Using the troublesolver package

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In this vignette we show an introduction to the package troublesolver and some examples of how to use the \texttt{dwmw} function (whose name was motivated because of \textit{Dealing With Model Warnings}).

In 2014, Ben Bolker wrote the publication \url{https://rpubs.com/bbolker/lme4trouble1}, with some hints to solve convergence warnings produced by the functions \texttt{lmer} and \texttt{glmer}. Along the past years, he also have answered several related questions on the \texttt{lme4} repository in Github and in the SO forums. He also treated these issues in the [GLMM FAQ](https://lme4.r-forge.r-project.org/) mainly in the section [Troubleshooting] This package was inspired by these documents and by the \texttt{lme4} documentation pages troubleshooting and convergence. This is the reason to make a homage to Ben Bolker in the package name, being a “Solver for (4) \texttt{lme4} troubles”, making the “troub-lme4-Solver” a “BB [Ben Bolker]-troub-lme4-Solver”, i.e., \texttt{trouBBlme4SolverR}.

Let’s start by the same example explained by Ben Bolker in his 2014’s publication. Scaling and updating the optimizer to avoid model failed to converge is automatic by means of \texttt{dwmw}. Beyond that, while the final model in the publication is yet singular, the output model by \texttt{dwmw} is not.

```r
> library(lme4)
> data("fly_parameters", package = "trouBBlme4SolveR")
> df <- fly_parameters
> df$SUR.ID <- factor(df$SUR.ID)
> df$replicate <- factor(df$replicate)
> Rdet <- cbind(df$ValidDetections, df$FalseDetections)
> Unit <- factor(1:length(df$ValidDetections))
> m1 <- glmer(Rdet ~ tm:Area + tm:c.distance +
+ c.distance:Area + c.tm.depth:Area +
+ c.receiver.depth:Area + c.temp:Area +
+ c.wind:Area +
+ c.tm.depth + c.receiver.depth +
+ c.temp +c.wind + tm + c.distance + Area +
+ replicate +
+ (1|SUR.ID) + (1|Day) + (1|Unit),
+ data = df, family = binomial(link="logit"))
> summary(m1)
```
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: binomial ( logit )
Formula: Rdet ~ tm: Area + tm: c.distance + c.distance: Area + c.tm.depth: Area +
c.receiver.depth: Area + c.temp: Area + c.wind: Area + c.tm.depth +
c.receiver.depth + c.temp + c.wind + tm + c.distance + Area +
replicate + (1 | SUR.ID) + (1 | Day) + (1 | Unit)
Data: df

AIC     BIC   logLik deviance df.resid
252.2   316.7 -107.1  214.2      201

Scaled residuals:
            Min      1Q  Median      3Q     Max
-3.1211   0.0000   0.0000   0.3433   1.2976

Random effects:
  Groups   Name       Variance     Std.Dev.
  Unit     (Intercept) 4.624e-01  0.679983
  Day      (Intercept) 1.181e-04  0.010867
  SUR.ID   (Intercept) 5.241e-05  0.007239
Number of obs: 220, groups: Unit, 220; Day, 5; SUR.ID, 3

Fixed effects:
                     Estimate Std. Error   t value  Pr(>|t|)
(Intercept)        -11.379308   7.149613  -1.592 0.111475
  c.tm.depth       -1.036422   1.389863  -0.746 0.455848
  c.receiver.depth  6.855221   8.986477   0.763 0.445560
  c.temp           -5.482533   2.796059  -1.961 0.049901 *
  c.wind           -6.263240   3.715552  -1.686 0.091857 .
  tmPT-04          -2.148023   0.567118  -3.788 0.000152 ***
  c.distance       -0.004259   0.003003  -1.418 0.156132
  AreaFinger       11.617257   7.252924   1.602 0.109214
  replicate2       2.705058   1.260891   2.145 0.031925 *
  tmPT-04:AreaFinger  0.449961   0.689452   0.653 0.513991
  tmPT-04: c.distance 0.005923   0.003675  -1.612 0.107046
  AreaFinger: c.distance 0.013033   0.004453   2.927 0.003425 **
  AreaFinger: c.tm.depth -2.887978  4.990921  -0.579 0.562828
  AreaFinger: c.receiver.depth -34.952817 16.835765  -2.076 0.037884 *
  AreaFinger: c.temp    2.185838  1.865843   1.172 0.241397
  AreaFinger: c.wind    8.334450  4.162632   2.002 0.045262 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
optimizer (Nelder_Mead) convergence code: 0 (OK)
Model failed to converge with max|grad| = 0.252244 (tol = 0.002, component 1)
Model is nearly unidentifiable: very large eigenvalue
- Rescale variables?

