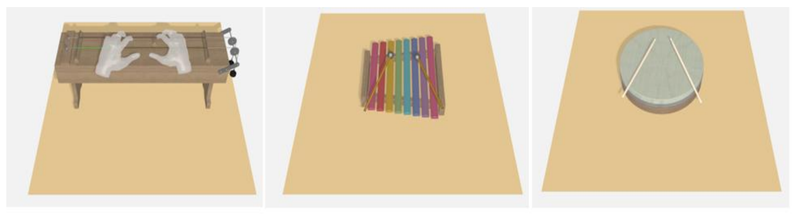
Instrument	Dominant Hand	Subdominant Hand
Air Guitar	Performs up-and-down plucking gestures at the height of the user waist.	Determines the played note, moving along the fretboard.
Upright Bass	Performs left-and-right bowing gestures.	Determines the played note, moving along the fret of the bass.
Air Xylophone	Performs downwards, hitting gestures towards the bars.	Performs downwards, hitting gestures towards the bars.
Air Membranes	Performs downwards, hitting gestures towards the membrane.	Performs downwards, hitting gestures towards the membrane.

Overall System Architecture



Interactions Involving Leap Motion

When using Leap Motion as a sensor, the user interaction is visualized as **a pair of hands** (for string based instruments) or **mallets** (for percussion-based instruments). The instrument appears in the center of the screen.



• **String-based interactions:** A plucking sound is produced whenever a pluck-like gesture is recognized. The sound produced corresponds to the string closer to the hand's location.
• **Surface & membrane interactions:** The hand movement controls the mallets or drumsticks. Sound is produced whenever the mallet/drumstick collides with the virtual instrument.

Experimental Setup

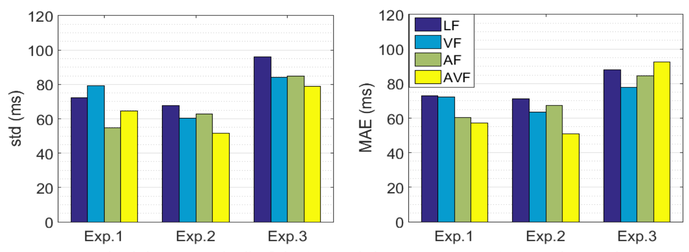
• **Goal**: Determine the extent in which our platform, and the audiovisual feedback it offers, can aid in specific tasks pertaining to musical education.

•**Case study**: Usage of a pair of virtual membranes in **matching specific rhythmic patterns**.
• **Setup**: A total of 23 users evaluated the system by replicating the following rhythmic patterns:

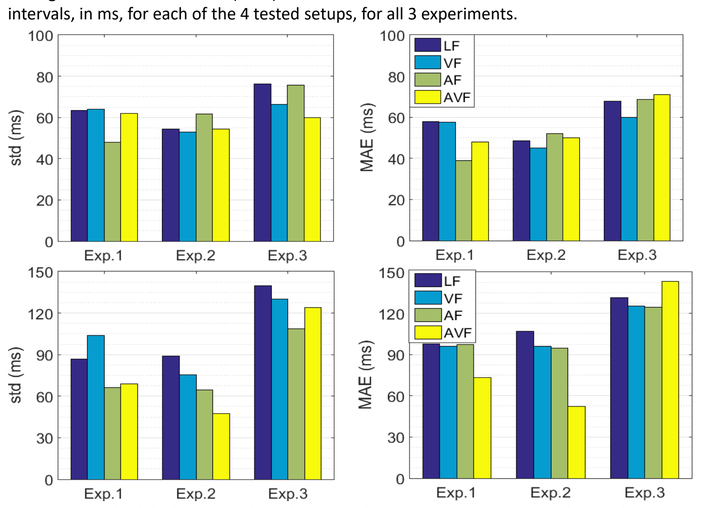
Exp.	Dominant Hand	Subdominant Hand
1	80 BPM, 15 sec	-
2	80 BPM, 15 sec	40 BPM, 15 sec
3	40, 80, 120, 160 BPM, 7.5 sec each	-

•**Evaluation:** 4 attempts for each pattern (no feedback/ auditory feedback/ visual feedback/ audiovisual feedback) – setups were presented in a randomized order. A 40 BPM metronome was used in all cases for user assistance.
• **Metrics:** **STD** of user hit intervals (measuring the ability to keep a steady rhythm), and **MAE** between the user hit intervals and the desired ones (measuring the ability to keep the predetermined rhythm).
• Comparisons were also carried out with regards to the **number of repetitions**, as well as **the musical background** of the users.

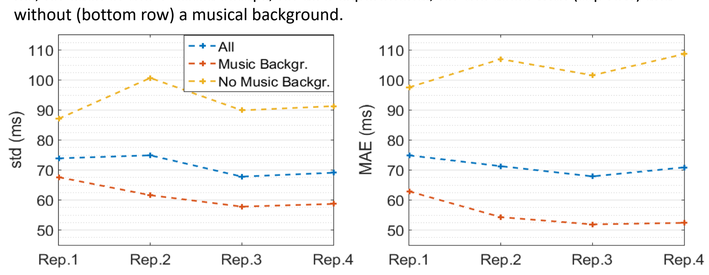
Results and Discussion



Average standard deviations (std) of the intervals between successive user hits and average mean absolute errors (MAE) between recorded and dictated successive user hit intervals, in ms, for each of the 4 tested setups, for all 3 experiments.



Average standard deviations (std) of the intervals between successive user hits and average mean absolute errors (MAE) between recorded and dictated successive user hit intervals, in ms, for each of the 4 tested setups, for all 3 experiments, for the users with (top row) and without (bottom row) a musical background.



Average standard deviations (std) of the intervals between successive user hits and average mean absolute errors (MAE) between recorded and dictated successive user hit intervals, in ms, averaged over all three experiments, ordered by repetition.

• **In general**, the presence of **audiovisual feedback** does help in maintaining the required rhythm patterns.
• **Comparison between auditory and visual feedback**: while the **auditory feedback** helps in all experiments, the **visual** helps mainly in the second (that requires hand/eye coordination due to usage of both hands) and the third (that involves a number of rhythmic changes).
• **Effect of musical background of the users:** The improvement in the scoring metrics in existence of the audiovisual feedback is significantly more prevalent in the set of **users without musical background**, especially in the first two experiments – those **with a background in music** are more assisted in the more challenging third experiment.
• **Effect of repetitions:** Trend improvement of the general results if we order the results for every experiment **by repetition** (regardless of the feedback setup used in each case), more profound for the users with a musical background.

References

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