Using gaussian process metamodels for sensitivity analysis of an individual-based model of a pig fattening unit

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Objective

To define and implement an appropriate sensitivity analysis approach for an individual-based model

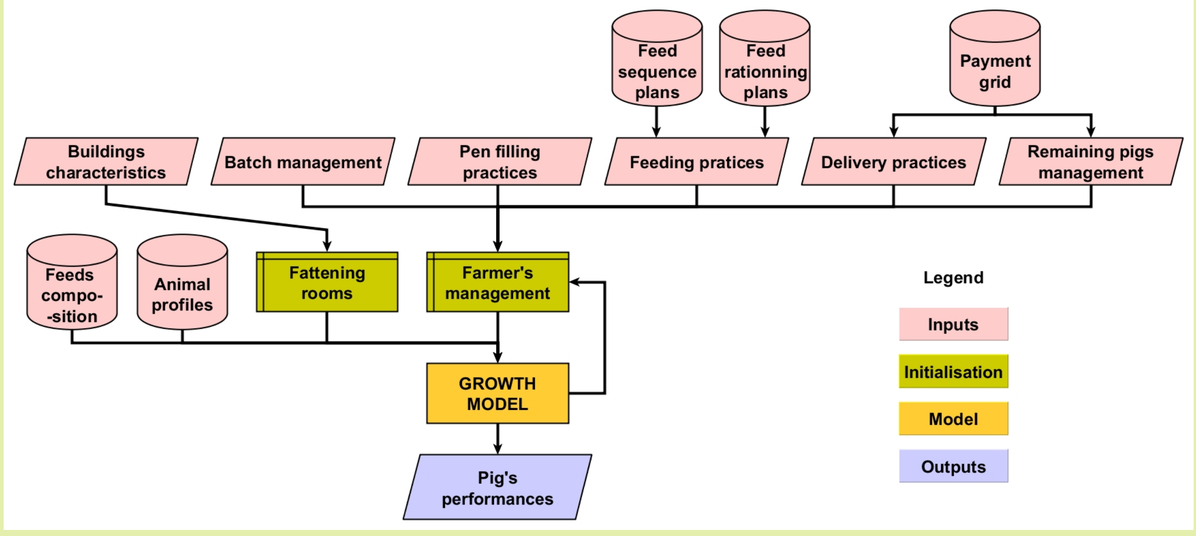
Model description

a pig fattening unit model able to

i) Simulate individual performance of pigs (variability) X with farmer's practices

ii) Evaluate the effects of these practices on technical, economic and environmental performance.

- Dynamic (daily time step)
- Stochastic (animal profiles, mortality)
- Mechanistic
- Discrete-event model (agenda of events)
- ~10 min per simulation



Sensitivity analysis

- 14 inputs tested (5 integers, 9 real numbers)
- 10 outputs studied (technical and environmental results)

Two steps approach (due to calculation time)

i) One gaussian process metamodel per output (using 100 simulations)

ii) Extended Fourier Amplitude Sensitivity Test **(eFAST)** method (N = 1500 scenarios for each trajectory: 21000 simulations per metamodel)

→ ~200 time faster using gaussian process metamodels than using our model itself (2 h vs. 2.5 weeks of calculation)

Fig. A: Coefficients of variation of the model's studied outputs (using the 100 simulations for the metamodels)

- Variations of phosphorus excretion: 85% due to phosphorus intake
- Variations of nitrogen excretion: 84% due to nitrogen intake
- Variations of percentage of pigs in optimal slaughter weight range: 38% due to cleaning period, 18% due to minimum number of pigs per delivery to slaughterhouse, 14% due to quantity of feed intake, 8% due to the number of places per pen

