

## Research Article

# Finger and Palm Dynamic Pressure Monitoring for Basketball Shooting

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Received 3 February 2017; Accepted 4 May 2017; Published 23 May 2017

Academic Editor: Andrea Cusano

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This study verified general inferences on the finger and palm pressure distribution of a basketball player in the moment before that player shoots a basketball through a scientific qualitative testing method. We mounted the sensor on the hands of college basketball players and monitored the dynamic pressure of each player's hand while the player threw a basketball. The dynamic pressure distribution of the fingers and palm of a basketball player throwing a ball can be verified. According to the experimental results, college basketball players typically use the index finger to control the direction and power of force in the moment before shooting a basketball. This study successfully used a scientific qualitative test method to monitor the dynamic pressure of the fingers and palms of basketball players and verified the general inference that a typical basketball player mainly uses the index finger to control the direction and power of force in the moment before throwing a ball. In the future, this study, measuring the dynamic pressure distribution of the fingers and palm, can be applied to simulate hand manipulation in many biomedical and robotic applications.

## 1. Introduction

A variety of pressure sensors are currently used in the industry, mainly piezoresistive, capacitive, and piezoelectric sensors. Among these, piezoresistive pressure sensors [1–5] have scope for use in practical applications for sensing the human body [6–12], such as all kinds of haptic sensing of the human body [13–17] including haptic sensing of fingers and palms [18–20].

Recently, a general inference on the finger and palm pressure distribution of a basketball player in the moment before shooting a basketball has been derived: a typical basketball player uses the index finger to control the direction and power of force in the moment before throwing a basketball. To support this general inference, some researchers claimed that, according to the principles of human-motion mechanics, the basketball player uses the index finger to control the direction and the power of the shooting force in the moment

right before shooting a basketball [21]. This is because the index finger is the longest finger and the working distance is the longest distance, and both are helpful to control the direction and the power of the force for shooting the basketball. However, currently, no related experimental dynamic pressure sensing/monitoring research has been completely conducted on a basketball player using the index finger in the moment before throwing a basketball. In other words, the aforementioned general inference has not been scientifically verified. To qualitatively measure and scientifically verify this general inference, we used the TekScan Grip system [22] as a pressure sensor to monitor the dynamic pressure of the fingers and palms of basketball players while they were throwing balls. By analyzing each player's result from the dynamic pressure monitoring of the fingers and palm, we verified the aforementioned general inference by using a scientific qualitative test method. Furthermore, our verified approach measuring the dynamic pressure distribution of

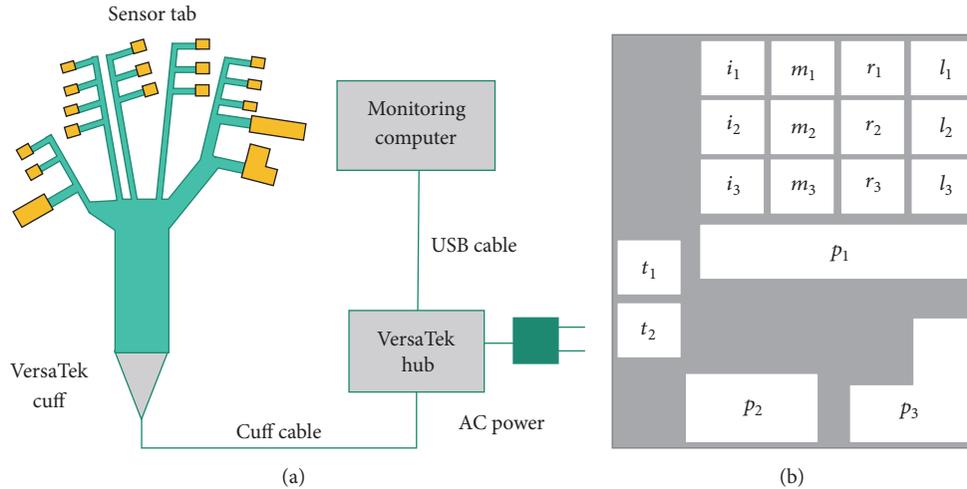


FIGURE 1: (a) Illustration of TekScan Grip system configuration. (b) Illustration of the finger and palm pressure distribution.

the fingers and palm can be applied in many biomedical and robotic applications for simulating hand manipulation. For example, our approach can be modified to design an anthropomorphic robot hand and measure the pressure distributions of the robot hand [23], to achieve haptic feedback (tactile and force) [24, 25] in robotic surgery using the da Vinci robotic system [26], and to measure the hand-arm biodynamic response for real power tool handles [27]. Due to these, our approach not only can be used for current sport-science applications, but also can provide an important design reference for developing future hand-manipulation stimulating technologies in medical and robotic applications. The design, testing, results, and discussion of our approach are described in the following sections.

