synthesizing programs that procedurally generate plant graphics

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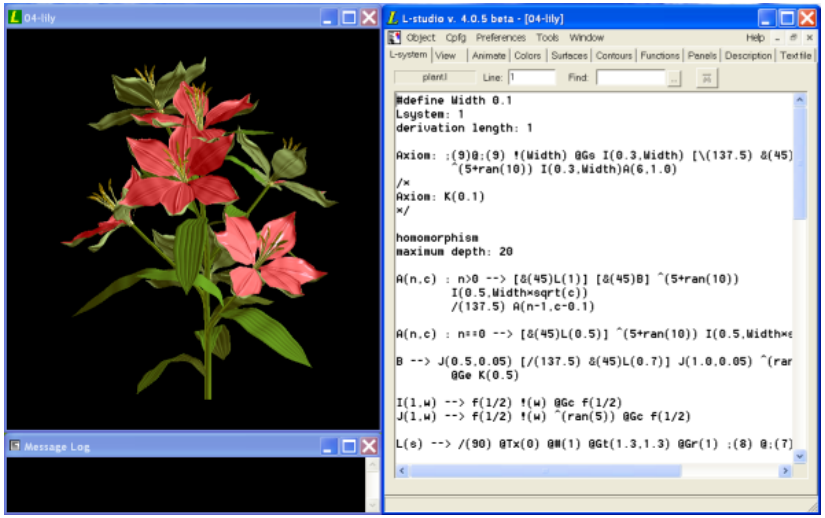
Programming Languages & Software Engineering (PLSE) Group

writing programs that generate lots of plant graphics is hard

Generated plants in virtual reality video game, No Man's Sky



A program that can generate field of plants (right), one example of a generated plant that would belong to the field (left)

writing programs that generate lots of plant graphics is hard

