

The 14th International Workshop on Genetic Improvement (GI @ ICSE 2025)

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ABSTRACT

The GI @ ICSE 2025 workshop, held 27 April, in addition to presentations, contained a keynote on the latest results on automated program generation for testing static program analyzers, which could have huge impact on GI for improving programs for APG, and a tutorial on Magpie, a widely used language independent GI tool. We summarise these, the papers, people, prizes, acknowledgements, discussions and hopes for the future.

1. INTRODUCTION

The fourteenth International Workshop on Genetic Improvement (GI 2025) was held in Ottawa, Ontario, Canada, co-located with the 47th International Conference on Software Engineering (ICSE 2025). The workshop offered both in-person and virtual participation through Zoom. Genetic Improvement (GI) is a research area focused on improving existing software using automated search techniques [51]. GI has been successfully applied to many software engineering tasks, as demonstrated by the wide range of work presented in the recent editions of the GI workshop. These include for example work on automated bug fixing [31, 32, 50, 59]; on optimisation of non-functional properties such as execution time [14, 24, 38, 58, 71], energy consumption [17], or network usage [21]; and on domain-specific context such as deep neural networks security [8], generative art [29], shoreline evolution forecasting models [1], or procedural story generation [27]. We have also observed a growing interest in work at the intersection of software improvements and large language models [70], investigating, for example, how LLMs can guide or accelerate automated software improvement or how GI techniques can be used to refine or adapt LLM-generated code [15, 33, 63]. GI research has won five “Humies” [6, 7, 34, 52, 65], prestigious cash prizes awarded for demonstrating human-competitive results at difficult-to-automate tasks. As of the workshop, the community website’s GPbib-based living survey covers almost 600 GI-related work (Figure 1). As in previous editions, the workshop brought together GI researchers and enthusiasts, offering a productive space for exchanging ideas, fostering collaboration, and identifying new challenges and directions for the GI community.

2. WORKSHOP FORMAT

As per previous editions, this year’s Genetic Improvement workshop was once again held as a full-day event. It took place on Sunday, April 27th, before the main ICSE 2025 conference. The complete program is available on the workshop website <http://geneticimprovementofsoftware.com/events/icse2025> as well as in the ICSE 2025 workshop proceedings [10]. GI @ ICSE 2025 featured one keynote, one tutorial, five research paper presentations, one position paper talk, and an open discussion session.

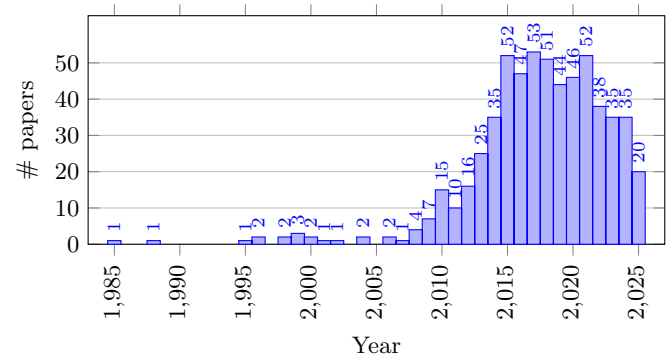


Figure 1: Publication year distribution of the 592 GI-related papers currently identified in the community website’s living survey (<https://geneticimprovementofsoftware.com/learn/survey>)



Figure 2: Keynote speaker Dr. Shin Hwei Tan

Keynote Dr. Shin Hwei Tan:

Put on Your Tester Hat: Improving programs for Automated Program Generation.

This year we were treated to an invited keynote presentation by Dr. Shin Hwei Tan of Concordia University [59], Figure 2. Dr. Tan obtained her PhD degree from National University of Singapore with Abhik Roychoudhury, having previously studied for both undergraduate and masters degrees at the University of Illinois at Urbana-Champaign (USA). During her Masters degree she was co-advised by Darko Marinov and Lin Tan. Prior to joining Concordia two years ago, Dr. Tan was a lecturer in SUSTech (China). She organised the GI workshop, in 2019, when ICSE was also held in Canada (Montreal) [46], before founding the international series

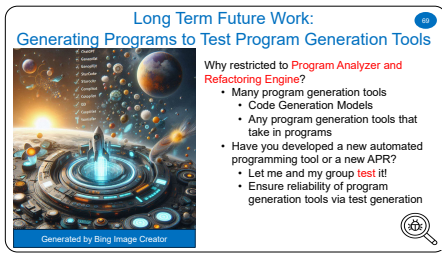


Figure 3: Put on Your Tester Hat, Dr. Shin Hwei Tan keynote. Genetic Improvement testing program generation tools [59].

of workshops on Automated Program Repair (APR) at ICSE in 2020. Next year she will be the general chair of the ACM's International Conference on the Foundations of Software Engineering (FSE 2026), when it will be hosted by Concordia University in Montreal.

