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Color of Rhythm – A 3-D Visual Representation

Lin Wang[1], Rongkai Guo[2], Peng Lu[3] and Ping-Sing Tsai[3]

[1]Health & Kinesiology Department, University of Texas-Pan American, U. S. A.

[2]Computer Science Department, University of Texas at San Antonio, U. S. A.

[3]Computer Information Systems, and Quantitative Methods Department, University of Texas-Pan American, U.S.A

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Abstract. Rhythm is needed for all coordinated movements to be performed accurately and, without exception, sports skills are considered rhythmic in nature. Mature motor skill patterns have a definite stable rhythmic structure. Of all sensory systems, vision alone provides human beings with more than half of the information. Contrary to the fluidity of rhythm itself, static images, such as charts and figures have been used to illustrate the limited visual representations of rhythm. Present study explored the possibility of creating a 3-D visual representation of color-coded rhythm.

Keywords: Rhythm, visual representation, 3-D

1. Introduction

It was the beginning of the school year: Joe and Maria signed up for badminton class. Having the experience of quickly learning to under-hand drive and over-hand attack a shuttlecock, they expected to make progress in mastering the skills easily. After the instructor demonstrated to the class what a proper under-hand drive and over-hand attack looked like, Joe and Maria practiced the skills themselves with a racket. Maria performed powerful drives and attacks that send the shuttlecock far to the other end of the court; however, Joe was having a very difficult time getting the shuttlecock where he would like for it to be. Instead of generating great drives and attacks like Maria did, Joe seemed to have trouble in making the swings powerful. As he continued to have trouble with the rhythm of both under-hand and over-hand swings, he became frustrated, making it difficult for him to enjoy the exercise.

Why is it the case? Joe missed the rhythm, the critical piece of information needed to reproduce any motor skill correctly and to generate a powerful swing. Unfortunately, finding information on how to teach/learn the badminton swing rhythm (or for that matter any motor skill that requires rhythm) is surprisingly difficult.

1.1. What is Rhythm?

Rhythm is needed for all coordinated movements to be performed accurately and, without exception, sports skills are considered rhythmic in nature [3]. Mature motor skill patterns have a definite stable rhythmic structure; this includes swimming, hurdling, juggling, volleyball spiking, and piano playing. For example, in swimming, the arms and legs move rhythmically in all strokes to propel the swimmer forward; moving arhythmically is inefficient and slows down the swimmer. Additionally, professional athletes turn high-level performance into art by demonstrating the beauty of being rhythmic. In some cases (e.g. dance, gymnastics), students' abilities to move rhythmically are set as goals to achieve. However, no information on how to teach the rhythmic component is mentioned directly in the literature. Information on enhancing relative timing can only be inferred from studies examining the effectiveness of a generalized motor program (GMP). Furthermore, such evidence on methods to enhance relative timing acquisition has not been tested extensively in practical settings [12].

1.2. Why is Rhythm a Critical Piece of Information for Motor Skill Acquisition?

The unique rhythm associated with one particular motor skill or shared by a group of motor skills is considered one of the key proponents of motor schema [9]. Even researchers holding contrasting thoughts on how motor skills are acquired agree on the vital meaning of the rhythm of the skill as an attractive state for

movement pattern organization. As stated by Schmidt and Lee [9], the temporal pattern of a motor skill (rhythmic component of the skill), serves as a marker and separates one motor skill from another. For example, although both are even rhythms, a rhythm needed for walking can be considered very different from a rhythm needed for jogging when the speed is concerned. Rhythm needed for these two skills is even more different from an uneven, a rhythm needed for galloping. Some sport skills have similar temporal patterns, such as the swing pattern of a volleyball spike and the serve in tennis. Thus, when one is mastered, mastery of the second follows with ease. Not until one can perform a motor skill with its unique rhythm can he or she be confident about mastering the skill.

1.2.1 Relative Timing and Rhythm

Relative timing is the theoretical concept that corresponds with rhythm. Relative timing inclusively refers to the relative ratio of timing components of a skill [11]. To illustrate, let's look at the rhythm of walking. The alternative pendulum motion of the two steps is equal, making the relative timing of walking a 1:1 ratio. Relative timing has been analyzed in theoretical experiments by having participants perform similar movements such as finger tapping with the target goals of 1500ms (from the first point to the second point) and 750ms (from the second point to the third point), making the relative timing a 2:1 ratio. Relative timing is proposed in Schmidt's Schema Theory as one of the invariant features that distinguish one category of movement from another [3]. In an effort to explain how motor skills were controlled and executed, Schmidt's schema theory has received the most attention and has been explored in a number of empirical studies from different disciplines [12].

