Scales of knowledge

Complex coupled systems arise in medicine, science and engineering. Mathematically, these can be nonlinear coupled systems of PDEs or the nonconvex minimization problems found in deep learning. Progress has been driven by the mathematics of modeling, numerical simulation, data analysis and artificial intelligence, supported with ever increasing computational power. The resulting virtual models – discretized PDEs or trained networks – can be used for simulation, prediction and optimization. Many challenges remain, due to the richness of the systems’ behavior across multiple scales.

In this talk, we show how multi-scale approaches give a mathematical technique for accurate and efficient simulation of complex systems. Using applications from cardiology, geothermal energy, engineering and deep learning, we will illustrate multi-scale decompositions and explain how mathematical ideas from approximation theory, optimization and numerics can also be used to exploit the capacities of modern supercomputers and specialized hardware through efficient parallel methods.

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