PhD position: Computational Design of Marionettes

Figure 1: Don Giovanni "performed" by marionettes. Photo by Sandy Kemsley (CC BY-NC-ND 2.0).

Environment

This doctoral position will take place at Inria Grenoble in the IMAGINE team. The goal of IMAGINE is to develop a new generation of models, algorithms and interactive environments for easily creating and conveying animated 3D scenes. Our insight is to revisit models for shapes, motion, stories and virtual cinematography from a user-centred perspective, i.e. to give models an intuitive, predictable behaviour from the user's view-point. This will ease both semi-automatic generation of animated 3D content and fine tuning of the results.

Context

Marionettes are puppets actuated by strings attached to different marionettes' body parts and to rigid control plates. Thanks to the simplicity of their structure and their actuation mechanism, marionettes are relatively easy to fabricate. However the relation between the pose of a marionette and the orientation of the rigid plate, which also depends on the number, locations and lengths of the strings, is far from intuitive and mastered only by skilled marionette puppeteers - the marionettists. Therefore, the use of marionettes is mostly reserved to these professionals, and marionettes are almost exclusively seen on the stage of dedicated marionette theaters.

This PhD aims at developing novel computational tools to help casual users to design hand-operated marionettes so that they can be used for broader applications. Indeed, as physical embodiments of imaginary characters, marionettes could be exploited to facilitate the exploration of alternate choregraphies by artists, for social experiments [4], as tangible interfaces [3], for educational purposes or simply for casual entertainment. This goal brings new challenges related to the optimization of the marionette design parameters (number, locations and lengths of the strings), which typically depends on the targeted marionette performance, and to the representation of this target performance itself, which will need to be as intuitive as possible. This project is thus distinct from previous research in the field, which mostly focused on robotic marionettes with fixed design parameters and explored, in particular, the design of robotic actuation systems [1] and control policies [6]. While Murphey and Egerstedt tackled the problem of automation of marionettes plays [2], they assumed the marionettes strings locations and lengths to be known, whereas we are concerned with the design of the full system, which makes the problem more difficult, but also more interesting.

Objectives

The goal of this PhD is to develop novel computational tools to help casual users and artists to design marionettes manually operated by strings. In particular, we will investigate algorithms to efficiently simulate the movements of the marionettes and to automatically optimize the marionettes' design parameters (e.g. lengths of the strings, attachment points) such that the marionettes can be used to replicate target animations or to be able to reach static target poses. To this end, one possibility will be to adapt and extend the formulation that we developed for the design of actuated deformable characters, based on a constrained minimization problem that encourages sparcity of the actuation points [5]. Along the way, this PhD will try to address several open research questions. Since marionettes are under-actuated, several solutions for the strings locations and lengths can lead to the same pose. Can we leverage this redundancy and optimize these parameters such that users can easily compose the results obtained for canonical movements into a single animation? What's the best way to represent the target motions? From a broader point of view, this PhD will be the opportunity to work on the co-optimization of design and actuation parameters of dynamic systems as well as on the representation of complex target motions from, for example, simpler building blocks.

Main activities

Main activities:

- Research, design and implementation of algorithms for the direct simulation and inverse modeling of marionettes.
- Design and implementation of graphical user interfaces for interacting with the above algorithms.
- Evaluation of the developed methods

Additional activities:

- Writing of research papers
- Presentation of research work in conferences, seminars

Eligibility criteria

The candidate should be fluent in English and hold a Master's degree (or be about to earn one) or have a university degree equivalent to a European Master's (5-year duration). He/she should be proficient with C++, have a strong background in computer science and applied maths, and ideally some experience with computational fabrication or computer graphics.

Applicants will have to send an application letter in English and attach:

- Their degree certificates and transcripts for Bachelor's and Master 's
- Their CV
- A short presentation of their scientific project (2 to 3 pages max)

We encourage candidates to submit a recommendation letter from the person who supervises (or supervised) their Master's thesis (or research project). The recommendation letter should be sent directly by their author to melina.skouras@inria.fr and remi.ronfard@inria.fr.

Supervisors

Mélina Skouras, Inria Grenoble - Rhônes-Alpes (melina.skouras@inria.fr)
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Starting date and length

October 1, 2018, 36 months.

Application deadline

May 1, 2018.

Key Words

Marionettes, computational fabrication, physically-based simulation, optimization

References

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[4] Mohammad Mahzoon, Mary Lou Maher, Kazjon Grace, Lilla Locurto, and Bill Outcault. The willful marionette: Modeling social cognition using gesture-gesture interaction dialogue. In *Proceedings, Part II, of the 10th International Conference on Foundations of Augmented Cognition: Neuroergonomics and Operational Neuroscience - Volume 9744*, 2016.

[5] Mélina Skouras, Bernhard Thomaszewski, Stelian Coros, Bernd Bickel, and Markus Gross. Computational design of actuated deformable characters. *ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH)*, 32(4), 2013.

[6] K. Yamane, J. K. Hodgins, and H. B. Brown. Controlling a marionette with human motion capture data. *IEEE International Conference on Robotics and Automation*, 3, 2003.