Final Year Design Project Showcase
Batch-2022
Year 2026

	Department: Textile Engineering Programme: Bachelors of Textile Engineering
1	**Project Title**: Investigating the impact of conductive yarn and Knitting Structures on the Hysteresis and Dimensional Stability of Soft Actuators.
2	**Project Idea:** This project investigates the influence of conductive yarn integration and different knitted structures on the hysteresis behavior and dimensional stability of soft pneumatic actuators. The actuator combines a TPU based pneumatic chamber with knitted textile reinforcement to produce controlled bending while simultaneously functioning as a textile strain sensor through changes in electrical resistance. Various knitted structures were developed and experimentally evaluated to determine their suitability for wearable rehabilitation and soft robotic applications. The study aims to identify the knitted structure that provides the best combination of mechanical performance, sensing stability, and repeatable actuation.
3	**Process:** A comprehensive literature review was conducted to understand the working principles of textile-based soft actuators, conductive yarns, and knitted sensing mechanisms. Four knitted structures, namely Single Jersey, Cross Miss, Piqué, and La Piqué, were produced using conductive and non-conductive acrylic yarns under controlled knitting parameters. TPU based pneumatic chambers were fabricated and integrated with the knitted strain-limiting layers to develop soft actuators. The actuators were experimentally characterized by measuring loop length, tightness factor, dimensional stability, electrical resistance variation, hysteresis, bending angle, pressure requirements, and tip force. Comparative analysis was then performed to determine the effect of each knitting structure on actuator performance and sensing reliability.
4	**Outcome:** The developed soft pneumatic actuators were able to achieve controllable bending together with sensing using resistance mechanism. The study conducted clearly shows the correlation between the looped shape of knitting, conductive yarn pattern and the performance of the actuator. Out of all the structures analyzed, the Cross Miss structure showed better stability and consistent bending behavior, and incorporation of the conductive yarn allowed for reproducible strain sensing with good hysteresis.
5	**Evidence (Theoretical Basis):** Soft pneumatic actuators have gained considerable attention because of their inherent flexibility, lightweight construction, and safe interaction with humans. Textile reinforcement plays a critical role in controlling actuator deformation by restricting expansion in selected directions while allowing controlled bending. The geometry of knitted loops governs extensibility, stiffness, and pressure distribution throughout the

	actuator. When conductive yarns are incorporated into knitted structures, deformation alters the contact between conductive loops, resulting in measurable resistance changes that can be utilized for real-time sensing. Different knitting structures exhibit varying loop densities, loop constraints, and mechanical responses, which directly influence both the actuation characteristics and sensing performance. During cyclic inflation and deflation, hysteresis occurs because of the viscoelastic behavior of textile materials and the changing contact resistance between conductive loops. Therefore, selecting an appropriate knitted architecture is essential for improving dimensional stability, minimizing hysteresis, and enhancing sensing repeatability. The present study experimentally evaluates four commonly used knitted structures by comparing their loop geometry, tightness factor, dimensional stability, hysteresis, bending performance, and tip force. The results demonstrate how structural design significantly influences the mechanical and electrical behavior of textile soft actuators. The developed actuator provides an effective foundation for wearable rehabilitation devices, assistive gloves, and next-generation textile-integrated soft robotic systems.
6	**Competitive Advantage or Unique Selling Proposition** (Cost Reduction, Process improvement, Attainment of any SDG (Sustainable Development Goal), increase of market share or capturing new market or having superior performance over a competitor. In summary, any striking aspect of the project that compels the industry to invest in FYP or purchase it. Some detailed description is required in terms of how, why when what. You can select one or more from the following dropdown and delete the rest of them). Please keep relevant options, delete the rest of them, and correct the sequence
a	**Attainment of any SDG**: **SDG 3 – Good Health and Well-being** The actuator supports the development of wearable rehabilitation technologies for patients requiring hand therapy, improving accessibility to low-cost rehabilitation systems. **SDG 9 – Industry, Innovation and Infrastructure** The project advances smart textile technologies by integrating conductive knitted sensors with soft robotic actuators for next-generation wearable devices.
b	**Cost Reduction of Existing Product:** The actuator is fabricated using commercially available knitting yarns and TPU based material instead of expensive conventional robotic components. Textile manufacturing also enables scalable and economical production.
c	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process:** The proposed actuator integrates both actuation and sensing within a single knitted textile structure, eliminating the need for external displacement sensors. This simplifies the overall system while improving monitoring capability during operation.

