Skill Level Evaluation of Motion Curved Surface Character

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Keywords: Skill Level, Microsoft Kinect, B-spline Curve Surface, Visualization, Gradient Curvature Distribution, Experts and Beginners, Correlation Diagram, Motion Curved Surface Training.

Abstract: The skill teaching/succession method is not quantitative but qualitative, which is abstract oral or gesture expression. Quantitative teaching is difficult for teacher/instructor. In previous research, Expert and beginner perform the sports and entertainment motion, and the character of the motion curved surface is analysed using Microsoft Kinect (RGBD camera). The character is the maximum curvature and surface area. However, the usage of characters is uncertain. In this research, we investigate the correlation of maximum curvature and surface area from motion curved surface in before and after training. Therefore, we visualize the different correlation of experts and beginners from the characters and the transition of the skill training.

1 INTRODUCTION

The physical motion of experts, in the entertainment, traditional ceremony, sport, engineering, is difficult to play for beginners. Then, learners/beginners are taught the skill by expert teacher/instructor, and are training repeatedly. The training method is watching and imitating the expert physical motions (Hashimoto et al., 2011). However, the teaching method is still not quantitative but qualitative, which are expressions in abstract words, onomatopoeia words, or metaphor (Fujino et al., 2005). The quantitative skill teaching is difficult to express and perform (Taki et al., 1996). Therefore, beginners cannot always imitate the same motion because of the different recognition from beginners (learners) and experts (teachers).

In conventional research, physical movements are captured and analyzed by multiple video camera movie and application (Takeo and Natsu, 2011), (Cheung et al., 2003), (Sigal and Black, 2006). However, the capture of physical movement is difficult in equipment, which should be wearing the many markers and installing the large space. Furthermore, only the movie evaluation is limited or no meaning. Therefore, the physical motion (of experts and beginner) is evaluated just a little. On the other hand, we focus Microsoft Kinect, which is a reasonable and easy operation/equipment. Kinect can recognize pictures and depth positions, and is a useful tool function and expected the application to three-dimensional (3D) measurement. Kinect can extract a human's outline and the position of the human skeletons/joints automatically. Then, angles of the skeleton and joint positions are measured (Murao et al., 2011), (Hashimoto et al., 2014). However, they can only evaluate the joint angle in time, but cannot invest the whole body motion. Moreover, the only quantitative evaluation of joint angle and extracting position may be no meaning. Namely, only joint angle evaluation is not necessary in many cases.

In previous research, we visualize a physical motion (human joint trajectory) into a motion curved surface, and extract the difference between beginners and experts (Mitsuhashi et al., 2014), (Suneya et al., 2014). Therefore, we can evaluate physical/technical skill quantitatively, and suggest the skill succession/teaching method for expert teacher/instructor. In addition, we compose the motion curved surfaces made from the multiple Kinect view, so as to track the whole joint motion in more detail, and confirm the validity of skill succession by watching skeleton motion movie and curved surface (Mitsuhashi et al., 2015). However, the exemplary motion curved surface has not been yet established for physical/technical motion, because the number of subjects is very few. Only the visualizing motion curved surface for expert instructor cannot be evaluated the skill level or the exemplary motion. Therefore, the large number of subjects and numerical tendency for motion curved surface is

Mitsuhashi, K., Hashimoto, H. and Ohyama, Y.
Skill Level Evaluation of Motion Curved Surface Character.
DOI: 10.5220/0006004304990504
In *Proceedings of the 13th International Conference on Informatics in Control, Automation and Robotics (ICINCO 2016) - Volume 2*, pages 499-504
ISBN: 978-989-758-198-4

necessary for skill evaluation.

In this paper, we create many motion curved surfaces using the previous method, and investigate the correlation of character from the motion curved surface. The character is maximum curvature and surface area. By means of expressing the diagram of the motion curved surface character, the different and tendency of experts and beginners is extracted. In addition, we investigate the transition of training effectiveness for beginners from correlation diagram.

2 EXPERIMENT METHOD

2.1 Motion Tracking Method

In this paper, the movement of the whole body in physical motion is tracked by Kinect. The trajectories of human's joints are measured by depth sensing and image recognition. Figure 1 shows the motion tracking state. Multiple Kinects are placed the height position of 1.0-1.75m and the distances between Kinects and human are 1.5-2.0m. We measured using multiple Kinect, because some joints are not tracked by occluding an obstacle or body parts oneself in large or rotating motion. In addition, the motion curved surfaces are different shape from the front view and back view, because the motion curved surface exist both the correct tracking parts and incorrect tracking parts.

