计算概论A—实验班

函数式程序设计

Functional Programming

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Adapted from Graham’s Lecture slides

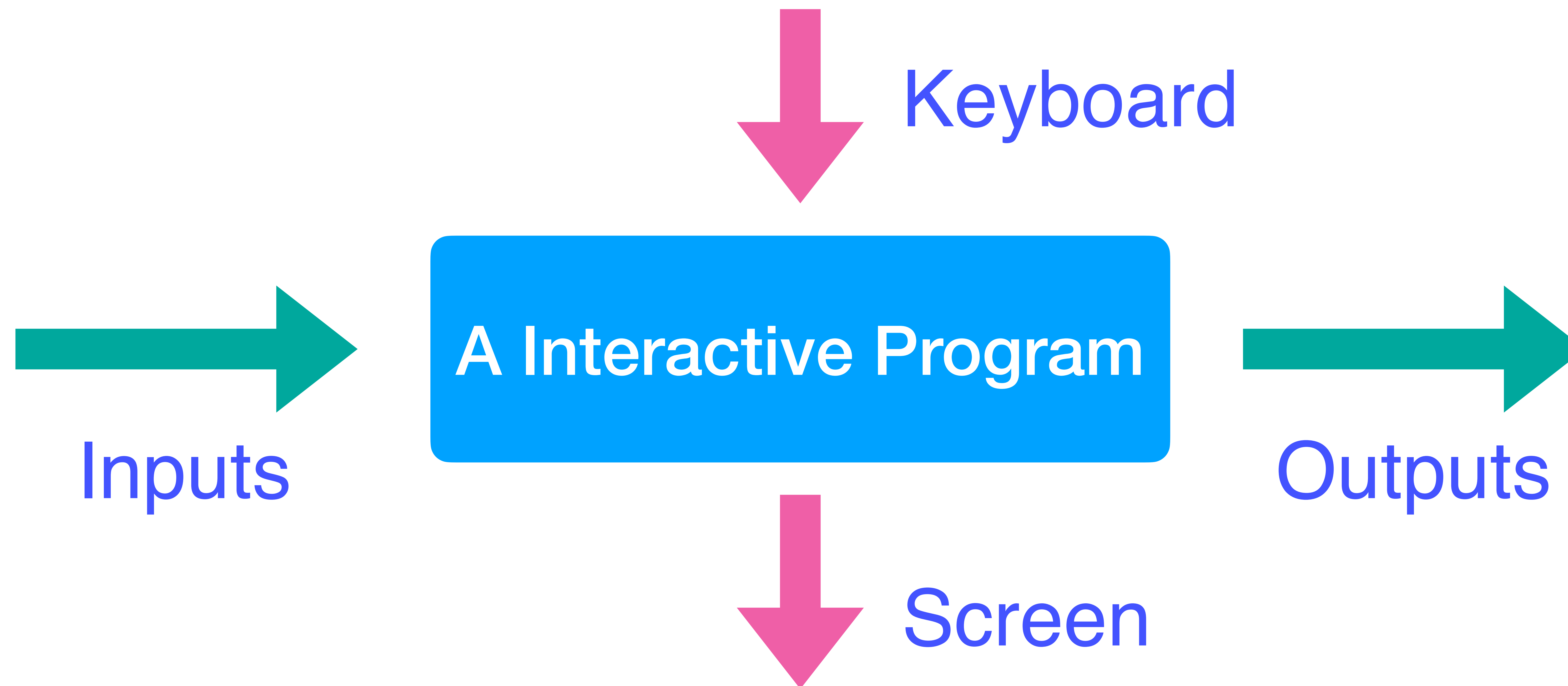
第10章：交互式程序设计
Interactive Programming

Batch Programs

- To date, we have seen how Haskell can be used to write batch programs that take all their inputs at the start and give all their outputs at the end.

Interactive Programs

- However, we would also like to use Haskell to write interactive programs that read from the keyboard and write to the screen, as they are running.



Interactive Programs in Haskell: Difficulties

- Haskell programs are pure mathematical functions:

Haskell programs have no side effects.

- However, reading from the keyboard and writing to the screen are side effects:

Interactive programs have side effects

A solution that looks perfect

An interactive program can be viewed as:

✳ **a pure function** that

- takes *the current state of the world* as its argument, and
- produces *a modified world* as its result.

```
type IO = World -> World
```

✤ To represent a returning result in addition to performing side effects, we generalize the type to:

```
type IO a = World -> (a, World)
```

A solution that looks perfect

- So, interactive programs are written in Haskell by using types to distinguish pure expressions from impure actions that may involve side effects.

```
IO a
```

The type of **actions** that return a value of type **a**.