Temporal structure, relative timing, or phasing, is the marker of motor patterns supported by studies conducted to help researchers find ways to facilitate effective learning of motor skills in the laboratory and in practical settings [11]. Frank and Stanley [4] used computer-generated waveform tracking was chosen as the task to examine what is learned during motor skill acquisition. Results of the study supported the notion of "invariant relative timing" among the content acquired. Similarly, Hay and Schoebel [6] used the track event hurdles to examine the temporal invariants concept in a real world activity. With empirical support of relative timing as one of the invariant features learned though practice, it was proposed that mastering the rhythmic component (or relative timing) of a skill is a critical step toward skill acquisition [14].

1.2.2 Visual vs. Auditory Model of Rhythm

Bandura [1] identified two different modalities of observational modeling: visual and auditory. This classification helped distinguish information conveyed through modeling. O'Connor and Hermelin [10] pointed out that spatial information (relative positioning), temporal information (duration and sequence), and strategic information are the three aspects of information content that can be transferred by observing a model. Information transferring efficiency enhances when the presented model correspond with the sensory receiving modality. McCullagh, Weiss, and Ross reported that visual modeling conveyed spatial information whereas auditory modeling transferred temporal information [9].

Relative timing, relative ratio of timing components of a skill [11] a theoretical term from the Generalized Motor Program theory is used interchangeably with the term rhythm in the applied fields. Learning of relative timing was found to be facilitated by providing an auditory model [2,5,7,8,13,15,16,17,18]. Auditory modeling has been a relatively ignored area of investigation compared to visual modeling [7]. Limited in numbers, investigations on auditory modeling have been primarily conducted in laboratory settings and even fewer studies included real world sport skills.

1.3. Visual Representation of Rhythm

In rhythm learning, which sensory modality is more efficient? Sensory modality used to deliver information related to rhythm has been inconsistent [10]. Some researchers claimed visual model as the efficient one while others argues that auditory model needs to be used.

Let's take a closer look. Rhythm, a marker of movement pattern [11], is associated closely with formation of such movement pattern, similarly to its relationship with the composing of a piece of music. When a piano instructor teaches a student to replicate a whole note, he/she often says, "Listen to this, 2-3-4, 4 beats". A physical educator or a coach may say, "Your swing was fast to begin with and slow towards the end. It should be backwards". Both scenarios are referring to the formation correct rhythm/timing.

Sound from a movement (i.e. piano note playing, water splashing sound from swimming, etc.) is the easiest catch of a specific rhythm. What sound characteristics can be used to determine mature level of a movement? Is it true that larger the sound better the technique? Is it true that longer the sound better the

technique? Where should the largest sound be located? Taking badminton as an example, the swish sound of the moving bat tells a lot about one's technique. Matured badminton bat swinging has the following sound characteristics: longer the continuity better the swing, changing pitch of the sound better the swing and the highest swish sound needs to appear towards later of the continuity. Sound provides an easy tool for teachers and coaches when performing their daily job of compare mature versus immature movement patterns.

Of all sensory systems, vision along provides human beings with more than half of the information. All students favor presenting a visual. Literature search has found limited visual representation of rhythm. Contrary to the fluidity of rhythm itself, static images, such as charts and figures have been used to illustrate the limited visual representations of rhythm. A 3-D visual representation of rhythm is in need to reflect rhythm with its special characteristics. By providing various representations (in both visual and auditory format) of rhythmic components of a skill (whether the skill be baseball hitting, volleyball spiking, swimming, dancing), learners at different levels, ages, cultural background could associate themselves with the mode that accommodate their learning style and master the to be learned material.

Purpose of this project is to explore the possibility of providing a 3-D visual representation of rhythm to assist related skill acquisition process. Based on characteristics of certain sound that a movement creates, a visual representation of such rhythm is provided to learners.

2. Proposed Methodology

Two systems were used to design and develop a 3-D visual representation of rhythm under the Ubuntu operating system. One of which was an audio processing system, and the other a visual representation generating system.

Java programming language was used to develop the sound processing system, called "sound capture"(Fig 1).

