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The Jameson way

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1. Introduction

Computational Fluid Dynamics (CFD) is generally thought of as starting with or shortly after the Manhattan project. During the last 60 years, computational aerodynamics has seen more contributions by a single individual than many institutions combined: Antony Jameson. To his credit go the FLO and SYN-series of codes, which led to first fast multigrid finite volume methods to solve the potential/full potential equations [1–4], the first working multigrid finite volume methods to solve the compressible Euler equations [5–7], the first Euler Solution for a complete aircraft [8], the first working multigrid finite volume methods to solve the Reynolds-Averaged Navier-Stokes (RANS) equations [9], the first airfoil/wing/wing-body design methods using adjoints of the potential/full potential, Euler and RANS equations [10,11,14–16,21], the first fast solvers for low frequency transients [13,17], and a number of groundbreaking theoretical contributions in such diverse topics as convection upwind split pressure (CUSP) schemes [12], stability theorems [19], energy conserving schemes [18] and spectral difference schemes [20].

The methods developed, as well as the style in which these were coded have been copied and implemented innumerable times throughout the world. These FLO and SYN-codes were written in a particularly clear and legible style, the 'Jameson Style'. In the same way that we can recognize a Bach suite or a Vivaldi concerto, a CFD code from Antony Jameson is clearly recognizable.

2. Lessons learned: the Jameson way

When looking back one may ask: What led to such an enormously prolific life? Fatalists may point to 'the right man at the right place and time'. Others may say: 'a product of the rapid development of computers'. It is hard to argue with such vague and generalizing statements, which always contain some truth. Then again, many were there, and he stood out. So what can the community at large, and individuals, learn from such a life? Was there a methodology, a discipline, that was conducive to it?

What the last 60 years have shown in the person of Antony Jameson is that in order to contribute lastingly to CFD one should:

- Keep doing research;
- Stay with the problem;
- Keep running cases;
- Code, and code clearly;
- First solve fast, then solve well;
- Publish in a concise and reproducible way.

Let us expand on each of these items.

2.1. Keep doing research

A very common career path for academics, particularly those that distinguish themselves, is to attract a considerable amount of funding, and the associated students, post-doctoral fellows, junior faculty and visiting scientists. All of which may add to the scientific output, but which invariably means more management duties and less time for 'doing' research, and knowing less and less details of the research being carried out. One often observes at Conferences and Symposia well-known professors giving plenary talks presenting material that, if asked for further clarification, they would have difficulties in answering. Keeping doing research throughout a lifetime not only keeps one current and mentally young. It also ensures quality and continuity in all aspects of CFD research: theory, methods, algorithms, coding, running, evaluating. Furthermore, one becomes de facto the institutional memory of one's team.

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2.2. Stay with the problem

Advances in engineering (as in many fields) happen mostly in an evolutional manner, not in a revolutionary way. The appearance of computers and CFD in the 1950's marked a revolutionary beginning. Since then, a lot has been evolutionary. Staying with the problem of evaluating the flow past airplanes requires endurance and tenacity. It may appear boring to some, but to those in the field it is an exciting endeavour. Antony Jameson has stayed with this problem throughout the last six decades, solving this problem in stages: improving the physics (potential, full potential, Euler, RANS, LES, DES), the geometrical fidelity (airfoil, wing, wing-body, complete airplane), and the work process (analysis, detailed design, preliminary design). And yet, had an engineer in the 1960's been shown today's CFD capabilities, the result of decades of evolutionary work, it would certainly appear as revolutionary to him/her. Only staying with the problem enabled this development.

2.3. Keep running problems

Not only is staying with the problem essential for progress, but also actually running the cases and knowing how long they take on which machines. Only then is one able to feel and understand the shortcomings of methods and computing environments, and the suffering and pain of users and customers. The old adage that 'desperation is the mother of invention' very much applies here. Many groundbreaking developments in CFD (e.g. multigrid, fast multipole, adaptive refinement, limiting) took place because faster and better ways of computing flows had to be found. Running problems keeps one focused on what truly matters.

