User Testing of a Continuum Manipulator for Assistive Technology

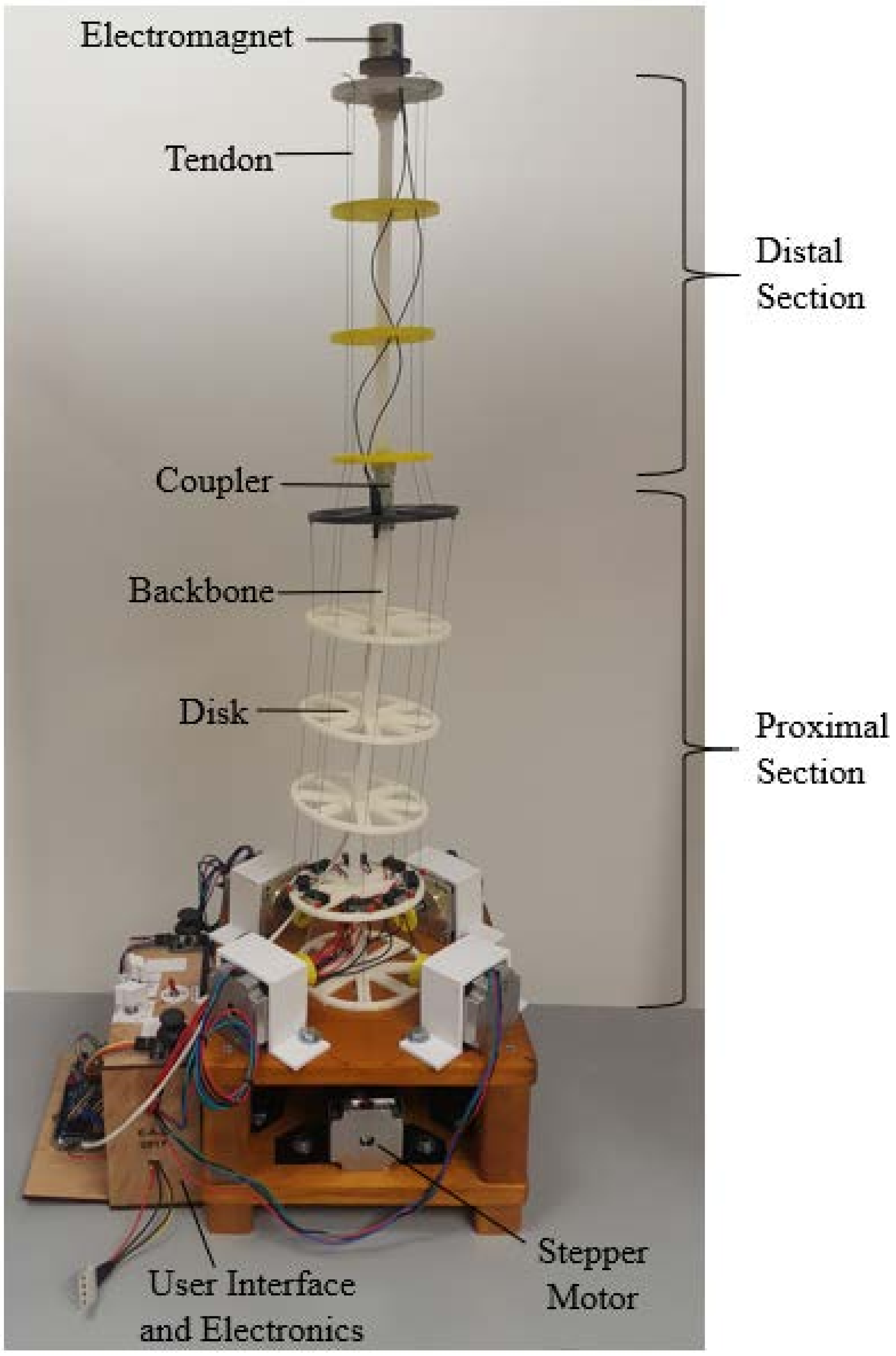
Ryan Coulson[1, 2], Max Kirkpatrick[1, 3], Megan Robinson[1, 4], Meghan Donahue[5], Devin R. Berg[1]

