# WEARABLE KNEEPAD DEVICES WITH MOTION DATA DETECTION

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**Abstract-** The rapid progress of modern medical technology causes aging society, and the accompanying impact renders medical care and senior care current important topics. The elderly generally have the phenomenon of degenerative arthritis and go to a hospital periodically for diagnosis and treatment. This research proposes wearable kneepad devices, which provides a monitoring system that records the motion status of joints through the Web; for instance, the three-axis vector, bending degree, and pulse rate can be continuously detected during the process of joint motion, while walking steps and calorie consumption are recorded and calculated through GPS; then, the various measured data are integrated and Smartphone is used to transmit the data to the database, as established by MySQL. Through the data stored in the network database, doctors can understand the changes of relevant parameters during users' joint motion, and evaluate their recovery and health care condition.

**Index Terms-** Degenerative Arthritis, Sports Data Detection, Wearable Kneepad Devices, Smartphone, Network Database.

## I. INTRODUCTION

In recent years, due to the integration and advancements of wireless communication and imbedded microcontroller technology, foreign and domestic research related to telemedicine and the wireless health care system has achieved vigorous development. The biggest change is the wireless sensor, which has continuous operation that renders the collection of physiological signals more precise, thus, a home health care system becomes feasible. The progress of medical technology and sanitation concepts lead to the development of an aging society, and thus, increased demand for long-term medical care. The establishment of a telemedicine care system has become the current trend [1]–[4].

The Smartphone has developed rapidly in recent years and almost everyone has one nowadays. In addition, the Android system with its open program code allows Smartphone to apply diverse applications. In many researches, the Smartphone is used for diagnosis and treatment [5]–[6], as the popularization of Smartphone helps to reduce health care costs. The miniaturization of micro-processing chips contribute to the gradual realization of many the conceptions that could not be previously realized, including wearable devices. Wearable devices refer to microelectronic devices that can be worn for outdoor activities. For this reason, the wearable device can be universally applied to the healthcare system, and thus, will have great development potential for telemedicine care.

## II. RESEARCH BACKGROUND

Degenerative arthritis is a kind of common joint disease in humans, and the elderly suffer from such illness more frequently. Therefore, it is generally believed that degenerative arthritis is a degenerative disease aggravated by increasing age. If degenerative symptoms can be found earlier, health care can be offered in advance to postpone the phenomenon of joint degeneration in the elderly. Procedure for Paper Submission.

## III. SYSTEM ARCHITECTURE

This system divides the knee device into 3 parts: sensing side, Smartphone including APP, and remote database, and the system architecture diagram is shown in Figure 1. The sensing side of this system is composed of bending, three-axis acceleration sensor, and pulse sensor measurement. After knee bending degree, the three-axis sensor and pulse are measured, and the signals are transmitted wirelessly by Arduino's Bluetooth and received by Smartphone's Android system; meanwhile, after the Android system obtains the movement distance via GPS positioning, the data are processed, and then, transmitted via wireless network to a remote database for recording.

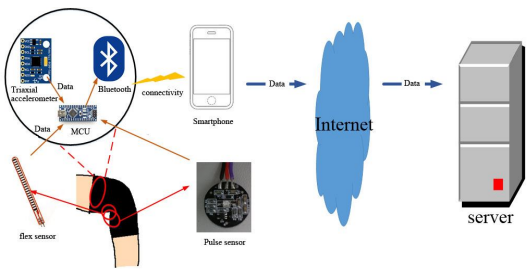



**Figure 1 System Architecture Diagram**

This system can convert the bending degree, pulse rate, and walking steps measured by users to calculate slope and distance, pulse rate, and calorie

consumption. Upon determination of use, the minutely records will be uploaded to a remote server through a wireless network, in order that health care workers can obtain the detailed and complete data for the reference of knee diagnosis and treatment.

## IV. METHODS AND SKILLS

### A. Arduino program

After the program is implemented, the data of the bending sensor, three-axis accelerometer, and pulse are implemented and obtained, and then, transmitted to the Android program through a Bluetooth module. When Android requires the data in this system, the data are transmitted by Arduino through Bluetooth.

