Sound Feedback for Powerful Karate Training

Masami Takahata, Kensuke Shiraki, Yutaka Sakane, Yoichi Takebayashi
Faculty of Information, Shizuoka University
3-5-1 Johoku, Hamamatsu 432-8011 JAPAN
{cs9054,cs7044,sakane,takebay}@cs.inf.shizuoka.ac.jp

ABSTRACT

We have developed new sound feedback for powerful karate training with pleasure, which enables to extract player's movement, understand player's activities, and generate them to sounds. We have designed a karate training environment which consists of a multimodal room with cameras, microphones, video displays and loud speakers, and wearable devices with a sensor and a sound generator. Experiments have been conducted on ten Karate beginnners for ten months to examine the effectiveness to learn appropriate body action and sharpness in basic punch called TSUKI. The experimental results suggest the proposed sound feedback and the training environments enable beginners to achieve enjoyable Karate.

Keywords

Sound feedback, Karate, Learning environment, Wearable device

1. INTRODUCTION

Various functions of sound are installed in daily devices such as a cellular phone and a digital camera, and become lifestyle-oriented entertainments. Many researches applying sounds to human activities in large fields such as sports, entertainments, learning environments, welfare have been conducted[1, 2, 3, 4, 5, 6].

We intend to realize a learning environment of Karate[7], which beginners can easily participate in and deeply learn from, by using sounds. The environment enables the beginners to learn how to use their body which are said to be important by basic practice of karate through sounds. Beginners can also learn deep tactics in karate by describing them as sounds.

To realize this, it's essential to understand each movement of trainees by analyzing sensor data which reflect each motion. We have been developing a new learning environment which can sense complicated motions and strategy in a match, and creating a model of karate. Based on this model, we design a new environment of learning karate by generating sound feedback.

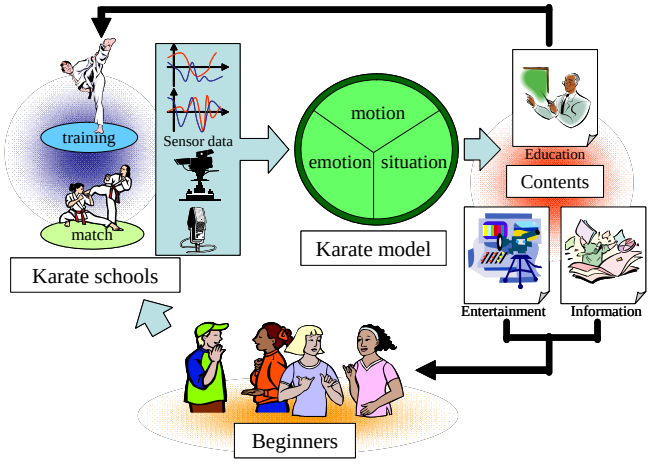

Figure 1: The concept of the ubiquitous karate

2. FUSION OF KARATE AND MUSIC

Establishment of the HENZAI style karate club

Figure2 shows a training scene of the HENZAI style karate club. ' HENZAI ' means ' ubiquitous '. Installed in the hall are 8 sets of speaker, 8 cameras built in them, a camera with a wide-angle lens which can take pictures of the whole room, and a 50-inch screen which can display contents.

Figure3(the upper) shows a free curved surface mirror camera placed in the hall. The images reflected in the downward-looking mirror on the ceiling are captured by the upward-looking camera. The obtained camera images are analyzed and the locations of the players in them are calculated. Figure3(the lower) shows the location information on the computer screen. The system can performprocessing which extracts players from camera images by 30 frame/sec, and store the data into a database.

The Sound Feedback Device

The sound feedback device we propose makes it possible to measure the acceleration of each part of trainees' body and generate sounds in real time. The sound feedback device enable to measure the acceleration of each part of trainees' body and generate sounds in real time. This device also makes it possible to measure karate motions and give trainees sound feedback.

Figure4 shows a sound feedback device put on a wrist. This

Figure 2: The ubiquitous karate school

device is equipped with the 2 axis acceleration sensor (ADXL202) by Analog Devices, Inc, a sound generator LSI (ymz294) by YAMAHA CORPORATION and the micro processor (PIC16F876) by Microchip Technology Inc. The sound generator carries the three sequence square wave generator, the noise generator, and the envelope generator which function in accrodance with the set parameters. This allows for the generation of music, special effects, warnings, and various others types of sounds. The volume level is controlled for each of the three channels (A, B, and C). The output range of the acceleration sensor is from -2G to +2G. The sensor data obtained from the acceleration sensor are controlled by using the micro processor. The micro processor is generating the parameters which controls the sound generator. The analogue data obtained from the acceleration sensor are converted to digital data by using the micro processor, and the digital data are output through the RS-232C port.