```
(rule F FF)
(rule X
F[[X]+X]+F
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```
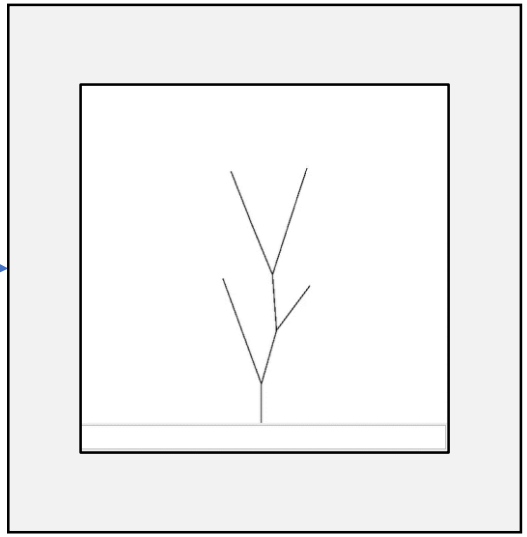
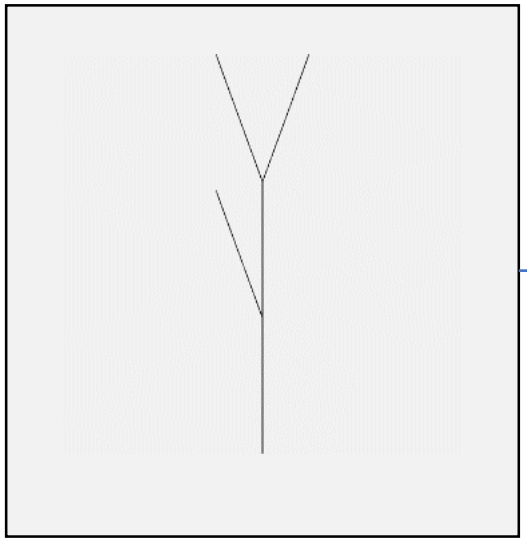

a program that generates graphics (an L-system)



graphics generated by program

idea: make computer synthesize those programs from an example graphic provided by designer



an example of a graphic that a designer wants the program to generate

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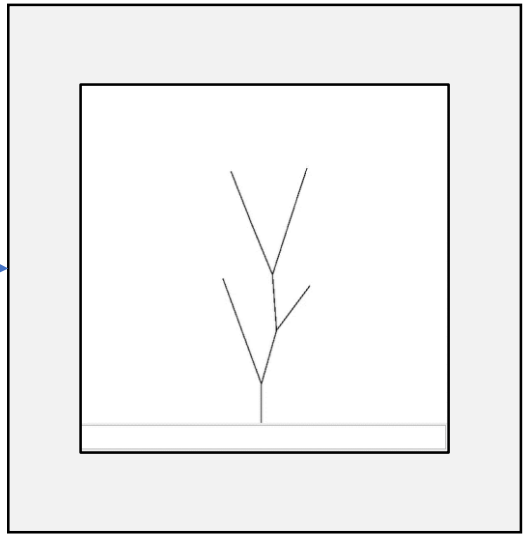