[1]Engineering & Technology Department, University of Wisconsin-Stout; [2]Department of Mechanical Engineering, Lafayette College; [3]Department of Mechanical Engineering, University of South Carolina; [4]Department of Electrical Engineering and Computer Science, Case Western Reserve University; [5]Stout Vocational Rehabilitation Institute, University of Wisconsin-Stout

Abstract

The use of robots in assistive technology is well-studied, with numerous robotic arms for rehabilitative applications that have been designed and tested to-date, and several that are commercially available [1, 2, 3]. These robots are intended to improve independence and quality of life for people who are unable to perform activities of daily living (ADLs) without additional aid. Unfortunately, they are often prohibitively expensive, costing tens of thousands of dollars [4]. Additionally, they pose a risk of harmful collision to their users and must incorporate sophisticated sensors and control methods to ensure the users' safety. This work evaluates an alternative platform for assistive robotics which alleviates these issues: continuum manipulators.

Continuum manipulators are robots that lack rigid segments and discrete joints [5]. Instead, they function by bending continuously along their length, like the trunk of an elephant or the tentacle of an octopus. The use of continuum manipulators in assistive technology has been proposed with respect to the ADL of bathing by Ansari et al., 2017 [6], although no user testing of this proposal has been completed.



Key Results

Table 1. Results from Round One of user testing for n = 14 users.

Control Scheme	Avg Completion Time (s)	Standard Deviation (s)	Average Intuition Ranking
Single-Joystick Compensative	63.00	54.61	1.86
Dual-Joystick	72.76	42.60	1.93
Single-Joystick Segmented	96.20	55.58	2.21

Table 1 shows the results from Round One of user testing. On average, users were able to complete the given task most quickly using Compensative control, followed by Dual control and then Segmented control. The standard deviations for these data are relatively large, as users demonstrated a wide range of skill levels when using the robot. Examining the average intuition rankings, it can be seen that users rated Compensative control as most intuitive, followed by Dual control and then Segmented control. This result further supports Compensative control as the superior of the three control schemes.

Table 2. Results from Round Two of user testing: Peg-in-hole task.

User No.	Average Completion Time (s) – Session One	Average Completion Time (s) – Session Two	Average Completion Time (s) – Session Three	Percent Improvement
1	115.18	121.79	58.84	48.91
2	121.79	112.57	66.02	42.96
3	170.65	149.66	120.40	29.45

Tables 2 and 3 show results from Round Two of user testing. It can be seen that for both the peg-in-hole and drawer tasks, all three users were able to complete the task more quickly, on average, in the last session than the first session. In most cases, these improvements were considerable, with some nearing fifty percent. These results indicate that users are able to substantially increase their proficiency using Bendy ARM with a relatively low amount of practice (the total amount of time spent using the robot between the first and last sessions was less than one hour per user). The significance of this test is that it demonstrates the potential of a continuum manipulator to be effectively used in completing ADLs without requiring a large amount of training.

Table 3. Results from Round Two of user testing: Drawer task.

User No.	Average Completion Time (s) – Session One	Average Completion Time (s) – Session Two	Percent Improvement
1	235.14	168.18	28.47
2	234.57	214.89	8.39
3	435.57	288.30	33.81

References

[1] Chung, C. S., Wang, H., & Cooper, R. A. (2013). DOI: 10.1179/2045772313Y.0000000132
[2] Driessen, B. J. F., Evers, H. G., & v Woerden, J. A. (2001). DOI: 10.1243/0954411011535876
[3] Maheu, V., Archambault, P. S., Frappier, J., & Routhier, F. (2011). DOI: 10.1109/ICORR.2011.5975397
[4] Allin, S., Eckel, E., Markham, H., & Brewer, B. R. (2010). DOI: 10.1016/j.pmr.2009.09.001
[5] Walker, I. D. (2013). DOI: 10.5402/2013/726506
[6] Ansari, Y., Manti, M., Falotico, E., Mollard, Y., Cianchetti, M., & Laschi, C. (2017). DOI: 10.1177/1729881416687132

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