Onomatopoeia Expression by Sound

In sport training, instructors often use vague words or senses which their students cannot understand intuitively.

When those expressions or senses are difficult to understand, beginners become puzzled and begin to think, “I can understand and do it almost correctly, but I feel some difference present which I have not acquired. What should I do?” Onomatopoeia is a typical example of this[8, 9, 10]. There have been several researches on onomatopoeic expressions and their meanings[8].

In the field of sports involving complicated motions, onomatopoeic words and phrases are considered to be effective to abstractively express the images of what instructors have in mind. But for beginners, they are too vague to understand in many cases. For example, when an instructor says to his or her beginner trainees, ”Gutto chikara-wo irero (meaning ”With all your strength”)”, they can imagine what the onomatopoeia expression gutto means, but can’t understand what to do in actual training.

Figure 3: Positions of the players

In the ubiquitous karate environment, training images can be shown as music or sounds instead of onomatopoeic expressions.

Musical Rhythm Training

There is a report which describes the effectiveness of the musical rhythm training in sports education[11, 12]. Sanborn and Wyrich (1969) reported the balance ability to be related to speed, agility and rhythm.

The martial arts are no exception, and trainees who have a sense of rhythm improve in karate much more quickly than those who do not[13]. Rhythm is defined as the movement characterized by the regular recurrence of strength and weakness.

Figure5 shows the motions of the right wrist and the waist when a trainee TSUKI with the motion devices. The horizontal axis of the graph is the time (msec) from the experiment start and the vertical axis is the acceleration (G) obtained by the devices. Plotted in the graph are the acceleration data of the anteroposterior direction of the wrist and the rotation direction of the waist.

If we note the data near 2,000msec of the beginner(a) and the expert(b), we can find the differece between them in the peaks of the timing of the waist rotation and that of the wrist movement. In the case of the beginner, the values of the 2 peaks are almost the same. In the case of the expert, on the other hand, the peak of the wrist movement is about 100msec behind that of the waist roation. This delayed action is equivalent to the action of pooling power for a heavy TSUKI.

Such small time lag is very difficult for beginners to adjust.

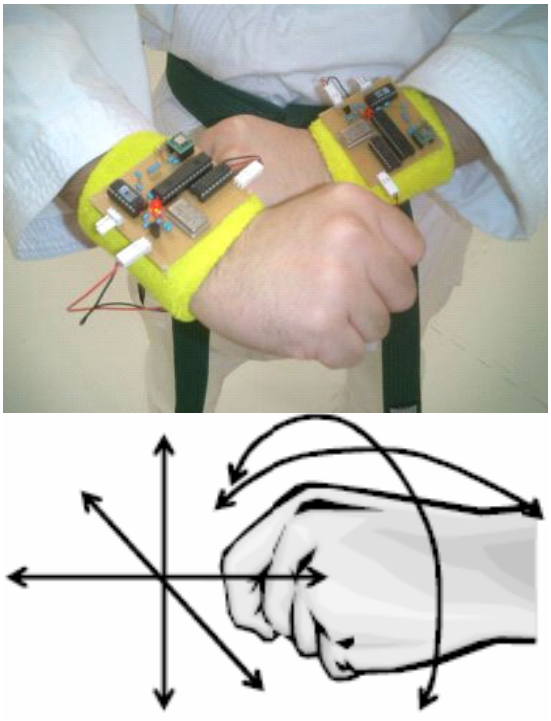

Figure 4: Sensor devices for karate

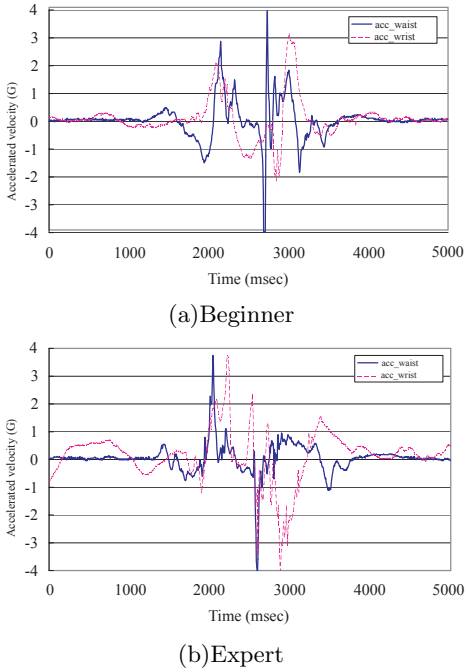

Figure 5: Motion data of the waist and a wrist

In the ubiquitous karate environment, however, the musical rhythms of trainees' motions are properly controlled, which leads to learn karate rhythm effectively.

Some studies reported the following relationships between rhythm and exercise[14, 15, 16].