### B. Android program

After the program is implemented, the weight input by the last user, the current time, and the longitude and latitude are set, and then, Bluetooth is connected to receive the data from Arduino and GPS is used to calculate calorie consumption. Later, the collected data are sorted, then displayed and recorded in a graph, and finally, they are transmitted to a remote server.

Android Bluetooth can be initially used when paired and connected online with Android. The Bluetooth function of this system receives the bending degree, three-axis accelerometer, and pulse signal per second; in order to ensure data integrity, this system sends a receiving command to Android. If the data are not received, the command will be resent until it is disconnected online. This system uses GPS to calculate the user's calorie consumption, in order to judge user's amount of exercise. The GPS in this system gains the longitude and latitude of the current location every 60s, subtracts the longitude and latitude gained since the last reading, and then, divides the accumulated seconds to gain movement speed; movement speed is converted into METs (calorie consumed per hour by per kilogram of body weight) Table 1, and METs multiplies the weight and accumulated seconds to obtain calorie consumption. In terms of the calculation of longitude and latitude, every 10 degrees is regarded as 1 region, and then the distance is calculated in equal ratio. In spite of the possible error in the calculation of long distance, an error in the short distance can be ignored. As this system is used for walking, this method can omit complex calculation and the error is small.

| Speed(m/s) | METs | Speed(m/s) | METs |
|---|---|---|---|
| 0.9 | 2.8 | 3.58 | 11.8 |
| 1.12 | 3 | 4.02 | 12.8 |
| 1.57 | 4.3 | 4.47 | 14.5 |
| 1.78 | 5 | 4.92 | 16 |
| 2.02 | 7 | 5.37 | 19 |
| 2.23 | 8.3 | 5.82 | 19.8 |
| 2.68 | 9.8 | 6.27 | 23 |
| 3.13 | 11 | | |

**Table 1 Table of Calorie METs**

The bending degree, the value of the three-axis accelerometer, and pulse rate per second are drawn minutely into a graph; when 1 minute passes, the graph for this minute is eliminated. Moreover, users can choose hour/day/month/year to display the graph drawn by using the value collected at that time or on that day is show in Figure 2.

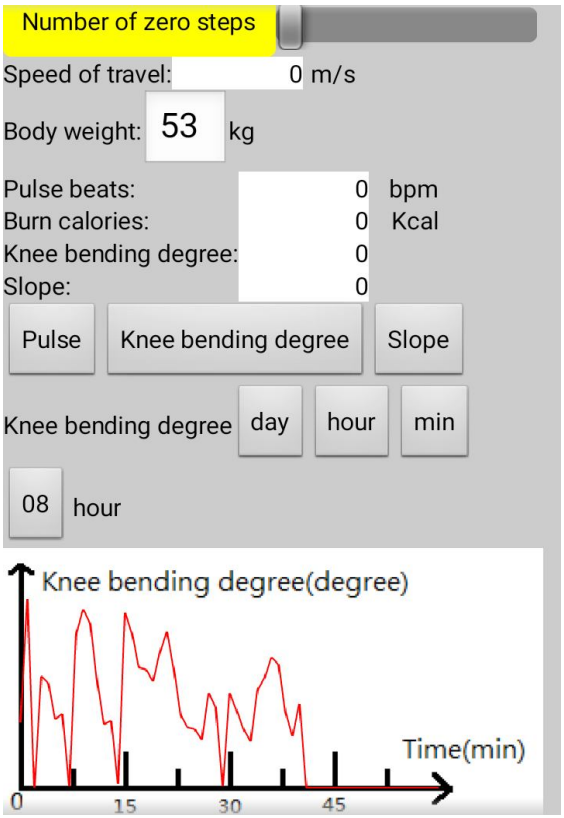



**Figure 2 Interface of Display**

When the system is running, users can set their targeted steps per day; the program will judge whether Bluetooth is connected online to judge whether the system device is used to measure steps by three axes; and then, judge whether the targeted steps for each day have been achieved. In case of failure to achieve the goal, the user will be reminded every minute by an Android shaking device, starting 30 minutes ahead of the daily settlement.

