Synthetic Benchmarks for Genetic Improvement

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In a Nutshell

Motivation:

- Empirical comparisons of GI approaches
- Parameter configuration of GI
- Genetic improvement of GI
- Quick experimentation for GI ideas

Idea:

- Premise: GI applied on software is very slow
- Bottleneck: fitness evaluation
- Proposition: synthetic benchmarks

Synthetic Benchmarks

Issues with real-world benchmarks:

- Evaluation is expensive
- Good data is scarce
- Uncertain features

Possible solutions:

- Surrogate modelling
- Artificial instances
- Synthetic benchmarks


Dang et al., GECCO 2017 (AC(AC) using surrogate modelling)


Malitsky et al., LION 2016 (Structure preserving instance generation)

Formalism

Standard GI:

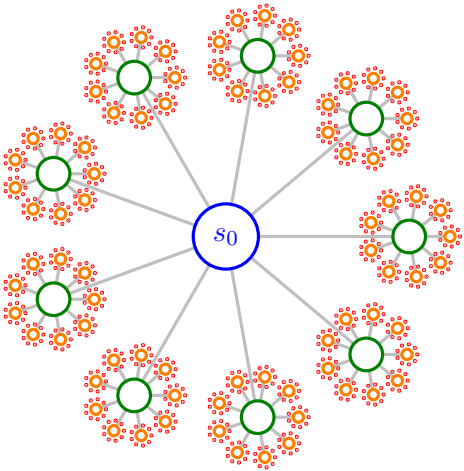
$$\text{(GI)} \quad \begin{cases} \text{optimise} & E[o(s,i),\ i \in \mathcal{D}] \\ \text{subject to} & s \in S \end{cases}$$

with:

- E: statistical population parameter (e.g., average)
- o: cost metric (e.g., running time)
- $\mathcal{D}$: input distribution (e.g., test cases, instances)
- s: software variants
- S: search space

Idea: Replacing $E[o(s,i), i \in (D)]$ by a single instantaneous query

Software Analysis



Search space:

- Around n deletions
- Around n^2 replacements
- Around n^2 insertions
- $\rightsquigarrow$ $\sum_{i=1}^{k}(n^{2i})$ sequences up to size k
- that's too big!

Assumption:

- Edits are independent
- $\rightsquigarrow$ only around n^2 fitness values
- reasonable to model

Synthetic Model

Empirical analysis:

- Sample edits
- Collect data, e.g.:
  - did it compile?
  - did it run?
  - was it correct?
  - how much better/worse?
- Compute underlying distribution

Contribution aggregation:

- Compilation errors propagate
- Runtime errors propagate
- Wrong outputs propagate
- Duplicate edits are ignored
- Fitness ratios are multiplied

E.g.: $[80\%, 100\%, 105\%] \rightarrow 84\%$

Conclusion

Problem:

- `GI(software)` is much slower than `software`
- `GI(GI(software))` is *much* much slower than `GI(software)`

Idea:

- Replace `software` with `model`
- `model` is free
- `GI(model)` is cheap
- `GI(GI(model))` should be reasonable

Advantages:

- Cheap, reusable benchmarks
- Model as complex as designed
- Possible focus on particular software feature

Selected References

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