The shades of gray in model building and its opportunities for precision livestock farming

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For many years, the literature in animal modelling has had the tendency of opposing two apparently irreconcilable approaches, namely the white-box and the black-box modelling approaches. In the white-modelling approach, the modeller is motivated by the goal of providing a mechanistic insight of the system under study. Modelling construction is then supported from the knowledge of the mechanisms that underlie system behaviour. The models resulted from this approach are named with different adjectives such as mechanistic, phenomenological-based, knowledge-based or white-box models. The white-black models fulfil the property of interpretability. That is that the variables and in particular the model parameter have biological meaning. The black-box modelling approach is data-driven. The modeller goal here is to approximate the observed behaviour of a system without the need of incorporating knowledge on the mechanisms responsible of the observed data. The models are derived from data analysis to quantify relationships between variables of interest. Models in this category are called empirical, data-driven, behavioural or black-box models. The black-box models are powerful tools for exploiting high-throughput data and time-series data for predictions and diagnosis. However, these models lack of interpretability. The relevance of the dichotomy between white-box and black-box modelling approaches has recently being revisited by new perspectives of the modelling practice in the context of precision livestock farming (PLF) and big data. Between the white and the black, there are shades of gray. Hybrid modelling approaches combining white-box and black-box models result in gray-box models that can handle big data while having some level of interpretability. By this property, the gray-box modelling approach offers great opportunities for PLF. In this work, we elaborate on how mathematical tools from the automatic control domain can contribute to the development of gray-box models adapted to address animal science problems. We illustrate our approaches via relevant examples addressing the dynamics of methane emissions from cattle and the animal response facing perturbations. We expect this contribution will motivate the animal science community to enlarge the spectrum of modelling tools for efficient PLF developments.