Language Proposal: Pp

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2019-09-23

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1. Purpose of the project

The purpose of this project is to develop a language focused mainly on engineers and scientists who do statistical analysis and use linear algebra in their day to day life. The main data structure the language will support is the matrix or dataset, which will allow the storage of two-dimensional data. This language will allow the users to speed up their workflow and have a nicer syntax than other languages with this focus such as R but also not be so advanced and difficult to learn for non-programmers such as Python.

2. Language main objective

The main objective of Pp is to be readable by both, developers and non-developers, to be a common ground of collaboration between them and be intuitive and easy to program. The language will be a high-level imperative scripting programming language for statistical analysis, having as the basic data structure the matrix, supporting all of its operations as well as basic statistic functions.

3. Language Requirements

3.1. Examples of the language

3.1.1. Function declaration

```
func int myFunctionName(int a, float b) {
     return a;
}
```

3.1.2. Variable declarations and assignments (Basic types)

```
let int a, b, c;
let float f, g;
let string s;
let bool t;

a = 1;
a = 2+2;
a = 2^10;
a = myFunctionName(a, f);

f = 1.0E18;
f = 1.;
f = 3.14159;
f = 2.0E-10;

t = true and false;
t = not true;
t = not false;

s = “Hello World”;
s = “a”;
```

3.1.3. Matrices and datasets

```
let matrix<int>[3][3] matA, matB;
let dataset<int, float, string, float> myData;

matA = [[1, 2, 3], [4, 5, 6], [7, 8, 9]];
matA = matA*matB;
matA[0][0] = 10;
```

```
myData.add(1, 3.14, “Eduardo”, 4.5);
myData[0][0] = 10;
myData[0][1] = 3.5;
myData[0][2] = “Hugo”;
myData[0][3] = 20.3;

readcsv(myData);
```

