Let’s Build A Simple Interpreter. Part 8. (https://ruslanspivak.com/lsbasi-part8/)

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Today we’ll talk about **unary operators**, namely unary plus (+) and unary minus (-) operators.

A lot of today’s material is based on the material from the previous article, so if you need a refresher just head back to Part 7 (http://ruslanspivak.com/lsbasi-part7/) and go over it again. Remember: repetition is the mother of all learning.

Having said that, this is what you are going to do today:

- extend the grammar to handle unary plus and unary minus operators
- add a new *UnaryOp* AST node class
- extend the parser to generate an AST with *UnaryOp* nodes
- extend the interpreter and add a new *visit_UnaryOp* method to interpret unary operators

Let’s get started, shall we?

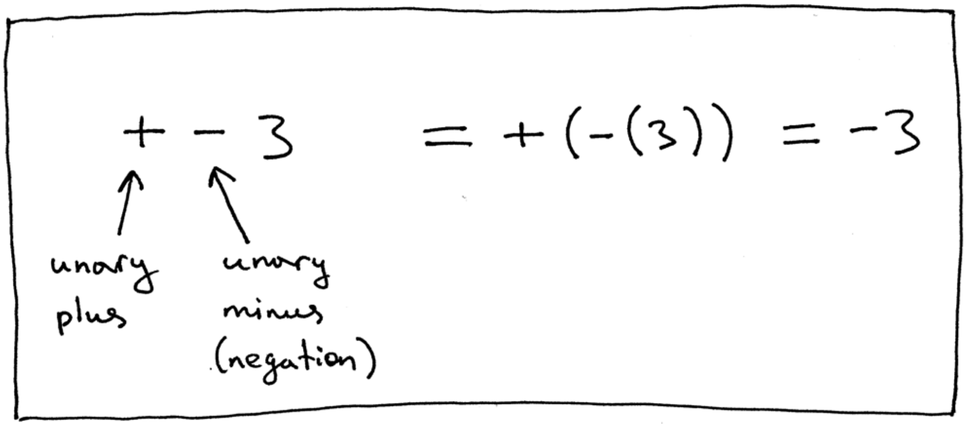
So far we’ve worked with binary operators only (+, -, *, /), that is, the operators that operate on two operands.

What is a unary operator then? A *unary operator* is an operator that operates on one *operand* only.

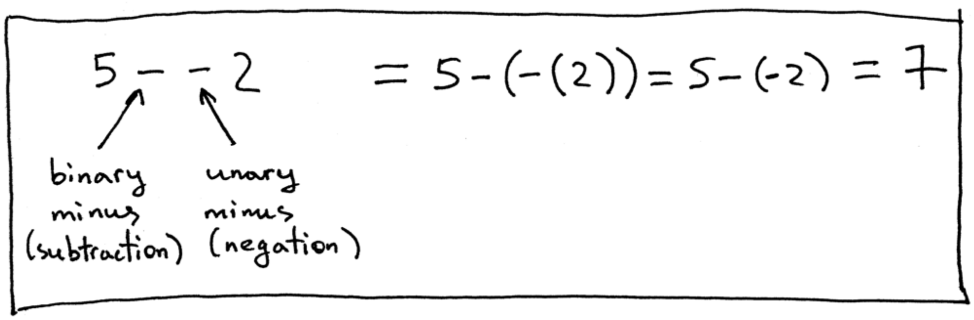
Here are the rules for unary plus and unary minus operators:

- The unary minus (-) operator produces the negation of its numeric operand
- The unary plus (+) operator yields its numeric operand without change
- The unary operators have higher precedence than the binary operators +, -, *, and /

In the expression “+ - 3” the first ‘+’ operator represents the unary plus operation and the second ‘-‘ operator represents the unary minus operation. The expression “+ - 3” is equivalent to “+ (- (3))” which is equal to -3. One could also say that **-3** in the expression is a negative integer, but in our case we treat it as a unary minus operator with 3 as its positive integer operand:

