Interactive SPA Skin

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Introduction

The interactive soft pneumatic actuator (SPA) skin is a soft wearable device with integrated actuation and sensing. The SPA skin is a flat flexible *patch* that can be worn on the body, consisting of a 2-D matrix with independent actuation and sensing elements at each node (*a taxel)* [1].

The SPA skin acts as a bidirectional communication interfacing device. Vibrotactile actuation is achieved using SPAs and the tactile sensing is done via piezo-electric sensors [2,3]. It can take in input from the user, as well as actuate in various patterns, simulating various sensations such as touch, brush, move, etc. thus allowing a bidirectional communication.

Performance

The device generates modulable and high fidelity vibrotactile feedback. Actuating different taxels in different sequences creates different types of actuation patterns. Each taxel can provide a force output of up to 1 N and can be actuated at different frequencies, from 0 up to 100 Hz. The human skin is more sensitive to certain frequencies than others, and using this device, different sensory receptors can be stimulated.
The current device demonstrates four novel modes of operation way for interaction as shown in Figure 2B. Simultaneously, the device can also sense inputs from the user as shown in Figure 2C.

Applications

Entertainment and robotics: Bidirectional tactile feedback can be coupled with traditional audio-visual modes to have a augmented communication experience.

Medical rehabilitation : Vibrotactile feedback with multiple distributed sensors as shown in Figure 2C can be used in rehabilitation or prosthetics (phantom limb control). Interactive SPA skin is being used to study effects of vibrotactile stimulation on the wrist proprioception [4].

Fabrication

The Interactive SPA skin is made using layer-by-layer fabrication methods. The presented prototype consists of the following layers:

Actuator:
1. Silicone layer
2. Mask layer
3. Silicone layer

Sensor:
4. Silicone layer
5. Cu-Kapton electrode
6. PZT element
7. Cu-Kapton electrode
8. Silicone layer

Actuation – The mask in the second layer creates a thin channel. When pressurized, this layer inflates.
Sensing – The PZT crystal generates a voltage proportional to the force applied [2].

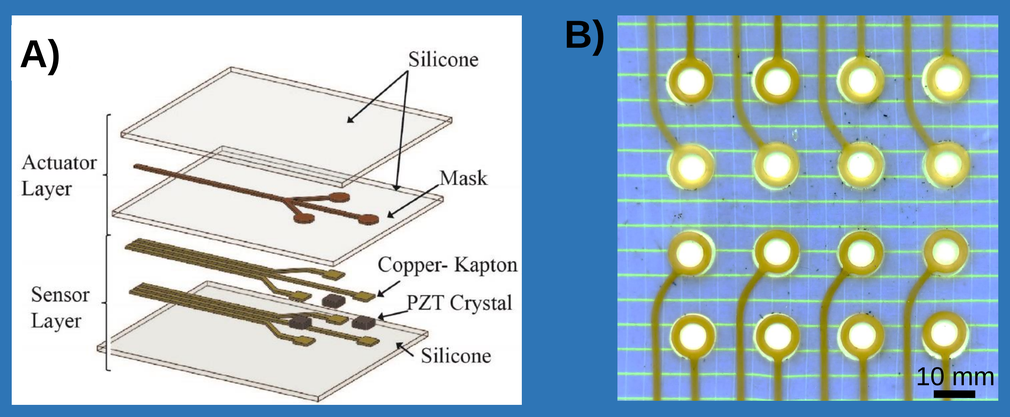

Figure 1: A) Exploded view of layers B) Actual Prototype

References

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Interactive device

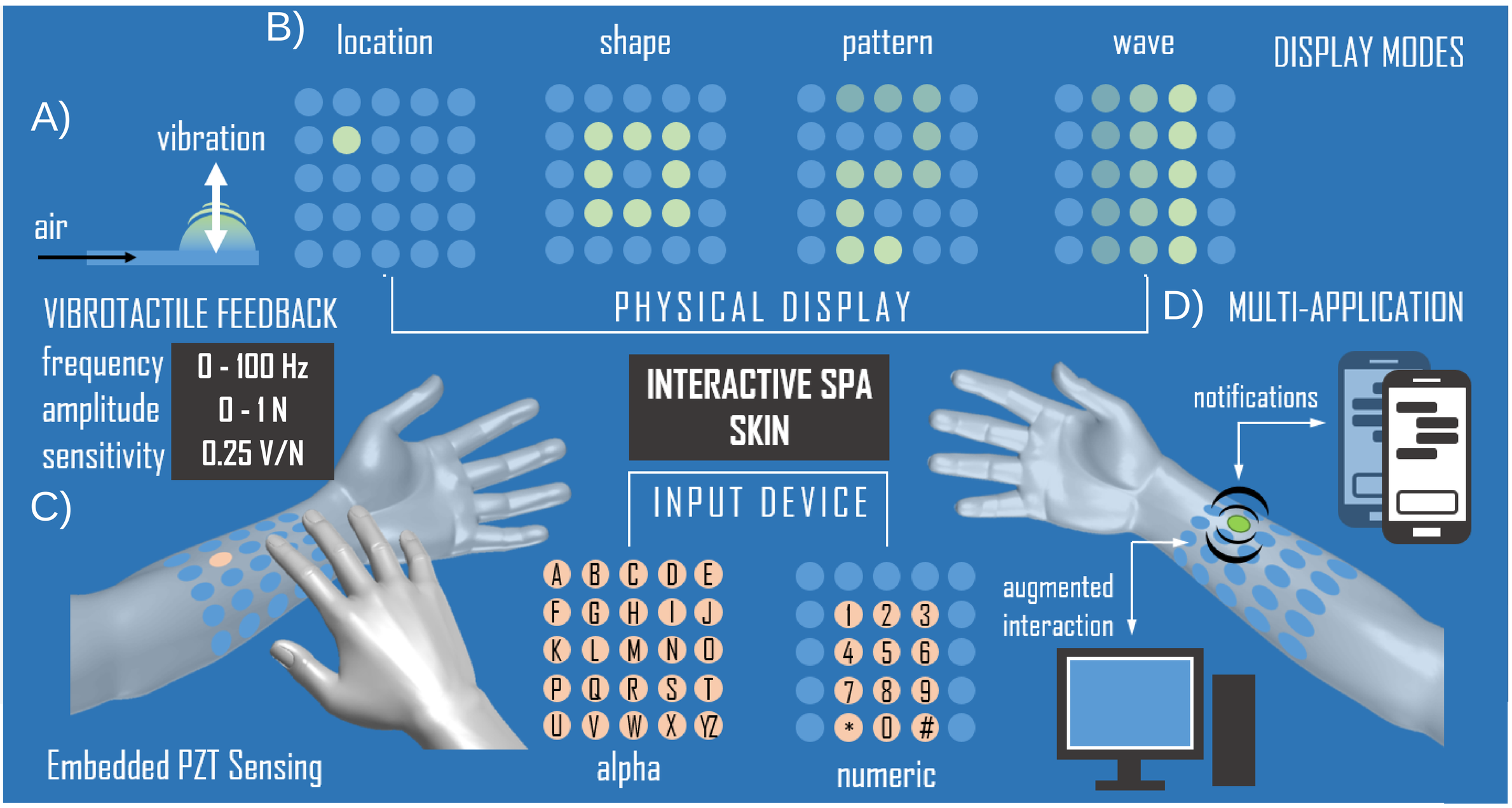

Figure 2: A) actuation principle, B) Types of output modes. C) SPA skin as input device D) SPA skin interfaced with multimedia devices