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M.Sc. Thesis Proposal: *Extending DGrowthR with Penalized Spline Models for Microbial Growth Curve Analysis*

Background: Quantitative analysis of microbial growth curves is essential for understanding how bacterial populations respond to environmental cues. Traditional analysis approaches make rigid assumptions about the functional form of these curves, limiting their usefulness for studying conditions that distort standard growth curves. In order to address these challenges, DGrowthR was created, a package for end-to-end analysis of large scale microbial growth data. The DGrowthR package (<https://bio-datascience.github.io/DGrowthR/>) currently provides tools for analyzing growth trajectories using Gaussian processes, which offer flexible non-parametric modeling of growth curves with uncertainty quantification. Apart from Gaussian processes, penalized splines offer a complementary approach for flexible growth curve modeling while providing computational efficiency and interpretability. The ability to model growth curves using both Gaussian processes and penalized splines within a unified framework is key to providing researchers with appropriate tools for diverse growth data scenarios (<https://www.biorxiv.org/content/10.1101/2025.03.25.645164v2>).

Objectives: The purpose of this M.Sc. thesis project is to extend the DGrowthR package by integrating penalized spline models as an alternative to Gaussian processes for growth curve analysis. The extended framework will therefore provide users with the choice between Gaussian process and spline-based approaches depending on their data characteristics and computational constraints. The implementation will ensure compatibility with DGrowthR's existing API and workflow.

Plan and deliverables: A successful completion of the M.Sc. thesis requires the following computational and scientific advances. Implementing and evaluating penalized spline models within DGrowthR that complement the existing Gaussian process functionality for modeling growth curves. A write-up in thesis form and commented code on GitHub are mandatory deliverables at the end of the thesis.

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