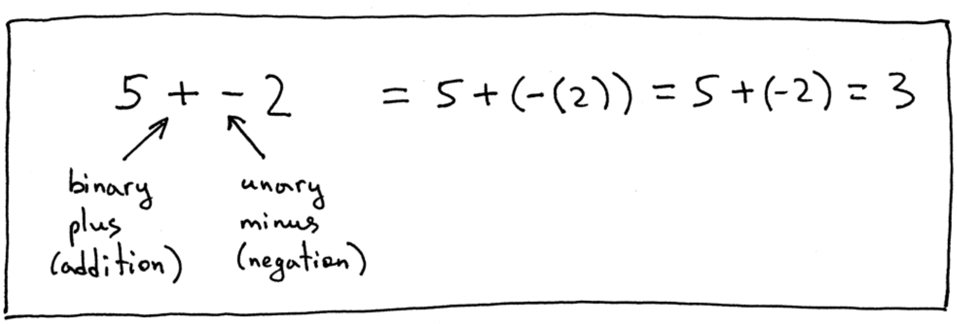


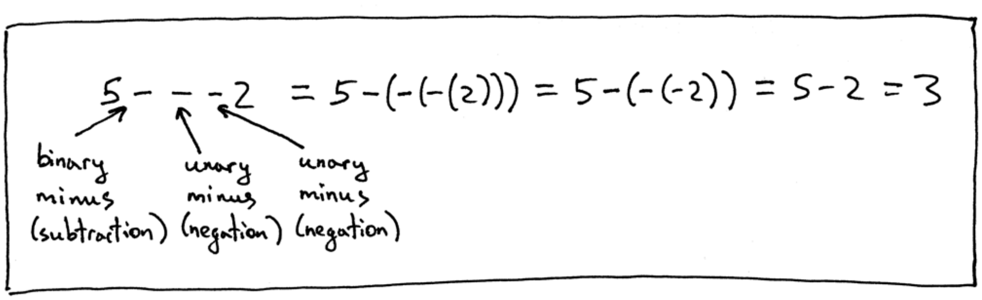
Let’s take a look at another expression, “5 - - 2”:



In the expression “5 - - 2” the first ‘-‘ represents the *binary* subtraction operation and the second ‘-‘ represents the *unary* minus operation, the negation.

And some more examples:





Now let’s update our grammar to include unary plus and unary minus operators. We’ll modify the *factor* rule and add unary operators there because unary operators have higher precedence than binary +, -, * and / operators.

This is our current *factor* rule:

factor : INTEGER | LPAREN expr RPAREN

And this is our updated *factor* rule to handle unary plus and unary minus operators:

factor : (PLUS | MINUS) factor | INTEGER | LPAREN expr RPAREN

As you can see, I extended the *factor* rule to reference itself, which allows us to derive expressions like “- - - + - 3”, a legitimate expression with a lot of unary operators.

Here is the full grammar that can now derive expressions with unary plus and unary minus operators:

expr : term ((PLUS | MINUS) term)*
term : factor ((MUL | DIV) factor)*
factor : (PLUS | MINUS) factor | INTEGER | LPAREN expr RPAREN

The next step is to add an AST node class to represent unary operators.

This one will do:

```
class UnaryOp(AST):
    def __init__(self, op, expr):
        self.token = self.op = op
        self.expr = expr
```

The constructor takes two parameters: *op*, which represents the unary operator token (plus or minus) and *expr*, which represents an AST node.

Our updated grammar had changes to the *factor* rule, so that’s what we’re going to modify in our parser - the *factor* method. We will add code to the method to handle the “(PLUS | MINUS) factor” sub-rule:

```python
def factor(self):
    """factor : (PLUS | MINUS) factor | INTEGER | LPAREN expr RPAREN"""
    token = self.current_token
    if token.type == PLUS:
        self.eat(PLUS)
        node = UnaryOp(token, self.factor())
        return node
    elif token.type == MINUS:
        self.eat(MINUS)
        node = UnaryOp(token, self.factor())
        return node
    elif token.type == INTEGER:
        self.eat(INTEGER)
        return Num(token)
    elif token.type == LPAREN:
        self.eat(LPAREN)
        node = self.expr()
        self.eat(RPAREN)
        return node
```

And now we need to extend the *Interpreter* class and add a *visit_UnaryOp* method to interpret unary nodes:

