RESEARCH LINE GAIT CYCLE. MODELIZATION, SIMULATION & TECHNOLOGICAL APPLICATIONS

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SUMMARY

The goals and objectives of this research line are oriented to the development and evolution of the current human gait knowledge. Advances in the physiology and characteristics of the lower limbs musculoskeletal system is also one of the cornerstones of this research line. Although there is still a need of scientific knowledge in the field of human gait biomechanics, the development and improvement of the current technology is not limited by these unknowns. This research line is based on the use of reverse engineering processes and methodology for the creation of virtual models for the lower limbs musculoskeletal system. Tools for improving design problems on wearable robots such as prosthetics devices and exoskeletons are being developed. The use of simulation software based on the Finite Element Method (FEM), Multibody Dynamics, three-dimensional scanning techniques and additive manufacturing has led to the study of a wide variety of conditions during the gait cycle. Improving the performance of future devices that will help people with different mobility disorders. This research line is expected to validate and improve new technology developed in the field of biomechanics applied to the human gait cycle.

KEYWORDS: Human gait, Exoskeleton, Prosthetic, FEM, Multibody Dynamics, Wearable robots, Reverse engineering, Biomechanics, Biomechatronics, Additive manufacturing.

1. INTRODUCTION

Biomechanics of Human gait cycle

Nowadays the degree of scientific knowledge around the internal execution of the human gait is still incomplete. Situations like the response of the musculoskeletal system to maintain the equilibrium despite external actions that disturb walking. The simultaneous activation of muscular groups that produce movement around joints, the response from the cognitive system to control the speed and force of these movements. The complexity of the musculoskeletal system makes difficult determining the function of muscles, tendons and ligaments on each instant during a movement and the muscle energy efficiency. These are some aspects of the human gait currently under research by scientists. Therefore, creating an accurate model of the system is still a challenge. [1],[2],[3],[4].

Technology. Wearable robots

Throughout the history, technology applied to human locomotion has been developed around the world. During the last decade, there has been a notorious increase of technology in assistive, rehabilitation and restoration applications through the use of devices such as exoskeletons or wearable robots.

Computational, processing and data collection advancements have facilitated the development of new biomechatronic devices with different applications mainly because of cost and size reduction. The use of these devices for rehabilitation purposes has spread due to the positive results experienced by the patients. However, in some other applications, other design aspects such as actuators autonomy or the kinematic behavior of the device are limiting the development of efficient wearable robots. The lack of lightness and flexibility between other aspects puts them away from being an alternative to other means of transport [5],[6],[7],[8],[9],[10],[11].

1.1. FUNDAMENTAL CONCERNS

- Lower limb musculoskeletal system model improvement.
- Manufacturing costs for exoskeletons and wearable robots.
- Simulation and validation test for different range of users.
- Adaptability of the design regarding the different operation and application of the device. Joint degrees of freedom, active and passive actuation, etc.

1.2. GOALS

The possibilities of the future technology and proliferation in scientific knowledge about the human gait cycle show a promising and exciting future for this research line.

Biomechanical simulations

- Standardization and results validation of the biomechanical simulation equipment. Designed and manufactured by research facilities such as Universities and research institutes.
- Creation of a lower limb musculoskeletal model for FEM simulations.

Technological applications

- Development of a design and manufacturing methodology for cost efficient exoskeletons.
- Flexibility and times improvement on the design and evolution in exoskeletons and wearable robots.
- Cost efficiency improvement for the manufacturing and maintenance of exoskeletons and wearable robots.

1.3. METHODOLOGIES AND MATERIALS

- FEM Simulation software & Biomechanics of human musculoskeletal software.
- Additive & subtractive manufacturing equipment, digitalization devices.
- Control Hardware & Software.
- Acquisition and processing data systems.

2. RESULTS

2.1. PRODUCTS

- LESE Prototype (Lower Extremity Simulation Exoskeleton) for the simulation and validation of human gait models.
- Musculoskeletal system simplified model for FEM simulations.

2.2. PUBLISHING AND LECTURES

2.2.1. PUBLICATIONS

- McCartney, W., Lostado-Lorza, R., & Donald, B. J. (2015). Analysis of Cementless Acetabular Cup Rotation. International Journal of Applied Research in Veterinary Medicine, 13(2).
- McCartney, W. T., Lostado-lorza, R., & Mac Donald, B. J. (2014). Cementless Acetabular Cup Rotation: Artificial Bone Implantation, Theoretical And Finite Element Analyses With Correlation To Surgery. Veterinary Surgery, 43(5), E130.

- Lorza, R., McCartney, W., Mac Donald, B. (2014). Theoretical Model for Calculating the Rotation in Cementless Acetabular Cup Prosthesis Implanted by Press Fit into a Hip of Canines. In-Applied Mechanics and Materials (Vol627, pp. 101-104). Trans Tech Publications.

