数据挖掘课程作业之海藻数据的分析

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一．问题描述

某些高浓度的有害藻类对河流生态环境的破坏是一个严重的问题。它们不仅破坏河流的生物，也破坏水质。能够监测并在早期对海藻的繁殖进行预测对提高河流质量是很有必要的。

针对这一问题的预测目标，在大约一年的时间内，在不同时间内收集了欧洲多条河流的水样。对于每个水样，测定了它们的不同化学性质以及 7 种有害藻类的存在频率。在水样收集过程中，也记录了一些其他特性，如收集的季节、河流大小和水流速度。

二．数据说明

有 200 个水样，每条记录是同一条河流在该年的同一个季节的三个月内收集的水样的平均值。

每条记录由 11 个变量构成，3 个是标称变量，分别描述水样收集的季节，河流大小和河水速度，剩下的 8 个变量是水样的化学参数：

最大 pH 值(mxPH)

最小含氧量(mnO2)

平均氯化物含量(Cl)

平均硝酸盐含量(NO3)

平均氨含量(NH4)

平均正磷酸盐含量(oPO4)

平均磷酸盐含量(PO4)

平均叶绿素含量(Chla)

a1-a7 为 7 种不同有害藻类在相应水样中的频率数目。

三. 分析报告及程序

实验环境：Microsoft Windows 10 家庭中文版 (64 位)

Intel(R) Core(TM) i7-6700HQ CPU @ 2.60GHz(2592 MHz)

16.00 GB 内存

实验软件：RGui（3.3.0）

实验内容：

0. 安装 R 添加包

> install.packages('DMwR')

此添加包中包含实验所需数据，名为‘algae’，当出现：

下载的二进制程序包在

C:\Users\...（程序包安装路径）里时，则表示安装成功。

1. 数据摘要

> library(DMwR)

> head(algae)

使用 library 命令载入 DMwR 包，展示数据 algae 的前 6 行，如下图：

```
> library(DMwR)
载入需要的程辑包：lattice
载入需要的程辑包：grid
> head(algae)
  season  size  speed mxPH mnO2     Cl     NO3     NH4    oPO4     PO4 Chla   a1   a2   a3  a4   a5   a6  a7
1 winter small medium 8.00  9.8 60.800  6.238 578.000 105.000 170.000 50.0  0.0  0.0  0.0 0.0 34.2  8.3 0.0
2 spring small medium 8.35  8.0 57.750  1.288 370.000 428.750 558.750  1.3  1.4  7.6  4.8 1.9  6.7  0.0 2.1
3 autumn small medium 8.10 11.4 40.020  5.330 346.667 125.667 187.057 15.6  3.3 53.6  1.9 0.0  0.0  0.0 9.7
4 spring small medium 8.07  4.8 77.364  2.302  98.182  61.182 138.700  1.4  3.1 41.0 18.9 0.0  1.4  0.0 1.4
5 autumn small medium 8.06  9.0 55.350 10.416 233.700  58.222  97.580 10.5  9.2  2.9  7.5 0.0  7.5  4.1 1.0
6 winter small   high 8.25 13.1 65.750  9.248 430.000  18.250  56.667 28.4 15.1 14.6  1.4 0.0 22.5 12.6 2.9
```

> summary(algae)

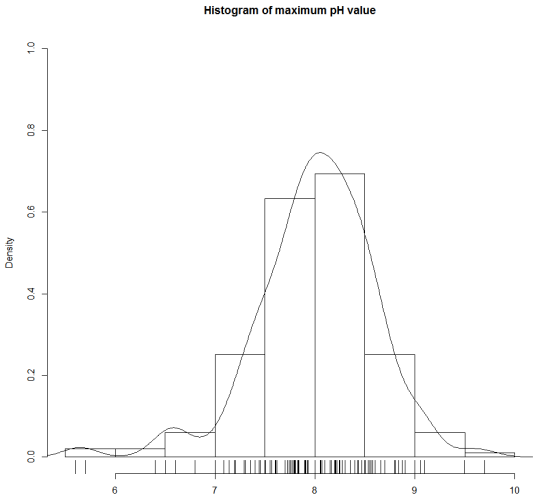
输出数据摘要。对于标称属性，给出每个可能取值的频数。对于数值属性，给出最大、最小、均值、中位数、四分位数及缺失值的个数。

