Rethinking Genetic Improvement Programming

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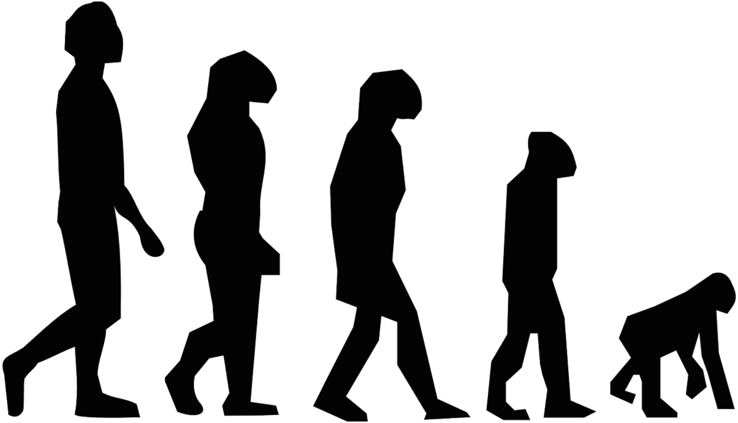
GI 2015, GECCO

Genetic Programming

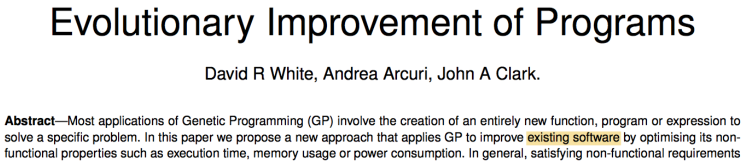
has gone backwards.

http://www.davidrwhite.co.uk/2014/11/27/genetic-programming-has-gone-backwards/

Starting at the End



An Early Paper (2011)



Evolutionary Improvement of Programs

David R White, Andrea Arcuri, John A Clark.

Abstract—Most applications of Genetic Programming (GP) involve the creation of an entirely new function, program or expression to solve a specific problem. In this paper we propose a new approach that applies GP to improve existing software by optimising its non-functional properties such as execution time, memory usage or power consumption. In general, satisfying non-functional requirements

Readymades (Marcel Duchamp)

Image from the Walker Art Center

How does existing code help us?

Existing code provides:

1. An Oracle
2. A starting point
3. Raw material

Existing Software as an Oracle

The Oracle of Delphi

An Oracle

- Full (non-functional optimisation) or partial (bug-fixing)

We can effectively treat the Oracle as a specification for new versions:

- N-Version programming[1]
- Reverse Engineering[2]

[1] R. Feldt. Generating Multiple Diverse Software Versions with Genetic Programming. In *Euromicro Conference*, 1998

[2] M. Harman, W. B. Langdon, and W. Weimer. Genetic Programming for Reverse Engineering. In *Working Conference on Reverse Engineering*, 2013

Research Direction: Translating Software

Why not consider software translation in a very general sense?

- Porting to new languages.
- Target to new platforms and technologies.
  - Automated parallelisation?[3]
  - CUDA and GPGPU[4]
- Compressing and simplifying programs.
- A solution to the problem of *legacy software*?

[3] C. Ryan. *Automatic Re-engineering of Software Using Genetic Programming*. Springer US, 2000

[4] W B Langdon and M Harman. Evolving a CUDA kernel from an nVidia template. In *CEC*, 2010

Existing Software as a Starting Point

https://www.flickr.com/photos/t_buchtele/3422507814

A Starting Point

The number of possible trees of depth d is given by:

$$c(d) = \begin{cases} n_0 & \text{for } d = 1 \\ \displaystyle\sum_{a=0}^{max} n_a \cdot c(d-1)^a & \text{for } d > 1 \end{cases} \tag{1}$$

n_a is the number of functions in N that have arity a. max is the maximum arity of functions in the function set.

Example Numbers for a Simple Function Set

Max Depth	Search Space Size
1	2
2	10
3	202
4	81610
5	$3.5x10^{20}$

David Robert White. *Genetic programming for low-resource systems*. PhD thesis, University of York, 2010

A Starting Point

- Reasonable assumption that the solution is close to the original program.
- Profiling the existing code reduces the size of the search space.
- Provides the basic units of manipulation, course-grained search.

Research Direction: Static and Dynamic Analysis

Plethora of techniques we have yet to exploit.

