Knee Data - Sequential/Cumulative Random Effects Logit Models

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For the sequential and cumulative random effects logit models we use the knee data from "catdata". We load the data "kneesequential" and "kneecumulative" which are already transformed and ready for use in the sequential or cumulative model.

```
> library(catdata)
> data(kneesequential)
> data(kneecumulative)
```

The covariate "Age" is centered around 30 years and a quadratic effect of "Age" is created for both data sets.

```
> kneesequential$Age <- kneesequential$Age - 30
> kneesequential$Age2 <- kneesequential$Age^2
> kneecumulative$Age <- kneecumulative$Age - 30
> kneecumulative$Age2<-kneecumulative$Age^2
```

For the sequential random effects logit model with Gauss–Hermite–Quadrature the function "glmer" from "lme4" is used.

```
> library(lme4)
```

Now the sequential model with 25 quadrature points (option "nAGQ=25") and a random intercept is fitted.

```
> seqGH<-glmer(y~-1+Icept1+Icept2+Icept3+Icept4+Th+Age+Age2+(1|Person), family=binomial(li
> summary(seqGH)
```

```
Generalized linear mixed model fit by the adaptive Gaussian Hermite approximation
Formula: y ~ -1 + Icept1 + Icept2 + Icept3 + Icept4 + Th + Age + Age2 +      (1 | Person)
   Data: kneesequential
 AIC BIC logLik deviance
 836 876   -410      820
Random effects:
 Groups Name        Variance Std.Dev.
 Person (Intercept) 34.9     5.91
Number of obs: 1018, groups: Person, 127

Fixed effects:
```

```
        Estimate Std. Error z value Pr(>|z|)
Icept1 -7.45916    1.11173   -6.71  2.0e-11 ***
Icept2 -4.72017    1.07414   -4.39  1.1e-05 ***
Icept3 -0.79305    1.05674   -0.75   0.4530
Icept4  6.65642    1.32916    5.01  5.5e-07 ***
Th      2.40205    1.11678    2.15   0.0315 *
Age     0.03688    0.06108    0.60   0.5459
Age2    0.02286    0.00707    3.23   0.0012 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


Correlation of Fixed Effects:
      Icept1 Icept2 Icept3 Icept4 Th     Age
Icept2  0.921
Icept3  0.861  0.915
Icept4  0.542  0.568  0.601
Th     -0.524 -0.541 -0.520 -0.336
Age     0.142  0.141  0.145  0.158  0.123
Age2   -0.611 -0.611 -0.605 -0.429 -0.012 -0.287
```

The sequential model with Penalized Quasi–Likelihood is fitted with the function "glmmPQL" from the "MASS" library.

```
> library(MASS)
```

Here the sequential model with Penalized Quasi–Likelihood is fitted.

```
> seqPQL<-glmmPQL(y ~-1+Icept1+Icept2+Icept3+Icept4+Th+Age+Age2, random=list(Person=~1), f
> summary(seqPQL)

Linear mixed-effects model fit by maximum likelihood
 Data: kneesequential
  AIC BIC logLik
   NA  NA     NA

Random effects:
 Formula: ~1 | Person
        (Intercept) Residual
StdDev:        5.43    0.631

Variance function:
 Structure: fixed weights
 Formula: ~invwt
Fixed effects: y ~ -1 + Icept1 + Icept2 + Icept3 + Icept4 + Th + Age + Age2
       Value Std.Error  DF t-value p-value
Icept1 -7.10     0.964 888   -7.36  0.0000
Icept2 -4.03     0.937 888   -4.30  0.0000
Icept3 -0.18     0.928 888   -0.19  0.8485
Icept4  6.75     1.018 888    6.63  0.0000
Th      2.11     1.006 124    2.10  0.0377
Age     0.03     0.055 124    0.48  0.6346
```

```
Age2   0.02    0.006 124   2.77  0.0064
 Correlation:
       Icept1 Icept2 Icept3 Icept4 Th      Age
Icept2  0.948
Icept3  0.913  0.954
Icept4  0.745  0.775  0.806
Th     -0.528 -0.540 -0.530 -0.437
Age     0.166  0.168  0.172  0.171  0.118
Age2   -0.613 -0.613 -0.609 -0.528 -0.020 -0.330

Standardized Within-Group Residuals:
    Min      Q1     Med      Q3     Max
-5.2851 -0.3074 -0.0354  0.2488 11.1251

Number of Observations: 1018
Number of Groups: 127
```

The cumulative models will be fitted with "clmm2" from the package "ordinal".

```
> library(ordinal)
```

For the sequential random effects logit model with Gauss–Hermite Quadrature the number of quadrature points is defined by the option "nAGQ=25". Now the model is fitted again with a random intercept as the only random effect.

```
> cumGH<-clmm2(as.factor(y)~1+Th+Age+Age2, random = as.factor(Person), data = kneecumulati
> summary(cumGH)

Cumulative Link Mixed Model fitted with the adaptive Gauss-Hermite
quadrature approximation with 25 quadrature points

Call:
clmm2(location = as.factor(y) ~ 1 + Th + Age + Age2, random = as.factor(Person),
    data = kneecumulative, start = c(-5, -3, 3, 5, rep(0.001,
        4)), Hess = TRUE, link = "logistic", nAGQ = 25)

Random effects:
                  Var Std.Dev
as.factor(Person) 39.1    6.25

Location coefficients:
     Estimate Std. Error z value Pr(>|z|)
Th   -2.380    1.205      -1.975  0.048
Age  -0.034    0.066      -0.516  0.606
Age2 -0.021    0.008      -2.772  0.006

No scale coefficients

Threshold coefficients:
    Estimate Std. Error z value
```

```
1|2 -7.461    1.257    -5.937
2|3 -4.498    1.169    -3.846
3|4 -0.396    1.119    -0.354
4|5  7.363    1.391     5.294


log-likelihood: -380.42
AIC: 776.84
Condition number of Hessian: 227717.49
```

For Laplace–Approximation the option "nAGQ" can be dropped.

```
> cumLP<-clmm2(as.factor(y)~1+Th+Age+Age2, random = as.factor(Person), data = kneecumulati
> summary(cumLP)

Cumulative Link Mixed Model fitted with the Laplace approximation

Call:
clmm2(location = as.factor(y) ~ 1 + Th + Age + Age2, random = as.factor(Person),
    data = kneecumulative, start = c(-5, -3, 3, 5, rep(0.001,
        4)), Hess = TRUE, link = "logistic")

Random effects:
                    Var Std.Dev
as.factor(Person) 40.6    6.37

Location coefficients:
     Estimate Std. Error z value Pr(>|z|)
Th   -2.667    1.263     -2.112  0.035
Age  -0.038    0.068     -0.561  0.575
Age2 -0.025    0.008     -3.289  0.001

No scale coefficients

Threshold coefficients:
    Estimate Std. Error z value
1|2 -8.024    1.338     -5.995
2|3 -5.073    1.239     -4.093
3|4 -0.949    1.170     -0.811
4|5  6.900    1.202      5.738

log-likelihood: -382.90
AIC: 781.80
Condition number of Hessian: 259398.88
```