**Geo**

A geometric solution language

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# Chapter 1 – Introduction

Geo is a geometric solution language that enables students, physicists, mathematicians, as well as other geometry-interested professionals to solve spatial problems efficiently. It involves functionalities that computes relationships among geometric figures, including lines, circles, and rectangles, etc. Users are able to define figures, set their moving patterns, and perform various analysis (including static and dynamic analyses) of the interacting figures. If desired, a user can also change the moving pattern or shape of objects.

## 1.1 Motivation

Many complex problems can be solved with graph beautifully, however, most standard programming languages do not have convenient tools for creating and manipulating graphs, especially dynamic graphs. So we decide to design a simple while powerful graph oriented programming language, Geo. It provides built-in support for graph, so users can define graphs in an intuitive way. In addition, the most important part about Geo is that graphs can move and interact, allowing dynamic analysis with a user-friendly interface.

## 1.2 Key Features

### 1.2.1 Geometric Specific

We provide an intuitive way for declaring graphs, defining relationships and make calculations. Users can declare a line by specifying the start point and end point. Users can also calculate the intersecting point of a line and a circle by a single command.

### 1.2.2 Dynamic Movement

Users can define moving objects in Geo, and see the animations directly through our panel interface. Dynamic analysis can be done easily with run statement, which will be explained in detail in the Language Tutorial part.

### 1.2.3 Complete Programming Functionality

Geo also has complete functionality as a normal programming language, simple algorithms such as Fibonacci number can be expressed in Geo in a recursive or iterative fashion; more complicated algorithms such as Dijkstra's shortest path algorithm can also be expressed.

# Chapter 2 - Language Tutorial

## 2.1 Basic Structure of a Geo Program

The hello world example of Geo is provided below, which contains a simplest function which takes in no arguments and only executes print.

// hello word

function hello(): void:

print("Hello World!");

end

## 2.2 Built-in Data Types and Variable Assignment

Geo supports the following primitive types: int, float, bool, char and string. The code below illustrates on how to assign values for built-in data types. One thing to notice is that we do not need to specify the types of variables because Geo knows types implicitly.

x = 10;

c = ’a’;

s = "hello";

flag = true;

## 2.3 Control Structures

The code below shoes the usage of if-else statement, for loop and while loop. It should print -1, h, e, l, l, o, 0 successively.

a = 0;

if(a>0):

a = a + 1;

else:

a = a - 1;

end

print(a);

for i in "hello":

print(i);

end

while(a<0)

a = a + 1;

print(a);

end

## 2.4 Writing and Calling a Function

The function declaration consists of the function keyword, function name, input arguments and their types, and finally a return type followed by a colon. A Geo program has no entry function, so main() is not necessary. The function body is all the statements above the end keyword. Below is an example of a recursive gcd algorithm that illustrates the usage of 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

## 2.5 Advanced Date Types

For all primitive types, Geo has a corresponding array type. To declare an array, the size of the array is explicitly written in “[ ]” on the left side. The following example illustrates that, a does not have an associated data type until it is initialized, and its type cannot be changed then.

a[3];

a = [0, 0, 0];

## 2.6 Geometric data types

Geo supports geometric types including dot, line, polygons and circle. For geometric type, the declaration is quite different from the basic type variable declaration. For example, the declaration and initialization of a dot is shown as follow:

dot1 = [1.5,4.0];

dot2 = [3.0,4.0];

line1 = [dot1, dot2];

A dot has a x coordinate value and a y coordinate value which should be defined simultaneously, and a line has a start point and an end point. More on this are in chapter 3.

## 2.7 Defining graphs

A typical Geo program of graphs includes:

panel presets;

function declaration and definition;

geometric shape declaration and initialization;

runset declaration and initialization;

run statement description.

An example follows the above structure description is shown:

//panel presets

@panel panel\_demo

@mode figure

//function declaration and definition

function print\_dot\_list(dots[]:dot):void:

for d in dots:

print(d.getX(),' ',d.getY(),'\n');

end

end

//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

This example defines a function called print\_dot\_list to print every dot’s coordinates in a dot set using for loop. Then it declares a line and a circle, and they are set to move dynamically through setRunstep which lets objects move one step per second.

# Chapter 3 - Language Reference Manual

## 3.1 Lexical Elements

This section specifies the lexical elements of Geo programming language.

### 3.1.1 Seperators

Geo compiler regards the following char as the characters to separate tokens:

' '

'\t'

'\n'

At least one of these characters is required to separate otherwise adjacent identifiers, constants, and certain operator-pairs. Arbitrary combination of such characters to separate tokens is permitted for the Geo compiler will automatically ignored such characters when analyzing the program.

### 3.1.2 Comments

There are two kinds of comments in Geo:

Multiple-line comment: all the text in /\* comments \*/ is ignored (as in C and Java):

/\* text \*/

Single-line comment: all the text after // to the end of the line is ignored (as in Java):

// text

### 3.1.3 Identifiers

An identifier consists of a sequence of letters, digits and '\_', where the first character must be a letter. Identifiers are case-sensitive in Geo.

The following identifiers are legal:

abc

a7G

Foo

a\_b

The following identifiers are illegal:

7a

\_a

### 3.1.4 Keywords

The following identifiers are reserved as the keywords and cannot be used as identifiers.

bool

break

char

const

dot

elif

else

end

float

for

function

if

import

in

int

list

model

return

run

string

submodel

void

while

### 3.1.5 Constants

#### 3.1.5.1 Integer Constants

An integer constant is a sequence of digits starts with an optional positive/negative sign.

0

1

20

+210

-15

#### 3.1.5.2 Float constants

A float constant consists of an integer part, a decimal part, a fraction part, an e, and an optionally signed integer exponent. The integer and fraction parts both consist of a sequence of digits. Either the integer part, or the fraction part (not both) may be missing; either the decimal point or the e and the exponent (not both) may be missing.

1.0

.5

2e3

5e-5

2.5e+10

#### 3.1.5.3 String Constants:

A string constant consists of a sequence of characters enclosed in double quotes.

"Hello world!"

"1234567890"

"Name\tID\tScore\n"

#### 3.1.5.4 Mathematical Constants

Mathematical constants include some frequently used parameters such as:

PI = 3.14159

### 3.1.6 Separators

Several characters are used as the separators:

( ) { } [ ] ; , .

Note that ';' denotes the end of a sentence. '.' is the access operator.

### 3.1.7 Operators

Following characters are regarded as the operators by Geo compiler:

|  |  |  |
| --- | --- | --- |
| Operator | Usage | Associativity |
| = | Assignment | Right |
| == | Equal to | - |
| != | Unequal to | - |
| > | Greater | - |
| >= | Greater or equal to | - |
| < | Less | - |
| <= | Less or equal to | - |
| & | Logic AND | - |
| | | Logic OR | - |
| ! | Logic NOT | Right |
| + | Addition | Left |
| - | Subtraction | Left |
| \* | Multiplication | Left |
| / | Division | Left |
| . | Access | Left |
| ^ | Exponentiation | Left |
| % | Modulo | Left |

The precedence of operators is as follows:

**.**

**\* / % ^**

**+ -**

**> >= < <=**

**!**

**& |**

**== !=**

**=**

## 3.2 Data Types

This chapter introduces all standard data types in Geo.

### 3.2.1 Basic Types

Basic Types includes int, float, bool, char and string.

For integer type int, the data ranges from -2147483648 to 2147483648.

For floating point type float, the data ranges from about -3.4E+38 to +3.4E+38.

For boolean type bool, it has two optional value true and false.

For character type char, the data ranges from NUL to DEL, that is, from 0 to 127.

For character string type string, the data consists of zero or more characters enclosed in double quotes. string is a powerful data type with several build-in functions in Geo STD library. Please refer to Geo STD library in 3.6 for more information about string.

### 3.2.2 Geometric Types

Geometric types includes geometric control type runset and geometric shapes include dot, line, polygons and circle.

#### 3.2.2.1 runset

Geometric control type runset is a data type to be recognized by the keyword run. In Geo STD library, runset is defined as:

model runset: runset(times\_of\_run:int,

g1:geometric\_shape, run\_para\_g1:char, ...);

times\_of\_run denotes the times that the run statement will execute. Note that the input of runset is not limited. After the first parameter times\_of\_run, the definition of runset allows unlimited **pairs** of geometric\_shape and run\_para\_g1. The parameter of the geometric instant (i.e., run\_para\_g1) must be set with a runstep using setRunstep function before adding to the runset. Otherwise, compilers will raise parameter\_unset error. For more build-in functions of runset, please refer to Geo STD library in 3.6.

#### 3.2.2.2 dot

Geometric shape dot represents a dot in panel. In Geo STD library, dot is defined as:

model dot: dot(x:float, y:float);

dot is a very special geometric type. The instantiation of a dot is quite different from other geometric shapes. Please refer to Section 4.1 for more information. For more build-in functions of dot, please refer to Geo STD library in 3.6.

#### 3.2.2.3 line

Geometric shape line represents a line (either finite or infinite long) in panel. In Geo STD library, line is defined as:

model line:

line(a:float,b:float);

line(dot1:dot,dot2:dot);

line(a:float,b:float,endpointx1:float,endpointx2:float);

line(dot1:dot,dot2:dot,endpointx1:float,endpointx2:float);

Any of the above four definitions can be used to initialize a line object. endpointx1 and endpointx2 are the x-coordinates of two endpoints of a line. For more build-in functions of line, please refer to Geo STD library in 3.6.

#### 3.2.2.4 polygons

Geometric shape polygons is a set of different shapes. Polygons has two special cases: Triangle Tri and Rectangle Rec. Polygons is defined as:

model polygons: polygons(num\_of\_apex:int,apex[]:dot);

Note that apex[] is a list of dots. For list, please refer to Section 3.3. Note that the length of apex must be exactly as num\_of\_apex and the apexes in the list should be in a reasonable order (i.e., either clockwise or counterclockwise). For more build-in functions of polygons, please refer to Geo STD library in 3.6.

#### 3.2.2.5 circle

Geometric shape circle represents a circle in panel. In Geo STD library, circle is defined as:

model circle: circle(center:dot,radius:float);

A circle is defined with a center coordinate and a radius. For more build-in functions of circle, please refer to Geo STD library in 3.6.

### 3.2.3 list

list is a set of a certain type of objects. A list contains a number of variables. The number of variables may be zero, in which case the list is said to be empty.

A list named listdemo with length of length\_of\_list and type of t is defined as:

listdemo[length\_of\_list]={t1:t,t2:t, … , tlength\_of\_list:t};

Syntax to get the nth element in listdemo is simple: listdemo[n-1];

For more build-in functions of list. For all lists, Geo offers several build-in functions shown as bellow:

function empty():bool;

function length():int;

function insert(ele:type\_in\_list);

function remove(order:int);

### 3.2.4 model

model is a keyword that allows users to define their own data type. Typically a model is built as follow:

model modelname:

variable declaration;

model initialization function;

function declaration;

end

model initialization function is a special function without return value and function keyword. The name of the initialization function is the same as name of the model.

