CICANT – Centro de Investigação em Comunicação Aplicada, Cultura e Novas Tecnologias
Universidade Lusófona de Humanidades e Tecnologias

Título do projeto

Linear and non-linear modeling of human motor pattern variability

- **Objetivos do Projecto (indicar endereço eletrónico do(s) site(s) criado(s), quando aplicável) (500 palavras)**

Variability is a common word in the human movement sciences. The observed movement results from the communication between the sensory system with the central nervous system and it response to the adjustment and adaptation needs. The modeling (linear and non-linear) of the joint stability of the locomotion system can be used as a tool to understand and describe the variability, that depends of the adaptation and adjustment of the motor control system process. The dynamics of the Human movement is highly complex, non-linear and hierarchical. Muscles with different dynamics of contraction and excitation, transform neural action potentials into forces, in a synergic action that results in the observed movement aimed towards a subjects defined objective. The success of goal achievement, is dependent of the system ability to control it output with the influence of the entropy provided by the environment and external feedback resources, which can decrease the adaptation and adjustment process, increasing it variability. Joint stability is the joint's ability to maintain a certain joint position along a defined path, where dynamic joint stiffness, vertical stiffness and leg stiffness, are tools orientated to

express joint and body stability strategy towards the accomplishment of a certain task. Our works define that this tools do not present footedness related differences but are sensitive to explain stability changes and proprioception of motor activity in pathological populations: as Women with rheumatoid arthritis or "special feet" of Paramiloidosis Portuguese population.
In this context the objective was to increase the certitude of linear models and to base the first non-linear models.

- **Breve descrição das atividades desenvolvidas bem como dos desvios ocorridos durante a execução do projeto (500 palavras)**

The framework of the project had its roots in the previous developments and recognition of the topic developed by the team. This recognition was well represented by the invitation for the Keynote lecture of the 2016 European Society for Movement Analysis in Adults. The project leader introduce the topic "Dynamic Joint Stiffness as index of joint stability".

Task 1: Analysis of multiplane kinetic-kinematic relations: This first task aimed to stablish the relationship of kinetic and kinematic variables, in different populations, allowing it study in a research design. The experimental setups and software developed to achieve this first task result of linear models, as well as the statistical procedure to analyze it, will be applied to a lower, but significant, sample of subjects in order to verify if the developed procedures and data processing strategies are able to describe the control mechanism of human movement as aimed.

Task accomplished with application of linear models.

Task 2: Can Joint stability multiplane assessment describe human movement control mechanism? This task is high depended of previous data collection task. The expected results comprises a manuscript that demonstrated the

walking motor pattern in subjects clinical healthy and with a "normal" motor control output. The goal is to discussed the advantages and disadvantages of the linear and non-linear models as well as a discussion of which model describes it better.

Task partially accomplished. The reduction of initial budget (from 10 000 to 2 500) take the opportunity to hire a specialist in mathematical models in order to give support to the team. The small developments were based on the ability of the team.

Task 3: Does joint stability multiplane assessment describes pathological adaptations in specific human locomotion tasks? Similar to task 2 but applied to abnormal motor pattern, due motor control or musculoskeletal disorders. The expected results comprise a manuscript for each human motor pattern on normal and each pathological setting selected. Is expected to observe common tasks as gait, for pathological settings as rheumatoid arthritis, foot injuries, and sports injuries, among others.

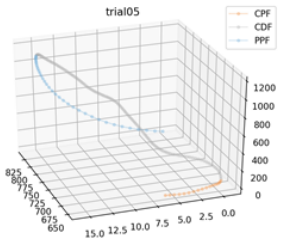
Task partially accomplished by linear models in the area of " ... gait, for pathological settings as rheumatoid arthritis ..." but not accomplished in the multiplane assessment (result of task 2 developments) and " ... sports injuries ...". Every enumerated outcome in the below list had been developed just by the team project members (in bold) or, rather, in collaboration with other institutions within the objective of interaction and internationalization.

- **Objetivos atingidos (500 palavras)**

Task 1: Analysis of multiplane kinetic-kinematic relations
Goals: Task accomplished with application of linear models.

Task 2: Can Joint stability multiplane assessment describe human movement control mechanism?

Goals:Task partially accomplished. The reduction of initial budget (from 10 000 to 2 500) take the opportunity to hire a specialist in mathematical models in order to give support to the team.
The representation of "multiplane assessment" was developed by image but not by the useful applied numerical nonlinear model. However the image development gave the opportunity of explore the communication factor of the phenomena. This approach, in the best of our knowledge, never had been found in bibliography. The image is an example of 1 experimental trial. These kind of approaches have a framework developed in last years by MovLab team represented by a precise outcome (*Biomechanics and Animation: information technology and arts interactions*)



Task 3: Does joint stability multiplane assessment describes pathological adaptations in specific human locomotion tasks?

Goals: Task partially accomplished by linear models in the area of " … gait, for pathological settings as rheumatoid arthritis and sports injuries" but not accomplished in the multiplane assessment (result of task 2 developments). The application to the area of "sports injuries" was developed with external collaboration (specific outcomes).