d	**Any Other Aspect:** The developed actuator combines sensing and motion generation in a single textile structure, making it suitable for smart gloves, wearable rehabilitation devices, human-machine interaction systems, and future soft robotic applications.	
7	**Target Market**: The developed technology targets manufacturers of rehabilitation devices, wearable medical equipment, soft robotic systems, smart textiles, and assistive technologies. It is also valuable for textile research laboratories, universities, robotics researchers, biomedical engineers, healthcare institutions, and companies involved in human-machine interaction and advanced wearable product development.	
8	**Team Members** (Names along with email address)	• Wusqa Irshad (irshadwusqa@gmail.com) • Syeda Noor-ul-Huda (nooulhuda4397@gmail.com) • Sana Haseeb (sanahaseeb08@gmail.com) • Syeda Mahnoor (mahnooryasir252@gmail.com)
10	**Supervisor Name** (along with email address)	• Prof. Dr. M. Dawood Husain (dawood@cloud.neduet.edu.pk) • Engr. Danyal Rashid (danyalr@neduet.edu.pk)

Video Link:
https://drive.google.com/file/d/1q9pB82NC7L_ZEE6T43J6haqAL1mdPXor/view?usp=drive_link

Pictures : (Pasted below)

NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF TEXTILE ENGINEERING

INVESTIGATING THE IMPACT OF CONDUCTIVE YARN AND KNITTING STRUCTURES ON THE HYSTERESIS AND DIMENSIONAL STABILITY OF SOFT ACTUATORS

1. PROBLEM

Millions of people suffer from
- Stroke
- Parkinson's Disease
- Hand Injuries
- Neurological Issues

Current rehabilitation devices are

Heavy | Expensive | Rigid

Requires therapists assistance

2. OUR SOLUTION

Textile-Based Soft Pneumatic Actuators are

- Light-weight
- Flexible
- Comfortable
- Machine knitted
- Suitable for prolonged use

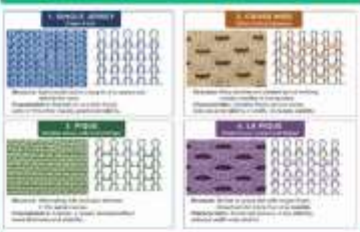
Bends like a human finger
Ideal for wearable rehabilitation glove and assistive devices

3. OBJECTIVES

01. Investigating the impact of 4 different knitting structres on the behaviour of actuator
02. Analyzing the hysteresis of conductive actuators under repeated cyclic loading
03. Evaluate Tip force and Bending Performance at different pressures
04. Determine the best performing knitted structure for wearable rehabilitation application

4. METHODOLOGY

5. KNITTING STRUCTURES



6. TESTING

BENDING ANGLE TEST
Measures the bending angle of actuators at different air pressures

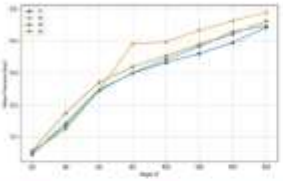
TIP FORCE TEST
Measures the force exerted at the tip of actuators at different angles

FATIGUE TEST
Repeated inflation and deflation cycles to evaluate stability and durability

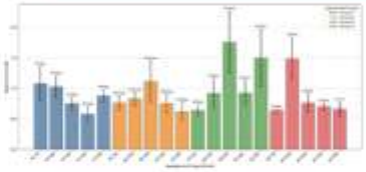
RESISTANCE TEST
Measures electrical resistance during loading and unloading

