Assisted Piano Pedagogy through 3D Visualization of Piano Playing

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Abstract – **Having a correct posture at the piano requires a lot of practice to master; however, a visual feedback can help students realize potential problems and adopt a better position when playing the instrument. This paper discusses an innovative application of the techniques used for the 3D visualization of piano performances in any possible view, with the purpose of comparing them to an ideal piano playing. It includes the capture and reconstruction of the 3D motion and posture of a professional piano player so that it may be compared against the posture and movements of students, by overlaying 2D videos of their recital. Issues with respect to displaying data and adding useful interface features are also discussed. The motion can be adjusted to fit measurements of anthropometrical different students, so that learners can see themselves and better understand what position they should adopt while they are at the piano.**

Keywords – motion capture, 3D visualization, piano pedagogy, piano posture, visual feedback

I. INTRODUCTION

Piano Pedagogy is the field which refers to the interactions between an instructor, a student and a musical instrument with the objective of the instructor teaching the students how to properly play the piano. These interactions are quite diverse and consist of verbal communications, auditory perception, visual demonstrations, physical interaction and an instructor's feedback based on audio and visual inspection and verification of the student's performance. In the last few years, the field of piano pedagogy has gradually been opening up to innovative advancements in technology in order to enhance the learning experience.

In recent years, video cameras have entered many music studios in order to support and facilitate the various interactions coming into play during a music lesson. Newsletters for piano teachers have regular columns on technology [1] with titles such as "The Video Camera: A Teacher's Best Friend". Teacher training manuals [2] devote whole chapters to new technology. It is now certain that the video camera and the advancement of technology have expanded the traditional piano teaching approach by enriching and diversifying the teaching tools available [3].

Professional piano teachers still rely extensively on visual observation of posture and gestures to help their students improve their performance. Experts in piano pedagogy are recognizing more and more the benefits of using visual technologies to monitor the upper and lower parts of the body, arms, and hands of piano students during live performances [4]. Such monitoring can assist piano teachers and students in evaluating piano playing more efficiently, either in real-time through instant replay [5, 6] or in delay-time through post-analysis of the performance [7].
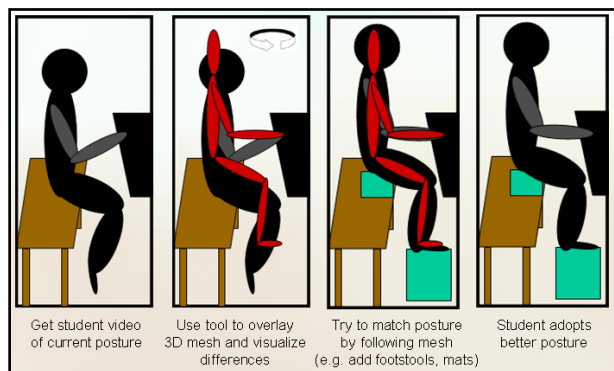

Figure 1 – A video shows incorrect body alignments of a student. By overlaying the 3D mesh of a proper posture, the student is able to visualize the mesh in any view and adopt a better posture at the piano.

In recent years, we have witnessed significant advancements in human-computer interfaces and interaction capabilities. In addition, advancements in 3D video technology, motion capture (MoCap) and Virtual Reality (VR) have led to a richer user experience and discrete analyzable interaction between humans and computers. So far, to our knowledge, no research has attempted to use the playback of motion capture data from professional players for piano posture lessons. It is the aim of this research project to come up

with creative methods that will provide the piano instructor and the piano student with a rich and unprecedented experience in understanding correct piano postures with the support of a 3D reconstruction model.

As shown in Figure 1, the idea of the project is to provide a tool that when used, relevant posture suggestions can be determined by comparing the student posture on video, with a 3D mesh representation of the proper posture. The tool helps the user visualize these differences in posture and once they have been observed, the student may proceed to make the necessary adjustments [8].

