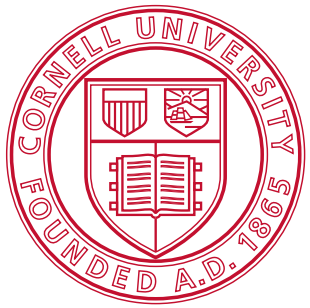
Lecture 06

Pseudocode, Algorithms

Erdal Yılmaz



Cornell University

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Before we begin

HW1 Solutions posted

HW2 Due Monday, July 15, 6pm

PL Prelim Date

Today

- Pseudocode
- Algorithms
  - Prime Sieve
  - Number Guessing
  - Sorting Numbers
- Switch/Case

Definitions

Algorithm

is a step-by-step description of a calculation, like a recipe.
Examples: Prime Sieve, Binary Search, Bubble Sort.

Pseudocode

is a high-level description of a program or algorithm.
It can be converted to a program easily.

Primes Function

Question

What are all prime numbers $\leq N$?

Using what we know

```
function p = primes1 (N)
  p = [];  % creates an empty array
  for j = 1:N
     if isprime(j)  % built-in isprime
        p = [p, j]; % expands the array
     end
  end
end
```

A Better Primes Function

Add knowledge

All prime numbers, except 2, are odd numbers.

Updated code

```
function p = primes2 (N)
  if N>1, p = [2]; else p = []; end
  % check only odd numbers
  for j = 3:2:N
     if isprime(j)
        p = [p, j];
     end
  end
end
```

Measuring Performance

tic/toc

tic starts the timer, toc returns the elapsed time.

Comparing primes functions

```
N = input('Enter N: ');

tic                 % Start timer
p0 = primes(N);     % Call built-in primes
t0 = toc;           % Stop timer and
                    % store elapsed time

% Let's also measure our functions
tic; p1 = primes1(N); t1 = toc;
tic; p2 = primes2(N); t2 = toc;
```

Why is it slow?

- We check isprime for 3,5,7,9,11,13,15,..
- Why do we check 9? 15? 21? 25? ..

Current Version

```
function p = primes2 (N)
  if N>1, p = [2]; else p = []; end
  % there are unnecessary checks
  for j = 3:2:N
      if isprime(j)
        p = [p, j];
     end
  end
end
```

Sieve of Eratosthenes

Prime Sieve

- Idea: Eliminate the multiples of a number ahead of time, so that we don't need to check it.

Algorithm

```
% Create an array X of all 1's of length N
% Set X(1) to 0
% Find position k of next 1 in the X array
% If k is less than or equal to sqrt(N)
%    Set X(2*k), X(3*k), X(4*k) ... to zero
%    Go back to finding k
% Else
%    Find the indices of all 1's in X array
% These indices are prime numbers
```

Sieve of Eratosthenes

```
function p = primes3 (N)
   X = ones(1,N);       % An array of N 1's
   X(1) = 0;            % 1 is not a prime number
   m = floor(sqrt(N)); % The maximum number upto
                        % which we have to work
   k = 2; % The next available 1 in X array
          % if X(2) exists :)

   while k <= m

      % Set X(2*k) X(3*k) etc to zero
      for j = 2*k:k:N
         X(j) = 0;
      end

      % Find the next 1 in X array
      k = k + 1;
      while X(k) ~= 1
         k = k + 1;
      end

   end

   p = find(X == 1); % Find all indices of elements
                     % which are equal to 1 in X array
end
```

Too many possibilities

Handling with if/elseif/else/end

```
n = input('enter a digit: ');
if n == 1
   disp('one');
elseif n == 2
   disp('two');
elseif n == 3
   disp('three');
elseif n == 4
   disp('four');

% and many more

else
   disp('something else');
end
```

Switch/Case

switch

branches based on several **case**s

Usage

```
switch switch_expr
   case case_expr1
      do_something1
   case case_expr2
      do_something2
   case {case_expr3, case_expr4}
      do_something3
   otherwise
      do_some_other_thing
end
```

Switch/Case - Examples

```
n = input('enter a digit: ');
switch n
  case 1
    disp('one');
  case 2
    disp('two');
  case 3
   disp('three');
  case 4
   disp('four');

% and many more

  otherwise
   disp('something else');
end
```

Switch/Case - Examples

```
hall = 'Morrill';

switch hall
   case {'Morrill','Goldwin Smith'}
      disp('Arts Quad');
   case {'Warren','Roberts'}
      disp('Ag Quad');
   case {'Upson','Duffield','Kimball'}
      disp('Engineering Quad');
   otherwise
      disp('Unknown Hall');
end
```

Number Guessing - 1

numbergame.m

```
number = fix(10*rand);

guess  = input('enter a digit: ');

if number == guess
   disp('that is my number!');
else
   if number > guess
      disp('my number is greater');
   else
      disp('my number is smaller');
   end
end
```

Number Guessing - 2

numbergame2.m

```
number = fix(10*rand);
guess  = -1;

while guess ~= number
  guess  = input('enter a digit: ');
  if number == guess
     disp('that is my number!');
  else
     if number > guess
        disp('my number is greater');
     else
        disp('my number is smaller');
     end
  end
end
```

Number Guessing - 3

numbergame3.m

```
disp('Pick a number between 1—100!');
pause
high = 100; low  =   1; trial = 0;

while 1
   guess = floor((high+low)/2);
   trial = trial + 1;
   fprintf('(Trial %d) Is it %d ? ', trial, guess);
   response = input('(y —> Yes, d —> Go down, u —> Go up) ','s');

   switch response
      case {'y','Y'}
          disp('Yay!'); break;
      case {'u','U'}
          low = guess;
      case {'d','D'}
          high = guess;
      otherwise
         disp('Please enter ''y'', ''d'' or ''u''');
         response = input('(y —> Yes, d —> Go down, u —> Go up) ','s');
   end
end
```

Bubble Sort

```
function x = bubblesort(x)

 disp('==================== INPUT ARRAY ============================')
 fprintf('(Array x) '); disp(x)
 disp('=============================================================')

n = length(x);
step = 0;
for i=1:n
   for j=1:n-1
      if x(j) > x(j+1)
         temp = x(j+1);
         x(j+1) = x(j);
         x(j)   = temp;
      end
      step = step + 1;
      fprintf('(Step %2d) ',step); disp(x); pause
   end
   fprintf('(Pass %2d) ',i); disp(x); pause
end
```