2018-01133 - PhD offer: HoBiS: simulation of plausible bipedal locomotion of human and non-human primates

Niveau de diplôme exigé : Bac + 5 ou équivalent
Fonction : Doctorant
Niveau d'expérience souhaité : jeune diplômé

A propos du centre ou de la direction fonctionnelle

Inria, the French national research institute for the digital sciences, promotes scientific excellence and technology transfer to maximise its impact. It employs 2,400 people. Its 250 agile project teams, generally with academic partners, involve more than 3,000 scientists in meeting the challenges of computer science and mathematics, often at the interface of other disciplines. Inria works with many companies and has assisted in the creation of over 160 startups. It strives to meet the challenges of the digital transformation of science, society and the economy.

Contexte et atouts du poste

Within the framework of a partnership

- National project ANR HoBiS, in collaboration with CNRS/LAAS (robotics)
- public with French National Research Agency (ANR) HoBiS project, in collaboration with CNRS/LAAS in Toulouse

A new method to simulate plausible bipedal locomotion for human and non-human primates, more specifically dedicated to applications in paleo-anthropology.

Is regular travel foreseen for this post ? yearly national project meeting, travel to conferences, and a long stay (one year) in Toulouse with the co-supervised PhD in CNRS/LAAS. All these travels will be financially covered by the ANR HoBiS Project.

Within the framework of a national collaborative project “HoBiS” funded by the French ANR agency, the goal of this position is to design a new simulation framework aiming at simulating plausible bipedal locomotion given an anatomical model. The project gathered experts in paleoanthropology, anatomy, biomechanics, computer science and robotics. This part of the HoBiS project aims at increasing fundamental knowledge about bipedal locomotion of disappeared species (Afarensis, Neanderthal...) in an evolutionary perspective. To achieve such challenge, anatomists and paleoanthropologists from the Museum National d’Histoires Naturelles (CNRS) together with a CNRS primatology platform will gather a unique collection of anatomical and motion data for various species, such as humans and non-human (olive baboons, bonobos...) primates. Thus, this PhD project aims at simulating bipedal locomotion of living species (primates and humans) first, and then to adapt the simulation to disappeared species. MimeTIC Inria team (computer sciences, biomechanics and sports sciences) and CNRS-LAAS (robotics and biomechanics) will supervise the PhD to address the problem of simulating plausible locomotion for such anatomical models. The co-supervised PhD position will work on this specific task, in collaboration with the two teams involved in the HoBiS Project.

MimeTIC inria team (team.inria.fr/mimetec) is associated with M2S laboratory (Movement, Sport, Health) of the University of Rennes 2 in part of the top 200 in the Shanghai ranking of the best universities in the field of sports sciences. MimeTIC promotes a multidisciplinary approach based on computer simulation and motion analysis, in order to better analyze and simulate human motion. MimeTIC can rely on an exceptional ImmerMove platform that includes a virtual reality room (12x4x4 m) and a sports hall (30x20x10 m) dedicated exclusively to the analysis of human movement. This platform includes various human motion capture systems, external force evaluation and electromyographic systems. MimeTIC has a long experience in human motion simulation using various approaches developed in the computer animation domain. MimeTIC also develops an expertise in musculoskeletal analysis and simulation using nonlinear optimization.

CNRS/LAAS (www.laas.fr). The Laboratory for Analysis and Architecture of Systems, LAAS, of Toulouse, has a long experience in human movement analysis, humanoid robot motion planning and control. In 2000, it gave rise to the start-up Kineo CAM devoted to motion generation for virtual prototyping. Gepetto team research aims to model, understand and generate anthropomorphic movements for humanoid robots, virtual mannequins and human beings. This implies a research at the crossing of robotics, automation and control, biomechanics and neurosciences, integrated toward the production of algorithms for motion and action modelling. The team is recognized as a world leader of anthropomorphic motion generation and humanoid robotics. LAAS has developed HP2 and Pinocchio, software development tools dedicated to motion planning and control for complex redundant robots. Many original results have been experimentally validated on the several platforms of the laboratory (humanoid robot HRP-2, Romeo and Pyrene). LAAS-Gepetto was engaged in several FP7 and H2020 european projects.

