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How can Machine Learning Support the Practice of Modeling and Simulation? —A Review and Directions for Future Research

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Outline

- Discussion on why and how to integrate M&S with ML.

- Insights from reviewing studies integrating M&S and ML.

- Prospective questions for research directions.

Why Machine Learning ?

Most of the knowledge in the world in the future is going to be extracted by machines and will reside in machines", (LeCun 2014).

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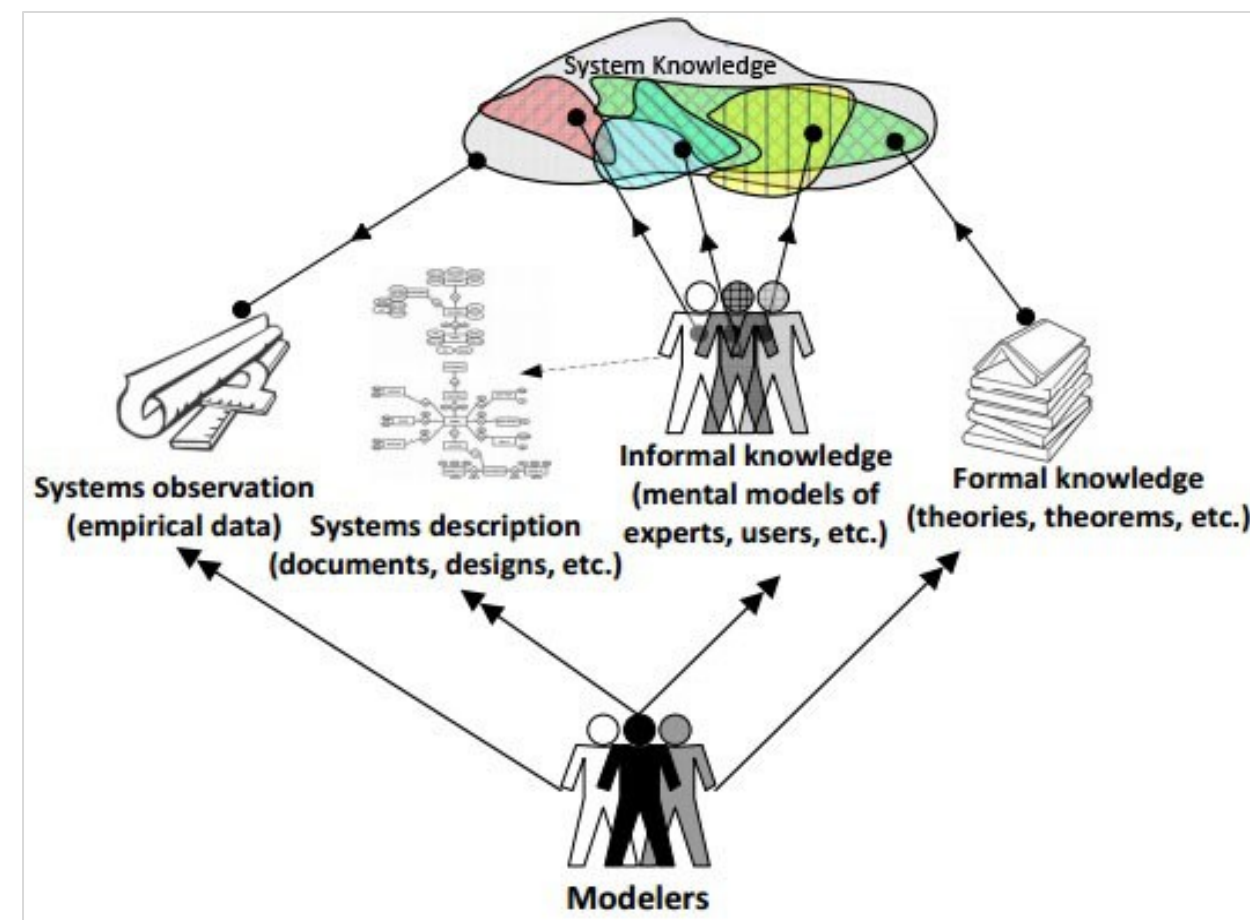
When to Integrate M&S with ML?

