A Camera-based human contact detection & dynamic projection system

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Abstract. In this research, we propose a novel human body contact detection and projection system. We use Kinect V2 camera and generated human 3D model to detect the contact between user 's bodies. A special algorithm of dividing human mesh into small pieces of polygons to do collision detection is developed and detected hit information will be dynamically projected according to its magnitude of damage. Our system can be used in various sports with body contacts and virtual martial training.

1 Introduction and Related Works

In martial sports such as boxing or karate, it is difficult for the viewer to notice hit information received by the actual players. Therefore, we proposed a contact detection system using Kinect RGB-D camera which can visualize the hit information on user's bodies. Our system generates precise 3D body models representing users and developed a novel algorithm to recognize the collisions. Furthermore, the magnitude of a collision is displayed dynamically in different colors. Our system is therefore suitable for supporting martial sports by visualizing damage information or make martial training more safer by controlling the virtual 3D model remotely.

Augmented Studio[1] is a project dealing with human body projection. However, it can only be applied to a person moving slowly and is not suitable for objects with fast movements as in sports. There are some previous works that focus on dynamic projection mapping like Ballumiere[2] and LightSpace[3]. Although Ballumiere is doing projection on dynamic sphere but not on bodies, it proposed a novel projection system for high-speed moving objects by applying dynamic Kalman Filter. The LightSpace is another project we looked into that deals with a variety of interactions between surfaces with multiple depth camera. However, LightSpace is limited to emulating interactive display features on flat and static shapes that are designated beforehand, which means it is not suitable for quickly changing surfaces such as human body. This research targets to detect contacts between moving people by visualizing the exact position and damage level with color on the body.

Fig 1: Damages are projected to hit position in different colors according to their magnitudes.

2 Implementation

We use one Kinect V2 Camera for capturing user motion and generating 3D human model from user contour. After skeleton fitting, the 3D model becomes a virtual representation of specific user. Since it is difficult to calculate collisions between all point clouds of user in real time due to high computation, we divide the human mesh into small pieces for collision detection. At last, we import RoomAlive to calibrate the projector using Kinect.

2.1 Human Model Generation

A perfect matching model of user would be desirable, but such precision requires multiple depth camera which lead to the cost of increased delay. We designed a body matching function to obtain exact body size of user. The gray-scale data from Kinect is used to represent the human body with great quality. Our algorithm aims to get the contour of body from these data with different angles and calculate the parameters of user body, which is used to adjust the model.

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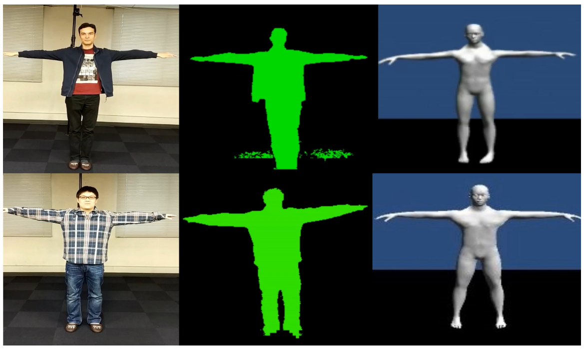
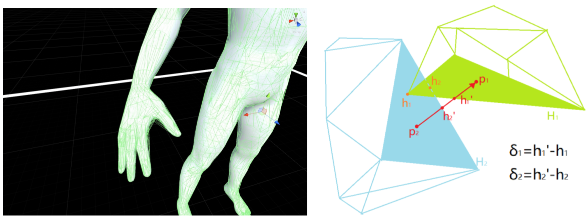


Fig 2: 3D Model Generation



(a) (b)

Fig 3: (a) Divided meshes. (b) Collision between two hulls H_1 and H_2.

2.2 Collision detection

Dividing human mesh: Detecting collision between multiple dynamic humans precisely requires a high processing power to calculate each point of human whether it is colliding or not. This is, however, practically impossible with such a precise human model and we therefore divide our model into about 200 segments, which we called 'hulls', while each of these hulls contains a collider that matches its segment and is assigned to corresponding bone so that they move and rotate with the joints accordingly. Figure 3a shows how meshes are divided into hulls.

Detection algorithm: Our approach is that when a collision happens, the approximate coordinate h'_1 is calculated by first determining the center position $\overrightarrow{p}_{1,2}$ of both hulls. From one of the central positions, a ray $\overrightarrow{r} = \overrightarrow{p}_2 - \overrightarrow{p}_1$ is casted towards the other central position. We take the coordinate $\overrightarrow{h_1}'$ when the ray hits the surface of the other hull which is between $\overrightarrow{p}_1$ and $\overrightarrow{p}_2$ by definition: $\overrightarrow{h_1}' = \overrightarrow{p}_2 + (\overrightarrow{p}_2 - \overrightarrow{p}_1) \cdot \alpha$, in which $\alpha \in [0, 1]$. We can also get another projection point h'_2 by swapping p_1 and p_2. As one can see in figure3b , the actual collision points $\overrightarrow{h}_{1,2}$ are slightly below the perspective projection points $\overrightarrow{h}'_{1,2}$. The difference distance $\delta_{1,2}$ can be estimate according to the figure.

3 Application

Damage Visualization Since the force of damage will be calculated and visualized, the system can also project an illustration of damage heat map of user's body. Which also has the possibility to become a combat game with HP gauges and make the sports more interesting and understandable for the audience.

Safe Martial Training To avoid injury, many players will not fight seriously during martial training. We can develop a safe training system with adjustments to specific sports, for example, by setting the 3D model nearer than reality to let the user control them remote which means the users are not really fighting but can recognize the damage they receive.

4 Conclusions & Futureworks

We proposed a novel 3D model-based human contact detection method and its visualization system. Currently, this project is still facing some problems:

Latency of projection: Since high speed dynamic projection mapping has being realized nowadays, it is possible to improve the projection accuracy with the help of high speed cameras.

Accuracy of hit position: Multiple Kinects might solve the accuracy problem, however, Kinect has a low resolution rate along with only 30 frame rate and other fabric technologies might disturb the sportsmen. We believe that deep learning-based pose estimation method could solve this problem, and simple high speed RGB camera could work as motion capture in the future.

References

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