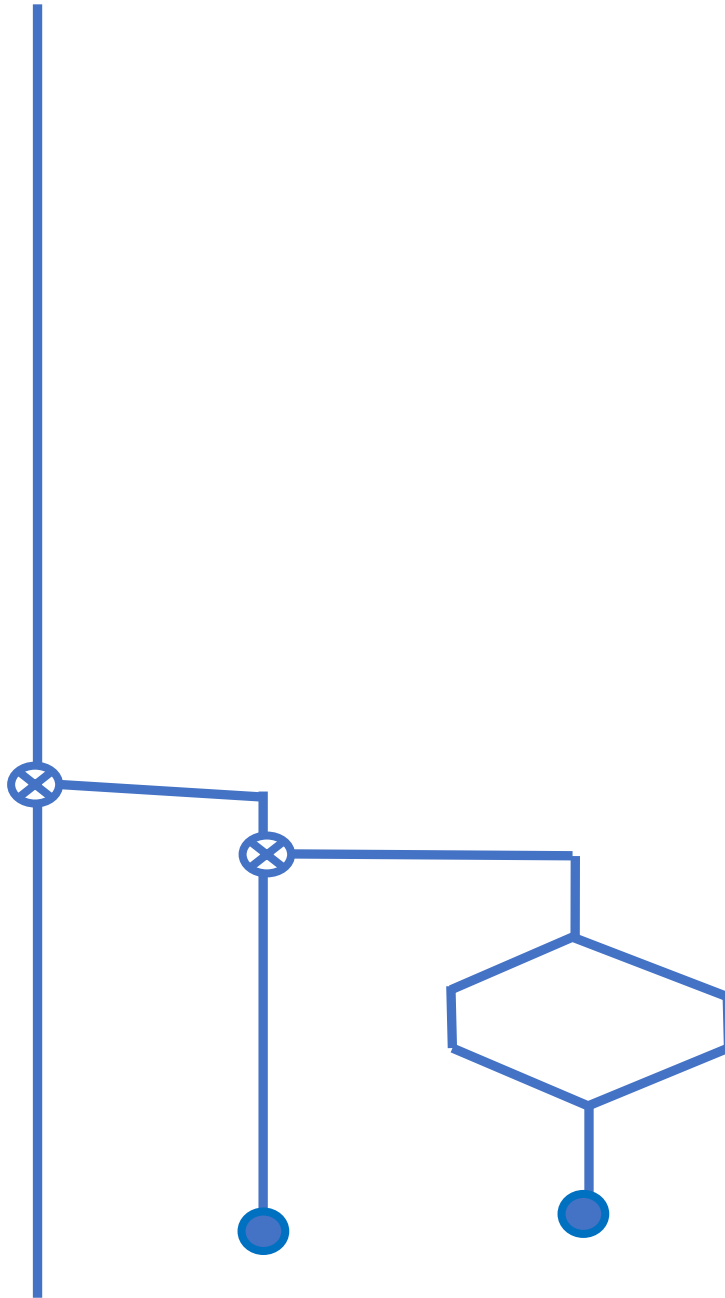


A Two-Dimension Data Structure

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Forth Data Structures

Forth has a variety of data structures. But they exist for its internal operation.

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Forth's inherent data structures:

Byte/character	_	C@ C!
Word	_ _	W@ W!
Cell	_ _ _ _	@ !
Float	_ _ _ _ _ _ _ _	F@ F!
Array	_ . . . _	specific words
Files		Include, Require

The General Need

Problem oriented data structures are the programmer's responsibility.

Data base

Matrices

Vector graphics

Bit graphics

Sound

Video

AI structures

Simulation structures

My Need

Intended for math and statistical analysis.

Data loaded from .csv files.

Results saved to .csv files.

Data cell size from bytes (1) to floats (8).

Floats and characters for the present.

Notation from *Scientific Forth* by Dr. Julian Noble.

What Can This Structure Do?

Load with literal values

Load with random numbers

Read and write data files.

Formatted print

Math on matrix, row, column, sub-area, cell.

Copy and move by row, column, sub-area, cell.

Multicolumn sort

Linear algebra operations

Transpose, matrix multiply, equation solution

Inversion, Gaussian elimination, etc.

