Multi-object Recognition and Motion Detection Based on Flexible Pressure Sensor Array and Deep Learning

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Table S1. Comparison with other sensors.

	Cost	Versatility	Reliability	Longevity	Usage environment	Advantages	Disadvantages
[55]	1. Uses common materials such as PVA and Ag, which have lower costs. 2. The multi-channel signal processing chip and feedback control have increased complexity, but the overall cost is controllable.	1. Suitable for various scenarios, such as prosthetic hands and robotic hands. 2. Strong scalability and can be integrated into different robot systems.	1. High sensitivity (0.017 kPa^{-1}) and fast response. 2. Has shown good stability in multiple cyclic tests.	1. Uses durable materials that are suitable for long-term use. 2. Long life design, suitable for repeated use.	1. Strong adaptability and can be used in various environments. 2. Suitable for dynamic and static pressure monitoring.	1. High sensitivity and fast response capability. 2. Strong scalability, suitable for various application scenarios.	1. The complexity of the system increases, resulting in higher research and development costs. 2. Sensitive to environmental humidity and may require additional protective measures.
[59]	1. Uses CNT/TPE coating technology; the cost is low. 2. No external power supply is required, reducing system costs.	1. Suitable for various scenarios, such as VR/AR control and gesture recognition. 2. Strong compatibility and can be integrated with multiple devices.	1. High sensitivity and fast response (100 ms). 2. Has shown good stability in multiple cyclic tests.	1. Uses durable materials that are suitable for long-term use. 2. The superhydrophobic coating improves waterproof performance and extends service life.	1. Strong adaptability and can be used in humid environments. 2. Suitable for daily wear and dynamic monitoring.	1. High sensitivity and fast response capability. 2. The superhydrophobic coating improves waterproof performance and is suitable for humid environments.	1. Sensitive to mechanical wear and may require additional protective measures. 2. The data processing requirements are complex and require professional algorithm support.
[60]	1. Uses PVA and an acrylic fluorescent layer; the material cost is low. 2. The manufacturing process is simple and suitable for large-scale production.	1. It can be used in various scenarios, such as sports monitoring, rehabilitation therapy, human–computer interaction, etc. 2. Strong compatibility and can be combined with machine learning algorithms.	1. High precision recognition (99.75%) and high reliability. 2. Has shown good stability in multiple tests.	1. Uses high-density EVA sponge with strong durability. 2. Suitable for long-term use.	1. Strong adaptability and can be used in high-humidity environments. 2. Suitable for daily wear and exercise monitoring.	1. High-precision recognition capability, suitable for various application scenarios. 2. The superhydrophobic coating improves the waterproof performance.	1. Performance may be poor in extreme environments such as those with high and low temperatures. 2. The data processing requirements are complex and require professional algorithm support.
Ours	1. The use of PDMS and MWCNTs results in low material costs. 2. A simple manufacturing process, suitable for large-scale production.	1. Suitable for various scenarios, such as pressure monitoring and health monitoring. 2. Strong scalability and can be integrated into different devices.	1. High sensitivity and fast response (119 ms/68 ms). 2. Has shown good stability in multiple cyclic tests.	1. Suitable for long-term use. 2. After multiple cycles of testing, the performance is maintained.	1. Strong adaptability and can be used in various environments. 2. Suitable for dynamic and static pressure monitoring.	1. High sensitivity and fast response capability. 2. Suitable for low-pressure and low-frequency dynamic pressure monitoring. 3. Has good recognition ability for an individual and different individuals.	1. Sensitive to mechanical wear and require additional protective measures. 2. The data processing requirements are complex and require professional algorithm support.

Table S2. Comparison with the process steps in reference [54].

Process steps	The process in this article	The process in [54]	Advantage	Disadvantage	Influence
Ultrasonic immersion time	10 minutes, repeat 3 times	2 hours	Increased productivity	Coating uniformity or adhesion may be insufficient	High production efficiency
Plasma processing time	20 seconds	20 seconds			
Material selection	MWCNTs	Graphene	Provides higher conductivity and mechanical strength	Difficulty in dispersion	Better conductivity and mechanical properties
Electric field treatment	AC electric field	DC electric field	Suitable for inducing the curing of MWCNTs	Difficulty inducing oriented arrangement of graphene	
Textile pretreatment	2 g/L detergent, 30 minutes	Not described in detail	30-minute ultrasonic cleaning		

Material Information:

The PET (120.32 g/m²) twill woven fabric was provided by Zhejiang Miandu Textile Co., Ltd. Neat wash agent 209 (AR) was purchased from Guangzhou Wangnilai Chemical Co., Ltd. Anhydrous ethanol (AR) was obtained from Shanghai Titan Technology Co., Ltd. Polydimethylsiloxane (M.W. 770) was supplied by Shanghai Alpha Aisa Co., Ltd. Multi-walled carbon nanotubes (diameter = 10^{-20} nm, length < 30 μm) were purchased from Chengdu Organic Chemicals in China. High-purity argon gas (99.999%) was provided by Shanghai Canghai Industrial Gases Co., Ltd.

