UNIVERSITÀ DEGLI STUDI DI BERGAMO | Dipartimento di Ingegneria Gestionale, dell'Informazione e della Produzione

G-CODE PARSER AND SHAPER

Project documentation

Course: Linguaggi formali e compilatori

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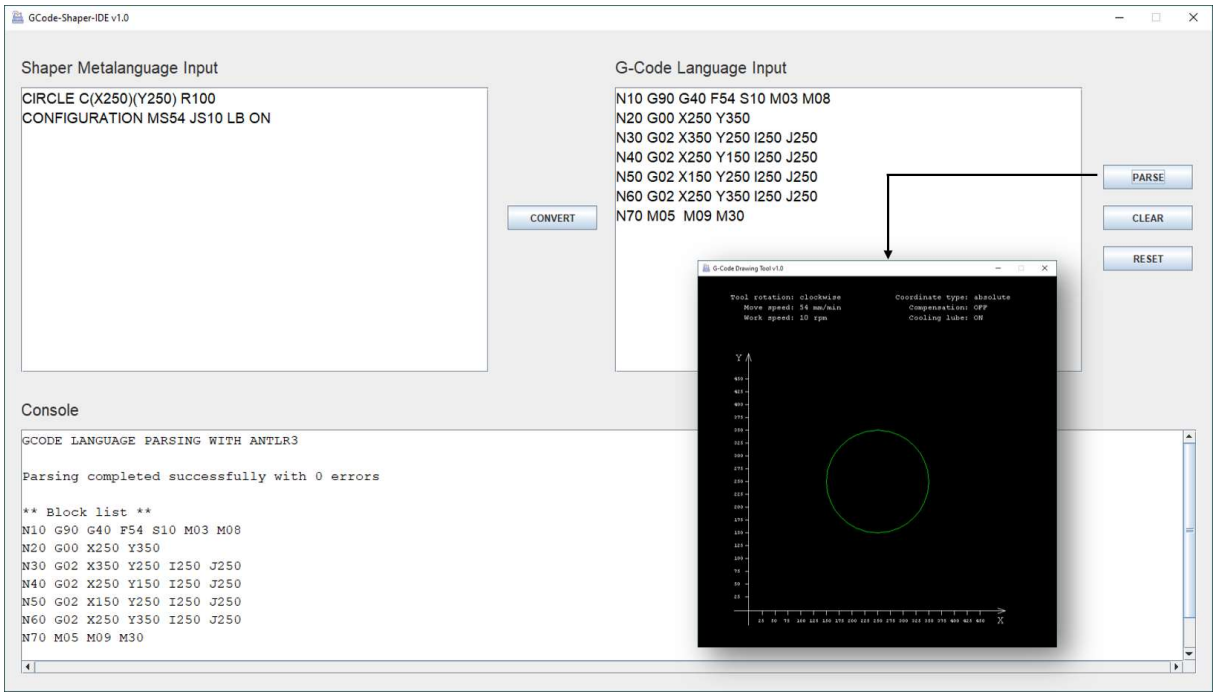
What are GCODE Parser and Shaper

GCode-Shaper-Parser aims to provide students an useful tool for understanding and practicing with G-code, a programming language for CNC machines:

- ***GCODE Parser*** is the main compiler developed for parsing G-code language and provide a graphical representation of the written code.
- ***Shaper*** is a metalanguage built upon G-code in order to simplify the definition of CNC commands and help the users understand the rules of G-code language.

Both GCODE Parser and Shaper are written in Java using ANTLR package.
GCode-Shaper-IDE is a GUI developed for helping users in the usage of *GCode-Shaper-Parser*.



Installation

GCode-Shaper-IDE v1.0 executable program can be downloaded from the Releases section of this repo ("GCodeShaperIDE.exe").

Docs

Helpful docs with syntax, examples and errors for understanding both *GCODE Parser* and *Shaper* are here provided:

1. G-code Parser docs

2. Shaper docs

Errors

All errors in G-code Parser and Shaper are here listed:

1. G-code Parser error list
2. Shaper error list

Contributors

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G-Code parser Overview

G-code Parser is built with the idea of being able to parse a simplified version of the original G-code programming language used to program CNC machines. The are some differences between the real G-code and the G-code which is parsed by this compiler, like:

- G-code Parser requires a stricter order for the directives defined inside the N-blocks (*info_geometriche-info_tecnologiche-info_3M*)
- G-code Parser is not parsing any rules concerning unit of measurement (like G94, G95, G96, G97). The parser is built considering G94 and G97 as default and they can't be changed
- G-code Parser can't deal with arcs which are not exactly equal to 90 degrees

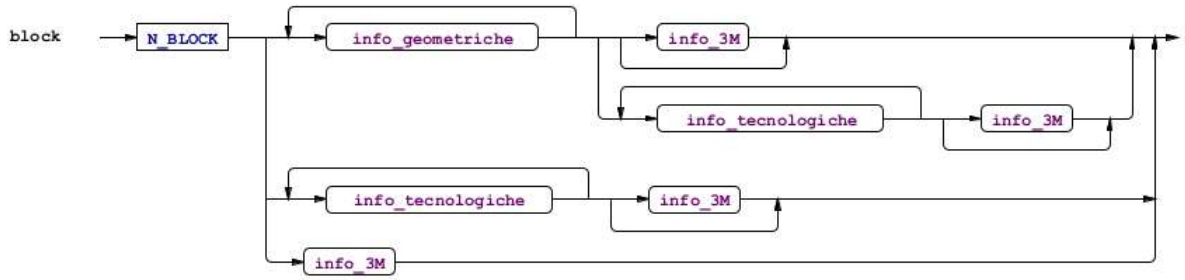
A G-code specification is composed by an infinite number of N-blocks, each of them with same structure. Each block must begin with an **increasing** N-block number and the last block must containt the **M30** directive. The structure of a block is composed by 3 main structures that, if defined, must follow the following order:

1. *info_geometriche*
2. *info_tecnologiche*
3. *info_3M*

EBNF Notation

```
block ::= N_BLOCK (
                    ( info_geometriche )+  (
                                              ( info_3M )?
                                            | ( info_tecnologiche )+ ( info_3M
)?
                                           )
                    | ( info_tecnologiche )+ ( info_3M  )?
                    | info_3M
                  )
```

Syntax Diagram

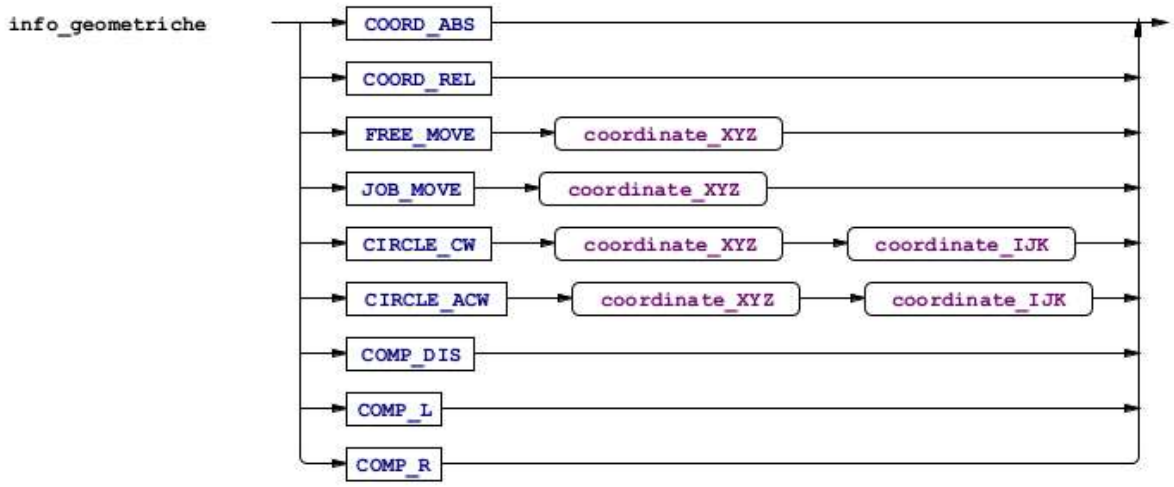


info_geometriche

EBNF Notation

```
info_geometriche ::= (  COORD_ABS
                      | COORD_REL
                      | FREE_MOVE coordinate_XYZ
                      | JOB_MOVE coordinate_XYZ
                      | CIRCLE_CW coordinate_XYZ coordinate_IJK
                      | CIRCLE_ACW coordinate_XYZ coordinate_IJK
                      | COMP_DIS
                      | COMP_L
                      | COMP_R
                     )
```