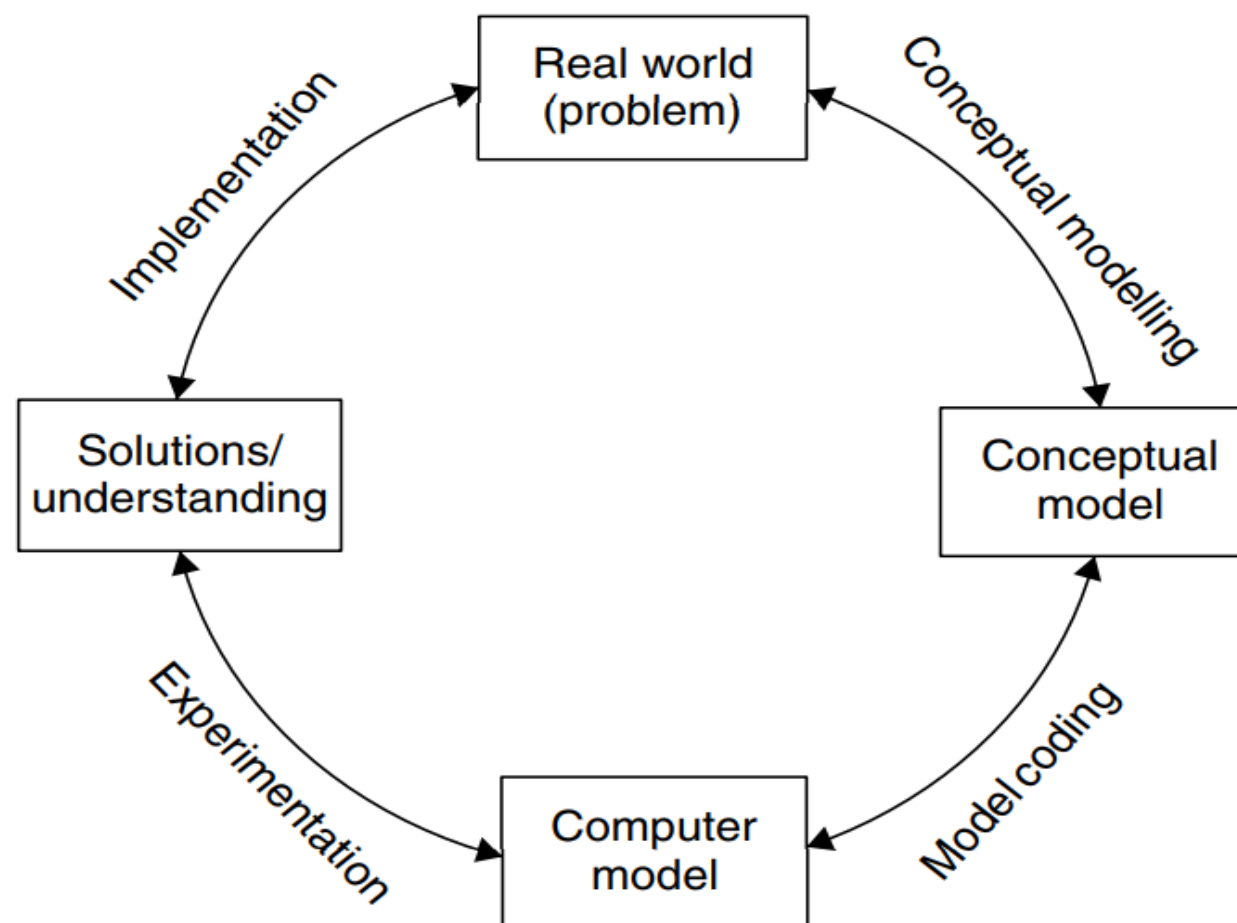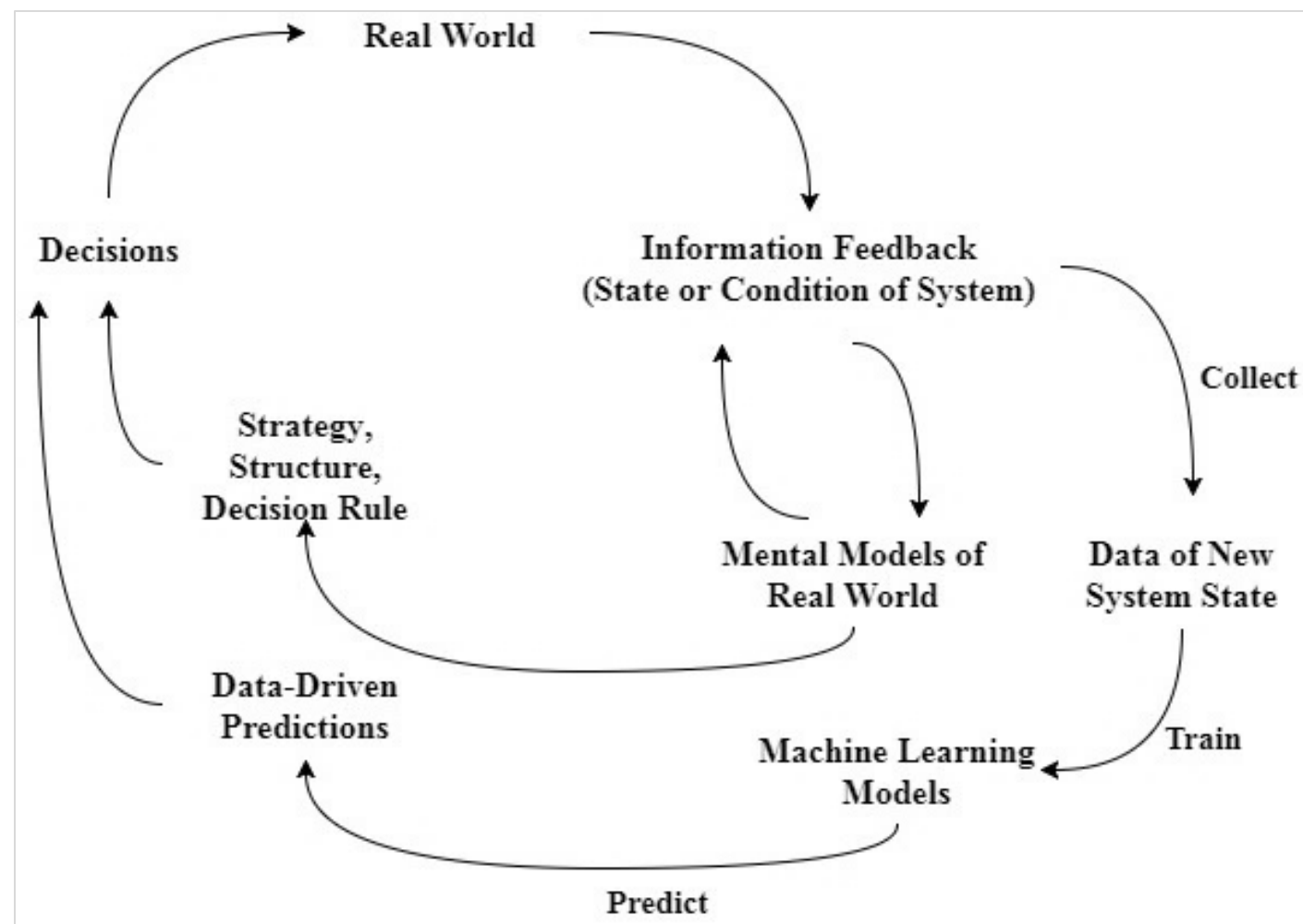