Limited alphabetic processing

A Quick Demonstration

```
1 4 create{ x{  
x{ <[ 1 2 3 4 ]>          1.00 2.00 3.00 4.00  
x{ }list
```

```
x{ 4 4 }resize  
x{ }transpose  
x{ }list
```

A Quick Demonstration

```
1 4 create{ x{  
x{ <[ 1 2 3 4 ]}  
x{ }list
```

```
1.00 2.00 3.00 4.00
```

```
x{ 5 3 }resize  
x{ }transpose  
x{ }list
```

```
1.00 0.00 0.00  
2.00 0.00 0.00  
3.00 0.00 0.00  
4.00 0.00 0.00  
0.00 0.00 0.00
```

```
ok
```


Components

Data area of 'row x column x cell-size' bytes.

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A descriptor holding: f (cellsize), R (rows), C (columns) and control pointers.

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A descriptor holding: f (cellsize), R (rows), C (columns) and control pointers.

A Forth name for each matrix.

Words to access matrices, single cells and various row & column combinations.

Conventions

Matrices are referred to by the address of the first byte in their data area.

Descriptors are located by the negative offset from their data area.

Row and column numbers run from 0 .. R-1.

`x{` matrix names end in `{`

`x{ }name` ‘`}`’ operates on a full matrix

`x{ r1 c1 }negate` ‘`}}`’ operates on one cell.

The Descriptor

Pointer to its name's PFA

Backlink if resized

Pointer to its data area

Cells size: f (8 bytes for floats)

Number of columns: C

Number of rows: R

```
3 5 create{ x{      x{ }.descriptors
```

```
data located at: 44BB94
```

```
    pfa: 44BB78 i.e. x{
```

```
    backlink: 0
```

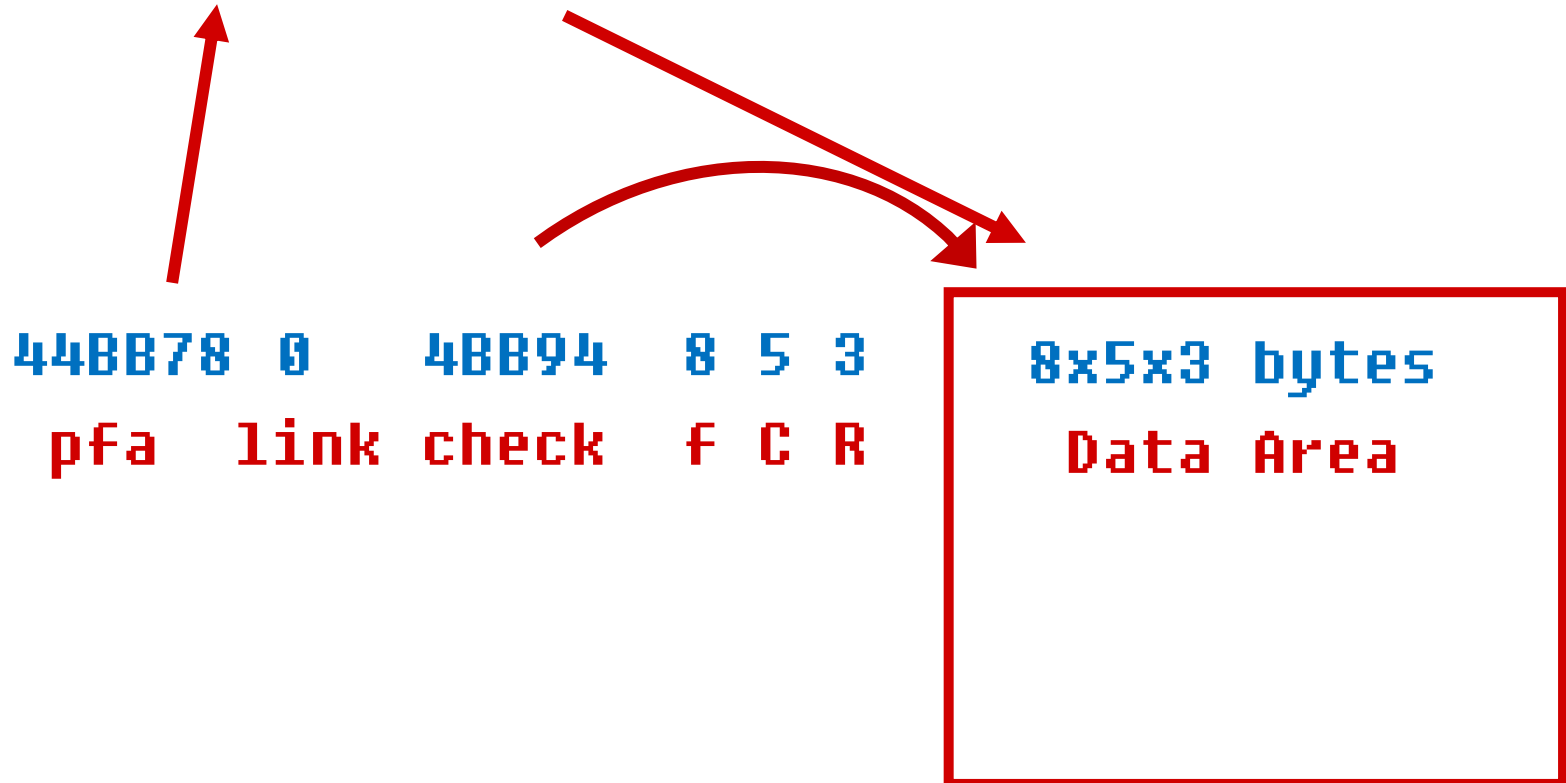
```
    check: 44BB94
```

```
    size: 8
```

```
    params: 5 3 ok
```