Syntax Diagram

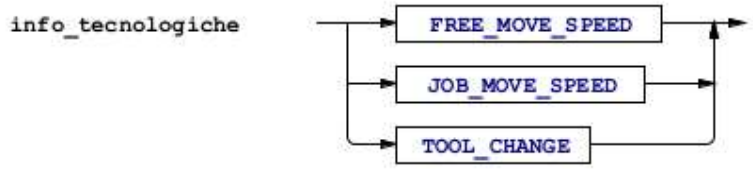


info_tecnologiche

EBNF Notation

```
info_tecnologiche ::= FREE_MOVE_SPEED
                    | JOB_MOVE_SPEED
                    | TOOL_CHANGE
```

Syntax Diagram

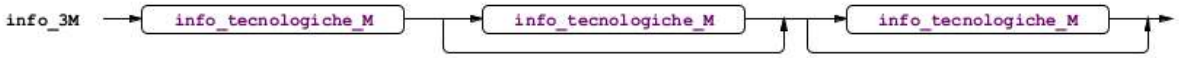


info_3M

EBNF Notation

```
info_3M::=info_tecnologiche_M ( info_tecnologiche_M )? ( info_tecnologiche_M )?
```

Syntax Diagram

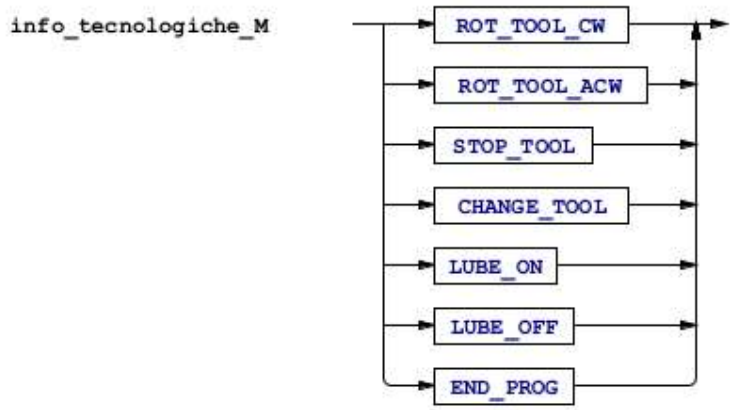


info_tecnologiche_M

EBNF Notation

```
info_tecnologiche_M ::= ROT_TOOL_CW
                      | ROT_TOOL_ACW
                      | STOP_TOOL
                      | CHANGE_TOOL
                      | LUBE_ON
                      | LUBE_OFF
                      | END_PROG
```

Syntax Diagram



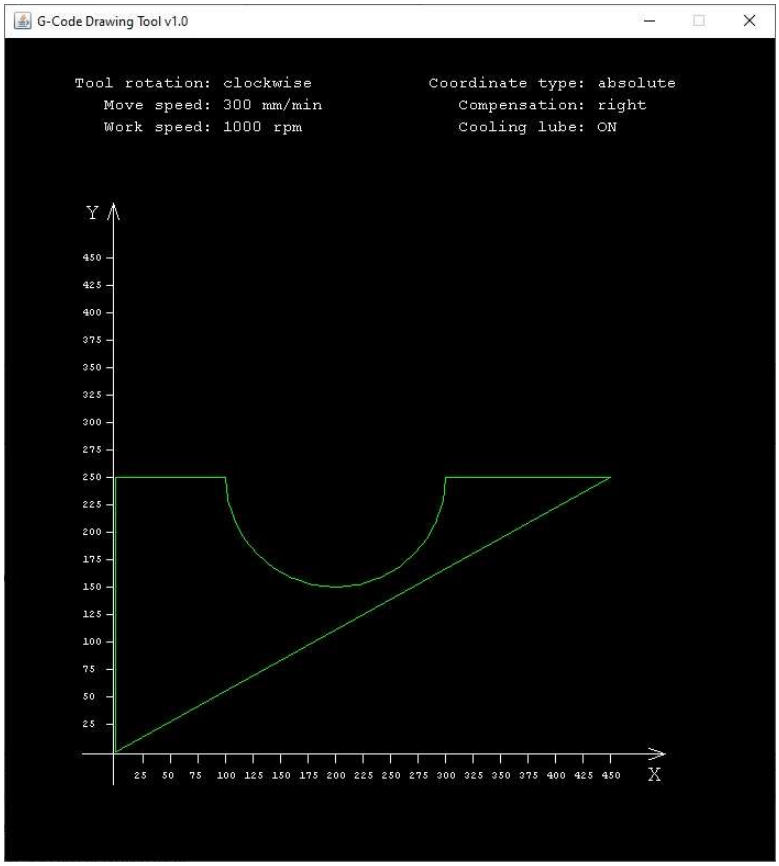
Examples

Example 1

G-code Specification

```
N10 G90 G42 F300 S1000 T0101 M06  M03 M08
N20 G00 X0 Y-10
N30 G01 Y250
N40 G01 X100
N50 G03 X200 Y150 I200 J250
N60 G03 X300 Y250 I200 J250
N70 G01 X450
N80 G01 X0 Y0
N90 G00 X0 Y-10 M05 M09 M30
```

