Design and Implementation of Rugby Tackle Technology Assisted Training System Based on Somatosensory Capture

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Abstract. Rugby is a highly challenging and spectator contact team sport with intense physical confrontation, specific technique, and group tactics, which requires athletes have tenacious will, courage and teamwork. “Tackle” is an essential feature of rugby which is the smallest action unit of body contact and confrontation between the offensive and defensive players during match. Tackling ability is not only a demonstration of personal skills, courage, and experience, but also the base of tacitly cooperating with other teammates in helpful defense which a well-trained part of team needed. For rugby beginners’ tackle training, this study designs and implements rugby tackle technology assisted training system based on somatosensory capture to help beginners master rugby tackle correctly and effectively during single or double training so that beginners could complete the confrontation exercises from simple to difficult.

1. Introduction
Rugby is a highly challenging contact team sport with intense physical confrontation. As the trigger of confrontation, “rugby tackle” is one of the few necessary skills which rugby player is needed to master, and it is the smallest action unit of body contact between the attackers and defenders. And, it is also the base action of, and the key to getting ball possession, inversing to attack status and win the advantage for team. The level of rugby ability is not only the demonstration of personal technology, courage and experience, but also the manifestation of helping to defend, tacitly collaborating with teammates in a well-trained, brave and tenacious group [1].

“One Tackle, One Try!”’, the description to tackle in rugby, and it is mean that a good tackle is worth the equivalent of a touchdown which is the method to get highest score in Rugby match. An excellent and effective defense tackle not only prevent attackers from continues attacking and scored breakthrough, but also win the advantage in match which is helpful for spiriting all teammates.

This study analyses the characteristics of rugby, the importance and correct concepts of tackle, and reasonable approaches corresponding to common technology problems for tackler. Aiming at gradually guiding and steadily improving tackle skill for beginners in an experiential process, we design a rugby tackle technology assisted training system based on somatosensory capture which can help users master rugby tackle correctly and effectively through mode of single or double player(s) training. Microsoft Kinect is used to capture beginner’s action by combination of depth sensor and skeletal tracking and determine the coordinate of every joint point, then data captured can be
compared with right action model built beforehand (standard parameters). The final score will be shown and right suggestions can be proposed according to every beginner’s characteristic.

2. System Design

2.1. Introduction to Tackle Training
Tackle occurs on attacker and defender, named, tackler and ball carrier, respectively. The process of tackle generally can be divided into these parts as shown in Figure 1:

1. Tackler and ball carrier stand opposite (Figure 1a). Tackler’s legs are as wide as shoulders and knees are on the knees, the hip joints are straight; Kneel on both knees with straight hips and hold the ball tightly in front of chest. The distance between the them is 0.5 m.

2. Starting tackle (Figure 1b). Tackler bends the hips and leans back, shoulders are higher than hips, eyes are fixed on the ball carrier’s thighs, the elbows on both sides are close to the ribs, both hands are extended and the arms are bent at 90°. Then stretch the hips to drive the body forward, while the shoulders hit the ball carrier’s thighs, the arms are stretched forward tightly to hold the ball carrier’s legs, the head is behind the ball holder’s hips or thighs, and the side face (right cheek) close to the body of the ball carrier.

3. Tackle confrontation (Figure 1c). Tackler is prone and his waist is straight, his legs and ankles are stretched tightly, and he hugs the ball carrier tightly. The ball carrier’s hip joint is slightly curved, the arms are locked with the chest and shoulders, the elbows are close to the ribs, and they give a certain resistance when resisting the impact of the flutterer, and then fall sideways. After falling to the ground, the tackler is on the ball carrier. Then, tackler releases the ball carrier and rises to return to the previous of position when they are in step (1), and the ball carrier also returns to the position ready to be tackled.

![Figure 1. The main process of tackle training](image)

As we know, attacking part as soon as keeps the ability to confront and retain the ball possession, can launch continuous attacks to defense line which is important for defense part. In advanced competitive match, there are often several or dozens or even dozens of consecutive attacks. The powerful, cruel, and bloody fighting scenes are the eye-catching charm of the rugby, and also the extremely ultimate test of the skills, physical fitness and will of the players on both sides of the offense and defense. In match, unreasonable technique action and unclear consciousness both make tackle mistake so that complete defense line built by defense part will collapse.

In a word, the main work of this study is to take use of somatosensory for realizing tackle training action capture of step (2), and score will be given to adjust the user action for next tackle training.