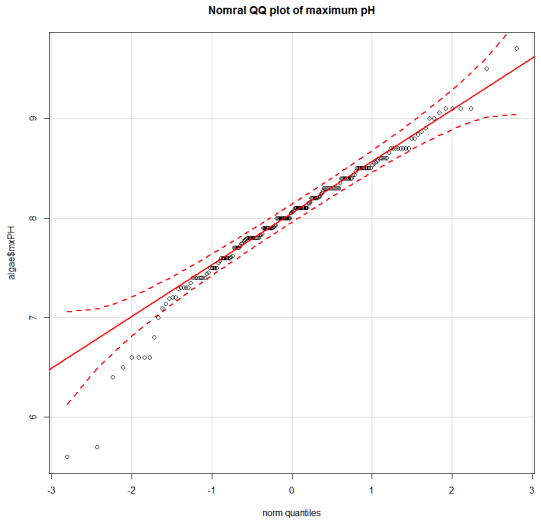
```
> summary(algae)
    season       size       speed        mxPH           mnO2             Cl              NO3              NH4
 autumn:40   large :45   high  :84   Min.   :5.600   Min.   : 1.500   Min.   :  0.222   Min.   : 0.050   Min.   :    5.00
 spring:53   medium:84   low   :33   1st Qu.:7.700   1st Qu.: 7.725   1st Qu.: 10.981   1st Qu.: 1.296   1st Qu.:   38.33
 summer:45   small :71   medium:83   Median :8.060   Median : 9.800   Median : 32.730   Median : 2.675   Median :  103.17
 winter:62                           Mean   :8.012   Mean   : 9.118   Mean   : 43.636   Mean   : 3.282   Mean   :  501.30
                                     3rd Qu.:8.400   3rd Qu.:10.800   3rd Qu.: 57.824   3rd Qu.: 4.446   3rd Qu.:  226.95
                                     Max.   :9.700   Max.   :13.400   Max.   :391.500   Max.   :45.650   Max.   :24064.00
                                     NA's   :1       NA's   :2        NA's   :10        NA's   :2        NA's   :2
       a4               a5               a6               a7
 Min.   : 0.000   Min.   : 0.000   Min.   : 0.000   Min.   : 0.000
 1st Qu.: 0.000   1st Qu.: 0.000   1st Qu.: 0.000   1st Qu.: 0.000
 Median : 0.000   Median : 1.900   Median : 0.000   Median : 1.000
 Mean   : 1.992   Mean   : 5.064   Mean   : 5.964   Mean   : 2.495
 3rd Qu.: 2.400   3rd Qu.: 7.500   3rd Qu.: 6.925   3rd Qu.: 2.400
 Max.   :44.600   Max.   :44.400   Max.   :77.600   Max.   :31.600


      oPO4             PO4              Chla              a1               a2               a3
 Min.   :  1.00   Min.   :  1.00   Min.   :  0.200   Min.   : 0.00   Min.   : 0.000   Min.   : 0.000
 1st Qu.: 15.70   1st Qu.: 41.38   1st Qu.:  2.000   1st Qu.: 1.50   1st Qu.: 0.000   1st Qu.: 0.000
 Median : 40.15   Median :103.29   Median :  5.475   Median : 6.95   Median : 3.000   Median : 1.550
 Mean   : 73.59   Mean   :137.88   Mean   : 13.971   Mean   :16.92   Mean   : 7.458   Mean   : 4.309
 3rd Qu.: 99.33   3rd Qu.:213.75   3rd Qu.: 18.308   3rd Qu.:24.80   3rd Qu.:11.375   3rd Qu.: 4.925
 Max.   :564.60   Max.   :771.60   Max.   :110.456   Max.   :89.80   Max.   :72.600   Max.   :42.800
 NA's   :2        NA's   :2        NA's   :12
```

2. 数据的可视化

```
> library(car)
> par(mfrow=c(1,2))
> hist(algae$mxPH, prob=T, xlab='', main='Histogram of maximum pH value', ylim=0:1)
> lines(density(algae$mxPH,na.rm=T))
> rug(jitter(algae$mxPH))
> qqPlot(algae$mxPH,main='Nomral QQ plot of maximum pH')
> par(mfrow=c(1,1))
```