Shin Hwei took as her title “Put on Your Tester Hat: Improving programs for Automated Program Generation”, Figure 3 (see also tester's red hat in Figure 4). After a whistle stop tour through early work [53, 60–62, 64, 69], she concentrated upon automated ways to create tests to test static analysers. Like computer compilers, static analysers process computer programs. Today Artificial Intelligence (AI) is quite capable of generating small programs. However Dr. Tan proposed the clever bit was not just generating source code but also having ways to check that the source analyser was giving the right answer. I.e. having a test oracle [47]. Ways forward included metamorphic testing and comparing answers given by different static analysers. Although she noted that of the five static analysers she had tested, there were cases when they contained similar bugs. Nonetheless mutation operators which produced non-trivial semantically equivalent source code, should cause a static analyser to give the same answer as before the mutation. That is, if the outputs differ, the test has found a bug. Also production of nearly equivalent mutations may induce interesting corner-cases. These tests may cause the analyser to fail completely or it may fail to give “similar” answers.

Also these ways of automatically generating source code might be good at finding bugs in source code refactoring tools.

The Q&A was joined by Prof. Roychoudhury. The discussion included possible ways to increase the tradeoff between performance and functionality. Also to what extent software engineers feel able to understand and interact with automatically generated program source code, as well as ways to ameliorate developer induced errors.

The keynote slides are available via http://gpbib.cs.ucl.ac.uk/gi2025/gi_2025_slides/GIworkshop-keynote.pdf

Tutorial.

Dr. Aymeric Blot (Figure 5) gave an extensive review of his Magpie system [11], tracing its development from the earlier PyGGI [3, 4] GI framework. Magpie builds upon the capabilities of PyGGI, showcasing compatibility with any programming language and support for improving both functional and non-functional aspects of software. However, Magpie also introduces novel features such as an improved user interface, the addition of parameter configuration to complement program source code manipulation, and the support for a much broader range of local search, genetic programming, and validation algorithms. During the tutorial, participants gained insights into the framework's structure, philosophy,



Figure 4: Shin Hwei Tan Keynote “Put on Your Tester Hat”



Figure 5: Dr. Aymeric Blot's Magpie Tutorial [9]

key components, and newest developments, whilst also engaging with practical examples. Dr. Blot concluding by outlining future directions and challenges.

Magpie is free and open source, accessible on GitHub at <https://github.com/bloa/magpie>. The tutorial slides are available via http://www0.cs.ucl.ac.uk/staff/a.blot/files/slides/blot_gi@icse_2025.pdf

Paper presentations. This year, the GI workshop accepted five research papers [14, 15, 40, 58, 63] and one position paper [24]. Each having received three independent reviews from the workshop's programme committee (Section 6). The authors of the accepted research papers had 20 minutes for the presentation and 10 for questions (Figures 10–14), whilst the accepted position paper had 10 minutes for the presentation and 5 minutes for questions (Figure 15).

Figure 7 shows some of the workshop participants.



Figure 6: Aymeric Blot leading online and in person discussion.

Awards. Following the GI workshop tradition, the best paper award is given to researchers for their outstanding contributions to the Genetic Improvement field, and is decided based on reviews provided by the programme committee (Section 6). Similarly the best presentation award followed tradition and was decided by a vote amongst the participants of the workshop (Figure 6).

Best research paper award: “Large Language Model based Code Completion is an Effective Genetic Improvement Mutation” by Jingyuan Wang and Carol Hanna and Justyna Petke [63] (Figure 8).

Best presentation award: Dimitrios Bouras for “LLM-Assisted Crossover in Genetic Improvement of Software” [15] (Figure 9), which was delivered via the Internet from Peking University in China.

