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Vision: Digital Twin for Additive Manufacturing

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The simulation of complex multi-physical processes as additive manufacturing (AM) is extremely demanding and time-consuming using conventional numerical methods. Therefore, in engineering often only simplified analytical or empirical models are used. Thanks to advances in machine learning, reliable empirical approaches can increasingly be obtained from big data. However, the generation of big data in additive manufacturing requires complex and expensive sensor technology. In the presence of high speed and large thermal gradients it is sometimes simply not possible to reliably generate certain data, even with the best sensor technology at hand.

It has already been shown that neural networks can also be trained without big data, only on the basis of initial and boundary conditions which are available anyways. These networks make use of the underlying Partial Differential Equation and are known as Physics-Informed Neural Networks (PINN). A recent extension of PINN is the Neural Particle Method (NPM), an accurate and stable meshfree method applicable to free surface, incompressible fluid flow as occurring in metal AM processes [Wessels et al., 2020]. However, this method is not intelligent, i.e. the training only replaces the solution of a system of equations as it is necessary e.g. within Finite Elements. Predictions for the future beyond the trained time step cannot be made.

The talk starts with an overview of numerical simulation for Additive Manufacturing. This is the motivation for the development of the NPM which is presented in detail. Ideas to combine simulation with neural networks on the one hand and data-driven empirical modeling on the other hand in a symbiotic manner will be shared for discussion. The ultimate goal is the generation of reliable models for complex dynamical systems known as digital twins.