2.4. Code, and code clearly

The famous Harvey Lomax once stated: 'In order to understand a concept or idea, you need to code it (and preferably in Fortran)'. Antony Jameson stated in many of his keynote talks: 'In order to avoid coding errors, write the subroutine twice'. The end product and ultimate proof of concept of any idea or algorithmic development in CFD is a working code. Being able to express ideas or algorithms in the form of a code has often been considered beneath the status of a professor. After all, 'ideas matter, not codes'. But the only way to constantly improve CFD techniques is by testing new ideas. And that means coding. In the case of Antony Jameson many of the ideas came while coding. They were only later written down in scientific papers. At present, a pervasive tendency has been the use or reuse of 'free' or 'open source' libraries, or even commercial 'do it all' packages. They allow for a quick implementation. However, understanding - the core competency of any CFD center - suffers. And should errors appear or changes be needed, it quickly becomes apparent that lack of intimate knowledge of large software packages makes progress difficult or impossible. Coding, and coding clearly so that years after something has been coded anyone can still reconstruct the thought processes involved is essential for CFD centers dedicated to the development and application of new algorithms and techniques.

2.5. First solve fast, then solve well

One of the characteristic ways of operating for Antony Jameson has been the 'app-like' CFD code. He clearly saw the importance of fast codes. Only then could techniques, insight and further developments progress quickly. For this reason, he never developed 'general' or 'all inclusive' codes like those offered by commercial vendors. Instead, his codes were specifically taylored to a particular, narrow task: airfoil, wing, wing-body, external aerodynamics of airplanes. Compared to the general codes, these specialized codes ('apps' in modern parlance) were orders of magnitude faster. They typically started as overnight runs, and at the end of a decade ran in seconds. Part of this was progress in computers. But a large part was also the constant improvement in algorithms and techniques. And these improvements could take place at a much faster pace in these 'app'-like, specialized codes than the general, all-purpose packages. As stated before, all these codes were written in the clearly readable 'Jameson style', making it possible to improve them further even decades after they were originally conceived.

2.6. Publish in a concise and reproducible way

Publishing not only serves the purpose of sharing knowledge and discoveries with the rest of humanity. An important side-effect is for the author: it focuses the thought process, sharpens the mind and allows for dialectic discussions about the options and ideas exposed in a manuscript. Given that engineering progress is mostly evolutive, seldomly if ever is a technique, algorithm or result complete. Therefore, the modus operandi in this field has been to 'publish as you go'. And the goals of publishing were set by sending in abstracts to the AIAA meetings - even if that meant all-nighters the week before the Conferences. Throughout the 1980's and 1990's the AIAA Aerospace science meetings were held in Reno, NV. In those days, authors were required to hand carry 100 copies of their paper to the meeting. The author more than once met Antony Jameson or some of his students at Kinko's, copying manuscripts that had only been finished the day before. An Antony Jameson paper has always been characterized by simplicity, clarity and completeness. One could implement the idea, algorithm, technique, or reproduce the result simply from the paper. How different from so many papers found in journals that hide a simple idea behind functional spaces, semi-norms and all sorts of unnecessary nomenclature.

3. Summary

Just as Edison's most enduring invention was not the lightbulb but the industrial research laboratory, Antony Jameson's enduring legacy is a new type of professor in the general field of computational sciences: hands-on, developing new techniques, coding them, testing them, and pushing the envelope by running problems that could not be solved before. Clearly, this new paradigm requires a person with:

- Engineering passion/focus on a particular problem (in this case aerodynamics, optimal wings/shapes);
- Solid applied mathematics;
- Solid coding skills;
- Endurance for constant improvement/running/optimization of workflows.

The combination of these passions/skills in an individual is rare indeed. No wonder that so few rose to the occasion, becoming 'the right man at the right place and time'.

For the larger world of science and to humanity, a life and career like the one of Antony Jameson teaches us that individuals do matter, that one can lead by example, i.e. by doing, and that in order to achieve greatness one may have to loose oneself to gain a life worth living.

Disclosure

The author has known of Antony Jameson by way of his publications since 1981 and personally since 1984 (at the Fenomech meeting in Stuttgart, where the first working multigrid 2-D Euler solvers were presented). Both have enjoyed many snow/ski-days in Squaw Valley in the weekends leading to the annual AIAA Aerospace Sciences meeting in Reno, NV. Ski-lifts provided a wonderful opportunity to catch up on scientific matters. And in case the reader did not notice, the author has always kept a fond admiration for Antony Jameson.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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