State Monad – Examples (6C)

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Based on

Haskell in 5 steps

https://wiki.haskell.org/Haskell_in_5_steps

Game Example (1)

Example use of **State** monad

Passes a string of dictionary **{a,b,c}**

Game is to produce a number from the string.

By default the game is off,

a '**c**' toggles the game on and off.

a '**a**' gives +1 and

a '**b**' gives -1.

E.g

'ab' = 0 +1-1=0

'ca' = 1 on, +1

'cabca' = 0 on,+1-1,off

State = (game is on/off, current score) = (Bool, Int)

https://wiki.haskell.org/State_Monad

Game Example (2)

```
module StateGame where
import Control.Monad.State

type GameValue = Int
type GameState = (Bool, Int)

playGame :: String -> State GameState GameValue
playGame [] = do
    (_, score) <- get
    return score
```

State s a

when input string is null

https://wiki.haskell.org/State_Monad

Game Example (3)

```
playGame :: String -> State GameState GameValue
playGame (x : xs) = do
   (on, score) <- get
   case x of
      'a' | on -> put (on, score + 1)
      'b' | on -> put (on, score - 1)
      'c'      -> put (not on, score)
      _        -> put (on, score)
   playGame xs

startState = (False, 0)

main = print $ evalState (playGame "abcaaacbbcabbab") startState
```

when input string is not null

A	(off, 0)
B	(off, 0)
C	(on, 0)
A	(on, 1)
A	(on, 2)
A	(on, 3)
C	(off, 3)
B	(off, 3)
B	(off, 3)
C	(on, 3)
A	(on, 4)
B	(on, 3)
B	(on, 2)
A	(on, 3)
B	(on, 2)

https://wiki.haskell.org/State_Monad

Game Example Source Code

```
import Control.Monad.State

type GameValue = Int
type GameState = (Bool, Int)

playGame :: String -> State GameState GameValue
playGame [] = do
    (_, score) <- get
    return score
```

```
playGame (x : xs) = do
    (on, score) <- get
    case x of
        'a' | on -> put (on, score + 1)
        'b' | on -> put (on, score - 1)
        'c'      -> put (not on, score)
        _        -> put (on, score)
    case x of
        'a' | on -> return $ score + 1
        'b' | on -> return $ score - 1
        'c'      -> return $ score
        _        -> return score
    playGame xs

startState = (False, 0::Int)
```

```
*Main> runState (playGame "abcaaacbbcabbab") startState
(2,(True,2))
*Main> execState (playGame "abcaaacbbcabbab") startState
(True,2)
*Main> evalState (playGame "abcaaacbbcabbab") startState
2
```

https://wiki.haskell.org/State_Monad

Incrementer Example (1)

```
-- a concrete and simple example of using the State monad
-- non monadic version of a very simple state example
-- the State is an integer.
-- the value will always be the negative of of the state

import Control.Monad.State

type MyState = Int
type MyStateMonad  = State MyState

valFromState :: MyState -> Int
valFromState s = -s

nextState :: MyState->MyState
nextState x = 1+x
```

https://wiki.haskell.org/State_Monad

Incrementer Example (2)

```
-- this is it, the State transformation.
-- add 1 to the state, return -1*the state as the computed value.

getNext ::   MyStateMonad  Int
getNext  = state  (\st -> let st' = nextState(st) in (valFromState(st'),st') )


-- advance the state three times.
inc3::MyStateMonad Int
inc3 =  getNext >>= \x ->
        getNext >>= \y ->
        getNext >>= \z ->
        return z
```

https://wiki.haskell.org/State_Monad

Incrementer Example (3)

```
-- advance the state three times with do sugar
inc3Sugared::MyStateMonad Int
inc3Sugared = do  x <- getNext
                  y <- getNext
                  z <- getNext
                  return z

-- advance the state three times without inspecting computed values
inc3DiscardedValues::MyStateMonad Int
inc3DiscardedValues =    getNext >> getNext >> getNext
```

https://wiki.haskell.org/State_Monad

Incrementer Example (4)

```
-- advance the state three times
-- without inspecting computed values with do sugar
inc3DiscardedValuesSugared::MyStateMonad Int
inc3DiscardedValuesSugared =    do
                        getNext
                        getNext
                        getNext

-- advance state 3 times, compute the square of the state
inc3AlternateResult::MyStateMonad Int
inc3AlternateResult = do  getNext
                          getNext
                          getNext
                          s<-get
                          return (s*s)
```

https://wiki.haskell.org/State_Monad

Incrementer Example (5)

```
-- advance state 3 times, ignoring computed value, and then once more
inc4::MyStateMonad Int
inc4 = do
        inc3AlternateResult
        getNext

main =
    do
        print (evalState inc3 0)                        -- -3
        print (evalState inc3Sugared 0)                 -- -3
        print (evalState inc3DiscardedValues 0)         -- -3
        print (evalState inc3DiscardedValuesSugared 0)  -- -3
        print (evalState inc3AlternateResult 0)         -- 9
        print (evalState inc4 0)                        -- -4
```

https://wiki.haskell.org/State_Monad

Dice Examples

The result type : Int dice : a number between 1 and 6

The state type : a pseudo-random generator of type **StdGen**

the type of the **state processors** will be

State StdGen Int

StdGen -> (Int, StdGen)