HYSTERESIS TEST
Calculates hysteresis to evaluate energy loss and repeatibility

7. KEY RESULTS



PRESSURE VS BENDING ANGLE



PRESSURE VS TIP FORCE(N)

Structure				Tightness factor	Fatigue behavior
A1	0.394	0.875	3	2.89	Low
A2	0.402	0.919	2.55	3.44	High
A3	0.415	1.148	3.58	2.39	Moderate
A4	0.406	0.892	4.28	3	High

OVERALL COMPARISON

8. INNOVATION

- Seameless machine knitted actuators
- Conductive yarn integrated for real time sensing
- Textile replaces rigid robotic components
- Comfortable, Lightweight and wearable

9. NATIONAL IMPACT

Potential applications:
- Hospitals and Rehab centers
- Home-based Rehabilitation
- Elderly Care
- Assistive Robotics
- Smart Rehabilitation center

10. PROTOTYPE

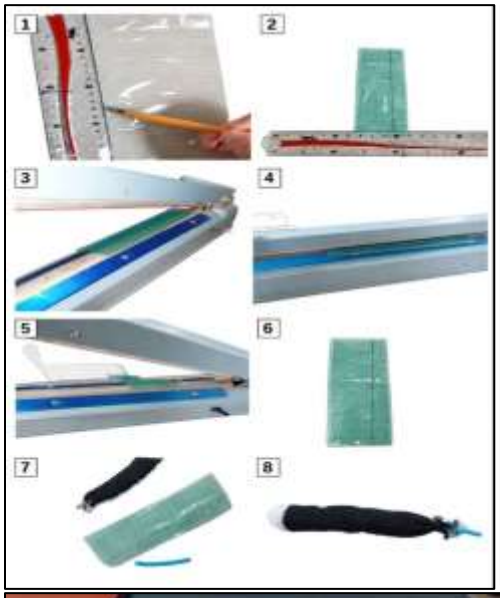
"Cross-miss structure demonstrated superior dimensional stability and repeatibility, making them the most promising structure for future wearable robotic rehabilitation system"

"FABRIC THAT BENDS LIKE A HUMAN FINGER"

BY: WUSQA IRSHAD, SYEDA NOOR-UL-HUDA, SANA HASEEB, SYEDA MAHNOOR

SMART Laboratory

SUPERVISED BY: PROF. DR. M. DAWOOD HUSAIN & ENGR. DANYAL RASHID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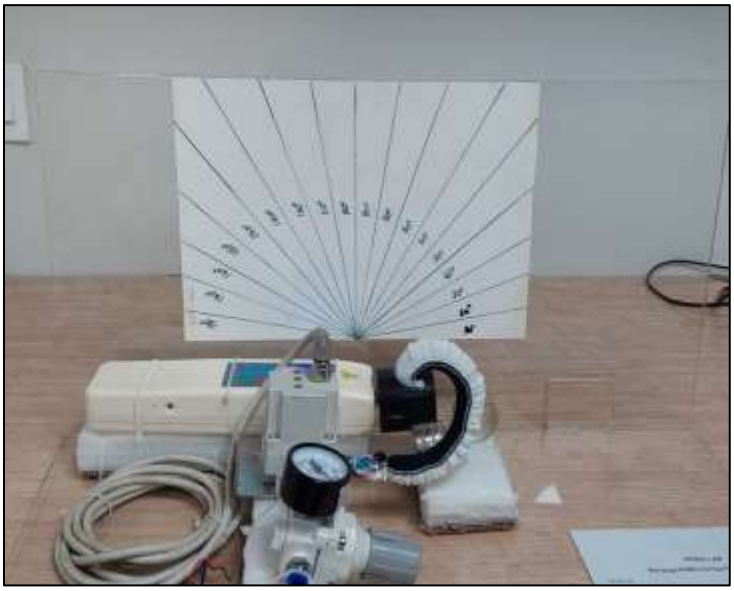

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