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Physically-enhanced data visualisation: towards real time solution of Partial Differential Equations in 3D domains

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Information provided by visualisation environments can be largely increased if the data shown is combined with some relevant physical processes and the used is allowed to interact with those processes. This is particularly interesting in VR environments where the user has a deep interplay with the data.

For example, a geological seismic line in a 3D "cave" shows information of the geological structure of the subsoil. The available information could be enhanced with the thermal state of the region under study, with water-flow patterns in porous rocks or with rock displacements under some stress conditions.

The information added by the physical processes is usually the output of some numerical technique applied to solve a Partial Differential Equation (PDE) that describes the underlying physics. Many techniques are available to obtain numerical solutions of PDE (e.g. Finite Elements, Finite Volumes, Finite Differences, etc). Although, all these traditional techniques require very large computational resources (particularly in 3D), making them useless in a real time visualization environment -such as VR- because the time required to compute a solution is measured in minutes or even in hours.

We present here a novel alternative for the resolution of PDE-based problems that is able to provide a 3D solutions for a very large family of problems in real time. That is, the solution is evaluated in a one thousands of a second, making the solver ideal to be embedded into VR environments.

Based on Model Order Reduction ideas, the proposed technique divides the computational work in to a computationally intensive "offline" phase, that is run only once in a life time, and an "online" phase that allow the real time evaluation of any solution within a family of problems.

Preliminary examples of real time solutions of complex PDE-based problems will be presented, including thermal problems, flow problems, wave problems and some simple coupled problems.