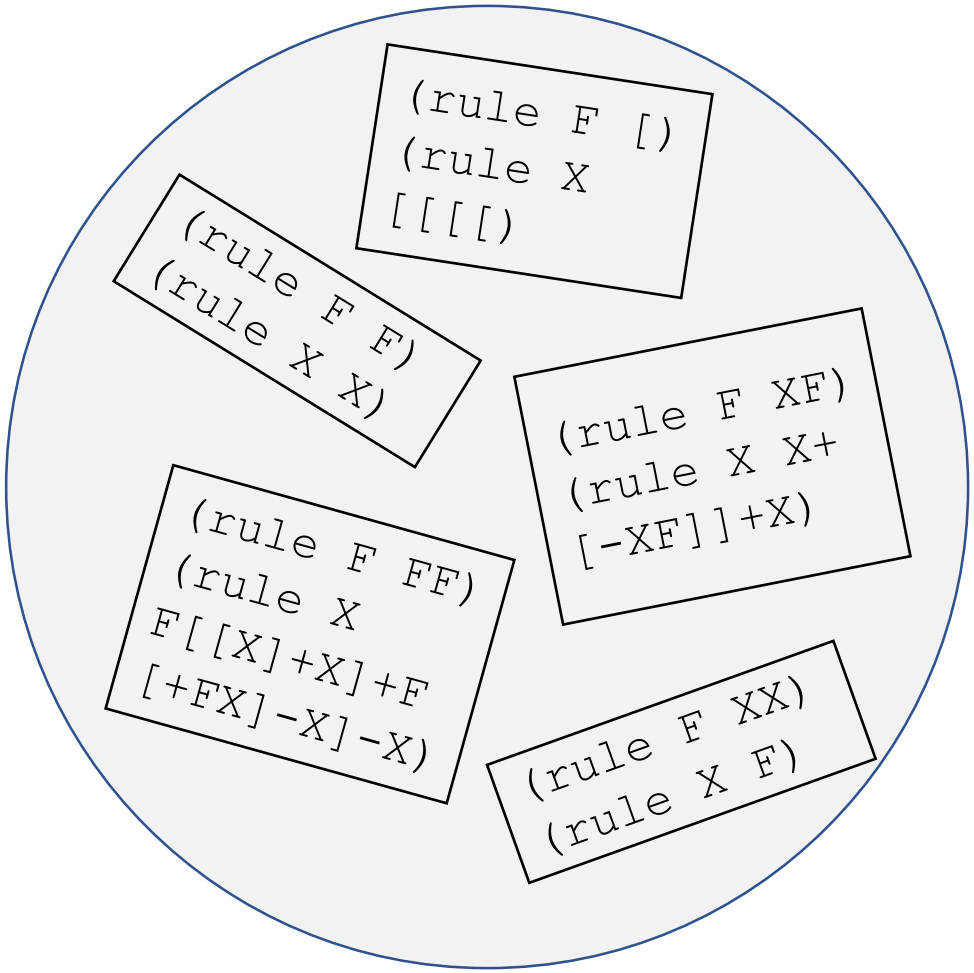


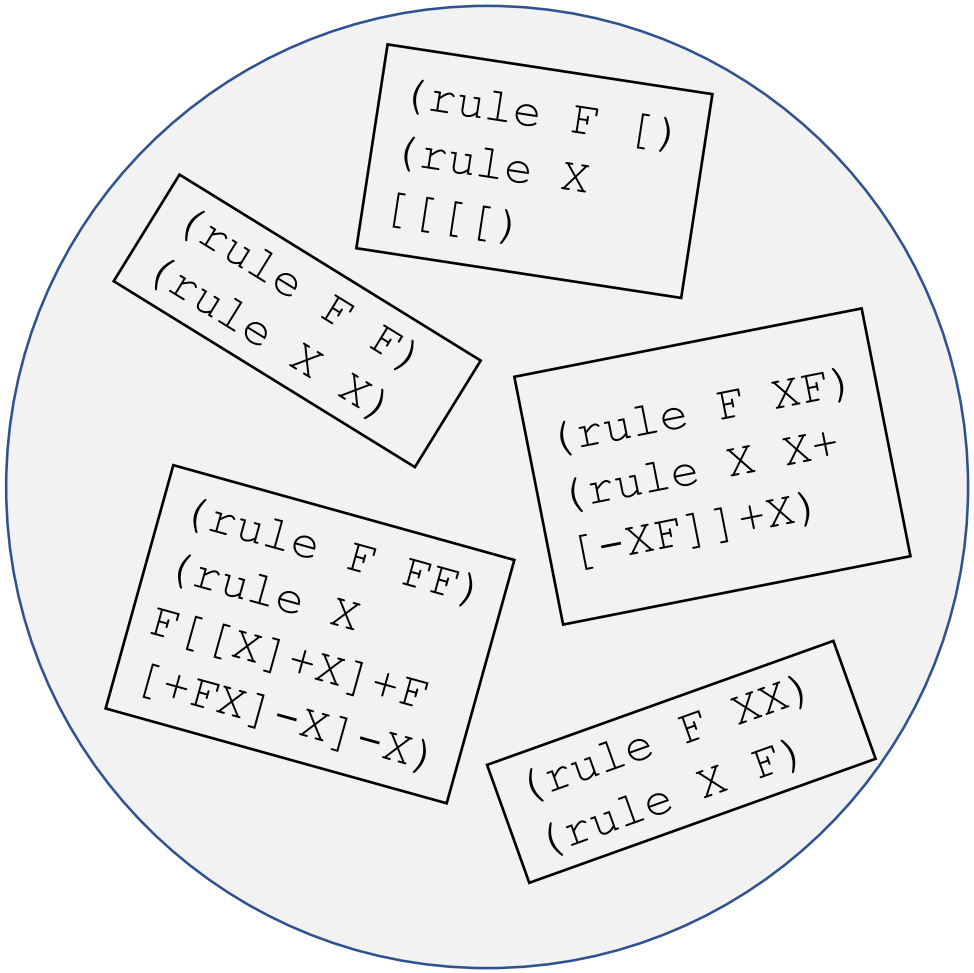
graphics generated by program

step 1: prune set of possible programs



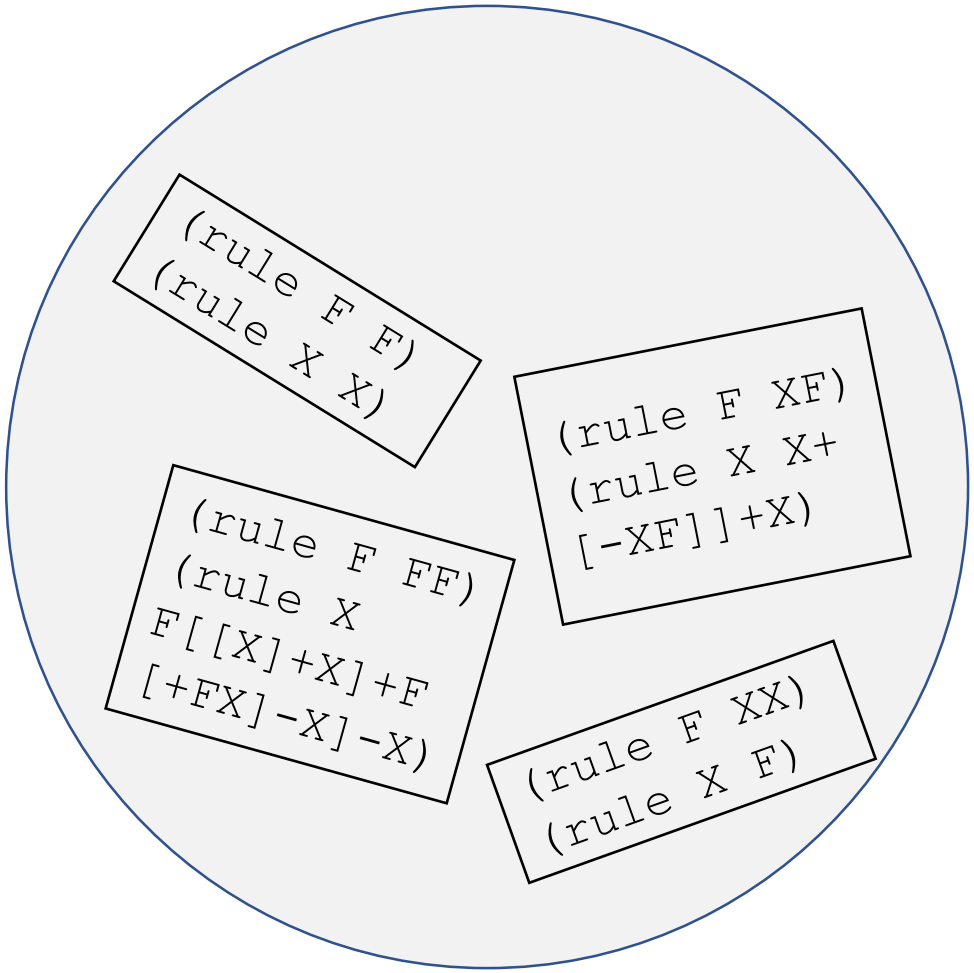
(0) take infinite set of all programs

step 1: prune set of possible programs



(1) remove programs that generate invalid plant parts

step 1: prune set of possible programs



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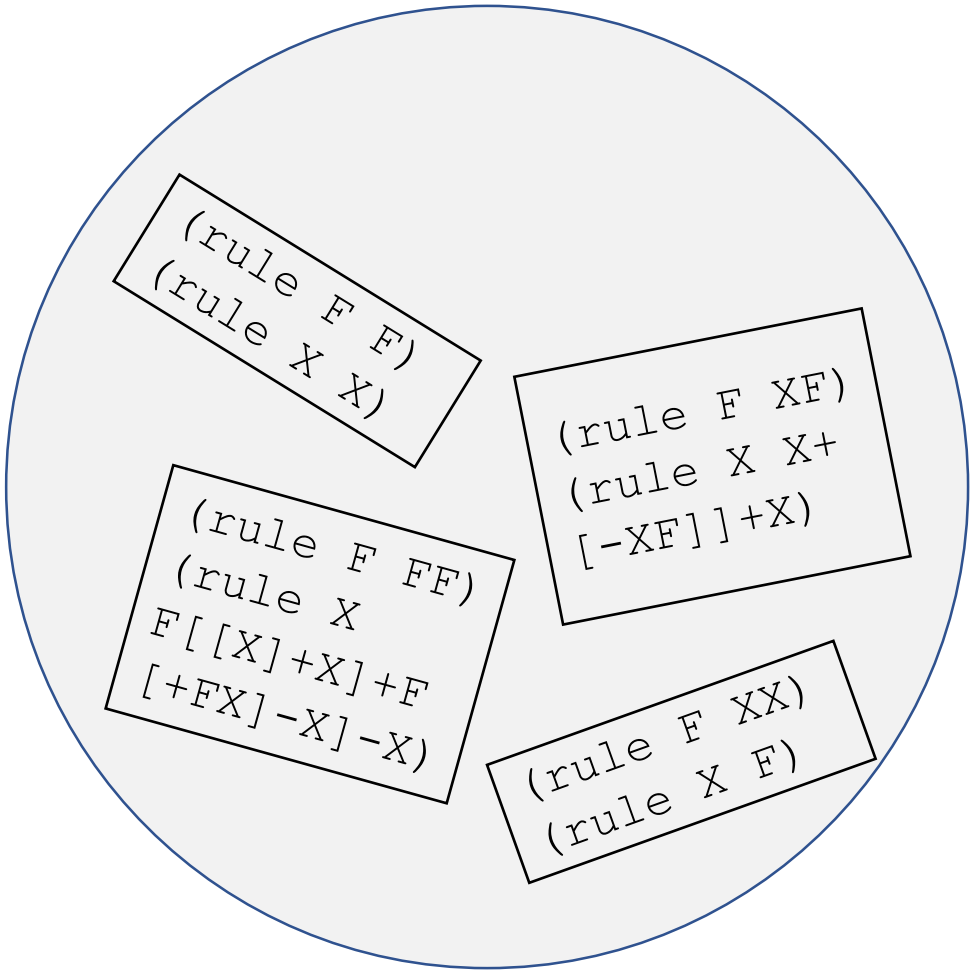

(1) remove programs that generate invalid plant parts