Existing research has shown that learning from self-observation through video has positive effects on a learners' skill acquisition and that video playback can support cognitive processes. This 3D pose information augmented project builds on this research to develop a tool to be used in a user friendly way during a piano lesson. In a particular scenario, a student's performance is recorded during a piano lesson. Through its replay, the teacher and the student can then analyze body postures and movements by comparing them with a superimposed 3D mesh of a correct posture.

II. 3D FEEDBACK OF AN IDEAL PIANIST

The project includes a set of areas that deal with different technologies utilized on this approach:

A. Motion Capture: method for cleaning and reconstructing the captured data, minimizing errors caused by missing information, reconstruction of the skeleton and its conversion to proper BVH format.

B. Features and User-Interface: deals with the display of the BVH skeleton and 3D data, overlay of AVI videos, and the implementation of additional features to the interface.

A. Motion Capture

A VICON MX 3D Motion Capture System [9] was used to record the posture and movements of a professional piano player. The system consisted of eight infrared cameras which captured the 3D position in space of the reflective markers positioned along the body of the pianist. As shown in Figure 2, there were on average 79 markers across different trials in order to record the position of relevant body components. Trials included drop and rolls, slurs, legatos, staccatos and scales. Taking into account MoCap reconstruction requirements, markers were positioned following the educational advice of a professional musician and Eutony therapist.

The captured data goes through a labeling and cleaning process. That process includes fixing broken trajectories, removing flickering, crossovers, and phantom markers caused by noise, minimizing clothe movements as well as errors in camera calibration. A low-pass filter is used to block unwanted high-frequencies that represent spikes in the trajectories.

The skeleton is reconstructed using a VICON anatomical converter that notes the position of the markers and estimates the position of the skeletal joints. The output of this reconstruction is a set of ASF/AMC motion capture files, in which the ASF file contains the skeletal information while the AMC file contains the motion information. Using Autodesk | Alias MotionBuilder [10], these files are subsequently converted into a BVH format that encapsulates the ASF and AMC data into one file.
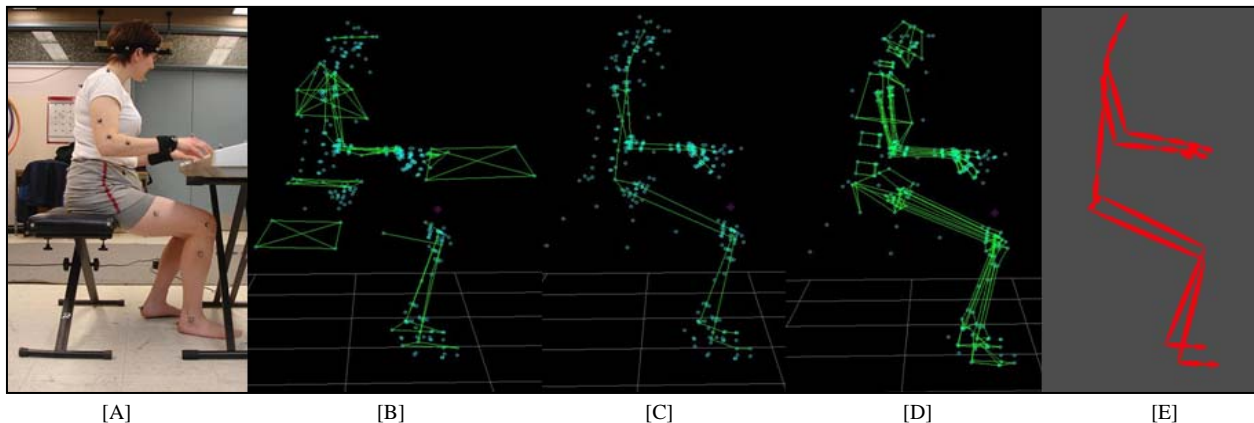

| [A] | [B] | [C] | [D] | [E] |

Figure 2 – [A] Data is acquired via Motion Capture System. [B]Markers are cleaned and labeled. [C] Anatomical converter estimates joints. [D] Skeleton is constructed with its hierarchy in ASF/AMC format. [E] Data is converted to .BVH to use with tool

