COMP108
Data Structures and Algorithms

Data structures - Arrays (Part II Finding Maximum/Minimum)

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2022-23

Finding maximum / minimum

- Input: n +ve numbers
- Output: find the maximum number
- Solutions:
  - Sort all numbers in descending order?
  - Any better way?

Finding maximum from n +ve numbers

```
// Skeleton is the same as before
$i \leftarrow 1$
while $i \leq n$ do
begin
    $i \leftarrow i + 1$
end
```

Finding maximum from n +ve numbers

```
$i \leftarrow 1$
$M \leftarrow 0$



output $M$
```

```
// Skeleton is the same as before
$i \leftarrow 1$
while $i \leq n$ do
begin
    $i \leftarrow i + 1$
end
```

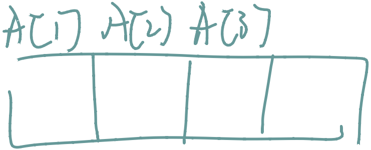
Finding maximum from n +ve numbers

```
$i \leftarrow 1$
$M \leftarrow 0$
while $i \leq n$ do
begin


    $i \leftarrow i + 1$
end
output $M$
```

```
// Skeleton is the same as before
$i \leftarrow 1$
while $i \leq n$ do
begin
    $i \leftarrow i + 1$
end
```

Finding maximum from n +ve numbers



```
$i \leftarrow 1$
$M \leftarrow 0$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

```
// Skeleton is the same as before
$i \leftarrow 1$
while $i \leq n$ do
begin
  $i \leftarrow i + 1$
end
```

Finding maximum from n +ve numbers

```
$i \leftarrow 1$
$M \leftarrow 0$    $\Longleftarrow$  A[1]
while $i \leq n$ do
begin                                   $<$
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

What about minimum?

```
// Skeleton is the same as before
$i \leftarrow 1$
while $i \leq n$ do
begin
    $i \leftarrow i + 1$
end
```

Finding minimum from n +ve numbers

```
while $i \leq n$ do
begin



    $i \leftarrow i + 1$
end
output $M$
```

Finding minimum from n +ve numbers

```
$\boxed{M \leftarrow A[1]}$
while $i \leq n$ do
begin
    if $\boxed{A[i] < M}$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding minimum from n +ve numbers

```
$i \leftarrow 2$
$\boxed{M \leftarrow A[1]}$
while $i \leq n$ do
begin
    if $\boxed{A[i] < M}$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding minimum from n +ve numbers

Time complexity?

```
$i \leftarrow 2$
$\boxed{M \leftarrow A[1]}$
while $i \leq n$ do
begin
    if $\boxed{A[i] < M}$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding minimum from n +ve numbers

Time complexity?

$O(n)$

```
$i \leftarrow 2$
$\boxed{M \leftarrow A[1]}$
while $i \leq n$ do
begin
    if $\boxed{A[i] < M}$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding minimum from n +ve numbers (see `SampleFindMin.java` on Canvas)

```
$i \leftarrow 2$
$\boxed{M \leftarrow A[1]}$
while $i \leq n$ do
begin
    if $\boxed{A[i] < M}$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Time complexity?

$O(n)$

Finding location of maximum

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding location of maximum:

```
$loc \leftarrow ??$  1
$i \leftarrow ??$  2
while $i \leq n$ do
begin
    if $A[i] > ??$ then        A[loc]
        ??                      loc ← i
    $i \leftarrow i + 1$
end
output $loc$ and $A[loc]$
```

Finding location of maximum

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding location of maximum:

```
$loc \leftarrow 1$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] >$            then

    $i \leftarrow i + 1$
end
output $loc$ and $A[loc]$
```

Finding location of maximum

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
        if $A[i] > M$ then
                $M \leftarrow A[i]$
        $i \leftarrow i + 1$
end
output $M$
```

Finding location of maximum:

```
$loc \leftarrow 1$
$i \leftarrow 2$
while $i \leq n$ do
begin
        if $A[i] > A[loc]$ then

        $i \leftarrow i + 1$
end
output $loc$ and $A[loc]$
```

Finding location of maximum

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding location of maximum:

```
$loc \leftarrow 1$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > A[loc]$ then
        $loc \leftarrow i$
    $i \leftarrow i + 1$
end
output $loc$ and $A[loc]$
```

Finding location of maximum

10, 20, 20, 30, 15, 30, 40, 20, 40

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding location of maximum:

```
$loc \leftarrow 1$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > A[loc]$ then
        $loc \leftarrow i$
    $i \leftarrow i + 1$
end
output $loc$ and $A[loc]$
```

≥

first/last location?

