Geo

A geometric solution language

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Motivation

- Geometry is useful in mathematics, physics, computer science and so many fields.
- But built-in support for graphs are not provided in most programming languages.
- Geo is here to help!
- A simple while powerful language for graph creation and manipulation.
- The best part about Geo - dynamic graphs.

Language Tutorial

A basic sample

No entry function

```
function gcd(a:int, b:int): int:
    while(a != b):
        if(a>b):
            a = a - b;
        else:
            b = b - a;
        end
    end
    return a;
end
```

control structures: if-else, while, for

data types: int, float, bool, char, string

keyword end defines the scope

Language Tutorial

Something special

- Geometric types: line, dot, polygon, circle

  dot(x:float, y:float);
  line(dot1:dot,dot2:dot);
  polygons: polygons(num_of_apex:int,apex[]:dot);
  circle: circle(center:dot,radius:float);

- Presets:

  @panel panelname (essential) - defines a panel
  @mode workingmode (optional) – console/figure
  @co cosystem (optional) - coordinate system, cartesian/polar
  @end (essential) - the boundary of a specific panel

- Dynamics:

  model runset: runset(times_of_run:int, g1:geometric_shape, run_para_g1:char, ...);
  function setRunstep(val:float,pos:char):void;

Language Tutorial

Advanced stuff

```
//panel presets
@panel panel_demo
//geometric shape declaration and initialization
line1 = line(2.0,3.0);
circle1 = circle([3,4], 5);

//runset declaration and initialization
line1.setRunstep(-0.5,'a');
circle1.setRunstep(0.1,'b');
rs = runset(50, line1, 'a', circle1, 'b');
//run statement description
run rs:
set = line1.intersect(circle1);
if (!set.empty())
    print_dot_list(set);
end
@end
```

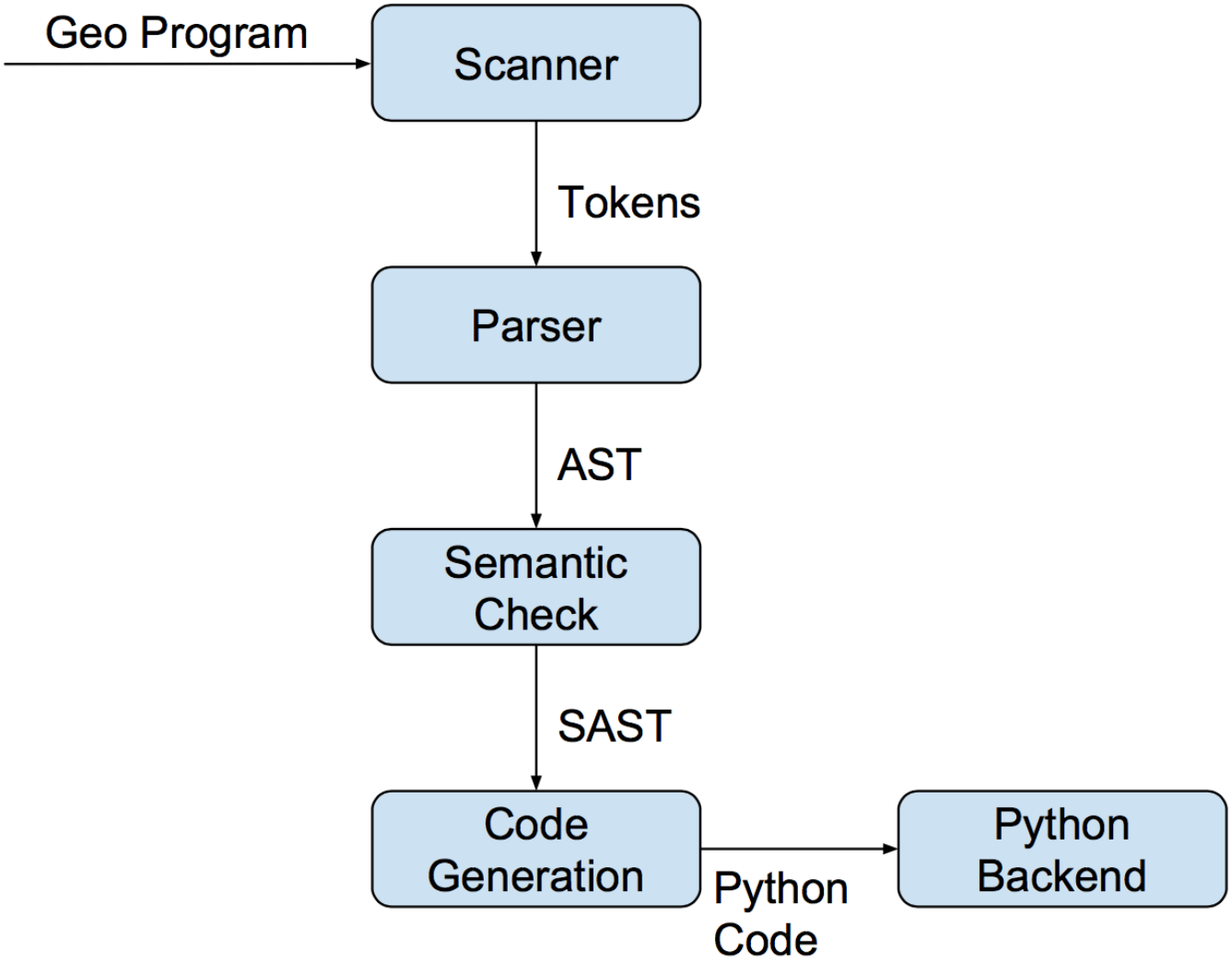
geometric types: dot, line, circle and polygons

