FlexPAL (Flexible Pneumatic Actuated Linkage): The future of assistive robotics to improve quality of life

Yinan Meng (1), Lutong Li (1), Helen Dawes (2), Andrew Weightman (1), Charlie C.L. Wang (1)

1. Department of Mechanical, Aerospace and Civil Engineering, School of Engineering, University of Manchester, United Kingdom;

2. Medical School, NIHR Exeter BRC, University of Exeter, United Kingdom;

INTRODUCTION

- Over **1.3 billion** people, about **16%** of the global population, suffer significant mobility impairments as of 2024. [1].
- The rigid structure of current assistive robots may cause secondary injuries due to **safety, comfort, and suitability challenges** for delicate health conditions [2].
- Soft assistive robots provide **better adaptability, comfort and safety interactions** with the human body, making them well-suited to overcoming the limitations of rigid systems [3].
- Most applications focused on wearable devices, with minimal attention directed toward **wheelchair-mounted assistive robotics**.

AIM

This research aims to design and develop a wheelchair-mounted soft assistive robotic that allows people with mobility impairments to use it at home.

METHOD

- Conceptual design through user requirements
- Identify and develop the FlexPAL specification
- Perception control for FlexPAL

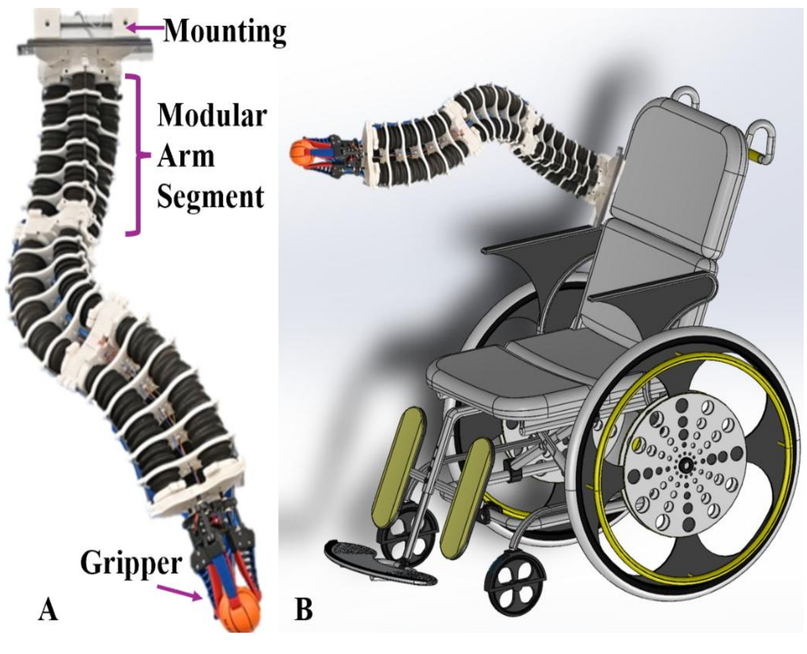


Figure 1: Illustration of FlexPAL (A) and the assemble on a wheelchair (B) (Wheelchair copyright Mr Gean Hay)

Table 1: Specification of the FlexPAL

Profile specification	Value
Profile size (mm)	180 x 180 x 940
Workspace (mm)	400 x 400 x 400
Elongation Range (mm/per module)	80-220
Max Bending Angle (Deg)	100
Pressure Range (Each Chamber) (kPa)	[-80, 40]
Self-Mass (kg)	3.88
Max Payload (kg)	1
Grasping Capability (Diameter-mm)	50
Manufacturing cost/per system (£)	9000