(2) remove programs that generate plant parts that don't come from plant given by designer

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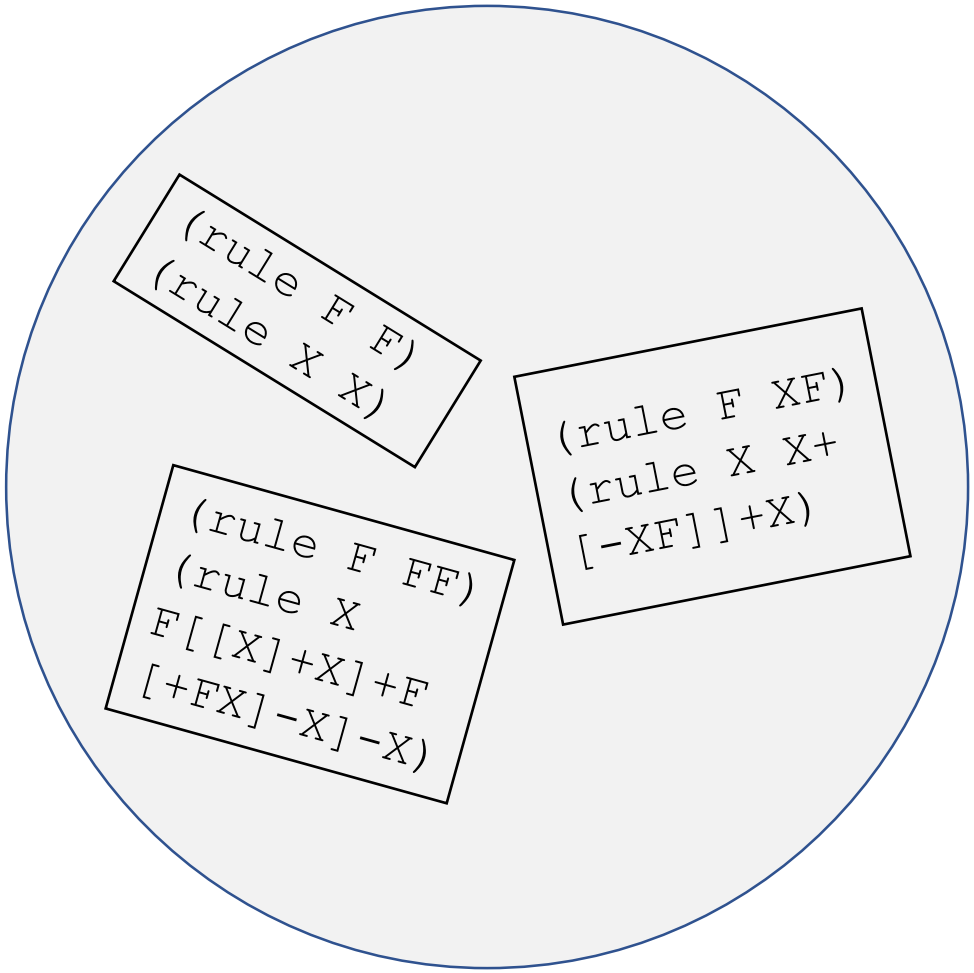

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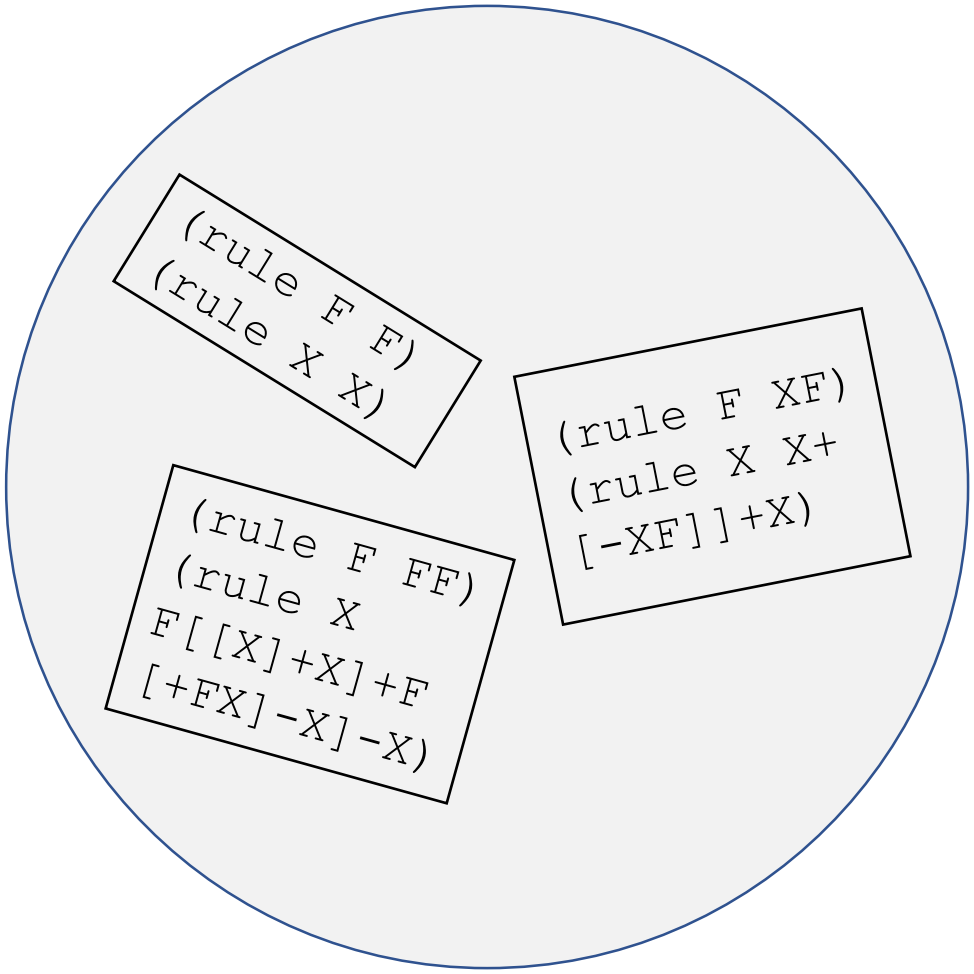

(1) remove programs that generate invalid plant parts

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(3) Remove programs that generate plant parts that are too big

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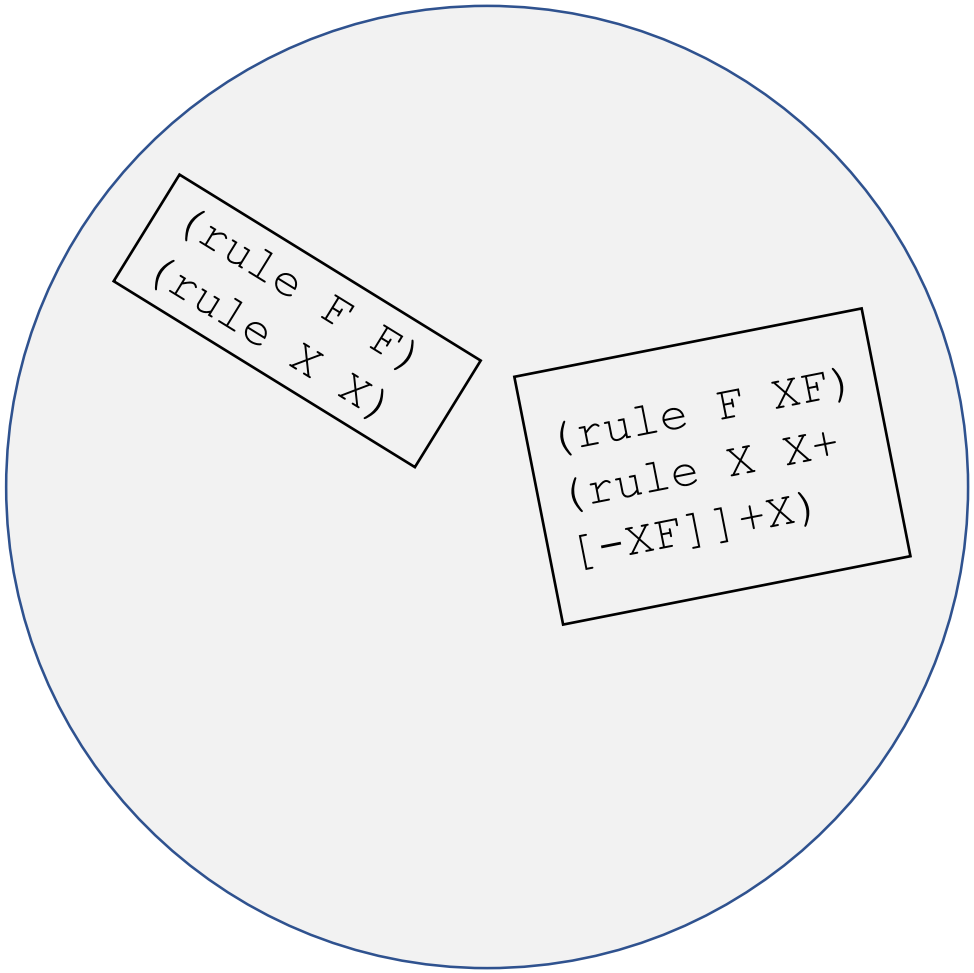