Model is nearly unidentifiable: large eigenvalue ratio
- Rescale variables?

```r
> numcols <- grep("^c\.", names(df))
> dfs <- df
> dfs[,numcols] <- scale(dfs[,numcols])
> m1_sc <- update(m1, data=dfs)
> ss <- getME(m1_sc, c("theta","fixef"))
> m3 <- update(m1_sc, start=ss, control=glmerControl(optimizer="bobyqa",
+ optCtrl=list(maxfun=2e5)))
> summary(m3)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]

Family: binomial ( logit )
Formula: Rdet ~ tm:Area + tm:c.distance + c.distance:Area + c.tm.depth:Area +
c.receiver.depth:Area + c.temp:Area + c.wind:Area + c.tm.depth +
c.receiver.depth + c.temp + c.wind + tm + c.distance + Area +
replicate + (1 | SUR.ID) + (1 | Day) + (1 | Unit)
Data: dfs
Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))

AIC   BIC    logLik deviance df.resid
252.2 316.7 -107.1 214.2    201
Scaled residuals:
 Min     1Q   Median     3Q    Max
-3.1643 0.0000 0.0000 0.3449 1.2866

Random effects:
 Groups     Name   Variance  Std.Dev.
 Unit  (Intercept)  0.4721  0.6871
 Day   (Intercept)  0.0000  0.0000
 SUR.ID (Intercept) 0.0000  0.0000
Number of obs: 220, groups: Unit, 220; Day, 5; SUR.ID, 3

Fixed effects:
 (Intercept)          -8.0961  4.8627 -1.665  0.095924 .
c.tm.depth            -0.5121  0.6748 -0.759  0.447914
c.receiver.depth      2.1910  2.8135  0.779  0.436136
c.temp                -13.7827  6.6778 -2.064  0.039021 *
c.wind                -21.8299 12.2512 -1.782  0.074772 .
tmpPT-04              -2.1344  0.5614 -3.802  0.000144 ***
c.distance            -0.5175  0.3868 -1.338  0.180950

3
```r
AreaFinger  10.8986  5.8368  1.867  0.061870 .
replicate2  2.8322  1.2668  2.236  0.025368 *
tmPT-04:AreaFinger  0.4551  0.6922  0.657  0.510896 
tmPT-04:c.distance -0.7847  0.4770 -1.645  0.099920 .
AreaFinger:c.distance  1.6900  0.5772  2.928  0.003411 **
AreaFinger:c.tm.depth -1.3272  2.4328 -0.546  0.585381 
AreaFinger:c.receiver.depth -11.3658  5.4363 -2.091  0.036554 *
AreaFinger:c.temp  5.6156  4.4754  1.255  0.209564 
AreaFinger:c.wind  28.9305  13.7390  2.106  0.035229 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
optimizer (bobyqa) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')

> library(trouBB1me4SolveR)
> m1_new <- dnmw(m1, scale = TRUE, max_message_iter = 3)
> summary(m1_new)

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: binomial  ( logit )
Formula: Rdet ~ c.tm.depth + c.receiver.depth + c.temp + c.wind + tm +
          c.distance + Area + replicate + (1 | Unit) + tm:Area + tm:c.distance +
          Area:c.distance + Area:c.tm.depth + Area:c.receiver.depth +
          Area:c.temp + Area:c.wind
Data: df-rescaled
Control: glmerControl(optimizer = next_optimizer, optCtrl = next_optCtrl)

