UKAN Computational Acoustics Survey 2019

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1. Introduction

The survey was sent to all members of UKAN within April & May (2019) newsletters by the Computational Acoustics Special Interest Group (SIG). The newsletters included the following introductory text: *"The survey asks about what you do, your company/employer, your skills and some particular questions around your use of software."* The survey had 58 responses, indicating a 9.6% return rate (based on UKAN having 606 members as of the April 2019 newsletter).

The purpose of the survey was to determine the existing software expertise, and particularly the related needs and challenges within the UKAN community.

The text of the questions can be found in the Appendix.

2. Results

2.1 Demographics

The first four survey questions sought to determine the demographics of the respondents. Questions 1-3 cover whether respondents work in academia, consulting or a commercial setting; on what basis they are employed; and how long they have worked in acoustics. Results are reported in Figure 1.

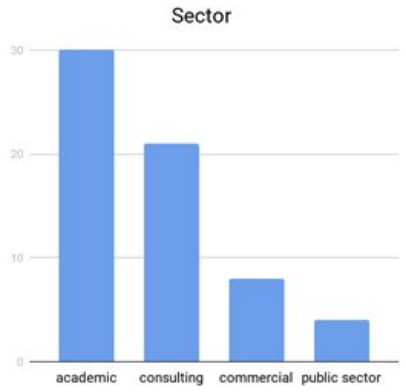

Figure 1(a). Responses to Q1: *What sector do you consider yourself to work in?*

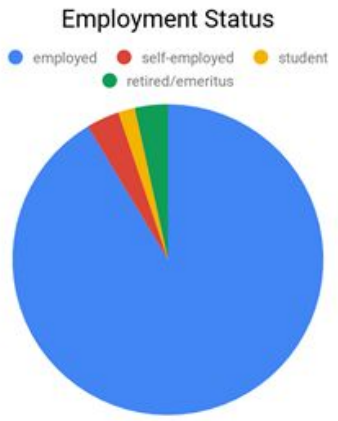

Figure 1(b). Responses to Q2: *Please tell us about your role.*

Figure 1(c). Responses to Q3: *How long have you worked in acoustics (excluding undergraduate study)?*

Question 4 asks respondents what area(s) they work in within the broad field of acoustics, with Question 5 narrowing this down to ask in what application areas the participants use computational methods, the particular focus of the questionnaire. Responses to Q5 are reported in Figure 2.

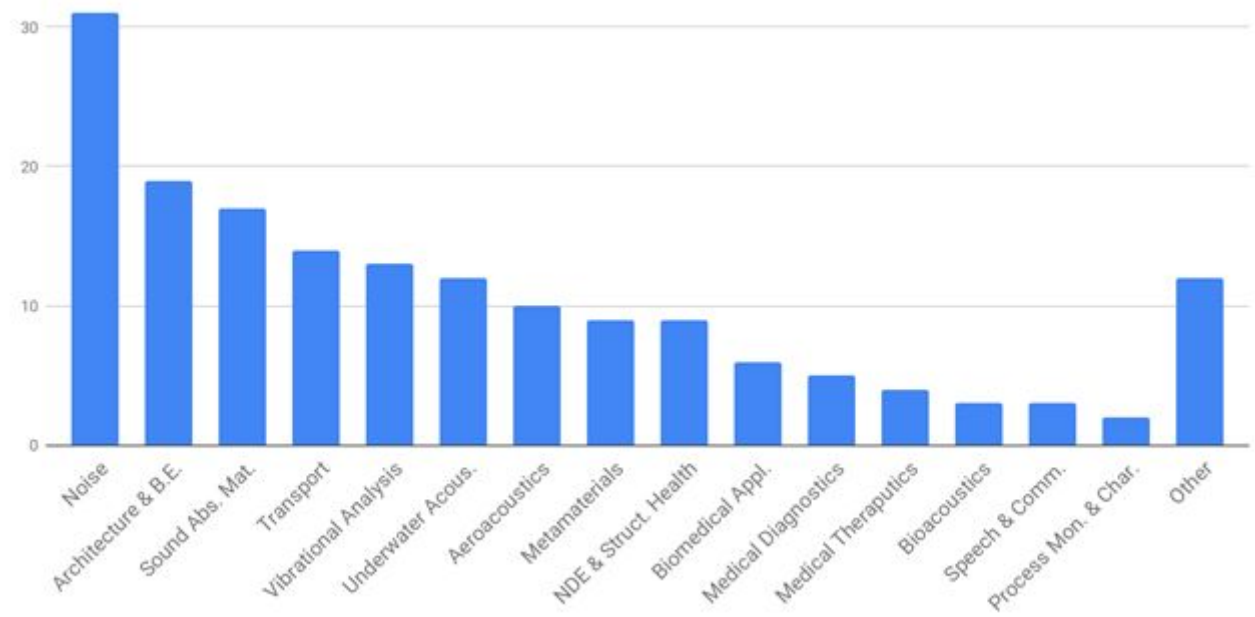

Figure 2. Responses to Q5: *In what application areas do you use computational methods in acoustics?*

