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Animation of Flocks Flying in Line Formations

Marina Klotsman & Ayellet Tal
Technion

Abstract

The coordinated flight of bird flocks is a pleasant and attractive sight. While most previous approaches have focused on animating cluster formations, this paper introduces a technique for animating flocks that fly in certain patterns (so-called line formations). We distinguish between the behavior of such flocks during initiation and their behavior during steady flight. We provide a biologically-motivated technique for animating bird flocks, which produces plausible and realistic-looking flock animations.

Figure 1: Animation of a flock of barnacle geese (snapshots)

1 Introduction

Researchers in computer graphics have long been intrigued by the challenge of realistically animating groups of animals. One such example is the synchronized motion of flocks of birds, which is a delightful and fascinating sight. Flying flocks can be classified by their formation – *cluster formations* or *line formations* [1]. In cluster formations, typical of small birds as well as fish and herds, the animals are organized in irregular shapes. Conversely, in line formations the flocks are organized in a characteristic pattern, such as a line, 'V', or 'U'. These formations are typically two-dimensional and exhibit a high degree of regularity in spacing and alignment. They are common in flocks of large birds, such as waterfowls, cranes, and pelicans.

In his ground-breaking paper, Reynolds proposed animating groups by simulating the behavior of each bird independently [2]. The results are pretty animations of cluster flocks. Others have also addressed the animation of cluster formations [3, 4]. This paper introduces a technique for realistically animating flocks of birds flying in line formations (Figure 1).

In nature, these flocks undergo two stages: flock *initiation* (also termed *formation*) and *steady flight*. Initiation occurs during takeoff, with many rapid changes in the locations of the birds within the flock. During steady flight the flock flies over large distances in more stable shapes. Previous approaches have not distinguished between these stages and applied the same rules to the whole animation. While this strategy suffices for clusters, it does not suit the long, steady flights of flocks flying in line formations. We propose modeling these stages differently.

Why flocks fly long distances (up to 20,000 miles) in specific patterns is still a puzzle [5]. While it is often believed that the central rationale is to save energy [6], no model exists that can precisely predict the birds' positions. This lack of knowledge directed us into choosing a data-driven approach, utilizing real examples of flying flocks, for animating the steady-flight stage. Since existing examples are typically very short, while the flight is extremely long, we augment these examples with calculations of potential energy-savings. This combination is shown to produce not only feasible, but also eye-pleasing animations of flying bird flocks.

Inspired by previous work, our approach for animating the initiation stage is rule-based, where the behavior of each individual bird governs the motion of the whole flock. We introduce a new set of rules that better suits line formations. These rules are based on two novel drives, target-reaching, and separation, which help us more accurately animate the flock in initiation.

Our contribution is hence threefold. First, we propose to distinguish between the initiation and the steady flight (Sec. 3). Second, we show how