SBHSE

Preliminary Study on Pneumatic Haptic Feedback Integration in Prosthetics with WISH School of **Biological** and **Health Systems Engineering**

Introduction

- Myoelectric prosthesis have had considerable advances in tactile and proprioceptive feedback [1]
- Sensory feedback has been shown to improve control, increase embodiment, and reduce phantom limb pain [2]
- This study explored the potential of pneumatic haptic feedback as an alternative feedback method
- Pneumatic soft haptic feedback provided by the WISH will increase subject performance compared to no haptic feedback

Materials and Methods

- Three subjects (2 female, aged 19, 67, and 69 years) with transradial limb loss or amelia (birth defect of lacking one or more limbs)
- SoftHand Pro (SHP): 19 degrees of freedom anthropomorphic hand using a single motor to produce synergistic finger movements [4]
- Wearable Integrated Soft Haptics (WISH): Electronic pneumatic pump that correlates real time current absorption in the SHP's single motor to pneumatic pressure [3]
- Randomized cross over study where subjects performed clinical exams under one study condition then the alternative study condition
- Exams performed: Activities Measure for Upper Limb Amputees (AM-ULA), Box and Blocks (BnB), Action Research Arm Test (ARAT), Jebsen Hand Function Test (JHFT), NASA-Task Load Index (NASA-TLX), and Likert questionnaire



Figure 1. CAD model of the SoftHand Pro [4]. Displays the single electric motor connecting the synergistic fingers.



Figure 2. An overview of the primary components of the WISH device [3].

nioli, A. Serio, C. Piazza, and A. Bicchi, "Adaptive synergies for the design and control of the Pisa/IIT SoftHand," The International Journal of Robotics Research, vol. 33, no. 5

Ellis Hatch¹, Simone Fani Ph.D¹, Marco Santello Ph.D¹ ¹School of Biological and Health Systems Engineering, Arizona State University, Tempe, AZ

Results



Figure 3. Displays AM-ULA overall results for each subject. This is the score difference between with using the WISH device and without using the device. Scores improved by the WISH device are shown in green, and scores that worsened are in red. Total is the overall net score, Average is the mean score per task, and Final is the standardized final score.

	WHP01			WHP02			WHP03		
	With	W/o		With	W/o		With	W/o	
Transported Blocks	9	10	-1	8	15	-7	8	12	-4
Time to transport	00:01.35	00:01.27	0.08	02:00.00	00:52.60	67.4	00:59.15	00:44.24	14.91
Broken blocks	0	1	-1	0	0	0	0	0	0
Number of regrasps	4	2	2	5	0	5	0	0	0

Figure 4. The box and blocks results table showing a negative trend across all subjects. Scores in red show subjects that performed worse with the WISH device, and green shows improved performance.

	WHP01 Time to Complete			WHP02			WHP03		
				Tin	ne to Compl	ete	Time to Complete		
	With	W/o		With	W/o		With	W/o	
Writing	01:09.68	00:49.84	19.84	00:31.41	00:27.21	4.20	01:15.35	01:17.56	-2.21
Simulated Page Turning	01:10.46	01:22.78	-12.32	01:48.52	00:32.96	75.56	01:12.94	00:51.01	21.93
Lifting Small, Common Objects	05:33.91	07:15.54	-101.63	05:10.14	02:05.99	184.15	02:11.40	01:41.57	29.83
Simulated Feeding	01:33.15	01:37.25	-4.10	00:31.26	00:23.76	7.50	01:20.52	00:56.69	23.83
Stacking Checkers	03:18.07	04:02.19	-44.12	05:01.54	39:00.00	-5638.46	39:00.00	39:00.00	0.00
Lifting Large, Light Objects	00:20.51	01:04.86	-44.35	00:34.28	00:16.97	17.31	00:37.30	00:22.41	14.89
Lifting Large, Heavy Objects	00:33.93	00:26.13	7.80	00:19.33	00:21.31	-1.98	00:20.26	00:24.20	-3.94

Figure 5. JTHF results table. Subject 1 did have a primarily positive trend with the feedback device, shown with each green highlighted cell. Subjects 2 & 3 had a negative trend when using the feedback device, shown with each red highlighted cell.

	WHP01			WHP02			WHP03		
	With	W/o		With	W/o		With	W/o	
Mental Demand	9	10	-1	19	19	0	14	14	0
Physical Demand	6	6	0	17	20	-3	15	14	1
Temporal Demand	4	4	0	15	15	0	11	12	-1
Performance	6	6	0	11	6	5	9	11	-2
Effort	11	10	1	19	19	0	16	15	1
Frustration	14	5	9	16	18	-2	12	14	-2

Figure 6. NASA-TLX results table. No clear trend is derived from the NASA-TLX questionnaire. Positive scores are shown in green and negative scores are in red with gradient colors in between.

Acknowledgements:

Thank you to my project mentors, Dr. Marco Santello, and Dr. Simone Fani. They have provided me with the tools and assistance I needed to succeed in completing this project effectively and efficiently. I would also like to thank Anthony Berland and Hanger Clinic for their assistance in recruiting subjects for this study.

It was easy to wear and use the h It was feeling uncomfortable while haptic device

I could focus on the provided hap performing the requested tasks To perceive and understand the f losing focus on the performed act The stimuli provided by the haptic enough to estimate the grasping To perceive and understand the fe losing focus on the performed act The device was not hampering m The provided feedback felt strang The sensation provided by the air forearm felt pleasant

I felt hampered by the air pressur I had the feeling of performing be receiving force feedback

I had the feeling of performing be not receiving any feedback

I think I would use this device in activities

I think the device is too complicat unnecessary

I feel the need for some type of fe prosthetic system

I can easily interact with others a environment without any type of When using the feedback I was at actions without feeling the need t time to the hand

Figure 8: The Likert Questionnaire results table. On average the subjects did find the haptic feedback to have a positive impact when using their prosthetic device.

- haptic feedback system
- attitude towards the WISH device.

• Current state of WISH device would not be able to compete with market devices • The WISH device offers unique stimulation compared to

other haptic / tactile systems prompting more investigation

Future Directions

training time with the SHP / WISH



Results

	WHP01	WHP02	WHP03	Average
aptic device	5	7	4	5.3
e using the	1	1	4	2.0
tic while	7	7	3	5.7
eedback I was	-	1	5	13
c device were			3	4.5
force	7	7	4	6.0
ions	1	1	5	2.3
y movements	7	7	4	6.0
e and unnatural	1	1	4	2.0
pump on the	7	4	5	5.3
e stimuli	1	1	4	2.0
tter while	2	4	2	2.7
tter when I was	2	4	6	4.0
ny everyday	5	7	4	5.3
ed and	2	2	3	23
edback from the	4	6	2	4.0
nd the feedback	7	4	5	5.3
ole to perform to look all the				
		4	4	3.0

Discussion

 Study did not produce strong evidence that the WISH device provided any additional assistance over a no

• Qualitative results suggest subjects had a positive

Conclusions

Future studies should include a larger sample size and • Newer models of the SHP / WISH should be used