3.1.4. Conditionals

```
if (a == 10) {
     ...
} elseif (b > 5) {
     ...
} else {
     ...
}
```

3.1.5. Loops

```
while (a > 0) {
     a = a - 1;
     ...
}
```

3.1.6. IO

```
read(a);
write(10);
write(“Hello world”);
plot(matX, matY);
```

3.1.7. Complete Example: Fibonacci number

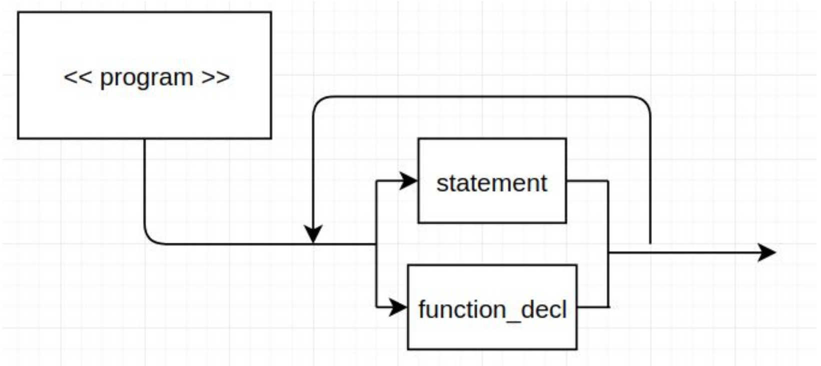
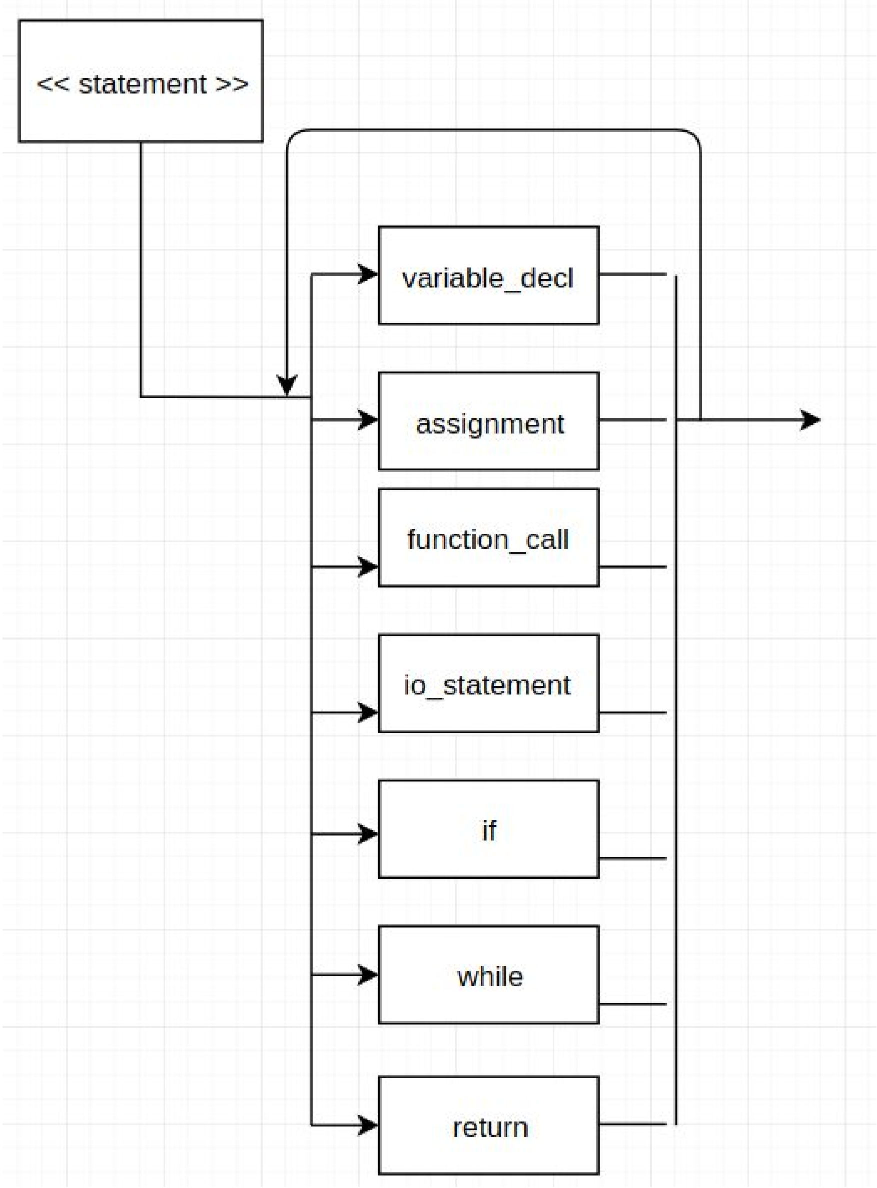
```
func int fibonacci(int n) {
     let int f1, f2, i;
     f1 = 1;
     f2 = 1;
     i = 0;
     while (i < n) {
          let int aux;
          aux = f2;
          f2 = f1 + f2;
          f1 = f2;
          i = i + 1;
     }
     return f1;
}

let int fib;
write(“Which Fibonacci number do you want?”);
read(fib);

write(fibonacci(fib));
```

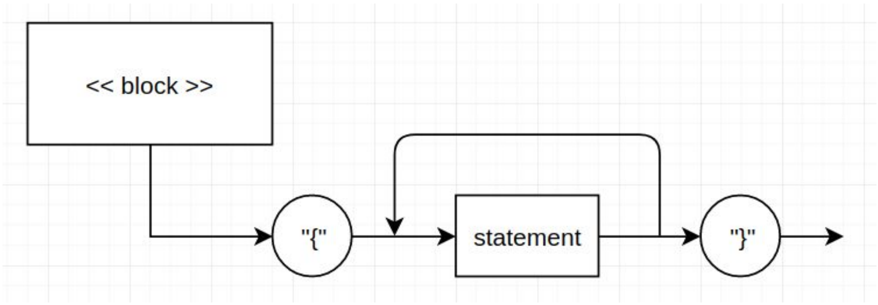
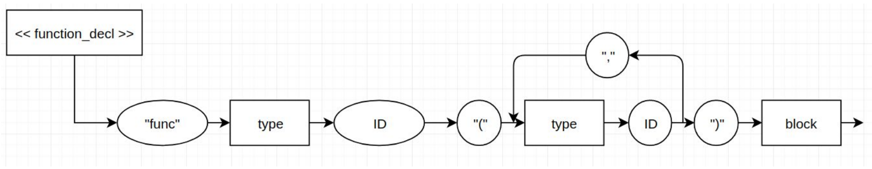
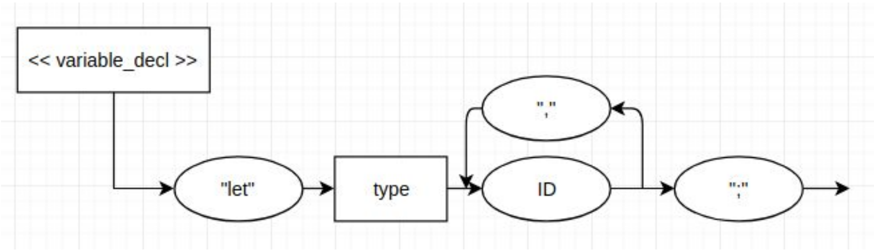
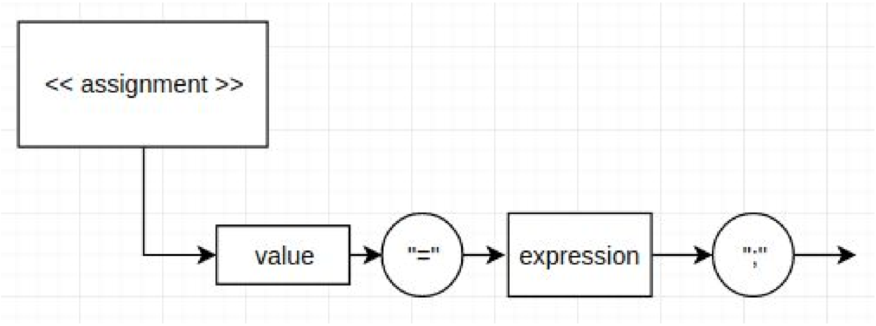
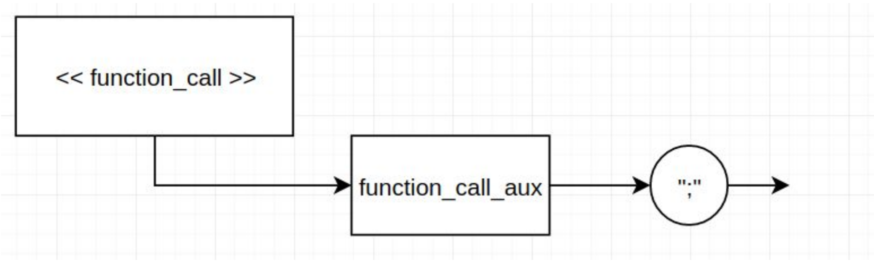
3.2. Basic Elements (Tokens)

