2 Foundations of Computer Science (rkh23)

A \( W \times H \) matrix can be represented in OCaml by a flat list: a list that concatenates the rows in order. For each of the following alternative ways to represent a 2D matrix in OCaml:

- State the type \( T \) of the representation;
- Give a function \( \text{create } w \ m \): \( \text{int} \to \text{float list} \to T \) that constructs the matrix of type \( T \) equivalent to the input flat list \( m \) with row width \( w \);
- Give a function \( \text{get } r \ c \ m \): \( \text{int} \to \text{int} \to T \to \text{float} \) that gets the element of the matrix \( m \) at row \( r \) and column \( c \);
- State the asymptotic complexity of the \( \text{get} \) function in terms of \( W \) and \( H \)

\[(a) \text{ A list of lists.} \quad [5 \text{ marks}] \]
\[(b) \text{ An array of arrays.} \quad [6 \text{ marks}] \]
\[(c) \text{ A functional array of functional arrays.} \quad [9 \text{ marks}] \]

Your answers may use the List module and assume this functional array code:

```ocaml
let rec update = function
| Lf, k, w ->
  if k = 1 then
    Br (w, Lf, Lf)
  else
    raise Subscript
| Br (v, t1, t2), k, w ->
  if k = 1 then
    Br (w, t1, t2)
  else if k mod 2 = 0 then
    Br (v, update (t1, k / 2, w), t2)
  else
    Br (v, t1, update (t2, k / 2, w));;

let rec sub = function
| Lf, _ -> raise Subscript
| Br (v, t1, t2), 1 -> v
| Br (v, t1, t2), k when k mod 2 = 0 -> sub (t1, k / 2)
| Br (v, t1, t2), k -> sub (t2, k / 2);;
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1