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A NEW CONTACT METHOD BASED ON A CONTACT DOMAIN

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ABSTRACT

Although the Particle Finite Element Method (PFEM) originally was introduced to analyse fluid mechanical problems ([1],[2]), it has been shown recently that this method represents a very powerful tool to tackle specific solid mechanical problems as well [3]. Applications of interest are for example metal forming, machining or manufacturing processes involving large deformations, multiple contacts and even the generation of new boundaries. One main task for establishing a robust solution method is an appropriate description of contact phenomena including friction and possible self-contact. This work presents a general theoretical framework as well as a suitable discretization strategy of a newly developed contact method based on a contact domain.

One of the main features working with the PFEM is the necessity of frequently remeshing the introduced particles, which are actually represented by the finite element nodes. The boundary detection which is necessary for the generation of the mesh is done utilizing the Alpha-Shape Method ([4],[5]). Having these utensils at hand, it seems quite natural to use the remeshing algorithm to construct an additional mesh between two domain boundaries, which might come into contact [3]. This additional domain, constructed between the possible contact boundaries, will be denoted as the contact domain.

In contrast to many existing contact descriptions, the formulation of the required contact constraints will not be done projecting one contact boundary onto the other, but using the whole contact domain, which has the same dimension as the contacting bodies. Lagrange Multipliers are introduced to represent the contact normal and tangential stresses within the contact domain. As the basis for the discretization with finite elements an appropriate weak form of the boundary value problem is introduced.

The discretization of this weak form finally leads to a classical Lagrange Multiplier Method type system of equations. Knowing that this might lead to problems in the solvability of the system, an additional, consistent stability term is introduced via an internal penalty parameter. This leads to a well posed system of equations which allows

for elimination of the introduced Lagrange Multipliers performing a static condensation.

The main properties of the introduced contact domain method can be summarized as follows:

- It can be easily implemented
- The computational cost is very low, as the contact-stiffness contributions can be computed locally for every contact-domain element
- The area of application is not limited to PFEM but can be utilized with any other discretization strategy

Various examples are presented to demonstrate the performance and the robustness of the developed contact domain method.

REFERENCES

[1] E. Oñate, S. Idelsohn, O.C. Zienkiewicz and R.L. Taylor, "A finite point method in computational mechanics. Applications to convective transport and fluid flow", *International Journal for Numerical Methods in Engineering*, Vol. **39**, pp. 3839–3866, (1996).

[2] E. Oñate and S. Idelsohn, "A mesh-free finite point method for advective-diffusive transport and fluid flow problems", *Computational Mechanics*, Vol. **21**, pp. 283–292, (1998).

[3] J. Oliver, J.C. Cante, R. Weyler, C. González and J. Hernandez, "Particle finite element methods in solid mechanics problems", in (E. Oñate, R. Owen, eds.): *Computational Plasticity (Computational Methods in Applied Sciences)*, Vol. 7, Springer-Verlag, 2007.

[4] N. Calvo, S. Idelsohn and E. Oñate, "The extended Delaunay tessellation", *Engineering Computations*, Vol. **20**, pp. 583–600, (2003).

[5] X.L. Xu and K. Harada, "Automatic surface reconstruction with alpha-shape method", *Visual Computer*, Vol. **19**, pp. 431–443, (2003).