# DESIGN OF A HAND DYNAMOMETER FOR TESTING AND ANALYSIS OF HAND FUNCTIONS

Wan-Seok Ryu, Se-Jong Ahn, Seung-Yong Kang, Sung-Taek Chung
*Department of Computer Engineering, KPU, Siheung-si, Gyeonggi-do, Korea*

Han-Soo Kang, Hyu-Jeong Kim
*Foretek Co., Ltd., Seonjin Bldg., #35-11, Samsung-dong, Gannam-gu, Seoul, Korea*

Keywords: Hand functions, Handgrip strength, Rehabilitation.

Abstract: The primary purpose of this study was to analyze quantitatively the degree of injury and/or the progress of treatment for physical impairment. This study provided a more detailed study that evaluates all test parameters including maximum grip strength, duration of operation, average grip strength, acceleration work, dynamic endurance time and percent change in static endurance. In addition, a complete database management system is developed and used to store related training, evaluation, and personal information. Designed device in this paper developed a grip sensor using load□cell transducer (≤60kg). The system will be efficient to operate and convenient to use, furthermore, it can be helped for understanding and analysis the progress of a patient during a doctor's rehabilitation program.

## 1 INTRODUCTION

The functions of hand are one of the important parts of our body that performs a lot of function in our lives. Therefore, hand injury including slight and acute injury such as distortion, bruise, fracture, occupational injuries, and amputations can seriously affect our life. To recovery from these injuries, latent risk due to the patient's detail information should be considered prior to the treatment to set a plan and goal of following treatment.

In addition, studies on hand function have reported that aging also affect hand function and reduce an amount of muscles. According to (Mathiowetz, Kashmand and Volland, 1985), reliable and valid evaluation of hand strength is of importance in measuring hand function and evaluating patient's ability to return to employment. (Gallery and Foster, 1985) presented that injured or diseased hand decreases its muscular strength and therefore it should be recovered rapidly. Furthermore, measurement of muscular strength prior to treatment is necessary procedure of evaluating states of patient, especially, when it is damaged by neurological disease, musculoskeletal system disorder or other factors. In addition, hand grip strength is used to diagnose the symptom of rheumatoid arthritis, chronic fatigue syndrome, developmental disabilities, muscular dystrophy and pakinson's disease (Innes, 1999; Andria, Attivissimo, Giaquinto & Sasanelli, 2006). (Bassey and Harries, 1993) reported a 2% loss of grip strength per year for men and women older than 65 years old. As described, studies on handgrip strength have been studied in various fields. To measure handgrip strength, various facilities and equipment have been developed for each purpose. Those include analog and digital types of equipment. Generally, digital type is preferred in order to get an accurate result. Due to this importance and requirement, generally, JAMAR's digital hand dynamometer is widely known and used to measure handgrip strength. However, functions of this system are only able to display real time variation and maximum value of handgrip strength. Thus, there has been a limitation of evaluating complex hand function only using the values from the existing system.

In this paper, we have developed software that is able to evaluate and analyze the quantitative degree of injury, disorder, etc. We have also developed grip



Ryu W., Ahn S., Kang S., Chung S., Kang H. and Kim H. (2010).
DESIGN OF A HAND DYNAMOMETER FOR TESTING AND ANALYSIS OF HAND FUNCTIONS.
In *Proceedings of the Third International Conference on Biomedical Electronics and Devices*, pages 155-158
DOI: 10.5220/0002589801550158

sensor using load-cell transducer (≤60kg) to measure real time for various functions of hand.

Acquired data using this system are able to help not only clinical studies but also effectively performing rehabilitation training and determining realistic treatment goals according to improvement of the measured value.