The workshop was followed by a social event along with the other ICSE 2025 workshops. Daniel Amyot persuaded the Cafe Nostalgica (Figure 16) to open especially and exclusively for ICSE on Sunday evening.

GI and LLMs:

The GI @ ICSE 2025 workshop featured two research papers that leveraged large language models (LLMs) to enhance the genetic improvement process.

LLM-Assisted Crossover [15]: This work proposed a novel LLM-based approach to the crossover operation in genetic programming. Implemented within the MAGPIE framework, the LLM-assisted crossover uses contextual information to intelligently select and combine edits from parent variants. Across seven benchmarks, it outperformed five traditional crossover methods in producing high-quality, performant, and viable program variants. Key results included an 8.5% improvement in fitness and 4.8% more viable variants on average, demonstrating the potential of LLMs to guide search more effectively.

LLM-based Masking Mutation [63]: This paper introduced a new mutation operator for GI, based on LLM code completion. Rather than replacing entire functions, this masking mutation replaces only selected statements using LLM-generated completions. Evaluated across five Java projects, the approach produced more valid, compiling, and test-passing patches than both traditional muta-

tions and a previous LLM-based replacement operator. It also reduced response time by up to 60.7%. However, combining it with traditional mutations yielded mixed results, pointing to future work on integration strategies.

Together, these papers exemplify how LLMs can be embedded into core GI operations—mutation and crossover—demonstrating tangible benefits in patch quality, performance, and efficiency. They signal a growing research direction at the intersection of software improvement and modern AI capabilities.

3. DISCUSSION/FUTURE TOPICS

Genetic Improvement [35, 51, 67] has been successfully applied across a wide range of software engineering tasks, including automated bug fixing [48, 65], optimising non-functional properties—such as execution time [5, 25, 42], memory usage [22, 41, 56, 68], energy consumption [2, 13, 19, 20, 26], among others [1, 12, 21]—and functionality transplantation from one system to another [6, 52]. Beyond general-purpose applications, GI has also been used in domain-specific contexts, such as bioinformatics [44, 49] and generative art [28]. This is demonstrated by the wide range of work presented in the recent editions of the GI workshop.

3.1 Future: AI for program improvement

We are already seeing great interest in using the latest artificial intelligence tools in GI. We have already mentioned that two papers presented at the workshop used large language models (LLMs) [15, 63]. Indeed LLMs for GI were first presented at an earlier workshop [33]. Other early works include [18, 54, 57]. Indeed our Keynote speaker Dr. Shin Hwei Tan, thinks AI will play an increasing role in automatic testing, Figure 3. We expect researchers to continue to explore the intersection of GI and large language models. Future directions may include: enhancing explainability of GI transformations, integrating with developer tools, and improving performance predictability.

3.2 Extension of Recent Work

Following the success of GI @ ICSE 2025, the community anticipates continued collaboration and a potential workshop at ICSE 2026. We also encourage submission of extended versions of accepted papers to a future GI special issue of Springer-Nature’s Automated Software Engineering journal.

4. WORKSHOP OUTCOMES

Following the success of the earlier Genetic Improvement special issues of the ASE journal, we anticipate that in future some authors of accepted papers will be invited to submit their extended work to future ASE special issues. (Special Issue editors: Oliver Krauss and Vesna Nowack) [23, 30, 36].

As with earlier workshops [16, 39, 43, 45, 46], there will be a short write up in the ACM SIGSOFT SEN newsletter (this document).



Figure 7: Some of GI @ ICSE 2025 workshop participants: Xi Zhang, Aymeric Blot, Bill Langdon, Shin Hwei Tan, Zoe Aghababaeian, Carol Hanna, Thanatad Songpetchmongkol, Haibo Wang.



Figure 8: Shin Hwei Tan presenting the Best Paper award to Carol Hanna for “Large Language Model based Code Completion is an Effective Genetic Improvement Mutation” by Jingyuan Wang and Carol Hanna and Justyna Petke [63]. Workshop organiser Aymeric Blot to left.

