Hierarchical run example

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08 April 2019

A short vignette showing how to run the hierarchical LFEM model on an example dataset. The example dataset in this case is a cleaned up version of white-bellied anglerfish data from the surveys that cover ICES subarea VII and divisions VIII a,b,d stock.

This method allows multiple surveys from different times of year.

Loading data and formatting

WD should be "LFEM/Vignettes" folder in order to locate .cpp files later

```
getwd()
```

```
## [1] "C:/Users/LukeB/Documents/LFEM/Vignettes"
```

```
#install.packages(c("Matrix","data.table","plyr","reshape","TMB","ggplot2"))
library(TMB)
library(plyr)
library(reshape)
library(ggplot2)
library(data.table)
load("../data/lfdat_MON.RData")
```

The dataframe should be formatted as below for the function, with four columns: Survey, Year, Length and RF (raising factor). The data has been aggregated by year, survey and length so as to compact the dataframe for speed. Observed log-likelihood is the same if individual fish lengths for each haul were used.

```
##    Survey Year Length RF
## 1 SP-PORC 2005      3  1
## 2 IE-IGFS 2007      4  1
## 3   EVHOE 2011      4  1
## 4 IE-IGFS 2012      4  1
## 5 SP-PORC 2004      5  1
## 6 IE-IGFS 2005      5  1
```

Objective functions have already been compiled so no need to do this again but here is the code to do it. Also set root directory for cpp/dll files so the function can find the .dll files.

```
dllroot<-paste0(dirname(getwd()),'/tmb/')
```

```
compile(paste0(dllroot,"hier_cL_CSD.cpp"))
compile(paste0(dllroot,"hier_cL_LSD.cpp"))
compile(paste0(dllroot,"hier_cL_CSD_OBSLL.cpp"))
compile(paste0(dllroot,"hier_cL_LSD_OBSLL.cpp"))

compile(paste0(dllroot,"hier_ck_CSD.cpp"))
compile(paste0(dllroot,"hier_ck_LSD.cpp"))
compile(paste0(dllroot,"hier_ck_CSD_OBSLL.cpp"))
compile(paste0(dllroot,"hier_ck_LSD_OBSLL.cpp"))

compile(paste0(dllroot,"hier_yk_CSD.cpp"))
```

```r
compile(paste0(dllroot,"hier_yk_LSD.cpp"))
compile(paste0(dllroot,"hier_yk_CSD_OBSLL.cpp"))
compile(paste0(dllroot,"hier_yk_LSD_OBSLL.cpp"))
```

Source the function

```r
source("../R/hier_fun.R")
```

Function arguments and starting parameters

Survey information

Values should be entered in alphabetical order of surveys in each case.

How many years of data in each survey? What year does data for each survey start?

```r
  no.years<-c(14,14,14)
  year0<-c(2003,2003,2003)
```

age1 is the assumed age of the first component in each of the surveys. In this case we assume that for the first two surveys alphabetically (EVHOE and IE-IGFS) that the first component observed in the length frequency data is approximately 0.875 years old, using the common assumption fish are born on the 1st of Jan (i.e. the midpoint of the fourth quarter of the year when these surveys are conducted). SP-PORC is mainly conducted over september so we set the age1 at 0.73

```r
age1<-c(0.875,0.875,0.73)
```

Starting parameters

- L is the mean of the final component
- l is the mean of the first component
- *k.reparam* is the starting growth parameter
- sigma.start is the starting standard deviation parameter(s)
- SD.type =
  - 3 -> linear SD relative to means, needs two sigma.start parameters e.g. c(5,10)
  - 4 -> constant SD
- RE.type =
  - 1 -> cohort random effects on l and L
  - 2 -> cohort random effects on l and k
  - 3 -> cohort random effects on l and yearly random effect on k
- fix.RESD =
  - TRUE -> standard deviations for the random effects are fixed to input values. These need to be specified in the function as sdl and sdL or sdk. This gives models more stability when data is lacking, but still provides enough flexibility (see haddock example of paper).
  - FALSE -> Estimates sd of random effects

#Run the function If rel.tolerance is set at 1e-8 as is standard then this will take some time to converge

```r
#Example where sd of RE is estimated
hier_test<- hier.LFEM(year0=year0,no.years=no.years,age1=age1,L=130,l=(16),
k.reparam=0.83,sigma.start=c(6,10),No.comp=9,SD.type=3,RE.type=1,fix.RESD=F,Lengths=lfdat,
niter=10000,rel.tolerance=1e-1,dllroot = dllroot)


#Example where sd of RE is fixed by the user
hier_test_fixedRESD<- hier.LFEM(year0=year0,no.years=no.years,age1=age1,L=130,l=(16),
k.reparam=0.83,sigma.start=c(6,10),No.comp=9,SD.type=3,RE.type=1,fix.RESD=T,Lengths=lfdat,
niter=10000,rel.tolerance=1e-1,dllroot = dllroot,sdl=-2,sdL=-2)
```

Load the test object if you haven't run the model

```r
load("../data/hier_test.RData")
```