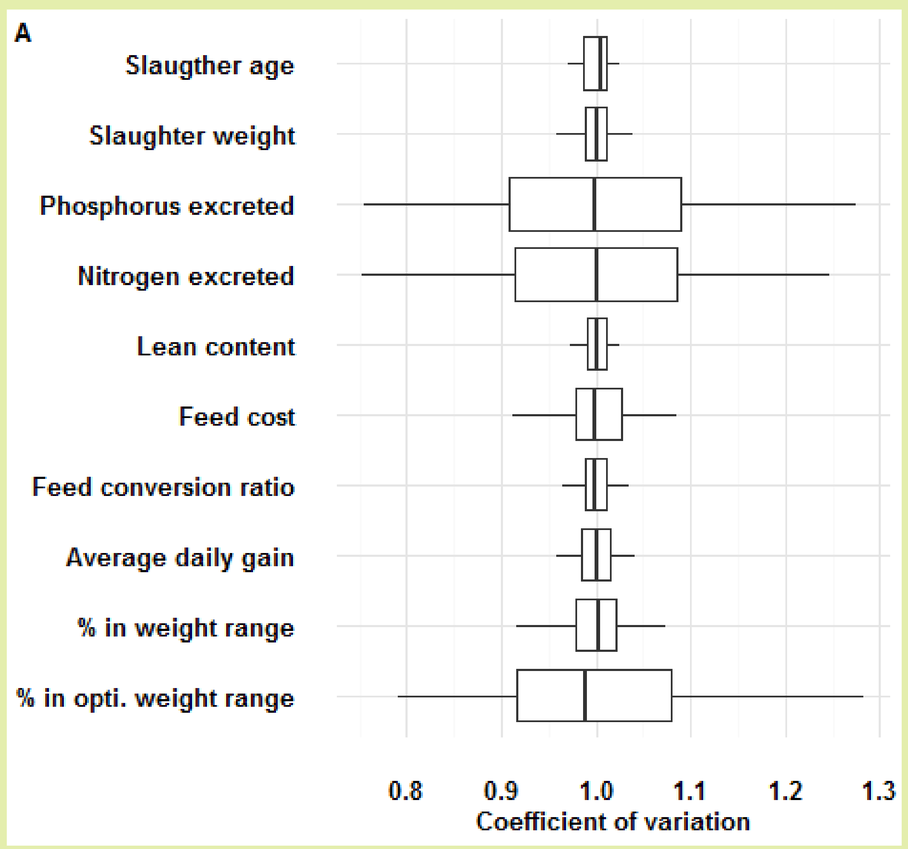
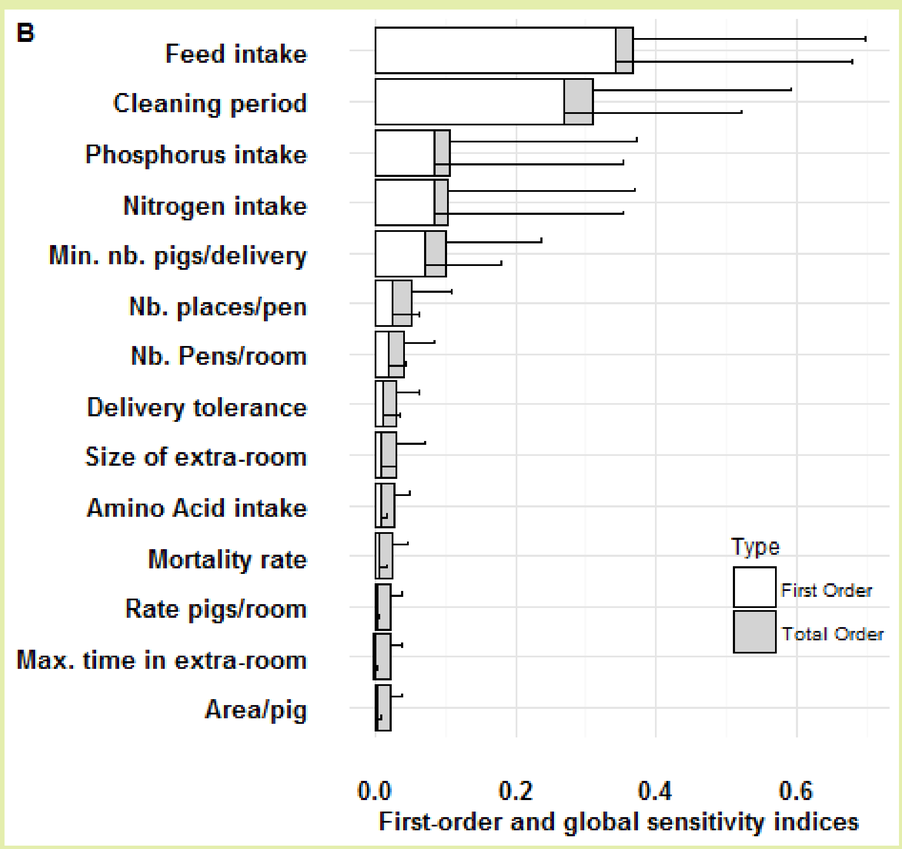


Fig. B: Average sensitivity indices of the inputs investigated, among all the outputs

- Feed intake explains 37 % of the variation
- Duration of cleaning period explains 31 % of the variation
- Phosphorus and Nitrogen intake explain each 11 % of the variation
- Minimum number of pigs per delivery explains 10 % of the variation
- The other inputs explain each less than 5 % of the variation



Conclusion

The sensitivity analysis allowed us to

i) Validate the **model behaviour** by expertise

ii) Identify the most sensitive inputs (>30% of sensitivity explained, feed intake, cleaning period) and the less sensitive inputs which can be set for routine use (<5% of sensitivity explained, number of places per pen, number of pen per room, delivery tolerance, size of extra-room, amino acid intake, mortality rate, rate of pigs per room, maximum time fatten in extra-room, area allocated per pig)

→ Perspective: These results will be confirmed by a second sensitivity analysis including newly implemented economic and environmental (calculated by Life Cycle Assessment) results.