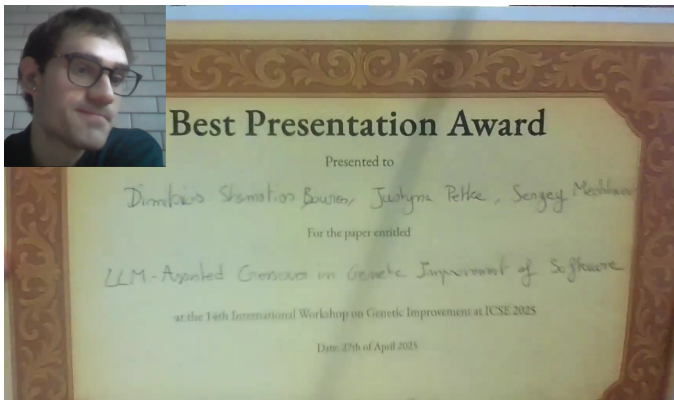


Figure 9: Shin Hwei Tan presented the Best Presentation award via zoom to Dimitrios Stamatis Bouras for “LLM-Assisted Crossover in Genetic Improvement of Software” by Dimitrios Stamatis Bouras, Justyna Petke, and Sergey Mechtaev [15].



Figure 10: Carol Hanna presenting the Best Paper “Large Language Model based Code Completion is an Effective Genetic Improvement Mutation” by Jingyuan Wang and Carol Hanna and Justyna Petke [63].

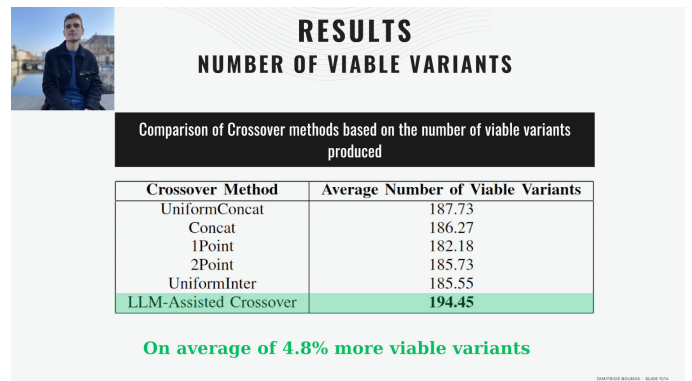


Figure 11: Dimitrios Bouras won the best presentation award: “LLM-Assisted Crossover in Genetic Improvement of Software” by Dimitrios Stamatis Bouras and Justyna Petke and Sergey Mechtaev [15].

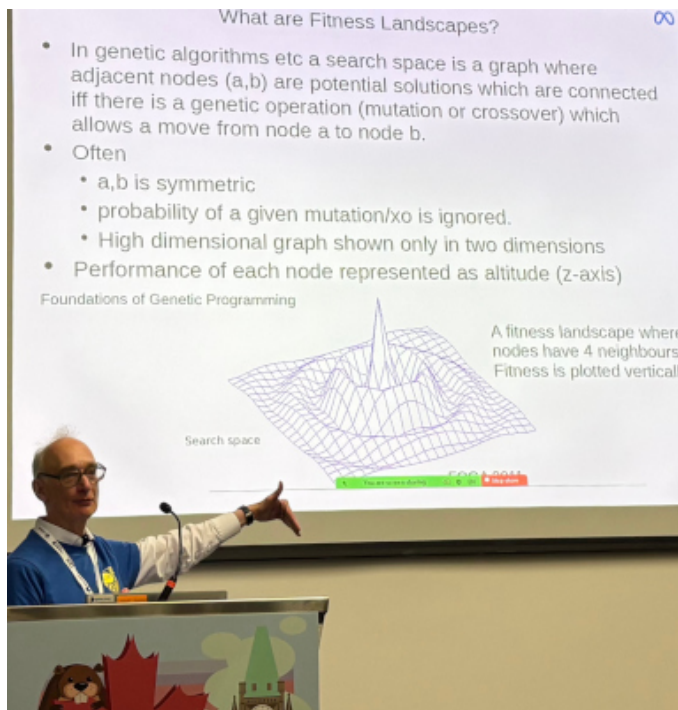


Figure 12: Bill Langdon [40]



Figure 13: Thanatad Songpetchmongkol [58]