2.2.2. LECTURES AND CONGRESSES COMMUNICATIONS

- Somovilla-Gómez, F., Lostado-Lorza, R., Íñiguez-Macedo, S., Corral-Bobadilla, M., Martínez-Calvo, M. Á., & Tobalina-Baldeon, D. (2017). Using the Finite Element Method to Determine the Influence of Age, Height and Weight on the Vertebrae and Ligaments of the Human Spine. In Advances on Mechanics, Design Engineering and Manufacturing (pp. 489-498). Springer International Publishing.
- Íñiguez-Macedo, S., Somovilla-Gómez, F., Lostado-Lorza, R., Corral-Bobadilla, M., Martínez-Calvo, M. Á., & Sanz-Adán, F. (2017). The design of a knee prosthesis by Finite Element Analysis. In Advances on Mechanics, Design Engineering and Manufacturing (pp. 447-455). Springer International Publishing.
- Lorza, R., Gomez, F., Martinez, R. F., Garcia, R., Bobadilla, M. (2016, October). Improvement in the Process of Designing a New Artificial Human Intervertebral Lumbar Disc Combining Soft Computing Techniques and the Finite Element Method. In International Conference on European Transnational Education (pp. 223-232). Springer International Publishing.
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3. RESEARCH TEAM

Members of the research team

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Congreso INGEGRAF Gijón 26, 27 de junio de 2017

NUEVOS MODELOS DE INVESTIGACIÓN Y COLABORACIÓN EN INGENIERÍA GRÁFICA

GAIT CYCLE. MODELIZATION, SIMULATION & TECHNOLOGICAL APPLICATIONS

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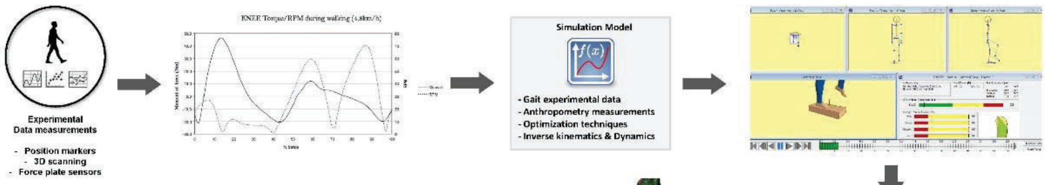
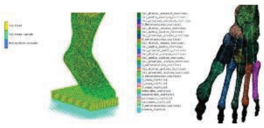
SUMMARY

This research line is based on the use of reverse engineering processes and methodology for the creation of virtual models for the lower limbs musculoskeletal system. Tools for improving design problems on wearable robots such as prosthetic devices and exoskeletons are being developed. The use of simulation software based on the Finite Element Method (FEM), Multibody Dynamics, three-dimensional scanning techniques and additive manufacturing has led to the study of a wide variety of conditions during the gait cycle as well as the creation of wearable robots. Improving the performance of future devices that will help people with different mobility disorders. This research line is expected to validate and improve new technology developed in the field of biomechanics applied to the human gait cycle. Mainly exoskeletons and wearable robots.

BIOMECHANICAL SIMULATIONS & TECHNOLOGICAL APPLICATIONS

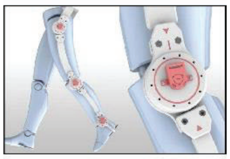


- Study of specific walking conditions.
- Validation of influences on walking.
- Creation of a lower limb musculoskeletal model for FEM simulations.

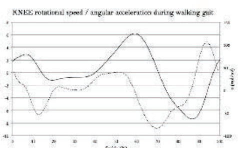


- Detailed studies of the human body parts during a variety of movement conditions.
- Design and validation of prosthetic devices.

TECHNOLOGY. EXOSKELETONS & WEARABLE ROBOTS



LESE f1 – Data Acquisition. Stage 1



Optimization for specific user on Assistive Exoskeletons

LESE f2 – Assistive Exoskeleton. Stage 2

- Standardization and validation of cost efficient biomechanical simulation equipment.
- Design and manufacturing methodology for cost efficient exoskeletons.
- Flexibility and times improvement for the design of exoskeletons.

Computational, processing and data collection advancements have facilitated the development of new wearable devices with different applications mainly because of cost and size reduction. The use of these devices for rehabilitation purposes has spread due to the positive results experienced by the patients. However in some other applications, other design aspects such as actuators autonomy, kinematic behavior of the device and cost factors are limiting the development of efficient wearable robots. Rethinking the methods and equipment of data acquisition with a cost effective mind and its future design evolutions allows the development of new wearable robots becoming a more affordable solution for walking assistance.

RESULTS

Methodologies

- FEM Simulation software & Biomechanics of human musculoskeletal software.
- Additive & subtractive manufacturing equipment, digitalization devices.
- Control Hardware & Software.
- Acquisition and processing data systems.

Products

- LESE Prototype (Lower Extremity Simulation Exoskeleton). Exoskeleton device for the simulation and experimental validation of human gait models.
- Musculoskeletal system simplified model for FEM simulations.

SCIENTIFIC PUBLICATIONS

(2014) Cementless Acetabular Cup Rotation: Artificial Bone Implantation, Theoretical And FEA With Correlation To Surgery. Veterinary Surgery, 43(5), E130.
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