The responses to the demographic questions indicate that a broad range of participants completed the survey, with approximately half being academics, and a wide range of experience levels being represented. Similarly, a wide range of application areas are represented, with a majority of respondents selecting multiple options for this question.

2.2 Software

The next part of the questionnaire sought to determine the existing software usage in the community. This was achieved by asking Questions 6, 7 and 10: what broad computational techniques respondents use; what form this software takes; and the specific software packages used and their associated challenges.

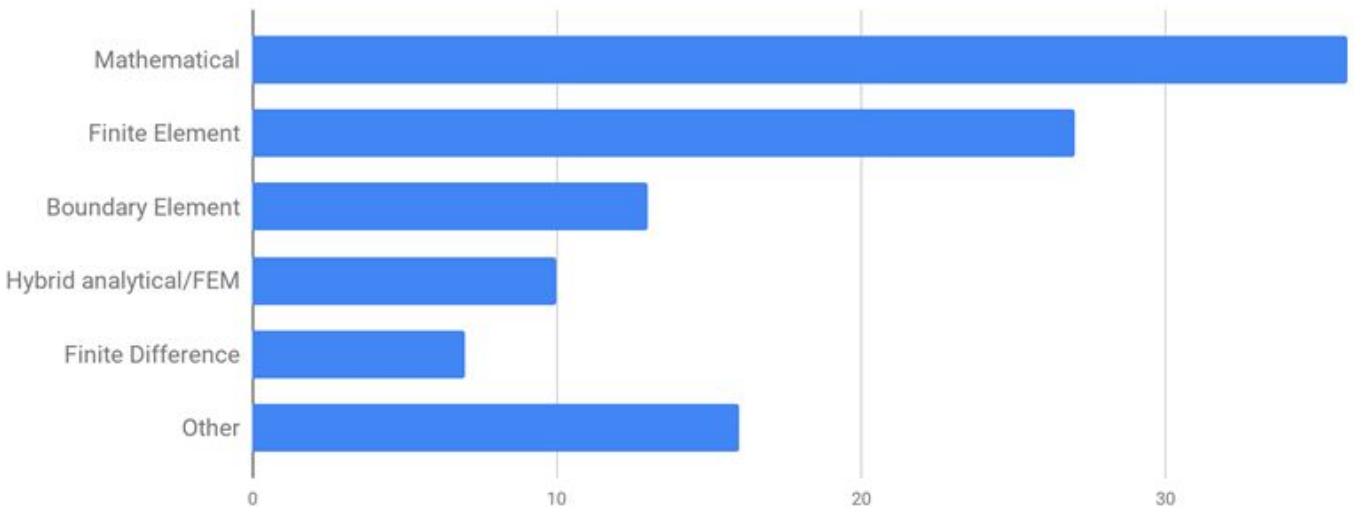

Figure 3. Responses to Q6: *What computational techniques do you use or develop?*

The responses to Q6 indicate that a majority of people are using mathematical techniques, many in addition to other computational methods (the most common of which was the finite element method). The design of

the question did not permit further elaboration on which mathematical techniques were included here. It should be noted that the questionnaire was completed prior to the establishment of the Mathematical Acoustics Special Interest Group within UKAN.

Responses to Question 7 (*What software do you use in acoustics?*) and Question 10 (*Please tell us about the specific software that you use and any challenges with it in addition to those noted previously*) can be summarised as follows:

- Most respondents reported using commercial software, however many reported using in-house solutions, and a few reported using open-source software. The design of this question did not permit multiple responses, so these responses may underestimate the true use of software by the community.
- The most commonly used software packages (those with 5+ users in survey data) were:
    - CadnaA
    - COMSOL Multiphysics
    - Insul
    - Odeon
    - MATLAB
    - CATT
- In addition to the packages above, use of many additional software packages was reported with many being used by only one respondent, reflecting the wide range of application areas represented.
- Commonly-reported problems (across all software) were:
    - Unfriendly interfaces
    - Steep learning curves
    - Occasional spurious results
    - Cost
    - High specificity to application
    - Lack of interoperability

2.3 General Challenges

Another aim of the questionnaire was to determine the challenges that users of computational acoustics methods and software encountered, so that the Computational Acoustics special interest group could focus on alleviating these. This aspect was addressed by Questions 8, 9 and 11, which asked about general challenge areas, and then provided options for respondents to elaborate using free text.