## 3.3 Expressions

### 3.3.1 Variables

Variable consists of two parts: name and value. Name of a variable must be a legal identifier mentioned in Section 2.2. value of a variable depends on the data type of the variable.

#### 3.3.1.1 Basic type variable declaration and initialization

For basic types, the variable declaration and initialization is quite straightforward:

//Initialize an int named i with value equals 2

i = 2;

//Initialize a float named afloat with value equals 3e-5

afloat = 3e-5;

//Initialize a bool named judge with value equals true

judge = true;

//Initialize a char named c with value equals 'c'

c = 'c';

//Initialize a string named str with value equals "str"

str = "str";

Variables declaration without initialization is also allowed in Geo, the declaration rule is identifier:data\_type:

i:int;

afloat:float;

judge:bool;

c:char;

str:string;

#### 3.3.1.2 Geometric type variable declaration and initialization

For geometric type, the declaration is quite different from the basic type variable declaration. To declare a dot, the declaration and initialization are shown as follow:

dot1 = [1.5,2.2];

A dot is declared with two float parameters within a pair of square brackets. For other geometric types, the declaration and initialization examples are shown as follow:

//Declare a line y=3x+2 with x in [0,5.5].

line1 = line(3.0,2.0,0,5.5);

//Declare a circle (x-5)^2+(y-10)^2 = 6.2^2

circle1 = circle([5,10],6.2);

//Declare a pentagon with apex [0,0][2,0][2,2][1,5][0,3]

apex = {[0,0],[2,0],[2,2],[1,5],[0,3]};

pentagon = polygons(5,apex);

//Declare a line without initialization.

line2:line;

//Declare a polygon without initialization.

pentagon:polygon;

### 3.3.2 Presets

Presets occur at the beginning of the Geo program (except @end). Basic analyzing environment is set in presets. Each preset begins with an @ sign.

@panel panelname (essential) defines a panel with a legal identifier panelname.

@mode workingmode (optional) defines the mode that the program will be executed in. workingmode could be either console or figure. By default it works in console mode.

@co cosystem (optional) defines the coordinate system to be either cartesian or polar. By default it works in cartesian coordinate system.

@end (essential) indicates the boundary of a specific panel.

## 3.4 Functions

This chapter introduces functions in Geo. Functions are the key of extending the usage of models and solving geometric problems. Geo provides a powerful STD library for geometric problem solution while most of the methods in STD library are encapsulation in functions.

### 3.4.1 Function Declarations

A function is declared as the following rule:

function func\_name(parameter:parameter\_type,...):return\_type;|

Here function is the keyword for function declaration. func\_name is the identifier for this function. input parameters must be in the form of identifier:data\_type. return\_type is the type of the return value. If the function does not have a return value, :return\_type part should be :void.

Note that when list is used as the return value of a function, the return\_type is shown as : datatype[]. For example, when return value is a float list, the return\_type is float[].

### 3.4.2 Function Definitions

A typical function definition is shown as below. Note that keyword const in the first line of the function definition is an *optional* word; :return\_val\_type and return value(s); is not needed when the function do not have a return value(s);

function func\_name(para:para\_type const,...):return\_val\_type:

local\_variable declaration and initialization;

function operations;

return value(s);

end

Note that, local variables are available only in the domain of a function. All local variables will be terminated as the function ends. All parameters of functions are reference parameters in default, which means that if the input parameters are modified in the function, the parameter will keep that change after the execution of the function. The keyword const is required to avoid modifying input parameters and is strongly recommended to add in if needed.

### 3.4.3 Calling Functions

A function is called as the following rule:

val = func\_name(para1,para2, ...);

As for the functions in models. The function is called as:

val = model\_instant\_identifier.func\_name(para1,para2, ...); |

## 3.5 Compound Statements

### 3.5.1 The if Statement

A if-elif-else control flow follows the following rule:

if (condition1):

statement1;

elif (condition2):

statement2;

else:

statement3;

end

if, elif, else and end are keywords for the control flow. Condition 1 through condition 2 defines conditions to enter the if/elif cases, and statements 1 through 3 defines the statements to execute in three corresponding cases.

### 3.5.2 The while Statement

A while loop follows the following rule:

while (condition):

statement;

end

while and end are keywords for the while-loop statement. The condition defines the condition when one continues entering the while-loop. The statement defines the code to execute inside the loop.

### 3.5.3 The for Statement

A for loop follows the following rule:

for element:element\_data\_type in set:

statement;

end

for and in are keywords in the for-loop statement. The element denotes an element in the set, and after the execution of a for-loop statement, all elements in set should be iterated exactly once. The statement denotes the statement to execute when one enters the loop.

### 3.5.4 The run Statement

run is a keyword for dynamic geometric analytics. Each run must correspond to an instant of runset. Each geometric shape that will be dynamically analyzed in the run statement must be added into the runset instant at first. A typical run statement is shown as follows:

run runset\_name:

dynamic analytics sentences;

change parameters for the next time run;

end

## 3.6 STD Library Reference

This chapter introduces the STD library of Geo. STD library (std.glib) is a file preloaded by Geo compiler before compiling the programs. STD library includes system functions declaration, geometric types (including build-in functions) declaration.

Part A: System constant declaration.

PI = 3.14159;

Part B: System function declaration.

function print(info:int const, ...):void;

function print(info:float const, ...):void;

function print(info:char const, ...):void;

function print(info:bool const, ...):void;

function print(info:string const, ...):void;

function int\_to\_string(input:int const):string;

function float\_to\_string(input:float const):string;

function bool\_to\_string(input:bool const):string;

function char\_to\_string(input:char const):string;

Part C: Geometric types declaration.

//controltype runset

model runset:

runEnable:bool;

times\_of\_run:int;

shape[]:geometricShape;

runpara[]:char;

runset(times\_of\_run:int, g1:geometricShape, run\_para\_g1:char, ...);

function refresh():void;

function addElement():bool;

function removeElement(g:geometricShape,para:char):bool;

function enableRun():void;

function disableRun():void;

end

model geometricShape:

step[]:float;

stepSet[]:bool;

geometricShape();

end

//geometricShape submodel: dot

//dot parameter name: 'x' 'y'

model dot:

topmodel(geometricShape);

step[2]:float;

stepSet[2]:bool;

dot(x:float, y:float);

function getX():float;

function getY():float;

function distance(dot1:dot const):float;

function distance(line1:line const):float;

function setRunstep(val:float,pos:char):void;

function getRunstep(pos:char const):float;

end

//geometricShape submodel: line

//line parameter name: 'a' 'b'

//line formula y = ax + b

model line:

topmodel(geometricShape);

step[2]:float;

stepSet[2]:bool;

endPoint[2]:dot;

endPointset:bool;

a:float;

b:float;

line(a:float,b:float);

line(dot1:dot,dot2:dot);

line(a:float,b:float,endpointx1:float,endpointx2:float);

line(dot1:dot,dot2:dot,endpointx1:float,endpointx2:float);

function getPara(pos:char const):float;

function getY(x:float const):float; //Exception may occur.

//If endPointset = false, return [0,0]

function getMidpoint():dot;

function setRunstep(val:float,pos:char):void;

function getRunstep(pos:char char):float;

function intersect(polygon1:polygon const):dot[];

function intersect(circle1:circle const):dot[];

end

//geometricShape submodel: circle

//circle parameter name: 'a' 'b' 'r'

//circle formula r^2 = (x-a)^2 + (y-b)^2

model circle:

topmodel(geometricShape);

step[3]:float;

stepSet[3]:bool;

a:float;

b:float;

r:float;

circle(center:dot,radius:float);

function setRunstep(val:float,pos:char):void;

function getRunstep(pos:char):float;

function getCenter():dot;

function getRadius():float;

//Out\_of\_range Exception may occur.

function getY(x:float const):float[];

function intersect(polygon1:polygon const):dot[];

function intersect(circle1:circle const):dot[];

end

//geometricShape submodel: polygons

//polygons parameter name: 'a' 'b' ...

//polygons formula: A set of dots

model polygons:

topmodel(geometricShape);

step[]:float;

stepSet[]:bool;

apexs[]:dot;

polygons(num\_of\_apex:int,apex[]:dot);

function setRunstep(val:float,pos:char):void;

function getRunstep(pos:char):float;

function getCenter():dot;

function getRadius():float;

//Out\_of\_range Exception may occur.

function getY(x:float const):float[];

function intersect(polygon1:polygon):dot[];

end

# Chapter 4 - Project Plan

## 4.1 Project Management

### 4.1.1 Planning

Our group members met every Friday afternoon since we were all available at that time. The whole project was divided to 4 stages, proposal, language design, basic functions implementation and graph functions implementation. Initially we worked individually on small problems, but as the project progressed, we found it more efficient to work together on major challenges. We chose CLIC as our main workspace, most part of this project was finished there.

### 4.1.2 Specification

We intended to implement everything exactly as stated in the LRM, however, later we realized that it was impossible to stick to it since many problems were not considered in the LRM. So we decide to update the reference manual as we develop our language. For example, in the first version of LRM we required user to specify the data type of iterator and set in the for loop, but since the iterator must belong to set there was not need to specify its type. And some features in the first LRM are not implemented because they are too hard or not necessary. For example, we planned to let the panel capable of showing two images at one time, however, in python it was too hard to realize, so we had to skip this part.

### 4.1.3 Development

To coordinat works of different members and keep track of our progress, we use Git as our version control system with Github as the host. When members have completed and tested their works, they push them to the master branch of our Geo project. Then we will look over the codes together, make improvements and combine different parts. Most time we work together in CLIC, especially the final stage of the project, because we can discuss together if any problem occurs.

### 4.1.4 Testing

A first simple test case was written for the hello world demo. Then we added many individual test cases, each focusing on some small functions of the language. Since the project is quite big in size, we have to test it this way otherwise we may easily get confused about which part is wrong. Also each test case is prepared with an expected result, if the actual output of the source code is not the same as our expected output then the compiler needs correction of this function.

## 4.2 Programming Style Guide

 • Initial lower case for function and variable names.

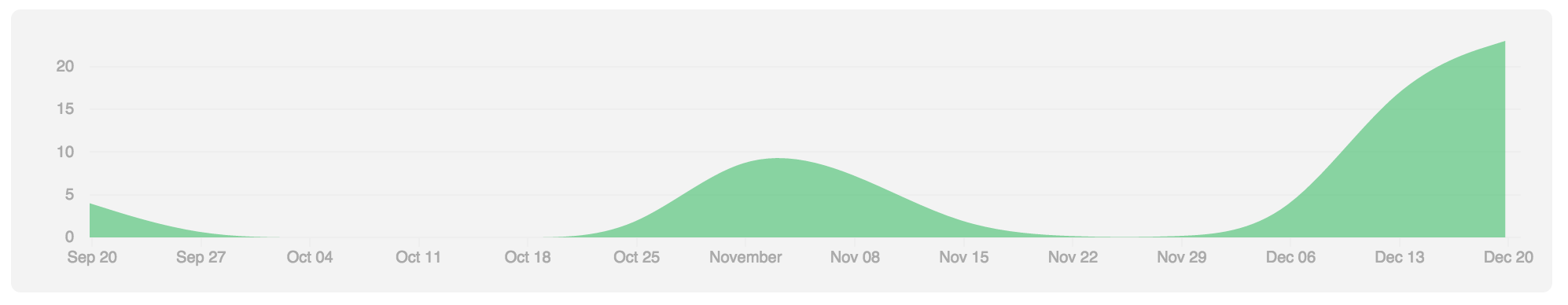
• Codes after the “let” statement and pattern matching are indented.