# 2 MATERIAL AND METHODS

## 2.1 System Block Diagram

Figure 1 shows the proposed system block diagram. Applied pressure to a load-cell changes into analog signals and the system transfer it to a MCU (a micro control unit) through an INA122 (a differential amplifier). These signals are converted to digital signals by a ADC (an analog to digital converter) then, firmware of the MCU transfer the converted value to a personal computer(PC), which consist of a database to manage user information, a friendly user interface to display real time variation and software to analyze data. As it is required to preserve a same potential difference between load-cell and the MCU, we operated the system with 3V voltage reference and applied it to both the load-cell and the MCU.

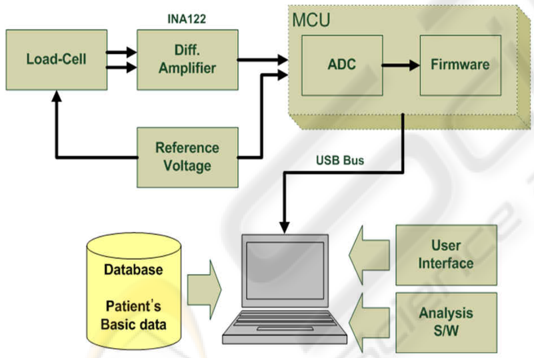


Figure 1: A system block diagram.

## 2.2 Design of Grip Sensor

The configuration of the grip sensor and a prototype sensor are shown in Figure 2 and Figure 3, respectively. We set a range of the prototype sensor as 0~60kg±0.1kg, which is capable of measuring a grip strength of an adult. Applied strength to load-cell turns into resistance through strain gage inside of the dotted line shown in Figure 2. Strain gage, generally, consists of Wheatstone bridge circuit; variation of output voltage depends on variation of input voltage according as changing of the resistance value. However, the output signal of load-cell is very weak, we amplified the signal through an INA 122. The amplified signals were sampled at an interval of 100ms.

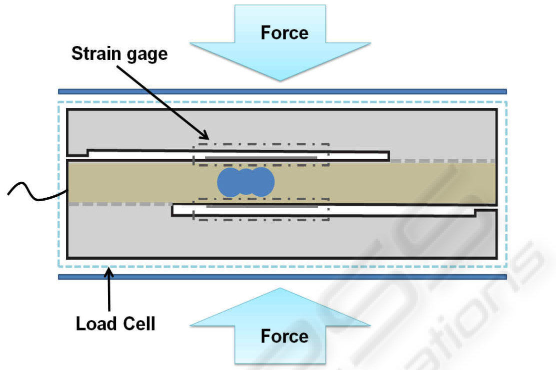


Figure 2: A configuration of grip sensor.

Figure 3: A prototype sensor using load-cell.

As we applied 3V voltage reference to ADC input, ADC level was 614. At this time, we amplified the signal 450 times through the INA122 to get an approximately 5mV/level of the ADC. For instance, when 1kg of grip strength is applied, the ADC level is approximately 10 including an error range of 0.1kg.

For a reliability of relative error of the load-cell, we measured given pressure to the load-cell using 1, 2, 5, 10, 20, 40kg balanced weights and results is shown in table 1. We set up a unit pressure as 9.2N/kg, which is a mean pressure resulted from calibration process.

Table 1: Measured and corrected value of load-cell with balanced weights.

| Balance Weight (kg) | Measured Value (N) | N/kg | Correction Value (N) |
|---|---|---|---|
| 1 | 9.6 | 9.6 | 9.2 |
| 2 | 18.6 | 9.3 | 18.4 |
| 5 | 44 | 8.8 | 46 |
| 10 | 89 | 8.9 | 92 |
| 20 | 184 | 9.2 | 184 |
| 40 | 386 | 9.4 | 376 |

Figure 4 shows an example of the calibrated results. As shown in Figure 4, the red line indicates the result before the calibration and the blue line indicates the result after the calibration, and relative error is negligible.