Results

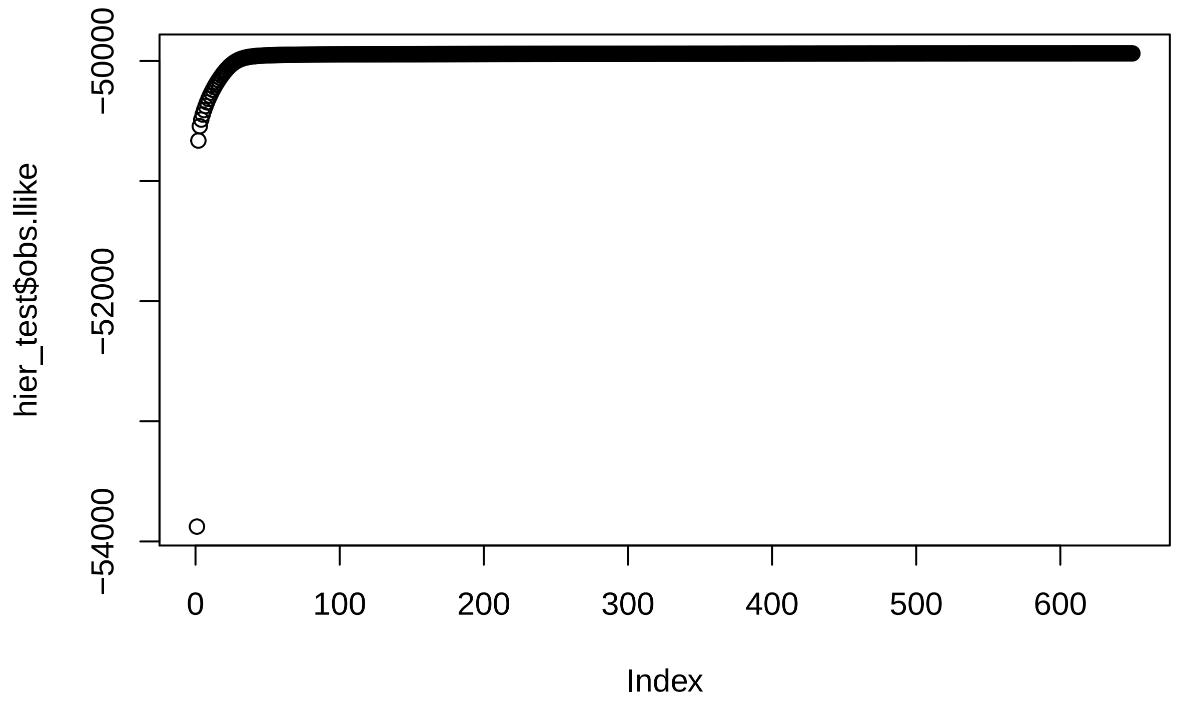
There are many results from the model

```
str(hier_test)
```

```
## List of 26
##  $ obs.llike           : num [1:650] -53876 -50663 -50543 -50488 -50446 ...
##  $ Mu.obs.years        : num [1:14, 1:9, 1:3] 17.6 16.5 14.9 14.4 16.6 ...
##  $ Mu.all.years        : num [1:30, 1:9, 1:3] 16.4 16.4 16.4 16.4 16.4 ...
##  $ Sd.obs.years        : num [1:14, 1:9, 1:3] 4.04 3.96 3.84 3.8 3.97 ...
##  $ Sd.all.years        : num [1:30, 1:9, 1:3] 3.95 3.95 3.95 3.95 3.95 ...
##  $ Lambda              : num [1:14, 1:9, 1:3] 0.279 0.637 0.171 0.306 0.285 ...
##  $ k.reparam           : Named num 0.915
##   ..- attr(*, "names")= chr "logit_k_reparam"
##  $ l                   : Named num 16.4
##   ..- attr(*, "names")= chr "log_l_mu"
##  $ L                   : Named num 118
##   ..- attr(*, "names")= chr "log_L_mu"
##  $ sd.l                : Named num 0.0721
##   ..- attr(*, "names")= chr "raw_sdl"
##  $ sd.L                : Named num 0.0647
##   ..- attr(*, "names")= chr "raw_sdL"
##  $ Rho                 : Named num -0.691
##   ..- attr(*, "names")= chr "raw_rho"
##  $ RE.mat              : num [1:14, 1:2] 0.06989 0.00645 -0.09629 -0.12958 0.01445 ...
##  $ l.par.vec           : num [1:14] 17.6 16.5 14.9 14.4 16.6 ...
##  $ L.par.vec           : num [1:14] 114 115 129 133 125 ...
##  $ sigma               : num [1:2] 3.95 11.65
##  $ K                   : Named num 0.0889
##   ..- attr(*, "names")= chr "logit_k_reparam"
##  $ Linf.overall        : Named num 215
##   ..- attr(*, "names")= chr "log_L_mu"
##  $ tzero.overall       : Named num -0.0146
##   ..- attr(*, "names")= chr "logit_k_reparam"
##  $ Linf.cohort         : num [1:22] 216 216 216 216 216 ...
##  $ tzero.cohort        : num [1:22] -0.015 -0.015 -0.015 -0.015 -0.015 ...
##  $ Lambda.params       : num 336
##  $ sample.size         : num 12060
##  $ age1                : num [1:3] 0.875 0.875 0.73
##  $ Final.Estimate.Error: num [1:71, 1:2] 2.8 4.77 -2.62 -2.72 -1.65 ...
##   ..- attr(*, "dimnames")=List of 2
##   .. ..$ : chr [1:71] "log_l_mu" "log_L_mu" "raw_sdl" "raw_sdL" ...
##   .. ..$ : chr [1:2] "Estimate" "Std. Error"
##  $ Entropy             : num 1217
```