• Avoid breaking expressions over multiple lines.

• Commonly reused code are written as a helper function.

## 4.3 Project Timeline

The following graph shows our commits to Github during the whole semester.



Sep 28, 2015

Finished proposal

Oct 15, 2015

Started with LRM

Oct 25, 2015

Finished LRM

Oct 30, 2015

Started with scanner and parser, AST

Nov 02, 2015

Finished scanner, parser and AST, started with compiler

Nov 07, 2015

Continued on compiler, modified parser and AST

Nov 07, 2015

Finished compiler, prepared simple test cases

Nov 16, 2015

Hello world demo

Nov 20, 2015

Started with semantic check, code generation and testing

Nov 30, 2015

Continued on semantic check, code generation, and testing

Dec 06, 2015

Updated SAST, code generator, added test cases

Dec 16, 2015

Finished with SAST and code generator, added more test cases

Dec 17, 2015

Started with final report, prepared for demo

Dec 20, 2015

Finished final report, demo worked well

Dec 21, 2015

Final presentation

## 4.4 Roles and Responsibilities

Zichen Chao - System Architect (worked on paser, ast, compiler, the major contributor of sast)

Qi Wang – Product Manager (worked on parser, ast, copiler, wrote final report and slides)

Yuechen Zhao - Language Guru (designed language features and helped with python functions)

Ziyi Luo – Tester (worked on scanner, created test suites and Geo python libraries)

## 4.5 Software Development Environment

The Geo project was built on OS X and as stated above, Git was used as a distributed version control system and Github was the host. We used sublime to write the compiler, including the scanner, parser, ast, sast, compiler and test cases. The language we used was mainly OCaml, and python for augmenting the graph visualization and animation. Lastly, makefiles were used to automate the process of compiling, shell scripts were used for testing.

## 4.6 Project Log

commit 010405f8865a579145149643400ffd5e7f566fa5

Author: Qi Wang <wang.qi@columbia.edu>

Date: Mon Dec 21 18:23:47 2015 -0500

add final final ppt

commit 5ce5019d9b2c2358d298349a61863194bc2e776b

Author: Qi Wang <wang.qi@columbia.edu>

Date: Mon Dec 21 18:20:28 2015 -0500

add ppt pdf

commit 3821402449cedaa8926b8cdbd7f12ff681cb21c8

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 17:35:32 2015 -0500

FINAL FINAL ppt

commit f1faebc79e6ad49f6073fbc309fe9160ff57a305

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 17:17:17 2015 -0500

BUGBUGBUG

commit f1b41d62f0576948851425790b54d80b3612b747

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 17:07:11 2015 -0500

ppt final version

hehe

commit d2cbd5637eed029ccf5932ddca37689526be0e82

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 16:51:14 2015 -0500

ppt

commit 46d7898ecbd6fbff132223870c7b1b947892a679

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 16:36:33 2015 -0500

ppt update

hehehe

commit 354fd045ba786b2d0488c98fe82aa21ed2871090

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 15:56:26 2015 -0500

Add code graph-ppt

commit eb2a5322704424f5270884073ff2c3907bcb8a42

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 15:28:39 2015 -0500

Update geo shell for producing independent executable python code

commit 8fbaa4ad0d37347b2e8d3f3af6a3a3b86f355468

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 14:40:55 2015 -0500

Clean older files and for better presentation

commit 50a9b858ea5a2248f4de1d13e2b3d5d54de6b4a9

Author: Qi Wang <wang.qi@columbia.edu>

Date: Mon Dec 21 12:17:33 2015 -0500

Update report and ppt

commit 8d98d44fd4a5d0c228bfd58af9cbf9aa0566c781

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 07:50:29 2015 -0500

Updates all test sets

commit 082076749ec07bf02c146f5346c50df84da45f64

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 05:56:29 2015 -0500

Update sysgeo.py

commit ac3317afb04e67bc9ba3eafb866991b73060f96f

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 05:46:45 2015 -0500

polygon shape

commit e9de5defcffd735b0dd6923243feba701ccfe058

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Dec 21 04:59:50 2015 -0500

Demo 1 Done

commit 5ee3c9d8b43f1f333c20995fbf4a98341171a891

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 04:08:19 2015 -0500

add rule

commit 77cf3b40d3a471dc0f72d5cfe275602dfea95f5e

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 04:04:05 2015 -0500

insert

commit 506494575f9cb4bdb19bbdef884de6d0bf5ef173

Author: Qi Wang <wang.qi@columbia.edu>

Date: Mon Dec 21 03:49:56 2015 -0500

Presentation PPT

commit 6d61734c0af2b37405ece4c33d3161bf62103c1c

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 02:38:46 2015 -0500

error checkings

commit 0dcc80a158c22894ce4d0186dbf23cc4554c1e9a

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 02:06:23 2015 -0500

gui demo 1

commit 90188e54712e0a97e9a0b72fab8015065f2b09e2

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 02:15:30 2015 -0500

rewrite run, break

commit e4588f00a4d5c7659c8b13dc37a429368759a2b4

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 01:38:48 2015 -0500

polygon added

commit c14f60d417d78c3fbf1c694805cc2ea572fc1fe6

Merge: 72a57d8 8fd94ba

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 01:32:14 2015 -0500

Merge branch 'master' of github.com:chaozc/Geo

commit 72a57d888d628262576c17bd7fc0d97f4698349c

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Dec 21 01:31:40 2015 -0500

list element fixed

commit 8fd94baad3e63c235c444d2639308f31895aefe7

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-179-18.dyn.columbia.edu>

Date: Mon Dec 21 00:22:57 2015 -0500

Gui

hahaha

commit 4b6faf936d95a80de91fd8b19c3233b11b6bfd43

Author: 江桐 <koukiri@dyn-129-236-238-220.dyn.columbia.edu>

Date: Sun Dec 20 23:00:04 2015 -0500

report

commit 5f7cc71644deafa2ad3e15fe7ad82bdd16f5bc10

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 19:29:26 2015 -0500

getEndpoints added

commit 47903b10fef2a7062bce21797ca02b2be78d3eac

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 19:27:29 2015 -0500

not found error fixed

commit db3d59acb40951bec56d1abf1009312dea1dce1d

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 19:19:42 2015 -0500

hardcode removed & syslib updated

commit 4d5786565aa59e0099d3678159cf8b889cee8623

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 19:07:48 2015 -0500

hardcode removed & syslib updated

commit fe8dcf5df7b01ad9656c0f713daf8815bd4758b0

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 18:35:27 2015 -0500

func tab fixed, sysfunc updated, semantic check updated

commit 2ab7d2a8b2c6a6fa9befc3a97873bd509d8ef3ff

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 16:53:25 2015 -0500

char eq

commit 4ed4cb4c36c95042a99e84d8fdee56b53aa4e87a

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 16:52:45 2015 -0500

char eq

commit 020981f7e099c9da15718c3e43ecc680bd60526f

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 16:38:52 2015 -0500

delete sympy

commit f7151c6d900551ffc67a2e630052804113954a06

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 16:37:20 2015 -0500

tab fixed

commit 910598c6992001af2d57a8b42261aecf50c37481

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 15:46:34 2015 -0500

and or<->eq neq

commit eebb8adbc3539d290b6b3bafb4a6ea8a5d75c824

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 15:45:25 2015 -0500

python ast added

commit 09f0e5fd0f65da7f57e853b3da246473a4f8adea

Author: chaozc <zichen.chao@gmail.com>

Date: Sun Dec 20 13:20:32 2015 -0500

import sysgeo

commit 198101f441966b042b7fb36c15472b5508df19c7

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sun Dec 20 02:32:17 2015 -0500

sysgeo - fix bugs in line.rotatebyarc

commit b7100804d457382f5535663407cab1856c7db21e

Merge: 60219f1 57b425b

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 22:41:15 2015 -0500

Merge branch 'master' of github.com:chaozc/Geo

commit 60219f1a16c9a4b7d1a07d3408a455c2e14f394a

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 22:41:01 2015 -0500

for i check

commit 57b425b66945fc25d6dbbc6711528f213957a2da

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Dec 19 22:32:42 2015 -0500

renew sysgeo -> Done without debug

commit 6faae02b88dff8f200f9cb013e24089ddb675d53

Merge: 295ab14 c4ef44d

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 22:02:27 2015 -0500

Merge branch 'master' of github.com:chaozc/Geo

commit 295ab14228f4a6fe9cffe2106dd02f1d049e88d5

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 22:02:11 2015 -0500

list check

commit c4ef44d3e5de5e11d88d598ae4d40ee86f09746b

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-133-196.dyn.columbia.edu>

Date: Sat Dec 19 21:52:38 2015 -0500

gtk graphical

hehehe

commit a459f319cf1d2b28c75cab3818f66500964d552b

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Dec 19 20:23:44 2015 -0500

Renew sysgeo.py

commit e96f70031940729b20da6feae370fafb1777dc1c

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 20:22:13 2015 -0500

list

commit 21ee233ce63a8d8d0743241e73cdf470f30994d9

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 19:09:07 2015 -0500

float, bool fixed

commit 21ba6952ee1946792b73d0a89c4fb95aa3bc6b1f

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 18:46:39 2015 -0500

operator type check

commit 16d0e96c49c48299be5f5443f6ec758bc77e64e6

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 16:45:24 2015 -0500

check function type

commit a99f2028c2070a7c0861530e76ee00070bb329ac

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 16:07:17 2015 -0500

check function type

commit 0b86400f0e680c3c1cea6877641b1a39bbacdd1a

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 15:55:06 2015 -0500

check function type

commit b3aa7a3b8e9b0690a4cf7db2d073375769a30b3c

Merge: 9fa758b 5f9f491

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 15:46:41 2015 -0500

Merge branch 'master' of github.com:chaozc/Geo

commit 9fa758ba405d52a1a57cc3de9018606140d6828b

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 15:46:17 2015 -0500

check function type

commit 5f9f491f5bde1ee017729087f43065fa356dec82

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Dec 19 15:08:33 2015 -0500

New update to sysgeo

commit 20016a043e03e48d884e90bda5fb36763512eefa

Merge: 17b0b0f b6a23ab

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 11:45:06 2015 -0500

merge

commit 17b0b0fcd01f33cb19f637e149e5c6442991fdd3

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Dec 19 11:43:15 2015 -0500

check vars

commit b6a23aba7149dd7bf4639fd5ce944249e6b06c16

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Dec 19 00:14:10 2015 -0500

geo geotype realisation - unfinished

12/18/2015

commit 748bacd67efe60fa41510f5908d402ed6b800d75

Author: chaozc <zichen.chao@gmail.com>

Date: Fri Dec 18 16:24:17 2015 -0500

bool

commit 5f7bd3b2194733e94b5f06e4522de50861bbc056

Author: chaozc <zichen.chao@gmail.com>

Date: Fri Dec 18 16:23:29 2015 -0500

bool

commit c09eedc8ffc8190ec4f56d7198644eb04f5b6470

Author: chaozc <zichen.chao@gmail.com>

Date: Fri Dec 18 15:10:08 2015 -0500

dot circle line

commit 038a36f53fd2624bbb73a753d13be4cf318ffae0

Author: chaozc <zichen.chao@gmail.com>

Date: Fri Dec 18 11:12:23 2015 -0500

chaozc

commit 616e282e41167e19e96a402e6f24305ee0b98c93

Author: chaozc <zichen.chao@gmail.com>

Date: Fri Dec 18 10:52:34 2015 -0500

printT

commit fc61b503abcccd7deb7e198235aa89fd5a8a87f5

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sun Dec 6 22:05:02 2015 -0500