Output

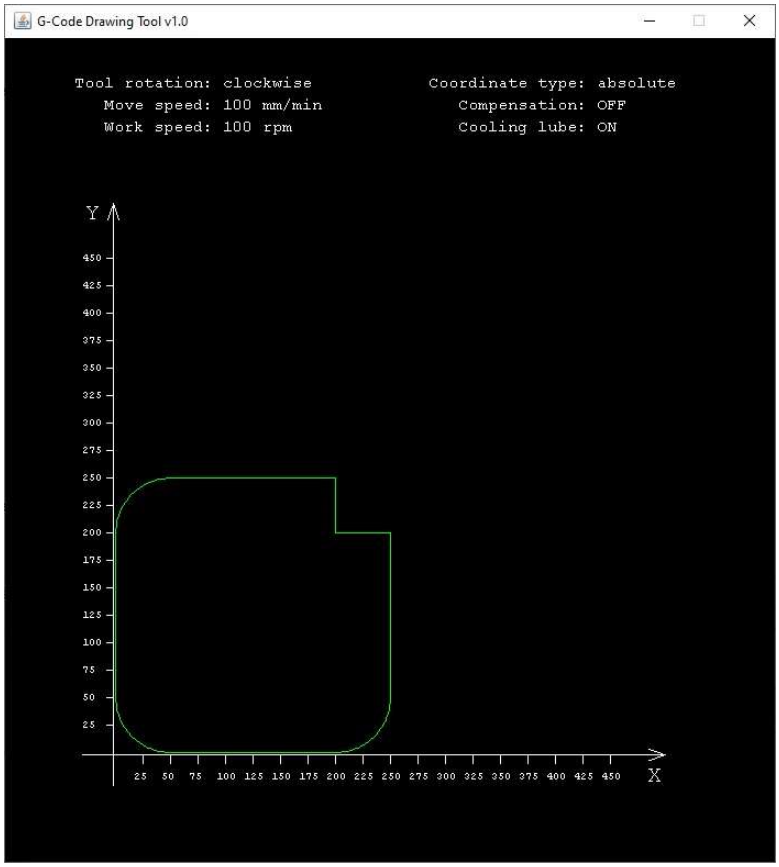


Example 2

G-code Specification

```
N0 G90 F100 S100 M03 M08
N1 G00 X0 Y50
N2 G01 X0 Y200
N3 G02 X50 Y250 I50 J200
N4 G01 X200 Y250
N5 G01 X200 Y200
N6 G01 X250 Y200
N7 G01 X250 Y50
N8 G02 X200 Y0 I200 J50
N9 G01 X50 Y0
N10 G02 X0 Y50 I50 J50
N11 M30
```