(1)The exact time order of music leads to steady exercise, and enables players to keep speed, duration, feeling, and timing of their movements.
(2)Group actions are adjusted easily by synchronizing power with breath.
(3)Rhythm tends to induce a synchronous reaction (to man).
(4)Rhythm controls body activities as the element which carries out minimization adjustment of power consumption.
(5)Physical rhythms make musical rhythms, and musical rhythms make physical rhythms.

Feedback for karate training

In instruction to beginners, there are several important points even in one basic motion. Moreover, it is very difficult for beginners to check the correctness of smaller motions like waist-twisting or arm-twisting on video by themselves after training. Therefore, this type of smaller motion training tends to be considered less serious. Furthermore, when beginners are willing to learn themselves, they have much difficulty checking the correctness of their own motions and often learn wrong motions or acquire the habit of moving their body incorrectly, which is very unfavorable for beginners.

In the field of sports or fighting sports, a method has often been used in motion sensing of athletes, namely, the method of attaching several markers to the appropriate positions on the surface of subject human body to algorithmically determine the 3-dimensional positions of the markers from the images captured by several video cameras[17]. Recently, the cameras which can photo at the high speed of 1000 frames per second has been developed and theirquality has greatly improved, but it is nonetheless difficult to detect the motions in detail such as waist roation on TSUKI by image processing.

Karate learners cannot check their small detailed motions, either. If they can pay attention to some of them, it is very diffucult to continue to pay attentionto the motions of their various body parts by themselves without an instructor. In that sense, we argue that sound feedback is very effective in so many different ways in karate lessons in order for trainees to pay attention to the various parts of their body and understand actual motions.

3. EXPERIMENTS

An experiment of training with music

Our 10 HENZAI style karate club members participated in this experiment. During training, we played hearing various kinds of music(Figure6). We examined the practical effectiveness of music in enjoyable training of karate, with use of musical elements (e.g. rhythms and tempos) controlled by DJ. Figure6 shows the experimental scene. This figure shows the scene in which karate trainees are practicing TSUKI to the musical rhythms created by DJ. After the experiments, we carried out a subjective evaluation by the questionnaires and the comments of free-description style.

Four of ten subjects answered that they feel the effectiveness

Figure 6: Training with music

of music, the rest are nonresponders. Each trainee has his own suitable rhythm and there were individual differences in the rhythm from trainee to trainee. Each member could move sharply and smoothly when he heard music suitable for his rhythm. Moreover, music provided us with an effect of relieving tiredness and promoting concentration on practice. We found some advantages in the use of music in karate training: good effects for trainees' movements, improvement of trainees' motivation, promotion of concentration, and so on.

An experiment of training with rhythm of motion

Four HENZAI style karate club members practiced TSUKI, one of the basic skills of karate, in the ubiquitous karate hall, equipped with the sound feedback devices on their wrists and waist. Focusing on the movements in punching, we made an experiment on the linkage of the waist and the arms, which is important for TSUKI training. To punch correctly and strongly, they need to pay attention on moving their body parts in the order of the waist, the left wrist, and the right wrist(Figure7). We examined the sounds generated by the devices put on each part of their body, and examined if they move their body parts correctly. After the experiment, we carried out a subjective evaluation by the questionnaires and the comments of free-description style.

By moving their body parts in accordance with the sounds generated by each device, the trainees could check the order of the motions and practice in their rhythm. This method is also helpful for beginners to control the rhythms of their motions and practice according to their skill levels. Furthremore, the method is valuable for beginners to enjoy learning the basic skills correctly in training as the sound feedback is generated from their body parts.

An experiment of training with sound feedback of motion

4 HENZAI style karate club members practiced karate in the ubiquitous karate hall, equipped with the sound feedback devices on their wrists. Also in this experiment, we focused on the movements in punching and made an experiment on the twists of their wrists(Figure8). As it is hard for them to get an aural instruction and understand smaller motions like

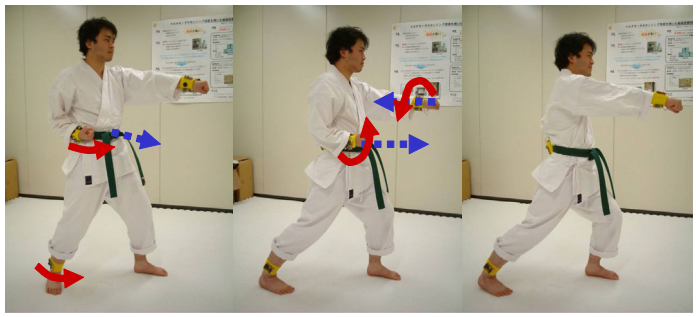

Figure 7: Basic body motion for powerful TSUKI (device put on both wrists, both ankles, and the waist)

