Extended Abstract

Governments, NGOs, and businesses use increasingly detailed computational models to support decision-making. For instance, model-based decision support during the COVID-19 pandemic was often done with large-scale agent-based models, which are deemed accurate because of their ability to capture individual-level heterogeneity and the structure of the contact network.

However, detailing a model increases the time and costs of developing, initialising, running, and analysing. Given a budget, this implies that fine-grained models allow for less experimentation than coarse models. Little experimentation is problematic, as modellers require model experiments to (a) understand the limitations of their model, (b) evaluate a wide range of policies, and (c) understand the effect of uncertainty on policy performance.

A potential solution to overcome this problem is to aggregate a detailed model. With aggregation, information is typically lost about the heterogeneity of objects in the model, the structure of the network in which objects are organized, and the allocation of resources among objects. Aggregation enables more experimentation, as it decreases the data demand, runtime, and analysis time. Still, very few case studies exist that show (a) how to aggregate and (b) the effect of aggregation for model-based decision support.

Therefore, we demonstrate with a case study in the asset management domain (a) how to aggregate a detailed model and (b) the effect of aggregation for model-based decision support. The case study is centred around early-stage ship design. In early-stage ship design, the aim is to evaluate many ship designs over many uncertainties within a short time frame. To enable broad exploration, early-stage ship designs have a low resolution. This implies that computational models need to be developed at a low resolution as well to match the data demand of early-stage ship designs. In this research, we aggregate a System Dynamics (SD) model that is tailored to ship designs that are in a more advanced stage. Due to a lower data demand, the aggregated SD model is more suitable for exploratory use during early-stage ship design. We cross-validated the aggregated SD model with the base SD model to understand the effect of aggregation in terms of decision support.

We found that aggregation decreases the precision of a model if the model is grounded in trustworthy theory and empirics. For this case study, this was because the aggregated SD model could not approximate the effect of heterogeneity of missions and components of a ship, as well as the redundancy network in which components are organized. Because of less precise model outcomes, the precision of decision support decreases as well. For instance, we found that under certain conditions, more redundant components in a ship design decrease the maintenance costs. To determine more precisely whether such conditions will occur in practice, the detailed SD model is needed that evaluates ship designs in a more advanced stage. Hence, we conclude that the main merit of a coarse model is that it supports strategic decision-making by highlighting areas of interest in the uncertainty- and solution space that would have remained unnoticed otherwise. Such areas of interest can guide further analysis with a more detailed model that supports more in-depth decision-making.

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