Extraction and Amplification of EMG Signal in Lower Limb Based on Kisavi Camera and Online Segmentation Technology

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Abstract. In order to reveal the biomechanical characteristics and injury risk factors of football special technology, the prevention of knee joint injury uses surface electromyography telemetry and 3D imaging technology to carry on synchronous test for the technical movement. Using the Butterworth low pass filter in MATLAB software, and combined with signal online segmentation model, this paper designs the signal extraction algorithm. Through the test and the simulation, the results show that the gluteus maximus is discharge obviously and the largest contribution, the contribution of anterior thigh muscles and crus muscle is second, and fast pedal is risk factors of knee joint injury in too small flexor angle, which provides technical reference for football basic skills practice and finalizing the correct technique.

Introduction

In the football match, both offensive and defensive players every hour and moment start time and space competition both with and without the ball moving, therefore players need to complete a large number of high speed and strong against sudden start, stop, turn quickly, turn, breakthrough mobile and other technology action, these techniques action all require knee joint stretch, twist and force in the semi flexion, however the angle of knee joint is the anatomy and physiology weakness [1,2]. Knee joints are often affected by the instantaneous impact force, big constant stress and shear stress effects, and it is easy to cause injury [3]. This study uses EMG and 3D camera technology to analyze the changes of lower limb action EMG and joint angle in football technology, and then by extracting the joint angle characteristics signal, it provides the basis for the risk factors of knee joint injury and prevention.

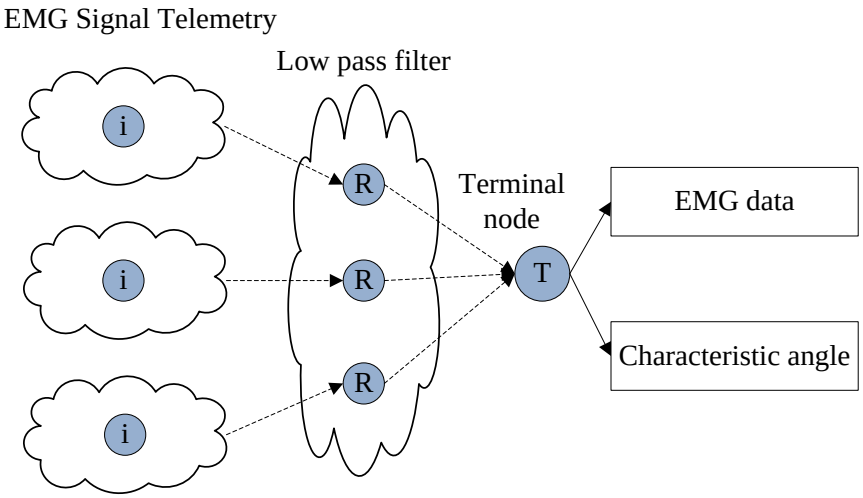

Fig.1: Schematic diagram of the lower extremity electromechanical signal extraction process

Figure 1 shows the overall framework diagram of lower limb EMG signal test in the football training process, it mainly uses the test instrument to carry on the on-site collection of moving image and EMG data in the field of football training, and then the signal will be extracted by

filtering algorithm, to remove the noise parts of the signal, we will eventually sensor signal into joint angle signal [4,5]. Through the research on the joint angle signal, we will realize the analysis of joint activities characteristics in the basketball training, which improves the reference data for the training intensity and the quantity of task.

Design of EMG Characteristic Signal Online Segmentation and Feature Extraction Algorithm

EMG signal is very weak, it is generally only about 1~10mV, the useful signal distribution is between 1~500Hz frequency range, the main energy distribution is in the frequency range of 50~150Hz. This paper uses the signal online segmentation technology [6-8]. According to the time sequence to segment EMG signals, assuming a time series $T = t_1, t_2, \cdots, t_N$, and assuming T satisfies the following conditions:

$$T = \begin{cases} g_1(t, t_1) + f_1(t) & 1 \le t < M \\ \cdots & \\ g_1(t, t_n) + f_n(t) & M \le t < N \end{cases} . \tag{1}$$

Among them, g is the partition function, f represents signal extraction function, M represents an intermediate constant, and N represents the number of segmentation. For the segmentation difference, it is defined as follows:

$$\mathrm{T} = \sum_{i=1}^{N} T_i = \sum_{i=1}^{N} \sum_{j=1}^{M} (f_i(M) + j - g_i(M_{i-1} + j, v_i))^2 . \tag{2}$$

The effect of time online segmentation needs to be evaluated using statistics theory, EMG online segmentation evaluation function can be written as:

$$\mathrm{J} = \begin{cases} \dfrac{\mathrm{T}}{\sum_{\mathrm{i}=1}^{\mathrm{n}} (y_i - \bar{y})} + \dfrac{p}{n} \\ \dfrac{p}{n} \end{cases} . \tag{3}$$

Where p is the segment number, $p < 2/n$; $\bar{y}$ is the mean of y. Through the following two ways to discuss the effect of segmentation, when $\sum_{\mathrm{i}=1}^{\mathrm{n}} (y_i - \bar{y})^2 = 0$, the time series are horizontal lines.