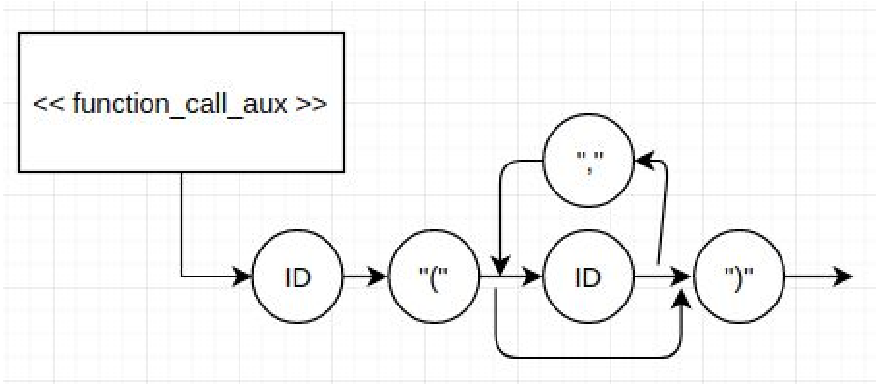
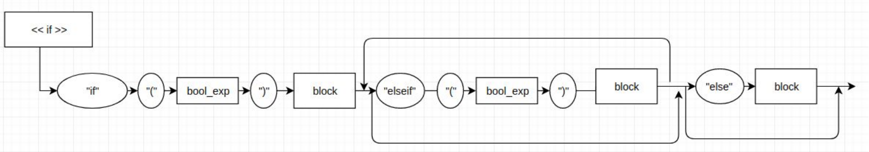
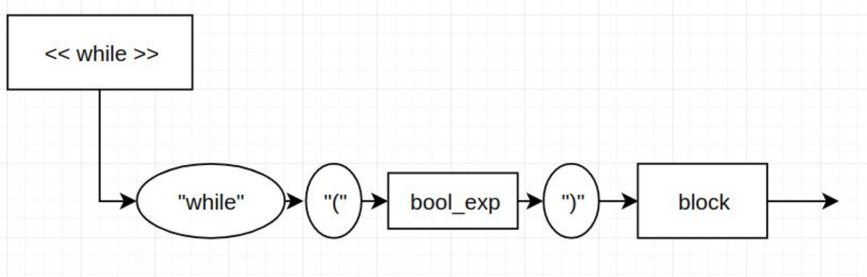
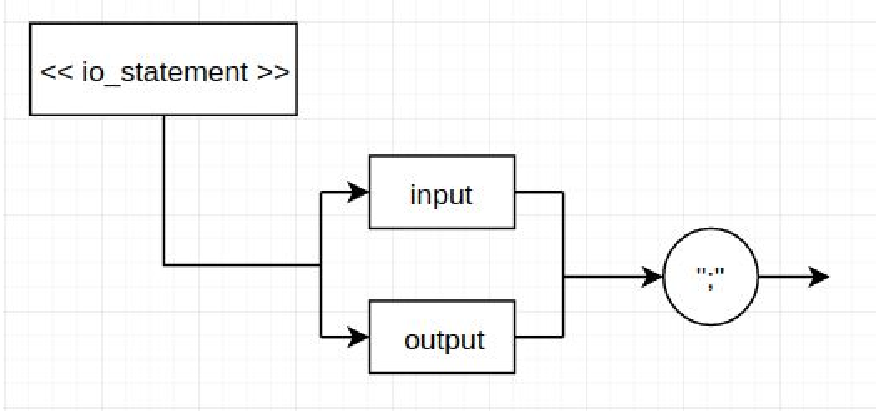
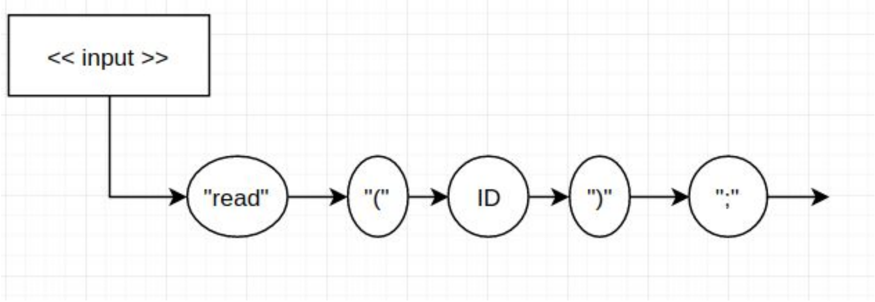
Allowed Tokens	Regular Expression
ADDITION_OPERATOR	“+”
SUBTRACTION_OPERATOR	“-”
MULTIPLICATION_OPERATOR	“*”
DIVISION_OPERATOR	“/”
EXPONENTIATION_OPERATOR	“^”
MODULUS_OPERATOR	“%”
ASSIGNMENT_OPERATOR	“=”
BOOLEAN_AND_OPERATOR	“and”
BOOLEAN_OR_OPERATOR	“or”
BOOLEAN_NOT_OPERATOR	“not”
EQUALITY_OPERATOR	“==”
INEQUALITY_OPERATOR	“!=”
LESS_THAN_OPERATOR	“<”
LESS_THAN_EQUAL_OPERATOR	“<=”
GREATER_THAN_OPERATOR	“>”
GREATER_THAN_EQUAL_OPERATOR	“>=”
SEMICOLON_DELIMITER	“;”
COMMA_DELIMITER	“,”
INPUT_STATEMENT	“read”
CSV_INPUT_STATEMENT	“readcsv”
OUTPUT_STATEMENT	“write”
PLOT_STATEMENT	“plot”
VARIABLE_STATEMENT	“let”
FUNCTION_STATEMENT	“func”

