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A Global/Local scheme for problems with steep moving gradients well-suited for reduction strategies

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The aim of this work is to solve parabolic problems with steep moving gradients as those present in Selective Laser Melting in the neighbourhood of the heat source. A naive approach to tackle this kind of problems would be to refine the mesh as much as needed in all the regions of the domain that are in the vicinity of the path of the moving gradient. One alternative is to adaptively refine the mesh following the moving gradient. Despite the fact that both previous options are valid, both are very expensive and they are not so friendly to the formulation of Reduced Order Models (ROMs) because they do not help to tackle the space-time coupling of such problems [1].

The alternative proposed in this work is to adopt a Global/Local scheme, in which a moving local domain with a fine mesh describes the neighbourhood of the moving heat source and a coarse global mesh which describes the analysis domain. The coupling between the local and global domains is based on Lagrange multipliers which are defined only on the boundary of the moving local domain and no-remeshing is involved. The advantage of the proposed strategy is the possibility to reduce both the Degrees of Freedom (DOFs) of the local domain and the Lagrange multipliers DOFs, while exhibiting good robustness to the space-time separability issue.

In some applications, such as in Selective Laser Melting, important material phase changes take place. In a Global/Local scheme this introduces a complication which must be carefully studied. Therefore, another detail to be tackled in this work is the description of material phase changes in the moving local domain. In a series of numerical examples, the performance of the proposed techniques will be shown.

References

[1] Alejandro Cosimo, Alberto Cardona, and Sergio Idelsohn. Improving the k-compressibility of hyper reduced order models with moving sources: Applications to welding and phase change problems. *Computer Methods in Applied Mechanics and Engineering*, 274(0):237 – 263, 2014.