针对数值属性，绘制 mxPH 属性的直方图，用 Q-Q 图检验其分布是否为正态分布。

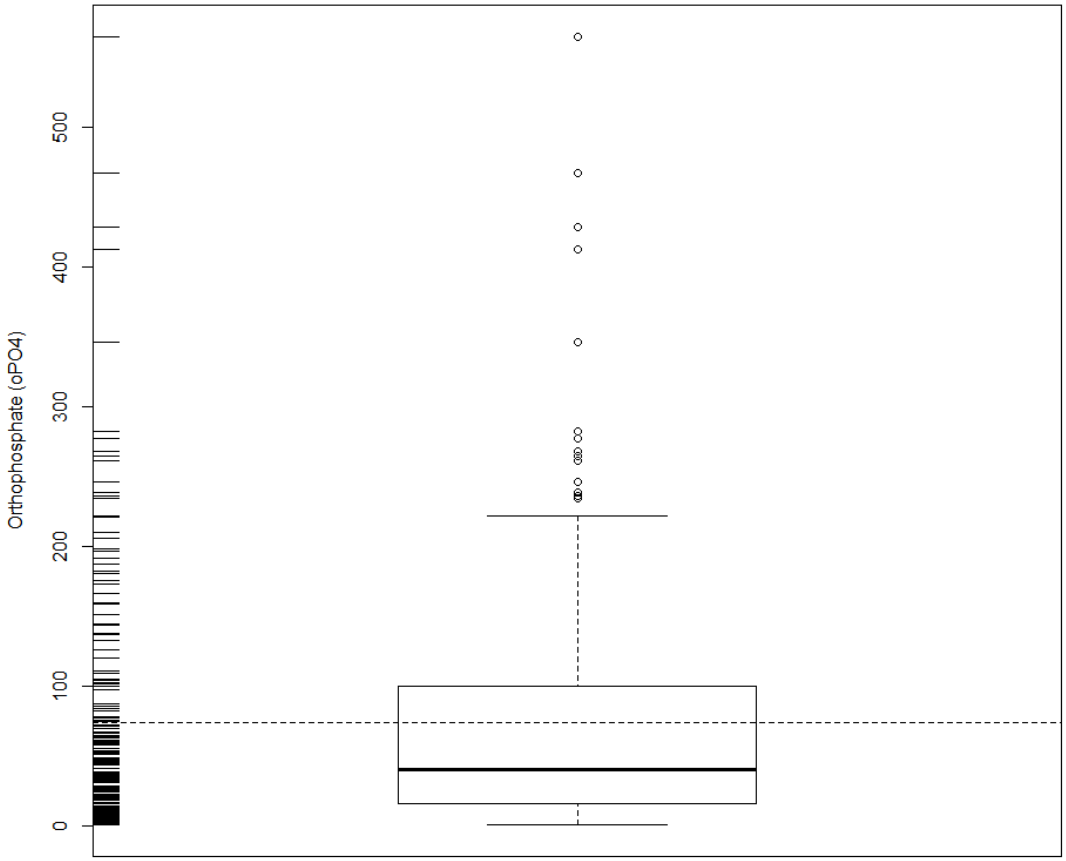




上图右侧是通过 qqPlot 得到的 Q-Q 图，它绘制变量值和正态分布的理论分位数的散点图。同时，它给出正态分布的 95%置信区间的带状图（虚线）。从图中可知，变量有几个小的值明显在 95%置信区间之外，它们不服从正态分布。

```
> boxplot(algae$oPO4, ylab = 'Orthophosphate (oPO4)')
> rug(jitter(algae$oPO4), side = 2)
> abline(h = mean(algae$oPO4, na.rm = T),lty = 2)
```

绘制 oPO4 属性的箱图，图中可以看出，oPO4 的分布集中在较小的观测值周围，因此分布正偏。大部分水样的 oPO4 值比较低，但也有几个水样的观测值比较高，甚至特别高。



针对 7 种海藻，下面分别绘制其数量与标称变量 size 的条件箱图

> bwplot(size ~ a1, data=algae, ylab='River Size',xlab='Algae A1')

> bwplot(size ~ a2, data=algae, ylab='River Size',xlab='Algae A2')

> bwplot(size ~ a3, data=algae, ylab='River Size',xlab='Algae A3')

> bwplot(size ~ a4, data=algae, ylab='River

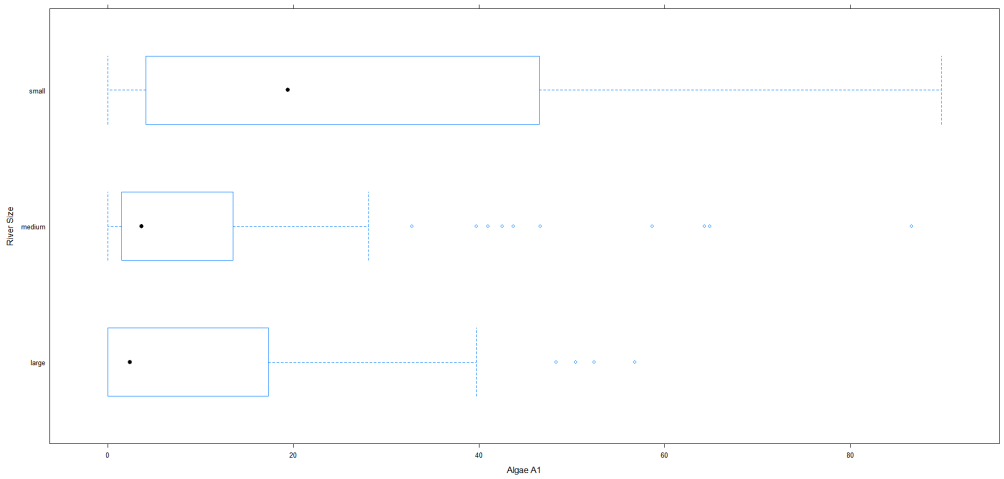
Size',xlab='Algae A4')

> bwplot(size ~ a5, data=algae, ylab='River Size',xlab='Algae A5')

