CSE216
Foundations of Computer Science

Instructor: Zhoulai Fu

State University of New York, Korea

Many slides taken from Cornell's CS3110. Thanks!
https://www.cs.cornell.edu/courses/cs3110/2014fa/lecture_notes.php

Plan

- A review exercise

- Option

Review exercises on lists

Good exercises from “99 Problems in OCaml”

https://v2.ocaml.org/learn/tutorials/99problems.html

0

- Find the number of elements of a list.

1

- Find the n_th element of a list. If n is smaller than list length, fail with error. Similar with List.nth

```
# List.nth ["a"; "b"; "c"; "d"; "e"] 2;;
- : string = "c"
# List.nth ["a"] 2;;
Exception: Failure "nth".
```

3

- Eliminate consecutive duplicates of list elements.

```
# compress ["a"; "a"; "a"; "a"; "b"; "c"; "c"; "a"; "a"; "d"; "e"; "e"; "e"; "e"];;
- : string list = ["a"; "b"; "c"; "a"; "d"; "e"]
```

4

- Duplicate the elements of a list.

```
# duplicate ["a"; "b"; "c"; "c"; "d"];;
- : string list = ["a"; "a"; "b"; "b"; "c"; "c"; "c"; "c"; "d"; "d"]
```

5

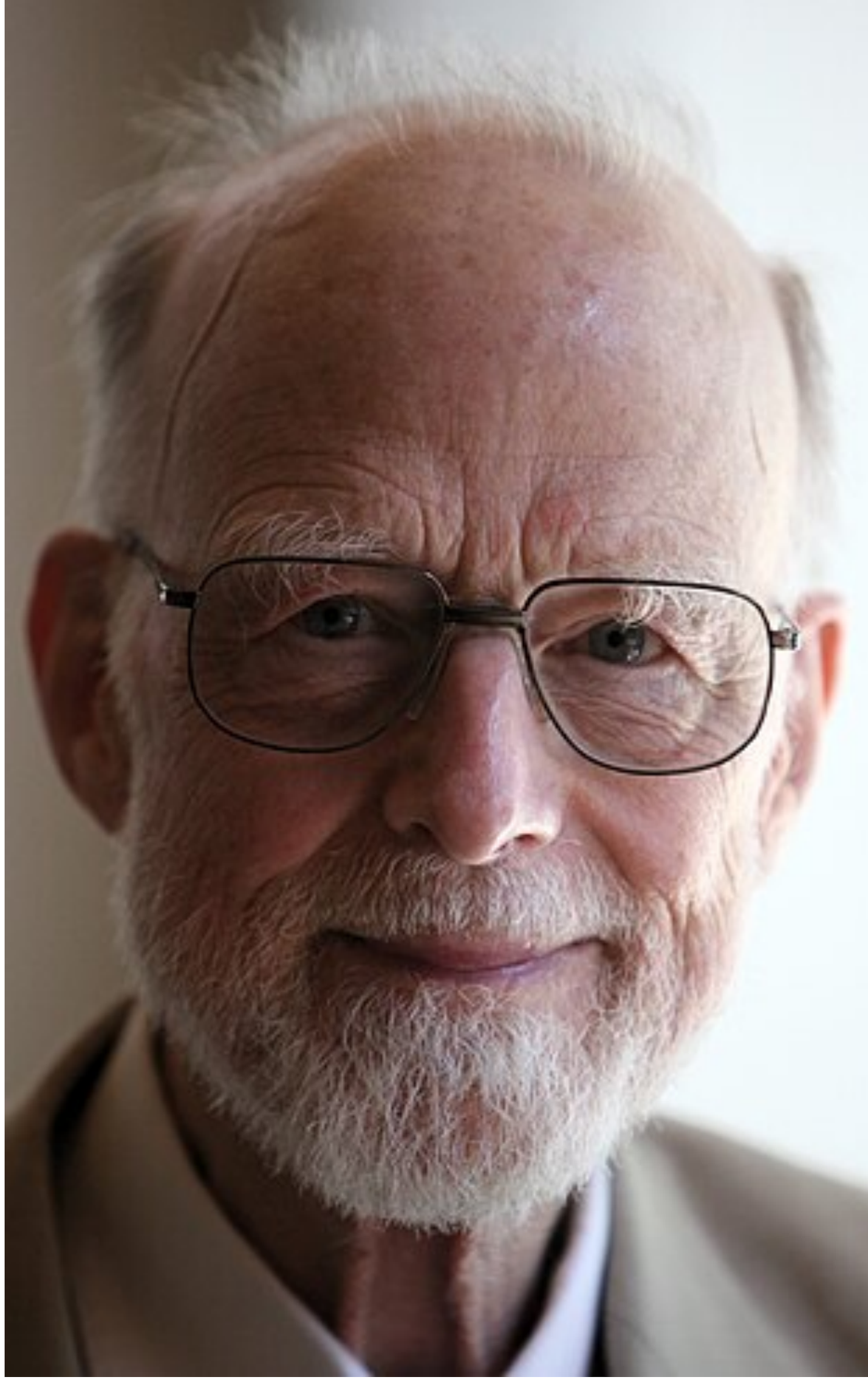
- Replicate the elements of a list a given number of times.

