

PINNs for structured population dynamics inference: Application to oocyte dynamics in fish ovaries

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Population dynamics are often observed as distributions of individuals with respect to structuring variables such as size or age. The associated inverse problem consists of inferring the underlying vital rates (recruitment/birth, growth, and death), which are typically complex, nonparametric functions due to limited prior knowledge.

Physics-Informed Neural Networks (PINNs) provide a natural framework for such problems by combining neural networks as universal function approximators with mechanistic constraints encoded in differential equations. We present a novel application of PINNs to inverse problems for size-structured partial differential equation models with nonlocal interaction terms. Our goal is to describe early oocyte dynamics in juvenile fish ovaries, a key process determining lifelong reproductive capacity and regulated by hormonal feedback.

We develop a model describing the dynamics of precursor germ cells and growing oocytes structured by size and coupled through a hormone-mediated feedback regulating precursor cell renewal. Using repeated cross-sectional measurements of oocyte size distributions, we apply the PINN framework to infer nonparametrically the size-dependent oocyte growth rate, the time-dependent recruitment of new oocytes, and the regulated renewal rate of precursor cells.

The calibrated model reproduces experimental oocyte size distributions and provides *in silico* access to key biologically meaningful quantities that are not directly observable.

Details of this work can be founded in [1].

- [1] L. Fostier, M. Lesage, V. Thermes, F. Clément, R. Yvinec. *Data-driven PINN inference of oocyte dynamics in fish ovaries*, 2026. Working paper or preprint.