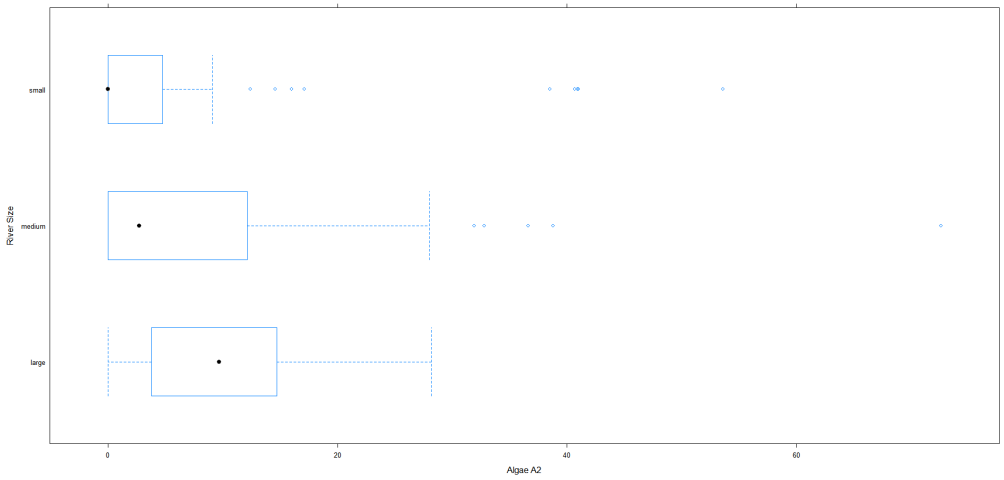
> bwplot(size ~ a6, data=algae, ylab='River Size',xlab='Algae A6')

> bwplot(size ~ a7, data=algae, ylab='River Size',xlab='Algae A7')