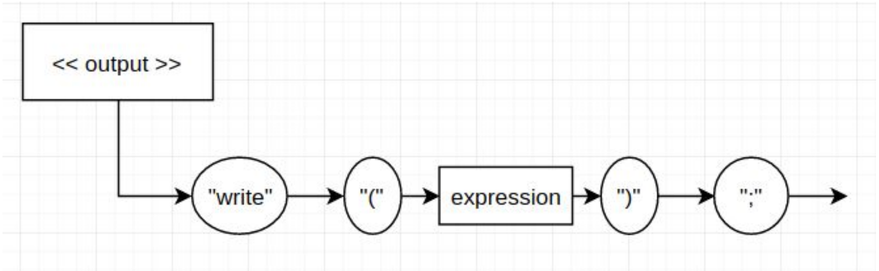
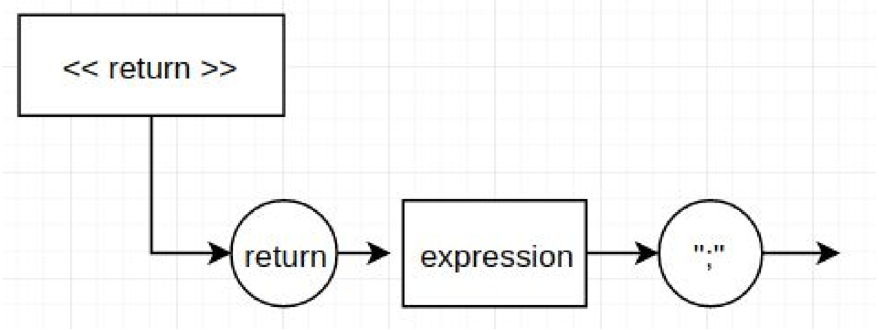
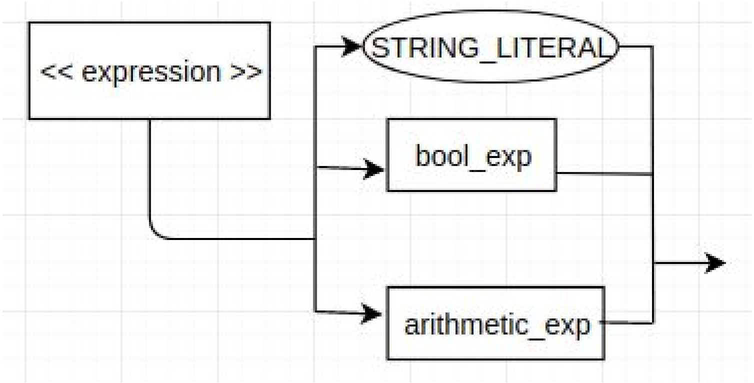
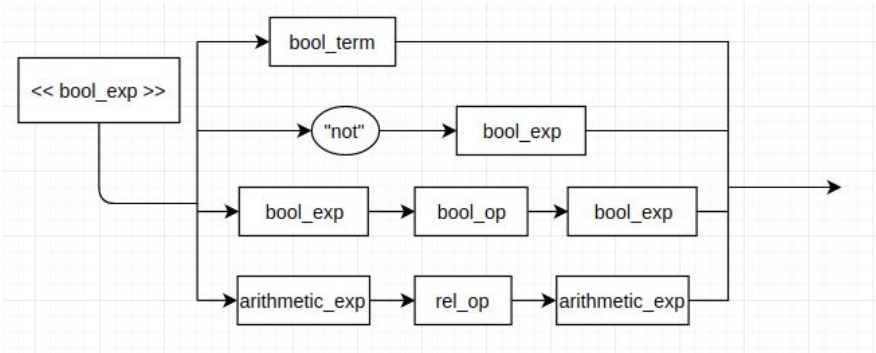
RETURN_STATEMENT	“return”
IF_STATEMENT	“if”
ELSE_IF_STATEMENT	“elseif”
ELSE_STATEMENT	“else”
WHILE_LOOP_STATEMENT	“while”
LEFT_SQUARE_BRACKET	“[“
RIGHT_SQUARE_BRACKET	“]”
LEFT_CURLY_BRACKET	“{“
RIGHT_CURLY_BRACKET	“}”
LEFT_PARENTHESIS	“(“
RIGHT_PARENTHESIS	“)”
INT_TYPE	“int”
BOOLEAN_TYPE	“bool”
FLOAT_TYPE	“float”
STRING_TYPE	“string”
DATESET_TYPE	“dataset”
MATRIX_TYPE	“matrix”
ID	“_”?[a-zA-Z][a-zA-Z0-9_]*
INT_NUMBER	[+|-]?[0-9]+
FLOAT_NUMBER	[+|-]?[0-9]+”.”([0-9]+)(E[-|+]?[0-9]+)
BOOLEAN_LITERAL	(“true” | ”false”)
STRING_LITERAL	“““.*?’”’