Output

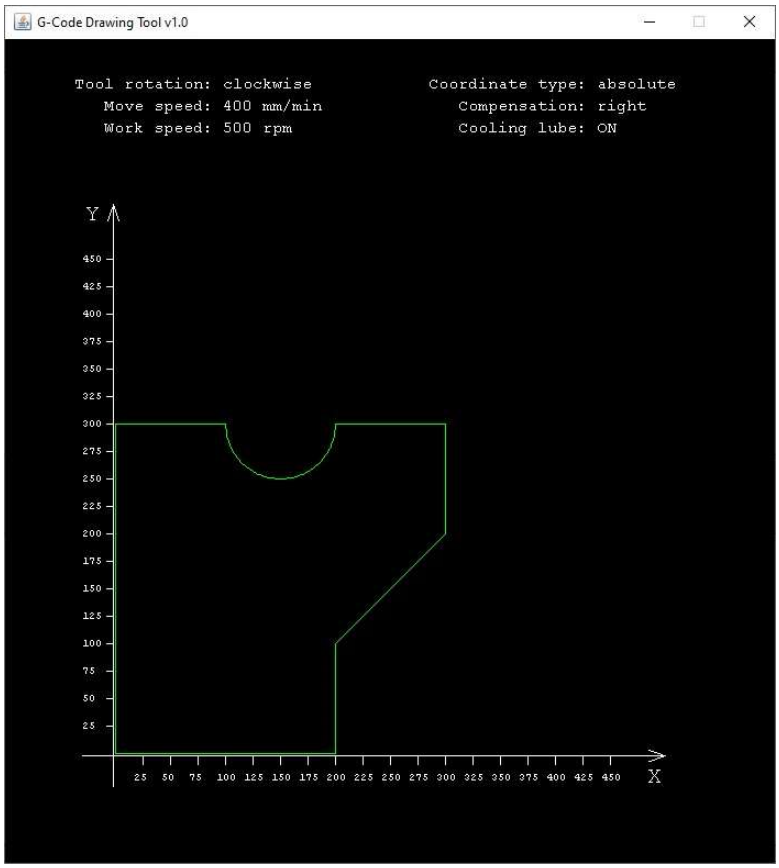


Example 3

G-code Specification

```
N10 G90 G42 T0301 F400 S500 M03 M06 M08
N20 G01 X0 Y300
N30 G01 X100 Y300
N40 G03 X150 Y250 I150 J300
N50 G03 X200 Y300 I150 J300
N60 G01 X300 Y300
N70 G01 X300 Y200
N80 G01 X200 Y100
N90 G01 X200 Y0
N100 G01 X0 Y0
N110 M05 M09 M30
```

Output



References

For the *token list specification* see description tokenList.md file.
For the full syntax grammar of GCode Parser check "GCode Parser Syntax Grammar.pdf" file.

List of tokens of the G-CODE Language

Token	Definition
Macro	
LETTER	['A'..'Z' \ 'a'..'z']
DIGIT	['0'..'9']
WS	[' ' \ '\t' \ '\r' \ '\n']+
COMMENT	['//' ~('\n'\ '\r')* '\r'? '\n' \ '/' *(options {greedy=false;} : .)* '*/']
Reserved Words	
END_PROG	'M30'
LUBE_OFF	'M09'
LUBE_ON	'M08'
CHANGE_TOOL	'M06'
STOP_TOOL	'M05'
ROT_TOOL_ACW	'M04'
ROT_TOOL_CW	'M03'
TOOL_CHANGE	'T0' ('1' .. '9') '0' ('1' .. '9')
JOB_MOVE_SPEED	'S' ('1' .. '9')(DIGIT)*
FREE_MOVE_SPEED	'F' ('1' .. '9')(DIGIT)*
COMP_R	'G42'
COMP_L	'G41'
COMP_DIS	'G40'
CIRCLE_ACW	'G03'
CIRCLE_CW	'G02'
JOB_MOVE	'G01'
FREE_MOVE	'G00'

Token	Definition
COORD_REL	'G91'
COORD_ABS	'G90'
N_BLOCK	'N' ('0' .. '9')(DIGIT)*
K_CORD	'K'CORD_DIGIT
J_CORD	'J'CORD_DIGIT
I_CORD	'I'CORD_DIGIT
Z_CORD	'Z'CORD_DIGIT
Y_CORD	'Y'CORD_DIGIT
X_CORD	'X'CORD_DIGIT
CORD_DIGIT	('-')?(DIGIT)+
I_CORD	'I'CORD_DIGIT
I_CORD	'I'CORD_DIGIT
I_CORD	'I'CORD_DIGIT

List of errors of G-code Parser

Here are listed all the errors that G-code parser is designed to throw. For more info check docs section.

Error number	Error name	Description
Lexical errors		
0	SCAN_ERROR	Invalid token
Syntax errors		
1	ERR_ON_SYNTAX	Invalid token order
Semantic errors		
2	BLOCK_NUMBERING_ERROR	Invalid sequence of N_i (N_i must be greater than N_{i-1})
3	NO_M30_ERROR	'M30' token (end program)
4	CHANGE_TOOL_ERROR	'M06' and 'T[][]' are not used together
5	NO_COORDINATE_TYPE_ERROR	'G90' or 'G91' is missing while using 'G00', 'G01', 'G02' or 'G03'
6	NO_SPINDLE_ROTATION_ERORR	'M03' or 'M04' is missing while using 'G01', 'G02' or 'G03'
7	DUPLICATED_COMMAND_ERROR	Duplicated command within a single block
8	END_ROTATION_ERROR	Spindle turned off before being turned on
9	NO_MOVE_SPEED_ERROR	Movement speed 'F0 not defined before command 'G00'
11	NO_JOB_SPEED_ERROR	Working speed 'S' not defined before command 'G01'
12	NO_COORD_TYPE_SPEED_ERROR	Speed 'F' or 'S' defined before setting the ordinate type 'G90' or 'G91'
13	NO_ABS_BEFORE_REL_ERROR	'G91' defined before setting an absolute reference point using 'G90'
14	NOT_90_DEGREE_ERROR	Circular interpolation is not equal to 90 degrees