## 2. Design

The TekScan Grip system is illustrated in Figure 1(a). The main devices constituting this system are the sensor tab, VersaTek cuff, VersaTek hub, and a monitoring computer. The area of the sensor tab comprises 18 independent pressure sensing areas, which can monitor the pressure of the fingers and palm. The connection configuration of the TekScan Grip system is as follows. First, the sensor tab is connected to the VersaTek cuff. The VersaTek cuff can transfer the signals from the sensor tab to the cuff cable. Subsequently, the cuff cable is connected to the VersaTek hub. Finally, the AC power of the VersaTek hub is connected to the TekScan Grip system, and the VersaTek hub is connected to the monitoring computer with a USB cable to monitor the pressure distribution of the fingers and palm. The finger and palm pressure distribution is shown in Figure 1(b); the figure shows the pressure distribution of each area of the palm ( $p_1$ ,  $p_2$ , and  $p_3$ ) and each segment of the thumb ( $t_1$  and  $t_2$ ), index finger ( $i_1$ ,  $i_2$ , and  $i_3$ ), middle finger ( $m_1$ ,  $m_2$ , and  $m_3$ ), ring finger ( $r_1$ ,  $r_2$ , and  $r_3$ ), and little finger ( $l_1$ ,  $l_2$ , and  $l_3$ ). By using the TekScan Grip system, we can monitor and record the

pressure of the fingers and palm of a basketball player while that player is throwing a ball and determine the pressure of each area of the palm and each segment of each finger.

## 3. Testing

To measure the actual behavior of basketball players, we asked the college basketball players to wear the sensor system and perform ball-shooting, and we monitored and recorded the pressure levels of their right hands. To facilitate the sensor installation on the hands of the basketball players, adjust the sensor positions, and avoid hygienic issues, we mounted the sensor tab on their gloves (latex gloves, thickness 0.15 mm; Taihang Enterprise Co. Ltd., Hsinchu, Taiwan), following the procedure of Mastalerz et al. [6]. Furthermore, to prevent the VersaTek cuff from affecting the operation of the basketball player while shooting the ball, we carefully affixed the VersaTek cuff to the upper arm of each player. After completing these configurations of the TekScan Grip system, we investigated the finger and palm pressure distributions of the players by analyzing the recording of the sensor system. In addition, the players who we chose for test have common features: college student, about 20 years old, having a little nonprofessional basketball training (e.g., school team member or department team member), and about 175–180 cm height with a similar stature. Due to the choosing criteria, the test results are comparable.

## 4. Results and Discussion

The records of the finger and palm dynamic pressure distributions of college basketball players, that is, the school basketball team member and the department basketball team member, are shown in Figures 2 and 3, respectively. We can analyze the results of the dynamic pressure monitoring of the fingers and palm in three stages (first, holding the ball; second, lifting the ball overhead; and third, the moment