2.2. Somatosensory Capture Hardware
Here, somatosensory capture is realized by detecting body action and interacted to users by computation and screen display. With continuous promotion of Microsoft Kinect, it has been applied to many different fields and gradually penetrated into daily life. The main work of this study is using Kinect which supports skeletal tracking according to coordinates computed from depth of 2D picture to capture tackle action [2–3]. Human-computer interaction (HCI), is a technology focused on interaction between human and computer, e.g., realizing communication by input and output of computer. Somatosensory interaction technology brought by somatosensory sensor Microsoft Kinect.
can help human control machine by using direct body action without complex operation. As shown in Figure 2, Kinect is an external device for the Xbox 360, it has three front cameras and four downward microphones (three on the right and one on the left). The former is used for recording RGB and infrared picture, and the latter is used for locating the sound source and recognize speech.

![Figure 2. Basic setup of Kinect](image)

2.3. Location of Kinect
The range that a Kinect sensor can detect does not mean that it is an interactive area suitable for the human body. All sensing devices have their own comfortable areas and restrictions. Kinect itself has two modes, one is close-range mode (also called half-body mode), which can only track ten joints points of the upper one. The other is the full-body mode. Our system needs to track the joints at the ankle, so the full-body mode is selected.

Combining the height of user and the view range of Kinect, we tested the vertical view at a height of 1-, 0.7- and 0.5-m distance away from the ground and horizontal view at 2-, 2.5- and 3-m away distance from the Kinect. We calculated the maximum visible distance of the level at different distances from Kinect shown in Figure 3a. And, Figure 3b shows the maximum visible distance of 3 m from the Kinect. In a word, if Kinect is at a 0.7-m height, and the user is at a vertical 3-m away, it can completely encompass the activity range of the user, and it will not tackle out of view of Kinect.

![Figure 3. Views of Kinect in vertical (a) and horizontal (b) direction, respectively](image)

2.4. Single Side Skeletal Tracking and Tackle Action Capture
Skeletal tracking is the key to Kinect. The Kinect sensor’s perception of the surrounding environment is through the infrared sensor on the device to generate a black and white gray depth image frame. Due to the limited detection distance of hardware, pure black represents the infinitely away place, and pure white represents the infinitely near one. The gray represents the physical distance between object and sensor. After that, human will be extracted from environment by image segmentation mask. For computation reduction, the useful image, accurately the pixels, will be only chosen and transmitted. Twenty joint points of human will be determined by system evaluation results which are given by machine learning, and a skeleton will be generated.
During the tackle process, the human body is not facing the Kinect, but his side is. If we specify that the direction of tackle is consistent with the inverse of the $x$-axis, then the bone data on the right side of the body can be better identified, so we can obtain more accurate ankle data.

![Figure 4](image)

**Figure 4.** Illustration of both (a) single (b) side(s) skeletal tracking of Kinect

### 2.5. Tackle Action Evaluation

After successfully recognizing the gesture that the user is about to start, the system records the point of right ankle joint (StartX, StartY) where the user started. Assume that during the tackle, the coordinate of the right ankle joint is $(X, Y)$. Then, real-time height $|Y-\text{StartY}|$ will be calculated to judge start and end of tackle. When $|Y-\text{StartY}| > m$ (a threshold to judge start), tackle action starts. In contrast, tackle end when $|Y-\text{StartY}| < h$ (a threshold to judge end), and (EndX, EndY) will be recorded at that time to calculate tackle distance $|\text{StartX}-\text{EndX}|$. Accordingly, Benchmark difference of the tackle, and score can be calculated, as shown in Figure 5.

![Figure 5](image)

**Figure 5.** Main logic module of score

The calculation method of the scoring system is: Maximum score is five, and 1-point deduction for every 0.1-m distance of skeletal movement beyond the standard distance. At the same time, the system will calibrate the actual difference between the initial position and the reference position. The result can provide trainers for reference and adjustment.

### 2.6. Design of whole Tackle Training Assisted System

Player should stay at the certain range of Kinect, and stand at the point ruled. After that, Kinect will recognize body automatically, and extract the skeleton information needed. Here, for representing the skeleton tracking, a real-time image will be shown at screen, where colorful lines connected represent
skeleton. Then data captured can be compared with right action model built beforehand. The final score will be shown and right suggestions can be proposed according to every beginner’s characteristic. The function flowchart and planer of system are shown in Figure 6 and 7, respectively.