RESULTS

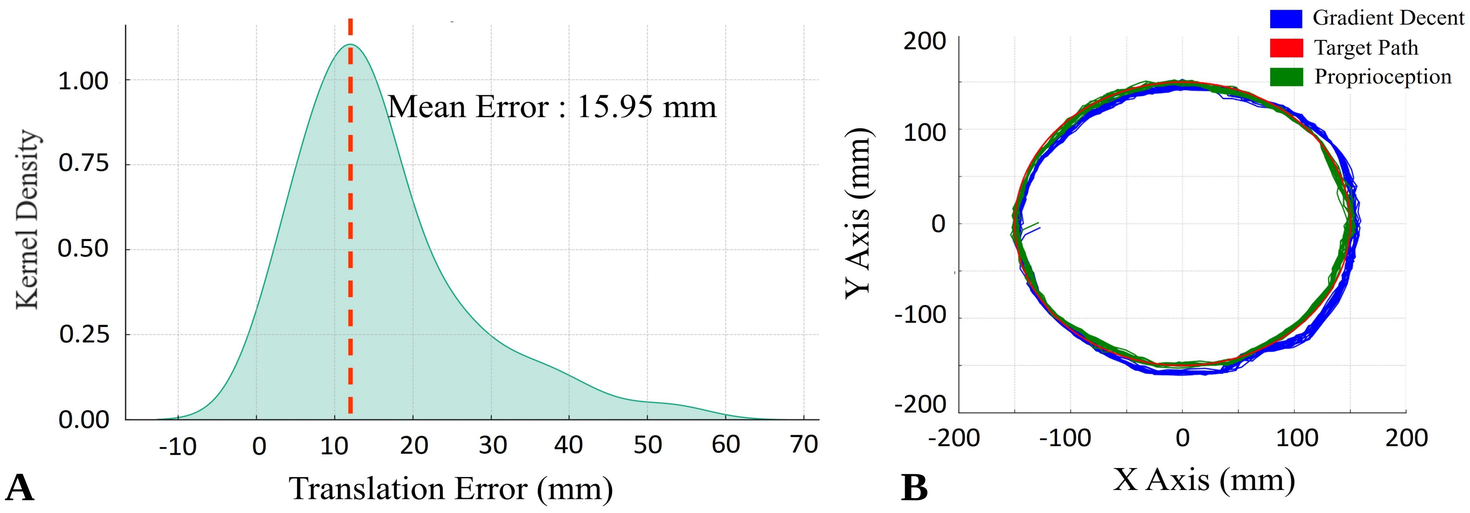


Figure 2: Illustration of FlexPAL control accuracy through a Kernel Density Plot from a random sampling experiment (A) and trajectory tracking experiment of a circle with 150mm radius (B)