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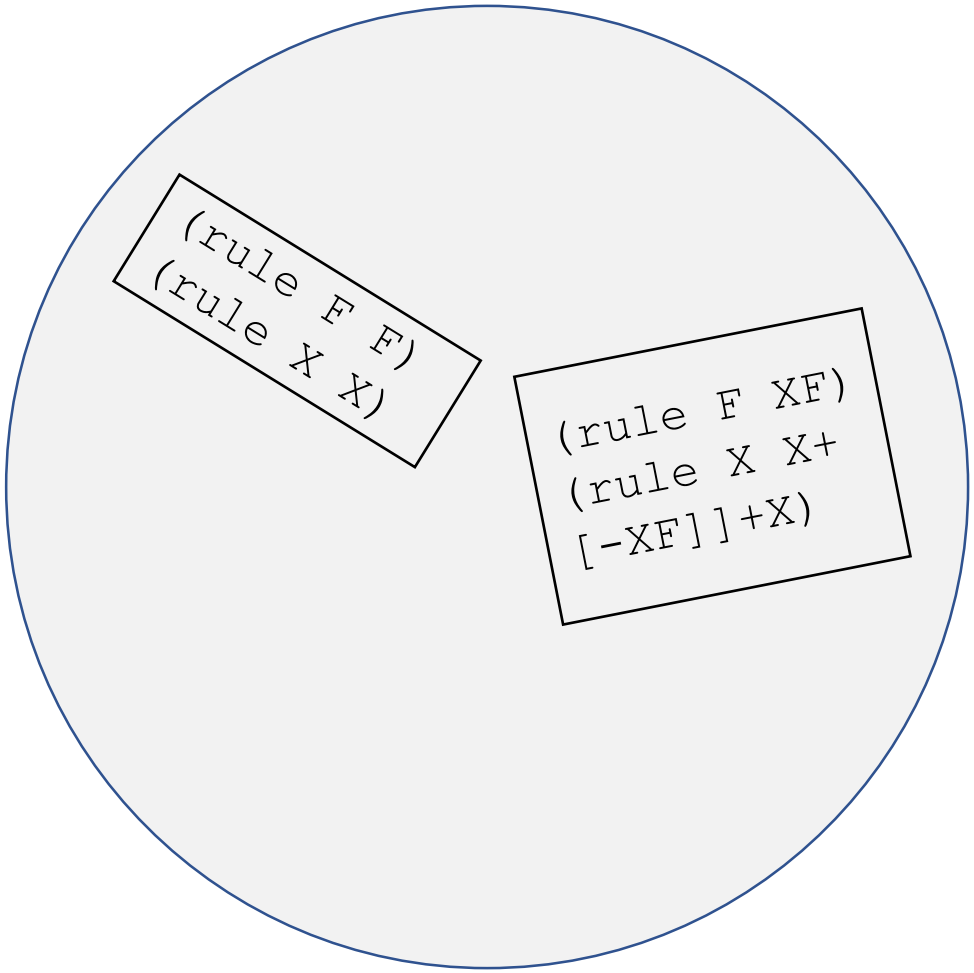

(1) remove programs that generate invalid plant parts

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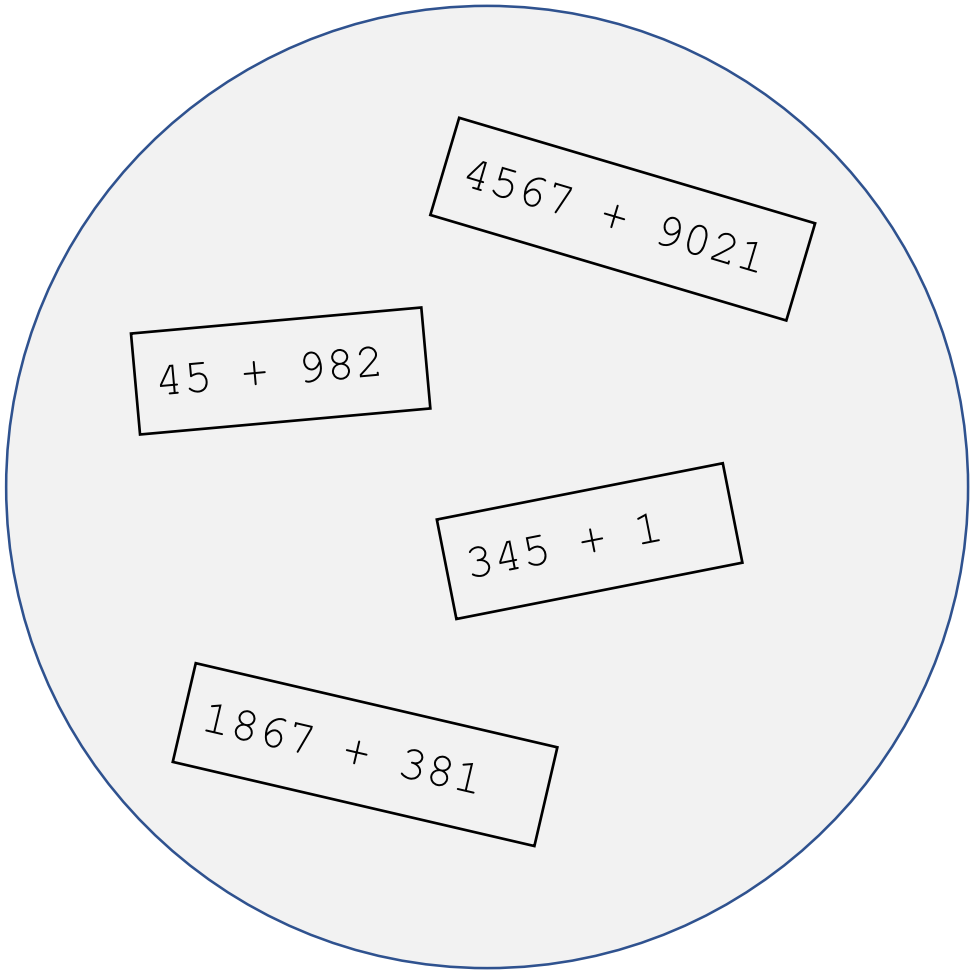
(4) smaller subset of possible programs

step 2: tell Rosette to constrain program

(Rosette is a framework for doing program synthesis, developed by Emina Torlak and Rastislav Bodik)

- define symbolic expression for a program using pruned set of possible programs

but what is a symbolic expression?