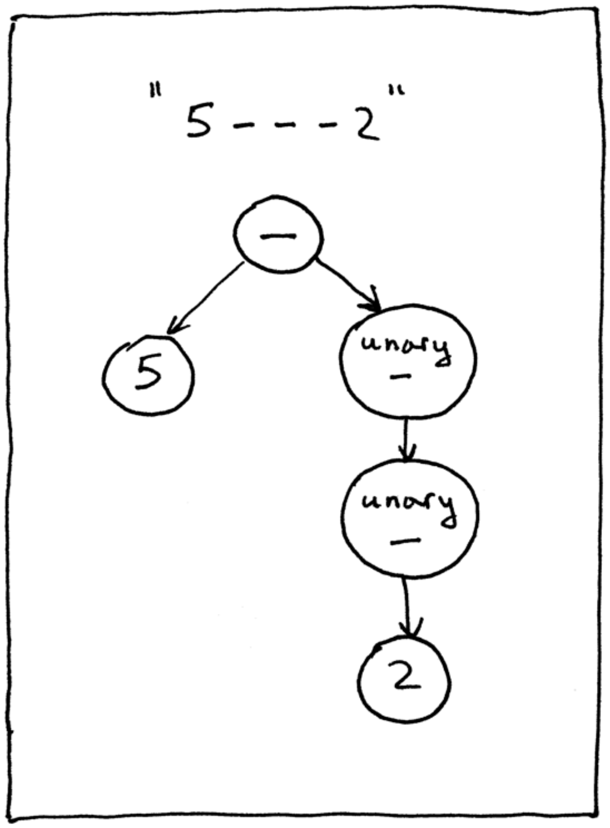
```python
def visit_UnaryOp(self, node):
    op = node.op.type
    if op == PLUS:
        return +self.visit(node.expr)
    elif op == MINUS:
        return -self.visit(node.expr)
```

Onward!

Let's manually build an AST for the expression "5 - - - 2" and pass it to our interpreter to verify that the new *visit_UnaryOp* method works. Here is how you can do it from the Python shell:

```python
>>> from spi import BinOp, UnaryOp, Num, MINUS, INTEGER, Token
>>> five_tok = Token(INTEGER, 5)
>>> two_tok = Token(INTEGER, 2)
>>> minus_tok = Token(MINUS, '-')
>>> expr_node = BinOp(
...     Num(five_tok),
...     minus_tok,
...     UnaryOp(minus_token, UnaryOp(minus_token, Num(two_tok)))
... )
>>> from spi import Interpreter
>>> inter = Interpreter(None)
>>> inter.visit(expr_node)
3
```

Visually the above AST tree looks like this:



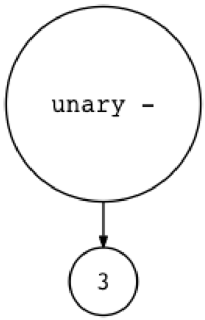
Download the full source code of the interpreter for this article directly from GitHub (https://github.com/rspivak/lsbasi/blob/master/part8/python/spi.py). Try it out and see for yourself that your updated tree-based interpreter properly evaluates arithmetic expressions containing unary operators.

Here is a sample session:

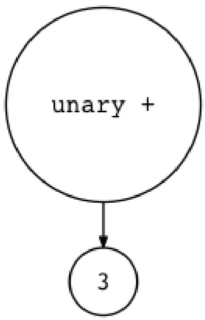
```
$ python spi.py
spi> - 3
-3
spi> + 3
3
spi> 5 - - - + - 3
8
spi> 5 - - - + - (3 + 4) - +2
10
```

I also updated the genastdot.py (https://github.com/rspivak/lsbasi/blob/master/part8/python/genastdot.py) utility to handle unary operators. Here are some of the examples of the generated AST images for expressions with unary operators:

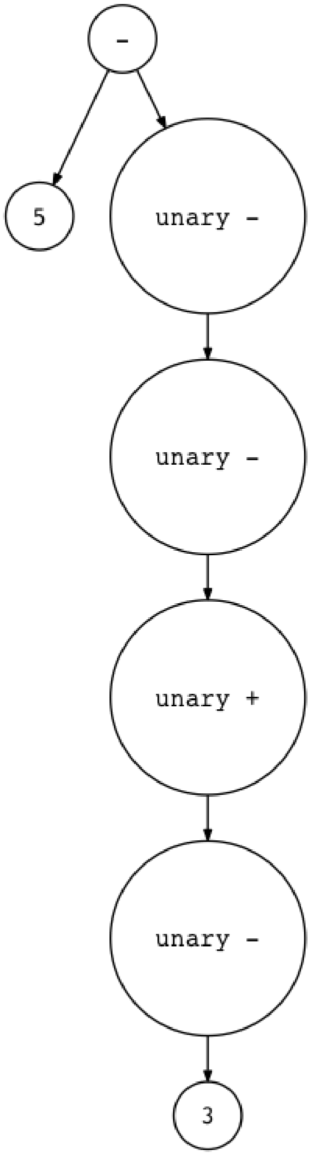
```
$ python genastdot.py "- 3" > ast.dot && dot -Tpng -o ast.png ast.dot
```