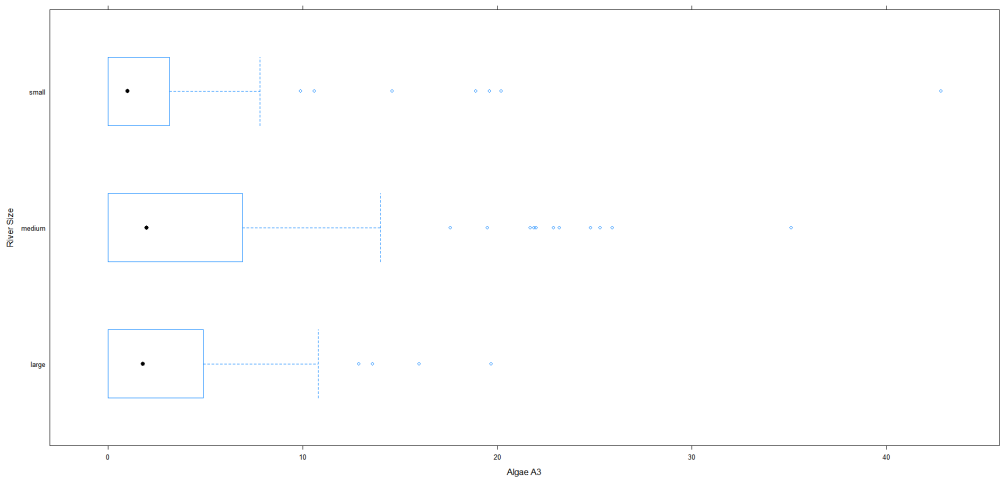
条件箱图（a1,a2,a3,a4,a5,a6,a7）分别如下：



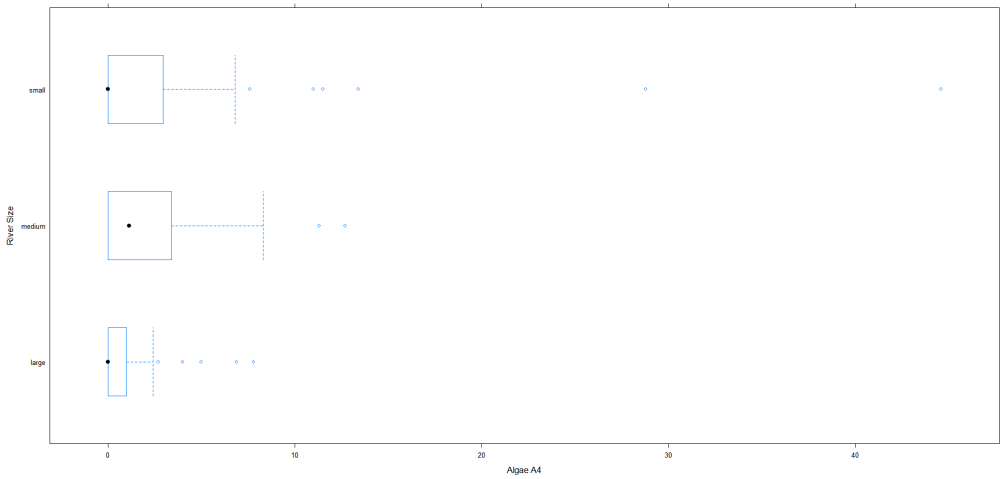
在规模较小的河流中，海藻 a1 的频率较多。



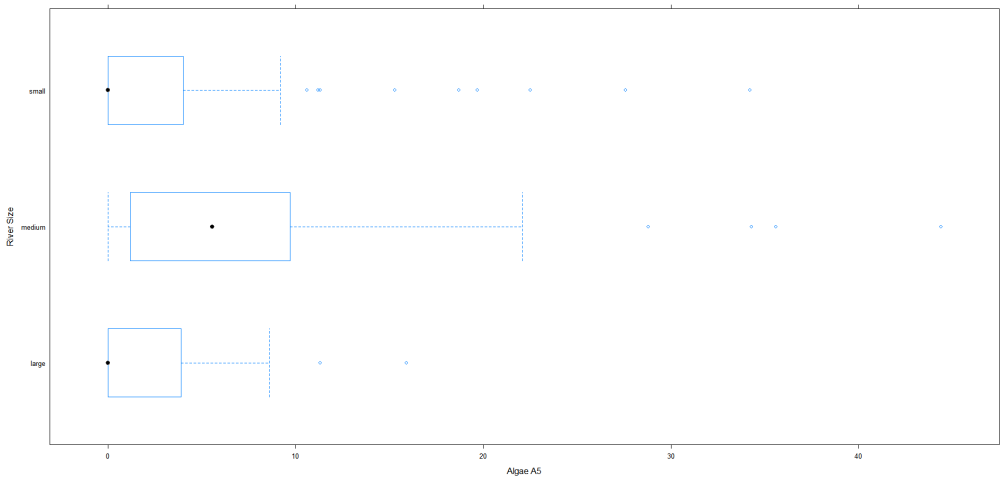
在规模较小和中等的河流中，海藻 a2 的频率较多。



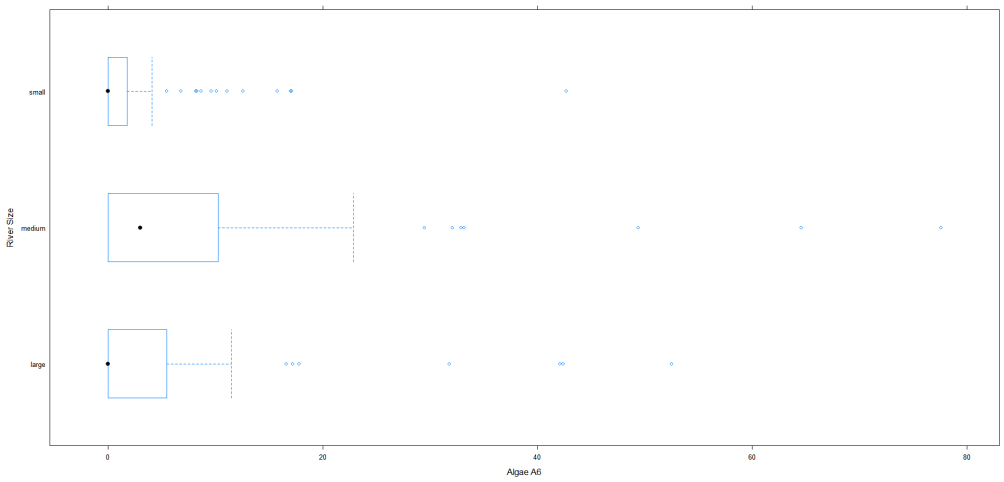
在规模中等的河流中，海藻 a3 的频率较多。



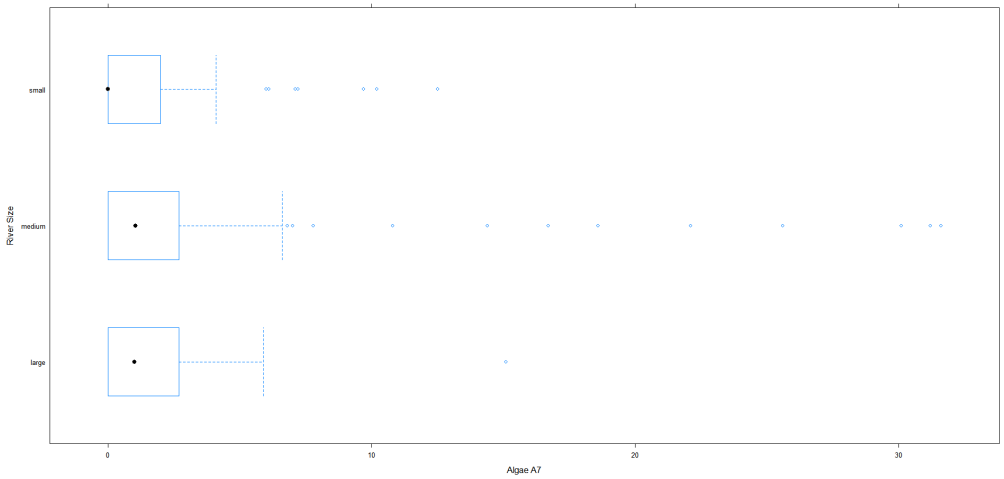
在规模较小和中等的河流中，海藻 a4 的频率较多。



在规模中等的河流中，海藻 a5 的频率较多。



在规模中等的河流中，海藻 a6 的频率较多。



在三种规模的河流中，海藻 a7 的频率相差不大。

3. 数据缺失的处理

> algae[!complete.cases(algae),]