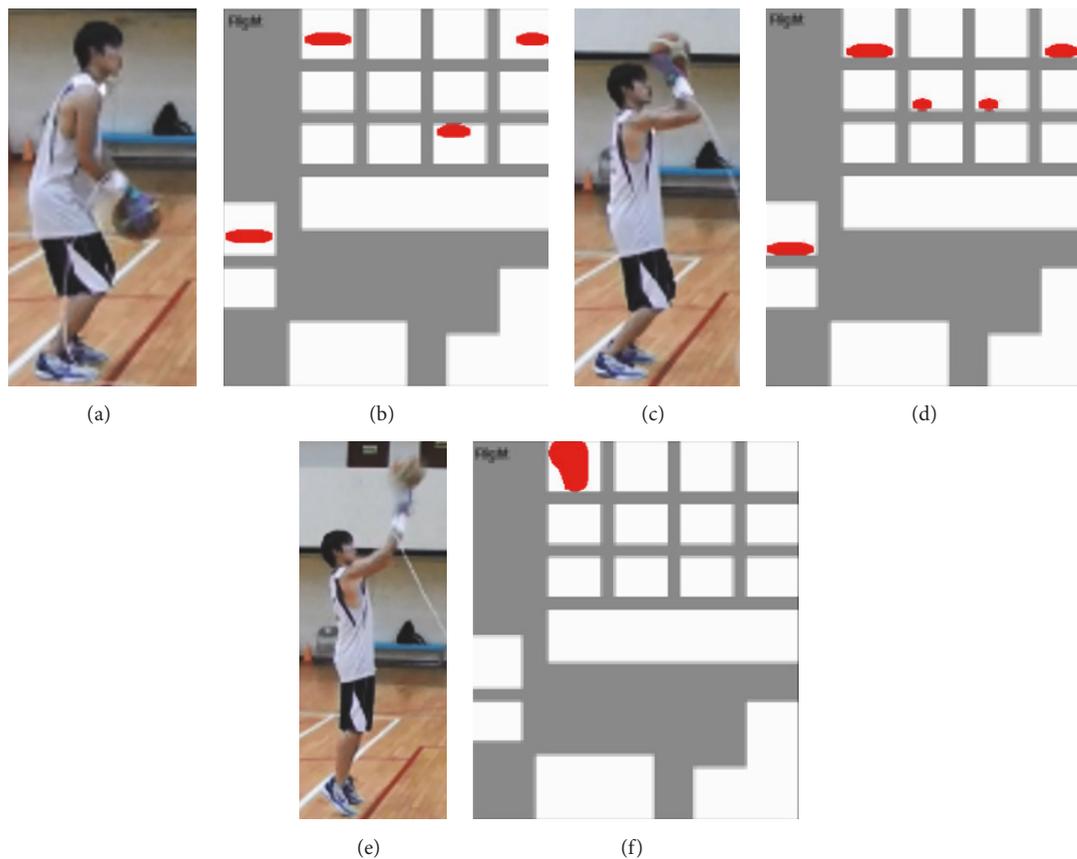


FIGURE 2: Photographs while shooting a ball and the finger and palm pressure distribution of the school basketball team member at the following stages: (a, b) holding the ball, (c, d) lifting the ball overhead, and (e, f) the moment before shooting the ball.

before shooting the ball). By comparing these distributions of dynamic pressure of the finger and palm, we obtained the following results. While holding the ball, most of the fingers of both basketball players had a high-pressure distribution, as shown in Figures 2(a), 2(b), 3(a), and 3(b). Because each player's habits are different, the pressure distributions were also different. While lifting the ball overhead, the finger and palm pressure distribution of both basketball players was observed on all fingers, as shown in Figures 2(c), 2(d), 3(c), and 3(d). Finally, in the moment before shooting the ball, both basketball players mainly used the index finger to control the direction and power for shooting the ball, as shown in Figures 2(e), 2(f), 3(e), and 3(f). These results are consistent with the aforementioned general inference. Thus, we successfully verified the general inference on the finger and palm pressure distribution by using the scientific qualitative test method.

## 5. Conclusions

By using the piezoresistive pressure sensing/monitoring system, we successfully verified the general inference on the finger and palm dynamic pressure distribution in the moment while the basketball players throw the ball (i.e., during

ball-shooting). The experimental results of the dynamic pressure monitoring revealed that the college basketball players mainly used the index finger to control the direction and power for shooting the ball. These results not only verified the general inference but also could provide a reference for current basketball sport science. Moreover, our approach can provide an important design reference for future hand-manipulation simulating technologies in medical and robotic applications.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

## Authors' Contributions

Chiao-Fang Hung and Chung-Chiang Chen contributed equally to this work.

## Acknowledgments

This work is supported by the Ministry of Science and Technology, Taiwan (Grant no. 105-2628-E-009-001-MY2).

