

# Probabilistic Search Algorithms with Applications in Biology

A proposal for a Master internship  
under the guidance Pierre Fraigniaud and Amos Korman

## Synopsis

The internship will be centered around the so-called *Lévy walks* (or *Lévy flights*), which are random walk processes whose step length follows a long-tailed power-law distribution. Movement patterns that follow such distributions have indeed been observed on all scales of the biological world, e.g., when birds or insects are looking for food.

The objective of this internship is to analyze the usefulness of these patterns as an efficient search strategy for finding treasures (food patches) in some domain (e.g., a Euclidean space or, more generally, a graph). In particular, the internship will be aiming at reconsidering what is known as the “Lévy flight foraging hypothesis”, related to which a recent breakthrough has been achieved in:

- “Intermittent inverse-square Lévy walks are optimal for finding targets of all sizes”, by B. Guinard and A. Korman. *Science Advances* 2021.

The internship will investigate possible extensions of the subject studied in the above paper. In particular, one aim would be to extend the results therein from 2-dimensional spaces to 3-dimensional spaces. Another, more challenging, direction would be to extend the results to general graphs, while finding a suitable extension for the notion of Lévy walks that would apply to general graphs.

## Dates and Location of the Internship

The Internship will take place at IRIF, Université Paris Cité, from April to September 2024, including a possible short stay at Haifa University, Israel.

## Synopsis

Ideally, the internship would progress into a PhD thesis at Université Paris Cité that will concentrate on probabilistic movement patterns, in both single-agent contexts, and multi-agent contexts. The computational aspects will focus on search but will also concern subjects such as recommendation systems and small-world phenomena.

The thesis aims to involve a unique blend of mathematical analysis (which will comprise most of the thesis) with analyzing data from biological experiments (mostly concerning the movement of bats).