

Programmering og Problemløsning

Datalogisk Institut, Københavns Universitet

Arbejdsseddel 5 - gruppeopgave

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28. september - 3. oktober.
Afleveringsfrist: lørdag d. 3. oktober kl. 22:00.

Med denne arbejdsseddel starter vi transitionen fra det imperative programmeringsparadigme til funktionsprogrammeringsparadigmet. Hvor imperativ programmering er som en kageopskrift og kendes på brug af variable, for- og while-løkker, så lægger funktionsprogrammering vægt på funktioner og kendes på værdier og rekursion.

I denne periode kigger på særligt på 2 ny datastrukturer arrays og lists. De er begge datastrukturer til at holde lister af elementer af samme type, men arrays er variable og lists er værdier. Derfor ser man også sjældent arrays i programmer, der følger funktionsprogrammeringsparadigmet. I denne periode vil vi lægge vægt på programmering af arrays og lists via de medfølgende `List` og `Array` moduler.

Emnerne for denne arbejdsseddel er:

- at kunne oprette, gennemløbe og lave beregninger med lists vha. `List`-modulet og med `for-in`-løkker,
- at kunne oprette, gennemløbe og ændre arrays vha. `Array`- og `Array2D`-modulet,
- at kunne beskrive de kvalitative forskelle mellem lists og arrays.

Opgaverne er opdelt i øve- og afleveringsopgaver. I denne periode skal I arbejde i grupper med jeres afleveringsopgaver. Regler for gruppe- og individuelle afleveringsopgaver er beskrevet i ”Noter, links, software m.m.” → ”Generel information om opgaver”.

Øveopgaver (in English)

5ø0 Explain the difference between the types `int -> (int -> int)` and `(int -> int) -> int`, and give an example of a function of each type.

5ø1 Write the types for the functions `List.filter` and `List.foldBack`.

- 5ø2 Write a function `oneToN : n:int -> int list` which returns the list of integers `[1; 2; ...; n]`.
- 5ø3 Write a function `printLstAlt: 'a list -> ()`, which uses `for-in`, to print every element of a given list to the screen. Ensure that your function works for lists of various types, e.g., int list and string list.
- 5ø4 Write a function `printLst: 'a list -> ()`, which uses `List.iter`, an anonymous function, and `printfn "%A"` to print every element of a given list to the screen. Ensure that your function works for lists of various types, e.g., int list and string list.
- 5ø5 Use `List.map` write a function, which takes a list of integers and returns the list of floats where each element has been divided by 2.0. For example, if the function is given the input `[1; 2; 3]`, then it should return `[0.5; 1.0; 1.5]`.
- 5ø6 Make a function `even: int -> bool` which returns `true` if the input is even and false otherwise. Use `List.filter` and `even` to make another function `filterEven : int list -> int list`, which returns all the even numbers of a given list.
- 5ø7 Write a function `multiplicity: x:int -> xs:int list -> int`, which counts the number of occurrences of the number `x` in the list `xs` using `List.filter`, an anonymous function, and the `Length` property.
- 5ø8 Write a function `rev: 'a list -> 'a list`, which uses `List.fold`, an anonymous function, and the `"::"` operator to reverse the elements in a list. Ensure that your function works for lists of various types, e.g., int list and string list.
- 5ø9 Use `List.map` to make a function `applylist : ('a -> 'b) list -> 'a -> 'b list`, which applies a list of functions to the same element and returns a list of results. For example `applylist [cos; sin; log; exp] 3.5` should return approximately `[-0.93; -0.35; 1.25; 33.11]`.

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- 5ø10 Use `Array.init` to make a function `squares: n:int -> int []`, such that the call `squares n` returns the array of the first `n` square numbers. For example, `squares 5` should return the array `[1; 4; 9; 16; 25]`.
- 5ø11 Write a function `reverseArray : arr:'a [] -> 'a []` using `Array.init` and `Array.length` which returns an array with the elements in the opposite order of `arr`. For example, `printfn "%A" (reverseArray [|1..5|])` should write `[5; 4; 3; 2; 1]` to the screen.
- 5ø12 Write the function `reverseArrayD : arr:'a [] -> unit`, which reverses the order of the values in `arr` using a while-loop to overwrite its elements. For example, the program

```
let aa = [|1..5|]
reverseArrayD aa
printfn "%A" aa
```

should output `[5; 4; 3; 2; 1]`.

Afleveringsopgaver (in English)

5g0 A table can be represented as a non-empty list of equally long lists, for example, the list `[[1; 2; 3]; [4; 5; 6]]` represents the table:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

- (a) Make a function `isTable : llst:'a list list -> bool`, which determines whether `llst` is a legal non-empty list, i.e., that
 - there is at least one element, and
 - all lists in the outer list has equal length.
- (b) Make a function `firstColumn : llst:'a list list -> 'a list` which takes a list of lists and returns the list of first elements in the inner lists. For example, `firstColumn [[1; 2; 3]; [4; 5; 6]]` should return `[1; 4]`. If any of the lists are empty, then the function must return the empty list of integers `[] : int list`.
- (c) Make a function `dropFirstColumn : llst:'a list list -> 'a list list` which takes a list of lists and returns the list of lists where the first element in each inner list is removed. For example, `dropFirstColumn [[1; 2; 3]; [4; 5; 6]]` should return `[[2; 3]; [5; 6]]`. Ensure that your function fails gracefully, if there is no first elements to be removed.
- (d) Make a function `transposeLstLst : llst:'a list list -> 'a list list` which transposes a table implemented as a list of lists, that is, an element that previously was at `a. [i,j]` should afterwards be at `a. [j,i]`. For example, `transposeLstLst [[1; 2; 3]; [4; 5; 6]]` should return `[[1; 4]; [2; 5]; [3; 6]]`. Ensure that your function fails gracefully. Note that `transposeLstLst (transpose t) = t` when `t` is a table as list of lists. Hint: the functions `firstColumn` and `dropFirstColumn` may be useful.
- (e) Make a whitebox test of the above functions.

5g1 Arrays are an alternative data structure for tables.

- (a) Use `Array2D.init`, `Array2D.length1` and `Array2D.length2` to make the function `transposeArr : 'a [,] -> 'a [,]` which transposes the elements in input.
- (b) Make a whitebox test of `transposeArr`.
- (c) Comparing this implementation with Assignment 5g0d, what are the advantages and disadvantages of each of these implementations?
- (d) For the application of tables, which of lists and arrays are better programmed using the imperative paradigm and using the functional paradigm and why?

Krav til afleveringen

Afleveringen skal bestå af

- en zip-fil, der hedder `5g-<navn>.zip` (f.eks. `5g-jon.zip`)

Zip-filen `5g-<navn>.zip` skal indeholde en `src` mappe og filen `README.txt`. I `src` skal der ligge følgende og kun følgende filer: `5g0.fsx`, `5g1.fsx` og `5g2.fsx` svarende til hver af delopgaverne. De skal kunne oversættes med `fsharpc`, og de oversatte filer skal kunne køres med `mono`. Funktioner skal dokumenteres ifølge dokumentationsstandarden som minimum ved brug af `<summary>`, `<param>` og `<returns>` XML-tagsne. Udover selve koden skal besvarelser indtastes som kommentarer i de `fsx`-filer, de hører til. Filen `README.txt` skal ganske kort beskrive, hvordan koden oversættes og køres, og evtuelle Black-box, White-box og håndkøringsresultater når relevant.

God fornøjelse.