It's the Journey Not the Destination: Building Genetic Algorithms Practitioners Can Trust

Jakub Vincalek
Swansea University
Swansea, United Kingdom
831491@swansea.ac.uk

Sean Walton
Swansea University
Swansea, United Kingdom
s.p.walton@swansea.ac.uk

Ben Evans
Swansea University
Swansea, United Kingdom
b.j.evans@swansea.ac.uk

ABSTRACT

This poster paper presents 2 recommendations for algorithm developers as best practices in the context of engineering design. Genetic algorithms are well suited for multi-objective optimisation problems which are common in engineering. However, the use of genetic algorithms in industry remains low. To understand why, 23 participants (N = 23) with varying degrees of expertise in the domain of engineering design took part in a 3-part mixed methods survey. The open-ended questions in the survey were analysed using reflexive thematic analysis. A common theme among participants was a lack of trust towards the results of genetic algorithms, as well as the process which the algorithms take to reach a result. Based on this, the following recommendations are made: better communication between developers and engineers, and visualising algorithm behaviour.

CCS CONCEPTS

• **Human-centered computing** → *Human computer interaction (HCI)*; • **Software and its engineering** → **Genetic programming**; • **Computing methodologies** → **Genetic algorithms**; • **General and reference** → **Surveys and overviews**.

KEYWORDS

reflexive thematic analysis, human in the loop, optimisation algorithms, design optimisation

ACM Reference Format:
Jakub Vincalek, Sean Walton, and Ben Evans. 2021. It's the Journey Not the Destination: Building Genetic Algorithms Practitioners Can Trust. In *2021 Genetic and Evolutionary Computation Conference Companion (GECCO '21 Companion), July 10–14, 2021, Lille, France.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3449726.3459483

1 INTRODUCTION

This paper provides algorithm developers with a series of recommendations focused on increasing engagement with their algorithms in industry. The recommendations were based on the results from a mixed-methods survey. A total of 23 participants took part. The first two parts of the survey contained qualitative questions while the third part consisted of 6 open-ended questions. The open-ended questions were analysed using reflexive thematic analysis [1]. The aim of the survey was to answer two research questions:

(1) To what extent is there a pre-existing sentiment (negative or positive) among practitioners towards genetic algorithm-based design?
(2) What are the requirements of students, engineers and managers with regard to design optimisation and the design optimisation process?

2 METHOD

The survey was made up of 3 parts. Participants were required to answer every question in Parts 1 and 2, while the open-ended questions were optional. A total of 23 participants were recruited over 9 days.

Part 1 gathered non-identifiable traits about the participants. This included their highest level of education, their experience in design engineering, and their current job or role.

Part 2 was used to determine participants' knowledge of genetic algorithm optimisation. Additionally, participants' preferences for engineering design tools was gathered.

In Part 3, participants were asked to answer 6 open-ended questions. The questions were designed to provide insight into the challenges, barriers, and obstacles that participants face during the design process and their attitudes towards genetic algorithm based design. The answers were analysed using reflexive thematic analysis developed by Braun and Clarke [1].

The survey was made and distributed electronically. A link to the survey was posted on various social media sites, focussing mainly on groups with a high proportion of engineers. Emails were also sent directly to experts in the field. Ethical approval for this study was granted by the Swansea University College of Science Ethics Committee (SU-Ethics-Student-110620/2921).

3 RESULTS

Much to the surprise of the authors, the answers did not vary significantly between participants based on their experience levels. This was true of both Parts 2 and 3.

A majority of participants (N = 15; 65%) had heard of both genetic algorithms and evolutionary programming. With regards to their preferences for engineering design tools, participants stated that the user interface is the most important factor.

From Part 3, three themes have were developed based on the responses: *human*, *product*, and *technology*. Each of these themes also contained sub-themes which grouped answers together. Answers could belong to more than one theme.

GECCO '21 Companion, July 10–14, 2021, Lille, France

ACM ISBN 978-1-4503-8351-6/21/07.
https://doi.org/10.1145/3449726.3459483

4 DISCUSSION

Key answers from each questions are given in this section. The 6 open-ended questions are also included for context.

Question 1: Describe your current process for optimizing designs; include proportion of time spent on each stage if possible.

4 participants noted that iteration/optimisation/redesign takes up a significant portion of their time. According to one participant, "the detailed subsystem design is usually the longest stage" and that "an iterative evolutionary algorithm would speed up this process." Another respondent also stated that this stage takes up 25% to 40% of the total design process time.

One manager said that finding an optimal solution is "highly unlikely" but also did say that solutions could be found that are quite close to the optimum. Similarly, an engineer mentioned multidisciplinary optimisation invariably results in compromises. These in turn lead to less-than-optimal designs. Of course, this is acceptable as long as the design requirements are met.

Question 2: What barriers do you have to overcome during the design process?

A manager and an engineer brought up trust in their answers. The manager said that "process credibility" is a barrier that must be overcome. Proving to their colleagues that a certain process works is important for them as trust was built from good results. The engineer had trust issues with regards to design simulations, especially when test data did not align with simulations.

Question 3: What comes to mind when you think of evolutionary algorithms?

Two managers responded with negative sentiments towards the term evolutionary algorithm. One manager said it is "over-rated in practice" and preferred other methods. The second manager did not believe that evolutionary algorithms could add value to the design process. Both managers added that convincing stakeholders of the benefits of a new process is a challenge.

Question 4: Do you trust the designs produced by automated optimisation algorithms? Explain your answer.

The level of trust varied throughout the answers. One engineer said that the results from algorithms are "usually overchecked" while another engineer's response stated "a 'blind' trust [in automated optimisation algorithms] is a bad approach."

Overall, 76% of respondents expressed a lack of trust to some degree.

Question 5: Do you think a computer-based algorithm could help your design process? Explain your answer.

One of the participants, a design engineer, listed some requirements in anticipation of using algorithms in their design process. For this participant, the most important requirement was a properly designed user interface. A link to other tools was also important. Having a good user interface is in line with results from Part 2 of the survey.

Question 6: Do you have any reservations about implementing more computer-based assistance in the design process? Explain your answer.

One engineer stated that algorithms have "disengaged the brains of engineers" and compromises research gains made up until now.

Two participants, a student and an engineer, cited job security as a reason why they would not want this technology implemented. This is a very real concern that needs to be addressed by properly explaining the intent of developing these tools.

5 RECOMMENDATIONS

5.1 Genetic Algorithm Developers Should Be Accountable for Their Algorithms

Algorithm developers make numerous claims with regards to the efficacy of their algorithms, often measured against mathematical formula and engineering benchmarks. The increase in efficacy against these benchmarks means these algorithms are getting worse at other problems according to the Free Lunch Theorem [2]. It is important for engineers to know which algorithms are suitable for different types of problems.

5.2 Genetic Algorithm Developers Should Include Visualisation as a Part of Their Development Process

A key theme throughout the data is that establishing trust between engineers and their processes is important. One of the ways that this could be established is through an increase in transparency and explainability. An effective way of increasing both transparency and explainability is through visualisations.

Two aspect of algorithm-based design can be visualised: the parameter space and the results. Both can help an engineer make better decision about inputs and constraints. Allowing engineers to visualise the parameter space will help them understand the process that the algorithms took towards a result. This can also be helpful when comparing two or more algorithms. Engineers will be easily be able to recognise which algorithms are more suited for their specific problem.

REFERENCES

[1] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[2] David H Wolpert, William G Macready, et al. 1995. *No free lunch theorems for search.* Technical Report. Technical Report SFI-TR-95-02-010, Santa Fe Institute.