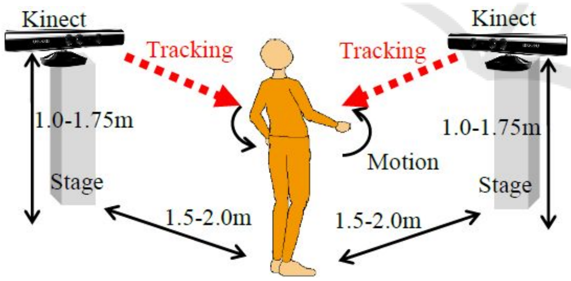
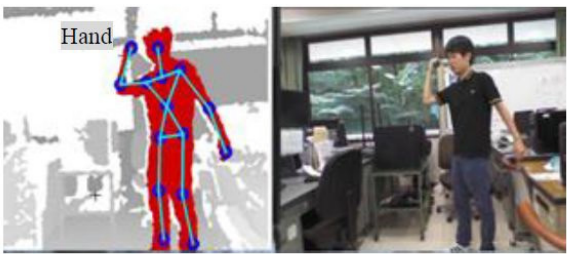


Figure 1: Motion tracking state.



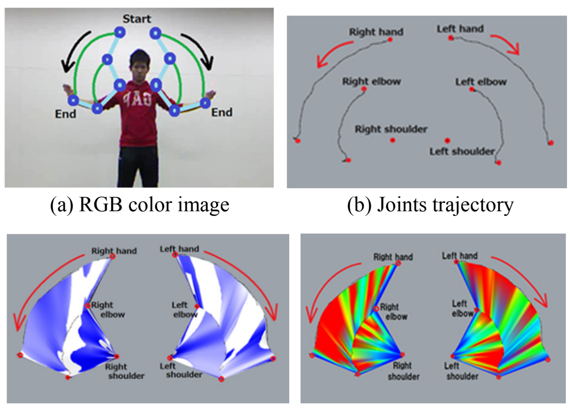
(a) Depth image (b) RGB color image

Figure 2: Kinect view.

Then, the multiple curved surfaces are composited from both correct curved surfaces. Figure 2 shows an image recognition of the user. Figure 2(a) shows an image recognition of the human. Figure 2(b) shows a depth image recognition with human joints and skeleton model. Positions of joints and skeletons are estimated by Kinect driver. Kinect can measure the position of 25 joints. Line segments in Figure 2(b) are displayed with measuring the position of the joints using the OpenCV library. Kinect programing language is C/C++ and using openNI2, NiTE2 library. A human's joint positions are measured/calculated in every 0.02 seconds with the time series.

2.2 Motion Curved Surface Visualization

The physical motion is visualized to a curved surface in the preceding section. In order to visualize a curved surface, the data of a human joint position of point cloud based on a time series is preserved, and B-spline curved surface is fitted to the point cloud by the approximation. The curved surface makes the human trajectory direction in time series, and makes the direction of joint positions, which is hand-to-elbow, elbow-to-shoulder, etc... Figure 3 shows the joint trajectories and motion curved surface when the human opens the arms and squats down. The generated curved surface calculates the area, size, normal vectors, tangent vectors, and curvatures using 3D-CAD software Rhinoceros in Figure 3. Figure 3(b) shows the trajectory of upper joints. Figure 3(c) shows the gradation display of curvature and Figure 3(d) shows the zebra mapping display. Zebra mapping is an analytical technique to visualize continuities of the curvature.



(a) RGB color image (b) Joints trajectory

(c) Gradient curvature (d) Zebra mapping

Figure 3: Visualized motion curved surface.

The motion curved surface is fitted by an approximation method. The lines are only continuous segments because the joint trajectories are discrete point cloud; that is, the lines are not enough to create curved lines. Then, the point cloud is converted to fitting curve lines by approximation methods. The approximation is the method for smoothly passing a curved line or surface through only the neighborhood of the point cloud, not through all the points. It enables to control fuzzily the occurrence of the gap and vibration of the joint trajectories by the error of the sensor or image recognition. In this paper, we adopt the approximation method, and the uniform cubic B-spline curved line or surface. B-spline surface allows for a singular point and maintaining the curvature continuity.