First thing to check is the convergence

```
plot(hier_test$obs.llike)
```



Then explore the rest of the results

Mu's and Sd's are now matrices rather than a vector for each survey. If we take a look at Mu.all.years this displays all component means including those that are used in the unbserved years. In this case the model assumes nine components(m), so we have (m-1) unobserved years before and after our survey data. Adding these in allows us to model cohorts. l values for unbserved years are given the average, as are their corresponding L. This gives the hierrarchical model more stability but also allows us to focus on the variability in the cohorts we observe from their very first year (i.e. the first year of our survey data).

```r
hier_test$Mu.all.years[,,1]
```

```
          [,1]     [,2]     [,3]     [,4]     [,5]     [,6]      [,7]
 [1,] 16.40885       NA       NA       NA       NA       NA        NA
 [2,] 16.40885 33.36121       NA       NA       NA       NA        NA
 [3,] 16.40885 33.36121 48.87134       NA       NA       NA        NA
 [4,] 16.40885 33.36121 48.87134 63.06195       NA       NA        NA
 [5,] 16.40885 33.36121 48.87134 63.06195 76.04528       NA        NA
 [6,] 16.40885 33.36121 48.87134 63.06195 76.04528 87.92406        NA
 [7,] 16.40885 33.36121 48.87134 63.06195 76.04528 87.92406  98.79224
 [8,] 16.40885 33.36121 48.87134 63.06195 76.04528 87.92406  98.79224
 [9,] 17.55225 33.36121 48.87134 63.06195 76.04528 87.92406  98.79224
[10,] 16.47330 33.68552 48.87134 63.06195 76.04528 87.92406  98.79224
[11,] 14.86485 33.00703 48.44624 63.06195 76.04528 87.92406  98.79224
[12,] 14.37815 34.00537 48.13415 61.95119 76.04528 87.92406  98.79224
[13,] 16.60571 34.13554 51.51750 61.97433 74.30720 87.92406  98.79224
[14,] 17.28760 34.64750 52.21206 67.53978 74.63705 85.61202  98.79224
[15,] 17.59978 33.86577 51.15437 68.75072 82.19896 86.22248  95.95508
[16,] 16.86383 34.09310 49.03355 66.25691 83.88234 95.61101  96.82228
[17,] 14.60102 32.59601 49.18324 62.91093 80.07460 97.72664 107.88202
[18,] 17.48241 32.78112 46.98977 62.98958 75.60768 92.71675 110.39313
[19,] 15.56920 33.49085 49.41455 60.15898 75.62134 87.22426 104.28336
[20,] 16.78517 32.68935 48.13737 64.63288 72.20782 87.17845  97.85255
[21,] 17.81319 31.08733 48.35300 61.53783 78.55651 83.23159  97.75234
[22,] 15.84743 33.85515 44.17274 62.68406 73.79825 91.29558  93.31752
[23,]       NA 33.11731 48.53233 56.14490 75.79591 85.01560 102.95087
[24,]       NA       NA 48.91795 61.96084 67.09852 87.79225  95.27863
[25,]       NA       NA       NA 63.37435 74.24692 77.12026  98.76801
[26,]       NA       NA       NA       NA 76.60087 85.48775  86.28940
[27,]       NA       NA       NA       NA       NA 88.70213  95.77227
[28,]       NA       NA       NA       NA       NA       NA  99.77388
[29,]       NA       NA       NA       NA       NA       NA        NA
[30,]       NA       NA       NA       NA       NA       NA        NA
           [,8]     [,9]
 [1,]        NA       NA
 [2,]        NA       NA
 [3,]        NA       NA
 [4,]        NA       NA
 [5,]        NA       NA
 [6,]        NA       NA
 [7,]        NA       NA
 [8,] 108.73580       NA
 [9,] 108.73580 117.8334
[10,] 108.73580 117.8334
[11,] 108.73580 117.8334
[12,] 108.73580 117.8334
[13,] 108.73580 117.8334
[14,] 108.73580 117.8334
[15,] 108.73580 117.8334
[16,] 105.41819 117.8334
[17,] 106.52030 114.0762
[18,] 119.10907 115.3933
[19,] 121.98201 129.3810
[20,] 114.86594 132.5850
```

```
[21,] 107.57663 124.5482
[22,] 107.42665 116.4734
[23,] 102.54538 116.2779
[24,] 113.61458 110.9882
[25,] 104.66853 123.3711
[26,] 108.81000 113.2596
[27,]  94.67847 117.9977
[28,] 105.18183 102.3538
[29,] 109.90369 113.7909
[30,]        NA 119.1717
```