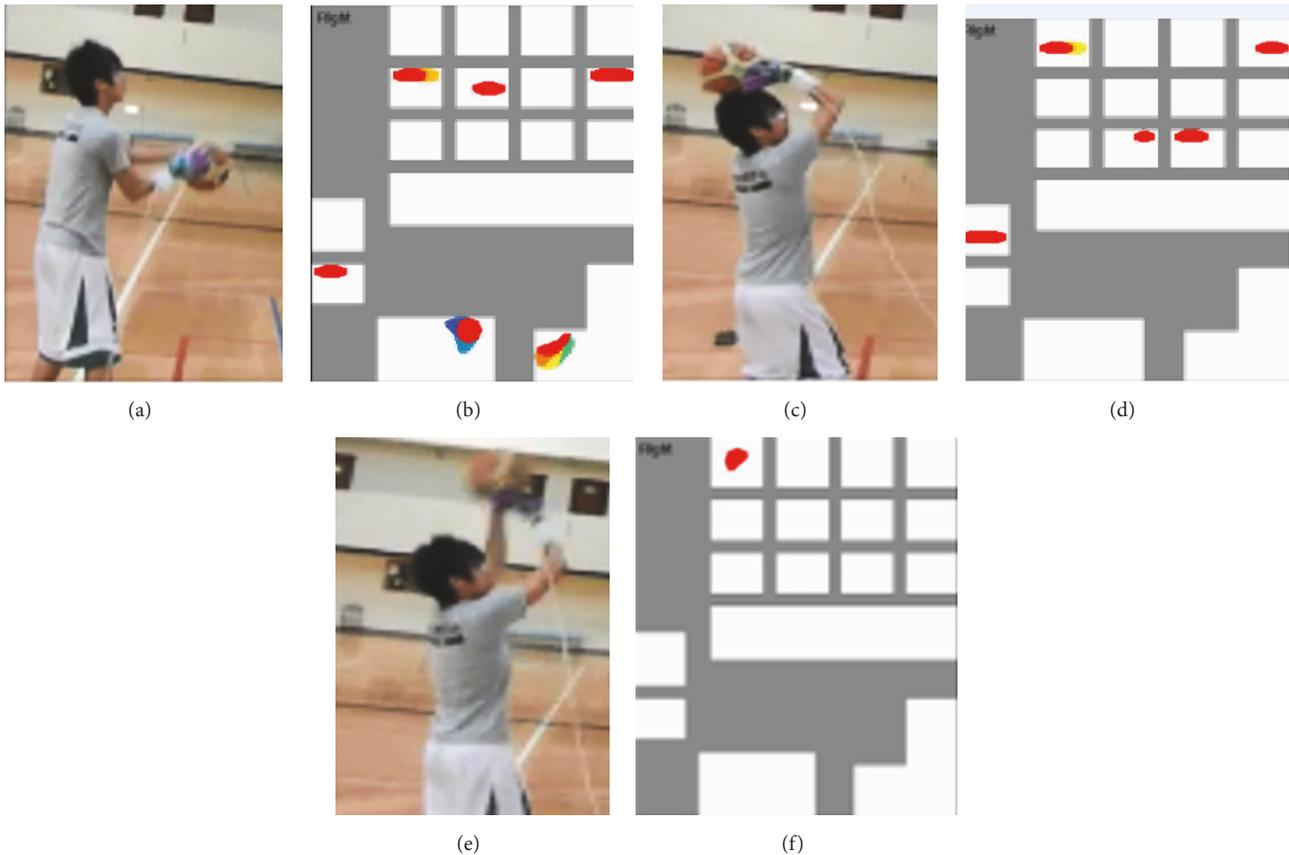
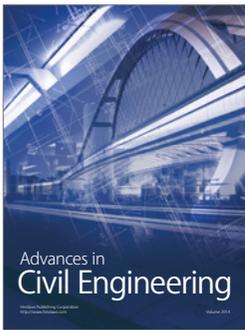
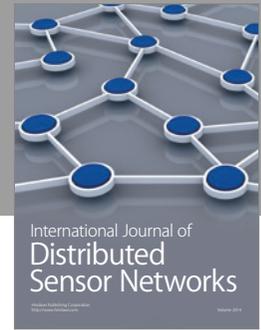
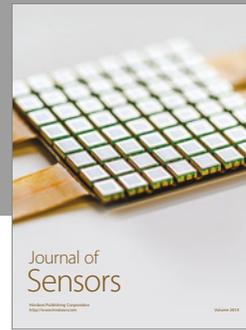
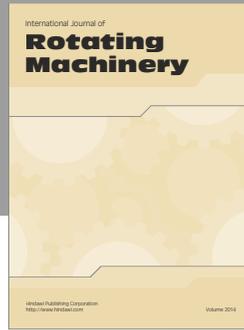


FIGURE 3: Photographs while shooting a ball and the finger and palm pressure distribution of the department basketball team member at the following stages: (a, b) holding the ball, (c, d) lifting the ball overhead, and (e, f) the moment before shooting the ball.

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