Wearable biomedical monitoring system using TextileNet

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Wearable Biomedical Monitoring System Using TextileNet

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Abstract

We developed and tested a biomedical monitoring system using TextileNet, a flexible conductive garment for wearable computing. TextileNet detects biological signals while simplifying communication and power supply wiring. TextileNet also acts as an electromagnetic interference (EMI) shield, which makes it possible to use simpler amplifiers in the system. Using TextileNet, a huge amount of biological information can be processed simultaneously.

1. Introduction

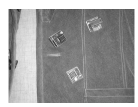
Biomedical monitoring systems are expected to be one of the most important applications of wearable computing. Various related research has been done before [2]. Having a large number of wires connected to sensors to monitor many biological signals makes such systems complicated and unstable, while the number of transmitter channels is limited. We previously developed a flexible network infrastructure system made of conductive fabric called TextileNet for wearable computing systems [1]. In this work, we developed and tested a biomedical monitoring system specially designed for electromyography (EMG) using TextileNet.

2. Biomedical monitoring system

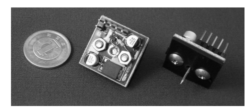
2.1. TextileNet

We have developed a fundamental environment for wearable computing called "TextileNet" as shown in figure 1. TextileNet was designed to be a wireless system with an adequate number of sensors and no need for independent sensor batteries. It consists of an electrically conductive garment with a power supply for devices and a wireless communication channel for each device installed on it. It features the flexibility of installing an adequate number of devices anywhere on the garment as desired. TextileNet is designed to be an infrastructure for all of a user's wearable computing systems.

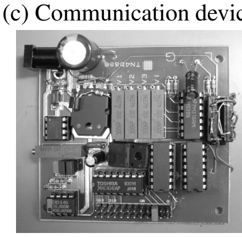
(a) Garment of conductive fabric.



(b) TextileNet devices in operation.



(c) Communication device.

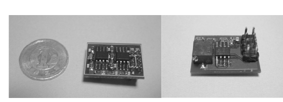


(d) Power supply.

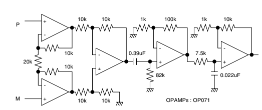
Figure 1. Development of TextileNet system

2.2. Small EMG amplifier module

We developed a small EMG amplifier for the TextileNet system as shown in figure 2. This amplifier was designed to be as small as possible using the components available to us. It consists of a differential amplifier, a high pass filter and a low pass filter as shown in figure 2(b).



(a) Small EMG amplifier.

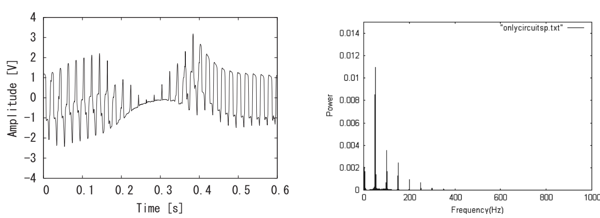


(b) EMG amplifier circuit.

Figure 2. The small EMG amplifier.

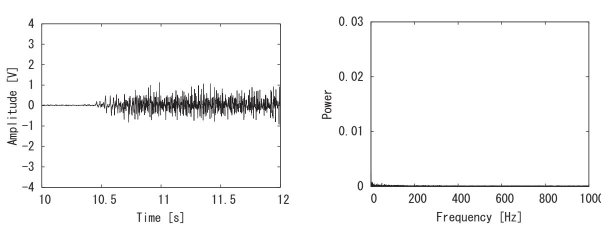
3. Evaluation and prototype system

The TextileNet garment is made of conductive fabric, so it should shield against EMI. We evaluated the electromagnetic shielding of TextileNet configured for electromyography measurements. Two Ag/AgCl electrodes were attached to the user's arm with paste, and the myoelectric signals were amplified by a differential amplifier with a gain of 1000, HPF of 5 Hz and LPF of 1000 Hz, as shown in figure 2(b). The EMG plus any noise present and the associated spectrum were sampled on a PC under three conditions: (1) with no electromagnetic shield, (2) in a shielded room made of copper mesh, and (3) with the TextileNet garment with the power supply unit and the communication units in operation. Figure 3 shows the measured EMG with no electromagnetic shield. A large amount of background noise is present. Figure 4 shows the measured EMG within the shielded room. Noise is much lower as expected, and a clear EMG can be measured. Figure 5 shows the EMG with no arm force applied while wearing the TextileNet garment. The flat EMG waveform indicates that noise is sufficiently eliminated to enable an EMG measurement. These results show that the system using TextileNet can function as an EMG measurement system with shield efficacy against external noise and no cables to the sensors.



(a) Waveform (without arm force). (b) Spectrum (without arm force).

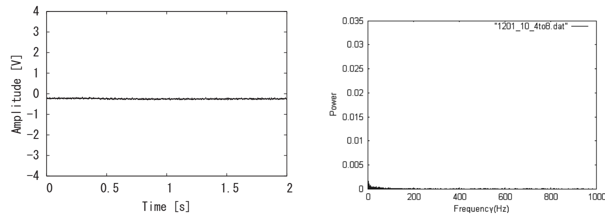
Figure 3. Measured EMG with no shield.



(a) Waveform (without arm force before 10.5 s and with arm force after 10.5 s). (b) Spectrum (without arm force).

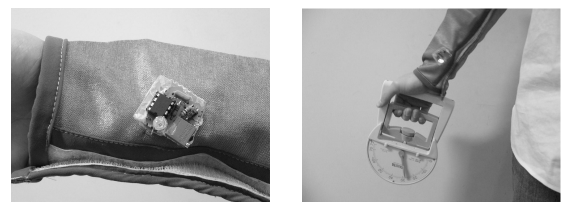
Figure 4. Measured EMG using shielded room.

Here, we experimentally made a device to convert the detected arm muscle force into intensity of light from an LED using the transmitted EMG signal, the amplifier, and the fabric as shown in figure 6 as a prototype system for biomedical monitoring.



(a) Waveform (without arm force). (b) Spectrum (without arm force).

Figure 5. Measured EMG using TextileNet.



(a) Appearance. (b) In operation.

Figure 6. Prototype system.

4. Discussion

In this project, we found that the system shields against EMI. Usually, when we measure biological signals, many kinds of noise strongly interfere with the measurement. Therefore, many kinds of filters are usually employed in such a system. However, with this system, the wearer's body was shielded enough by the conductive fabric to enable the detection of weak biological signals. This drastically simplified the amplifier . Also, eliminating the many wires normally used in such a system is very effective in eliminating electrostatic instability due to body movement.

5. Conclusion

TextileNet was used in a system to detect biological signals while greatly reducing the amount of wiring normally used in such a system. In addition to minimizing the wiring, the conductive fabric shielded against EMI, which helped make it possible to use simpler amplifiers. Using the features of TextileNet, a huge amount of biological information can be monitored simultaneously.

References

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