universität innsbruck

Advanced Functional Programming | WS 2026/2027 | LVA 703139

Exercise Sheet 4, 10 points | Deadline: Tuesday, November 3, 2026, 4pm

- Solve the tasks in file `Exercise04.hs` and upload only this file in OLAT.
- Mark the solved exercises in OLAT.
- Your modified `Exercise04.hs` file must compile with `ghci` without error messages.

Task 1 *Functor Laws* **3 p.**

Check that the implementation of the functor instance for `Parse` satisfies the first functor-law, i.e., `fmap id = id`. Here are the important equations:

```
runParse (Parse f) = f

instance Functor Parse where
  fmap f parser = parser ==> \result -> identity (f result)

identity :: a -> Parse a
identity a = Parse (\s -> Right (a, s))

firstParser ==> secondParser  =  Parse chainedParser
   where chainedParser istate   =
           case runParse firstParser istate of
             Left err -> Left err
             Right (res, newState) ->
                runParse (secondParser res) newState
```

Hints:

- expand the definitions from left-to-right when required
- two functions `f` and `g` are equal iff `f x = g x` for all `x`
- for `==>`, keep the `where`-clause, and simplify either in the `where`-clause, or in the equation itself.

Example: Your equivalence proof might look like this.

```
    fmap id = id
<-> fmap id (Parse f) = id (Parse f)                (for all f)
<-> ...
<-> ...
<-> Parse chainedParser = Parse f where
     chainedParser istate = case runParse (Parse f) ...
<-> ...
```

Task 2 *PGM Parsing* **7 p.**

1. Write a parser in the style of Slide 30 for *plain* PGM files. Plain PGM files are similar to raw PGM files, except that
   - plain PGM files have the header “P2” instead of “P5”, and

- the binary block is replaced by a list of ASCII encoded grey values, separated by whitespace, e.g., 12 0 255 17 ...

Writing this parser might require the definition of new auxiliary functions for parsing. (4 points)

2. Modify the plain PGM parser so that when parse errors occur, both the line number and the column numbers are reported; moreover, it should be checked that all numbers in the bitmap respect the max-grey value.

   Use this modified parser to identify and repair the mistakes in the example plain PGM file. (3 points)