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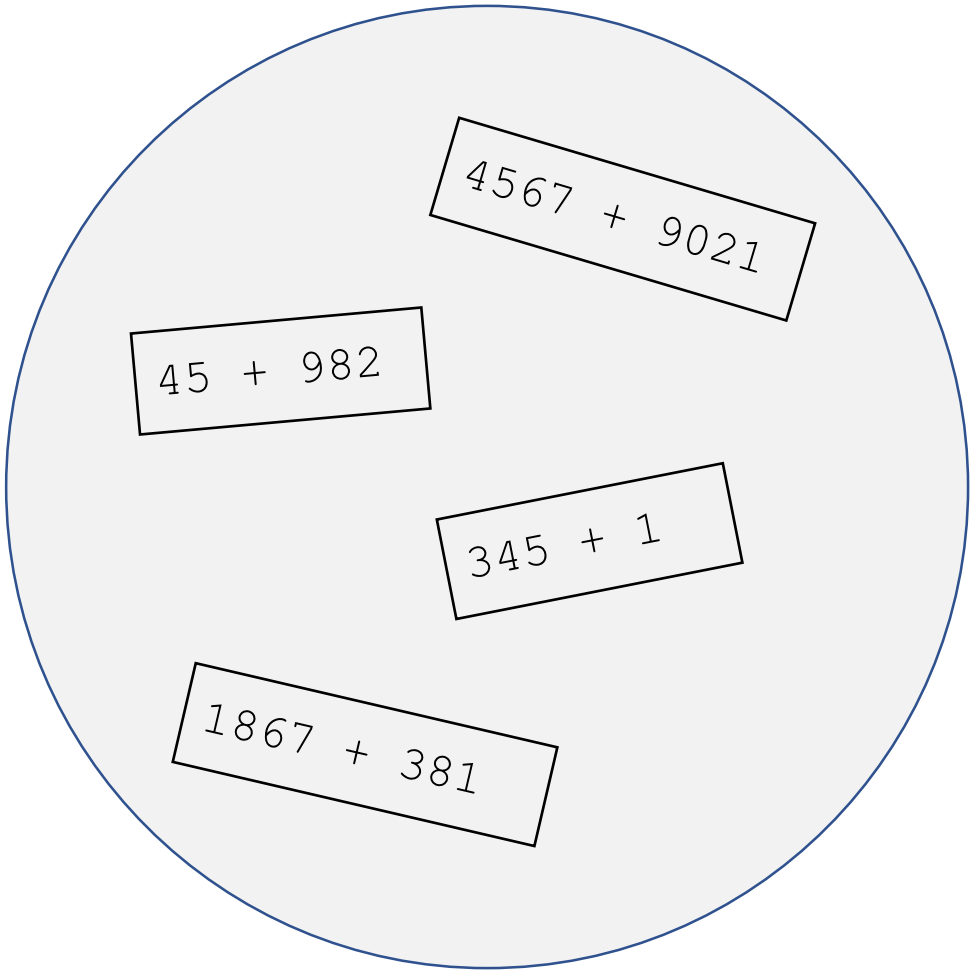

X + Y

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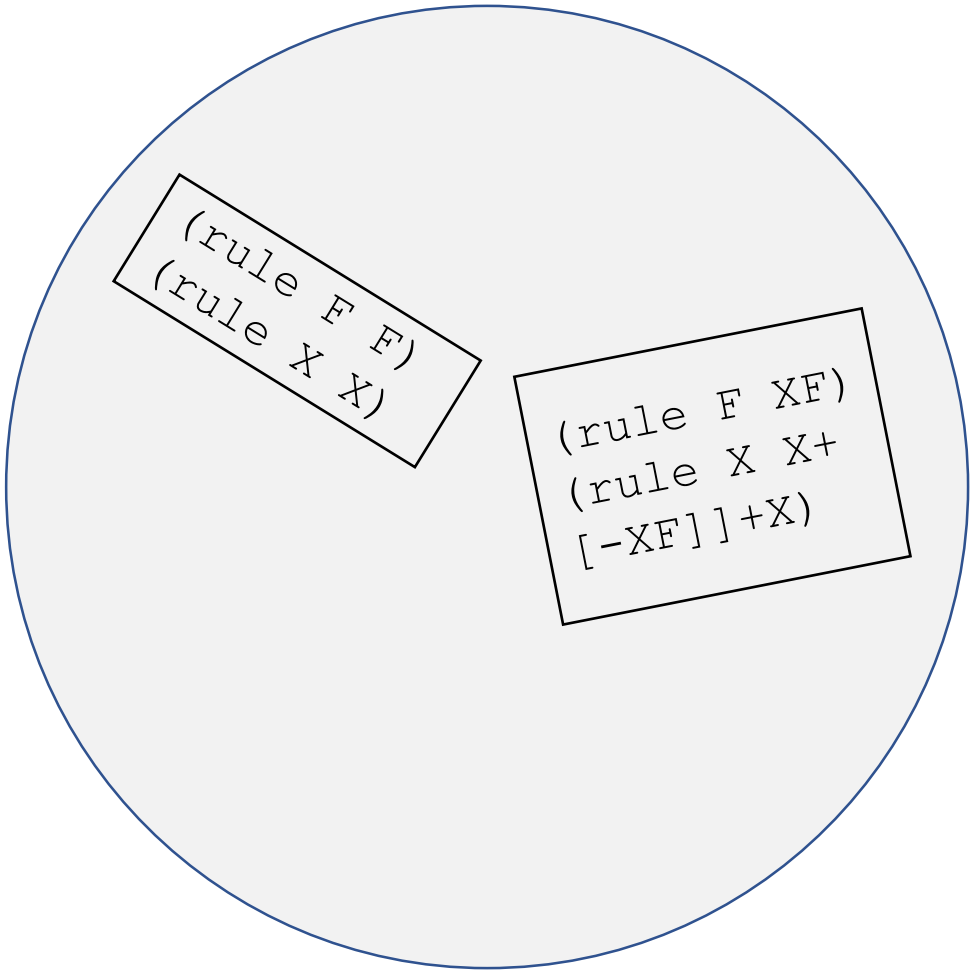

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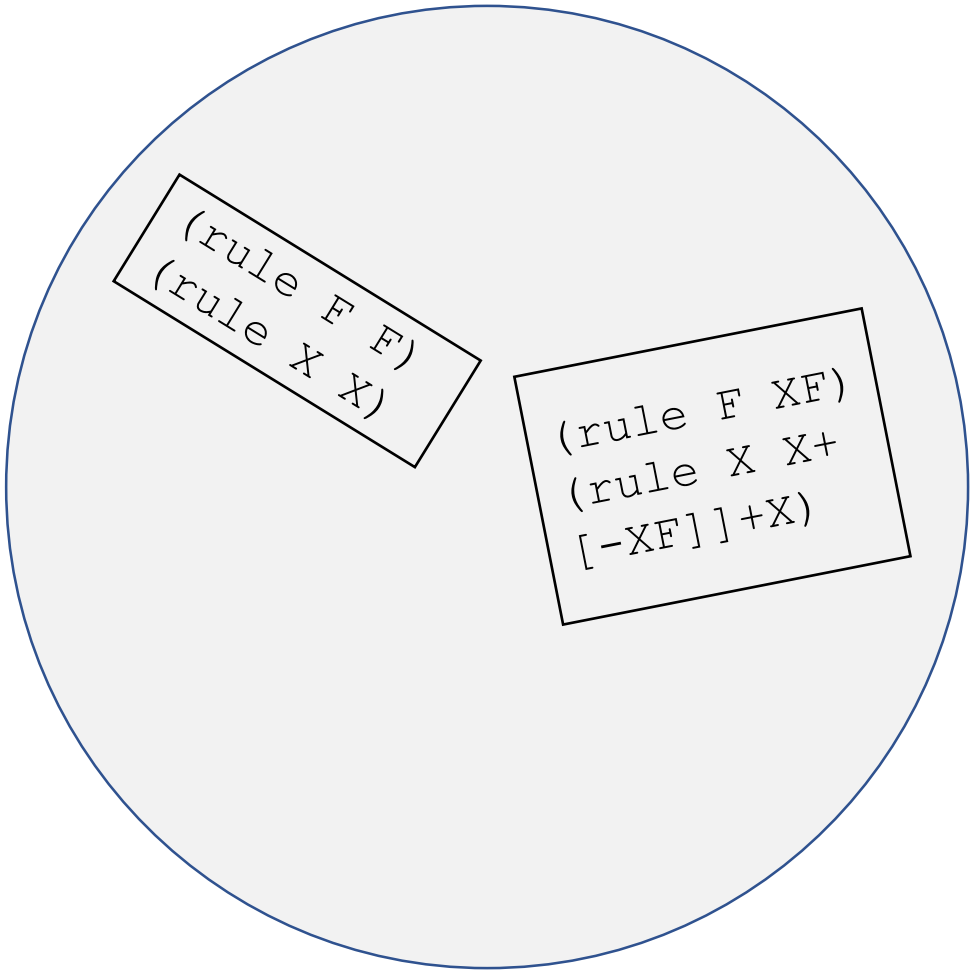

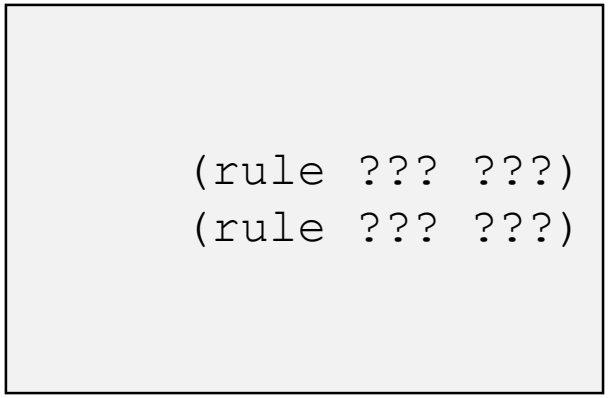

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- define symbolic expression for a program

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- define symbolic expression for a program
- define symbolic expression for output plant graphics from program

step 2: tell Rosette to constrain program

(Rosette is a framework for doing program synthesis, developed by Emina Torlak and Rastislav Bodik)