geometric control type - runset

keyword run - dynamic analysis

print intersection points

Architecture



Architecture

- Source code statistics

File	Lines	Role
scanner.mll	95	Breaks input stream into tokens
parser.mly	135	Parses tokens into an AST
ast.ml	50	Defines acceptable AST structure
pyast.ml	38	Defines acceptable python AST structure
compile_sc_py.ml	377	Translates geo AST to python AST
compile_to_pycode.ml	78	Generates python code
geo_sc_py.ml	13	Top level

Semantic Check

- Semantic Check
  - Use StringMap to implement translation environments
    vars: keep information about variables
    funcs: keep information about functions
    func_opt: keep information about types of function parameters
  - Check for:
    undeclared variables and functions
    mismatched types
    wrong types
    function parameters not match
    undefined operations
    Geo syntax error
    …..

Code Generation

- Algorithm Example (demo_fb.g)

test-gcd.g

```
@panel gcd
function gcd(a:int, b:int):int:
    if (a<b):
        return (gcd(b,a));
    else:
        if (a == b):
            return (a);
        else:
            return(gcd(a-b, b));
        end
    end
end
print(gcd(70,28));
print(gcd(147,21));
@end
```

test-gcd.py

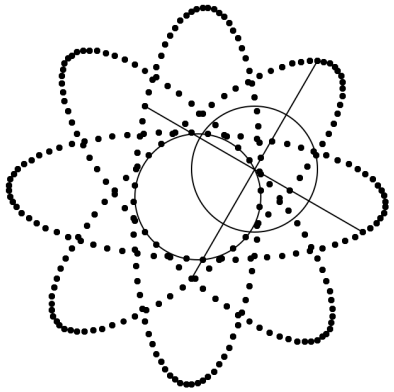
```
from Tkinter import *
from sysgeo import *
def gcd(a, b):
    if (a < b):
        return gcd(b, a)
    else:
        if (a == b):
            return a
        else:
            return gcd((a - b), b)
PI = 3.14159265359
print gcd(70, 28)
print gcd(147, 21)
```

Code Generation

- Algorithm Example

```
@panel qsort
function qsort(a:list, l:int, r:int):list:
   i = l;j = r; mid = (l+r)/2;
   while (i <= j):
      while (i <= j & a#[i] < a#[mid]):
               i = i+1;
      end
      while (i <= j & a#[j]> a#[mid]):
               j = j-1;
      end
      if (i <= j):
               k = a#[i];a#[i] = a#[j]; a#[j] = k; i = i+1;j = j-1;
      end
   end
   if (l < j):
      a = qsort(a, l, j);
   end
   if (i < r):
      a = qsort(a, i, r);
   end
   return(a);
end
b = {3,7,8,32,1,4,7,9,2,5}; b = qsort(b, 0, len(b)-1); print(b);
@end
```