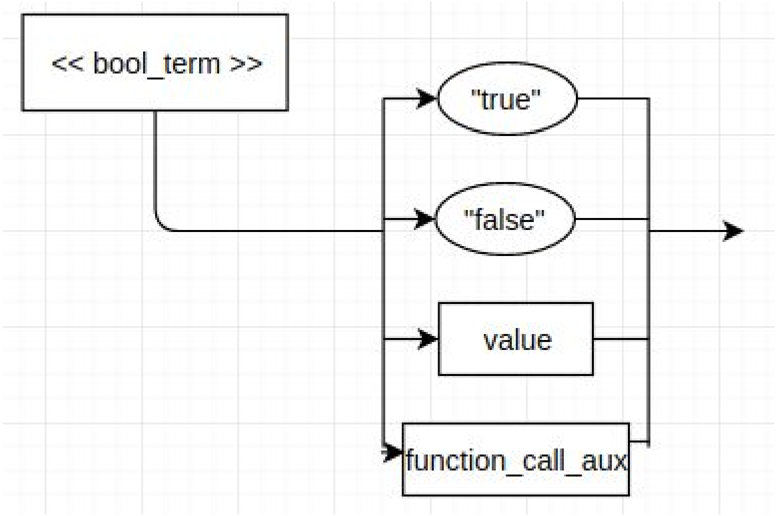
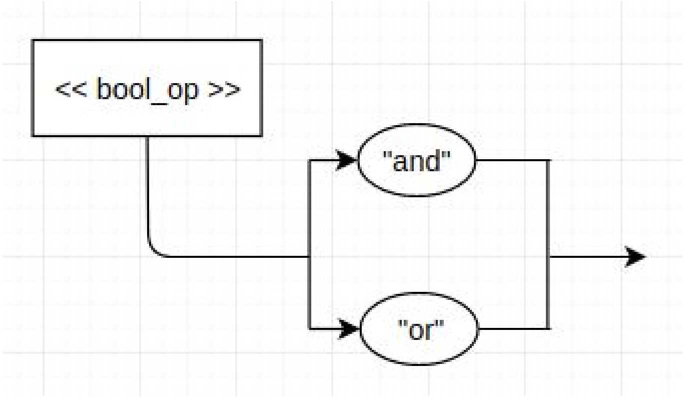
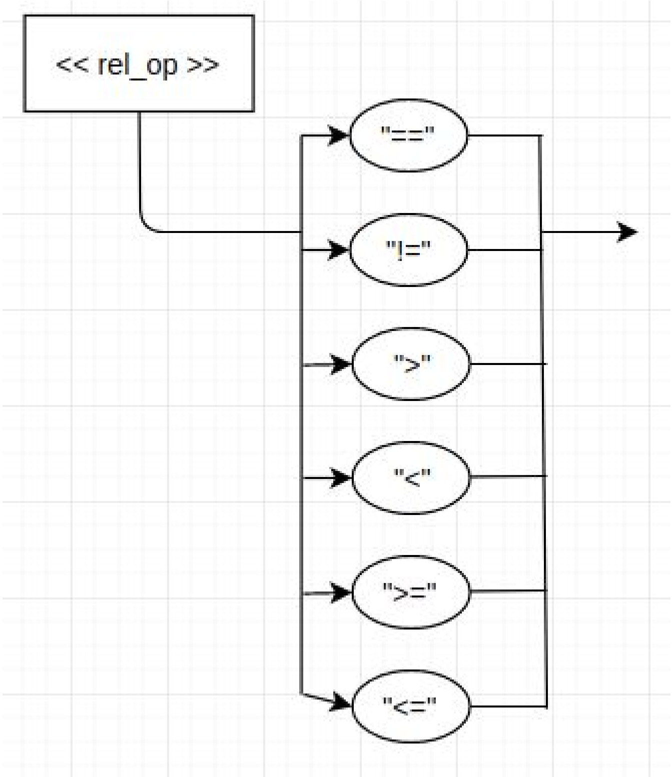
3.3. Syntax Diagrams