Update: compile .g using geo.sh 12/06/2015

commit 997b54cd3ed9667e71a8097f5c76b84dc4f3a61a

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sun Nov 15 00:22:59 2015 -0500

Update src. Current version 1.1

commit c72f7b3cead595a042df77a3de05e92dea28a58c

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Thu Nov 12 09:32:10 2015 -0500

Geo to python reference in compile.ml 11/12/2015

commit 7eee2e471b3e63bd67ec2e8d0a004eefd2cb15a5

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Wed Nov 11 11:22:58 2015 -0500

Log of syntax and semantic changes

commit 1d11eacb5c4e0f6501564a1ea23bb144d28b625e

Author: chaozc <zichen.chao@gmail.com>

Date: Tue Nov 10 22:29:33 2015 -0500

README

commit 9c69df285eb0b59729d6904b29cd3d75ef6c4517

Author: chaozc <zichen.chao@gmail.com>

Date: Tue Nov 10 21:31:43 2015 -0500

Simple helloworld

commit 026ff619fd00b3cc2ffb977fb1d4ed3db04733e2

Author: chaozc <zichen.chao@gmail.com>

Date: Tue Nov 10 00:19:17 2015 -0500

parser ast v1

commit 1da0285f1c1c521f7d9d04dc73b9d5c7bb13a9f7

Merge: 8d90fe9 006d8cb

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Nov 9 22:47:56 2015 -0500

Merge branch 'master' of github.com:chaozc/Geo

commit 8d90fe9f8697a7c225d46868ddc8612416756adc

Author: chaozc <zichen.chao@gmail.com>

Date: Mon Nov 9 22:46:39 2015 -0500

parser

commit 006d8cb4401b2fb7fc20271c1ba7b03731993f45

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Nov 9 18:59:15 2015 -0500

Update std.glib, current version v0.1 11/09/2015

commit b880e5103ae801b94c7956c5952b1386dcaaf4c0

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Mon Nov 9 11:56:35 2015 -0500

Remove token '@' and add two CFGs 11/09/2015

REMOVE

| '@' { AT }

ADD

| "@end" {ENDOFPROGRAM}

| '@'(['a' - 'z' 'A' - 'Z']+ as pre) {PRESET(pre)}

commit 1047bb793c3ff11b869deb8fa7a67bbe1a093fb6

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Nov 7 22:34:55 2015 -0500

Increase token '@' 11/07/2015

commit 46801b1f7eaf5cd8c4ea254e5375fcb1758061c2

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Nov 7 22:28:55 2015 -0500

Update scanner.mll 11/07/2015

<int> INTEGER -> <int> INTEGERLIT

.etc

commit a26968cc05ed7e72abe846a688b03595f556c471

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Nov 7 20:19:53 2015 -0500

Upload scanner 11/07/2015

Lichen & Qi, please note the comment on the top of scanner.mll.

commit 33c8c0eca445c9ba2e6ae00797af1922148bda90

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Nov 7 18:44:28 2015 -0500

src added

commit be5dcfa1b37e5b7b216f2165ca78f823f49974d5

Author: chaozc <zichen.chao@gmail.com>

Date: Sat Nov 7 16:45:35 2015 -0500

microc sample

commit 8c4af5c1de0d91e8fda4820c66b5839e47f279fa

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Nov 7 16:34:24 2015 -0500

Trivial action 11/07/2015

Delete file "hello"

commit f193478d19f23915946a28e4af1d6cff27446915

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Sat Nov 7 16:30:31 2015 -0500

Update LRM v1.1 11/07/2015

In v1.1, Geo

1. increases keyword "void"

2. modifies (non-return-value) function definition.

commit 9ca3d66442cc095af8749e04e0e3ff72527e7ad1

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Fri Nov 6 17:54:54 2015 -0500

Update 11/06/2015

commit e7d29017141856abe1c77e6bcb10d6d1c84e2394

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Fri Nov 6 17:54:31 2015 -0500

Language Demo v0.0

commit e2387b6e0942128963eeb25d946eb5137700cfad

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Fri Nov 6 17:46:01 2015 -0500

Geo std library 11/06/2015

commit 5988bcff6f7ca9f32b4c7b48e7c4fff8f55ee7c1

Author: Ziyi Luo <zl2471@columbia.edu>

Date: Fri Nov 6 17:41:33 2015 -0500

Reference doc renew 11/06/2015

commit a571b1602f67df940075b7391362caca420b2327

Author: 子仪\_ <samluo@dyn-209-2-216-195.dyn.columbia.edu>

Date: Mon Sep 28 15:21:09 2015 -0400

Mod by Ziyi 09/28

commit e6999a33e9697715c975eba1f27a39cd057e3845

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-178-121.dyn.columbia.edu>

Date: Fri Sep 25 16:47:51 2015 -0400

Proposal Draft

A total draft… Please edit in google docs if its more convenient!

commit f77dc63f8b5cf16fc0865e20bcd7909215c4070b

Author: Yuechen-Zhao <zhaoyuechen@dyn-160-39-178-121.dyn.columbia.edu>

Date: Fri Sep 25 16:44:41 2015 -0400

Hi

commit 12e4127e5c6d5aad6cb60056ed6c38e3b4a82846

Author: Qi Wang <wang.qi@columbia.edu>

Date: Wed Sep 23 23:44:20 2015 -0400

Create hello

commit 727c15962dfcc8e7fab64f20adbbc36cf68cc396

Author: 子仪\_ <samluo@ziyi-deMacBook-Pro.local>

Date: Wed Sep 23 23:40:24 2015 -0400

Ziyi adds a map of Columbia.

commit eaace90218857c2ed4730022310452a6d4d1b0f3

Author: chaozc <zichen.chao@gmail.com>

Date: Wed Sep 23 23:02:49 2015 -0400

first geo file

commit 38602f1aca8ffc03d95250344ca91b80d1f8af3c

Author: chaozc <zichen.chao@gmail.com>

Date: Wed Sep 23 22:50:33 2015 -0400

readme

commit 4cb6d4fd7116a521c96cae76adf103561bb2f566

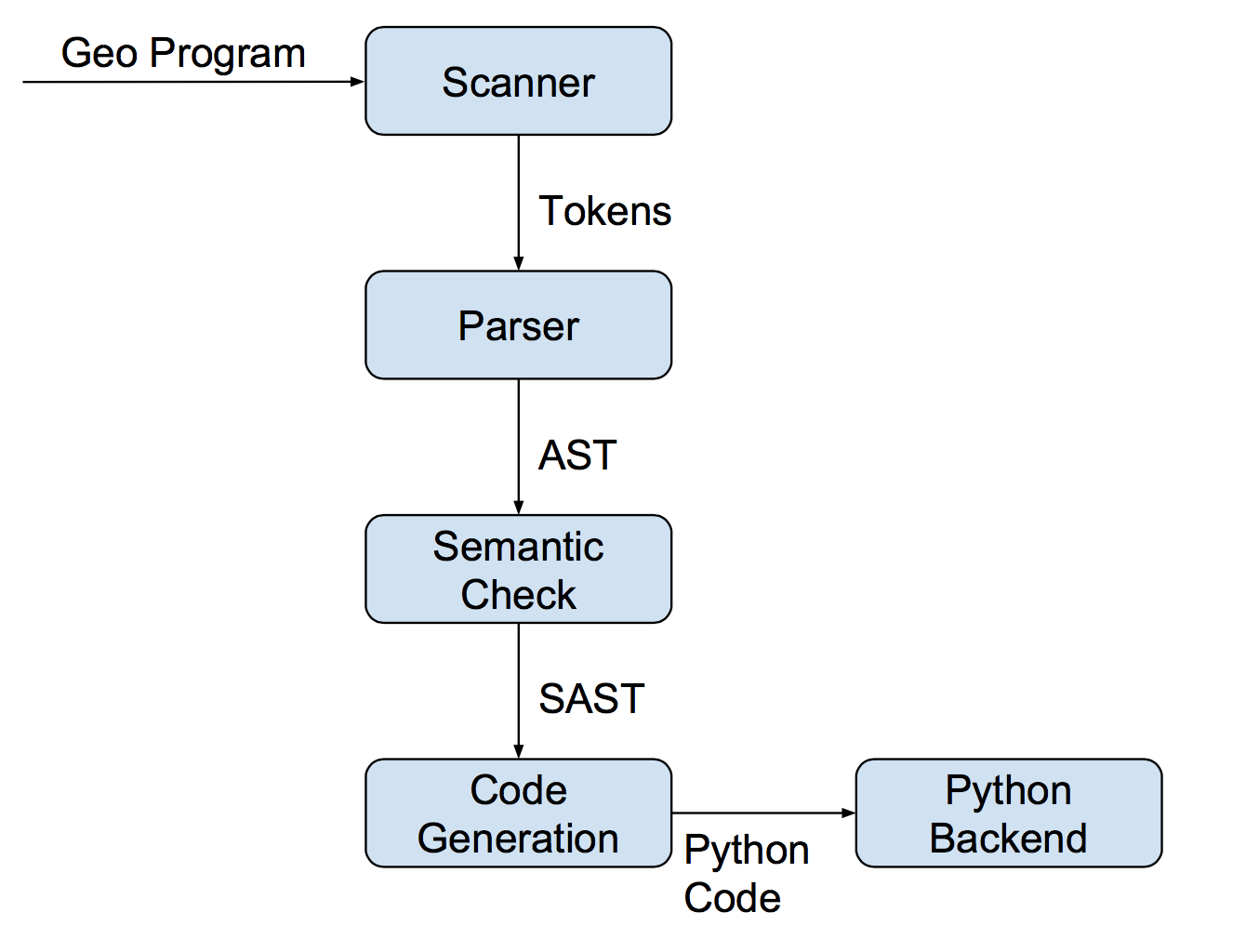
Author: chaozc <zichen.chao@gmail.com>

Date: Wed Sep 23 15:38:09 2015 -0400

Initial commit

# Chapter 5 - Architectural Design

## 5.1 Block Diagram



## 5.2 Components

### 5.2.1 Scanner

The scanner was implemented with ocamellex, with scanner.mll as the corresponding file. The scanner breaks down formatted input into tokens and translates individual tokens to some basic data types like int and char, discarding unnecessary information for compilation like whitespaces and comments. Also, it does basic syntax checking, any illegal symbols like # or $ are discovered and rejected.