AIC  BIC  logLik  deviance df.resid
248.2 305.9 -107.1 214.2   203

Scaled residuals:
    Min   1Q Median   3Q   Max
-3.1643  0.0000  0.0000  0.3449  1.2866

Random effects:
  Groups   Name        Variance  Std.Dev.
  Unit     (Intercept) 0.4721   0.6871
Number of obs: 220, groups: Unit, 220

Fixed effects:                     Estimate  Std. Error   z value  Pr(>|z|)
(Intercept)             -8.0962    4.8577     -1.667  0.095579 .
c.tm.depth               -0.5121    0.6748     -0.759  0.447910 
c.receiver.depth         2.1910    2.8132      0.779  0.436076 
c.temp                  -13.7828    6.6709     -2.066  0.038820 *
```
| Term                          | Estimate | Std. Error | t value | Pr(>|t|)  |
|-------------------------------|----------|------------|---------|----------|
| c.wind                       | -21.8301 | 12.2387    | -1.784  | 0.074474 |
| tmPT-04                      | -2.1344  | 0.5614     | -3.802  | < 0.0001 | ***    |
| c.distance                   | -0.5175  | 0.3867     | -1.338  | 0.1808   |
| AreaFinger                   | 10.8987  | 5.8311     | 1.869   | 0.0616   |
| replicate2                   | 2.8322   | 1.2656     | 2.238   | 0.0252   | *      |
| tmPT-04:AreaFinger           | 0.4551   | 0.6922     | 0.657   | 0.511     |
| tmPT-04:c.distance           | -0.7847  | 0.4770     | -1.645  | 0.0999   |
| c.distance:AreaFinger        | 1.6900   | 0.5772     | 2.928   | 0.0034   | **     |
| c.tm.depth:AreaFinger        | -1.3272  | 2.4321     | -0.546  | 0.5853   |
| c.receiver.depth:AreaFinger  | -11.3658 | 5.4345     | -2.091  | 0.0365   | *      |
| c.temp:AreaFinger            | 5.6156   | 4.4718     | 1.256   | 0.2092   |
| c.wind:AreaFinger            | 28.9307  | 13.7248    | 2.108   | 0.0350   | *      |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Next is an example in the lme4 documentation, which is singular. Our function desingularizes it.

```r
> if(requireNamespace("nlme")){
+     data(Orthodont,package="nlme")
+     Orthodont$nsex <- as.numeric(Orthodont$Sex=="Male")
+     Orthodont$nsex <- with(Orthodont, nsex*age)
+     fmo <- lmer(distance ~ age + (age|Subject) + (0 + nsex|Subject) +
+     (0 + nsexage|Subject), data = Orthodont)
+     # without warnings
+     fmo_new <- dwmw(fmo)
+ }

> summary(fmo)

Linear mixed model fit by REML ['lmerMod']
Formula: distance ~ age + (age | Subject) + (0 + nsex | Subject) + (0 +
   nsexage | Subject)
Data: Orthodont

REML criterion at convergence: 442.6

Scaled residuals:
    Min     1Q    Median     3Q    Max
-3.2232 -0.4938   0.0073  0.4722  3.9160

Random effects:
  Groups     Name         Variance  Std.Dev.   Corr
  Subject (Intercept) 5.414e+00 2.3268096
     age           5.126e-02 0.2264158 -0.61
  Subject.1 nsex     2.430e-08 0.0001559
  Subject.2 nsexage  0.000e+00 0.0000000

---
Residual 1.716e+00 1.3100560
Number of obs: 108, groups: Subject, 27

Fixed effects:

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>16.76111</td>
<td>0.77524</td>
</tr>
<tr>
<td>age</td>
<td>0.66019</td>
<td>0.07125</td>
</tr>
</tbody>
</table>

Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th>(Intr)</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>age -0.848</td>
<td></td>
</tr>
</tbody>
</table>

optimizer (nloptr) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')

> summary(fmo_new)

Linear mixed model fit by REML ['lmerMod']
Formula: distance ~ age + (age | Subject) + (0 + nsex | Subject)
Data: Orthodont