- define symbolic expression for a program
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- define symbolic expression for # of edits between output plant graphic and plant graphic given by designer

step 2: tell Rosette to constrain program

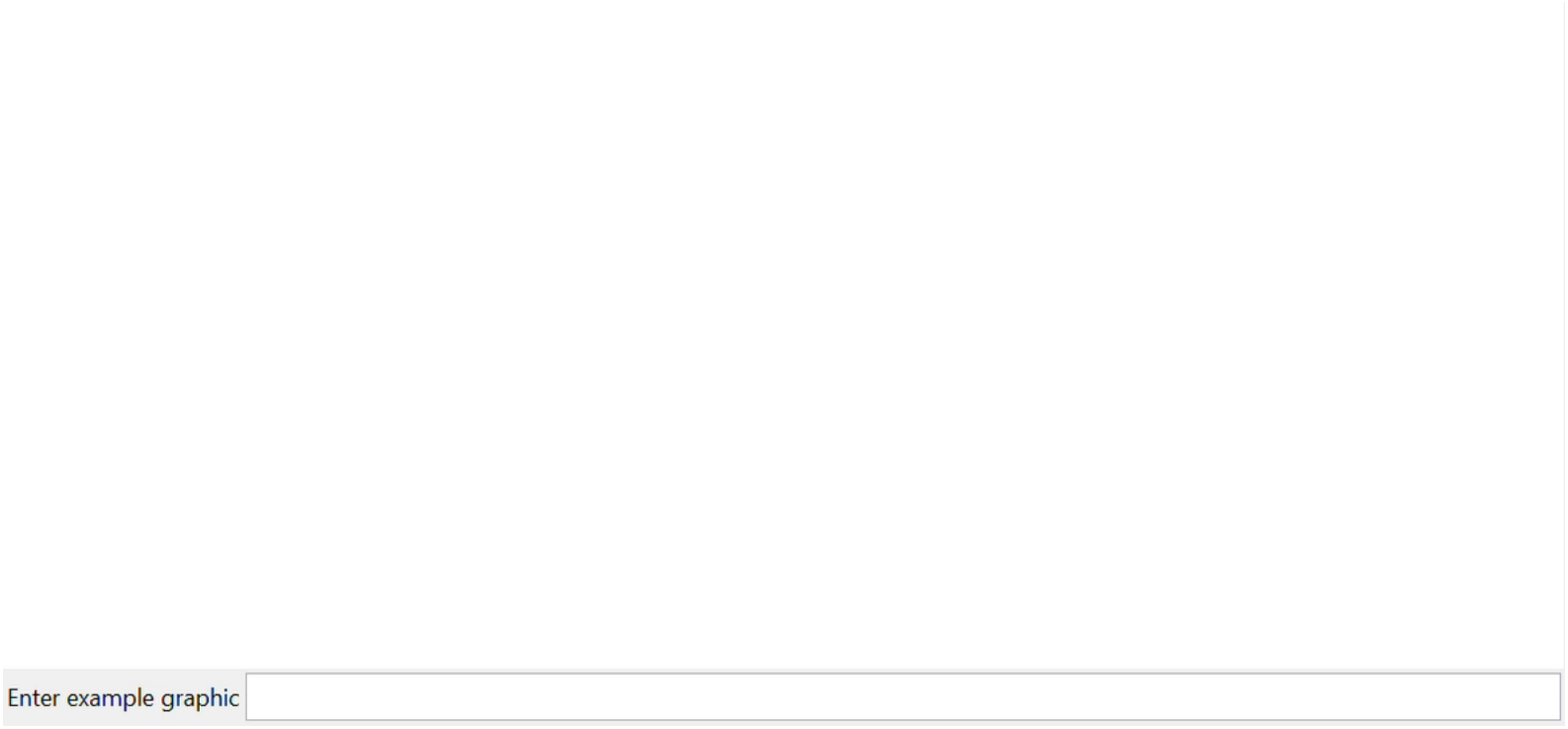
(Rosette is a framework for doing program synthesis, developed by Emina Torlak and Rastislav Bodik)

- define symbolic expression for a program
- define symbolic expression for output plant graphics from program
- define symbolic expression for # of edits between output plant graphic and plant graphic given by designer
- tell Rosette that # of edits must be less than a certain number

step 3: ask Rosette for solution program

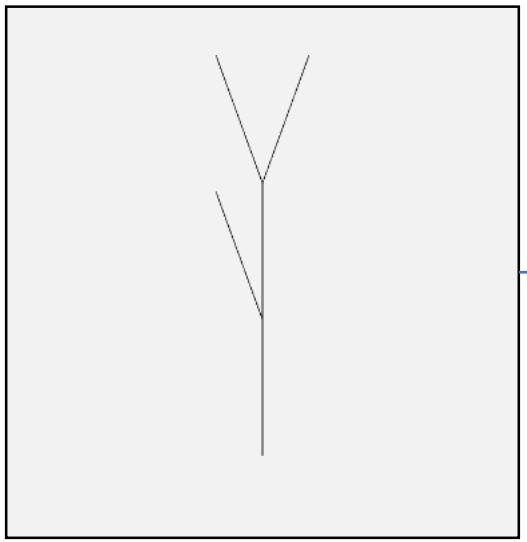