- For example: `IO char` `IO ()`

Some IO Actions exported by Prelude

- The action getChar (1) reads a character from the keyboard, (2) echoes it to the screen, and (3) returns the character as its result value.

```
getChar :: IO Char
```

- The action putChar c (1) writes the character c to the screen, and (2) returns no result value:

```
putChar :: Char -> IO ()
```

- The action return v simply returns the value v, without performing any interaction :

```
return :: a -> IO a
```

do a sequence of actions

- A sequence of actions can be combined as a single composite action using the keyword do.
- For example:

```
act :: IO (Char,Char)
act = do x <- getChar
         getChar
         y <- getChar
         return (x,y)
```

Some IO Actions exported by Prelude

Reading a string from the keyboard

```
getLine :: IO String
getLine = do x <- getChar
             if x == '\n' then
                return []
             else
                do xs <- getLine
                   return (x:xs)
```

Some IO Actions exported by Prelude

Writing a string to the screen

```
putStr :: String -> IO ()
putStr []     = return ()
putStr (x:xs) = do putChar x
                   putStr xs
```

Writing a string to the screen and move to a new line

```
putStrLn :: String -> IO ()
putStrLn xs = do putStr xs
                 putChar '\n'
```

A Simple Example

- We can now define an action that prompts for a string to be entered and displays its length:

```
strlen :: IO ()
strlen = do putStr "Enter a string: "
            xs <- getLine
            putStr "The string has "
            putStr (show (length xs))
            putStrLn " characters"
```

```
ghci> strlen
Enter a string: Haskell
The string has 7 characters
```

应用1：Hangman 游戏

✤ The Rules

- One player secretly types in a word.
- The other player tries to deduce the word, by entering a sequence of guess.
- For each guess, the computer indicates which letters in the secret word occur in the guess.
- The game ends when the guess is correct.

```
ghci> hangman
Think of a word:
-------
Try to guess it:
? pascal
-as--ll
? rust
--s----
? haspell
has-ell
? haskell
You got it!
```

应用1：Hangman 游戏

✤ We adopt a top down approach to implementing hangman in Haskell, starting as follows:

```haskell
hangman :: IO ()
hangman = do putStrLn "Think of a word: "
             -- get a string secretly
             word <- sgetLine
             putStrLn "Try to guess it:"
             play word -- play the game
```

应用1：Hangman 游戏

- The action sgetLine reads a line of text from the keyboard, echoing each character as a dash:

```
sgetLine :: IO String
sgetLine = do
    x <- getCh -- get a char without echoing
    if x == '\n' then
        do putChar x
           return []
    else
        do putChar '-'
           xs <- sgetLine
           return (x:xs)
```

应用1：Hangman 游戏

- The action getCh reads a single character from the keyboard, without echoing it to the screen:

```
import System.IO (hSetEcho, stdin)
...
getCh :: IO Char
getCh = do hSetEcho stdin False
           x <- getChar
           hSetEcho stdin True
           return x
```

应用1：Hangman 游戏

- The function play is the main loop, which requests and processes guesses until the game ends.

```haskell
play :: String -> IO ()
play word = do
    putStr "? "
    guess <- getLine
    if guess == word then
        putStrLn "You got it!"
    else
     do putStrLn (match word guess)
        play word
```

```haskell
match :: String -> String -> String
match xs ys =
  [if elem x ys then x else '-' | x <- xs]
```

```
ghci> match "haskell" "pascal"
"-as--ll"
```

应用2：Nim 游戏

The Rules

- The board comprises five rows of stars:

```
1: * * * * *
2: * * * *
3: * * *
4: * *
5: *
```

- Two players take it turn about to remove one or more stars from the end of a single row.
- The winner is the player who removes the last star or stars from the board.

Board的表示和显示

```haskell
type Board = [Int]

initial :: Board
initial = [5,4,3,2,1]

finished :: Board -> Bool
finished = all (== 0)
```

Board的表示和显示

```haskell
putBoard :: Board -> IO ()
putBoard [a,b,c,d,e] = do
    putRow 1 a
    putRow 2 b
    putRow 3 c
    putRow 4 d
    putRow 5 e
```

```
ghci> putBoard initial
1: * * * * *
2: * * * *
3: * * *
4: * *
5: *
```

```haskell
putRow :: Int -> Int -> IO ()
putRow row num = do
    putStr $ show row
    putStr ": "
    putStrLn $ concat $ replicate num "* "
```

游戏中的一步/一次操作：从某行删除若干个星号

判断一次操作是否合法

```haskell
valid :: Board -> Int -> Int -> Bool
valid board row del = board !! (row -1) >= del
```

```haskell
(!!) :: [a] -> Int -> a
```

List index (subscript) operator, starting from 0 (exported by Prelude)

进行一次操作

```haskell
move :: Board -> Int -> Int -> Board
move board row del = [update r n | (r,n) <- zip [1..] board]
  where update r n = if r == row then n - del else n
```

```haskell
play :: Board -> Int -> IO ()
play board player =
  do newline
     putBoard board
     newline
     if finished board then
        do putStr "Player "
           putStr $ show $ next player
           putStrLn " wins!!"
     else
        do putStr "Player "
           putStrLn $ show player
           row <- getDigit "Enter a row number: "
           del <- getDigit "Stars to remove: "
           if valid board row del then
              play (move board row del) (next player)
           else
              do newline
                 putStrLn "ERROR: Invalid move"
                 play board player
```

```haskell
nim :: IO ()
nim = play initial 1
```

作业

10-1

Define an action adder :: IO () that reads a given number of integers from the keyboard, one per line, and displays their sum.

For example:

```
ghci> adder
How many numbers? 5
1
3
5
7
9
The total is 25
```

10-2

Download the source codes of the two games (hangman and nim) from the following website:

http://www.cs.nott.ac.uk/~pszgmh/pih.html

read the codes carefully, and run them using ghci.

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就到这里吧