REML criterion at convergence: 442.6

Scaled residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
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<td>-3.2231</td>
<td>-0.4938</td>
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</table>

Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
<th>Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>(Intercept)</td>
<td>5.415e+00</td>
<td>2.32699989</td>
<td></td>
</tr>
<tr>
<td></td>
<td>age</td>
<td>5.128e-02</td>
<td>0.2264469</td>
<td>-0.61</td>
</tr>
<tr>
<td>Subject.1</td>
<td>nsex</td>
<td>3.427e-07</td>
<td>0.0005854</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>1.716e+00</td>
<td>1.3100290</td>
<td></td>
</tr>
</tbody>
</table>

Number of obs: 108, groups: Subject, 27

Fixed effects:

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<td>0.07125</td>
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</table>

Correlation of Fixed Effects:

<table>
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<tr>
<th>(Intr)</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>age -0.848</td>
<td></td>
</tr>
</tbody>
</table>

Other examples

- SO question [R error: boundary (singular) fit: see ?isSingular]
> data("plants", package = "trouBB1me4SolveR")
> fit <- lmer(Weight ~ 1 + (1|Rep:PLANT), data = plants)
> summary(fit)

Linear mixed model fit by REML ['lmerMod']
Formula: Weight ~ 1 + (1 | Rep:PLANT)
Data: plants

REML criterion at convergence: 2521.2

Scaled residuals:
    Min 1Q Median 3Q Max
-4.8883 -0.2685 0.1935 0.6554 1.8104

Random effects:
   Groups   Name   Variance Std.Dev.
   Rep:PLANT (Intercept) 0.000 0.000
   Residual             18.741 4.329
Number of obs: 437, groups: Rep:PLANT, 8

Fixed effects:
   Estimate Std. Error t value
(Intercept) 25.1625   0.2071   121.5

optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')

> fit_new <- dwm(fit)
> summary(fit_new)

Call:
  lm(formula = Weight ~ 1, data = plants)

Residuals:
     Min      1Q  Median      3Q     Max
-21.1625 -1.1625  0.8375  2.8375  7.8375

Coefficients:
     Estimate Std. Error t value Pr(>|t|)
(Intercept) 25.1625    0.2071  121.50 <2e-16 ***

---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.329 on 436 degrees of freedom
(99 observations deleted due to missingness)

In this case, as the package does not analyze the random effect of each of the factors in an interaction among them (Rep and PLANT), it does not try to
update the formula including them separately \((1|Rep)\) or \((1|PLANT)\), which is the final answer in the SO question, but it removes random effect specified and outputs a simple linear model.

- **lme4** issue convergence issues with continuous variables in model at Github.

In this example, scaling the continuous predictor makes the large-eigenvalue warning go away.

```r
> data("issue618", package = "trouBBlme4SolveR")
> fit <- glmer(outcome_dead ~ AGE + (1|ZIP), family = binomial, data = issue618)
> summary(fit)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]

Family: binomial (logit)

Formula: outcome_dead ~ AGE + (1 | ZIP)

Data: issue618

<table>
<thead>
<tr>
<th></th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>df.resid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>953.9</td>
<td>968.6</td>
<td>-474.0</td>
<td>947.9</td>
<td>997</td>
</tr>
</tbody>
</table>

Scaled residuals:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>-2.9350</td>
<td>0.3408</td>
<td>0.4074</td>
<td>0.4664</td>
<td>0.9831</td>
</tr>
</tbody>
</table>

Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIP</td>
<td>(Intercept)</td>
<td>0.3403</td>
<td>0.5834</td>
</tr>
</tbody>
</table>

Number of obs: 1000, groups: ZIP, 614

Fixed effects:

|            | Estimate | Std. Error | z value | Pr(>|z|) |
|------------|----------|------------|---------|----------|
| (Intercept)| -0.400877| 0.482552   | -0.831  | 0.406    |
| AGE        | 0.028986 | 0.007147   | 4.056   | 4.99e-05 *** |

---

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th>(Intr)</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>-0.961</td>
</tr>
</tbody>
</table>

optimizer (Nelder_Mead) convergence code: 0 (OK)
Model is nearly unidentifiable: very large eigenvalue
- Rescale variables?