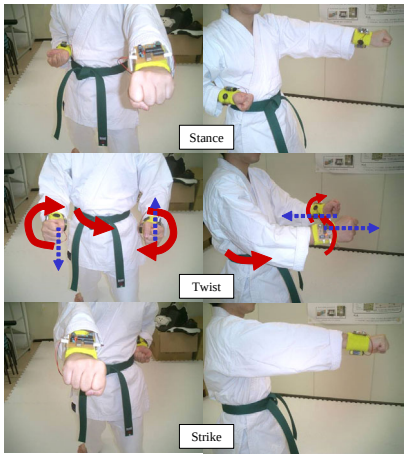

Figure 8: Twist of the wrist for powerful TSUKI (device put on both wrists, both ankles, and the waist)

the twists of their wrists, we generated sounds in accordance with the twists, gave clear feedback to them and examined if they could practice correctly. For sensing of the twists of the wrists, we measured the acceleration of adduction of the wrists and generated the sounds in accordance with the size of each acceleration. After the experiment, we carried out a subjective evaluation by the questionnaires and the comments of free-description style

If a trainee move sharply, he could get proper sound feedback. In that sense, this device was very useful as the trainee made a conscious effort to check his or her basic skills. If a trainee added excessive power, a good sound was not produced. So the trainee could practice in consideration of not only how to add power, but also of how to relieve power. And the trainees continued practicing until they could get good feedback. This means that the sound feedback system is highly effective for increasing their motivation.

4. DISSCUSSION

Karate training

Pleasure is one of the important factors to motivate sport players. Pleasure elements in sports have been researched on.[18] The positive attitude or emotion toward the achieve-

ment of a new goal is also one of the pleasures in sports.[19, 20]. According to the results of the questionnaire survey on experiment, sound feedback can be used to set up a new goal by confirm own skill improvement of karate by themselves. According to the results of the survey of the questionnaires on our experiments, we can say that the sound feedback can be used for each trainee to set up his or her new goal confirming his or her own skill improvement of karate by themselves. It is well known that feedback is necessary to evaluate skill improvement and that proper feedback increases the effectiveness in setting up a new goal. However, if too much additional information is given to learners, they tend to be lazy about processing the information, which does not lead to the promotion of learning [21, 22]. It is shown in Schmidt's experiment that it is quite useful to provide learners with additional information and aid to do something but that it also inhibits their information processing like cogitating multiple things beforehand that they should do by themselves. On the other hand, if they use sound feedback based on their own level, learners can practice at their own pace. For middle class learners, it is important to get encouraged to create new practice by themselves from the result of sound feedback. But for beginners, it is necessary to be led to get success experiences.

We got such an opinion that depending on the qualities of the practices or the characters of the learners, feedback for praise or feedback for calling attention is effective. In the present system, when a learner does a correct action, he or she gets feedback with sound. But when a learner does an incorrect action, the system urges the self solution to him or her by sound. Because of this, the system can be considered to be used as a very effective learning method in spite of some added information. We can also expect the effectiveness of the system to improve the motivation for learning in a way like "stick and carrot".

Feedback device

Too much sound feedback occurs when learners use several devices, but of course, they have a limitation in distinguishing multiple sounds. They can hear one or two sounds if the system tells their points to notice. But the more devices are used, they find it difficult to distinguish sounds by feedback. Thus they have to make clear the aim of their practice and decide the positions and sound types for feedback. In case of using several devices, the system gathers the outputs of the devices into one and feeds it back to learners.

Approach for the design of karate training environment

In experiments, we only have carried out a subjective evaluation by the questionnaires, but yet we have not carried out a scientific evaluation based on the objective data. Karate training model depends on each learner's skilled level. Thus, it is not decided that a unique karate training model. It is very important that learners understand what they should focus on and how they should practice in the situation. We actually have learned karate and evolved ourselves in the ubiquitous karate school and have designed a karate training environment.

5. CONCLUSIONS

In this paper, we have proposed a design of the ubiquitous karate environment with audio equipments and demonstrated the effective way of controlling the rhythms of trainees' motions in accordance with the musical rhythms presented during their practice. Moreover, we have shown that the effective way of motion recognition is to convert trainees' movements to sounds with the sound feedback devices which carry an acceleration sensor and a sound generator. We have been exploring the possibility of using music as "interface", and in so doing, we have presented the following prospects: (i) controlling the rhythms of trainees' body by providng them with the order and the timing of each motion, (ii) making them recognize their motions from the sounds, (iii) activating the state of their mind, for example, the increase of their concentration and motivation. In future work, we aim to design an environment for recording data about the players' motions and situations in matches, express in music powerful intractions between the players, and realize a design of the more powerful environment for karate learning.

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