- tell Rosette to solve for program that satisfies constraint for # of edits
- Rosette compiles the constraints for a program to a Satisfiability Module Theory
- Rosette solves for a solution
- Rosette uses solution to derive expression for solution program

demo



in summary…

- I developed a synthesizer for programs that generate plant graphics
- given an example plant graphic, our tool will find a program that generates similar graphics



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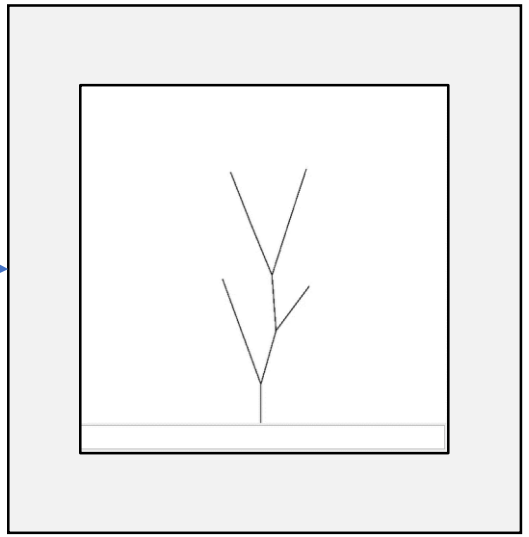

graphics generated by program

acknowledgements

- Professor Ras Bodik, Paul G. Allen School of Computer Science & Engineering
- Programming Languages & Software Engineering Group, Paul G. Allen School of Computer Science & Engineering