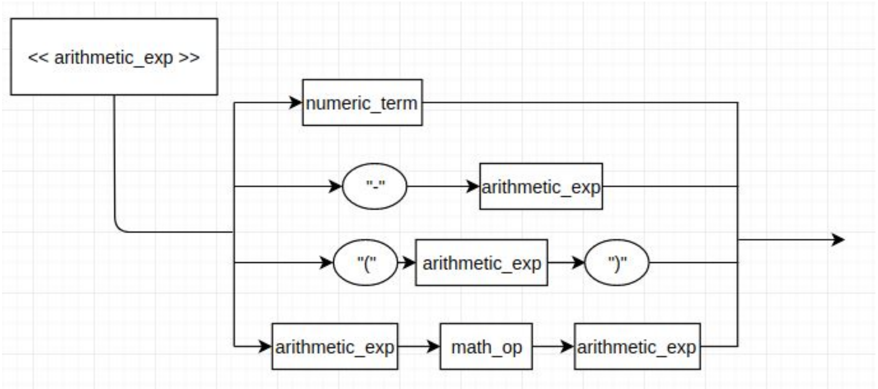
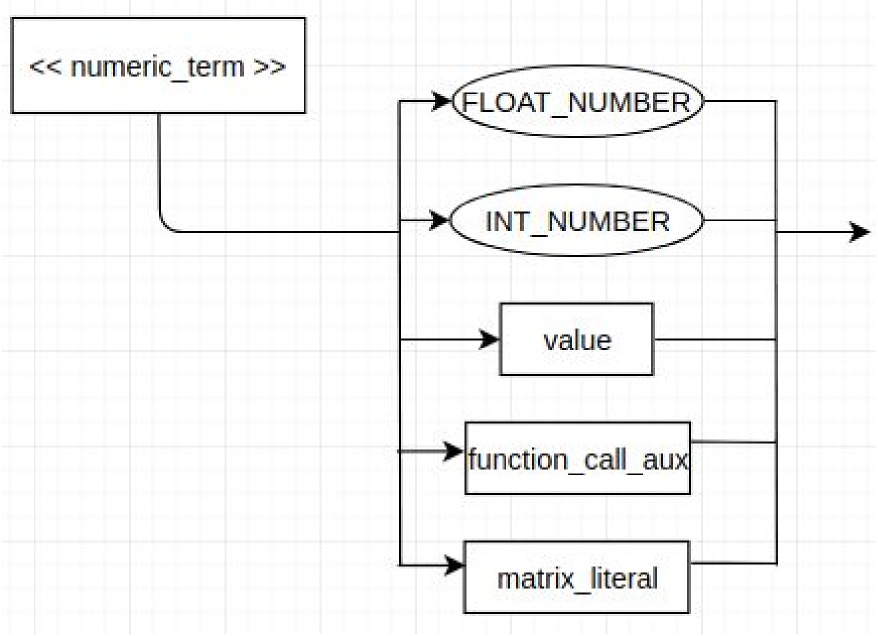
Rule	Diagram
program	
statement	 << statement >> variable_decl assignment function_call io_statement if while return

