CS 421 Lecture 15

- Today's class: APL
  - Functional programming – "no side effects"

Functional Programming

- "The assignment statement splits programming into two worlds. The first world comprises the right sides of assignment statements. This is an orderly world of expressions, a world that has useful algebraic properties.... It is the world in which most useful computation takes place.
- "The second world... is the world of statements. … This world of statements is a disorderly one, with few useful mathematical properties."

John Backus (creator of Fortran), "Can Programming be liberated from the von Neumann Style? A Functional Style and its Algebra of Programs." Turing Award lecture, 1977.

APL

- Computations on matrices using operators that have matrix arguments.
- Ken Iverson – "A Programming Language" – 1960
- Defined a set of operators on matrices, plus a typeface for those operators, and built terminals

APL operations

- Binary operations on numbers extended naturally to matrices
  - Comparison and boolean ops treated as arithmetic
- Reduction operations: +/, ×/, ^/, …
  - For vectors, put operator between every element
  - For matrices, reduce each row
- Compression: B / V
  - selects elements (or rows) of V where B = 1

APL font

ABCDEFGHIJKLMNOPQRSTUVWXYZ

0123456789

ˆ‰¬<>=¼½³∧/÷„*×+-

APL examples

- `1+M`
- `(+/V)÷n`
- `(+/V)÷½V`
- `(((V÷2)×2)=V)/V`

APL examples

- ```
  prime n = ^/(0¬n%(1+¼(n-2)))
  ```
  ```

APL examples

- Subscripting: `V[V']` – elements of V in positions given by `V'`.

```
reverse V = V[1+(½V)-¼½V]
```

APL examples

- Dyadic ½ – "restructure"
- V½A returns a value with shape V, values drawn from A

APL examples

- „ assignment
- ³ transpose

```
(³M) = M„(2½n)½¼n
```

APL examples

```
let zero = newint 0;;
let four = newint 4;;
let a = rho(newveci [2;3]) (indx (newint 6));;
let v = newveci [2;4;6];;
let c = newveci [1;0];;
let d = newveci [1;0;1];;
a *@ a
v -@ one
a >@ four
!+v
```

APL examples

maxR a

d % v

c % a

shape a

ravel a

rho (shape a) v

rho (shape v) c

a ^@ c

APL examples

indx (newint 5)

trans a

v @@ (indx two)

a @@ one

(trans a) @@ (indx two)

APL examples

```
let incr a = a +@ (newint 1);;
let fac n = !* (indx n);;
let avg v = (!+v) /@ (shape v);;
let reverse v =
  let sz = (shape v) @@ one
  in v @@ (incr (sz -@ (indx sz)));;
let prime n = !& (zero <>@ (n %@ (incr
  (indx (n -@ two)))));;
```