Outline:

**Abstract**

Recent technological advancements in soft actuators, flexible electronics, and system integration technologies have enabled the creation of a portable, low cost, and unobtrusive wearable sensor glove that is used in conjunction with a sensory feedback device. This combination of technologies has the ability to advance the status quo of healthcare, prosthetics, and rehabilitation. The application of a wearable sensor glove and sensory feedback device has emerged as a promising paradigm to enhance the care provided to patients with neurological and musculoskeletal conditions. The integration of soft and biocompatible materials with miniaturized electronics, sensors, and actuators is undoubtedly an attractive prospect to develop a wearable sensor glove and sensory feedback device. The development of soft pneumatic actuators that are used in conjunction with micro-motors provides one with the ability to physically actuate patients with perceived sensory transfer signals. A sensory feedback device that has a high performance requires a high degree of mechanical flexibility, low weight, and a simple user interface. This paper includes the most up-to-date materials, sensors, actuators, and system-packaging technologies to develop a wearable sensing glove and sensory feedback device. This paper presents a summary of the requirements for the material properties, sensor capabilities, electronics performance, and user interaction. Details of the mechanical, electrical, system architecture, and material properties are discussed in regard to their application in healthcare, prosthetics, and rehabilitation. Additionally, the limitations of the current materials and technologies are discussed, as well as the key challenges and the future direction of how a wearable sensor glove is used in conjunction with a sensory transfer device. Overall, this paper is used as an all-inclusive review of the technologies used to develop a wearable sensor glove and a sensory feedback device.

**Introduction**

Sensory impairment is a symptom of a variety of neurological conditions such as spinal cord injuries (SCI), cerebral palsy, peripheral neuropathy, sclerosis, and diabetes. Amputee patients face a similar issue with their prosthetics which are, up to date, unable to sense or feel. The lack of tactile, proprioceptive, and temperature feedback from a limb (whether human or artificial) often leads to a feeling of disembodiment over the limb, resulting in reduced use of the limb or rejection (in the case of prosthetics) [Design and evaluation of a sensory...][7]. Patients with sensory impairments rely solely on vision as a feedback mode to determine the state of their limbs, this can be greatly inconvenient [4]. The need for a device that is able to communicate the sensory and physical states of a sensing-less limb is evident.

Data Glove. Fine motions of digital joints are often difficult to capture using imaging techniques, such as the motion capture method, because there are many blind spots. Therefore, a glove-shaped device called a “data glove” is generally used for this purpose because it is capable of detecting fine finger motions and collecting electric motion data when worn on the hand. The data glove has generated significant outcomes in various fields that require electric expression of human finger motions, such as virtual reality (VR) studies, animation and computer graphics (CG) production, and ergonomics. 53−57 Commercially available data gloves are designed to detect and output the “natural motions” of human hands as electric signals through variable-resistance bending sensors in film form or fiber-optic bending sensors wired along the outer surfaces of finger joints. Various improvements have been made to the gloves since their introduction to the market, and they are advertised to fit to human hands well because they are stretchable and lightweight. However, these gloves tend to feel hard and tight because of the bending sensors and hard glove fabrics, and users’ hands tend to become sweaty after long-term use; further improvements are highly desirable. We developed prototype data gloves with less wearing burden by incorporating CNT strain sensors along the finger joint lines on a surface of thin compression fabric gloves, as shown in Figure 5c (see Supporting Information Movie\_S3).To evaluate these prototype data gloves, test measurements of finger motions during a piano performance requiring subtle finger movement were conducted using the data gloves. Through consultation with pianists, a compression fabric that did not disturb piano performances was selected, and the sensor length and stretchable wire layout and positions were optimized to independently detect finger motions. Finger sweatiness during a prolonged performance was also success-fully eliminated by using a breathable fabric. One CNT strain sensor was provided for each metacarpophalangeal (MP) joint and proximal interphalangeal (PIP) joint of every finger to independently detect the degree of bending of each joint. When a finger joint bends, the respective CNT strain sensor elongates, and the resistance increases. When a finger joint is stretched, the sensor contracts, and the resistance decreases. Generally speaking, professional pianists are more effortless and relaxed while performing than amateur pianists because their fingers bend less and their finger motions are smoother. Additionally, these differences have been reported to become more prominent as the performance speed increases.58,59Pianist subjects wore the data gloves incorporated with CNT strain sensors, and their finger motions were measured during performances. By synchronizing and comparing the finger

**Conclusions**

In this paper, we presented a survey of all the major wearable technologies available to measure hand joint angles for rehabilitation process of various hand deformities. We broadly categorized them in six categories i.e. Flex sensor based, Accelerometer based, Vision based, Hall-effect based, Stretch sensor-based and Magnetic sensor based. We critically analyzed all these categories and mentioned their advantages and drawbacks. Finally, based on various vital parameters, such as, accuracy of sensor’s sensitivity, size, cost and implementation, we proposed an optimal solution, which provides a cost-effective, easy and innovative alternative to the current methods of measuring hand joint angles for the rehabilitation. Our proposed device uses conductive ink based sensors for finger joints measurement and an accelerometer for the measurement of wrist joint angles. It also uses a smartphone app, which provides an easy user interfacing and automatic data entry. We also recommended to use this wearable device to measure the level of dexterity of a patient’s hand, which can be done by performing dexterity tests while donning the wearable and getting necessary readings

**Tables and Figures**

-Tables:

-Existing wearable sensor glove technology of pressure, temperature, and strain

-Figures:

-Existing wearable sensor glove technology

-Summarized key properties of wearable sensor gloves

-Overview of commercial wearable sensor glove technology

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**Pressure:**

Wearable hand rehabilitation system with soft gloves []

75,

**Strain:**

59, 60, 61, 62, 70,

**Temperature:**

63, 64, 73,

**Surveys:**

Wearable technologies for hand joints monitoring for rehabilitation [28]

**Images:**

**Prosthetics:**

**65,**

Commercial Products:

27- <https://www.rehabmart.com/product/smart-glove-for-stroke-rehabilitation-by-neofect-49247.html?gclid=Cj0KCQiA3NX_BRDQARIsALA3fILmFJC7fMqFPAU3qoxPEqXB0Ly_DZAwrzM9IlDR2tFiQVmghzk41lYaAuGyEALw_wcB>

19- [https://www.senspro.cz/index en.php](https://www.senspro.cz/index%20en.php).

20- <https://www.flexpoint.com/usbglovekit>.