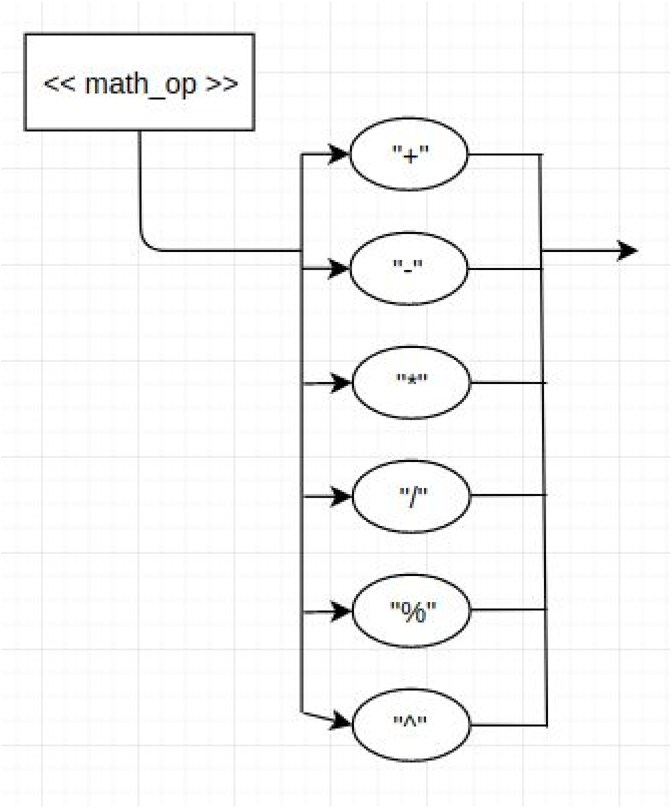
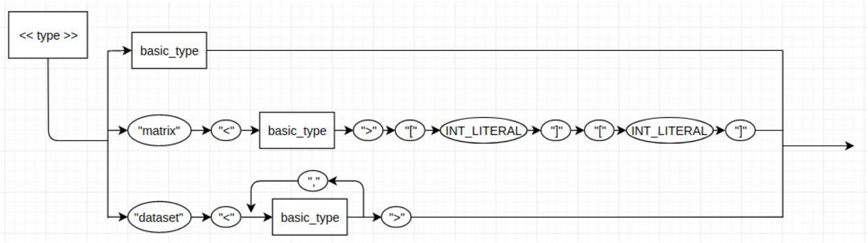
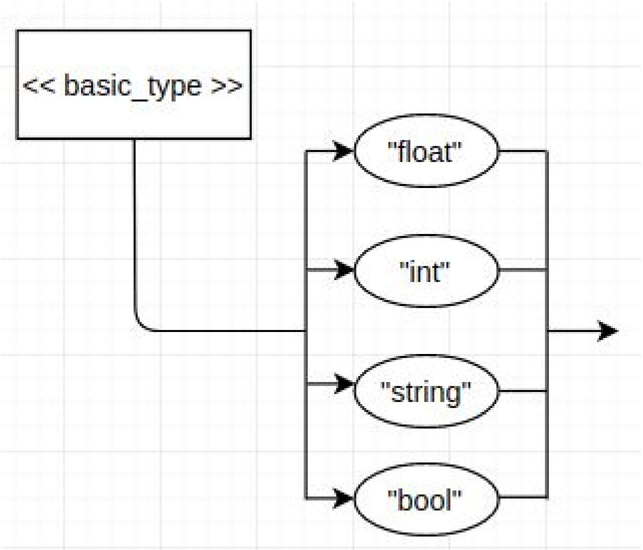
block	
function_decl	 << function_decl >> "," "func" type ID "(" type ID ")" block
variable_decl	
assignment	
function_call	