![Diagram](image)

**Figure 6.** The system function flowchart

![Skeleton tracking](image)

**Figure 7.** Skeleton tracking of system

3. Analyze and Conclusions

For accurately scoring, in skeleton tracking system, the judged skeleton tackle distance (JSTD) (JSTD=|StartX−EndX|) cannot simply be used as real computed tackle distance (RCTD) (RCTD=|StartX−Real EndX|). According to calculation model we build, errors $\Delta$ can be divided into two parts: (1) Delay between the time of tackle end judged by system and the actual time of tackle end so that JSTD will be $\delta$-m shorter than RCTD; (2) CTHD will be $\varepsilon$-m longer than measured artificially tackle distance (ATD). The details are shown in Figure 8, and real tackle distance (RTD) needed can be obtained by

$$RTD=\text{JSTD}+\Delta=\text{JSTD}+\delta−\varepsilon=\text{RCTD}−\varepsilon. \quad (1)$$
Figure 8. Error analyze in tackle distance calculation

For decreasing $\Delta$, the determination of suitable $h$ is important. So, we set $h=0.1$, 0.2, and 0.3 m, respectively to analyze the role of $h$. $\varepsilon$ introduced by hardware, so it is not considered in this study. We find a 1.6-m height volunteer to take part in test, and the data obtained as follows:

Table 1. Experimental results (m) measured when $h=0.1$, 0.2, and 0.3 m respectively

| ID | StartX | EndX | Real EndX | CTHD | RCTD | ATHD | $\delta$ | $\varepsilon$ |
|----|--------|------|-----------|------|------|------|--------|--------|
|    |        |      |           |      |      |      |        |        |
| $h=0.1$ |       |      |           |      |      |      |        |        |
| 1  | 0.58   | −0.44| −0.50     | 1.02 | 1.08| 1.02| 0.06   | 0.06   |
| 2  | 0.32   | −0.39| −0.82     | 0.71 | 1.14| 1.10| 0.43   | 0.04   |
| 3  | 0.34   | −0.19| −0.90     | 0.53 | 1.24| 1.20| 0.71   | 0.04   |
| 4  | 0.40   | −0.33| −0.83     | 0.73 | 1.23| 1.19| 0.50   | 0.04   |
| 5  | 0.45   | −0.16| −0.84     | 0.61 | 1.29| 1.23| 0.68   | 0.06   |
| 6  | 0.55   | 0.16 | −0.49     | 0.39 | 1.04| 1.00| 0.65   | 0.04   |
| $h=0.2$ |       |      |           |      |      |      |        |        |
| 1  | 1.00   | −1.26| −1.37     | 2.26 | 2.37| 2.31| 0.11   | 0.06   |
| 2  | 1.20   | −0.29| −0.50     | 1.49 | 1.70| 1.70| 0.21   | 0.00   |
| 3  | 1.26   | 0.00 | −0.40     | 1.26 | 1.66| 1.61| 0.40   | 0.05   |
| 4  | 1.24   | 0.27 | −0.23     | 0.97 | 1.47| 1.42| 0.50   | 0.05   |
| 5  | 1.09   | −0.26| −0.37     | 1.35 | 1.46| 1.43| 0.11   | 0.23   |
| 6  | 1.08   | −0.76| −0.74     | 1.85 | 1.82| 1.80| 0.03   | 0.02   |
| $h=0.3$ |       |      |           |      |      |      |        |        |
| 1  | 0.85   | −0.32| −0.29     | 1.17 | 1.14| 1.10| 0.03   | 0.04   |
| 2  | 0.86   | −0.11| −0.26     | 0.97 | 1.12| 1.07| −0.15  | 0.05   |
| 3  | 0.83   | −1.05| −1.03     | 1.88 | 1.86| 1.80| 0.02   | 0.06   |
| 4  | 0.84   | −0.63| −0.62     | 1.47 | 1.46| 1.40| 0.01   | 0.06   |
| 5  | 0.83   | −0.49| −0.52     | 1.32 | 1.35| 1.32| −0.03  | 0.03   |
| 6  | 0.87   | −0.21| −0.19     | 1.08 | 1.06| 1.00| 0.02   | 0.06   |

In the experiments, we record video consisted of frames, and analyze tackle action frame to frame. It’s obvious that right ankle point $Y$ will be decreased by 0.2–0.3 m at the start frame of tackling, and will be changed over 0.1 m compared with another frame. According to results shown above, if we set $h=0.1$ m, the error will be large because of it is too early for tackle end. When difference $|Y−\text{Start}Y|$ is lower than 0.1 m, there is a period of time to finish tackle which result in mistake distance. After optimizing $h$, the error can be decreased. So, a more suitable range can be concluded as 0.1 m–0.3 m.

In addition, functions of save and share are provided. If user tackle action satisfied evaluation rules, his grade will be shown on screen which can be saved and shared. This study proposed that rugby tackle technology assisted training system based on somatosensory capture. Compared with traditional coach training form, it combines the body tracking technology of Kinect sensor and depth sensing technology, which can capture the basic training movements of beginners. Then data captured will be compared with pre-built standard action model; the assisted system can provide suggestions combined with the characteristic of beginners. The main function of system realized are (1) Real-time skeletal motion capture (complete the basic tackle action), (2) User interaction interface (recognize the user’s gestures), and (3) ranking (rank according to training results). In the future publication, more complex tackle action will be considered in system, and more complex function will be developed for tackle training.
4. References

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