### 5.2.2 Parser and AST

We use ocamlyacc to implement the parser and ast, with parser.mly and ast.ml as the corresponding files. The parser parses the token stream produced by the scanner to an abstract syntax tree, which represents the abstract syntactic structure of the source code. The parsing process does further check of syntax following the specifications in ast file.

### 5.2.3 Semantic Check and SAST

The semantic check was implemented using OCaml, and the associated file is compile\_sc\_py.ml, which takes in an abstract syntax tree and produces a semantically checked tree of python. A standard python AST, pyast.ml, is used for comparing. Errors including inconsistent types in expressions, reference to undefined functions or variables are discovered during this process. We use two maps named vars and funcs to record variables and functions in the scope and raise undefined exceptions if there is no match in maps.

### 5.2.4 Code Generator

The generator was implemented using OCaml and the associated file is compile\_to\_pycode.ml. The generator takes in the sast produced before and generates python code from it. Most of the code it generates is hard coded by translating python.

# Chapter 6 - Test Plan

# Chapter 7 - Lessons Learned

## 7.1 Qi Wang

I have learned how to do a team project. When a project is extremely large and complex, like this one, it’s impossible to finish all the works individually. So communications are really important, we need to keep communicating with others about our own sub-tasks, and we should be able to combine different parts together. This is not easy, since many details are involved. And plan is very important, the first thing before start is to make a plan and follow it strictly. Even if we have a perfect plan, we still need to keep communicate with our teammates during the group project. Sometimes things can be different from what we have imaged. For example, the semantic check is far more difficult than we thought, so as soon as I found out that it might take us much more time, I told my teammates and we discussed on how to change the schedule.

## 7.2 Zichen Chao

The most important thing I have learned from this project is that we need to keep the whole picture in mind. There are many technologies, tools, theories and other details involved in making a compiler. In each part of the project, we have to apply several of these in our codes or designs. When we are doing the coding or design, these sub-tasks seem to be independent with each other. For example, the parsing tree of the code and the semantic check of the code seem to be two very different tasks. It is possible that we may not see any connection between these two things at the first sight. However, when we were implementing the semantic check, we found that several modifications on the parsing tree had to be made to help with the semantic check.

## 7.3 Yuechen Zhao

If I can use only one word to describe the key to success in this project, I will say communication. This is a large project and we have 4 members in our team. When working together, we have to go through many discussions because different people have different opinions. We need to make an agreement on one plan before we can start to divide the work, and it often takes us a lot of time to discuss the advantages and disadvantages of ideas. But the discussions do help us to save time from trying things that not work for us. During the discussion, we should be able to explain our opinions clearly and listen carefully to others. All these make our communications efficient.

## 7.4 Ziyi Luo

Before this course project, I have never realized that how important testing is in a project. After finishing the most part of our project, we decided to try several test cases. I thought our compiler was able to handle all the test cases, or we could make some little modifications to correct it.

However, when the test was done, we discovered so many problems and we were not able to resolve them by a few lines of codes. We had to adjusts the foundation part of our complier and rewrite several parts. We realized that we should spend more time on testing before finishing the compiler, since it’s much harder to resolve all the bugs in the end. So we designed many test cases, each one testing a single function of our compiler, to resolve problems one by one.

# Chapter 8 – Appendix

## 8.1 Scanner

(\*

scanner.mll - updated 11:25AM 11/09/2015

NOTE FROM ZIYI TO ZICHEN & QI 11/09/2015:

REMOVE '@' AS A TOKEN

ADD

| "@end" {ENDOFPROGRAM}

| '@'(['a' - 'z' 'A' - 'Z']+ as pre) {PRESET(pre)}

TO RECOGNIZE A PRESET

THEREFORE WE NEED TO ADD

%token <string> PRESET

%token ENDOFPROGRAM

in parser.mly

IN PARSER, THE PROCESSING SUGGESTION IS:

PRESET ID {Preset($1,$2)}

\*)

{ open Parser } (\* Get the token types \*)

rule token = parse

(\* Whitespace \*)

[' ' '\t' '\r' '\n'] { token lexbuf }

(\* Comments \*)

| "/\*" { comment lexbuf } | "//" { comment2 lexbuf}

(\* Basic tokens \*)

| '(' { LPAREN } | ')' { RPAREN } (\* Parentheses \*)

| '{' { LBRACE } | '}' { RBRACE } (\* Braces \*)

| '[' { LSQUAR } | ']' { RSQUAR } (\* Square brackets \*)

| ';' { SEMI } | ':' { COLON }

| '.' {GET} | ',' { COMMA }

| '=' { ASSIGN } (\*'@' { AT }\*)

| '#' { DOLL}

(\* Arithmetic operators \*)

| '+' { PLUS } | '-' { MINUS }

| '\*' { TIMES } | '/' { DIVIDE }

| '%' { PERCENT } | '^' {EXP}

(\* Logic operators \*)

| "==" { EQ }

| "!=" { NEQ } | '<' { LT }

| "<=" { LEQ } | '>' { GT }

| ">=" { GEQ } | '!' {NOT}

| '&' {AND} | '|' {OR}

(\* Keywords (totally 23) \*)

| "else" { ELSE } | "end" { END }

| "for" { FOR }

| "function" {FUNCTION} | "if" { IF }

| "import" { IMPORT } | "in" { IN }

| "polygon" { POLYGON } | "break" { BREAK }

| "model" {MODEL} | "return" { RETURN }

| "run" {RUN} | "const" { CONST }

| "submodel" {SUBMODEL} | "line" {LINE}

| "while" { WHILE } | "circle" {CIRCLE}

| "runset" { RUNSET }

| ("int"|"float"|"dot"|"void"|"bool"|"char"|"string"|"list") as tp {TYPE(tp)} (\* Type \*)

| "print" {PRINT}

| "printT" {PRINTT}

| eof { EOF } (\* End of file \*)

(\* Integers \*)

| ['0' - '9']+ as lxm { INTEGERLIT(int\_of\_string lxm) }

(\* Float \*)

| ['0'-'9']\*'.'['0'-'9']+ ('e'['+' '-']?['0'-'9']+)? as flo {FLOATLIT(float\_of\_string flo)}

| ['0'-'9']+'.'['0'-'9']\* ('e'['+' '-']?['0'-'9']+)? as flo {FLOATLIT(float\_of\_string flo)}

| ['0'-'9']+ ('e'['+' '-']?['0'-'9']+) as flo {FLOATLIT(float\_of\_string flo)}

(\* Char \*)

| '''(['\000' - '\038' '\040' - '\127'] as chr)''' {CHARLIT(chr)}

(\* Bool \*)

| ("true"|"false") as bl {BOOLLIT(bool\_of\_string bl)}

(\* String \*)

| '"'(['\000' - '\033' '\035' - '\127']\* as str)'"' {STRINGLIT(str)}

(\* ID \*)

| ['a' - 'z' 'A' - 'Z']['a' - 'z' 'A' - 'Z' '0' - '9' '\_']\* as lxm { ID(lxm) }

| \_ as char { raise (Failure("illegal character " ^ Char.escaped char)) }

(\* Preset \*)

| "@end" {ENDOFPROGRAM}

| '@'(['a' - 'z' 'A' - 'Z']+ as pre) {PRESET(pre)}

and comment = parse

"\*/" { token lexbuf } (\* Endofcomment\*)

| \_ { comment lexbuf } (\* Eat everything else \*)

and comment2 = parse

'\n' {token lexbuf}

| \_ {comment2 lexbuf}

## 8.2 Parser

### 8.2.1 parser.mly

%{ open Ast %}

%token LPAREN RPAREN LBRACE RBRACE LSQUAR RSQUAR SEMI COLON GET COMMA ASSIGN DOLL

%token PLUS MINUS TIMES DIVIDE PERCENT EXP

%token EQ NEQ LT LEQ GT GEQ NOT AND OR

%token BREAK CONST ELSE END FOR FUNCTION IMPORT MODEL RETURN RUN SUBMODEL WHILE IF IN LINE CIRCLE RUNSET POLYGON

%token <string> TYPE

%token PRINT PRINTT

%token ENDOFPROGRAM

%token EOF

%token <int> INTEGERLIT

%token <float> FLOATLIT

%token <char> CHARLIT

%token <bool> BOOLLIT

%token <string> STRINGLIT

%token <string> ID

%token <string> PRESET

%right ASSIGN

%left AND OR

%left EQ NEQ

%right NOT

%left LT GT LEQ GEQ

%left PLUS MINUS

%left TIMES DIVIDE PERCENT

%left EXP

%left GET

%start program

%type <Ast.program> program

%%

program:

preset bodies ENDOFPROGRAM EOF { $2 }

preset:

PRESET ID { Preset($1, $2) }

bodies:

/\* nothing \*/ { [], [] }

| bodies decl { ($2 :: fst $1), snd $1 }

| bodies stmt { fst $1, ($2 :: snd $1) }

decl:

fdecl { $1 }

fdecl:

FUNCTION ID LPAREN paras\_opt RPAREN COLON TYPE COLON stmt\_list END

{{

tp = $7;

fname = $2;

paras = $4;

body = List.rev $9

}}

paras\_opt:

/\* nothing \*/ { [] }

| paras\_list { List.rev $1 }

paras\_list:

ID COLON TYPE { [($1, $3)] }

| paras\_list COMMA ID COLON TYPE { ($3, $5) :: $1 }

stmt\_list:

/\* nothing \*/ { [] }

| stmt\_list stmt { $2 :: $1 }

stmt:

expr SEMI { Expr($1) }

| RETURN expr SEMI { Return($2) }

| IF LPAREN expr RPAREN COLON stmt\_list END

{ If($3, $6, []) }

| IF LPAREN expr RPAREN COLON stmt\_list ELSE COLON stmt\_list END

{ If($3, $6, $9) }

| WHILE LPAREN expr RPAREN COLON stmt\_list END { While($3, $6) }

| PRINT LPAREN expr RPAREN SEMI { Print($3) }

| PRINTT LPAREN expr RPAREN SEMI { PrintT($3) }

| FOR expr IN expr COLON stmt\_list END { For($2, $4, $6) }

| RUN expr COLON stmt\_list END { Run($2, $4) }

| ID ASSIGN expr SEMI { Assign($1, $3, Noexpr) }

| ID DOLL LSQUAR expr RSQUAR ASSIGN expr SEMI { Assign($1, $7, $4) }

| BREAK SEMI{ Break }

expr\_opt:

/\* nothing \*/ { Noexpr }

| expr { $1 }

digit:

INTEGERLIT { Int($1) }

| FLOATLIT { Float($1) }

expr:

INTEGERLIT { Int($1) }

| FLOATLIT { Float($1) }

| CHARLIT { Char($1) }

| BOOLLIT { Bool($1) }

| STRINGLIT { String($1) }

| ID { Id($1) }

| MINUS expr { Minus($2)}

| expr PLUS expr { Binop($1, Add, $3) }

| expr MINUS expr { Binop($1, Sub, $3) }

| expr TIMES expr { Binop($1, Mult, $3) }

| expr DIVIDE expr { Binop($1, Div, $3) }

| expr EQ expr { Binop($1, Equal, $3) }

| expr NEQ expr { Binop($1, Neq, $3) }

| expr LT expr { Binop($1, Less, $3) }

| expr LEQ expr { Binop($1, Leq, $3) }

| expr GT expr { Binop($1, Greater, $3) }

| expr GEQ expr { Binop($1, Geq, $3) }

| expr AND expr { Binop($1, And, $3) }

| expr OR expr { Binop($1, Or, $3) }

| expr PERCENT expr { Binop($1, Mod, $3)}

| expr EXP expr { Binop($1, Exp, $3) }

| NOT expr { Not($2) }

| ID LPAREN actuals\_opt RPAREN { Call($1, $3) }

| LPAREN expr RPAREN { $2 }

| LSQUAR expr COMMA expr RSQUAR { Dot($2, $4) }

| expr GET expr { Get\_Call($1, $3) }

| LINE LPAREN actuals\_opt RPAREN { Line($3) }

| POLYGON LPAREN actuals\_opt RPAREN { Polygon($3) }

| CIRCLE LPAREN actuals\_opt RPAREN { Circle($3) }

| RUNSET LPAREN actuals\_opt RPAREN { Runset($3) }

| LBRACE actuals\_opt RBRACE { List($2) }

| ID DOLL LSQUAR expr RSQUAR { ListEle($1, $4) }

actuals\_opt:

/\* nothing \*/ { [] }

| actuals\_list { List.rev $1 }

actuals\_list:

expr { [$1] }

| actuals\_list COMMA expr { $3 :: $1 }

## 8.2.2 parser.mli

type token =

| LPAREN

| RPAREN

| LBRACE

| RBRACE

| LSQUAR

| RSQUAR

| SEMI

| COLON

| GET

| COMMA

| ASSIGN

| DOLL

| PLUS

| MINUS

| TIMES

| DIVIDE

| PERCENT

| EXP

| EQ

| NEQ

| LT

| LEQ

| GT

| GEQ

| NOT

| AND

| OR

| BREAK

| CONST

| ELSE

| END

| FOR

| FUNCTION

| IMPORT

| MODEL

| RETURN

| RUN

| SUBMODEL

| WHILE

| IF

| IN

| LINE

| CIRCLE

| RUNSET

| POLYGON

| TYPE of (string)

| PRINT

| PRINTT

| ENDOFPROGRAM

| EOF

| INTEGERLIT of (int)

| FLOATLIT of (float)

| CHARLIT of (char)

| BOOLLIT of (bool)

| STRINGLIT of (string)

| ID of (string)

| PRESET of (string)

val program :

(Lexing.lexbuf -> token) -> Lexing.lexbuf -> Ast.program

## 8.3 AST

type op = Add | Sub | Mult | Div | Equal | Neq | Less | Leq | Greater | Geq | And | Or | Mod | Exp

type preset =

Preset of string \* string

type expr =

Noexpr

| Int of int

| Float of float

| Bool of bool

| String of string

| Char of char

| Id of string

| Binop of expr \* op \* expr

| Call of string \* expr list

| Dot of expr \* expr

| Get\_Call of expr \* expr

| Line of expr list

| Circle of expr list

| List of expr list

| Polygon of expr list

| Not of expr

| Minus of expr

| ListEle of string \* expr

| Runset of expr list

type stmt =

| Expr of expr

| Return of expr

| If of expr \* stmt list \* stmt list

| For of expr \* expr \* stmt list

| While of expr \* stmt list

| Print of expr

| PrintT of expr

| Run of expr \* stmt list

| Assign of string \* expr \* expr

| Break

type fdecl = {

fname : string;

paras : (string \* string) list;

body : stmt list;

tp : string;

}

type program = fdecl list \* stmt list

## 8.4 Semantic Check

open Ast

open Pyast

module StringMap = Map.Make(String)

type envType = {

vars : string StringMap.t;

funcs : string StringMap.t;

get\_call : string;

func\_opt: string list StringMap.t;

};;

let env = ref {

vars = StringMap.empty;

funcs = StringMap.empty;

get\_call = "";

func\_opt = StringMap.empty;

};;

(\*translate geoAst to pyAst\*)

env := {vars = StringMap.empty; funcs = StringMap.add ":len" "int" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add ":len" ["list"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "list:append" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "list:append" ["any"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "list:pop" "list\_ele" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "list:pop" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add ":sin" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add ":sin" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add ":cos" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add ":cos" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add ":tan" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add ":tan" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add ":cot" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add ":cot" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "dot:getX" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "dot:getX" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "dot:getY" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "dot:getY" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "dot:distance" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "dot:distance" ["dot"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:distance" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:distance" ["dot"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getPara" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getPara" ["char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:setPara" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:setPara" ["char";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getRunstep" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getRunstep" ["char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:setRunstep" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:setRunstep" ["char";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getY" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getY" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getX" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getX" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:contains" "bool" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:contains" ["dot"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getMidpoint" "dot" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getMidpoint" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:getEndpoints" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:getEndpoints" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:length" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:length" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:pointAway" "dot" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:pointAway" ["dot";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:isParallel" "bool" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:isParallel" ["line"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:intersect" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:intersect" ["shape"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:getCenter" "dot" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:getCenter" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:getRadius" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:getRadius" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:setCenter" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:setCenter" ["dot"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:setRadius" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:setRadius" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:getRunstep" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:getRunstep" ["char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:setRunstep" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:setRunstep" ["char";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:getPointbyarc" "dot" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:getPointbyarc" ["float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "circle:intersect" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "circle:intersect" ["shape"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:addPara" "bool" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:addPara" ["shape";"char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:renew" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:renew" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:enableRun" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:enableRun" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:disableRun" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:disableRun" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:removePara" "bool" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:removePara" ["shape";"char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "line:rotateonPoint" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "line:rotateonPoint" ["dot";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:setRunstep" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:setRunstep" ["char";"float"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getRunstep" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getRunstep" ["char"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getPoints" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getPoints" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getArea" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getArea" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getAngle" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getAngle" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getParimeter" "float" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getParimeter" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getCentroid" "dot" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getCentroid" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:getSides" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:getSides" [] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "polygon:intersect" "list" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "polygon:intersect" ["shape"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:mark" "void" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:mark" ["dot"] env.contents.func\_opt};;

env := {vars = StringMap.empty; funcs = StringMap.add "runset:getRuncount" "int" env.contents.funcs; get\_call = ""; func\_opt = StringMap.add "runset:getRuncount" [] env.contents.func\_opt};;

let translate (declarations, statements) =

let rec py\_of\_expr = function

Int(l) -> (PyInt(l), "int")

| Float(l) -> (PyFloat(l), "float")

| String(s) -> (PyString(s), "string")

| Char(l) -> (PyChar(l), "char")

| Bool(l) -> (PyBool(l), "bool")

| Id(s) -> (PyId(s), try StringMap.find s env.contents.vars with Not\_found -> raise(Failure("Undeclared Variable " ^ env.contents.get\_call ^ ":"^s)))

| Binop(e1, o, e2) ->

let result1 = py\_of\_expr e1 and result2 = py\_of\_expr e2 in

let digit\_op\_match op a b =

if (((a="string"||a="int"||a="float")&&a=b)||a="list\_ele"||b="list\_ele") then (true, a) else if ((a="float" && b="int")||(a="int" && b="float")) then (true, "float") else raise(Failure("Undefined Operation: " ^ a ^ op ^ b)) in

let eq\_op\_match op a b =

if (((a=b&&(a="string"||a="int"||a="float"||a="bool"||a="char"))&&a=b)||a="list\_ele"||b="list\_ele") then (true, "bool") else raise(Failure("Undefined Operation: " ^ a ^ op ^ b)) in

let bool\_op\_match op a b =

if (((a=b && a="bool")&&a=b)||a="list\_ele"||b="list\_ele") then (true, "bool") else raise(Failure("Undefined Operation: " ^ a ^ op ^ b)) in

let get\_type\_bi o =

(match o with

Add -> let ck = digit\_op\_match "+" (snd result1) (snd result2) in (snd ck, "+")

| Sub -> let ck = digit\_op\_match "-" (snd result1) (snd result2) in (snd ck, "-")

| Mult -> let ck = digit\_op\_match "\*" (snd result1) (snd result2) in (snd ck, "\*")

| Div -> let ck = digit\_op\_match "/" (snd result1) (snd result2) in (snd ck, "/")

| Mod -> let ck = digit\_op\_match "%" (snd result1) (snd result2) in (snd ck, "%")

| Exp -> let ck = digit\_op\_match "^" (snd result1) (snd result2) in (snd ck, "\*\*")

| Equal -> let ck = eq\_op\_match "==" (snd result1) (snd result2) in (snd ck, "==")

| Neq -> let ck = eq\_op\_match "!=" (snd result1) (snd result2) in (snd ck, "!=")

| Less -> let ck = eq\_op\_match "<" (snd result1) (snd result2) in (snd ck, "<")

| Leq -> let ck = eq\_op\_match "<=" (snd result1) (snd result2) in (snd ck, "<=")

| Greater -> let ck = eq\_op\_match ">" (snd result1) (snd result2) in (snd ck, ">")

| Geq -> let ck = eq\_op\_match ">=" (snd result1) (snd result2) in (snd ck, ">=")

| And -> let ck = bool\_op\_match "&" (snd result1) (snd result2) in (snd ck, "and")

| Or -> let ck = bool\_op\_match "|" (snd result1) (snd result2) in (snd ck, "or")

) in

let result\_op = get\_type\_bi o in

(PyBinop((fst result1), snd result\_op, (fst result2)), fst result\_op)

| Minus(e) ->

let result = py\_of\_expr e in

let ck\_minus x = if (x="int"||x="float") then x else raise(Failure("Undefined Operation: -" ^ x)) in

let tp = ck\_minus (snd result) in

(PyMinus(fst result), tp)

| Not(e) -> let result = py\_of\_expr e in

let ck\_not x = if (x="bool") then x else raise(Failure("Undefined Operation: !(" ^ x^")")) in