State s a

s -> (a, s)

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

randomR – a state processing function

```
randomR :: (Random a, RandomGen g) => (a, a) -> g -> (a, g)

randomR (1, 6) :: StdGen -> (Int, StdGen)
```

assume a is Int (a, a) : range

and g is **StdGen** a seed

the **StdGen** type : an instance of **RandomGen**

randomR a **state processing function**

A seed of the type **StdGen**

A new seed is generated

by **newStdGen**

(Int, StdGen)

(a random value**,** a new seed**)**

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

Generating a random number

to generate a random number with a seed

type **StdGen** must be used,

randomR is used to generate a number

newStdGen is used to create a new seed

(this will have to be done in IO).

```
import System.Random
g <- newStdGen
randomR (1, 10) g
(1,1012529354 2147442707)
```

A seed of the type **StdGen**

A new seed is generated

by **newStdGen**

The result of **randomR** is a tuple

(a random value, a new seed)

https://stackoverflow.com/questions/8416365/generate-a-random-integer-in-a-range-in-haskell

randomRIO

Otherwise, you can use **randomRIO**

to get a random number directly in the **IO** monad,

Without explicitly using a seed of type **StdGen**

```
import System.Random
randomRIO (1, 10)
6
```

https://stackoverflow.com/questions/8416365/generate-a-random-integer-in-a-range-in-haskell

randomR

```
randomR (1, 6) :: StdGen -> (Int, StdGen)
```

```
rollDie :: State StdGen Int
rollDie = state $ randomR (1, 6)
```

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

randomR

```
import Control.Monad.Trans.State
import System.Random

-- The StdGen type we are using is an instance of RandomGen.
randomR :: (Random a, RandomGen g) => (a, a) -> g -> (a, g)

randomR (1, 6) :: StdGen -> (Int, StdGen)
```

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

randomR

```
rollDice :: State StdGen (Int, Int)
rollDice = liftA2 (,) rollDie rollDie

GHCi> evalState rollDice (mkStdGen 666)
 (6,1)
```

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

rollDice

rollDice :: State StdGen (Int, Int)

rollDice = liftA2 (,) rollDie rollDie

That function rolls two dice.

Here, **liftA2** is used to make the two-argument function **(,)**

work within a monad or applicative functor, in this case **IO**.

It can be easily defined in terms of **(<*>)**:

liftA2 f u v = f <$> u <*> v

As for (,), it is the non-infix version of the tuple constructor.

That being so, the two die rolls will be returned as a tuple in **I**

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

Removing IO

```
randomR (1, 6) :: StdGen -> (Int, StdGen)

GHCi> :m System.Random
GHCi> let generator = mkStdGen 0          -- "0" is our seed
GHCi> :t generator
generator :: StdGen
GHCi> generator
1 1
GHCi> :t random
random :: (RandomGen g, Random a) => g -> (a, g)
GHCi> random generator :: (Int, StdGen)
(2092838931,1601120196 1655838864)
```

A seed of the type **StdGen**

A new seed is generated

by **newStdGen**

https://stackoverflow.com/questions/8416365/generate-a-random-integer-in-a-range-in-haskell

Dice without IO

GHCi> **randomR (1,6) (mkStdGen 0)**

(6, 40014 40692)

The resulting tuple combines

the result of throwing a single die with a new generator.

A simple implementation for throwing two dice is then:

```
clumsyRollDice :: (Int, Int)
clumsyRollDice = (n, m)
      where
      (n, g) = randomR (1,6) (mkStdGen 0)
      (m, _) = randomR (1,6) g
```

A seed of the type **StdGen**

A new seed is generated

by **newStdGen**

https://stackoverflow.com/questions/8416365/generate-a-random-integer-in-a-range-in-haskell

randomR

```
rollDie :: State StdGen Int
rollDie = state $ randomR (1, 6)

rollDie :: State StdGen Int
rollDie = do generator <- get
             let (value, newGenerator) = randomR (1,6) generator
             put newGenerator
             return value
```

```
GHCi> evalState rollDie (mkStdGen 0)
6
```

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

References

[1] ftp://ftp.geoinfo.tuwien.ac.at/navratil/HaskellTutorial.pdf

[2] https://www.umiacs.umd.edu/~hal/docs/daume02yaht.pdf