Data-driven Bird Simulation

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Figure 1: A sequence of a pigeon's flying motion

1 Introduction

Natural motion of living creatures such as human and animals has generated widespread interest in computer animation field. Many film and game industries want to present these virtual creatures on their products and exhibit natural and realistic motions as much as possible. Among them, flying animals such as birds have been particularly focused on because of their special condition moving in flight. Because they move in the sky with its wings and their motions are affected by subtle air flow, the principle for generating flying behavior has to be completely different from that for creating biped human's or quadruped animal's locomotion behavior.

Wu and Popović [2003] generated a bird character flying along a given path. They manually formulated and parameterized wingbeat motions of a bird by naive observations and simulated its flight in physically plausible manner. Although the result motions seemed to be physically correct, they could not guarantee reality of those motions due to its manual parameterization. In the case of biped behavior's simulation, there are some efforts to make a physically simulated controller based on motion capture data [Sok et al. 2007; Lee et al. 2010]. The data-driven controller took real human's motion as a reference data and made it possible to generate both natural and physically plausible locomotion without cumbersome procedure.

In this work, we propose a novel method to physically simulate flying motions imitating real bird flight. For reproducing realistic flight, we capture a pigeon's flying and parameterize a wingbeat motion from acquired data. Because we parameterize a bird's wingbeat using real motion automatically, we can get a convincing formulation representing wingbeat motion easily. Our flight controller based on real wingbeat data allows us to generate physically plausible as well as apparently realistic bird behaviors.

2 Our Approach

To acquire realistic bird flight data, we captured a pigeon's behaviors using both a Vicon optical motion capture system and high speed cameras. We attached 14 markers on wing joints and body parts including a head, a trunk and a tail, and a Vicon optical system with 28 cameras tracked these markers at 240 frames/second. This marker-based capture system played a role of recording wingbeat motions expressed by each joint mainly. Also we used four high speed cameras with a frame rate of 1000 fps for observing subtle motion of feathers closely.

Our bird character has one root joint and four kinds of controllable joints (shoulder, elbow, wrist, and tail). After acquiring three-dimensional marker positions from motion capture system, the captured data is analyzed to each DOF's angles of controllable joints. As a wingbeat motion is a cyclic behavior, the analyzed angle values also exhibit cyclic patterns. The wingbeat is represented by a kind of sinusoidal curve, however, each DOF has a different amplitude, phase and distinct details which are difficult to design manually. By using these captured data, we can formulate more realistic wingbeat motions easily. When we simulate bird flights, a natural deformation of feathers functions as reflecting aerodynamics correctly as well as demonstrating bird motions more realistically. However, because feathers have extremely light and soft property, it is hard to capture a feather's deformation using a marker-based capture system. High speed cameras with higher frame rates than a Vicon capture system record detail motions of feathers and allow us to observe and then reflect its deformations in aerodynamics simulation phase.

In our experiments, a simulation system consists of two parts; tracking the reference wingbeat motions using Proportional Derivative (PD) control approach and applying air resistance using simplified aerodynamics [Wu and Popović 2003]. The simple PD control method works well for tracking cyclic wingbeats on-the-fly at runtime. Simplified aerodynamics represents drag and lift forces applied to a flying bird properly and enables its feathers to exhibit deformations such as bending and twisting naturally. We can generate an animation of flight motion which is simulated at runtime without a complicated formulation process and a time-consuming optimization phase. Despite simulating regular and symmetry wingbeats repetitively, a bird character sometimes loses a balance by accumulation of physical simulation errors. Our simple feedback controller allows the bird to maintain its balance in real-time and go straight ahead consistently. Currently we are working on designing a dynamic controller which enables us to control speed and directions of flight motions and create various bird behaviors such as taking off, landing and an aerobatic flight.

References

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