Shown As In Memory

x{ parameter_field



See The Magic

The word doing the 'heavy lifting' is: `>>`

Used as: `x{ r c >> }`

Where C is the matrix number of columns,
`>>` computes

`address+((row * C) + column) * bytes/cell`

The initial byte address of a float cell.

```
: >> ( x{ r1 c1 --- addr )  
      swap 2pick }cols * +  
      over size: @ * + ; Us
```


Access A Cell

```
3 4 create{ x{   x{ }integers x{ }list
```

0.0	1.0	2.0	3.0
4.0	5.0	6.0	7.0
8.0	9.0	10.0	11.0



```
x{ 1 1 } F@ F.
```

```
5.0 ok
```

Row-wise Arithmetic

```
4 3 create{ x{
```

		0.0	0.0	0.0
x{ 1 7e }r#fill	→	7.0	7.0	7.0
x{ 2 2e }r#fill	→	2.0	2.0	2.0
x{ 1 x{ 2 x{ 3 }rrr+	→	9.0	9.0	9.0
x{ }list		ok		

Matrix Operators

`create{ create{*`

`}list, }sublist`

`}copy, }rcopy, }ccopy, }subcopy`

`}clear, }integers, }random, }resize`

`}dimensions, }rows, }cols, }cells, }bytes`

`}det, }transpose, }invert, }bubble`

All Math Operators

Matrix	>+	>-	>.*	>./
Common row	>r+	>r-	>r.*	>r./
Independent rows	>rrr+	>rrr-	>rrr.*	>rrr./
Common column	>c+	>c-	>c.*	>c./
Independent columns	>ccc+	>ccc-	>ccc.*	>ccc./
Single cell	>rc+	>rc-	>rc.*	>rc./
Common sub-cell	>com+	>com-	>com.*	>com./
Independent sub-cells	>sub+	>sub-	>sub.*	>sub./

Common root word



(}SubX)

Note: >.* and >./ are cell by cell.

Alphanumerics

```
1 3 15 create{* alpha{  
alpha{ }alphafill  
alpha{ }charlist
```

```
ABCDEFGHIJKLMNO  
PQRSTUVWXYZ[\]^  
_`abcdefghijklm ok
```

Look Within A Definition

```
0.00  1.00  2.00  3.00  4.00  
5.00  6.00  7.00  8.00  9.00  
10.00 11.00 12.00 13.00 14.00
```

```
x{ }transpose
```

Look Within A Definition

```
0.00  1.00  2.00  3.00  4.00  
5.00  6.00  7.00  8.00  9.00  
10.00 11.00 12.00 13.00 14.00
```

```
x{ }transpose
```

```
0.00  5.00  10.0  
1.00  6.00  11.0  
2.00  7.00  12.0  
3.00  8.00  13.0  
4.00  9.00  14.0
```

```
ok
```

Look Within A Word

```
: }Transpose ( x{ --- )
⌈{  dup }dimensions opentransient{
dup transient{ }copy
dup params: 2@ swap 2pick params: 2@
dup }dimensions swap
  0 do  dup 0 do
    transient{ i j }}@
    over j i }}*
  loop loop
2drop closetransient{ ;
```

Missing something? Find a model and modify.

