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Using Information Geometry to Find Simple Models of Complex Processes

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Effective theories play a fundamental role in how we reason about the world. Although real physical processes are very complicated, useful models abstract away the irrelevant degrees of freedom to give parsimonious representations. I use information geometry to construct simplified models for many types of complex systems, such as biology, neuroscience, statistical physics, and complex engineered systems. I interpret a multi-parameter model as a manifold embedded in the space of all possible data, with a metric induced by statistical distance. These manifolds are often bounded and very thin, so they are well-approximated by a low-dimensional, simple model. For many types of models, there is a hierarchy of natural approximations that reside on the manifold's boundary. These approximations are not black-boxes. They remain expressed in terms of the relevant combinations of mechanistic parameters and reflect the physical principles on which the complicated model was built. They can also be constructed in a systematic way using computational differential geometry.