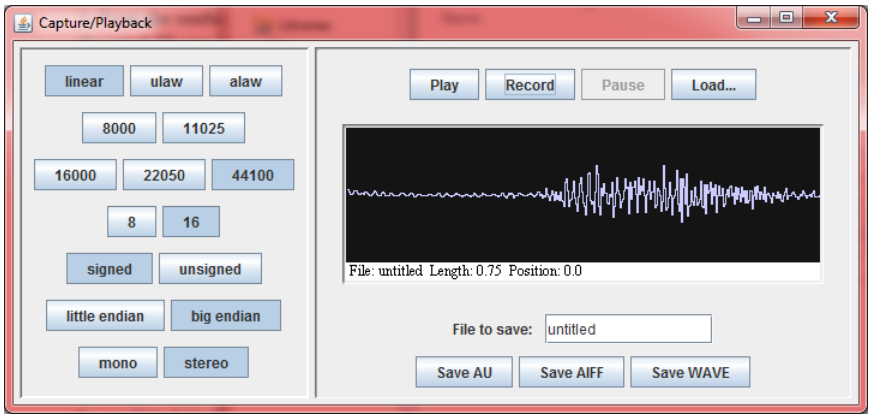

Fig1. Sound Capture

This revised software was developed by Sun Microsystems, Inc. It contains four components, which are a juke box, a capture/playback tool, a Midi synthesizer tool, and a groove box. But the capture/playback tool is the only one needed for this project. It can be used to load audio files such as those files with the extension names of .wav, .au or .aiff, and draw a wave form for the loaded file. User can also record any sound by this tool by click the "record" button. When a recording action is successfully completed, a wave form will be displayed by the tool as shown above. This tool has been modified based on the a non-exclusive, royalty free, license to use sample code (http://www.java.sun.com) provided by Sun Microsystems. A new function outputting all of the information of either a loaded audio or a recorded audio to a text file was added, because all of those data will be used to generate a 3-D graphic by the other system. This text file is used as a shared data file between the two systems.

Second section of the translation was to use python (free to use Python Programming Language from http://www.python.org) and vtk (an open source visualization Toolkit from http://www.vtk.org) draw the diagram to demonstrate audio files. As mentioned before, this component actually reads in two data files stored from last section, and uses it to draw two cylinders to demonstrate the rhythm of the audios. The first data file is a sample data file which is recorded a performance by a professional player and saved as a standard data file. The other one could be any related data. The cylinder shape was chosen as the visual representation due to its length compared to other choices like cone or cube. A color range scheme was

added to strength the visual representation, green represents the quite times, blue represents lowest volume of sound, and red represents peak value of the sound. 200 individual cylinders were used to represent the rhythm in 1 one second. Thus, the result includes two cylinders close to each other in one screen; as a result, users could analyze the audio not only by the visualized 3-D graphics but also by the comparison with the sample data.

3. Results

Badminton swing, under-hand or over-hand, is a technique easy to mimic. However, it's not easy to make the swing powerful. Rhythm of this technique is the key to a prevailing swing. Make rhythm of a badminton swing visual provides insight to the learning of such swinging techniques. The present project tried to interpret rhythm through color coded visualizations.

Here are the results generated. The cylinder on top (a 3-D visual representation on a computer screen) is visual representation of a standard one ecorded in a quality environment (without noticeable background noise) from a matured badminton player. In other words it is visual representation of a powerful over-hand swing. The cylinder on the bottom is a visual representation of an immature badminton over-hand swing. For a person knowing very little about badminton, he/she can tell the difference between the two swings easily.

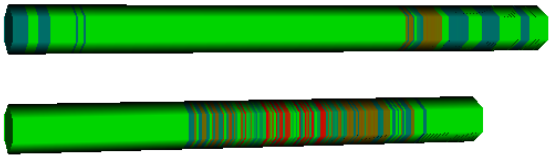

Figure 2: Colored cylinder visual representation of swing rhythm

As the 3-D visual representation illustrated the cylinder on top shows a well prepared attack swing. With a nice and slow beginning transition, the player was able to generate the power needed at the perfect moment which is towards the later part of the spike. This way the player was able to hit the shuttlecocks in an efficient way with full of power he generated. Let's look at the cylinder on bottom. As we can see from the color change, the second swing actually had more power (with more red pieces in the diagram). However visual display was not able to let us know when the player hit the shuttlecock, meaning it was not as an efficient way to swing because the player tried to generate force too early and the process was too long to be efficient. In other word, visual display on top had the right rhythm, but the one on bottom did not.

4. Future Works

There are software and equipments now in the market that helps motion analysis by analyzing videos (VICON, DARTFISH, etc.). All of the analysis is required to be completed by experts. We know video equipments are usually big, and users need good computers to do the video analysis. In addition, analyzing video can be a time consuming task. It takes away the critical feedback providing time from the learners that's usually a few seconds after the completion of a movement.

If an audio resource can be used to assist the analysis, the whole process can be done with greater efficiency. There are more audio equipments available now and all of them are portable devices. People can choose from cell phones, MD, mp3 players with recording feature, digital recording devices, PDAs, etc. The process of audio analysis may be completed in the same device. For example, some of the cell phones are extremely powerful such as Smartphone, pocket PC, or people can use PDAs. Those devices have enough capability to do the audio analysis, and it won't be slow. This means if people have one of those devices and have the designed software that this project proposed, they can perform the analysis themselves and find a better way to learn and train immediately. More research is called upon to explore the efficient and cost-effective means of conducting task analysis, whether it be accomplish audio analysis, or combine the audio with video.

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