Simple example: profiling of memory usage to eliminate memory leaks or inefficiencies.

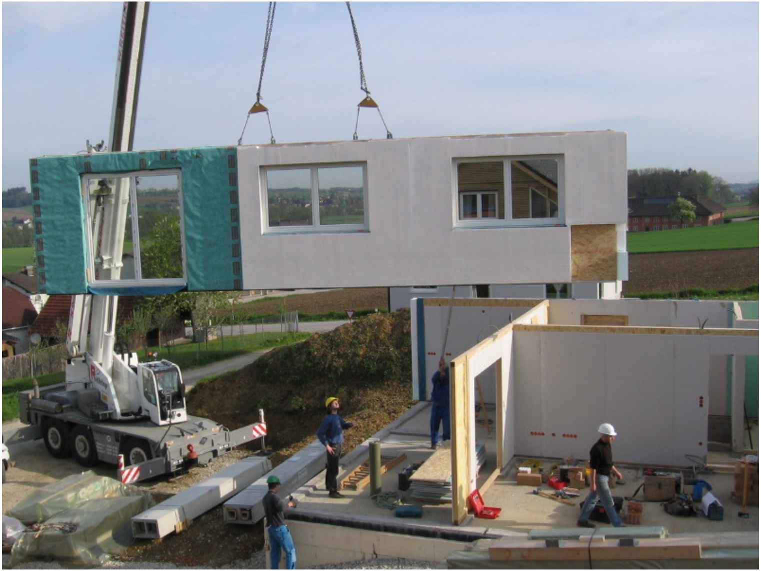
Existing Software as Raw Material

Raw Material

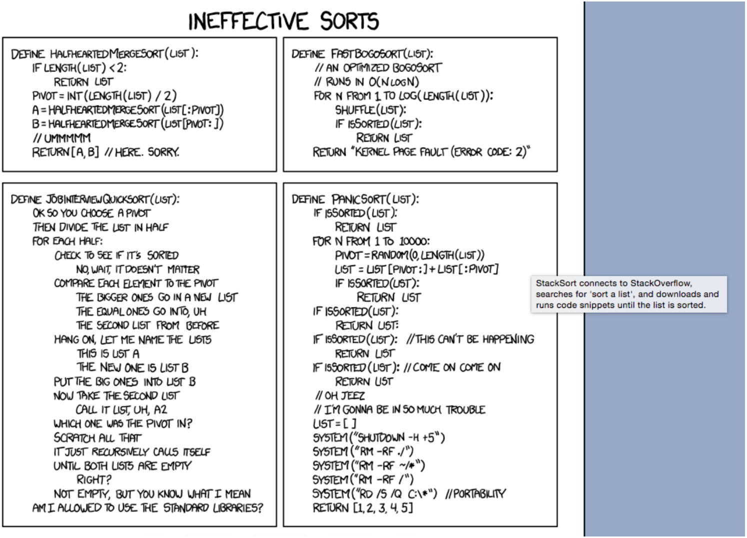
“In practice, a program that makes a mistake in one location often handles the situation correctly in another.”

D. Engler, D. Y. Chen, S. Hallem, A. Chou, and B. Chelf. Bugs As Deviant Behavior: A General Approach to Inferring Errors in Systems Code. In *SOSP '01*, 2001

Prefabs



Research Direction: Code Scavenging



INEFFECTIVE SORTS

```
DEFINE HALFHEARTEDMERGESORT(LIST):
    IF LENGTH(LIST) < 2:
        RETURN LIST
    PIVOT = INT(LENGTH(LIST) / 2)
    A = HALFHEARTEDMERGESORT(LIST[:PIVOT])
    B = HALFHEARTEDMERGESORT(LIST[PIVOT:])
    // UMMMMM
    RETURN [A, B] // HERE. SORRY.
```

```
DEFINE FASTBOGOSORT(LIST):
    // AN OPTIMIZED BOGOSORT
    // RUNS IN O(N LOG N)
    FOR N FROM 1 TO LOG(LENGTH(LIST)):
        SHUFFLE(LIST):
        IF ISSORTED(LIST):
            RETURN LIST
    RETURN "KERNEL PAGE FAULT (ERROR CODE: 2)"
```

