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ModFEM code development 2015/2016

Target

- Working versions of the code for:
 - NS_SUPG/heat (welding?, cooling?)
 - parallel with message passing (KM, KC)
 - hybrid mesh + remesh stubs (KM ???)
 - MKB with LAD_BCRS (KC ???)
 - free surface, mass transport – sequential (PC ???)
 - VOF (AS ???)
 - parallel free surface, mass transport (PC - ???????)
 - internal boundaries (PC ??? - paper)
 - turbulence (PC ???)
 - phase transition !!! (AS)
 - new preconditioner (KB, KC)
 - suite of examples/tests (PC, AS, KC, KM, JB)

Target

- **Working versions of the code:**
 - **plast_flow + heat**
 - **formulation (AS), mixed approximation (AS+JB)**
 - **traction boundary conditions (AS)**
 - **GUI (ŁR)**
 - **Importing files (KM)**
 - **Parallel versions**
 - **Shared memory (OpenMP, OpenCL? - KC, JB, FK)**
 - **Distributed memory (KM)**
 - **Massively multi-threaded (OpenCL, CUDA? - KC, JB, FK)**
 - **Exporting files (KM) + parallel checkpoint-restart**
 - **Visualization (PM)**
 - **Adaptivity (with remeshing)**

Target

- **Solver (KC, JB):**
 - **renumbering for:**
 - **parallel solution (MPI+OpenMP+OpenCL)**
 - **NS_SUPG and plast_flow preconditioner**
 - **assembly (and integration) with colouring and assembly tables (OpenMP+OpenCL, first order, second order)**
 - **multithreading with OpenMP**
 - **OpenCL, CUDA**
 - **direct solvers interacting with the iterative solver**
 - **multi-GPU cluster solution for coupled problems**

Publikacje, popularyzacja, itp.

- **Konferencje, publikacje, koła naukowe, raporty:**
 - **wyniki PHI, Xeon – OpenMP versus OpenCL - FK**
 - **wyniki GPU – shared memory + OpenCL – FK, JB**
 - **ns_supg + turbulencja – PC**
 - **ns_supg/heat + warunki kontaktu – PC**
 - **plast_flow – mixed versus stabilized formulations – AS**
 - **ns_supg/heat - scalability study for hybrid meshes – KM**
 - **ns_supg/heat – load balancing for hybrid meshes – KM**
 - **assembling for hp adaptivity, etc. - KC**
 - **integration for heat + ns_supg on GPU – JB**
 - **integration for 2nd order approximation on GPU – JB**
 - **assembly on GPU and multi-GPU – JB, KC**
 - **amg with mkb - DG**

Doktoraty - KM

- Working version MPI-OpenMP
- Analysis OpenMP with SIMD directives
 - profiles
- Final redaction
- -----
- Parallel input-output (checkpoint-restart)
- Parallel visualization
- Interakcja z pakietem/ami Open Source
- Adaptacja plast_flow (remeshing)

Doktoraty - PM

- Tests
- Final redaction

Doktoraty - PC

- Testy ns_supg+heat
 - Testy ns_supg+heat+ALE
 - Ostateczna redakcja
-
- Publikacje, raporty na podstawie testów – Innolot
 - Turbulencja
 - Warunek brzegowy kontaktu (poprawny!)

Doktoraty FK

- infrastruktura OpenCL
 - numerical integration: CPU, GPU, PHI
 - numerical integration: prisms, tetra
- auto-tuning
- OpenMP 4.0
 - infrastruktura
 - całkowanie numeryczne (CPU, GPU, PHI)
- ostateczna redakcja

- std_lin - szacowanie błędu (ZZ) na GPU
- std_lin - projekcja (proj_sol_lev) na CPU

Doktoraty - KC

- assembling – CRS, Ellpack(?) (CPU, GPU)
- multi-grid solver (CPU, GPU)
 - SpMV
 - GS iterations
 - ILU(0) iterations
 - projections (prolongation, restriction)
- MPI-OpenMP-OpenCL implementation!!!
- ctests
 - maintenance
 - extensions
 - documentation

Doktoraty - JB

- assembling 2nd_order (CPU, GPU)
- plast_flow – mixed formulation
- numerical integration 2nd_order
 - 1-entry – 1-thread
 - tetra, prisms
 - OpenCL (CPU, GPU, PHI), CUDA?
- error estimation 2nd_order (CPU, GPU)
- ns_supg+heat – 2nd_order (CPU, GPU)
- cmake
 - extensions
 - documentation

- contact boundary condition
- reading/importing from commercial formats
 - WSK – Ansys + contact BC (II 2015)
 - documentation, examples (10^6 elements)
- integration with Open Source external packages
 - gmsh?, netgen?, tetgen? (spring?)
 - <http://www.robertschneiders.de/meshgeneration//software.html>
- documentation (theory manual, user's guide) (summer)
- integration with PC code (summer?)
 - industrial strength version (max 10 buttons)
 - export in ModFEM format (checkpoint-restart)
- parallel checkpoint-restart (autumn)
- dynamic load balancing (2016)

Aproximation

- Linear approximation
 - error estimation (ZZ)
 - OpenMP – II 2015
 - projections (prolongation, restriction)
 - OpenMP – III 2015
 - OpenCL(?) - IV 2015
- Quadratic approximation
 - error estimation (ZZ)
 - OpenMP - 2016
 - projections (prolongation, restriction)
 - OpenMP -
 - OpenCL(?)

- wersja OpenMP
 - CRS, block_CRS – BLAS, ILU(0), GS - (II-III)
- OpenCL (spring)
 - CRS, ELLPACK, other? (spring)
 - ♦ assembling
 - ♦ BLAS, ILU(0), GS
- geometric multigrid - OpenMP
 - prolongation and restriction from approximation
 - system matrix from integration on coarse elements
 - example case: heat equation, ns_supg
- preconditioning ns_supg (summer)
- PARDISO interface (autumn)

- algebraic multigrid
 - grid coarsening algorithms
 - prolongation, restriction
 - Galerkin projection
 - generic interface
 - interaction with external software (e.g. MP solver)
 - interaction with FEM codes (ModFEM)
 - interface with BLAS for MKIS
 - example cases:
 - heat
 - ns_supg
 - ns_supg_heat

Problem modules

- Documentation (WSK):
 - `ns_supg`, `heat`, `ns_supg_heat`
- Test OpenCL
 - `heat`
 - `ns_supg`
 - `ns_supg_heat`
- New problem module for “coupled thermo-mechanical finite element formulation for incompressible plastic material”

Execution environment

- SVN, CMake
 - MPI + OpenMP
 - MPI + OpenMP + OpenCL
 - manuals
- Scripts
 - MPI
 - OpenCL

Examples and tests

- Coverage:
 - mesh management (parallel with load balancing)
 - approximation: DG, std, quad
 - ♦ convergence
 - ♦ constrained (R, 100, S)
 - adaptivity: error estimation, strategies
 - time integration: Euler, Crank-Nicholson, time-step adaptivity, local time-stepping
 - non-linear solver: strategies
 - linear equations solver: solvers, preconditioners, strategies, run-time configuration
 - problems:
 - ♦ conv-diff, heat, ns_supg, ns_supg_heat
 - ♦ plasticity