Equipment Information:

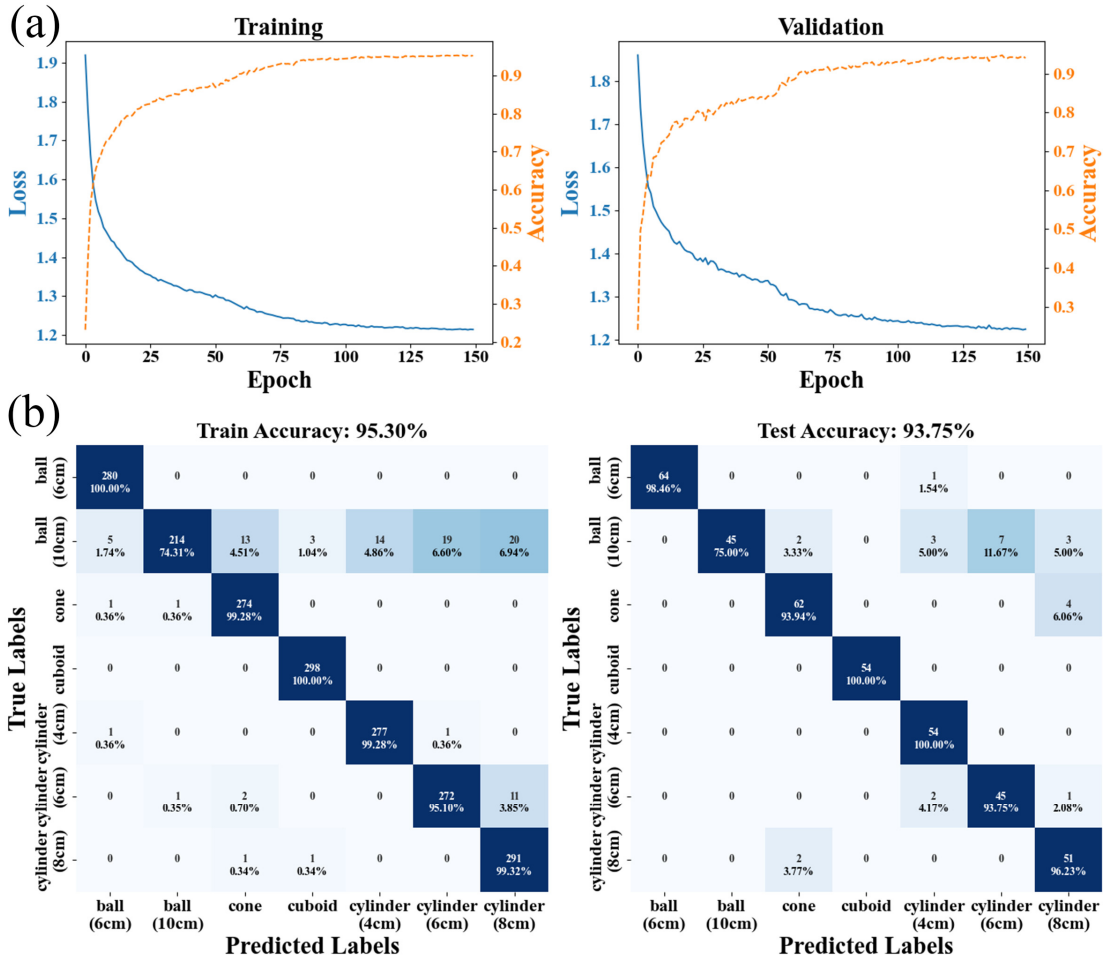
Analytical balance (FA2004A, Shanghai Precision Scientific Instrument Co., Ltd.). Ultrasonic oscillator (KQ400DB, Kunshan Ultrasonic Instrument Co., Ltd.). Radio-frequency power supply 13.56 MHz (AE Cesar 1320, Advanced Energy Industries, Inc., Denver, CO, USA). Ultrasonic cleaner (Shanghai Bilang Instrument Manufacturing, China).

Table.S3. Participant information.