```r
> fit_new <- dwmw(fit, scale = TRUE)
> summary(fit_new)
```
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: binomial  ( logit )
Formula: outcome_dead ~ AGE + (1 | ZIP)
   Data: issue618-rescaled

<table>
<thead>
<tr>
<th></th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>df.resid</th>
</tr>
</thead>
<tbody>
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<td>968.6</td>
<td>-474.0</td>
<td>947.9</td>
<td>997</td>
</tr>
</tbody>
</table>

Scaled residuals:

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<th>Median</th>
<th>3Q</th>
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<tbody>
<tr>
<td></td>
<td>-2.9350</td>
<td>0.3408</td>
<td>0.4074</td>
<td>0.4664</td>
<td>0.9831</td>
</tr>
</tbody>
</table>

Random effects:

Groups   Name   Variance  Std.Dev.
ZIP      (Intercept) 0.3403 0.5834
Number of obs: 1000, groups: ZIP, 614

Fixed effects:

|                  | Estimate | Std. Error | z value | Pr(>|z|) |
|------------------|----------|------------|---------|----------|
| (Intercept)      | 1.60681  | 0.13641    | 11.779  | < 2e-16 *** |
| AGE              | 0.34489  | 0.08503    | 4.056   | 4.99e-05 *** |

---

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:

(Intr)  AGE
AGE     0.228

The same with the larger dataset:

```r
> data("issue618large", package = "trouBBlme4SolveR")
> fit <- glmer(outcome_dead ~ AGE + (1|ZIP), family = binomial, data = issue618large)
> summary(fit)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: binomial  ( logit )
Formula: outcome_dead ~ AGE + (1 | ZIP)
   Data: issue618large

<table>
<thead>
<tr>
<th></th>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>df.resid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9815.3</td>
<td>9836.9</td>
<td>-4904.6</td>
<td>9809.3</td>
<td>9997</td>
</tr>
</tbody>
</table>

Scaled residuals:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2.7766</td>
<td>0.3902</td>
<td>0.4546</td>
<td>0.5168</td>
<td>0.9550</td>
</tr>
</tbody>
</table>
Random effects:

<table>
<thead>
<tr>
<th>Groups Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIP (Intercept)</td>
<td>0.02448</td>
<td>0.1565</td>
</tr>
</tbody>
</table>

Number of obs: 10000, groups: ZIP, 1235

Fixed effects:

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|----------|
| (Intercept) | -0.376328 | 0.149517 | -2.517 | 0.0118 * |
| AGE | 0.025962 | 0.002183 | 11.892 | <2e-16 *** |

---

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:

(Intercept) -0.984

Optimizer (Nelder_Mead) convergence code: 0 (OK)
Model failed to converge with max|grad| = 0.00416831 (tol = 0.002, component 1)
Model is nearly unidentifiable: very large eigenvalue
- Rescale variables?

```r
> fit_new <- dwmw(fit, scale = TRUE)
> summary(fit_new)
```

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: binomial (logit)
Formula: outcome_dead ~ AGE + (1 | ZIP)
Data: issue618large-rescaled

<table>
<thead>
<tr>
<th>AIC</th>
<th>BIC</th>
<th>logLik</th>
<th>deviance</th>
<th>df.resid</th>
</tr>
</thead>
<tbody>
<tr>
<td>9815.3</td>
<td>9836.9</td>
<td>-4904.6</td>
<td>9809.3</td>
<td>9997</td>
</tr>
</tbody>
</table>

Scaled residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2.7766</td>
<td>0.3902</td>
<td>0.4546</td>
<td>0.5168</td>
<td>0.9551</td>
</tr>
</tbody>
</table>

Random effects:

<table>
<thead>
<tr>
<th>Groups Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIP (Intercept)</td>
<td>0.02448</td>
<td>0.1565</td>
</tr>
</tbody>
</table>

