Chapter 3

Fish Tracking with Computer Vision Techniques: An Application to Vertical Slot Fishways

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ABSTRACT

Vertical slot fishways are hydraulic structures which allow the upstream migration of fish through obstructions in rivers. Their design depends on the interplay between hydraulic and biological variables to match the requirements of the fish species for which they are intended. However, current mechanisms to study fish behavior in fishway models are impractical or unduly affect the animal behavior. In this chapter, we propose a new procedure for measuring fish behavior in fishways using Computer Vision (CV) techniques to analyze images obtained from the assays by means of a camera system designed for fishway integration. It is expected that this technique will provide detailed information about the fish behavior and will help to improve fish passage devices. A series of assays have been performed in order to validate this new approach in a full-scale fishway model and with living fishes. We have obtained very promising results that allow reconstructing correctly the movements of the fish within the fishway without disturbing fish.

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1. INTRODUCTION

One of the most important and significant changes in the river ecosystems are related with the construction of water resources management works, such as dams, weirs, water diversions. These works provide many advantages to exploit the water resources, but they also present drawbacks, the main related with the fish natural movements because these structures constitute a physical barrier, what negatively impacts their populations. In fact, this interruption of free passage has been identified as the main reason for the extinction or the depletion of numerous species in many rivers (Jackson, Marmulla, Larinier, Miranda, & Bernacsek, 2001).

Among several solutions used to solve this problem, some of the most versatile are known as vertical slot fishways that are basically a channel divided into several pools separated by slots. Their main advantage lie in its ability to handle large variations in water levels, since the velocity and turbulence fields in the pools are independent of the discharge. Moreover, it allows fish to swim at their preferred depth and to rest in low-velocity areas, in contrast to other types of fishways.

An effective vertical slot fishway must allow fish to enter, pass through, and exit safely with minimum cost to the fish in terms of time and energy. Thus, the achievement of the best biological requirements required for the fishes should drive design and construction criteria for this type of structures. However, only some authors have characterized the flow in vertical slot fishways (Puertas, Pena, & Teijeiro, 2004; Tarrade, Texier, David, & Larinier, 2008; Wu, Rajaratma, & Katopodis, 1999) and others have studied fish swimming performance (Blake, 2004; Dewar & Graham, 1994). Besides, very few works have studied the interaction between the biological and physical processes that are involved in swimming upstream a vertical slot fishway (Puertas et al., 2012). Consequently, the knowledge of fish behavior and its relation with this kind of structures is very limited and the previously noted biological requirements usually rely on the designer’s experience, rather than on rational approaches.

In order to address this deficit, it should be required to complete the fishway design methodology with results from experimental assays with living fish. In these tests, fish are introduced into full-scale fishway models (see Figure 1). Their movements and behavior are analyzed. In the tests described in this chapter, the passage success is evaluated and the fish effort is measured by means of blood tests. That value measures the proportion of individuals that passes through the fishway. Nevertheless, these techniques should be used in combination with another that permits detailed characterization of the animal behavior during the assay, determining parameters such as: resting areas, resting times, fish velocities and accelerations, times spent for full ascent and in each pool, etc. Subsequently, these parameters can be linked to the hydraulic data and the results of the blood tests in order to measure the fish biological requirements.
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