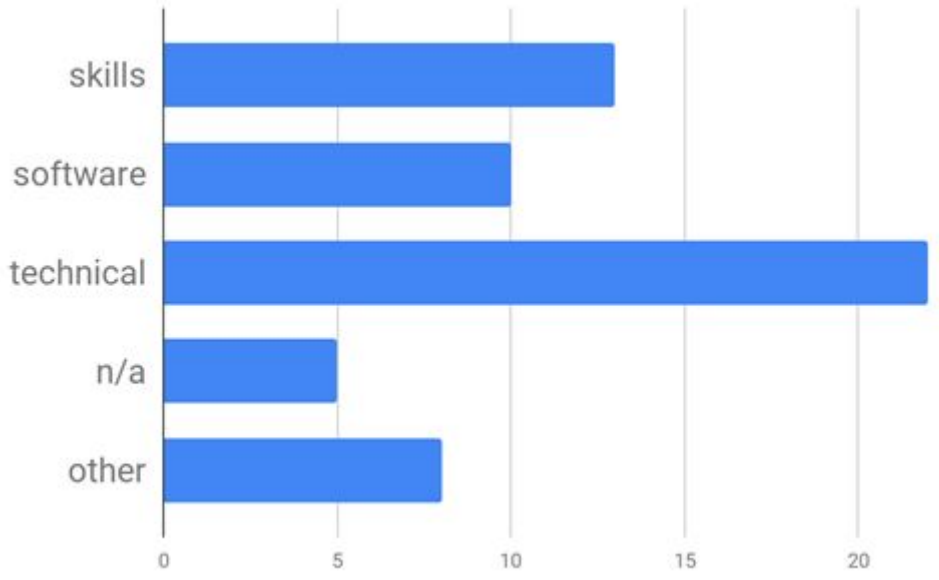

Figure 4. Responses to Q8: *What is your principal challenge relating to acoustics work using computational methods/software?*

From the responses to Q8 in Figure 4, it is clear that technical challenges (which the question elaborated on with "*e.g. difficulties with solving problems in your application area"*) were considered the main challenge for the most respondents. Note that respondents were only allowed to select one response for this question. Nevertheless, challenges relating to skills and software each received at least 10 responses. This indicates that there is also a clear need for all these types of challenges to be addressed.

Question 9 allowed respondents to provide further details about the challenge they selected in Q8 (*Thinking about your principal challenge in this area, please tell us a bit more about what that challenge is*), and Question 11 allowed respondents to provide details about other challenges (*Please list any other challenges that you experience in using computational methods in acoustics*). Responses to these questions can be summarised under the following five broad categories:

1. Computational expense
    - Running time vs. accuracy of simulations, especially for complex or multi-scale problems
    - Size of simulations
2. Lack of appropriate knowledge
    - Appropriate combination of technical skills and domain-specific knowledge
    - Attracting and retaining suitable staff; research funding
3. Complex simulation conditions
4. Advancement of methods
    - Development of new methods and incorporating them into commercial software
    - Combining / interfacing between different methods for multiscale problems
5. Software
    - Steep learning curves, due to unfriendly interfaces, specific software "quirks" and a lack of standardisation across packages
    - Reliability
    - Cost

2.4 Suggestions for the Future

Finally, the question asked respondents what new technologies they would like to see incorporated into computational acoustics software (Question 12: *Are there any recent advances in computational techniques or numerical methods that you have seen in other areas of science and engineering that you believe could be adapted and developed for acoustics?*). A list of responses to this question is given below:

- FPGA techniques
- Machine learning
- Compressive sensing
- Data management
- Open data
- GPU-CPU optimisation
- VR & AR
- Moving mesh methods for nonlinear problems
- VR & gaming technology
- Dynamical energy analysis
- Lattice Boltzmann method
- GPUs
- Dissipative particle dynamics

3. Summary

The main challenges identified in this survey can be summarised as follows:

- **Skills:** there is a necessity for technical skills combined with domain-specific knowledge, but a general lack of suitable training to address this.
- **Software:** most existing software packages have steep learning curves and plenty of “quirks”, and different application areas have specific software requirements which often means users must spend time learning the ins-and-outs of multiple packages. Additionally, many established software packages are based on older methods and newer methods are not always available.
- **Technology:** computational acoustics is computationally very expensive as a baseline. This is exacerbated by complex simulation problems which introduce specific technical challenges of their own e.g. incorporating inhomogeneous or moving media, or multi-scale problems. Additionally calibration and validation are essential but difficult given a lack of suitable standards and benchmarks.

