3. Semi-annual report

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Ph.D. Thesis title: Designing and Creating a Proto-type Semi-Autonomous Bird Inspired UAV for Bird Tracking and Filming

1. Introduction

In my third semester, according to my research proposal, the main goal was to finalize the analysis of GPS recordings of the bird species, which provide flight performance data for my future study. The non-flapping flight of birds, which can be considered in two flight phases, gliding and thermal circling, constitutes the most important parameter of my research. All gliding performance parameters (glide ratio and minimum sink speed) were found for 12 species from the GPS recordings. Now, I'm working on the thermal circling part of the dataset. In addition to this, I assembled a glider drone and made its first flight.

I'm still a collaborator of a KDP project of Doctoral Candidate Paula Perez Fraga in the department of Ethology. During the semester, my courses were parallel to assist my research topic and complex exam.

2. Research

I have been working on analysis of GPS recordings collected from several bird species at different resolutions to find out their flight performance. I found the gliding polar of 12 species (Figure 1). For visualization purposes, I merge the species into groups based on phylogenetics, shown by different colours. However, this approach still does not explain the variation between the species, so closely genetically related species can have different morphology, or the other way around, similar morphology could be achieved by species that are phylogenetically more distant. I grouped *Falco naumanni* (lesser kestrel), *Falco peregrinus* (peregrine falcon), and *Milvus migrans* (black kite) in a group (shades of red in the figure 1). Although black kite belongs to order *Accipitriformes,* but it's more suitable to evaluate it with falcons due to morphological features. Eagles are well-known and common creatures worldwide, but their classification is not easy. In our evaluations, 4 different species are classified in this group (Shades of blue in the Figure 1): *Haliaeetus leucocephalus* (bald eagle), *Haliaeetus vocifer* (African fish eagle), *Aquila verreauxii* (Verreaux's eagle), and *Aquila rapax* (Tawny eagle). The status of these species is determined by subfamily as *Haliaeetinae* (Sea eagle) and *Aquilinae* (booted eagle). *Gyps* is a genus of Old World vultures and the New World vultures or condor family, *Cathartidae* can be found in the vulture group (can be seen as shades of green in the Figure 1) according to our classification. Also, white storks (*Ciconia ciconia*) and northern bald ibises (*Geronticus eremita*) will be considered in another group named migratory birds.

Biometric data of the birds were collected to understand the morphological difference between species. Also, this biometric data will allow us to uncover the behavioural difference of similar size individuals in the same species. I'm now working on the thermalling part of their flight. This section aims to find the relationship between the horizontal and vertical speed of birds in thermal.

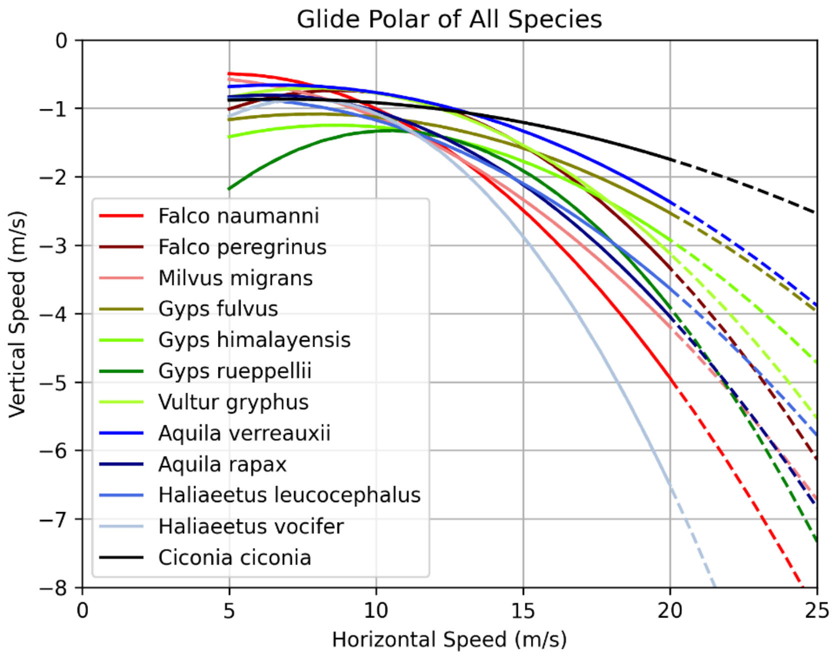

Figure 1: For all species, the effective polar curve as fitted to the measured average sinking and horizontal velocities (range between 5 m/s and 20 m/s) of the gliding parts of the flights.

Besides analysing the GPS data set, I assembled and flew the R/C (Radio control) model glider which is an important research aim for the MTA-ELTE 'Lendület' Collective Behaviour Research Group. In order to provide longer and safe flight, high-performance electric motor and servo assembled to the glider. The current propulsion system of the glider generates 1.3 kg thrust, but the same motor can generate 1.8 kg thrust by changing the battery. Although the suggested thrust-weight ratio for the powered sailplanes is 0.3 [2], the thrust-weight ratio of our glider is around 1. These parameters ensure us longer endurance of flight and a higher payload capacity. We did the flight tests in the controlled airspace of Farkashegyi airport (Figure 2). These flights confirmed that the glider is able to carry the necessary equipment for further experiments. This flight was recorded with a high-resolution GPS to learn about the glider's performance (Figure 3). According to GPS recordings, the glider reached the maximum altitude of 207 m from the ground level during the flight. In the test flights, I manually controlled the glider.

Figure 2: GPS-camera setup of the glider (left) and A frame from the test flight (right).

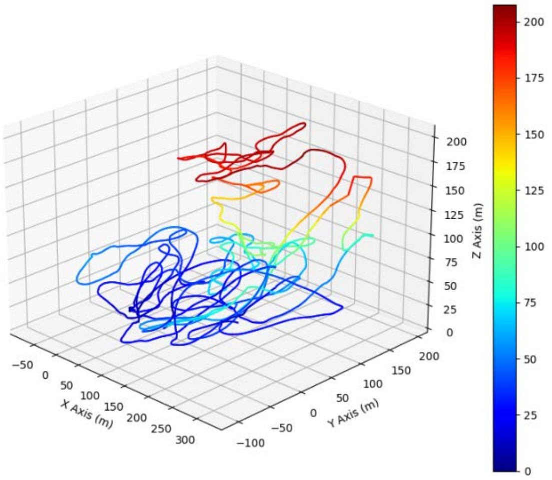

Figure 3: 3D GPS recording of the flight with the peregrine falcon.

In collaboration with Paula Perez Fraga and Dr. Attila Andics's research group at the Department of Ethology, I worked on analysing accelerometer data to get insight into individuals' behaviour. Ms. Perez presented the preliminary results in a talk at the 7th European Student Conference on Behaviour & Cognition.

3. Study Activity

Biophysics II (biophys2f20ex)

I joined this course to gain more in-depth knowledge in physics, as my main background is biology. I took Biophysics-I last semester. I attended and accomplished the second part of the course.

Evolutionary game theory (FIZ/3/059E)

This course was important to understand birds' strategy in the evolving population. My research topic is highly linked to the decision of migration timing of birds, which can be affected by population fitness easily. This course also helped me to prepare myself for the complex exam.

4. References

1 Ákos Z, Nagy M, Vicsek T. 2008 Comparing bird and human soaring strategies. Proceedings of the National Academy of Sciences, 105 (11) 4139-4143. Doi: 10.1073/pnas.0707711105

2 Raymer, D. P. 2012 Aircraft design: a conceptual approach, Section 5.1 (AIAA Education Series), Reston, Virginia.