



## CERTIFICATE OF PARTICIPATION



The Director of the « Laboratoire des Mathématiques Appliquées et de Modélisation LMAM », certifies that :

« *Slimane Benmahmoud* »

Has participated with an « *Oral Presentation* » and presented a paper entitled:

« *A novel fractional-order Cross entropy* »

During the 7th International Workshop on Applied Mathematics and Modelling « *WIMAM'2023* », held on 13 and 14 December 2023 at Université 8 Mai 1945 Guelma.

The Laboratory Director  
Pr. Hamza GUEBBAI



Chairman of the Organizing Committee  
Dr. Aries Mohammed es-salih



## A novel fractional-order Cross entropy

Slimane Benmahmoud

*Faculty of Technology. Department of Electronics Engineering, Signals and Systems' Laboratory  
(LASS). M'sila University. M'sila. Algeria*

E-mail: slimane.benmahmoud@univ-msila.dz

---

**Abstract.** In this work, we have derived a novel generalized fractional cross-entropy (FCE). To do so, we have differentiated the CE's generating function (i.e.,  $h(t) := \int_{S_X} \frac{f_X(x)}{f_Y(y)} f_Y^{-t}(x) dx$ ) using a  $\alpha$ -order Caputo fractional derivative. When the order of differentiation  $\alpha \rightarrow 1$ , we recover the ordinary Shannon's CE, which corresponds to the results from a first-order ordinary differentiation.

---

**Keywords:** Cross-entropy (CE), Riemann-Liouville/Caputo fractional integral/derivative, fractional calculus, entropy's generating function, Tsallis/Rényi entropy, information measure.

**Mathematics Subject Classification:** 26A33 · 34A08 · 34K37

## 1 Introduction

In 1948, Shannon proposed the concept of entropy in the context of communication theory [1]. It consists of a measure of surprise or uncertainty associated with the probability distribution of a random variable (RV). For a discrete RV  $X$  taking values in  $\mathcal{X} = \{x_1, x_2, \dots, x_q\}$  and having a probability mass function  $p_i = P(X = x_i)$  with  $\sum_{i=1}^q p_i = 1$  and  $p_i \geq 0$  for  $i = 1, \dots, q$ , it is given by

$$H(X) = - \sum_{i=1}^q p_i \log p_i. \quad (1.1)$$

This suggested measure of uncertainty (i.e., Eq (1.1)) with its properties has shown an agreement with the intuitive notions of randomness and justified its usefulness with respect to statistical problems in communication theory.