B. User-Interface

1) Display of BVH skeleton and 3D data

Figure 3 provides a sample BVH format hierarchy. This ASCII file is easy to read and it is supported by many motion capture devices on the market. This format can store motion for a hierarchical skeleton. The motion of the child bone is directly dependent on the motion of the parent bone. In this sample, the bone "Hips" is the root of the skeleton. All other bones are children of the bone "Hips". The rotation of the "LeftHip" is added to the rotation and translation of the root "Hips", and so on. At the beginning of the BVH file, the skeletal hierarchy is described by using matching opening and closing curly brackets. After the last curly bracket, the motion data is presented.

BVH files can be loaded onto an MFC/Open GL application from the Game Developer Magazine [11] that keeps track of the loaded bones, their movements and their displays into the drawing scene. The application source code is expanded and modified in order to incorporate the relevant features of the project.

```
HIERARCHY
ROOT Hips
{
    OFFSET 0 0 0
    CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
    JOINT LeftHip
    {
        OFFSET 3.5 0 0
        CHANNELS 3 Zrotation Xrotation Yrotation
        JOINT LeftKnee
        {
            OFFSET 0 -13.4 0
            CHANNELS 3 Zrotation Xrotation Yrotation
            JOINT LeftAnkle
            {
                OFFSET 0 -16.8 0
                CHANNELS 3 Zrotation Xrotation Yrotation
                End Site
                {
                    OFFSET 0 -5.23376 0
                }
            }
        }
    }
...
}

MOTION
Frames: 19
Frame Time: 0.0333333
0.00 68.1698 0.00 0.91267 ...
...
```

Figure 3 – Sample BVH file

2) Overlay of AVI videos

The implemented framework for this project incorporates an OpenGL rendering scene in which a plane is drawn on the background of the scene. 2D videos in AVI format captured at the piano studio are edited, resized and texture mapped into the plane. In addition, frames are loaded and played back to the user. This feature enables the user to appreciate the difference between the captured video and the 3D mesh that is rendered on top of it.

3) Skeleton Individualization

Not all students have the same body lengths and proportions; therefore, the tool provides a way to edit bone lengths on-the-go and adjust the body size of the 3D mesh to that of the video. Each bone is labeled and identified with a unique number that can be referenced through the interface. This permits each skeletal bone length to be adapted according to the user's needs.

Since the BVH skeleton is organized in a structural hierarchy, modifications to the length of a parent bone will automatically update the relative 3D position of any children that the modified bone may have. These length modifications can be saved as a new BVH skeleton file that is particular to an individual person. As a result, these new generated files can later be reloaded and re-used for new individual comparisons.

4) Additional features

In case of the mesh occluding parts of the video, setting transparency values permit users to adjust the opacity of the mesh so that they are able to see-through the representation. Custom video loading permits the user to browse and select a particular video for the purpose of posture comparison. In addition, custom animation loading permits the selection of different BVH files that contain different piano performances.

Since pianist students may be wearing different color of clothes every time a video is taken, the color of the mesh is also changeable as to avoid confusion in colors when overlaying the 3D mesh on top of the video. The type of the mesh can also be toggled from a wired to a solid representation based on the user's choice. In addition, a "Lights ON/OFF" feature activates the OPENGL glEnable(GL_LIGHTING) command in order to toggle between focus on the video and focus on the mesh.
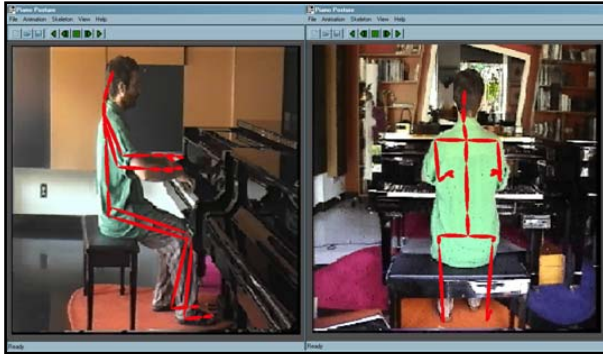
III. RESULTS

