

Minutes of
AD2CompEng: Automatic Differentiation and Adjoint
Applied to Computational Engineering
2nd Progress Meeting
Stephenson Room
RMCS Shrivenham

Shaun Forth

23rd June 2005

Present

- Cranfield University: Shaun Forth, Mohamed Tadjouddine, John Pryce, Rahul Kharche
- Southampton University: Alex Forrester
- Sheffield University: Ning Qin, Alan Le Moigne, Hao Xia
- Cambridge University: David Radford

Apologies

- Southampton University: Andy Keane
- Oxford University: Mike Giles
- Rolls-Royce: Leigh Lapworth
- Airbus UK: Stefano Tursi, Murray Cross

Minutes of Last Meeting

The minutes of the 14th May 2004 meeting were accepted as accurate.

Matters Arising

2(a): Mohamed Tadjouddine- exploiting Hermitian property of BEAM3D matrix. After checking the original code Andy Keane had acknowledged that the matrix concerned was not Hermitian and so no further action is required.

2: Shaun Forth - draft guidelines for application programmers - ongoing.

3(b): Several actions:

- Mohamed Tadjouddine - makefile and instructions for BEAM3D differentiation were sent to Southampton towards the end of May 2005.

- Mohamed Tadjouddine - strip out options in differentiated code - done and revised code sent to Southampton. Alex Forrester commented that he preferred the version with options.
 - Andy Keane - compare adjoint vs FD performance -
- 6: Shaun Forth - obtain HYDRA license and meet Oxford/Cambridge team and review differentiation. Meeting at Oxford on November 8th 2004 with Mike Giles and team + David Radford. Mike's team making good progress in using Tapenade to automate adjoining HYDRA's flux, source and boundary condition routines. Shaun and Mohamed gave advice on reducing tape operations by eliminating overwriting of variables. Mike felt it unnecessary for Shaun and Mohamed to apply Tapenade themselves and would contact them if further advice/support needed. This effectively deletes Phase 2 from the scope of the project.
 - 7: Shaun Forth, Mohamed Tadjouddine to visit Ning Qin, Alan LeMoigne to revise Phase 3 plan. At the meeting on May 27th 2004 it was agreed to pursue differentiation of DGrins2D, a 2-D time-dependent finite-volume ALE code written by Ning's PhD student Hao Xia. The time-dependent nature of the calculations would allow for checkpointing issues to be explored and the resulting adjoint code could be used by Ning's team within synthetic jet optimal design studies.
 - 8: Shaun Forth & Mohamed Tadjouddine - review introductory AD documents. None are really viewed as suitable for an engineer with standard computational background. Shaun will start drafting an introductory article based around relevant engineering problems.

Minutes

1. Shaun Forth reviewed progress (slides attached) on the AD2CompEng project. He pointed out that Mike Giles's Oxford team no longer felt it necessary for Shaun or Mohamed to pursue differentiation of the HYDRA code. In effect the slow start to the project caused by delays in appointment of a research office and the unsuitability and ultimate resignation of Dia Zeidan had given Oxford's team sufficient time to gain confidence with Tapenade that, apart from advice, they no longer required a large input from Shaun or Mohamed. Shaun explained the change of CFD code to be investigated in Phase 3 was to be DGrins2D in the light of changes of University and interests of Ning Qin. The code would give similar opportunities for investigating adjoints of time-dependent problems as offered by the originally proposed IMPNS solver.
2. Mohamed Tadjouddine reviewed progress (slides attached) on the differentiation of DGrins2D. In particular, he explained how the code had been "cleaned" prior to differentiation to remove both nonstandard Fortran constructs and constructs not differentiable by the current version of Tapenade. He also pointed out how subtle changes to the nonlinear code could dramatically reduce the number of variables saved to tape by Tapenade and hence improve efficiency. Shaun explained how a simple geometry definition module had been developed and could be used within geometric design. Hao Xia pointed out some inconsistencies in the code timings and Ning Qin expressed concern about discrepancies between optima found using FD and AD in a proof-of-concept optimization.
ACTION Mohamed Tadjouddine resolve timing and optima inconsistencies.
3. Alex Forrester (slides attached) outlined some issues in robust design and how S'ton were using AD gradients within a scheme aimed at reducing the standard deviation of a component's performance when subject to variability in manufacture. Alex also presented some initial work in geometry repair after an optimization process produced an unmanufacturable design. This work was implemented in MATLAB making use of Shaun's MAD package. Upcoming work on active vibration control would require differentiation of MATLAB code

which makes use of complex arithmetic.

ACTION Shaun Forth - extend MAD to handle complex arithmetic.

4. Hao Xia presented recent work on simulation of synthetic jets in both 2 and 3D. The 3D calculations were very expensive and required significant parallel computation facilities. Some of the 2D calculations were agreed to be suitable for 2D geometric design optimisation.

ACTION Shaun Forth/Mohamed Tadjouddine/Hao Xia/Ning Qin - liaise on 2D optimisation problems.

5. Alan LeMoigne presented some recent optimisations of bump geometries used to reduce shock strengths on transonic airfoils via the Sheffield/Cranfield MERLIN CFD solver. Current adjoint design capabilities are limited by the requirement to use the structured mesh variant of the code for which Alan has hand-coded the adjoint. Ning Qin was keen to see an adjoint capability for MERLIN's steady unstructured mesh solver developed.

ACTION Ning Qin - arrange of release of MERLIN to Shaun/Mohamed to enable assessment of whether its unstructured mesh adjoint development could replace that of Phase 3's HYDRA.

ACTION Shaun Forth/Ning Qin arrange meeting at Sheffield to review MERLIN and DGrins2D work.

Date of Next Meeting

It was agreed to meet at least once more before the project end, possibly in December or early 2006.

ACTION Shaun Forth - arrange final project meeting.