Swiss TPH

Practical on model fitting

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The data

- Weekly reported data of malaria cases in an region which historically had very few cases of malaria
- Over a year, the annual incidence has increased from 10 to 110 cases per 1’000.
- Data recorded between January 1st and December 31st 2024
- Data includes the week number, the number of uncomplicated cases, the incidence and the population size.

Part 1:

Manual fitting

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Data Visualisation & Model

1. Upload in R the file entitled “sis_si_weekly_cases.csv”
2. Visualize the data in R with ggplot
3. Code the ODE system (SIR-SI without interventions) in R with deSolve
4. Simulate and plot the model solution for $\alpha_{scale} = 0.8$ and then $\alpha_{scale} = 1.2$ overlaying the data
5. How well does the model correspond to the data?
6. Repeat for a few values of parameters searching for the best fit

Part 2:

Fitting using Least Square Error

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Fit the model using the Least Square method (RMSE)

1. Define the model and the initial parameters and states
2. Write the objective function using the cumulative number of cases
3. Write the Least Square Error = $\sum_{t=1}^{52}(X_{obs}(t) - X_{sim_\theta}(t))^2$
   - ✓ With $X_{obs}\ (t)$ the observed number of malaria cases
   - ✓ $X_{sim_\theta}(t)$ the cumulated number of simulated cases of malaria at time t with parameters $\theta = \{\alpha_{scale}, \rho_{scale}\}$
4. Find the parameters that minimize the Least Square Error using the optim function
5. Extract the parameters and visualize the fit

Part 3:

Fitting using MLE

Practical 2: Maximum Likelihood Estimation

Model fitting

1. Write the likelihood linking the model to the data
   - Assuming a negative binomial function as the observational model
   - Total number of cases scaled with reporting rate ρ_scale and multiplying factor α_scale so that: μ_t = ρ_scale · I_t(α_scale)

2. Use the R function **nlminb** to minimize the Negative Log Likelihood function and estimate α_scale and ρ_scale
   - Assume α_scale and γ are bounded on a log-scale to keep the solver in stable regions (e.g., alpha_scale ∈ [0.05, 20], rho_scale ∈ [1e−3, 100], size ∈ [0.5, 1e4]).
   - Pick your start values using the method of moments for the minimization algorithm

3. Visualize the fit. What are the estimated parameters?

Practical 2: Maximum Likelihood Estimation

Model fitting

1. Refit the model with a Poisson distribution.
   - Replace the NB term with $\Sigma\_t -\log \text{dpois}(Y\_t; \mu\_t)$
   - Drop size from θ.
2. How do the extracted values compare?

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