(ck\_not (snd result); (PyNot(fst result), snd result))

| Noexpr -> (PyNoexpr, "none")

| Dot(x, y) -> let result1 = py\_of\_expr x and result2 = py\_of\_expr y in

(PyCall("dot", [fst result1;fst result2]), "dot")

| Get\_Call(x, y) -> let result1 = py\_of\_expr x

in (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = snd result1; func\_opt = env.contents.func\_opt};

let result2 = py\_of\_expr y in

(PyGet\_Call(fst result1,fst result2), snd result2))

| Line(x) -> (PyCall("line", (List.map fst (List.map py\_of\_expr x))), "line")

| Circle(x) -> (PyCall("circle", (List.map fst (List.map py\_of\_expr x))), "circle")

| Polygon(x) -> (PyCall("polygon", (List.map fst (List.map py\_of\_expr x))), "polygon")

| Runset(x) -> (PyCall("runset", (List.map fst (List.map py\_of\_expr x))), "runset")

| List(x) -> (PyList(List.map fst (List.map py\_of\_expr x)), "list")

| ListEle(x1, x2) ->

let ln\_ = try (x1, StringMap.find x1 env.contents.vars) with Not\_found -> raise(Failure("Undeclared List " ^ x1)) and id\_ = py\_of\_expr x2 in

let ck\_list ln id = if ((snd ln = "list")&&((snd id) = "int" || (snd id)="list\_ele")) then (PyListEle((fst ln),(fst id)), "list\_ele") else raise(Failure("List Error: " ^ (snd ln) ^ "[" ^ (snd id) ^ "]")) in

let ans = ck\_list ln\_ id\_ in ans

| Call(f, el) ->

let gtc = env.contents.get\_call in

let result\_el = List.map py\_of\_expr el in

let returnType = try StringMap.find (gtc ^ ":" ^ f) env.contents.funcs with Not\_found -> raise(Failure("Undeclared Fuction " ^ gtc ^ ":" ^ f))

in let func\_opt\_types = StringMap.find (gtc ^ ":" ^ f) env.contents.func\_opt

in let opt\_match a b = if (a=b) then true else if (b="int" && a="float") then true else if (a="any"||b="list\_ele") then true else if (a="shape"&&(b="dot"||b="line"||b="circle"||b="polygon")) then true else false

in let opts\_match a b = if (List.for\_all2 opt\_match a b) then true else raise(Failure("Fuction Parameter Not Match\n" ^ "Required " ^ gtc ^ ":" ^ f ^ "(" ^ (String.concat "," func\_opt\_types) ^ ")\n" ^ "Get " ^gtc ^ ":" ^ f ^ "(" ^ (String.concat "," (List.map snd result\_el)) ^ ")"))

in let mat = try opts\_match func\_opt\_types (List.map snd result\_el) with Invalid\_argument "List.for\_all2" -> raise(Failure("Fuction Parameter Not Match\n" ^ "Required " ^ gtc ^ ":" ^ f ^ "(" ^ (String.concat "," func\_opt\_types) ^ ")\n" ^ "Get " ^gtc ^ ":" ^ f ^ "(" ^ (String.concat "," (List.map snd result\_el)) ^ ")")) in

(PyCall(f,(List.map fst result\_el)),returnType)

in let addTab s = "\t" ^ s

in let ck\_bool tp rb = if ((snd rb)="bool") then true else raise(Failure(tp ^ " Statement Need Bool Expression"))

in let rec py\_of\_stmt = function

Expr(e) -> (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyExpr(fst (py\_of\_expr e)))

| Assign(v, e, id) ->

let result = py\_of\_expr e in

(env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt};

if (id=Noexpr)

then (env := {vars = StringMap.add v (snd result) env.contents.vars; funcs = env.contents.funcs; get\_call = env.contents.get\_call; func\_opt = env.contents.func\_opt}; PyAssign(v, fst result, PyNoexpr))

else PyAssign(v, fst result, fst (py\_of\_expr id)))

| PrintT(expr) -> (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyPrintT(fst (py\_of\_expr expr)))

| Print(expr) -> (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyPrint(fst (py\_of\_expr expr)))

| While(e, s) -> let rb = py\_of\_expr e in (ck\_bool "While" rb;env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyWhile(fst rb, List.map py\_of\_stmt (List.rev s)))

| For(e1, e2, s) ->

let r1\_ck\_fori = function

Id(s) -> (env := {vars = StringMap.add s "list\_ele" env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; py\_of\_expr e1)

| \_ -> raise(Failure("Geo Syntax Error Forloop"))

in

let r1 = r1\_ck\_fori e1 and r2 = py\_of\_expr e2 in

let r2\_ck\_fori r2 = if ((snd r2)="list") then true else raise(Failure("Geo Syntax Error Forloop")) in

(r2\_ck\_fori r2;env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt};

PyFor(fst r1, fst r2, (List.map py\_of\_stmt (List.rev s))))

| Return(e) -> (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyReturn(fst (py\_of\_expr e)))

| If(e1, s1, s2) ->

let rb = py\_of\_expr e1 in

(ck\_bool "If" rb; env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt};

PyIf(fst rb, (List.map py\_of\_stmt (List.rev s1)), (List.map py\_of\_stmt (List.rev s2))))

| Run(e, s) ->

let re = py\_of\_expr e in

let ck\_id = function

Id(i) -> if ((snd re)="runset") then i else raise(Failure("Run must be followed by a variable Id with type 'runset' , not "^ (snd re)))

| \_ -> raise(Failure("Run must be followed by a variable with type 'runset' "))

in (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyRun(PyId(ck\_id e), List.map py\_of\_stmt (List.rev s)))

| Break -> (env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; PyBreak)

in let rec translate\_stmts = function

[] -> []

| hd::tl -> let result1 = py\_of\_stmt hd and result2 = (translate\_stmts tl) in (result1::result2)

in let para\_var paras\_tp = env := {vars = StringMap.add (fst paras\_tp) (snd paras\_tp) env.contents.vars; funcs = env.contents.funcs; get\_call = env.contents.get\_call; func\_opt = env.contents.func\_opt}

in let para\_type fn paras\_types = env := {vars = env.contents.vars; funcs = env.contents.funcs; get\_call = env.contents.get\_call; func\_opt = StringMap.add fn paras\_types env.contents.func\_opt}

in let py\_of\_func fdecl = (env := {vars = env.contents.vars; funcs = StringMap.add (":" ^ fdecl.fname) fdecl.tp env.contents.funcs; get\_call = env.contents.get\_call; func\_opt = env.contents.func\_opt};

List.map para\_var fdecl.paras;

para\_type (":" ^ fdecl.fname) (List.map snd fdecl.paras);

let ans = {pyfname = fdecl.fname; pyparas = List.map fst fdecl.paras; pybody = translate\_stmts fdecl.body} in

(env := {vars = StringMap.empty; funcs = env.contents.funcs; get\_call = ""; func\_opt = env.contents.func\_opt}; ans))

in let rec translate\_funcs = function

[] -> []

| hd::tl -> (py\_of\_func hd)::(translate\_funcs tl)

in let dofunc = ((List.rev (translate\_funcs (declarations)))) and dostms = (((translate\_stmts (List.rev statements))))

in (dofunc,dostms)

## 8.5 SAST

type pyExpr =

PyNoexpr

| PyInt of int

| PyFloat of float

| PyBool of bool

| PyString of string

| PyChar of char

| PyId of string

| PyBinop of pyExpr \* string \* pyExpr

| PyCall of string \* pyExpr list

(\*| PyDot of pyExpr \* pyExpr\*)

| PyGet\_Call of pyExpr \* pyExpr

(\*| PyLine of pyExpr list

| PyCircle of pyExpr list\*)

| PyList of pyExpr list

| PyNot of pyExpr

| PyMinus of pyExpr

| PyListEle of string \* pyExpr

type pyStmt =

PyExpr of pyExpr

| PyReturn of pyExpr

| PyIf of pyExpr \* pyStmt list \* pyStmt list

| PyFor of pyExpr \* pyExpr \* pyStmt list

| PyWhile of pyExpr \* pyStmt list

| PyPrint of pyExpr

| PyPrintT of pyExpr

| PyAssign of string \* pyExpr \* pyExpr

| PyRun of pyExpr \* pyStmt list

| PyBreak

type pyFuncDecl = {

pyfname : string;

pyparas : string list;

pybody : pyStmt list;

}

type pyProgram = pyFuncDecl list \* pyStmt list

## 8.6 Code Generation

open Pyast

let prestring = ["from Tkinter import \*\n";

"from sysgeo import \*\n" ]

let finalstring = [""]

let translate (declarations, statements) =

let rec string\_of\_expr = function

PyInt(l) -> string\_of\_int l

| PyFloat(l) -> string\_of\_float l

| PyString(s) -> "\"" ^ s ^ "\""

| PyChar(l) -> "\'" ^ (String.make 1 l) ^ "\'"

| PyBool(l) -> let tran\_bool x = if (x=true) then "True" else "False" in (tran\_bool l)

| PyId(s) -> s

| PyBinop(e1, o, e2) ->

let result1 = string\_of\_expr e1 and result2 = string\_of\_expr e2 in

"(" ^ result1 ^ " "^ o ^ " "^result2 ^ ")"

| PyMinus(e) ->

let result = string\_of\_expr e in "-" ^ result

| PyNot(e) -> let result = string\_of\_expr e in "not(" ^ result ^ ")"

| PyNoexpr -> ""

| PyGet\_Call(x, y) -> let result1 = string\_of\_expr x and result2 = string\_of\_expr y

in result1 ^ "." ^ result2

| PyList(x) -> "[" ^ String.concat ", " (List.map string\_of\_expr x) ^ "]"

| PyListEle(x1, x2) ->

let id = string\_of\_expr x2 in x1 ^ "[" ^ id ^ "]"

| PyCall(f, el) ->

let result\_el = List.map string\_of\_expr el in

f ^ "(" ^ String.concat ", " result\_el ^ ")"

in let addTab s = "\t" ^ s

in let rec string\_of\_stmt = function

PyExpr(e) -> (string\_of\_expr e) :: []

| PyPrintT(expr) -> ("print " ^ (string\_of\_expr expr)) :: []

| PyPrint(expr) -> ("print " ^ (string\_of\_expr expr)) :: []

| PyWhile(e, s) -> let rb = string\_of\_expr e in ("while (" ^ rb ^ "):"):: (List.map addTab (List.concat ((List.map string\_of\_stmt s))))

| PyFor(e1, e2, s) ->

let r1 = string\_of\_expr e1 and r2 = string\_of\_expr e2 in

("for " ^ r1 ^ " in " ^ r2 ^ ":")