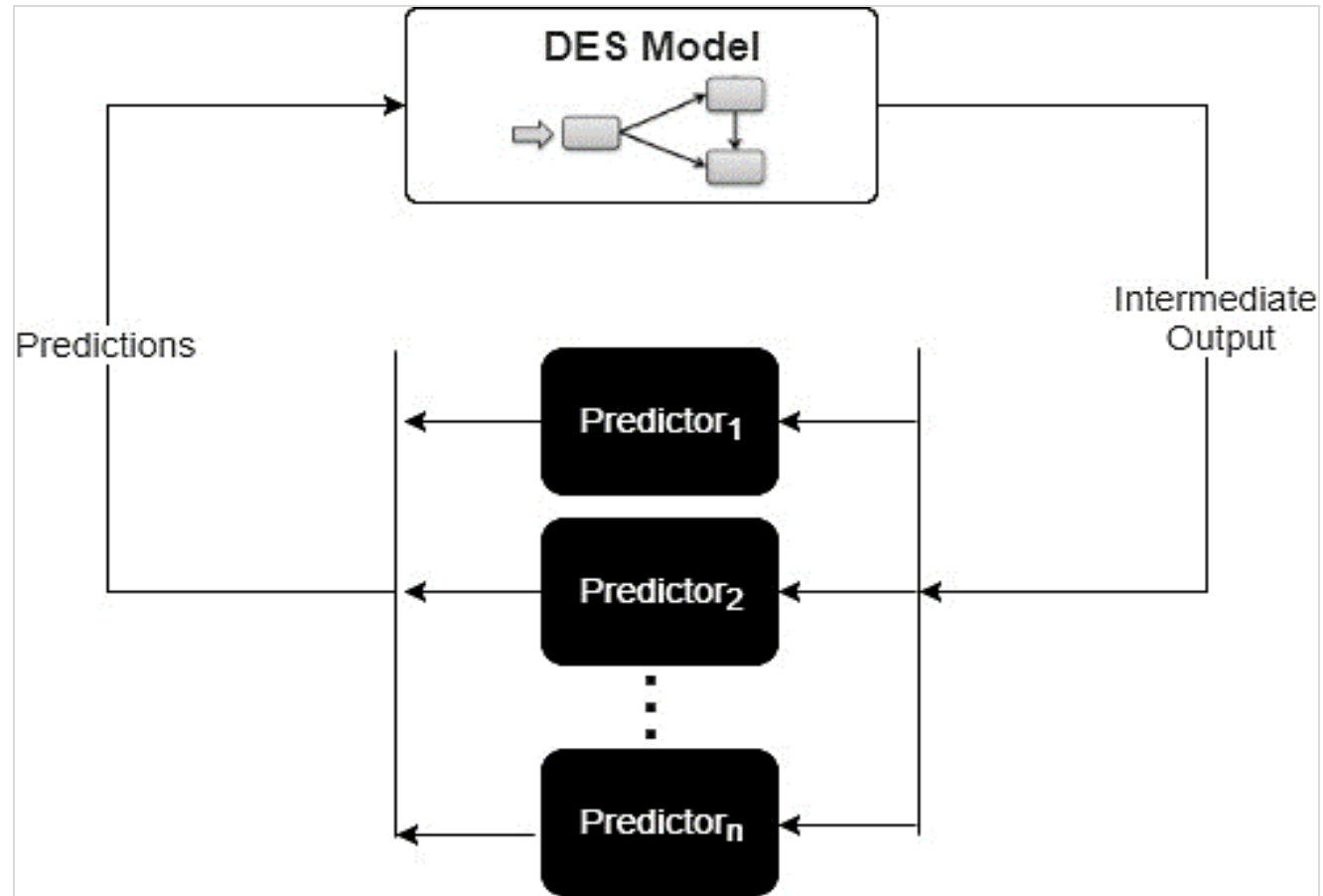Image Source:
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