Figure 4 – The red mesh corresponds to the motion captured data that is overlaid on top of an AVI video captured at the Piano studio. The mesh can be seen from any possible angle, (e.g. side, diagonal, back, top views)

As discussed earlier, building on existing research has shown that learning from self-observation through video has positive effects on a learner's skill acquisition and that video playback can support cognitive processes. In early stages of experimentation, a right angle on the hips-leg-knee alignment was assumed for a particular pianist. However, the use of this tool helped us to realize that the posture in this joint alignment actually presents a slight decrease on a right angle due to pianist comfort.

The ability of the tool to reposition the mesh 360 degrees on each axis permits the user to explore the different views of the mesh in order to analyze the proper posture to adopt at the piano. For instance, as shown in Figure 4, the user is able to evaluate the posture from the back view and the side view. It enables zoom in/out to focus on particular joints and body alignments for better visualization.

IV. CONCLUSION

The capture of a proper body posture at the piano, through the use of motion capture systems, can provide quality information to students who want to enhance and correct their position when playing the instrument. In this project the capture and reconstruction of 3D individualized skeletal information was displayed through an interactive user-interface that permits the comparison of piano postures in any possible 3D angle.

The idea of using MoCap technology to capture posture data and impose it above a range of available studio videos proves an innovative application to enhance and offer an extra pedagogy tool for piano teaching. Future work on this project would include user studies such as experimentation in the piano studio with students. This could be a launching point to numerous future experiments including: user studies to compare multiple experts to see if there is indeed a common posture that experts use; studies to learn if posture is dependent on the specific piece of music being performed; studies to learn whether student posture is improved using the system; and, implementation of visualization techniques to aid in discerning differences between student and expert.

REFERENCES

[1] The Piano Adventures Teacher (December, 2003). FJH Pedagogy Newsletter.

[2] Baker-Jordan, M. (2003). Practical Piano Pedagogy: The Definitive Text on for Piano Teachers and Pedagogy Students. Los Angeles: Warner Bros. Publication.

[3] Ruippo, M. (2003). Distance learning in music. Music Education Online. 1-8. Available at http://www.2.siba.fi/aluekehityshanke/tiedostot/raportit/musiceducationonline.pdf

[4] Comeau, G. (2004, March). *New Technologies and Cognitive Sciences: What Have They To Do With Piano Teaching?* Paper presented in the ORMTA Series, Ottawa University.

[5] Comeau, G., Payeur P., Keillor, E., Desjardins, A., Bresler, N. (2004, September*). Challenging 300 years of Piano Teaching Practices with 21st Century Technology – Piano playing-related health problems.* Symposium conducted at the Canadian Medical and Biological Engineering Society. Quebec.

[6] Comeau, G., Brooks, M., Spence, J. (2004, February). *Visual- and Broadband-Mediated Learning, with Special Emphasis on Music Education.* Conference on teaching, learning and technologies, McGraw-Hill Ryerson. University of Ottawa.

[7] Available at http://www.MusicGrid.ca

[8] The Balanced Pianist. Available at http://www.balancedpianist.com/bpseatingguide.htm

[9] VICON Motion Systems. Available at http://www.vicon.com

[10] Alias|Autodesk MotionBuilder. Available at Autodesk.com

[11] Lander J., Thoresz, K. (1998, January). Game Developer Magazine. *Companion Source Page. Darwin 3D*.