Realizing the promise of exoskeletons

Research efforts to increase the efficacy and acceptance through Artificial Intelligence-enabled wearable robots

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Tecnalia

Member of Basque research & technology alliance

With a multi-sectoral and multi-technological perspective, we listen and work with companies to respond to the major global challenges.

In this way, we are able to generate profit for companies and create value for society.

Energy transition, personalised health, sustainable mobility, smart manufacturing, urban ecosystem, digital transformation

Personalized Health at Tecnalia

We foster the development of customised products and services in prevention, diagnosis, prognosis, treatment and rehabilitation phases, through an integrated approach that includes genetics, nutrition and physical and social environments, as the main variables that affect people's health.

What can we do for you?

- Food ingredients and functional compounds
- Healthy foods
- In vitro diagnosis
- Regenerative medicine
- Neuroengineering
- Biomedical product
- Medical robotics
- Digital health and medical imaging
- Pharmaceutical development
- Health and safety
- wearable devices
- Healthy urban solutions

Why exoskeletons?

Injury and ill-health resulting from manual handling activities incur significant costs:

- 20% of all non-fatal workplace injuries are attributable to manual handling injuries
- One-third of musculoskeletal disorder injuries are also caused through manual handling activities.
- *About a fourth of European workers suffer from back pain*, which tops the list of all reported work-related disorders.

Exoskeletons

- The dream: Stronger! More agile! Who knows?!

- The Reality: Passive Devices to Transfer Loads

The goal

“As soon as I decide to move, the exoskeleton responds, raising my arms and supporting them while I perform the operation, without any effort”

“This exoskeleton is my second skin”

“I wish I had it sooner”

To be prevented

“Uff, it rubs against my arm”

“It prevents me from reaching the pieces”

“The more I wear it, the more tired I become. Please, take it off me!”

Toward better acceptance of exoskeletons

From simple mechanical solutions to intelligent mechatronic design

- *Usability*
  - Simplified User Interfaces
  - Kinematic Compatibility
- *Acceptability*
  - Intention detection/selection (e.g. for walking and lifting)
- *Efficacy*
  - Energy Storage and Release
- Passive, but Intelligent
- AI-enabled user Interactions
- “Like a second skin”

Intention Detection

- Anticipate the needs of the user (AI)
- Activate mechanisms “as needed”
- “Get out of the way” when not needed.

- Activity in leg and trunk muscles begins prior to targeted lifting of the arm.
- Amplitude of EMG activity depends on length of reaching movement.
- → *Intention Detection* may be achieved prior to movement onset by observing anticipatory responses in postural muscles as well as in prime movers.

Energy Storage and Release

Non-linear linkages open the possibility to modulate the apparent resistance to an otherwise passive element.

- Elliptical chain rings for bicycles represent a common example for optimizing exchange of power.
- Self-winding watches allow storage of energy with minimal impediment to movement.
- ➢ *Can clever mechanical designs optimize assistance for targeted motions while increasing transparency for auxiliary motions?*

- Store energy during "regular" activities
- Release energy when needed
- AI to anticipate when to store and when to release

Lowering barriers to exoskeleton uptake

Expert Services to predict Return on Investment

How to go from measurements to results?

Researchers

- Time to Complete Tasks
- Muscle Activity
- Exerted Forces
- Limb Kinematics
- Balance Indicators
- Precision
- Accuracy

AI can have an influence on decision-makers

- Are my workers safer?
  - lower risk of injury
  - greater longevity
- Are my workers "happier"?
  - increased comfort
  - less fatigue
- Are my workers more efficient?
  - shorter execution times
  - fewer workers for the same task

How to go from measurements to predictions?

Physics-informed AI for outcome predictions

InteX Performance Predictors

- Standardized analytical predictions from sensor data
  - Input data and processing involved: Direct interpretation of sensor readings
  - Outcome example: Total muscular effort
- AI optimized predictions from sensor data
  - Input data and processing involved: Physiological data linked to sensor data
  - Outcome example: Total Metabolic Effort (holistic)
- DATA mining
  - Input data and processing involved: Longitudinal data
  - Outcome example: Risk of injury, return on investment

Realizing the Promise of Exoskeletons

- Potential for exoskeletons as an effective tool for worker health
- Barriers to uptake of exos in the workplace
  - Lack of acceptance by users
  - Unproven efficacy
  - Uncertainty of return on investment
- AI approaches to overcome the barriers
  - Better acceptance through intelligent transparency
  - Decreased uncertainty through AI-enabled performance predictors