	Sex	Ball (6cm)	Ball (10cm)	Cone	Cuboid	Cylinder (4cm)	Cylinder (6cm)	Cylinder (8cm)
Participant A	Male	√	√	√	√	√	√	√
Participant B	Male			√	√			√
Participant C	Male	√	√		√			
Participant D	Female					√	√	√
Participant E	Male	√	√			√		
Participant F	Female	√		√			√	
Participant G	Female			√	√	√		
Participant H	Male		√				√	√

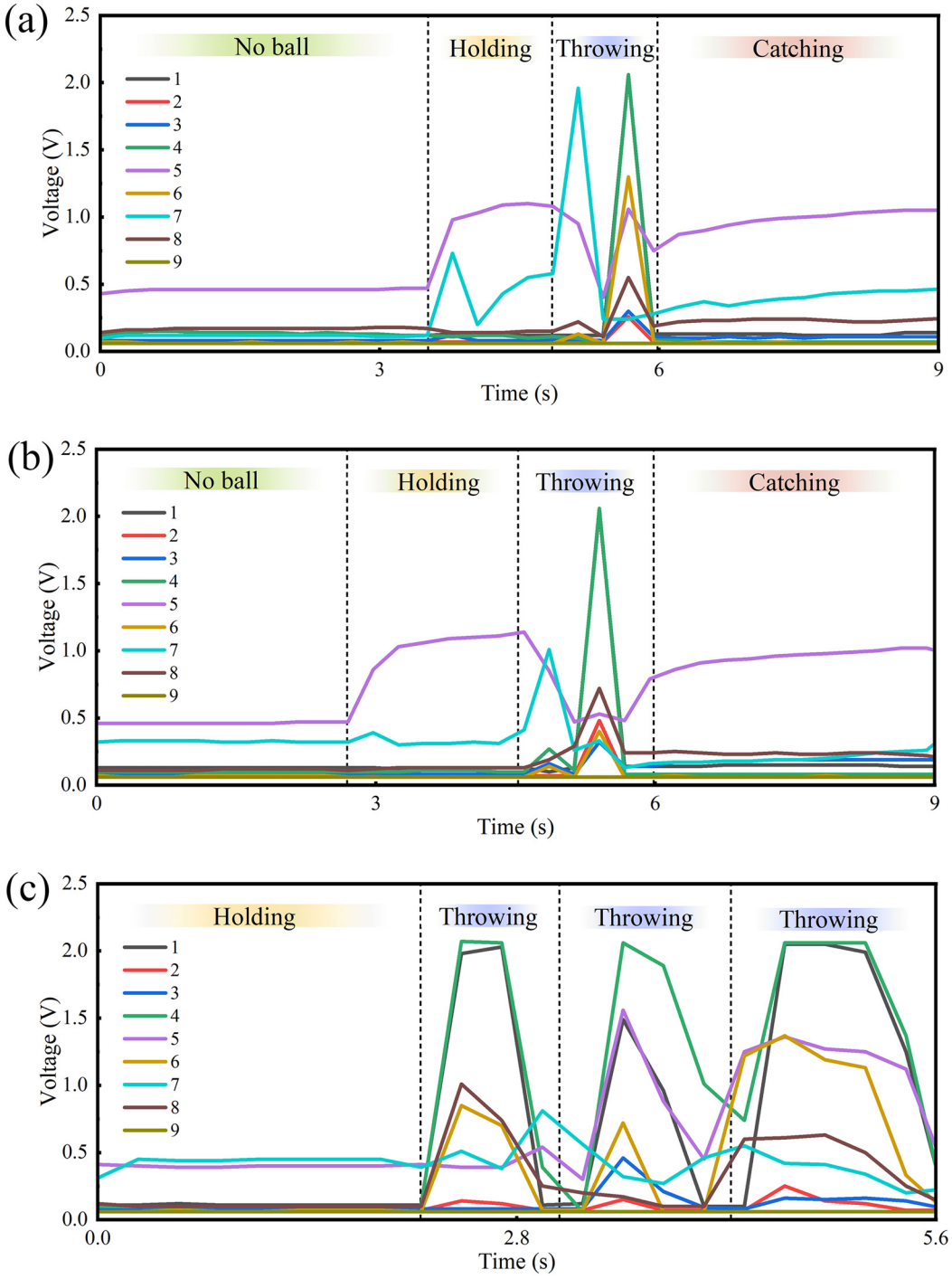
In Table 1, information on the participants in the experiment is presented. There were a total of eight individuals: five males and three females. For each participant, the symbol '√' is marked under the tests they participated in. Each action was tested by a total of four different participants. Each participant performed 100 trials of each action.

Figure S1. CNN training results obtained from different population data.



Based on the test results obtained from Table 1, a database was established for different populations and genders. Since this database is more complex than the one created from experiments with a single individual, the complexity of the CNN was appropriately increased. Data were normalized before being input into the CNN to avoid interference from large variations in signal amplitude within the same test item. Finally, as shown in Figure S1, the accuracy of the training set reached 95.30%, while the accuracy of the test set reached 93.75%.

Figure S2. Participant F: repeated throwing results and continuous throwing results.



For the ball-throwing test, we also conducted tests with other participants. In Figure S2, the results of Participant F are displayed. In Figure S2 (a) and (b), the results of two of the participant's ball-throwing tests are shown. It is clear that the different stages can still be distinguished when testing with various individuals. Additionally, a continuous ball-throwing test was performed, and each stage, as well as every individual throw, could still be clearly differentiated (Figure S2c).

Since each person has different gripping habits, the final signals show some variation. However, this does not affect the ability to distinguish between different stages.