When $\sum_{\mathrm{i}=1}^{\mathrm{n}} (y_i - \bar{y})^2 > 0$,

$$\hat{q}_j = g(t, t_j) \quad j = 1, 2, \cdots, n . \tag{4}$$

This can eventually get the EMG signal processing formula as follows:

$$J = \frac{\sum_{j=1}^{k} < f_j, f_j >}{\sum_{j=1}^{k} (< f_j, f_j > + (< \hat{q}_j - \bar{y}, \hat{q}_j - \bar{y} >)} + \frac{p}{n} . \tag{5}$$

In order to realize the signal filtering, we can extract the effective football angle signal as the characteristic signal. Combined with the above algorithm, this paper designs the signal extraction algorithm using the Butterworth low pass filter of MATLAB software, in which the used main program is as follows [9]:

```
wp=1500*2*pi;
ws=2200*2*pi;
Rp=2;Rs=15;
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```
 [N1,Wn]=buttord(wp,ws,Rp,Rs,'s');
[Z,P,K]=buttap(N1);
 [Bap,Aap]=zp2tf(Z,P,K);
for i=1:fix(N/M)
y2(i)=x(M*i); end
y2=fft(y2,i);
f2=0:fs2/i:fs2*(i-1)/i;
figure(4);subplot(322);
plot(f2,abs(y2));
.....
```

Study of the Characteristics of Football Technique Lower Limb Motion EMG and Joint Angle

In order to verify the effectiveness and reliability of signal low pass filtering algorithm designed in the second part, this paper takes lower limb myoelectric signal processing of football technique as an example [10,11]. Through the field signal acquisition, we carry out the signal processing, in which the field signal acquisition is shown in Figure 2.

Fig.2: Motion image and EMG data acquisition field

As shown in Figure 2, using electromyography telemetry and 3D imaging technique extracts EMG signals, and then the EMG signal of supporting link 12 muscles is converted integral EMG value by using MATLAB software, finally we carry out standard treatment.

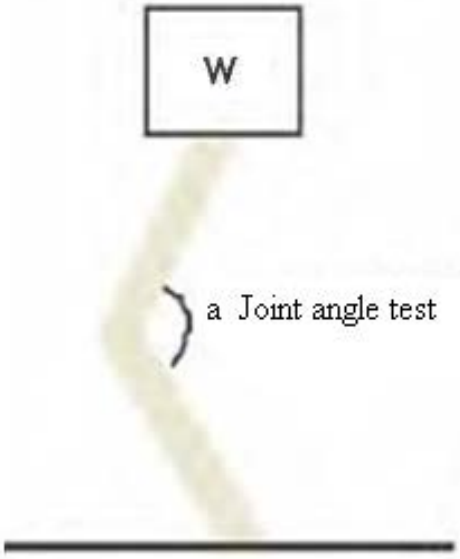

Fig.3: Knee joint angle test

Figure 3 shows the schematic diagram of knee joint angle test value. Through the signal analysis for each test action, we can get the knee joint data from the moment into ground process, to obtain the value from them as shown in Figure 2, its value can reflect the number of motor units to participate in the work and the discharge size of each motor unit in a certain extent, the contribution degree of muscle activity refers to the integral EMG value at the completion of an action value.

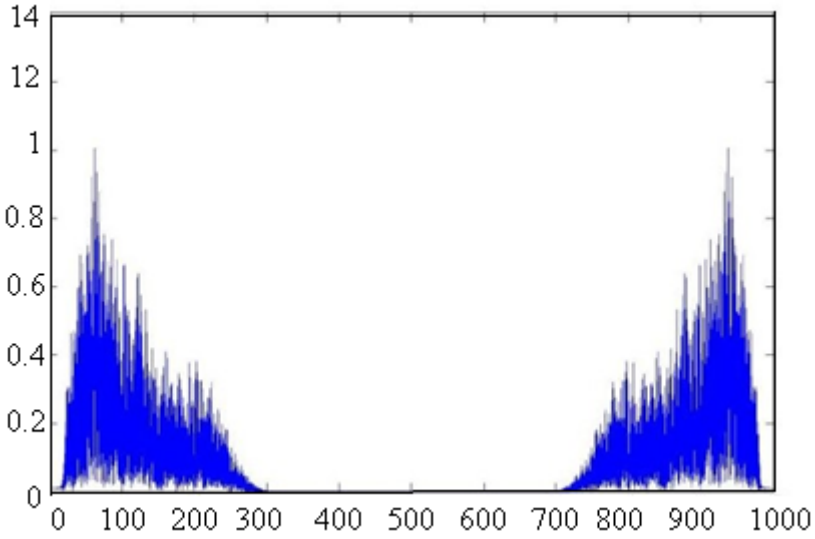

Fig.4: The signal mapping before pretreatment

Figure 4 shows the signal mapping before signal filtering, it can be seen from the chart that there are more noise signal before signal filtration [12]. If we do not filter out these signals, it will cause certain impact on the analysis of joint angle, so that the precision of calculation is greatly reduced.