Generate Random Data

Matrix 16 x 1	16 1 create{ ref{	0.00	4.3
		7.00	69.4
		5.00	79.9
Fill random integers	ref{ 10e 0e }random	2.00	9.6
		5.00	41.1
Matrix 16 x 2	16 2 create{ x{	0.00	44.5
		0.00	96.2
Fill random floats	x{ 100e 1e }random	8.00	77.1
		4.00	26.8
Copy integers column 0	ref{ x{ 0 }cCopy	1.00	43.4
		0.00	88.8
		2.00	16.7
List the composite	x{ }list	3.00	16.7
		0.00	57.0
		0.00	79.5
		9.00	51.4

Sort On Column 1 Then Column 0

0.00 4.3

7.00 69.4

5.00 79.9

2.00 9.6

5.00 41.1

0.00 44.5

0.00 96.2

8.00 77.1

4.00 26.8

1.00 43.4

0.00 88.8

2.00 16.7

3.00 16.7

0.00 57.0

0.00 79.5

9.00 51.4

x{ 1 }bubble

x{ 0 }bubble

x{ }list

0.00 4.6

0.00 44.5

0.00 57.0

0.00 79.5

0.00 88.8

0.00 96.2

1.00 43.4

2.00 9.6

2.00 16.7

3.00 16.7

4.00 26.8

5.00 41.1

5.00 79.9

7.00 69.4

8.00 77.1

9.00 51.4

Sort Performance

A bubble sort with comparisons: $(n^2 + n)/2$

```
10000 3 create{ x{ x{ 10000e 0e }random  
x{ 0 }bubble
```

100 rows	16 msec.
1,000 rows	1.9 seconds.
5,000 rows	31.8 seconds.
10,000 rows	1 min 57 seconds

For daily data that covers 27 years.

Benefits

A very flexible data structure.

A rich suite of support words.

Current words easily modified for other needs.

So, see my Win32Forth Guide on Github.

Future Work

Add file support.

Add statistics support.

Possibly, text entries and added number types.

Expand report generation choices.

Credits

- Andrew McKewan and Tom Zimmer for Win32Forth.
- The European team who updated it in the early 2000s.
- Dr. Julian V. Noble, *Scientific Forth*

References

- https://github.com/BillRagsdale/Forth_Projects
- <https://github.com/BillRagsdale/WIN32Forth-Guide>

Fourteen Tools To Success

1. Use command line input.
2. Write as a definition; test compilation.
3. Test from the command line.
4. Rewrite the code showing parameters.
5. Forth `'see'`.
6. Forth `'view'`.
7. Create a data test set.
8. Add breakpoints using `'exit'`.
9. Add `.s` internally.
10. Active test reporting `[IF] [ELSE] [THEN]`.
11. Add error trapping using `'abort''`.
12. Integrate testing with a wrapper word.
13. Use `'debug'`, directly or internally.
14. Selective compilation: `[IF] [ELSE] [THEN]`.