When the physical motions are converted the motion curved surface display, a curved surface may be twisted or overlapped. Then, the motion curved surface is divided if the angle between the standard vector and the other is larger than 180 degrees, after the first standard normal and tangent vectors are decided. Furthermore, the motion curved surface is divided also if the self-intersection on a curved surface or edge is occurring. Then, we are able to prevent a twist and overlap of a curved surface.

3 MOTION CURVED SURFACE OF SOCCER KICK

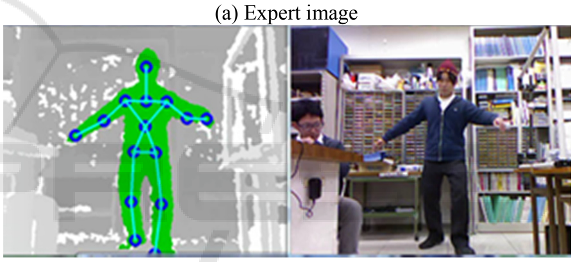
3.1 Motion Curved Surface Shape

We investigate the physical motion curved surfaces of the inside (pass) kick in soccer. The subjects are 10-year-experience expert and beginner, the number of experts is 3, beginner is 17. Subjects perform the kicking motion in the front and side of Kinects, their lower half of the body (foot, knee, and hip) is tracked. All subjects are measured two times every one week. The situation of inside kick motion in soccer is shown in Figure 4. From figure, the subjects kick in imaging pass far away.

Figure 4 (a) shows expert's motion of RGB and depth image with joints and skeletons, and Figure 4 (b) shows beginner's motion. The visualized physical motion curved surface of the expert's is shown in Figure 5. Figure 5 shows the motion curved surface with the gradient curvature distribution when the right leg is kicking. In this result, second time motion is not different from first motion. From the figures, the expert's motion curved surfaces have fanned shape, because the expert's hip motion is small and the foot trajectory is a conic arc (the foot motion is large). Three expert's surfaces (motions) are similar to other expert's surface (motion). These results are the same in zebra mapping.

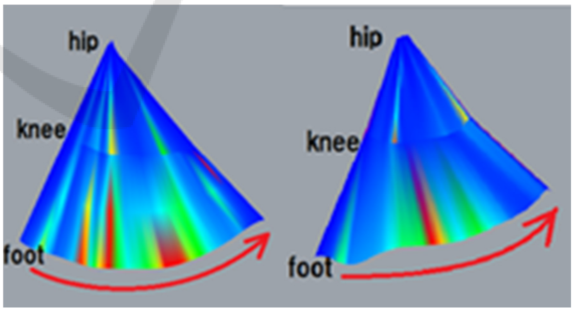
Figure 6 shows the beginner's motion curved surfaces with the gradient curvature distribution when the right leg is kicking. In this result, the beginner's motion curved surfaces have trapezoid or rectangular shape, because the beginner's hip motion is large and the foot trajectory is a straight line (the foot motion is small). All surfaces (motions) are not similar to other surfaces (motions). According to an expert's opinion, the pass ball control is bad, if the hip motion is large.

(a) Expert image



(b) Beginner image

Figure 4: Inside kick motion in soccer.



(a) 1st time (b) 2nd time

Figure 5: Motion curved surface of expert (gradient of curvature in inside kick).

In addition, stretching nee and fixing hip (waist) is most important. Learner (beginner) should kick without bending the legs. The striped zebra mapping (pattern) of the beginner's motion is heterogeneous.