有缺失数据的部分如下：

```
> algae[!complete.cases(algae),]
    season   size  speed mxPH mnO2     Cl    NO3 NH4     oPO4      PO4  Chla    a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1 9.000 0.630  20   4.000       NA  2.70 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00   NA 1.450 0.810  10   2.500    3.000  0.30 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low   NA 12.6 9.000 0.230  10   5.000    6.000  1.10 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8    NA 3.245  10   1.000    6.500    NA 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8    NA 2.220   5   1.000    1.000    NA 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8    NA 2.550  10   1.000    4.000    NA 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5    NA 1.320  20   1.000    6.000    NA 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8    NA 2.640  10   2.000   11.000    NA 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3    NA 4.170  10   1.000    6.000    NA 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4    NA 5.970  10   2.000   14.000    NA 66.9  0.0 0.0  0.0 0.0 0.0 0.0
62  summer  small medium 6.40   NA    NA    NA  NA      NA   14.000    NA 19.4  0.0 0.0  2.0 0.0 3.9 1.7
63  autumn  small   high 7.83 11.7 4.083 1.328  18   3.333    6.667    NA 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8 0.222 0.406  10  22.444   10.111    NA 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8    NA 0.900 142 102.000  186.000 68.05  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9 9.055 0.825  40  21.083   56.091    NA 16.8 19.6 4.0  0.0 0.0 0.0 0.0
199 winter  large medium 8.00  7.6    NA    NA  NA      NA       NA    NA  0.0 12.5 3.7  1.0 0.0 0.0 4.9
>
> nrow(algae[!complete.cases(algae),])
[1] 16
```

> nrow(algae[!complete.cases(algae),])

[1] 16

缺失行数为 16 行

(1) 将缺失部分剔除

> algae<-na.omit(algae)

直接将有缺失的部分剔除，如下图:

```
> algae<-na.omit(algae)
> algae[!complete.cases(algae),]
 [1] season size   speed  mxPH   mnO2   Cl     NO3    NH4    oPO4   PO4    Chla   a1     a2     a3     a4     a5     a6     a7
<0 行> (或0-长度的row.names)
```

(2) 用最高频率值来填补缺失值

使用平均值填补数据，如使用平均值数值填补 mxPH：

```
> algae[48,]
   season  size speed mxPH mnO2 Cl  NO3 NH4 oPO4 PO4 Chla   a1 a2 a3 a4 a5 a6 a7
48 winter small   low   NA 12.6  9 0.23  10    5   6  1.1 35.5  0  0  0  0  0  0
> algae[48,'mxPH']<-mean(algae$mxPH, na.rm = T)
> algae[48,]
   season  size speed     mxPH mnO2 Cl  NO3 NH4 oPO4 PO4 Chla   a1 a2 a3 a4 a5 a6 a7
48 winter small   low 8.011734 12.6  9 0.23  10    5   6  1.1 35.5  0  0  0  0  0  0
```

使用中位数填补数据，如使用中位数数值填补 Chla：

```
>  data(algae)
>  algae[!complete.cases(algae),]
    season   size  speed mxPH mnO2    Cl   NO3 NH4    oPO4     PO4  Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1 9.000 0.630  20   4.000      NA  2.70 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00   NA 1.450 0.810  10   2.500   3.000  0.30 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low   NA 12.6 9.000 0.230  10   5.000   6.000  1.10 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8    NA 3.245  10   1.000   6.500    NA 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8    NA 2.220   5   1.000   1.000    NA 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8    NA 2.550  10   1.000   4.000    NA 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5    NA 1.320  20   1.000   6.000    NA 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8    NA 2.640  10   2.000  11.000    NA 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3    NA 4.170  10   1.000   6.000    NA 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4    NA 5.970  10   2.000  14.000    NA 66.9  0.0 0.0  0.0 0.0 0.0 0.0
62  summer  small medium 6.40   NA    NA    NA  NA      NA  14.000    NA 19.4  0.0 0.0  2.0 0.0 3.9 1.7
63  autumn  small   high 7.83 11.7 4.083 1.328  18   3.333   6.667    NA 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8 0.222 0.406  10  22.444  10.111    NA 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8    NA 0.900 142 102.000 186.000 68.05  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9 9.055 0.825  40  21.083  56.091    NA 16.8 19.6 4.0  0.0 0.0 0.0 0.0
199 winter  large medium 8.00  7.6    NA    NA  NA      NA      NA    NA  0.0 12.5 3.7  1.0 0.0 0.0 4.9
> algae[is.na(algae$Chla), 'Chla']<-median(algae$Chla, na.rm = T)
> algae[c(28,38,48,55,56,57,58,59,60,61,62,63,116,161,184,199),]
    season   size  speed mxPH mnO2    Cl   NO3 NH4    oPO4     PO4   Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1 9.000 0.630  20   4.000      NA  2.700 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00   NA 1.450 0.810  10   2.500   3.000  0.300 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low   NA 12.6 9.000 0.230  10   5.000   6.000  1.100 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8    NA 3.245  10   1.000   6.500  5.475 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8    NA 2.220   5   1.000   1.000  5.475 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8    NA 2.550  10   1.000   4.000  5.475 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5    NA 1.320  20   1.000   6.000  5.475 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8    NA 2.640  10   2.000  11.000  5.475 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3    NA 4.170  10   1.000   6.000  5.475 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4    NA 5.970  10   2.000  14.000  5.475 66.9  0.0 0.0  0.0 0.0 0.0 0.0
62  summer  small medium 6.40   NA    NA    NA  NA      NA  14.000  5.475 19.4  0.0 0.0  2.0 0.0 3.9 1.7
63  autumn  small   high 7.83 11.7 4.083 1.328  18   3.333   6.667  5.475 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8 0.222 0.406  10  22.444  10.111  5.475 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8    NA 0.900 142 102.000 186.000 68.050  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9 9.055 0.825  40  21.083  56.091  5.475 16.8 19.6 4.0  0.0 0.0 0.0 0.0
199 winter  large medium 8.00  7.6    NA    NA  NA      NA      NA  5.475  0.0 12.5 3.7  1.0 0.0 0.0 4.9
```