The slope in this research is gained by subtracting the Y axis of the 3 axes from knee bending degree, as measured by the bending sensor, and the calculation method is shown in Figure 3. In this method, the slope is calculated when the feet are on the ground. However, as the sensor is always moving and moving data cannot be calculated when the feet are on the ground, such values must be subtracted. The data when the feet move on the ground should be collected first, and then, the slope closing to reality can be corrected and gained.

$$S = Y - a \quad (1)$$

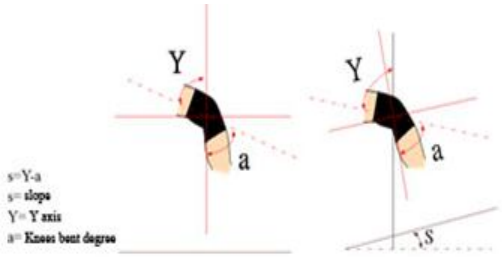



**Figure 3 Slop Calculation Method Diagram**

### C. Server program

The server used in the system of this research is a Linux system, which is a free operation system in most cases and has powerful functions. In this system, Mysql commands are implemented through the implementation of the server's PHP file when the data is uploaded. When Android implements the action of uploading, the data collected by Android are transmitted to a PHP file, and then, converted into Mysql commands to make the server establish the database is shown in Figure 4.

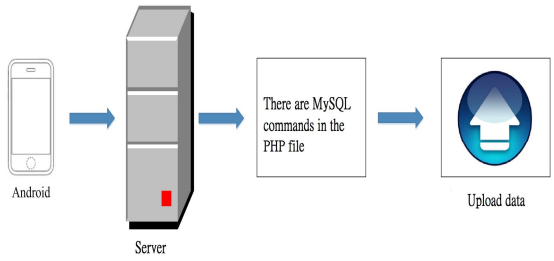



**Figure 4 Information Uploading Diagram**

## CONCLUSION

This system integrates bending sensors, 3-axis acceleration sensors, and pulse signal sensors into portable kneepad devices, and then, converts the signals of the measured values into distance, slope, consumed calories, and pulse rate. The above-mentioned data are transmitted by Bluetooth interface to a Smartphone, and then, transmitted by Smartphone to the required health care side for recording and measurement. Thus, the elderly or mountaineers can use this system to calculate and evaluate their daily motion steps and distance. On one hand, this system can postpone the degenerative arthritis of the elderly; on the other hand, it can be used by mountaineers for slope evaluation. In combination with Smartphone's GPS system setting, this intelligent portable kneepad device can be widely applied to telemedicine care systems.

## REFERENCES

[1] S. M. R. Islam, D. Kwak, M. H. Kabir, M. Hossain, K. S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey", IEEE Access, Vol. 3, pp. 678–708, 2015.

[2] S. R. Shinde, R. Shinde, S. Shanbhag, M. Solanki, P. Sable, S. Kimbahune, "mHEALTH-PHC - Application design for rural health care", Humanitarian Technology Conference - (IHTC), 2014 IEEE Canada International, pp. 1–5., 2014.

[3] S. K. Islam, A. Fathy, Y. Wang, M. Kuhn, M. Mahfouz, "Hassle-Free Vitals: BioWireleSS for a Patient-Centric Health-Care Paradigm", IEEE Microw. Mag., Vol. 15, pp. S25–S33, Nov. 2014.

[4] K. Wan, V. Alagar, "Context-aware, knowledge-intensive, and patient-centric Mobile Health Care Model" 2015 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD), pp. 2253–2260. 2015.

[5] S. Mohamed, "UCHEK: an affordable smartphone based point of care diagnostic system for a low resource medical setup" Appropriate Healthcare Technologies for Low Resource Settings (AHT 2014), pp. 1–4. 2014.

[6] T. He, R. Ogunti, M. Puppala, S. Chen, X. Yu, J. J. Mancuso, S. T. C. Wong, "A smartphone app framework for segmented cancer care coordination" 2016 IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI), pp. 372–375. 2016.

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