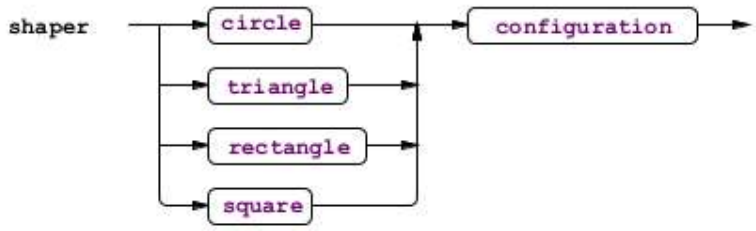
Shaper Parser Overview

A Shaper specification is composed by a *shape* followed by the job *configuration* machine parameters. The *configuration* definition must always be defined in each Shaper directive and it must follow the *shape* definition.

EBNF Notation

```
shaper ::=  (   circle
          | triangle
          | rectangle
          | square
             ) configuration
```

Syntax Diagram



Configuration

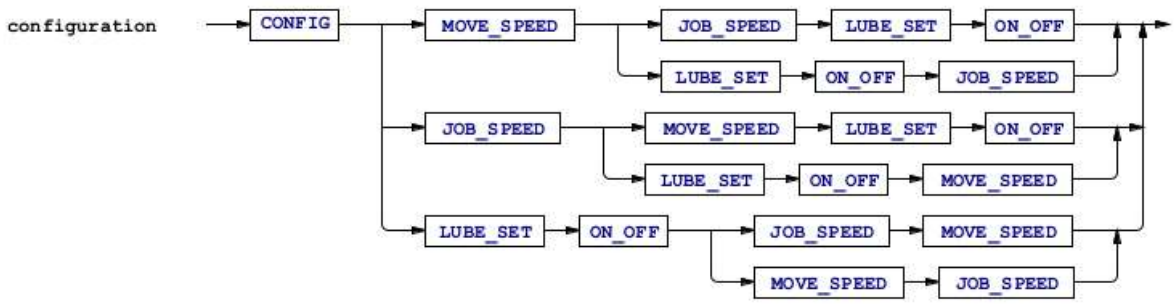
The *configuration* directive is indipendent from the particular *shape* defined and it requires to specify the following parameters:

- *movement speed*, that is the speed associated to the tool while not in use;
- *job speed*, defined as the speed associated to the tool while in use;
- *lube power option*, it is used to set the lube on or off (M08 or M09 G-code directive respectively)

EBNF Notation

```
configuration ::= CONFIG  (
                   ( MOVE_SPEED (
                                  JOB_SPEED LUBE_SET ON_OFF
                                | LUBE_SET ON_OFF JOB_SPEED
                              )
                    )
                  | ( JOB_SPEED (
                                  MOVE_SPEED LUBE_SET ON_OFF
                                | LUBE_SET ON_OFF MOVE_SPEED
                              )
                    )
                  | ( LUBE_SET ON_OFF (
                                JOB_SPEED MOVE_SPEED
                                  | MOVE_SPEED JOB_SPEED
                                )
                    )
                  )
```

Syntax Diagram



Examples

Examples of *configuration* definition are shown in the shapes paragraph.

