Principles and Observation: How do people move?

Jehee Lee

Department of Computer Science and Engineering
Seoul National University
jehee@cse.snu.ac.kr

Abstract. The study on human movements and animal locomotion has revealed various principles based on physics, biomechanics, physiology, and psychology. Many of existing animation techniques rely on those principles, which may be described as a form of mathematical equations, rules, procedures, or algorithms. Another stream of research, called data-driven animation, made use of human motion data captured from live actors. In this talk, we argue that these two approaches are complementary to each other. We observed that physics-based methods and data-driven methods may combine in several different ways. The combination opens up new possibilities in character animation.

Keywords: Human movements, Data-driven control, Biped control, Animal locomotion, Physically based simulation, Controller design, Motion capture

1 Introduction

The animation and simulation of human behavior is an important issue in the context of computer animation, games, robotics, and virtual environments. The study on human movements and animal locomotion has revealed various principles based on physics, biomechanics, physiology, and psychology. Many of existing animation techniques rely on those principles, which may be described as a form of mathematical equations, sets of rules, procedures, or algorithms. Another stream of research, called data-driven animation, made use of human motion data captured from live actors. The research on data-driven animation has developed a variety of techniques to edit, manipulate, segment and splice motion capture clips. In this talk, we argue that these two approaches are complementary to each other.

Over the past few years, we have explored several methods that addressed the problem of simulating human behaviors in virtual environments. Each solution relies on different principles of human movements and motion data captured at different scales. We found that principles and observed data can interact with each other in several ways. Sometimes, motion data drive physically-simulated bipeds to walk, turn, and spin [1, 2]. Physics principles guide interactive motion editing to make a canned jump higher/wider and a spin longer [3]. Some principles can be learned from observed data to understand how people move in complex environments, what regularities human motion tends to exhibit, and how pedestrians behave in crowds. [4–6]. Understanding the interaction between principles and observed data would be a key aspect of character animation research.

2 Principles and Observation

There are well-known principles that have been frequently exploited in character animation algorithms. Newton's laws of motion explain the physics of human movements. The principle of optimality states that humans tend to walk in an energy efficient way. The energy efficiency can be defined in several different ways. It can be total force or effort the muscles are generating. It can be metabolic energy expenditure over the duration of walking.

Ideally, we wish to have an ultimate principle that explains everything about human movements and animal locomotion. However, it is hopeless to find the ultimate principle in the near future and it is not clear if such a principle even exists. In practice, each individual principle explicates only a certain aspect of human movements. We need more principles to understand other aspects. Including many principles in a single framework would lead to various forms of complexity (computational complexity and the complexity of thinking/implementation) we have to cope with.

On the other hand, from the viewpoint of data-driven approaches, humans are just imitating what they have seen before. We observe how people move to collect databases of human motion. The generalization capability of data-driven methods allows us to create new motions based on our previous observation. It is highly advisable that the databases are large enough to cover the natural variations of human movements. Unfortunately, collecting such a large collection of motion data is often very challenging in practice.

We demonstrate that combining two aforementioned approaches allows us to use simple principles and a small collection of observed data to achieve better performance than employing either complex algorithms or a larger collection of motion data might achieve.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Ministry of Education, Science, and Technology (No. 2012-0001242 and No. 2012-0000789).

References

1. Kwang Won Sok, Manmyung Kim, Jehee Lee: Simulating Biped Behaviors from Human Motion Data. ACM Transactions on Graphics, 26(3), Article 107 (2007)

2. Yoonsang Lee, Sungeun Kim, Jehee Lee: Data-Driven Biped Control. ACM Transactions on Graphics, 29(4), Article 129 (2010)
3. Kwang Won sok, Katsu Yamane, Jehee Lee and Jessica K. Hodgins: Editing Dynamic Human Motions via Momentum and Force. ACM SIGGRAPH/Eurographics Symposium on Computer Animation (2010)
4. Kang Hoon Lee, Myeong Geol Choi, Jehee Lee: Motion Patches: Building Blocks for Virtual Environments Annotated with Motion Data. ACM Transactions on Graphics, 25(3), 898–906 (2006)
5. Manmyung Kim, Kyung Lyul Hyun, Jongmin Kim, Jehee Lee: Synchronized Multi-Character Motion Editing. ACM Transactions on Graphics, 28(3), Article 79 (2009)
6. Eunjung Ju, Myung Geol Choi, Minji Park, Jehee Lee, Kang Hoon Lee, Shigeo Takahashi: Morphable Crowds. ACM Transactions on Graphics, 29(6), Article 140 (2010)