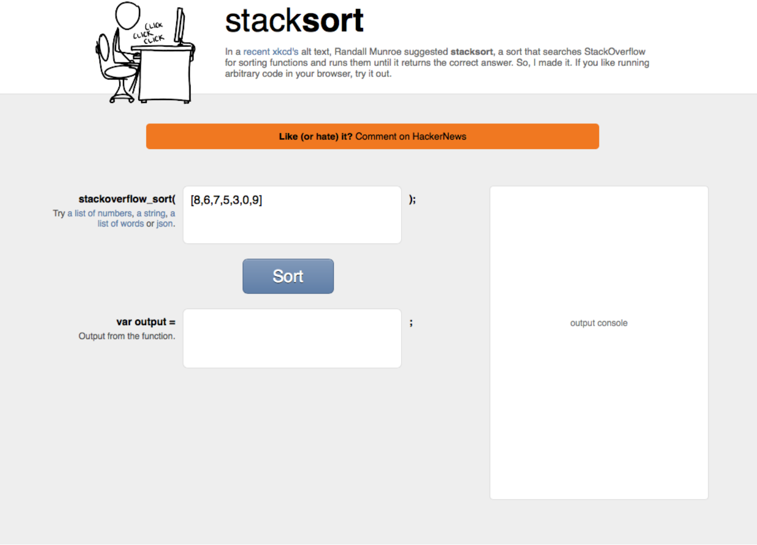
```
DEFINE JOBINTERVIEWQUICKSORT(LIST):
    OK SO YOU CHOOSE A PIVOT
    THEN DIVIDE THE LIST IN HALF
    FOR EACH HALF:
        CHECK TO SEE IF IT'S SORTED
            NO, WAIT, IT DOESN'T MATTER
        COMPARE EACH ELEMENT TO THE PIVOT
            THE BIGGER ONES GO IN A NEW LIST
            THE EQUAL ONES GO INTO, UH
            THE SECOND LIST FROM BEFORE
        HANG ON, LET ME NAME THE LISTS
            THIS IS LIST A
            THE NEW ONE IS LIST B
        PUT THE BIG ONES INTO LIST B
        NOW TAKE THE SECOND LIST
            CALL IT LIST, UH, A2
        WHICH ONE WAS THE PIVOT IN?
        SCRATCH ALL THAT
        IT JUST RECURSIVELY CALLS ITSELF
        UNTIL BOTH LISTS ARE EMPTY
            RIGHT?
        NOT EMPTY, BUT YOU KNOW WHAT I MEAN
    AM I ALLOWED TO USE THE STANDARD LIBRARIES?
```

```
DEFINE PANICSORT(LIST):
    IF ISSORTED(LIST):
        RETURN LIST
    FOR N FROM 1 TO 10000:
        PIVOT = RANDOM(0, LENGTH(LIST))
        LIST = LIST[PIVOT:] + LIST[:PIVOT]
        IF ISSORTED(LIST):
            RETURN LIST
    IF ISSORTED(LIST):
        RETURN LIST:
    IF ISSORTED(LIST): //THIS CAN'T BE HAPPENING
        RETURN LIST
    IF ISSORTED(LIST): // COME ON COME ON
        RETURN LIST
    // OH JEEZ
    // I'M GONNA BE IN SO MUCH TROUBLE
    LIST = [ ]
    SYSTEM("SHUTDOWN -H +5")
    SYSTEM("RM -RF ./")
    SYSTEM("RM -RF ~/*")
    SYSTEM("RM -RF /")
    SYSTEM("RD /S /Q C:\*") //PORTABILITY
    RETURN [1, 2, 3, 4, 5]
```

StackSort connects to StackOverflow, searches for 'sort a list', and downloads and runs code snippets until the list is sorted.

https://xkcd.com/1185/

Code Scavenging: Stacksort



stacksort

In a recent xkcd's alt text, Randall Munroe suggested **stacksort**, a sort that searches StackOverflow for sorting functions and runs them until it returns the correct answer. So, I made it. If you like running arbitrary code in your browser, try it out.

Like (or hate) it? Comment on HackerNews

stackoverflow_sort([8,6,7,5,3,0,9] **);**

Try a list of numbers, a string, a list of words or json.

var output = **;**

Output from the function.

`http://gkoberger.github.io/stacksort/`

Summary

It's all about existing software.

1. As an Oracle.
2. As a starting point.
3. As readymades.

Image from the Walker Art Center