Shapes

Shaper currently provides support for 4 different type of *shape* figures:

- circle
- triangle
- rectangle
- square

Circle

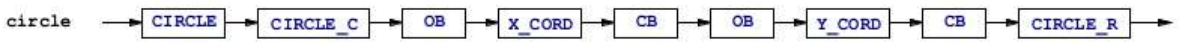
The *circle* command allows to draw a circle in the Cartesian plane with a given center and radius. It requires to specify the following parameters:

- *center coordinates*, that are the spatial coodinates of the circle's center
- *radius*, that is the distance between the center and any point belonging to the circle's circumference

EBNF Notation

```
circle ::= CIRCLE CIRCLE_C
                       OB
                 X_CORD
               CB
               OB
                 Y_CORD
               CB
          CIRCLE_R
```

Syntax Diagram



Examples

```
CIRCLE C(X250)(Y250) R100
CONFIGURATION MS54 JS10 LB ON
```

Errors

The *circle* command can raise the following *semantic errors*:

- *MAX_COORD_ERROR*: this error can be thrown due to huge radius lenght or due to center coordinates too close to the Cartesian plan limits

```
CIRCLE C(X400)(Y400) R300
CONFIGURATION MS54 JS10 LB ON

** Error list **
1 - Semantic Error (3) at [0, 0]: Found MAX_COORD_ERROR - all coordinates must
be positive and lower than 500 pixel to be displayed
```

Triangle

The *triangle* command allows to draw a triangle in the Cartesian plane with three given points. It requires to specify the following parameters:

- *first vertex coordinates*, that are the spatial coodinates of the first triangle's vertex
- *second vertex coordinates*, that are the spatial coodinates of the second triangle's vertex
- *third vertex coordinates*, that are the spatial coodinates of the third triangle's vertex

EBNF Notation

```
triangle ::= TRIANGLE P1
                      OB
               X_CORD
            CB
            OB
              Y_CORD
            CB
              P2
            OB
              X_CORD
            CB
            OB
              Y_CORD
            CB
              P3
            OB
              X_CORD
```

```
            CB
            OB
              Y_CORD
            CB
```

Syntax Diagram

Examples

```
 //isosceles triangle
 TRIANGLE P1(X100)(Y100)P2(X150)(Y250)P3(X200)(Y100)
 CONFIGURATION MS54 JS10 LB ON

 //scalene triangle
 TRIANGLE P1(X100)(Y100)P2(X150)(Y200)P3(X300)(Y100)
 CONFIGURATION MS54 JS10 LB ON

 //rectangle triangle
 TRIANGLE P1(X100)(Y100)P2(X100)(Y200)P3(X300)(Y100)
 CONFIGURATION MS54 JS10 LB ON
```

Errors

The *triangle* command can raise the following *semantic errors*:

- *MAX_COORD_ERROR*: this error can be thrown due to point coordinates too close to the Cartesian plan limits

```
 TRIANGLE P1(X400)(Y400)P2(X650)(Y650)P3(X600)(Y400)
 CONFIGURATION MS54 JS10 LB ON

 ** Error list **
 1 - Semantic Error (3) at [0, 0]: Found MAX_COORD_ERROR - all coordinates must
be positive and lower than 500 pixel to be displayed
```

Rectangle

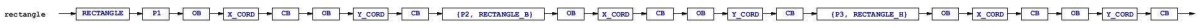
The *rectangle* command allows to draw a rectangle in the Cartesian plane with three given points. It requires to specify the following parameters:

- *first point coordinates*, that are the spatial coordinates of the first rectangle's point
- *second point coordinates*, that are the spatial coordinates of the second rectangle's point
- *third point coordinates*, that are the spatial coordinates of the third rectangle's point

EBNF Notation

```
rectangle ::= RECTANGLE P1
              OB
                X_CORD
              CB
              OB
                    Y_CORD
              CB
            ( P2 | RECTANGLE_B )
              OB
                X_CORD
                  CB
              OB
                Y_CORD
                  CB
            ( P3 | RECTANGLE_H )
                  OB
                X_CORD
                  CB
              OB
                Y_CORD
              CB
```

Syntax Diagram



Examples

```
 //rectangle generated by bottom-left vertex
 RECTANGLE P1(X100)(Y200) P2(X400)(Y200) P3(X100)(Y400)
 CONFIGURATION MS54 JS56 LB ON

 //rectangle generated by bottom-right vertex
 RECTANGLE P1(X400)(Y200) P2(X400)(Y400) P3(X100)(Y200)
 CONFIGURATION MS54 JS56 LB ON

 //oblique rectangle generated by top vertex
 RECTANGLE P1(X300)(Y200) P2(X250)(Y250) P3(X200)(Y100)
 CONFIGURATION MS54 JS56 LB ON

 //oblique rectangle generated by bottom vertex
 RECTANGLE P1(X200)(Y100) P2(X300)(Y200) P3(X150)(Y150)
 CONFIGURATION MS54 JS56 LB ON
```

Errors

The *rectangle* command can raise the following *semantic errors*:

- *MAX_COORD_ERROR*: this error can be thrown due to point coordinates too close to the Cartesian plan limits
- *NOT_RECT_PERP_ERROR*: this error can be thrown due to non-perpendicular shape's sides

```
RECTANGLE P1(X400)(Y200) P2(X500)(Y200) P3(X600)(Y500)
CONFIGURATION MS54 JS56 LB ON
```

```
** Error list **
1 - Semantic Error (3) at [0, 0]: Found MAX_COORD_ERROR - all coordinates must
be positive and lower than 500 pixel to be displayed
2 - Semantic Error (4) at [0, 0]: Found NOT_RECT_PERP_ERROR - sides of the
rectangle must be perpendicular
```

Square

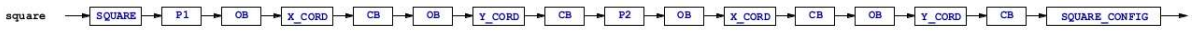
The *square* command allows to draw a square in the Cartesian plane with three given points. It requires to specify the following parameters:

- *first point coordinates*, that are the spatial coordinates of the first rectangle's point
- *second point coordinates*, that are the spatial coordinates of the second rectangle's point
- *square orientation*, that is the spatial orientation of the shape (UP, DOWN)

EBNF Notation

```
square ::= SQUARE P1
           OB
             X_CORD
               CB
               OB
             Y_CORD
               CB
             P2
           OB
             X_CORD
           CB
           OB
             Y_CORD
           CB
             SQUARE_CONFIG
```

Syntax Diagram



Examples

```
 //up square
 SQUARE P1(X150)(Y150) P2(X350)(Y150) CONFIG UP
 CONFIGURATION MS54 JS56 LB ON

 //down square
 SQUARE P1(X150)(Y350) P2(X350)(Y350) CONFIG DOWN
 CONFIGURATION MS54 JS56 LB

 //oblique suqare
 SQUARE P1(X150)(Y150) P2(X300)(Y200) CONFIG UP
 CONFIGURATION MS54 JS56 LB ON
```

Errors

The *square* command can raise the following *semantic errors*:

- *MAX_COORD_ERROR*: this error can be thrown due to point coordinates too close to the Cartesian plan limits
- `SQUARE P1(X150)(Y350) P2(X350)(Y350) CONFIG UP`
- `CONFIGURATION MS54 JS56 LB ON`
- `** Error list **`
- `1 - Semantic Error (3) at [0, 0]: Found MAX_COORD_ERROR - all coordinates must be positive and lower than 500 pixel to be displayed`

References

For the *token list specification* see description tokenList.md file.
For the full syntax grammar of Shaper metalanguage check "Shaper Parser Syntax Grammar.pdf" file.

List of tokens of the Shaper Language

Token	Definition
Macro	
LETTER	['A'..'Z' \ 'a'..'z']
DIGIT	['0'..'9']
WS	[' ' \ '\t' \ '\r' \ '\n']+
COMMENT	['//' ~('\n'\ '\r')* '\r'? '\n' \ '/' *(options {greedy=false;} : .)* '*/']
OB	'('
CB	')'
Reserved Words	
ON_OFF	'ON' \ 'OFF'
LUBE_SET	'LB'
JOB_SPEED	'JS' DIGIT+
MOVE_SPEED	'MS' DIGIT+
CONFIG	'CONFIGURATION'
Y_CORD	'Y' DIGIT+
X_CORD	'X' DIGIT+
SQUARE_CONFIG	'UP' \ 'DOWN'
P1	'P1'
P2	'P2'
P3	'P3'
RECTANGLE_H	'H'
RECTANGLE_B	'B'
RECTANGLE_P	'P'
SQUARE_L	'L'
CIRCLE_R	'R' DIGIT+
CIRCLE_C	'C'

Token	Definition
TRIANGLE	'TRIANGLE'
RECTANGLE	'RECTANGLE'
SQUARE	'SQUARE'
CIRCLE	'CIRCLE'

List of errors of Shaper Metalanguage

Here are listed all the errors that Shaper parser is designed to throw. For more info check docs section.

Error number	Error name	Description
Lexical errors		
0	SCAN_ERROR	Invalid token
Syntax errors		
1	ERR_ON_SYNTAX	Invalid token order
Semantic errors		
3	MAX_COORD_ERROR	Input coordinates does not respect X-Y axis limits
4	NOT_RECT_PERP_ERROR	Rectangle sides are not perpendicular