使用数据的中心趋势来填补数据：

```
>  data(algae)
>  algae[!complete.cases(algae),]
    season   size  speed mxPH mnO2     Cl   NO3 NH4    oPO4     PO4  Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1 9.000 0.630  20   4.000      NA  2.70 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00   NA 1.450 0.810  10   2.500   3.000  0.30 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low   NA 12.6 9.000 0.230  10   5.000   6.000  1.10 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8    NA 3.245  10   1.000   6.500    NA 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8    NA 2.220   5   1.000   1.000    NA 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8    NA 2.550  10   1.000   4.000    NA 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5    NA 1.320  20   1.000   6.000    NA 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8    NA 2.640  10   2.000  11.000    NA 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3    NA 4.170  10   1.000   6.000    NA 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4    NA 5.970  10   2.000  14.000    NA 66.9  0.0 0.0  0.0 0.0 0.0 0.0
62  summer  small medium 6.40   NA    NA    NA  NA      NA  14.000    NA 19.4  0.0 0.0  2.0 0.0 3.9 1.7
63  autumn  small   high 7.83 11.7 4.083 1.328  18   3.333   6.667    NA 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8 0.222 0.406  10  22.444  10.111    NA 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8    NA 0.900 142 102.000 186.000 68.05  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9 9.055 0.825  40  21.083  56.091    NA 16.8 19.6 4.0  0.0 0.0 0.0 0.0
199 winter  large medium 8.00  7.6    NA    NA  NA      NA      NA    NA  0.0 12.5 3.7  1.0 0.0 0.0 4.9
> algae<-algae[-manyNAs(algae),]
> algae<-centralImputation(algae)
> algae[c(28,38,48,55,56,57,58,59,60,61,62,115,160,183),]
    season   size  speed mxPH mnO2      Cl   NO3 NH4    oPO4     PO4   Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1  9.000 0.630  20   4.000 104.000  2.700 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00  9.8  1.450 0.810  10   2.500   3.000  0.300 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low 8.06 12.6  9.000 0.230  10   5.000   6.000  1.100 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8 32.730 3.245  10   1.000   6.500  5.475 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8 32.730 2.220   5   1.000   1.000  5.475 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8 32.730 2.550  10   1.000   4.000  5.475 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5 32.730 1.320  20   1.000   6.000  5.475 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8 32.730 2.640  10   2.000  11.000  5.475 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3 32.730 4.170  10   1.000   6.000  5.475 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4 32.730 5.970  10   2.000  14.000  5.475 66.9  0.0 0.0  0.0 0.0 0.0 0.0
63  autumn  small   high 7.83 11.7  4.083 1.328  18   3.333   6.667  5.475 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8  0.222 0.406  10  22.444  10.111  5.475 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8 32.730 0.900 142 102.000 186.000 68.050  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9  9.055 0.825  40  21.083  56.091  5.475 16.8 19.6 4.0  0.0 0.0 0.0 0.0
```

(3) 通过属性的相关关系来填补缺失值

> symnum(cor(algae[,4:18],use='complete.obs'))

获得变量之间的相关值矩阵，如下图：

```
> symnum(cor(algae[,4:18],use='complete.obs'))
     mP mO Cl NO NH o P Ch a1 a2 a3 a4 a5 a6 a7
mxPH 1
mnO2    1
Cl         1
NO3           1
NH4           ,  1
oPO4     .  .        1
PO4      .  .        * 1
Chla .                  1
a1          .        . .    1
a2    .                   .     1
a3                                  1
a4       .              .              1
a5                                        1
a6             .  .                       .  1
a7                                              1
attr(,"legend")
[1] 0 ' ' 0.3 '.' 0.6 ',' 0.8 '+' 0.9 '*' 0.95 'B' 1
```

由图可知，PO4 与 Opo4 之间相关值很高。

> lm(PO4~oPO4,data=algae)