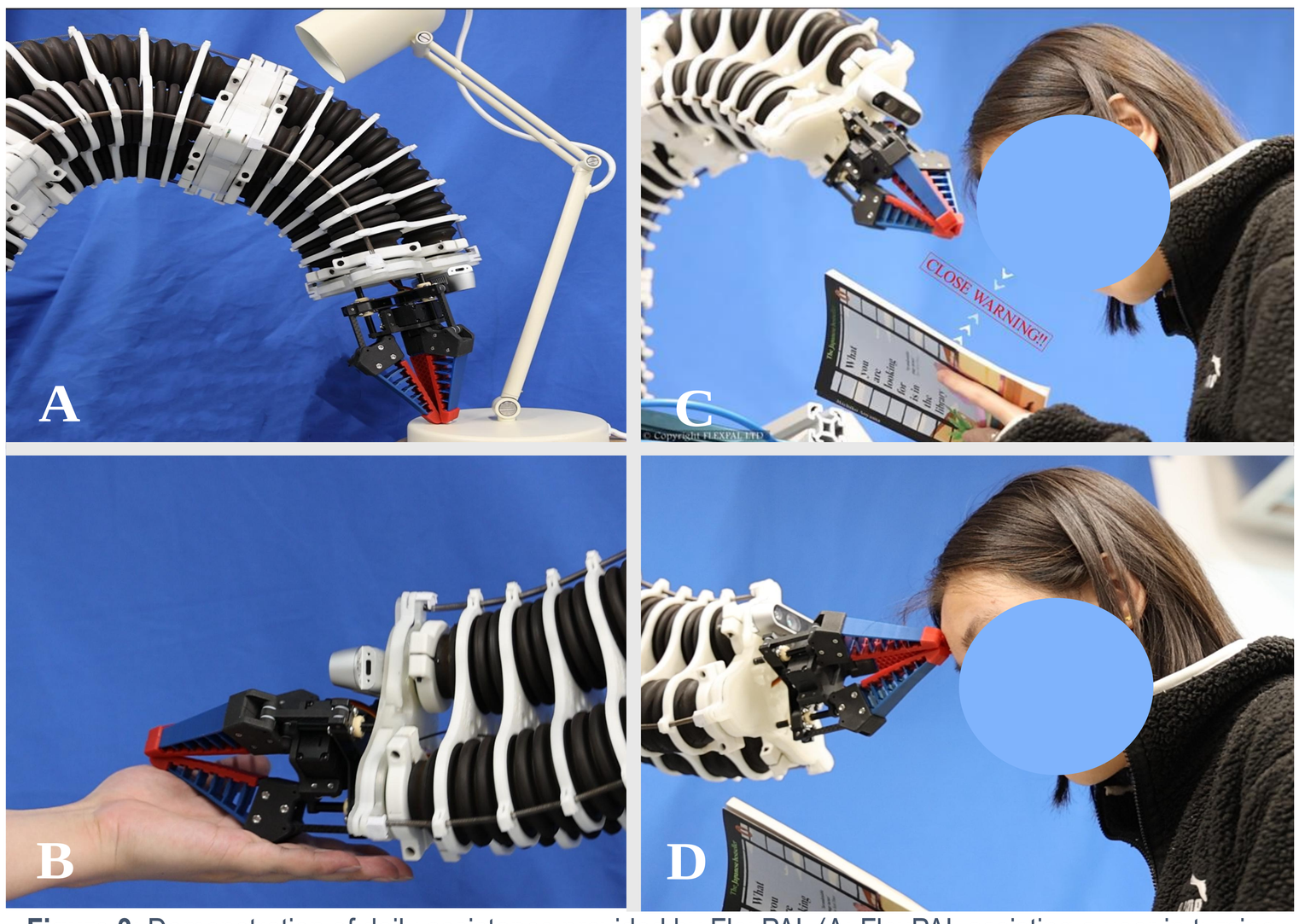


Figure 3: Demonstration of daily assistance provided by FlexPAL (A: FlexPAL assisting a user in turning on a lamp; B : Physical interaction between FlexPAL and a human hand; C and D: FlexPAL monitoring and helping to maintain the distance between a book and the user's eyes during reading; more details can be seen in the showcase video by scanning the QR code)

DISCUSSION

- This research highlights the significant advantages of soft wheelchair-mounted assistive robotics, as exemplified by FlexPAL, in addressing the needs of individuals with mobility impairments
- FlexPAL achieves a high level of positional precision (error<15.95mm), with errors well within acceptable thresholds for assistive tasks.
- FlexPAL (£4,000) offers a more cost-effective solution, enhancing accessibility for people with mobility challenges and improving their quality of life.

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REFERENCE

1. E. Kirk-Wade, "UK disability statistics: Prevalence and life experiences," House of Commons Library, no. 09602, 2022.
2. H. F. M. V. d. Loos, "VA/Stanford rehabilitation robotics research and development program: lessons learned in the application of robotics technology to the field of rehabilitation," IEEE Trans Rehabil Eng, vol. 3, no. 1, pp. 46-55, 1995, doi: 10.1109/86.372891
3. M. Pan et al., "Soft Actuators and Robotic Devices for Rehabilitation and Assistance," Advanced Intelligent Systems, vol. 4, no. 4, p. 2100140, 2022, doi: https://doi.org/10.1002/aisy.202100140.

CONTACT INFORMATION

Video

Group webpage

Yinan Meng: yinan.meng@manchester.ac.uk