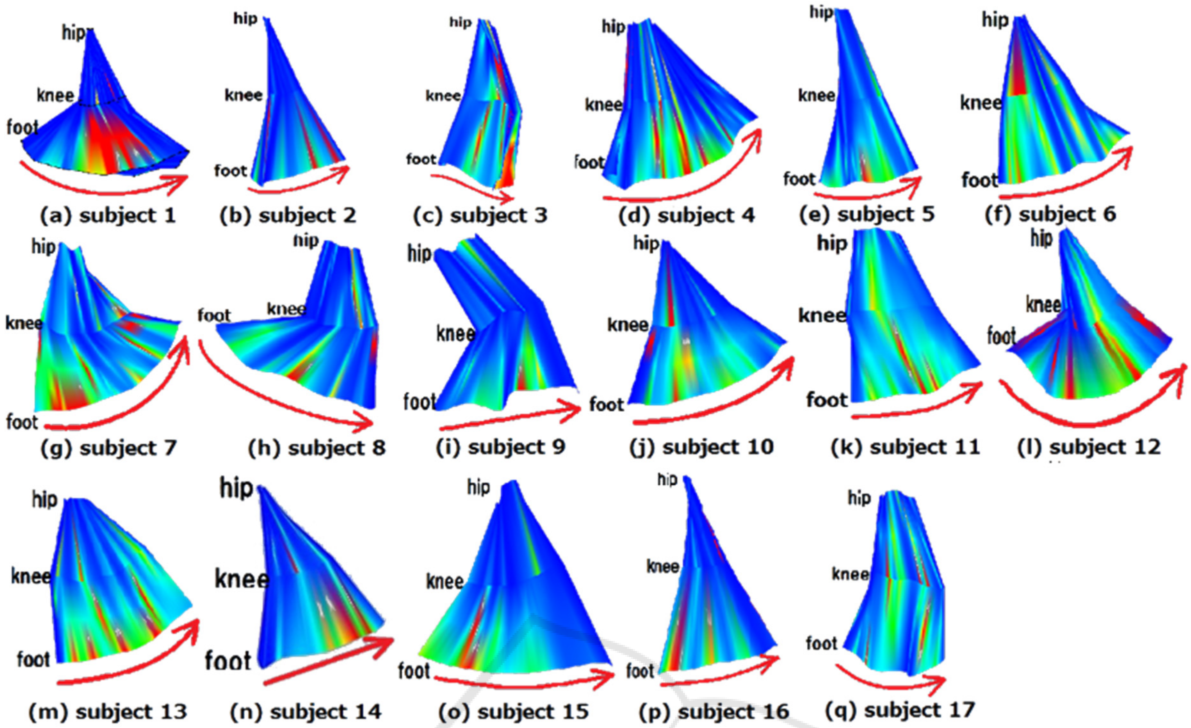


Figure 6: Motion curved surfaces of beginner (gradient of curvature in inside kicking motion).

3.2 Correlation of Surface Character

We investigate the correlation of motion surface characters, which are the maximum curvature and surface area. The correlation of the maximum curvature and the curved surface area are shown in Figure 7. From the figure, expert's distribution is gathered to small regions, that is, experts repeat the similar physical motion. On the other hand, beginner's distribution is large and varied (scattered). The beginner's maximum curvatures are large, because the leg is bent.

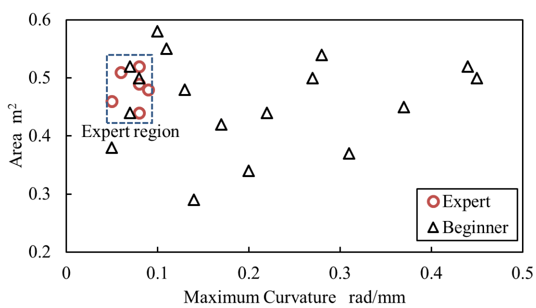


Figure 7: Correlation of motion surface character.

The beginner's surface areas are small, because the foot motion is small. According to an expert's opinion, the reason is that beginner kick strongly or weakly. Then, we decide the expert's region, which is 0.05-0.10 rad/mm maximum curvature and 0.40-0.55 m2 surface area. If learner's (beginner's) data is placed near expert's region, the learner's skill level is increasing. Therefore, skill level can be evaluated using the expert's region.

4 KICK TRAINING USING MOTION CURVE SURFACE

We have not confirmed the increasing level and changing the motion curved surface characters yet, only visualized the skill level using the characters. Then, we investigate the character correlation using kick training. The training method is watching a motion movie with or without motion curved surface. The movie is 2D viewer. The movie with motion curved surface is to watch the expert's curved surface model made by ARToolKit and OpenGL library using head mount display (Mitsuhashi et al., 2015).