Discussion of the results at the Computational Acoustics SIG meeting on 10th February 2020 included suggestion of the following potential solutions for some of these challenges:

- Development of a **knowledge base**: for example incorporating validation and benchmarking data, material properties, and a database of experts.
- Development of **training resources**: for specific methods and software, and general good practice including data and code management.
- Development of **standards** for improved interoperability.

Appendix: Questions

The text of the questions was as follows:

1. What sector do you consider yourself to work in?

   Response: select multiple

- *Academic*
- *Commercial*
- *Consulting*
- *Other (please specify)*

2. Please tell us about your role. Are you:

   Response: select one

- *Employed*
- *Self-Employed*
- *A Student*
- *Other (please specify)*

3. How long have you worked in acoustics-related activities (not including undergraduate study)?

   Response: select one

- *Less than 1 year*
- *1-5 years*
- *6-10 years*
- *11-15 years*
- *16-20 years*
- *21-30 years*
- *More than 30 years*

4. In what application areas in acoustics do you work?

   Response: select multiple

- *Aeroacoustics*
- *Architectural Acoustics*
- *Bioacoustics*
- *Biomedical Applications*
- *Medical Diagnostics*
- *Medical Therapeutics*
- *Metamaterials*
- *Noise*
- *Nondestructive Evaluation and Structural Health Monitoring*
- *Process Monitoring and Characterisation*
- *Speech and Communication*
- *Sound Absorbing Materials*
- *Transport*

- *Underwater Acoustics*
- *Vibrational Analysis*
- *Other (please specify)*

5. In what application areas do you use computational methods in acoustics (e.g. simulation software for environmental noise or building acoustics)?

   Response: select multiple
   Options as for Q4.

   a. Please list as many systems that you work on in acoustics using computational methods e.g. noise transmission in vehicles, sound insulation etc. This allows you to be more specific about your applications than the broad categories noted above. (Note: This is not asking about specific software - that will appear in a later question.)
      Response: free text

6. What computational techniques do you use or develop (select as many as apply)?

   Response: select multiple

- *Boundary Element Method*
- *Discrete Element Method*
- *Finite Difference Method*
- *Finite Element Method*
- *Finite Volume Element Method*
- *Hybrid Analytical/Finite Element Methods*
- *Mathematical Methods*
- *Other (please specify)*
- *I do not use any computational techniques*

7. What software do you use in acoustics? Please answer for the main software you use. (Please answer for your own work rather than that of your company or research group as a whole).

   Response: select one[1]

- *I use commercially-available software*
- *I use software developed by myself or my group for use within the group*
- *I work on the development of commercial software packages*
- *Other (please specify)*
- *I do not use software for acoustics*

[1] Note that the design of this question was flawed: the response options should have included open-source / freely available software, and respondents should have been allowed to select multiple options.

8. What is your principal challenge relating to acoustics work using computational methods/software? Please choose a category for the challenge - you can provide more detail in the next question.

   Response: select one

- *Skills-based challenges e.g. availability of skilled staff*
- *Technical challenges e.g. difficulties with solving problems in your application area*
- *Use of software e.g. complexity of user interface*
- *Other category of challenge*
- *Other (please specify)*
- *Not applicable: I do not use computational methods for acoustics*

9. Thinking about your principal challenge in this area, please tell us a bit more about what that challenge is e.g. lack of graduate engineers with the relevant technical skills, or the difficulty of solving the acoustic fields in real devices with highly complex geometry.

   Response: free text

10. Please tell us about the specific software that you use (names of packages), and any challenges with it in addition to those noted previously e.g. a difficult software interface for a particular package, robustness of results etc.

    Response: free text

11. Please list any other challenges that you experience in using computational methods in acoustics.

    Response: free text

12. Are there any recent advances in computational techniques or numerical methods that you have seen in other areas of science and engineering that you believe could be adapted and developed for acoustics? Please tell us briefly about them (with a specific reference if possible).

    Response: free text