The PhD will mainly take place in MimeTIC in Rennes, in Inria building. The recruited PhD will have a laptop and an office in Inria, with all the facilities proposed by this institute. A long stay (one year) in CNRS/LAAS in Toulouse is expected during the three years of the PhD to practice optimal control and DDP (differential dynamic programming).
Mission confiée

Assignments:
With the help of the co-supervisor and partners in the HoBis project, the recruited person will be taken to propose an efficient simulation framework to propose plausible locomotion knowing anatomical and paleo-anthropological knowledge. He or she will have to deal with kinematic constraints, together with the dynamics of the musculoskeletal system.

The recruited person will have to propose a new framework to simulate plausible locomotion based on anatomical descriptions. Previous works in computer animation [Multon1999] proposed to address this problem as a motion retargeting problem [Gleicher1998, Kulpa2005]: adapting the trajectories of a character to another one with different morphologies. This approach is mainly based on solving kinematic constraints to ensure non-sliding foot contact with the ground, or ensure static balance. However, it does not enable to simulate totally new motion that correspond to a given anatomical description. To tackle this problem, other works proposed to model gait kinematics as a parametric mathematical function, and use non-linear optimization to calculate plausible locomotion for simplified anatomical models [Nicolas 2008, Nicolas2009]. However all these approaches based on computing kinematic trajectories fail to ensure the physical realism of the resulting motion.

An alternative consists in modeling bipedal gait as a sequence of states (single, double stances, ...) and to design controller to drive a physical model based on the anatomical description, plus masses and inertias [Yin2007]. Although the result is physically valid, the decomposition into states strongly influence the result, which is a too strong constraint for simulating very new gait patterns. At LAAS-CNRS [Maldonado 2018, Saab 2011], two ways are actually used to simulate a given motion. In a first way named hierarchical control, the motion is generated by prioritizing some tasks (i.e: foot position first and center of mass trajectory in second for example). In another way [Costes 2018, Turpin 2017], optimal control leads to determine whole body motion by minimizing a given cost functions (i.e: energy expenditure, joint torque, ...). In this project we will define which way could be used with the maximal efficiency to simulate plausible gait.

References


COSTES A., TURPIN N., VILLEGER D., MORETTO P., WATIER B. (2018) Spontaneous change from seated to standing cycling position with increasing power is associated with different morphologies. In another way [Gleicher1998, Kulpa2005]: adapting the trajectories of a character to another one with different morphologies. This approach is mainly based on solving kinematic constraints to ensure non-sliding foot contact with the ground, or ensure static balance. However, it does not enable to simulate totally new motion that correspond to a given anatomical description. To tackle this problem, other works proposed to model gait kinematics as a parametric mathematical function, and use non-linear optimization to calculate plausible locomotion for simplified anatomical models [Nicolas 2008, Nicolas2009]. However all these approaches based on computing kinematic trajectories fail to ensure the physical realism of the resulting motion.

For a better knowledge of the proposed research subject:

- The recruited PhD will participate in the meetings and joint works of the national HoBis project. A budget is dedicated to travels and publication fees to encourage scientific publications all along the PhD.

For a better knowledge of the proposed research subject:

- A state of the art, bibliography and scientific references are available at the following URL, do not hesitate to log in:
  - team.inria.fr/mimetic/
  - http://m2slab.com

Collaboration:

- The recruited person will be in connection with Bruno Watier from CNRS/LAAS who will co-supervise the PhD.

Responsibilities:

- The person recruited is responsible for developing a new method to efficiently simulate plausible locomotion for bipedal human and non-human primates, according to the available data: anatomical model and paleo-anthropological knowledge.
Principales activités
Main activities (5 maximum):

- state of the art in dynamic simulation of bipedal creatures,
- develop optimal control of a biomechanical model
- evaluation experiments with human and non-human primates in collaboration with partners of HoBis
- write scientific papers and present his/her work in international conferences and project meetings
- write reports/documentation for the projet and the final PhD report

Compétences
Technical skills and level required:

- Computer sciences, and especially computer simulation would be an advantage (Matlab, C++, Python)
- Applied mathematics, especially nonlinear optimization
- Skills in (bio)mechanics and physics would be a plus
- Interest in machine learning would be a plus

Languages: English (read, write papers, talk to international conferences and with other team members)

Relational skills: work in a group of scientist, dynamic, curious, interested in both simulation, robotics, human motion, software development and experimental set-ups.

Avantages sociaux

- Subsidised catering service
- Partially-reimbursed public transport

Rémunération

Monthly gross salary amounting to 1982 euros for the first and second years and 2085 euros for the third year.