First, four beginner subjects are tracked the kicking motion in soccer. Next, two subjects watch the movie without surface model, and the movies are only expert's motion. The others watch the movie with expert's motion curved surface model. And both subjects train to watch or move in 10 minutes. Figure

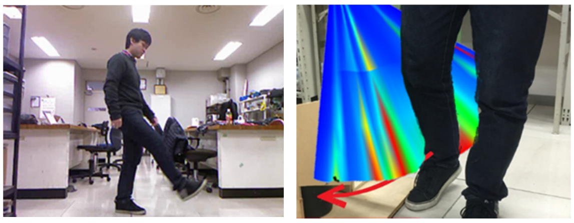
8 (a) shows the watching situation only the movie without movie, Figure 8 (b) shows the training situation with expert's motion curved surface model, which is placed at right lower half body (foot, knee, and hip) side. After training, four subjects are tracked the kicking motion again.

Figure 9 shows the before training curved surface for four beginners. They are trapezoid (large hip motion) or bending shape (bending the knee), or narrow triangle shape (small foot motion). Figure 10 shows the after training curved surface. Figure 10 (a) shows the watching movie without surface model (Subject 1 and 2), Figure 10 (b) shows the watching movie with surface model (Subject 3 and 4). From the figures, all the surfaces are similar to expert's fan-shaped surface, and their foot trajectory is a curved line (segment). However, motion curved surfaces of training with the model are nearer the expert's surface than training without a model. We consider that train with model is enabled to understand the lower half body trajectory.

We investigate the skill level change from the character correlation. Figure 11 shows the correlation and the change of the maximum curvature and the curved surface area. From the figure, all beginners approach the expert's region. The approach of learners with surface model is larger than the learners without model, because the learner to model move the foot consciously. On the other hand, the learners without model can't recognize the lower half body trajectory in learner's opinion. In this result, we prove the skill training validity using the motion curved surface. Therefore, increasing skill level can be evaluated using the character correlation.

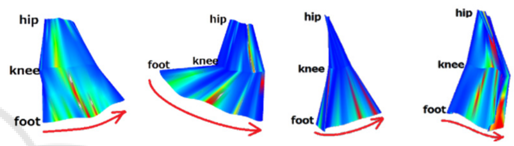
5 CONCLUSIONS

We investigate the correlation of the character using the motion curved surface, and the different and tendency of experts and beginners is extracted. In this result, the curved surface of expert's motion is created repeatedly as the same shape, and different from many beginner surfaces. From the correlation of the maximum curvature and the curved surface area, expert's distribution is gathered to small region. On the other hand, beginner's distribution is large and varied. In addition, we investigate the transition of training effectiveness for beginners from character correlation. In this result, all the shapes of surface are similar to expert's shape, but motion curved surfaces of training with the model are nearer the expert's surface than training without a model. According to the character correlation, all beginners approach the expert's region. The approach of learners with the surface model is larger than the learners without a model. Therefore, we prove the skill training validity using the motion curved surface. In future work, the motion velocity or acceleration curved surface is suggested, and the new method of skill training using motion curved surface.



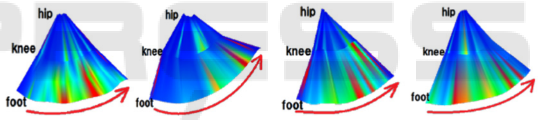
(a) Only watching movie (b) Motion with surface

Figure 8: Training the inside kicking motion in soccer.



(a) Only watching movie (b) Motion with surface

Figure 9: Motion curved surface of before training.



(a) Only watching movie (b) Motion with surface

Figure 10: Motion curved surface of after training.

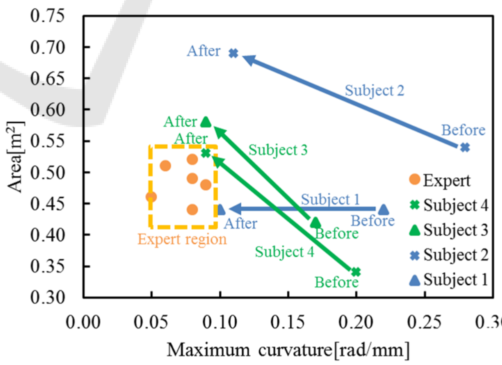


Figure 11: Correlation of motion curved surface character in before and after training.

ACKNOWLEDGEMENTS

This work was in part supported by JST RISTEX Service Science, Solutions and Foundation Integrated Research Program.

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