10, 20, 30, 15, 30, 25

loc is 3 or 5?

Finding all locations of maximum

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
```

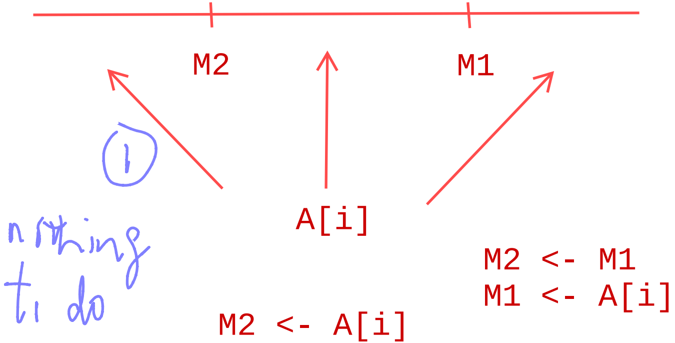
Finding all locations of maximum:

```
$i \leftarrow 1$
while $i \leq n$ do
begin
    if $A[i] == M$ then
        output $i$
    $i \leftarrow i + 1$
end
output $M$
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```



nothing to do

M2 <- A[i]

M2 <- M1
M1 <- A[i]

x y
4 6

```
x <- y
y <- x
```

```
tmp <- x
x <- y
y <- tmp
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding 1st and 2nd maximum:

```
$M1 \leftarrow ??$
$M2 \leftarrow ??$
$i \leftarrow ??$
while $i \leq n$ do
begin
    if $A[i] > M1$ then
    begin
        ??
        ??
    end
    else if $A[i] > M2$ then
        ??
    $i \leftarrow i + 1$
end
output $M1$ and $M2$
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding 1st and 2nd maximum:

```
$M1 \leftarrow \max(A[1], A[2])$
$M2 \leftarrow \min(A[1], A[2])$
$i \leftarrow 3$
while $i \leq n$ do
begin
    if $A[i] > M1$ then
    begin



    end
    else if $A[i] > M2$ then

    $i \leftarrow i + 1$
end
output $M1$ and $M2$
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding 1st and 2nd maximum:

```
$M1 \leftarrow \max(A[1], A[2])$
$M2 \leftarrow \min(A[1], A[2])$
$i \leftarrow 3$
while $i \leq n$ do
begin
    if $A[i] > M1$ then
    begin
        $M2 \leftarrow M1$
        $M1 \leftarrow A[i]$
    end
    else if $A[i] > M2$ then

    $i \leftarrow i + 1$
end
output $M1$ and $M2$
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Finding 1st and 2nd maximum:

```
$M1 \leftarrow \max(A[1], A[2])$
$M2 \leftarrow \min(A[1], A[2])$
$i \leftarrow 3$
while $i \leq n$ do
begin
    if $A[i] > M1$ then
    begin
        $M2 \leftarrow M1$
        $M1 \leftarrow A[i]$
    end
    else if $A[i] > M2$ then
        $M2 \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M1$ and $M2$
```

What about finding both first and second max (in a single loop)?

Finding maximum:

```
$M \leftarrow A[1]$
$i \leftarrow 2$
while $i \leq n$ do
begin
    if $A[i] > M$ then
        $M \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M$
```

Time complexity?

Finding 1st and 2nd maximum:

```
$M1 \leftarrow \max(A[1], A[2])$
$M2 \leftarrow \min(A[1], A[2])$
$i \leftarrow 3$
while $i \leq n$ do
begin
    if $A[i] > M1$ then
    begin
        $M2 \leftarrow M1$
        $M1 \leftarrow A[i]$
    end
    else if $A[i] > M2$ then
        $M2 \leftarrow A[i]$
    $i \leftarrow i + 1$
end
output $M1$ and $M2$
```

$O(n)$

Summary: Finding max/min, 2nd max/min, locations

Next: 2D Arrays

For note taking