获得两个变量之间的线性关系，并通过线性关系 PO4 = 42.897 + 1.293 * Opo4 来填补数据：

```
> data(algae)
> algae[28,]
   season  size speed mxPH mnO2 Cl  NO3 NH4 oPO4 PO4 Chla   a1  a2 a3 a4  a5  a6  a7
28 autumn small  high  6.8 11.1  9 0.63  20    4  NA  2.7 30.3 1.9  0  0 2.1 1.4 2.1
> algae<-algae[-manyNAs(algae),]
> lm(PO4~oPO4,data=algae)

Call:
lm(formula = PO4 ~ oPO4, data = algae)

Coefficients:
(Intercept)         oPO4
     42.897        1.293

> algae[28,'PO4']<-42.897+1.293*algae[28,'oPO4']
> algae[28,]
   season  size speed mxPH mnO2 Cl  NO3 NH4 oPO4    PO4 Chla   a1  a2 a3 a4  a5  a6  a7
28 autumn small  high  6.8 11.1  9 0.63  20    4 48.069  2.7 30.3 1.9  0  0 2.1 1.4 2.1
```

(4) 通过数据对象之间的相似性来填补缺失值

我们通过寻找与含有缺失值的数据最相似的 10 个水样，并用它们来填充缺失值。通过 knnImputation()函数用中位数来填补缺失值。

> algae<-knnImputation(algae,k=10,meth='median')

```
>  data(algae)
> algae<-algae[-manyNAs(algae),]
>  algae[!complete.cases(algae),]
    season   size  speed mxPH mnO2    Cl   NO3 NH4    oPO4     PO4  Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.1 9.000 0.630  20   4.000      NA  2.70 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00   NA 1.450 0.810  10   2.500   3.000  0.30 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low   NA 12.6 9.000 0.230  10   5.000   6.000  1.10 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.8    NA 3.245  10   1.000   6.500    NA 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.8    NA 2.220   5   1.000   1.000    NA 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.8    NA 2.550  10   1.000   4.000    NA 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.5    NA 1.320  20   1.000   6.000    NA 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.8    NA 2.640  10   2.000  11.000    NA 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.3    NA 4.170  10   1.000   6.000    NA 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.4    NA 5.970  10   2.000  14.000    NA 66.9  0.0 0.0  0.0 0.0 0.0 0.0
63  autumn  small   high 7.83 11.7 4.083 1.328  18   3.333   6.667    NA 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.8 0.222 0.406  10  22.444  10.111    NA 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.8    NA 0.900 142 102.000 186.000 68.05  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.9 9.055 0.825  40  21.083  56.091    NA 16.8 19.6 4.0  0.0 0.0 0.0 0.0
> algae<-knnImputation(algae,k=10,meth='median')
> algae[c(28,38,48,55,56,57,58,59,60,61,62,115,160,183),]
    season   size  speed mxPH  mnO2      Cl   NO3 NH4    oPO4     PO4  Chla   a1   a2  a3   a4  a5  a6  a7
28  autumn  small   high 6.80 11.10  9.0000 0.630  20   4.000  14.300  2.70 30.3  1.9 0.0  0.0 2.1 1.4 2.1
38  spring  small   high 8.00 10.95  1.4500 0.810  10   2.500   3.000  0.30 75.8  0.0 0.0  0.0 0.0 0.0 0.0
48  winter  small    low 7.75 12.60  9.0000 0.230  10   5.000   6.000  1.10 35.5  0.0 0.0  0.0 0.0 0.0 0.0
55  winter  small   high 6.60 10.80  5.6500 3.245  10   1.000   6.500  0.55 24.3  0.0 0.0  0.0 0.0 0.0 0.0
56  spring  small medium 5.60 11.80  7.8450 2.220   5   1.000   1.000  0.60 82.7  0.0 0.0  0.0 0.0 0.0 0.0
57  autumn  small medium 5.70 10.80  8.8450 2.550  10   1.000   4.000  0.55 16.8  4.6 3.9 11.5 0.0 0.0 0.0
58  spring  small   high 6.60  9.50 11.4335 1.320  20   1.000   6.000  1.85 46.8  0.0 0.0 28.8 0.0 0.0 0.0
59  summer  small   high 6.60 10.80  7.0000 2.640  10   2.000  11.000  0.60 46.9  0.0 0.0 13.4 0.0 0.0 0.0
60  autumn  small medium 6.60 11.30  7.8450 4.170  10   1.000   6.000  0.85 47.1  0.0 0.0  0.0 0.0 1.2 0.0
61  spring  small medium 6.50 10.40  6.9815 5.970  10   2.000  14.000  0.95 66.9  0.0 0.0  0.0 0.0 0.0 0.0
63  autumn  small   high 7.83 11.70  4.0830 1.328  18   3.333   6.667  0.90 14.4  0.0 0.0  0.0 0.0 0.0 0.0
116 winter medium   high 9.70 10.80  0.2220 0.406  10  22.444  10.111  1.35 41.0  1.5 0.0  0.0 0.0 0.0 0.0
161 spring  large    low 9.00  5.80 55.5415 0.900 142 102.000 186.000 68.05  1.7 20.6 1.5  2.2 0.0 0.0 0.0
184 winter  large   high 8.00 10.90  9.0550 0.825  40  21.083  56.091  9.50 16.8 19.6 4.0  0.0 0.0 0.0 0.0
```

4. 总结

通过完成海藻的数据分析作业，我学习了 R 语言的使用，对于数据分析有了初步的了解，掌握了中位数，平均值，四分位数等概念，熟知了数据的可视化和缺失数据的简单处理，为今后进行更深层的数据挖掘工作做了准备。