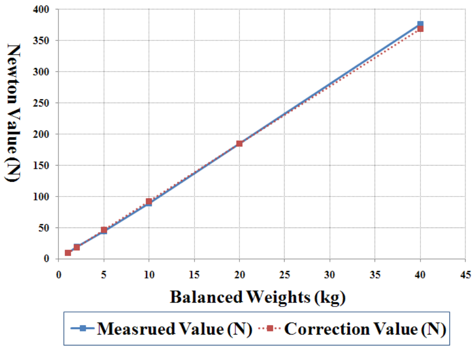


Figure 4 : A comparison graph of measured value and correction value.

## 2.3 Analysis Software of Hand Functions

In this paper, we implemented the software by Visual C++ .Net 2003 in order to evaluate hand functions. In addition, we designed a database in order to store patient's personal information and results of each functional test with the acquired data so that these data can be used to perform and plan rehabilitation treatment as well as compare the data with previous data.

The software consists of cases of examination, diagnosis and analysis. Figure 5 shows the case of examination. In this case, the software can measure grip strength on dynamic and static endurance test mode. (Nicolay & Walker, 2005; Crosby & Wehbe, 1994), and displays it in real time. The case of diagnosis is shown in Figure 6. It diagnoses data from examination by offering not only simple values such as maximum grip strength, duration of operation, average grip strength and acceleration work (Yang, Huang & Yang, 2006), but also variations and standard deviation of grip strength such as dynamic and static endurance test mode. Figure 7 shows the case of analysis. It presented tracing of patient's examination by comparing current data with previous data in order to display variation of patient's results based on each test mode obviously.

Consequently, the functions of the proposed system would help determining the effectiveness of various treatment procedures as diagnosing by accurate data.


Figure 5: A picture of examination.


Figure 6: A picture of diagnosis.


Figure 7: A picture of analysis.

# 3 RESULTS AND CONCLUSIONS

We developed a digital hand dynamometer for measure handgrip parameter quantitatively and implemented user interface to evaluate hand functions. As the results of this study offer quantitative values of handgrip strength, it would contribute in understanding of hand functions to various fields. In addition, visualized results would make patients interesting to take part in rehabilitation programs. Moreover, doctors would evaluate patient's hand functions conveniently.

The proposed system easily carried and able to connect to a personal computer through USB Bus, which means patients can transfer measured data to their doctors by network service so that patients can save their cost and times.

Future work with this system will involve adding wireless communication system as discussed above and a comparing study through a clinical study.

## ACKNOWLEDGEMENTS

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MEST) (No. 2009-0071567).

## REFERENCES

Andria, G., Attivissimo, G. A., Giaquinto, N., & Sasanelli, N., 2006. Functional evaluation of handgrip signals for Parkinsonian patients. *IEEE Transaction On Instrumentation and Measurement*, 55 (5), 1467-1473.

Bassey, E. J. & Harries, U. J., 1993. Normal values for handgrip strength in 920 men and women aged over 65 years and longitudinal changes over 4 years in 620 survivors. *Clinical Science*, 84, 331-337.

Crosby, C. A. & Wehbe, B. M., 1994. Hand strength: normative values. *Journal of Hand Surgery*, 19, 665-670.

Gallery, P. M. & Forster, A. L., 1985. *Human Movement*. Churchill Livingstone Co., 98-99.

Innes, E., 1999. Handgrip strength testing: A review of the literature. *Australian Occupational Therapy Journal*, 46, 120-140.

Mathiowetz, V., Kashman, N., & Volland, G., 1985. Grip and pinch strength: Normative data for adults. *Archive Physical Medical Rehabilitation*, 66, 69-72.

Nicolay, C. W. & Walker, A. L., 2005. Grip strength and endurance: Influence of anthropometric variation, hand dominance, and gender. *Industrial Ergonomics*, 35, 605-618.

Yang, H. Y., Huang, H. C., & Yang, C. H., 2006. A generic grip strength training and evaluation system. *Journal of Medical and Biomedical Engineering*, 26, 75-80.