The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

The Feel++ software: automation, code generation, applications

Christophe Prud'homme[1], Joubine Aghili[1], Luca Berti[1], Vincent Chabannes[1], Zohra Djatouti[1], Romain Hild[1], Thibaut Métivet[2], Philippe Ricka, Thomas Saigre-Tardif[1], Abdoulaye Samaké[3], Marcela Szopos[4] and Christophe Trophime[5]

[1] Université de Strasbourg, CNRS, IRMA UMR 7501, Cemosis, F-67000 Strasbourg, France, contact:`christophe.prudhomme@cemosis.fr`, `https://www.cemosis.fr`
[2] Inria Grenoble - Rhône-Alpes, LJK - Laboratoire Jean Kuntzmann
[3] Université des Sciences, des Techniques et des Technologies de Bamako, BPE 423, Bamako, Mali
[4] MAP5 UMR CNRS 8145, Université de Paris, Paris 75006, France
[5] LNCMI-EMFL, CNRS, Univ. Grenoble Alpes, INSA-T, UPS, F-38042 Grenoble, France

Keywords: *Feel++, Multiphysics toolboxes, automatic differentiation, Hybridized Discontinuous Galerkin methods, Hybrid High Order methods*

Feel++ is a Finite Element method Embedded Language written in C++ [1] to solve partial differential equations using standard Galerkin methods. Feel++ provides a mathematical kernel that encompasses a broad range of numerical methods such as (i) arbitrary order continuous and discontinuous Galerkin methods in 1D, 2D, and 3D, (ii) domain decomposition methods, (iii) fictitious domain methods, (iv) level-set methods and (v) reduced-order methods.

Feel++ enjoys a set of mono and multiphysics toolboxes — CFD, CFD, heat, heat fluid, thermoelectric and FSI — with a rich set of features. The latest toolbox addition is the coefficient form PDE toolbox that allows to solve an arbitrary number of possibly coupled linear and non-linear PDE from 0D+t to 3D with or without time dependency.

The enabler for the generic toolbox and flexible setup for the toolboxes in general is a new expression handling allowing for automatic differentiation in our C++ code. Other features include seamless parallelism in the C++ and Python interfaces and an API that allows to create new applications.

We have also added the support for advanced numerical methods such as Hybridized Discontinuous Galerkin methods (HDG) — in the context of multiscale in space and time coupling [2] — and Hybrid High Order methods (HHO) [3].

In this talk, we present a general overview of the Feel++ framework with a focus on a few recent features and illustrate with examples and advanced applications.

REFERENCES

[1] `http://www.feelpp.org`, `http://www.github.com/feelpp/feelpp`

[2] A HDG method for elliptic problems with integral boundary condition: Theory and Applications, S. Bertoluzza, G Guidoboni, R. Hild, D. Prada, C Prud'homme, R. Sacco, L. Sala, M. Szopos, Submitted, 2022

[3] Bridging the hybrid high-order and hybridizable discontinuous Galerkin methods, B Cockburn, D. A. Di Pietro and A. Ern, ESAIM: M2AN 50 (2016) 635-650, DOI: 10.1051/m2an/2015051