:: (List.map addTab (List.concat ((List.map string\_of\_stmt s))))

| PyReturn(e) -> ("return " ^ (string\_of\_expr e)) :: []

| PyAssign(v, e, id) ->

let result = string\_of\_expr e in

if (id=PyNoexpr)

then ((v) ^ " = " ^ result) :: []

else ((v) ^ "[" ^ (string\_of\_expr id) ^ "] = " ^ result) :: []

| PyBreak -> ["break"]

| PyRun(e, s) -> let str=string\_of\_expr e in (("def runfun\_\_(" ^ str ^ "):") :: (List.map addTab (List.concat ((List.map string\_of\_stmt s))))) @ ["drawmain(" ^ str ^ ")"]

| PyIf(e1, s1, s2) ->

let rb = string\_of\_expr e1 in

match s2 with

[] -> ("if " ^ rb ^ ":") ::

(List.map addTab (List.concat ((List.map string\_of\_stmt s1))))

|\_ -> (("if " ^ rb ^ ":") ::

(List.map addTab (List.concat ((List.map string\_of\_stmt s1))))) @

("else:" :: (List.map addTab (List.concat ((List.map string\_of\_stmt s2)))))

in let rec translate\_stmts = function

[] -> []

| hd::tl -> let result1 = (string\_of\_stmt hd) and result2 = (translate\_stmts tl) in (result1 @ result2)

in let string\_of\_func fdecl = "def " ^ fdecl.pyfname ^ "(" ^ (String.concat ", " fdecl.pyparas) ^ "):\n\t" ^ (String.concat "\n\t" (translate\_stmts fdecl.pybody))

in let rec translate\_funcs = function

[] -> []

| hd::tl -> (string\_of\_func hd)::(translate\_funcs tl)

in let dofunc = (String.concat "\n" ( (translate\_funcs (declarations)))) and dostms = (String.concat "\n" ((translate\_stmts (statements))))

in let tra = dofunc ^ "\n" ^ dostms ^ "\n"

in (String.concat "" prestring) ^ tra ^ (String.concat "" finalstring)

## 8.7 Tests

### 8.7.1 test.py

from Tkinter import \*

from sysgeo import \*

PI = 3.14159265359

dot1 = dot(3, 5)

line1 = line(4, 5)

line2 = line(dot(1, 2), dot(2, 3))

line3 = line(4, 5, -5, 5)

line4 = line(dot(0, -2), dot(0, 2), 0, 0)

print line1

print line2

print line3

print line4

print line2.intersect(line4)

print line3.distance(dot1)

print line4.length()

print line2.pointAway(dot(2, 3), 5)

print line4.pointAway(dot(0, 0), 1)

print line3.getEndpoints()

print line3.getMidpoint()

print line1.isParallel(line2)

print line1.getX(5)

print line4.getX(1)

print line2.getY(0)

line2.setRunstep('a', 0.5)

line3.setRunstep('b', 1.)

line3.setRunstep('x', 1.)

r1 = runset(8, 0.1)

r1.addPara(line2, 'a')

r1.addPara(line3, 'b')

r1.addPara(line3, 'x')

def runfun\_\_(r1):

print line2

print line3

print line4

line4.rotateonPoint(dot(0, 0), (PI / 4))

##########################################

global w

global argv

global runsets

def transaxis(p):

transx = float(p.x)

transy = float(p.y)

tx = transx\*25+250

ty = transy\*25+250

tx = int(tx)

ty = int(ty)

return Point(tx,ty)

def draw(args):

global w

i = 0

if(isinstance(args,line)):

if(args.isLine):

if(args.a != float("inf")):

d1=transaxis(Point(-10,args.getY(-10)))

d2=transaxis(Point(10,args.getY(10)))

else:

tx = float(args.line\_.points[0].x)

d1=transaxis(tx,-10)

d2=transaxis(tx,10)

else:

d1=transaxis(args.line\_.points[0])

d2=transaxis(args.line\_.points[1])

w.create\_line(d1.x,d1.y,d2.x,d2.y)

elif(isinstance(args,circle)):

c = transaxis(args.getCenter())

r = int(float(args.getRadius())\*25)

w.create\_oval(c.x-r, c.y-r, c.x+r, c.y+r)

elif(isinstance(args,dot)):

d = transaxis(args)

w.create\_oval(d.x-2, d.y-2, d.x+2, d.y+2, fill="black")

def delete():

global w

global runsets

w.delete("all")

# print "start sleep"

# sleep(1)

for argv in runsets.objlist:

draw(argv)

for argv in runsets.marklist:

draw(argv)

runfun\_\_(runsets)

if(runsets.run()):

#print runsets.runtime

w.after(int(runsets.sleeptime\*1000),delete)

def drawmain(runs):

global w

global runsets

runsets = runs

master = Tk()

# index=0

w = Canvas(master, width=500, height=500)

w.pack()

# print "in loop"

# w.delete("all")

for argv in runsets.objlist:

draw(argv)

w.after(100, delete)

mainloop()

return True

###########################################

drawmain(r1)

### 8.7.2 error-semantics1.g

a=foo(3);

### 8.7.3 error-semantics2.g

function foo(i:int):int:

return 1;

end;

foo(0.1);

### 8.7.4 error-syntax1.g

function foo(i:int):

### 8.7.5 error-syntax2.g

end

### 8.7.6 error-syntax3.g

a=3

### 8.7.7 error-syntax4.g

if():

### 8.7.8 error-syntax5.g

if()

else

### 8.7.9 test-assignments.g

@panel panel1

a=3;

b=3;

c=123e-1;

d="Ocaml sucks!";

e='@';

f=3.4\*2==4.;

printT(a);

printT(b);

printT(c);

printT(d);

printT(e);

printT(f);

@end

### 8.7.10 test-circle.g

@panel panel1

dot1=[3,5];

circle1=circle([3,5],5);

circle2=circle([0,0],5);

printT(circle1);

printT(circle2);

printT(circle2.intersect(circle1));

printT(circle2.intersect(line([0,2],[1,2])));

printT(circle2.intersect(line([0,2],[1,2],-1,1)));

printT(circle2.intersect(line([0,-2],[0,2])));

printT(circle2.intersect(line([0,-2],[0,2],0,0)));

printT(circle1.getRadius());

printT(circle2.getCenter());

circle1.setCenter([2,2]);

printT(circle1);

circle2.setRadius(3);

printT(circle2);

printT(circle2.getPointbyarc(PI/4));

@end

### 8.7.11 test-comparison.g

@panel panel1

printT(5>3);

printT(5==5 & 3<2);

a=4.3;

b=8.6/2.0;

c=a==b;

printT(!c);

printT(a==b);

printT(false | true);

printT(!false & true);

@end

### 8.7.12 test-dot.g

@panel panel1

dot1=[3,5];

dot2=[5,7];

printT(dot1.distance(dot2));

printT(dot1.getX());

printT(dot1.getY());

@end

### 8.7.13 test-fit.g

@panel fib

function fib(x:int):int:

if (x == 1):

return(1);

else:

if (x == 2):

return(1);

else:

return(fib(x-1)+fib(x-2));

end

end

end

i = 1;

while (i < 10):

print(fib(i));

i = i+1;

end

@end

### 8.7.14 test-for.g

@panel panel1

for i in {1,"zcCHAO",2,"zyLUO",3,"qWANG",4,"ycZHAO",true,';'}:

printT(i);

end

@end

### 8.7.15 test-function.g

@panel panel1

function test1(str:string):bool:

if(str=="PLT"):

return true;

else:

//end

return false;

end

end

function test2():void:

if(test1("PLT")):

printT("is PLT");

else:

printT("is not PLT");

end

end

test2();

@end

/\*

function test1(str:string):bool:

if(str=="PLT"):

return true;

//else:

end

return false;

//end

end

function test2():void:

if(test1("PLT")):

printT("is PLT");

//else:

end

printT("is not PLT");

//end

end

test2();

\*/

### 8.7.16 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

### 8.7.17 test-if.g

@panel panel1

if(5==3):

printT("5==3");

else:

if(5>3):

printT("5>3");

else:

printT("5<3");

end

end

@end

### 8.7.18 test-list.g

@panel panel1

d={1,2,3,4,5,6};

e={"str",45,'c',3.4};

printT(d);

printT(d#[2]);

printT(e);

printT(e#[0]);

@end

### 8.7.19 test-line.g

@panel panel1

dot1=[3,5];

line1=line(4,5);

line2=line([1,2],[2,3]);

line3=line(4,5,-5,5);

line4=line([0,-2],[0,2],0,0);

printT(line1);

printT(line2);

printT(line3);

printT(line4);

printT(line2.intersect(line4));

printT(line3.distance(dot1));

printT(line4.length());

printT(line2.pointAway([2,3],5));

printT(line4.pointAway([0,0],1));

printT(line3.getEndpoints());

printT(line3.getMidpoint());

printT(line1.isParallel(line2));

printT(line1.getX(5));

printT(line4.getX(1));

printT(line2.getY(0));

line2.setRunstep('a',0.5);

line3.setRunstep('b',1.0);

line3.setRunstep('x',1.0);

// r1=runset(8,0.1);

// r1.addPara(line2,'a');

// r1.addPara(line3,'b');

// r1.addPara(line3,'x');

// run r1:

// printT(line2);

// printT(line3);

// printT(line4);

// line4.rotateonPoint([0,0],PI/4);

// end

@end

### 8.7.20 test-operation.g

@panel panel1

//int+int

printT(1+1);

//float+float

printT(.1+1.0);

//int+float

printT(1+1.0);

//float-int

printT(.1-5);

//int

printT(1+2\*3-4/2);

//float

printT(1.+2.\*3-4./3);

//int

printT(1-5\*2^3+4\*5/2\*7%3);

//float mix with int

printT(1.+2.\*3-4/3);

//string+string

printT("Hello "+"World");

@end

### 8.7.21 polygon.g

@panel panel1

li={[0,0],[5,0],[5,3],[0,3]};

l2={[0,0],[2,2],[0,4],[-2,2]};

p1=polygon(li);

p2=polygon(l2);

print(p1);

print(p1.getPoints());

print(p1.getArea());

print(p1.getAngle());

print(p1.getParimeter());

print(p1.getCentroid());

print(p1.getSides());

print(p1.intersect([5,6]));

print(p1.intersect(line([0,0],[2,2])));

print(p1.intersect(circle([0,0],3)));

print(p1.intersect(p2));

@end

/\*

r1=runset(5,0.1);

circle1.addRunstep('x',1);

circle1.addRunstep('y',-1);

circle2.addRunstep('r',1);

printT(circle1.getRunstep());

r1.addPara(circle1,'x');

r1.addPara(circle1,'y');

r1.addPara(circle2,'r');

run r1:

printT(circle1);

printT(circle2);

end

\*/

### 8.7.22 test-print.g

@panel panel1

printT(123456);

printT(123.456);

printT(5e-5);

printT('a');

printT('%');

printT(true);

printT(false);

printT("Hello world!");

@end

### 8.7.23 test-qsort.g

@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

### 8.7.24 test-while.g

@panel panel1

count=0;

while(count<11):

printT(count);

count=count+2;

end

@end