جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

INLA

Short course - São Carlos - August 12-13 2024

TITLE: Efficient joint modeling of longitudinal and survival data through the user-friendly INLAjoint R package.

Abstract: Regression models for longitudinal and survival data have become increasingly important in medical research, Integrated Nested Laplace Approximation (INLA) is a fast and flexible algorithm that has been shown to outperform current state-of-the-art methods in terms of computational time, making it an ideal tool for personalized medicine. This short course covers the latest developments in survival analysis and multivariate joint longitudinal-survival models, emphasizing the benefits of using INLA for efficient model fitting and dynamic risk predictions. The R package INLAjoint simplifies the process of using INLA for joint models by providing a user-friendly interface and a flexible modeling framework. It can handle a wide range of models, allowing researchers to analyze complex medical data as shown in Rustand et al. (2023).

The course includes an explanation of the INLA methodology, an overview of joint models, and a hands-on tutorial on using the software. Participants will learn about model fitting and evaluation, as well as real-world applications of INLA in diverse medical scenarios. By the end of the course, participants will have the knowledge and tools to effectively use INLA for fitting joint models and compute dynamic risk predictions in their research, ultimately contributing to more informed decision-making and better patient care.

Relevant references:

Denis Rustand, Janet van Niekerk, Elias Teixeira Krainski, Håvard Rue & Cécile Proust-Lima, **Fast and flexible inference for joint models of multivariate longitudinal and survival data using Integrated Nested Laplace Approximations.** Biostatistics, 2023. doi: 10.1093/biostatistics/kxad019.

Danilo Alvares, Janet van Niekerk, Elias Teixeira Krainski, Håvard Rue, and Denis Rustand. **Bayesian survival analysis with INLA.** 2024 (arXiv preprint arXiv:2212.01900).

Denis Rustand, Janet van Niekerk, Elias Teixeira Krainski, and Håvard Rue. **Joint Modeling of Multivariate Longitudinal and Survival Outcomes with the R package INLAjoint.** 2024 (arXiv preprint arXiv:2402.08335).

Course content

Part 1: Introduction to INLA
In the first session, participants will be introduced to the INLA methodology, highlighting its advantages in computational efficiency. The suitability of INLA for fitting joint models will also be emphasized, showing how INLA significantly outperforms current state-of-the-art methods in terms of computational time. This session is providing a foundation for the practical application of this algorithm.

Part 2: Introduction to models handled by INLAjoint
In this session, we describe the various models for longitudinal and survival data that can be fitted with the INLA methodology through the INLAjoint R package, which is a versatile tool that can handle a wide range of models, including univariate and multivariate longitudinal models such as generalized linear mixed models, zero-inflated models, and proportional odds models. It can also handle univariate and multivariate survival models, including competing risks, multi-state, frailty and cure models with parametric or semi-parametric baseline risks. The concept of multivariate joint models for longitudinal and survival data is introduced with a focus on how this modeling approach allows researchers and clinicians to better understand the interplay of different outcomes, ultimately leading to improved patient care and more informed clinical decision-making. The importance of these models in medical research will be discussed, along with the motivation for using the Integrated Nested Laplace Approximation (INLA) approach in joint modeling.

Part 3: Software Implementation
The next session will focus on a hands-on tutorial using the INLA method through the R packages INLA and INLAjoint. INLA is a powerful tool for Bayesian inference, but it can be challenging to use for complex models involving longitudinal and survival data. We'll show how INLAjoint simplifies the process by providing a user-friendly interface and a flexible modeling framework, making these advanced methods more accessible to researchers and clinicians without extensive programming skills. This session will illustrate how these models can be used as building blocks to formulate various joint models, allowing researchers to analyze complex medical data and enabling participants to effectively use INLA in their research. We will show that various options are available to link longitudinal and survival outcomes in the context of joint modeling, such as the current value, current slope or shared random effects associations with the possibility to have a non-linear effect of these quantities through splines. The possibility to include spatial random effects in these models will also be discussed and illustrated with an example.

Part 4: Model Fitting, Evaluation and Risk Predictions
In this session, participants will receive practical guidance on fitting joint models using INLA, including model selection, diagnostics, and performance evaluation. They will also be introduced to risk prediction methods using INLA-fitted joint models. Furthermore, case studies will be presented to demonstrate the application of INLA in diverse medical scenarios, highlighting its adaptability and potential for improving patient outcomes. The session will involve a discussion of ongoing research and potential future developments in joint modeling and INLA methodology. This will provide participants with an understanding of the current state of the art and inspire them to explore further advancements in their own research.

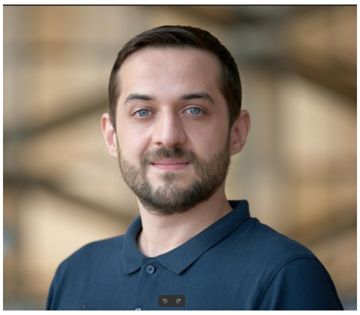
By the end of this short course, participants will have a good understanding of models for longitudinal and survival data that can be fitted with INLA's methodology. They will be equipped with the knowledge and tools to effectively use INLA in their research.

Schedule (subject to changes):
Day 1 - Morning: Part 1
Day 1 - Afternoon: Part 2
Day 2 - Morning: Part 3
Day 2 - Afternoon: Part 4

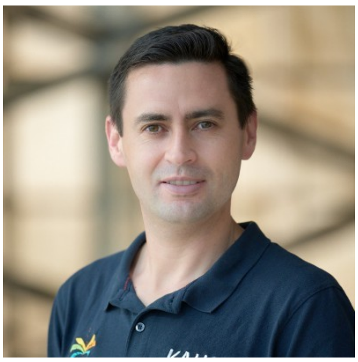
Learning Objectives:
As a result of the course, participants will be able to:
LO1: Comprehend the INLA methodology, its advantages in computational efficiency, and its suitability for fitting models for longitudinal and survival data.
LO2: Understand the principles of multivariate joint longitudinal-survival models and develop a deeper understanding of their importance and applications in medical research.
LO3: Apply practical guidance to fit models using INLA through the INLAjoint R package, including model selection, diagnostics, and performance evaluation.
LO4: Perform dynamic risk predictions using INLA-fitted joint models
LO5: Evaluate the performance of INLA-fitted joint models and interpret the results.
LO6: Apply joint models to real-world medical data and generate insights that can improve patient care.

Course level:
This short course is designed for students and researchers who are interested in learning about the INLA methodology in the context of fitting models for longitudinal and survival data. Prior knowledge of mixed effects model theory and survival analysis basics is recommended, but advanced statistical knowledge is not required. The course is suitable for participants who are new to joint modeling and have limited experience with statistical modeling. The course is designed to be accessible and user-friendly, including illustrative examples on using the INLA and INLAjoint R packages. Overall, the course is of intermediate difficulty level.

Authors / Instructors:



Dr. Denis Rustand obtained his Ph.D. in Public Health, Biostatistics in 2020 from Bordeaux University, France. He is now a Post-Doctoral fellow at KAUST where he joined the INLA development team. He received Harvard's Higher Education Teaching Certificate. He is the main developer and maintainer of the INLAjoint R package, a user-friendly interface to fit joint longitudinal-survival models with INLA. He has published 6 papers in Biostatistics, Biometrical Journal and Computational Statistics & Data Analysis, amongst others.



Dr. Elias T. Krainski is a statistician with teaching experience at the Universidade Federal do Parana and in modeling with INLA. He has been working with model developments and applications in INLA over the last years. His publications includes a book in spatial and spatio-temporal models and papers on modeling spatial, spatio-temporal, and joint longitudinal and survival data.