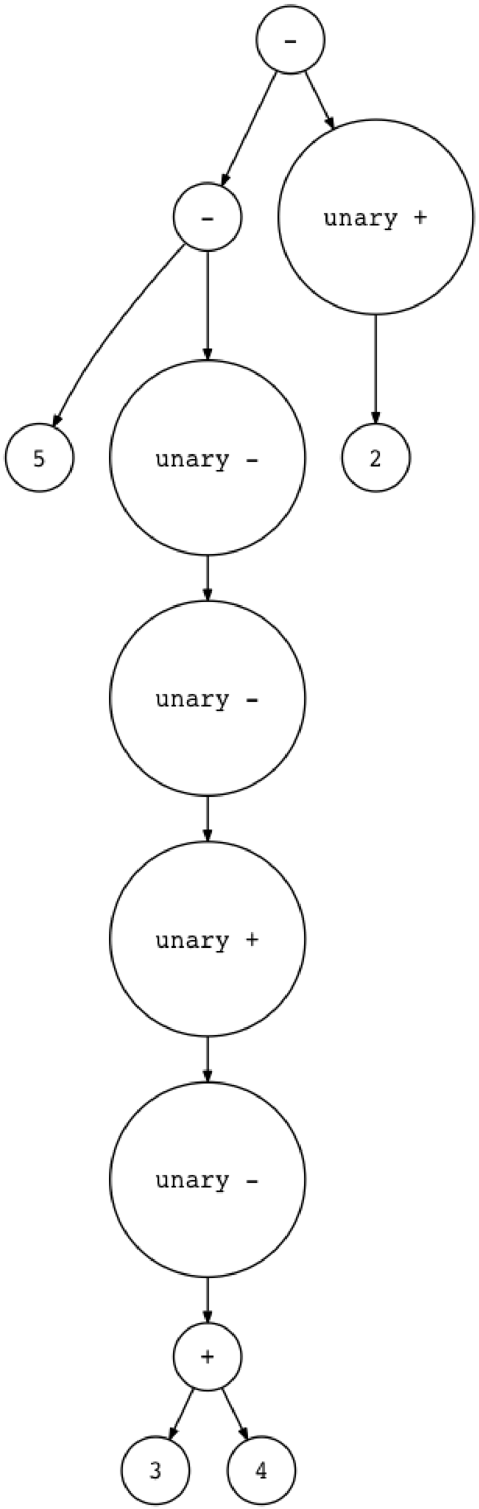

```
$ python genastdot.py "+ 3" > ast.dot && dot -Tpng -o ast.png ast.dot
```



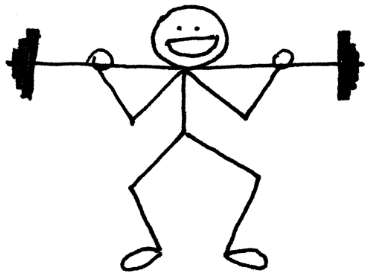

```
$ python genastdot.py "5 - - - + - 3" > ast.dot && dot -Tpng -o ast.png ast.dot
```




```
$ python genastdot.py "5 - - - + - (3 + 4) - +2" \
  > ast.dot && dot -Tpng -o ast.png ast.dot
```



And here is a new exercise for you:



- Install Free Pascal (http://www.freepascal.org/), compile and run testunary.pas (https://github.com/rspivak/lsbasi/blob/master/part8/python/testunary.pas), and verify that the results are the same as produced with your spi (https://github.com/rspivak/lsbasi/blob/master/part8/python/spi.py) interpreter.

That's all for today. In the next article, we'll tackle assignment statements. Stay tuned and see you soon.

Here is a list of books I recommend that will help you in your study of interpreters and compilers:

1. Language Implementation Patterns: Create Your Own Domain-Specific and General Programming Languages (Pragmatic Programmers) (http://www.amazon.com/gp/product/193435645X/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=193435645X&linkCode=as2&tag=russblo0b-20&linkId=MP4DCXDV6DJMEJBL)
2. Writing Compilers and Interpreters: A Software Engineering Approach (http://www.amazon.com/gp/product/0470177071/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=0470177071&linkCode=as2&tag=russblo0b-20&linkId=UCLGQTPIYSWYKRRM)
3. Modern Compiler Implementation in Java (http://www.amazon.com/gp/product/052182060X/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=052182060X&linkCode=as2&tag=russblo0b-20&linkId=ZSKKZMV7YWR22NMW)
4. Modern Compiler Design (http://www.amazon.com/gp/product/1461446988/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=1461446988&linkCode=as2&tag=russblo0b-20&linkId=PAXWJP5WCPZ7RKRD)
5. Compilers: Principles, Techniques, and Tools (2nd Edition) (http://www.amazon.com/gp/product/0321486811/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=0321486811&linkCode=as2&tag=russblo0b-20&linkId=GOEGDQG4HIHU56FQ)

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