PhD: Groups of humans and animals in natural environments: a multi-scale approach.

Localisation: LIX (Ecole Polytechnique, IP Paris), Palaiseau, France.
Supervisors: Damien Rohmer, Pooran Memari
Collaborator: Marie-Paule Cani
Starting date: October 2020
Web Link

Motivation and Context

This PhD takes place in the context of the Innovative Training Network CLIPE project addressing the core challenges of designing new techniques to create and control interactive virtual characters, benefiting from opportunities open by the wide availability of emergent technologies in the domains of human digitization and displays, as well as recent progresses of artificial intelligence.
This PhD, among the 15 ones taking place within the CLIPE network, will specifically address the objective of animating group of believable characters in dynamic natural environments.

The design of motion for virtual creatures is a key task for many applications. They can be used to enhance the realism of 3D films or to create plausible reactive characters for video-games. In a more scientific basis, controlled characters can be used for computing visual simulations from priors.
We will consider the particularly challenging application of generating realistic animation for prehistoric humans and animals. While only sparse data about prehistoric population displacement and behavior are known from Archaeologist's studies, these could be used as prior knowledge to adapt and transfer available data from current human morphology and locomotion to prehistoric one.

Objective and methodology

Our objective is to define a multi-scale approach to control the locomotion of group of human and animals, with a specific emphasis of models applicable to pre-humans in natural environments.
At a large scale (1), one should be able to control group behavior, as well as the interaction between different groups and the type of characters. At the individual level (2), the locomotion of the individuals should both be valid with respect to their morphology, as well as automatically adapting to the type of terrain (walking or running on a flat ground, in a meadow, in water, versus climbing a steep slope). At the smaller scale (3), the interaction with the terrain should be taken into account,

and may impact itself the motion of the character (slipping in the mud, or walking on stones that may roll under the feet).

These steps may be tackled in the following way:

(1) At the group scale, we may extend our previous work on animating adaptable crowd patches [Jordao 2014] to the case of open, natural environment. This extension should take into account terrain-related constraints such as slope, water or vegetation, as well as integrating the notion of group interaction that can be modeled as soft constraints or forces. Refinement and adaptation of the individual trajectory taking into account the constraints and prior knowledge on the group structure can also be integrated [Ecormier-Nocca 2019]. These trajectories will also need to be segmented and labeled into specific animation-related gaits expressing the type of displacement such as walking, hunting, fleeing, etc. At the end of this step, each gait will be associated with a precomputed 3D standard animation, of a contemporary human or animal.

(2) At the individual scale, we will tackle the animation transfer from contemporary character animation to match the morphology of its prehistoric counterpart. More specifically, we will need to adapt a standard skeleton animation, described as a set of varying joint angles, to a new morphology taking into account the change of limb dimensions, and possibly a change of mass distribution as well as muscle amount and power. Lastly, the transfer should lead to a valid motion, ie. free of intersection with the modified morphology.
Before handling animation data, a static transfer of the skeleton within a new morphology should be performed. To this end, a mapping between morphological envelope and animation-skeleton will be developed through the use of advanced geometric modeling and analysis methods, for instance using reverse engineering techniques for raw animated models inspired from cage-based models and barycentric representations [Thiery 2012]. A fully kinematic approach may be used first to take into account new limbs dimensions [Hecker 2008] and geometrical morphology while preserving contacts with external elements [Basset 2019], or between body parts themselves. The change of dynamic and equilibrium should be handled using a physically-based model based on the new distribution of mass. Finally, an extra layer of adaptation may also be added before handling collision explicitly in considering a simulation triggered by controllers optimized via the use of deep reinforcement learning, optimizing the locomotion from the new muscle distribution.

(3) In the last step, we will develop the local adaptation of the character motion to the terrain. Indeed, walking in mud, piles of rocks, on a river, or within dense vegetation, impacts the way each character should move. The terrain, or the vegetation, may also deform under the action of the human or animal [Sumner 1999], which should itself respond accordingly to preserve its stability. We aim at tackling this problem using an efficient, hierarchical approach. A global animated model used as a proxy may be set at a high level. Then subparts of this model will be refined to locally tackle the interaction/collision with the deformable elements of the terrain. Each response on the character motion may be locally adapted using efficient and adapted models, possibly based on simple physically based simulation and taking into account the overall character equilibrium [Yin 2007].

Information on the position
- Team: Geometric and Visual Computing team, LIX (Laboratoire d’Informatique de l’Ecole Polytechnique), CNRS.
- Place: Palaiseau, France (see details)
- Employer: Ecole Polytechnique
- University of registration/graduation in PhD: Institut Polytechnique de Paris (IPP).
- Duration: 3 Years contract: Oct. 2020-2023.

This PhD is associated to very competitive salary in France. The successful candidate will be expected to travel regularly to partner University within Europe, as well as presenting his work to International conferences. All travel expenses are fully funded and will be covered by the project.

During your PhD you are expected to collaborate and visit the following European institutes and companies:
[3 months] **Univ. Cyprus** (Yiorgos Chrysanthou). Adapting individual motion
[3 months] **Univ. Politècnica de Catalunya** (Nuria Pelechano). Semantics to drive behaviors
[3 months] **Gobo**. Application to games.

Requirements
- Recently graduated from a **Master level in Computer Science**.
- Good background (classes followed, internships, projects,etc) in **Computer Graphics** (3D Modeling, 3D Animation). Please detail this background experience in your application. Knowledge in machine learning is a plus.
- International experience: You should have **spent less than 12 months in France since October 2017** (required by the funding agency - this condition is not negotiable).

To Apply
Please send your application to Damien Rohmer (*Damien.Rohmer@polytechnique.edu*) with the following elements:

- Curriculum Vitae. Please state clearly your current position and your diplomas, field of study, previous experiences/internships, and detail your skills in Computer Graphics and related fields (machine learning, computer vision, experience with OpenGL, Unity, etc).
- Motivation Letter
- Copy of your Master transcript
- At least two recommendation letters or alternatively contacts of referents who know you, and work in Computer Graphics or related fields.

References

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[Thiery 2012] Thiery J.M., Tierny J., Boubekeur T. 2012. Cager: Cage-based reverse engineer-ing of animated 3d shapes. *Computer Graphics Forum* 31 (8), 2303-2316.
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[Sumner 1999] Animating sand, mud, and snow. RW Sumner, JF O'Brien, JK Hodgins, *Computer Graphics Forum* 18 (1), 17-26, 1999
[Yin 2007] Simbicon: Simple biped locomotion control. KK Yin, K Loken, M Van de Panne. *ACM Transactions on Graphics (TOG), Proc ACM SIGGRAPH* ,26 (3), 105, 2007.