Multivariate forecasting

```
library(tidyverse)
source("multivariate_forecasting.R")
source("initialization_functions.R")
source("constrained_gls.R")
source("mle.R")
```

We will make a synthetic data set of 5 weeks of call volume from 2 streams, assuming each day is divided into 4 time intervals.

```
set.seed(101)

df <- tibble(
  stream = rep(1:2, each = 5*7*4),
  call_volume = rpois(5*7*4*2, 5),
  wd = rep(rep(1:7, 5*2), each = 4),
  d = rep(rep(1:(5*7), each = 4), 2),
  t = rep(1:4, 5*7*2)
)
```

```
head(df)
```

```
## # A tibble: 6 x 5
##   stream call_volume    wd     d     t
##    <int>       <int> <int> <int> <int>
## 1      1           4     1     1     1
## 2      1           2     1     1     2
## 3      1           6     1     1     3
## 4      1           6     1     1     4
## 5      1           3     2     2     1
## 6      1           4     2     2     2
```

See the code in `multivariate_forecasting.R` for the function's documentation.

For demonstration, we use low-storage BFGS algorithm, a local optimization algorithm. Global optimization algorithms, such as StoGO, can also be used; however, the computation time may increase substantially.

```
rslt <- multivariate_forecasting(
  df = df,
  horizon = 7*4, # Forecast for one week into the future
  max_iter = 100, # In practice, set to 1,000 or greater
  algo = "NLOPT_LD_LBFGS", # Can use other algorithms, e.g., NLOPT_GD_STOGO
  verbose = FALSE
)
```

```
names(rslt)
```

```
## [1] "df_pred"        "step1_converge" "step2_converge" "params"
```

The forecasts are given in a data frame, which can be accessed through the `df_pred` component of the resulting list.

```
head(rslt$df_pred)
```

```
## # A tibble: 6 x 3
##   stream     h  pred
##    <int> <dbl> <dbl>
## 1      1     1  3.97
## 2      1     2  5.97
## 3      1     3  5.76
## 4      1     4  5.97
## 5      2     1  4.35
## 6      2     2  4.97
```

The estimated parameters of the model can be accessed through the `params` component of the resulting list.

```
rslt$params
```

```
## $u_vec
##  [1]  8.528934  8.120150  9.898162  9.964613  7.674236  9.866935  9.211987
##  [8]  8.645659  8.814356  8.657320  8.848095  8.179070  7.796919  9.895120
## [15]  9.500675 11.030653  8.487891 10.815907  9.638783  8.851139 10.925775
## [22]  8.415014  8.468160  8.791465  6.845943  7.753672  7.143941  9.335779
## [29] 11.257179  9.417611  7.673488  9.074034  8.651002  8.405738 10.109334
## [36] 10.176299  9.465553  7.236543  8.990625 10.054270 10.641715 10.700589
## [43]  9.545057 10.901141 10.958546  9.683548  6.269900  7.049514  8.988419
## [50]  9.395871  8.425887  9.412749  9.672348  8.331822  8.714214  8.680455
## [57]  8.759271  9.322636  8.364440  8.698360  8.051862  7.096925  8.638231
## [64]  9.057841  9.134141  8.659934  9.234220  8.998835 10.587587  8.926629
##
## $sigma
##             [,1]        [,2]
## [1,]  0.15257554 -0.01651803
## [2,] -0.01651803  0.15800153
##
## $f_vec
##  [1] 0.2164600 0.2625991 0.2581982 0.2627427 0.2413013 0.2198719 0.2457591
##  [8] 0.2930676 0.2642700 0.2544204 0.1964102 0.2848994 0.2471752 0.2799795
## [15] 0.2248530 0.2479923 0.2696455 0.2150455 0.2590212 0.2562878 0.2566510
## [22] 0.2508610 0.2277504 0.2647376 0.2583466 0.2892760 0.2158800 0.2364974
## [29] 0.2336629 0.2488749 0.2651442 0.2523180 0.2761998 0.2516649 0.2249047
## [36] 0.2472306 0.2425665 0.2454467 0.2658761 0.2461107 0.2690445 0.2796108
## [43] 0.2167959 0.2345488 0.2644649 0.2736327 0.1923508 0.2695516 0.2653137
## [50] 0.2427509 0.2949335 0.1970019 0.2527588 0.2723777 0.2389967 0.2358669
##
## $alpha
```

```
##  [1] 9.447827 9.144402 8.772289 9.067088 8.514247 8.420193 9.723312 9.068891
##  [9] 9.258467 9.134299 9.153030 8.789373 8.821320 8.807535
##
## $A
##            [,1]       [,2]
## [1,] 0.09568367 0.08511747
## [2,] 0.15231991 0.42291895
##
## $omega
##            [,1]       [,2]
## [1,] 0.88466564 0.00340837
## [2,] 0.00340837 0.87373159
```