Electrotactile Stimulator for Modeling Localized Touch in the Hand

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OBJECTIVE

- To develop a portable device that will stimulate realistic localized touch in the fingertips of the subject with high spatial and temporal resolution
- To characterize the brain's response to different tactile stimulations in the hand by pairing electrocorticography (ECoG) recordings with the stimulations from our electrotactile stimulator

BACKGROUND

- When an external stimulus is applied to the skin, the mechanoreceptors under the skin are activated, and they convert this external stimulus to an electronic signal, which is sent to the brain. Specifically, the fingertips are one of the most sensitive parts of the skin because they contain many sensory neurons condensed in a small area. Thus, the fingertips are useful for studying haptics.
- Although many researchers have developed wearable devices such as gloves and skin electrodes to stimulate realistic touch sensations in the hand via electrical impulses, these devices are not ideal because they are bulky, use expensive equipment, and cannot precisely induce a localized touch signal.
- Artificial recreation of haptics will enable us to help people, such as spinal cord injury (SCI) patients and amputees, who have lost their sense of touch to regain normal physiological skin function.
- For researchers and surgeons, understanding which regions of the brain are activated when patients acquire a feeling of touch is important for surgical procedures and mapping of the brain.

METHODS AND MATERIALS

- The electrotactile stimulator is designed using a TENS unit, Arduino Uno, silver cap electrodes, silicone finger cots, a group relay, and a wrist brace to encase the device.

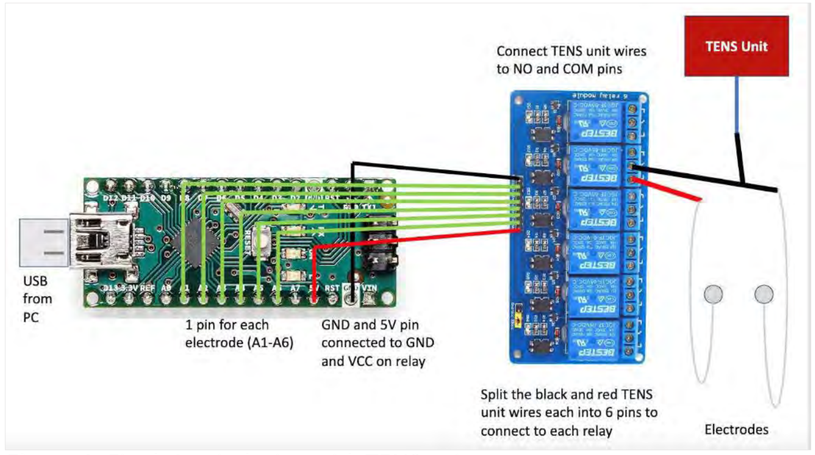

Figure 1: Final circuit design with TENS unit

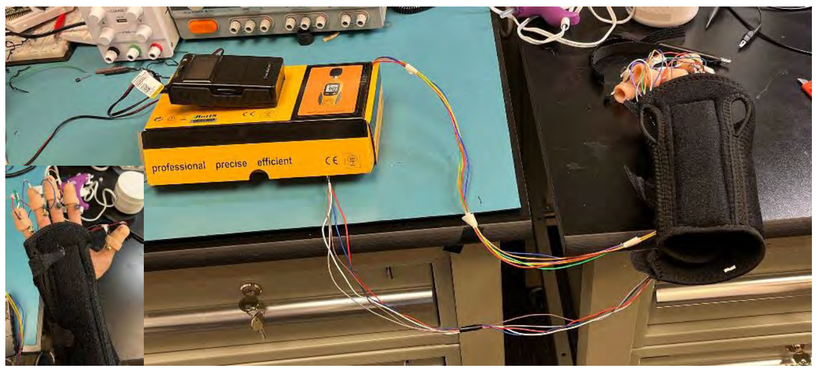

Figure 2: Device design depicted in real-world

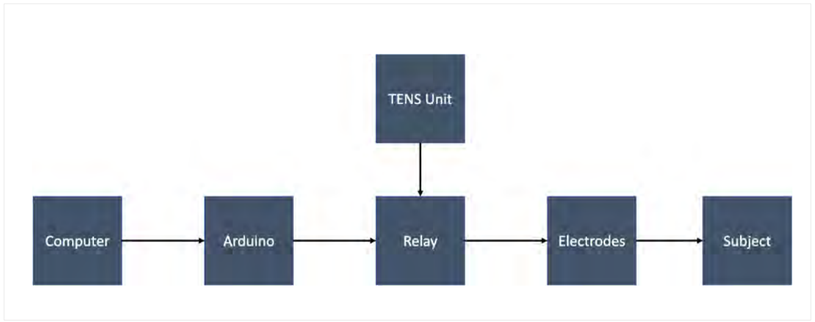

Figure 3: Block design showing current flow in our electrotactile stimulator

RESULTS

Raed Data	Location	Current	Impedence	Description		Note: Pulse Rate is 50, Pulse Type Steady
Index Finger	1-2	1000	46000	nothing		
	1-2	2000	41000	flinch	Too much	
	1-2	1500	36000	comfortable		
	1-2	1200	33000	slight	Start to feel it	
	1-2	1400	30000	Perfect		
	1-3	1400	55000	Same as the previous	Stimulation is more clear at 1/3 vs 1/2	*Note: got used to the stimulation, should take break
	1-3	2000	50000	Slightly uncofmortable		
	1-4	1500	53000	Comfortable		
	1-4	2000	53000	Initial shock but becomes tolerable	Same thing as 1-3 at 2000	
	2-3	1500	48000	Nothing, again might have gotten used to it		
	2-3	2000	47000	Didn't feel anything	Stronger shock at 1/3 vs 2/3	
	4-5	1500	39000	Does not feel anything		
	4-5	2000	38000	Feels it very slightly		
	4-5	2500	36000	Feel the full finger from top to bottom, even being at 4/5		
	4-5	3000	36000	Felt like 2000 in the previous one		Conclusion: Must have one at 1, and then between 3
	1-5	2000	36000	Felts like a shock		
	1-3	2000	55000	Same as middle finger 1/3, light sensation		
	1-5	2000	62000	Stronger but good stimulation through the whole finger		
Middle Finger	1-5	1500	50000	Same previous 1-5 on index		
	1-5	2000	43000	A little stronger, exact same as index		

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- Based on the data we collected, we determined that the most ideal range of phase amplitudes for the 1-5 electrode configuration is from 2250µA to 2750µA (with a steady pulse rate of 50 Hz), but the placement of electrodes should be at regions 1 and 3 to achieve the most localized sensation in the fingers.

CONCLUSION

- We were able to develop a device that could stimulate the fingertips and thereby model various touch sensations in the hand. The device was safe to use, adaptable to every hand size/person, and easy to transport from one place to another.

ACKNOWLEDGMENTS

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