Language Independence Via Synthesis
Final Project Report

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December 12, 2019
1 Abstract

For my senior project, I joined Bill Hallahan and Mark Santolucito in working on their novel program synthesis technique, and the accompanying engine.

Program synthesis is an increasingly successful field of research with promising results. However, applying program synthesis to a new language requires a type system, or deep understanding of the semantics of that language and an exhausting engineering effort to encode the semantics into a usable form. To simplify this process, we introduce the concept of language independence via synthesis (LIVS) to allow program synthesis to be applied to new languages, included untyped (or dynamically typed) languages. Users only need to provide an interpreter for the language - there is no need for user-defined semantics. Our insight is that, for the purposes of programming-by-example, we do not need a complete model of the source code - the model must only be sound for the subset of behavior we need for the particular examples provided by the user. We implement LIVS in our open-source tool, LIT (Language Independence Tool). To evaluate LIT, we run it on 614 benchmarks in JavaScript, and find we are able to synthesize more than 90% of these benchmarks. We additionally make this dataset of benchmarks open source for further work into synthesis for JavaScript functions.

Our work on LIVS culminated in a submission to PLDI ’20. My principle contribution to this effort was the construction of a comprehensive and useful benchmark set, and the evaluation of that benchmark set. I additionally investigated and debugged common errors thrown by LIT to increase the robustness of the tool, and assisted with writing and proofreading other sections of the paper.

2 The Paper

The provided paper serves as an adequate summary of our work, including the motivation, algorithm, methods, evaluation, and related and future work.

I leave to this supplementary report the description of my particular contributions and what we worked on throughout the semester.

3 Process

I began working with Mark and Bill on LIVS over the summer. Even when I joined, LIT was already substantially developed and could be used and tested on basic examples. I
poked at the implementation to discover bugs and potential areas for improvement, and experimented with extending their program synthesis algorithm to program repair.

When senior year started, I switched to working on LIVS itself, rather than extensions, to help meet the goal of submitting the project to the late November PLDI ’20 deadline, and this would be my senior project for the semester.

As Mark and Bill refined and optimized the codebase, my first goal was to find a benchmark set with which to evaluate LIVS. We quickly realized that this would be a harder task than anticipated due to the specificity of our benchmark needs. We needed many examples of short functions in “pure” JavaScript (i.e., no interaction with the DOM). Writing the functions ourselves would not be scientifically justifiable, but there were no JS function databases online, nor JS function generators.

My goal then became to write a parameterized benchmark generator for creating random JavaScript functions, and a script that would transform those functions into PBE problems and evaluate LIVS on those problems. This code and the subsequent evaluation section in the paper ultimately became my biggest contribution to the project. The workings of the generator and the methodology of our evaluation are both described in detail in the paper.

Through working on the generator I also occasionally discovered bugs in LIVS which I detoured to fix.

As the paper deadline approached, I transitioned to working on the text of the paper itself, where I primarily focused on sections 1, 4.3, and 5.2, and the associated figures, along with general proofreading.

4 Acknowledgements

I’m incredibly grateful to Mark, Bill, and Ruzica, not just for letting me join them on this project, but for everything that they’ve helped me with since we started working together last summer. They introduced me to the world of academic research, and as they have guided me through my first projects, they have always been patient and kind. I would never have been able to go to CAV ’19 if I hadn’t started working with them, and they are the reason I’ve decided to apply for graduate school for next fall. I’ll always be thankful for all of the support and direction they have provided me.