Code Generation



- Graph Example

```
@panel panel1
c1 = circle([0, 0], 2);
c2 = circle([2, 0], 2);
l1 = line([2,-4],[2,4],0,0);
l2 = line([-2,0],[6,0],-2,6);
r1=runset(360,0.05);
r1.addPara(c1,'r');
r1.addPara(c2,'r');
r1.addPara(l1,'b');
r1.addPara(l2,'b');

run r1:
    p1 = c1.getPointbyarc(r1.getRuncount()*PI/(-36));
    print(p1);
    l1.rotateonPoint(p1,PI/36);
    l2.rotateonPoint(p1,PI/36);
    c2.setCenter(p1);
    t1=l1.getEndpoints();
    r1.mark(t1#[0]);
    r1.mark(t1#[1]);
    t1=l2.getEndpoints();
    r1.mark(t1#[0]);
    r1.mark(t1#[1]);
end
@end
```

```
PI = 3.14159265359
c1 = circle(dot(0, 0), 2)
c2 = circle(dot(2, 0), 2)
l1 = line(dot(2, -4), dot(2, 4), 0, 0)
l2 = line(dot(-2, 0), dot(6, 0), -2, 6)
r1 = runset(360, 0.05)
r1.addPara(c1, 'r')
r1.addPara(c2, 'r')
r1.addPara(l1, 'b')
r1.addPara(l2, 'b')
def runfun__(r1):
    p1 = c1.getPointbyarc(((r1.getRuncount() * PI) / -36))
    print p1
    l1.rotateonPoint(p1, (PI / 36))
    l2.rotateonPoint(p1, (PI / 36))
    c2.setCenter(p1)
    t1 = l1.getEndpoints()
    r1.mark(t1[0])
    r1.mark(t1[1])
    t1 = l2.getEndpoints()
    r1.mark(t1[0])
    r1.mark(t1[1])
########################################
```

Testing

Test case statistics – comprehensive check

File	Lines	File	Lines	Role
test-assignments.g	14	test-assignments.ref	6	All kinds of assignments
test-circle.g	19	test-circle.ref	12	Geo type circle & obj funcs
test-comparison.g	11	test-comparison.ref	6	Comparison & boolean opts
test-dot.g	7	test-dot.ref	3	Geo type dot & obj funcs
test-fib.g	18	test-fib.ref	9	Recursive function
test-for.g	5	test-for.ref	10	For statements
test-function.g	37	test-function.ref	1	Function & if & while
test-gcd.g	15	test-gcd.ref	2	Function & if statement
test-if.g	11	test-if.ref	1	If statements (nested)
test-line.g	35	test-line.ref	15	Geo type line & obj funcs
test-list.g	8	test-list.ref	4	List
test-operations.g	20	test-operations.ref	9	Check +-*/^% opertations
test-polygon.g	20	test-polygon.ref	11	Geo type polygon & obj funcs
test-print.g	10	test-print.ref	8	Print function
test-qsort.g	35	test-qsort.ref	1	List & recursive function
test-while.g	7	test-while.ref	6	While statement

Testing

Test case statistics – error check

File Name	Lines	Role
error-semantics1.g	2	Undeclared funtion
error-semantics2.g	5	Funtion input para type error
error-semantics3.g	6	Undefined argument
error-semantics4.g	3	Char cannot plus int/float
error-syntax1.g	1	Lose end
error-syntax2.g	1	Unrecognized token
error-syntax3.g	1	Lose semicolon
error-syntax4.g	2	Wrong function declaration
error-syntax4.g	1	If statement error

Testing

- Auto check – geotestall.sh

First: Check whether all files can be successfully compiled;
Then: Compared the output with the ref answer.

```
Compiling tests/test-assignments.g...
Compiling tests/test-circle.g...
Compiling tests/test-comparison.g...
Compiling tests/test-dot.g...
Compiling tests/test-fib.g...
Compiling tests/test-for.g...
Compiling tests/test-function.g...
Compiling tests/test-gcd.g...
Compiling tests/test-if.g...
Compiling tests/test-line.g...
Compiling tests/test-list.g...
Compiling tests/test-operations.g...
Compiling tests/test-polygon.g...
Compiling tests/test-print.g...
Compiling tests/test-qsort.g...
Compiling tests/test-while.g...
diff -b tests/test-print.out tests/test-print.ref > tests/test-print.diff
tests/test-qsort
diff -b tests/test-qsort.out tests/test-qsort.ref > tests/test-qsort.diff
tests/test-while
diff -b tests/test-while.out tests/test-while.ref > tests/test-while.diff
OK
###### SUCCESS
```

Lessons Learned

- Qi Wang:

  "Start early on the project and make a plan ahead, if things are different from scheduled, discuss together and activate soon."

- Yuechen Zhao:

  "Effective communications are the key to success, do not waste too much time on arguing plans, but discussion is important."

- Zichen Chao:

  "Keep the whole picture in mind, modify the plan as the project progressed and learn Ocaml as early as possible!"

- Ziyi Luo:

  "Comprehensive test cases are important and test early, you can never imagine how many problems you may encounter when testing."