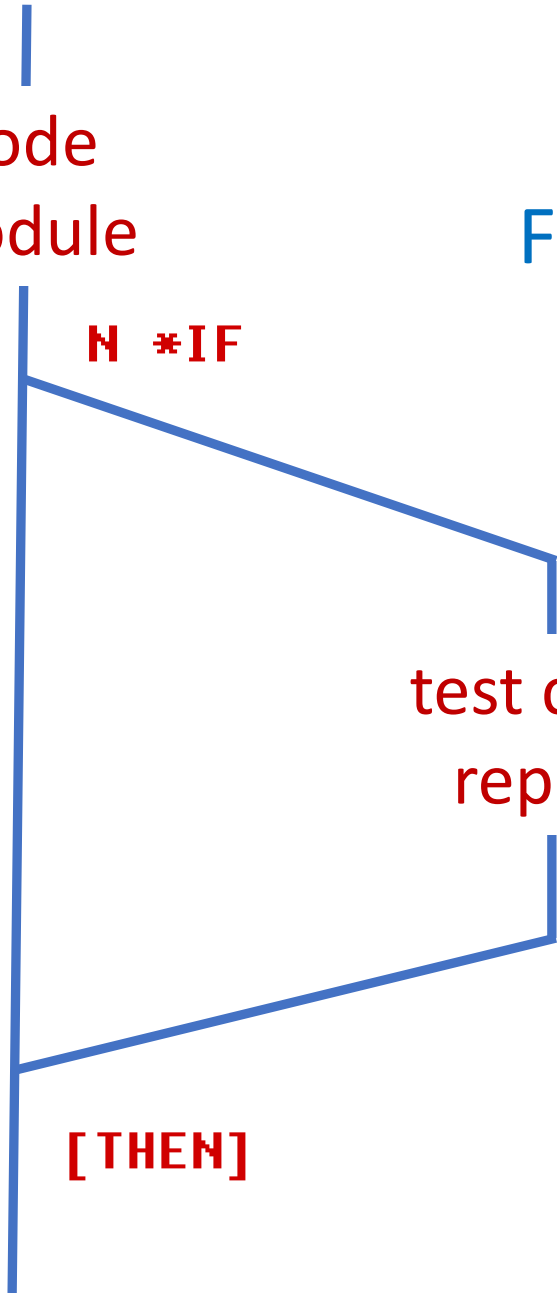
Code
Module

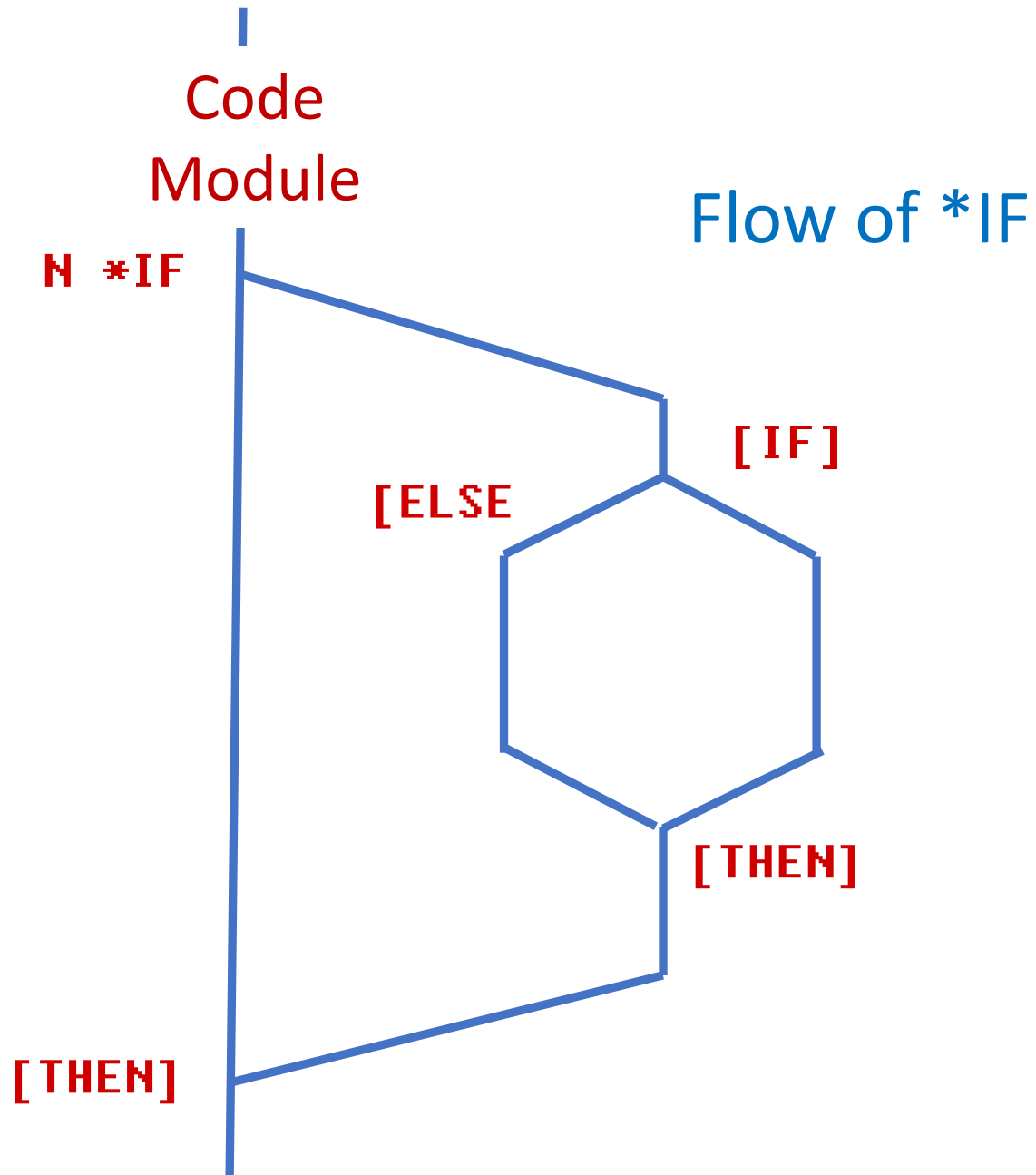
Flow of *IF

N *IF

test code
report

[THEN]





7. Using A Data Test Set

Create words to support testing.

```
: input 12000 3 200 70 30 ;
```

```
: output ." and see " . ;
```

```
ok  
input math output
```

```
and see 40 ok
```

```
Base: decimal | Stack: empty | Floating point
```

References

- <https://github.com/BillRagsdale/Matrix-Forth-Wordset>
- <https://github.com/BillRagsdale/WIN32Forth-Guide>