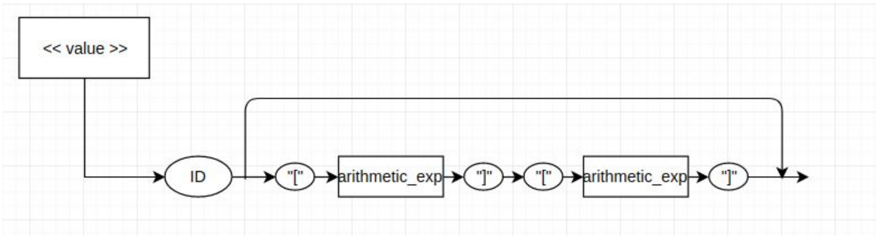
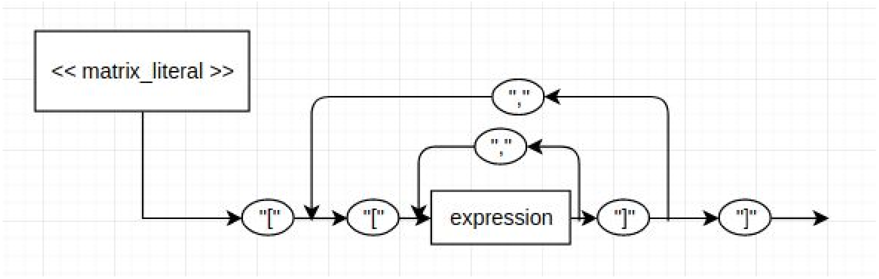
function_call_aux	
if	 << if >> "if" "(" bool_exp ")" block "elseif" "(" bool_exp ")" block "else" block
while	
io_statement	
input	

output	
return	
expression	 << expression >> STRING_LITERAL bool_exp arithmetic_exp
bool_exp	 << bool_exp >> bool_term "not" bool_exp bool_exp bool_op bool_exp arithmetic_exp rel_op arithmetic_exp

bool_term	 << bool_term >> "true" "false" value function_call_aux
bool_op	
rel_op	

arithmetic_exp	 << arithmetic_exp >> numeric_term "-" arithmetic_exp "(" arithmetic_exp ")" arithmetic_exp math_op arithmetic_exp
numeric_term	 << numeric_term >> FLOAT_NUMBER INT_NUMBER value function_call_aux matrix_literal

math_op	
type	 << type >> basic_type "matrix" "<" basic_type ">" "[" INT_LITERAL "]" "[" INT_LITERAL "]" "," "dataset" "<" basic_type ">"
basic_type	

value	 << value >> ID "[" arithmetic_exp "]" "[" arithmetic_exp "]"
matrix_literal	 << matrix_literal >> "," "," "[" "[" expression "]" "]"

3.4. Main Semantic Characteristics

The following arithmetic operation will be supported (order of operands does not matter):

Left operand	operator	Right operand	Result
int	+, -, *, %, ^	int	int
int	/	int	float
int	+, -, *, /, ^	float	float
float	+, -, *, /, ^	float	float
matrix	+, -, *	matrix	matrix (The dimensions must be compatible and of type int or float)
int	+, -, *	matrix	matrix
float	+, -, *	matrix	matrix
matrix	^	int	matrix (The order does matter here!)

3.5. Special Functions

The language will include the common matrix operations overloaded so it will be as easy to add to matrices as it is to add to integers. It will also have the capacity to plot points and join them given two column matrices (n*1 dimension) representing the x values and y values.

The language will also include a dataset type which allows the user to have a matrix-like data structure where each column may be of a different type. This data structure will be able to grow freely by adding several values or read them from a CSV.

3.6. Data Types

The basic data types supported by this programming language are:

- int: Signed integer with no memory limitation. Will work as BigIntegers in Java or like integers in Python.
- float: Signed double-precision floating-point number.
- string: Chain of 8 bit ASCII characters.

The other more complex data types supported will be:

- matrix: 2-dimensional arrays of contiguous memory. The matrix is a collection of the same basic data type. This data type will also be used for the traditional array, being either a column matrix (n*1 dimensions) or row matrix (1*n dimensions).
- dataset: A dataset is a set of column matrices where each matrix can have a different data type. All matrices should have the same number of rows and only one column.

4. Development Environment

The programming language here specified will be developed using ANTLR as the syntax and lexical analyzer with Python. The environment in which it will be developed and tested will be Linux Ubuntu 16.04+