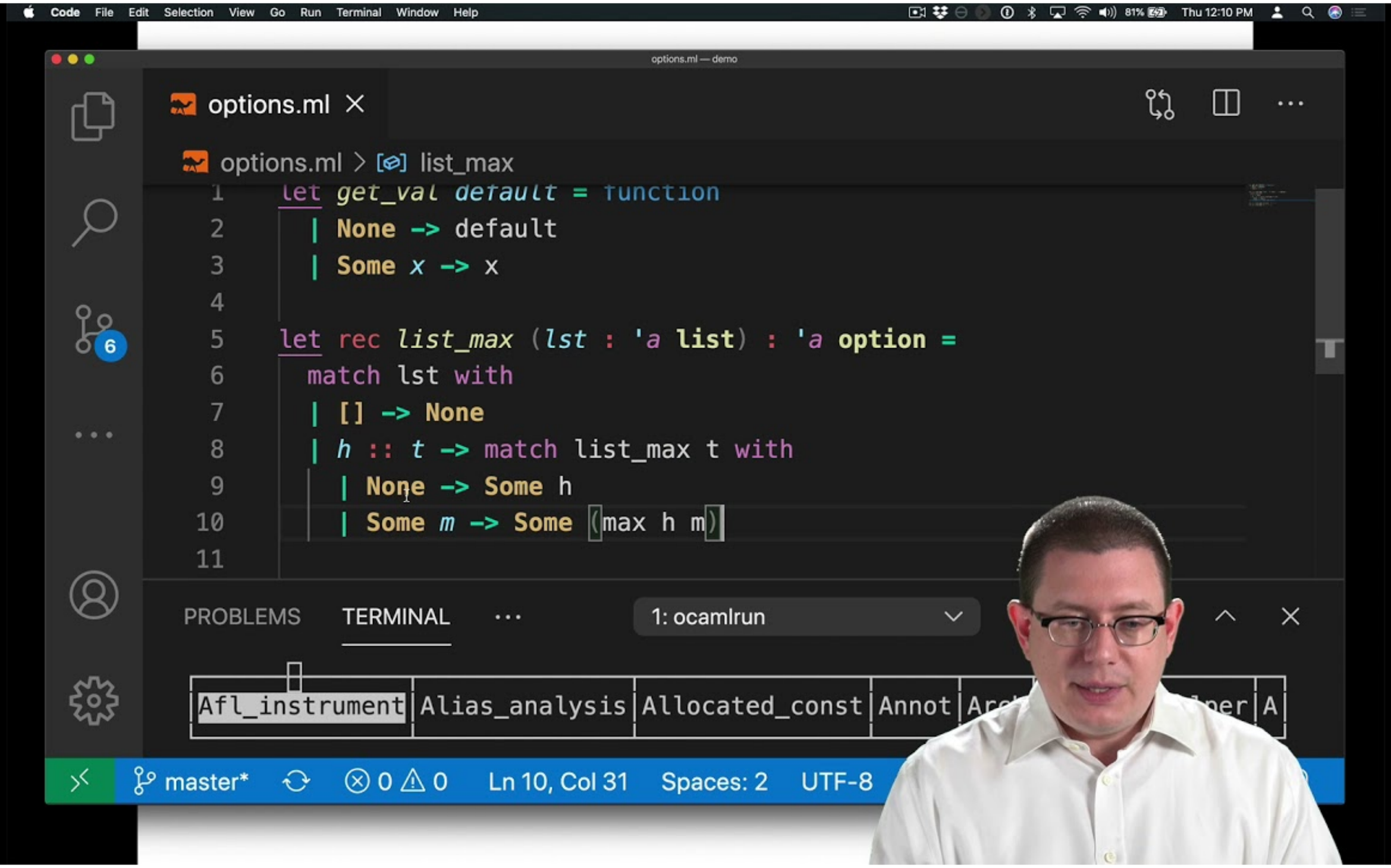
```
# replicate ["a"; "b"; "c"] 3;;
- : string list = ["a"; "a"; "a"; "b"; "b"; "b"; "c"; "c"; "c"]
```

Option

“I call it my billion-dollar mistake...
the invention of the null reference.
It has led to countless errors,
vulnerabilities, and system crashes.”

- Sir Tony Hoare, Turing Award Recipient (1980)





https://youtu.be/lByoIw5wpao

Question

- How would you implement maximum of a list?

```
let rec max_list (lst : int list)  : int =
   match lst with
   [] -> ???
| h::t -> max(h,max_list(t))
```

Ocaml likes to use Option for such a situation

Type *t option*

- A value v has type **t option** if it is either:
  - – the value **None**, or
  - – a value **Some** v, and v has type t
    - type 'a option = None | Some of 'a
- Options can signal there is no useful result to the computation
  - • Example: we loop up a value in a hash table using a key. – If the key is present in the hash table then we return Some v where v is the associated value
  - – If the key is not present, we return None

Constructing an option

- None
- Some 1
- Some “hi”

Accessing an option

```
match e with
    None -> ...
  | Some x -> ...
```

Revisit: What is max of empty list?

```
let max (x, y) =
   if x>y then x else y

let rec max_list (lst : int list) : int option =
   match lst with
     []    -> None
  | h::t -> match max_list(t) with
                None    -> Some h
              | Some x -> Some (max(h,x))
```

Very stylish!
...no possibility of exceptions
...no chance of programmer ignoring a "null return"

Exercise #1

- Write a function **last : 'a list -> 'a option** that returns the last element of a list.

```
# last ["a" ; "b" ; "c" ; "d"];;
- : string option = Some "d"
# last [];;
- : 'a option = None
```

Exercise #2

- Find the last two elements of a list.

```
# last_two ["a"; "b"; "c"; "d"];;
- : (string * string) option = Some ("c", "d")
# last_two ["a"];;
- : (string * string) option = None
```

Exercise #3

- Write a function **at : int -> ‘a list -> 'a option** that returns the n-th element of a list.

```
# at 2 ["a"; "b"; "c"; "d"; "e"];;
- : string option = Some "c"
# at 2 ["a"];;
- : string option = None
```