○ Indicadores

Indicadores de Realização Física

Indicadores	Quantidade realizada
A - Publicações	
Livros e capítulos de livro	1
Artigos em revistas internacionais	8
Artigos em revistas nacionais	1
B - Comunicações	
Comunicações em encontros científicos internacionais	1

Comunicações em encontros científicos nacionais	1
C - Relatórios	n/a
D - Organização de seminários e conferências	2
E - Formação avançada	
Teses de Doutoramento	n/a
Teses de Mestrado	n/a
Outras	n/a
F - Modelos	n/a
G - Aplicações computacionais	n/a
H - Instalações piloto	n/a
I - Protótipos laboratoriais	n/a
J - Patentes	n/a
L - Outros	

o Lista de Publicações, eventos e outros Outputs científicos

e- book
Atalaia, T., Abrantes, J (2017) Lateralidade e Membro Inferior. Retrieved from. https://leanpub.com/lateralidadeemembroinferior-umarevisodaliteratura
Artigos em revistas internacionais
Aleixo P., Atalaia, T., Vaz-Patto J., & **Abrantes** (2018) Sit-to-stand of rheumatoid arthritis post-menopausal women vs. healthy post-menopausal – antero-posterior displacement of centre of gravity and centre of pressure. In, Gait & Posture 65 - S1 (September) 384-385. https://doi.org/10.1016/j.gaitpost.2018.07.026
Santos, D., **Abrantes**, J., Lewis, P., Macedo, A. (2018) "Influence of the use of cane on the gait cycle of individuals who are blind" British Journal of Visual Impairment. Vol.36 (3) 251-261 https://doi.org/10.1177/0264619618782576
Aleixo P., Vaz-Patto J., Moreira H. & **Abrantes** (2018) Gait Kinematic Parameters in Healthy and Rheumatoid Arthritis Postmenopausal Women .Ortho Res Online J. 3(2).
Psurny M., Svoboda Z., Janura M., Kubonova E., Bizovska L., Martínez-Lemos I., **Abrantes J.** (2018) The effects of Nordic walking and slope of the ground on

lower limb muscle activity. J Strength Cond Res. 2018 Jan 32(1):217-222. doi: https://doi.org/10.1519/JSC.0000000000002195
Aleixo P., Vaz-Patto J., Moreira H. & **Abrantes** J. (2018) Dynamic joint stiffness of the ankle in healthy and rheumatoid Arthritis postmenopausal women Gait & PostureGait and Posture (60), February 2018, Pages 225-234. DOI: https://doi.org/10.1016/j.gaitpost.2017.12.008
Silva, D., Gabriel, R., Moreira, H., **Abrantes, J.,** & Faria, A. (2017). Foot Rollover Temporal Parameters During Walking Straight Ahead and Stepping Over Obstacles: Obese and Non-Obese Postmenopausal Women. Journal of Aging and Physical Activity, 1-23. DOI: https://doi.org/10.1123/japa.2017-0045
Aleixo P., Vaz-Patto J., **Abrantes J. (2017)** Ankle kinematics and kinetics in rheumatoid arthritis postmenopausal women fallers and non-fallers. Gait & Posture, 57 (S1), 308-9.
Aleixo P., Vaz-Patto J., **Abrantes J.** (2017) Dynamic joint stiffness of the ankle in rheumatoid arthritis postmenopausal women fallers and non-fallers. Gait & Posture, 57 (S1), 324-5.
Artigos em revistas nacionais
Aleixo P., Tavares C., Vaz-Patto J. & Abrantes J. (2017) Segurança e Eficácia dos Exercícios Propriocetivos em Doentes com Artrite Reumatóide (Revisão Sistemática). Gymnasium. 2(1). http://g-se.com/es/journals/gymnasium/articulos/seguranca-e-eficacia-dos-exercicios-propriocetivos-em-doentes-com-artrite-reumatoide-revisao-sistematica-2204
Comunicações em encontros científicos internacionais
C. Rodrigues, M.V. Correia, J.M.C.S. **Abrantes**, J. Nadal e M.A. Benedetti (2017) Software tool for significant analysis of complementary domains at human gait. In 15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering 26-29 March, Lisbon, Portugal
Comunicações em encontros científicos nacionais
Dinis J., Costa-Luz, F. & **Abrantes** J. (2017). Biomechanics and Animation: information technology and arts interactions. In, Atas IX Congresso Sopcom - Comunicação e Transformações Sociais. Vol. 1 (186-195). Eds. Carlos Camponez, Bruno Araújo, Francisco Pinheiro, Inês Godinho, João Morais. 12-14 Novembro 2015. Coimbra, Portugal. ISBN 978-989-99840-0-4 http://www.bocc.ubi.pt/pag/sopcom/1-ix-congresso.pdf
Organização de seminários e conferências

MovLab Workshop (2018) - Biomechanics: Methodologies and Interactions in Linear and non-linear modeling of human motor pattern variability -
Workshop first component: (2017, May, 8 to 10) *João Abrantes; Tiago Atalaia; Pedro Aleixo; João Martiniano* (MovLab team)
Carlo Frigo (Politecnico di Milano, Italia) – Under the support of Erasmus program
Workshop second component: (2017, June, 7 to 9) *Zdeněk Svoboda* (Palacky University, Czech Republic) – Under the support of Erasmus program
Fernanda Nora (Federal University of Goiás, Brasil) – *ad hoc* work visit looking for future interactions
MovLab Spring School (2017) - Biomechanics of Locomotion and Injuries Prevention *Key speaker: Joseph Hamill* (University of Massachusetts) http://movlab.ulusofona.pt/springschool2017