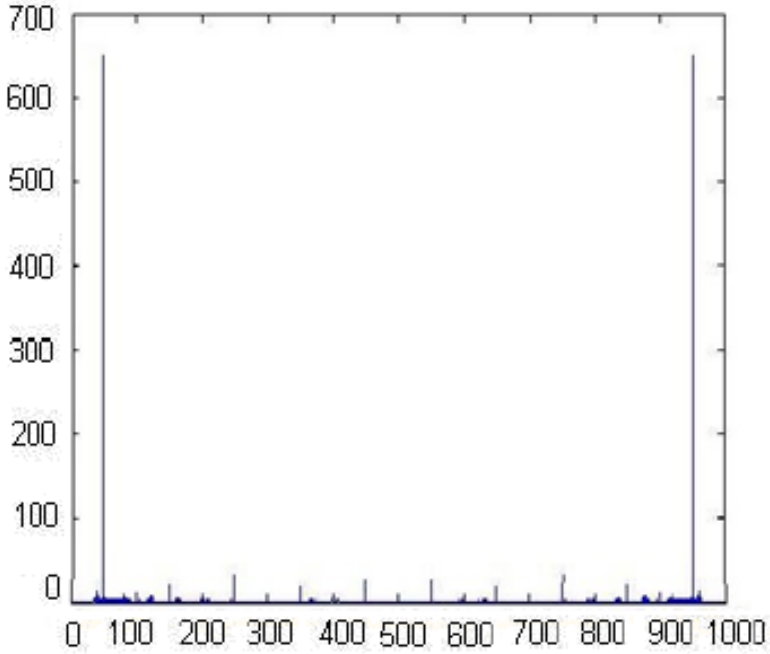

Fig.5: The signal mapping before pretreatment

Figure 5 shows the frequency spectrum of the EMG signal after signal filtering. We can clearly see a lot of noise dropped removal after treatment, which is more beneficial to the subsequent signal analysis. This research mainly records the gluteus maximus, anterior femoral muscle and leg muscle and other electromyography, they are shown in Figure 6.

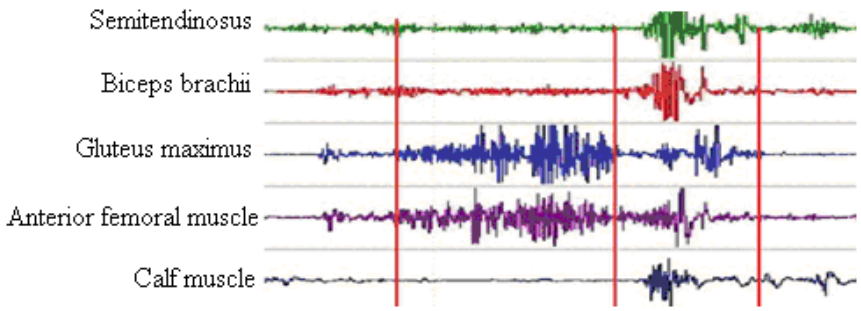

Fig.6: EMG signal graph

Through the graph 6, it can be more intuitive to see, the gluteus maximus discharge is more obviously and the greatest contribution; the contribution of anterior thigh muscles and crus muscle is smaller, and varies depending on the specific action and gender; hamstrings activity is relatively weak, the specific data is shown in Table 1.

Table 1: Different tester different muscle EMG data

Muscle testing	Tester 1	Tester 2	Tester 3	Tester 4
Semitendinosus	15.3	16.2	13.1	12.2
Biceps brachii	22.1	23.3	22.8	20.2
Gluteus maximus	55.3	52.1	59.3	53.1
Anterior femoral muscle	43.1	40.1	47.2	49.3
Calf muscle	31.3	30.2	33.1	38.1

As shown in Table 1, the discharge quantity of different subject same muscles are also different in the same technical movements, it can reflects subject muscle physiological characteristics and technology action muscle force situation, the view of different muscle activity has great difference, therefore each muscle work is different in a technology movement process, they have different contribution [13]. In the process of football training, we need to consider the contribution of each joint, and then we adjust the amount of various parts training making the training effect to achieve the optimal.

Summary

(1) In order to improve the accuracy and reliability of football EMG signal testing, we use surface electromyography telemetry and 3D imaging EMG signal technology to carry on feature extraction for the EMG signal of football athletes training process, and design the signal online segmentation algorithm.

(2) In MATLAB toolbox, this paper uses Butterworth low pass filter to carry on signal processing, and then carries out programming design for the partition function, we can obtain a new EMG signal filtering method. Through the test, we can effectively remove EMG interference noise signal.

(3) Through the result analysis of signal, we found that joint on muscle contribution is the largest of the gluteus maximus in the process of football training, we can find out the main risk factors of knee joint injury, which provides sports medicine reference for the football technical movement and joint training rehabilitation research.

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