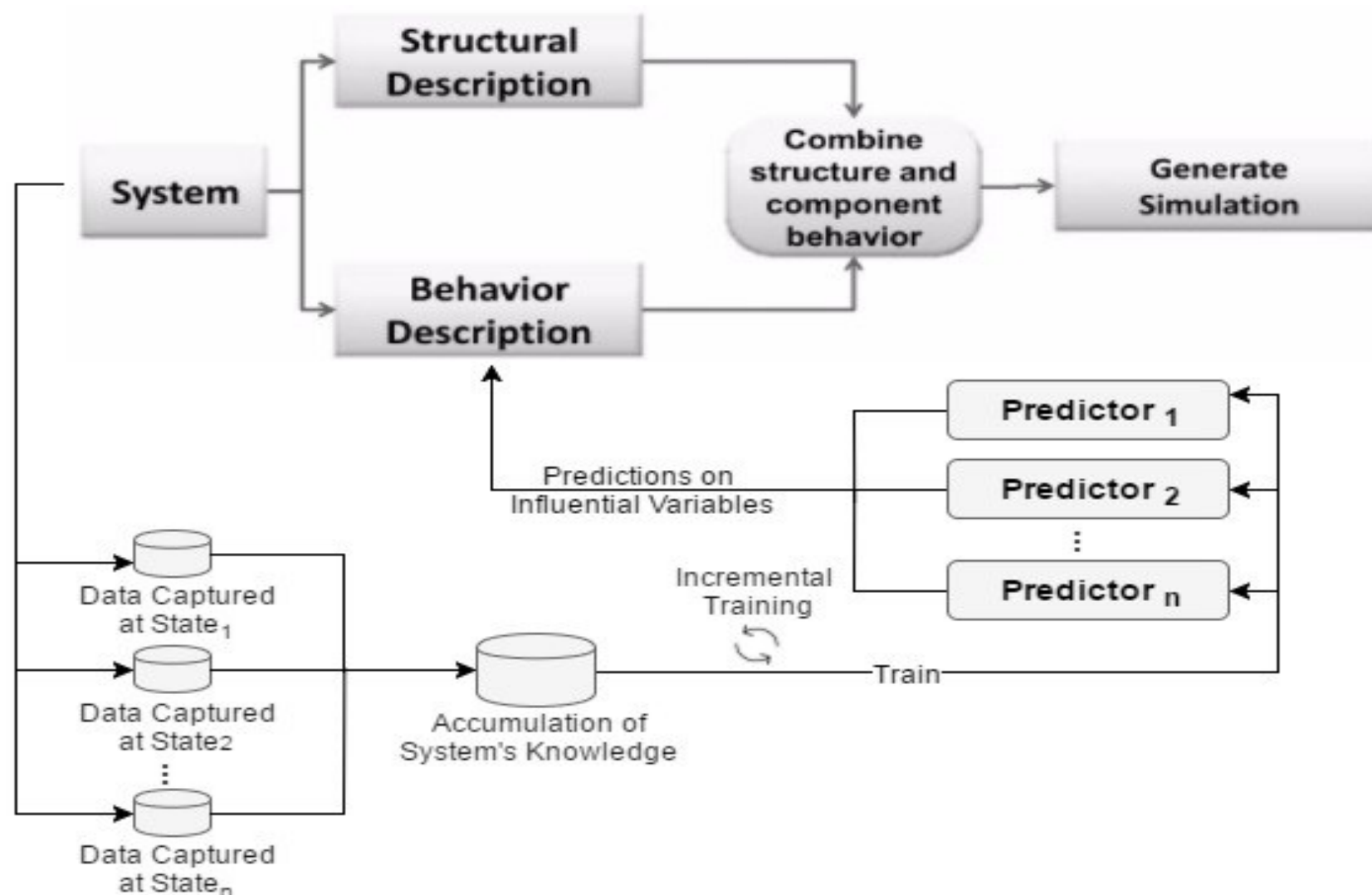
Data-Driven Feedback Loops