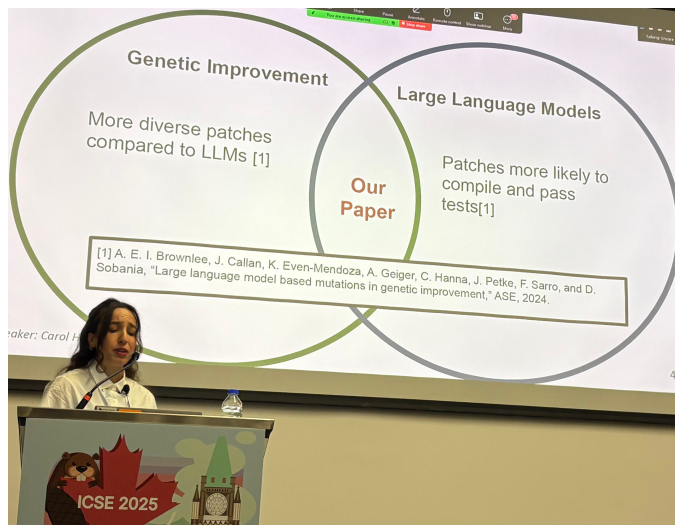


Figure 14: Carol Hanna presenting "Enhancing Software Runtime with Reinforcement Learning-Driven Mutation Operator Selection in Genetic Improvement" by Damien Bose, Carol Hanna and Justyna Petke [14].

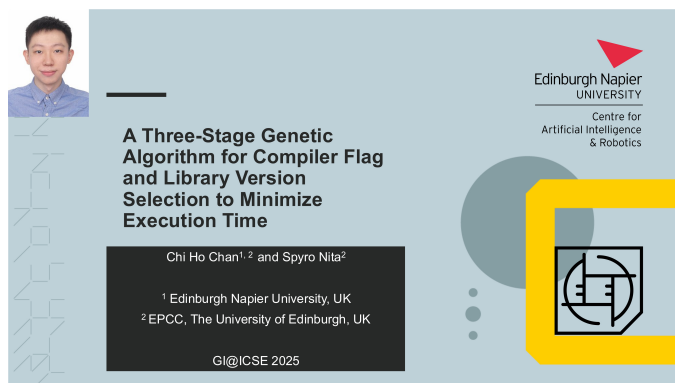


Figure 15: Chi Ho Chan presented "A Three-Stage Genetic Algorithm for Compiler Flag and Library Version Selection to Minimize Execution Time" by Chi Ho Chan and Spyro Nita [24] via the Internet.



Figure 16: Social event: Cafe Nostalgica, University of Ottawa. Right: Korean Canadian dish kimchi poutine.

5. GI 2024 WORKSHOP ORGANISERS



Aymeric Blot



Vesna Nowack



Penn Faulkner Rainford



Oliver Krauss

6. GI 2025 PROGRAMME COMMITTEE

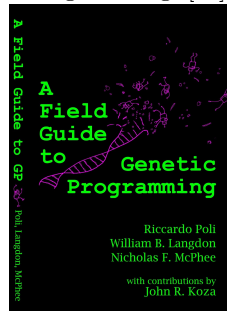
Each submission received three independent reviews from the workshop's programme committee (see Figure 17).

In addition to providing feedback to the authors and deciding which submissions to accept, the best paper award (Figure 8) was decided by the organisers using the reviewers' comments.

Acknowledgement

We would like to thank: our ICSE 2025 student volunteer, photographer "Dif" Thanatad Songpetchmongkol, and session chairs: Justyna Petke, Carol Hanna and Thanatad Songpetchmongkol. Also our thanks to Carol Hanna for additional photographs and to Daniel Amyot for organising the very enjoyable ICSE 2025 workshops' social event at Cafe Nostaligica on Sunday evening (Figure 16).

Sponsored by A Field Guide to Genetic Programming [55].



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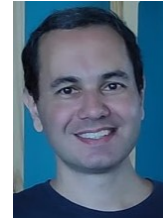
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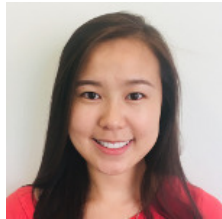
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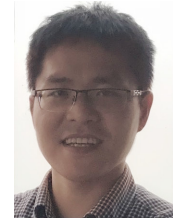
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Wuhan Uni., China



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Figure 17: GI @ ICSE 2025 Reviewers

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