Elbattah, M., & Molloy, O. *WinterSim 2017.*

Adaptive Simulation Models

Incremental Learning = Adaptive Behaviour

Elbattah, M., & Molloy, O. (2018). *SIGSIM PADS 2018.*

Modeling Complex Behaviour of Systems

Summary of Review

Source of Studies: WSC, PADS, DS-RT over 2013-2018
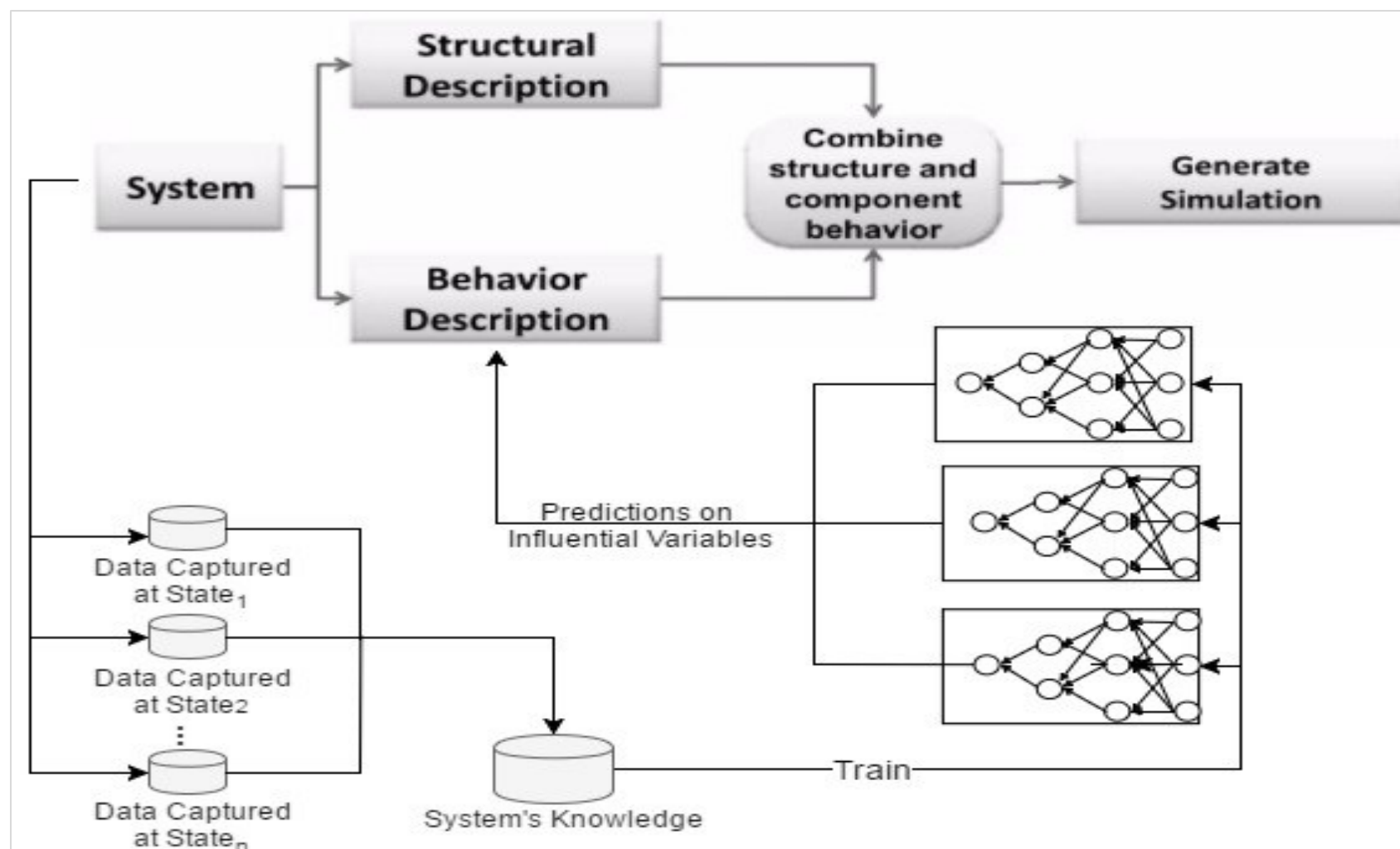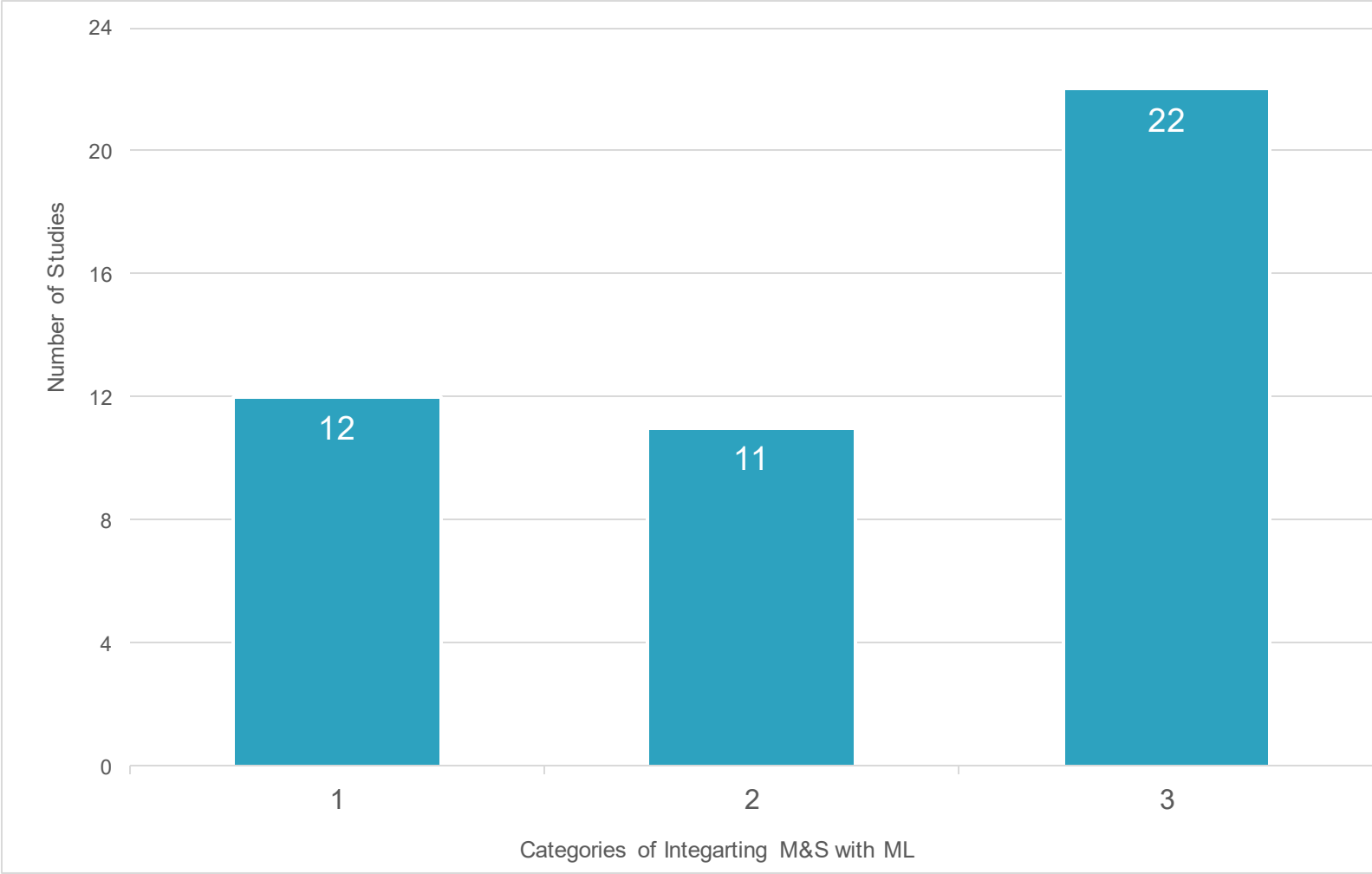
Prospective Questions for Research Directions

Questions	Motivation / Payoffs
Q1. How can ML be employed to assist the conceptualisation of systems or problem formulation?	Taking advantage of ML for the acquisition and utilisation of data-driven knowledge to support the process of learning about systems.
Q2. How to integrate mental models with ML models in a way that supports the learning process to develop based on a more data-driven manner?	Mitigating the limitations of our mental models through relatively less biased reasoning methods.
Q3. How to identify patterns and correlations within systems so that ML can be applicable and useful?	ML can be applicable for learning useful patterns in massive amounts of data, which can describe an important part of the system behaviour.
Q4. Which ML techniques can be appropriate for the perception of structure, or behaviour involved in a problem?	Exploring the possible approaches/methods (e.g. supervised or unsupervised learning) to avail of ML at different stages of M&S.
Q5. How ML be used to inform simulation models about behavioural or structural changes in the actual system with minimal, or perhaps without, human input?	Automating or semi-automating the process of learning about systems through capturing knowledge from data using ML.
Q6. Can the integration with ML lead to a higher level of confidence in simulations given by a more measurable accuracy of ML models?	The predictive accuracy of ML models is robustly measurable. This may in turn extend the confidence in simulation models if designed based on insights learned by ML models.
Q7. Would the well-measurable accuracy of ML models allow for a better representation of the realism of simulation models?	A simulation model may be considered as a closer approximation of reality as the accuracy of assistive ML models continue to increase.
Q8. How sophisticated ML techniques such as Deep Learning be utilised to facilitate the modeling of complex systems?	The multi-layer structure of deep Neural Networks helped represent and tackle hard problems in ML. We generally conceive that they can similarly be utilised to help represent and understand complex systems, which are intrinsically difficult to approach or model.

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THANK YOU!