Number of obs: 10000, groups: ZIP, 1235

Fixed effects:

| Estimate | Std. Error | z value | Pr(>|z|) |
|----------|------------|---------|----------|
| (Intercept) | 1.43141 | 0.02731 | 52.41 | <2e-16 *** |
| AGE | 0.29822 | 0.02508 | 11.89 | <2e-16 *** |
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:

(Intr)
AGE 0.181

- Cross Validated question lme4: glmer() warning messages with count data
  mixed-effects model and how to proceed with model fit

The convergence issue posted is solved by means of updating the model start
parameters:

> data("treatments", package = "trouBBim4SolveR")
> glmm.1 <- glmer(total_no ~ week * treatment * fzone + (1|plot), data = treatments, family = poisson)
> summary(glmm.1)

Generalized linear mixed model fit by maximum likelihood (Laplace
Approximation) [glmerMod]
Family: poisson ( log )
Formula: total_no ~ week * treatment * fzone + (1 | plot)
Data: treatments

AIC      BIC    logLik deviance df.resid
1558.4   1596.8  -766.2 1532.4      129

Scaled residuals:

Min      1Q   Median      3Q     Max
-5.3750  -1.3546  -0.0084  1.1502  9.5257

Random effects:

Groups     Name        Variance          Std.Dev.       
plot (Intercept) 0.2361 0.4858

Number of obs: 142, groups: plot, 16

Fixed effects:

             Estimate Std. Error     z value  Pr(>|z|)
(Intercept)  2.791843  0.379427  7.358000 1.87e-13 ***
week         0.015903  0.021304  0.746959  0.455355
             0.736043  0.528725  1.391981  0.163892
             0.149514  0.486590  0.307283  0.758653
fzonepioneer 2.325944  0.474349  4.902514  9.42e-07 ***
week: treatment+3 -0.067099  0.028233 -2.367431  0.017454 *
week: treatmentambient -0.025210  0.026678 -0.944823  0.344576
week:fzonepioneer -0.086580  0.022333 -3.876486  0.000106 ***
treatment+3:fzonepioneer -0.884566  0.664383 -1.331549  0.183057
treatmentambient:fzonepioneer -0.418383  0.631882 -0.661988  0.507898
Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th></th>
<th>(Intr)</th>
<th>week</th>
<th>treatment+3</th>
<th>trtm+3</th>
<th>trtmnt</th>
<th>fzonepioneer</th>
<th>wk:t+3</th>
<th>wk:trt</th>
<th>wk:fzn</th>
<th>trt+3:week</th>
</tr>
</thead>
<tbody>
<tr>
<td>week</td>
<td>-0.399</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>treatment+3</td>
<td>-0.718</td>
<td>0.286</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trtmntmbnt</td>
<td>-0.780</td>
<td>0.311</td>
<td>0.560</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fzonepioneer</td>
<td>-0.800</td>
<td>0.319</td>
<td>0.574</td>
<td>0.624</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wk:trtmnt+3</td>
<td>0.301</td>
<td>-0.755</td>
<td>-0.369</td>
<td>-0.235</td>
<td>-0.241</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wk:trtmntmb</td>
<td>0.319</td>
<td>-0.799</td>
<td>-0.229</td>
<td>-0.380</td>
<td>-0.255</td>
<td>0.603</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>week:fznprn</td>
<td>0.380</td>
<td>-0.954</td>
<td>-0.273</td>
<td>-0.297</td>
<td>-0.332</td>
<td>0.720</td>
<td>0.762</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trtmnt+3:fz</td>
<td>0.571</td>
<td>-0.228</td>
<td>-0.796</td>
<td>-0.445</td>
<td>-0.714</td>
<td>0.294</td>
<td>0.182</td>
<td>0.237</td>
<td></td>
<td></td>
</tr>
<tr>
<td>trtmntmbnt:</td>
<td>0.600</td>
<td>-0.240</td>
<td>-0.431</td>
<td>-0.770</td>
<td>-0.751</td>
<td>0.181</td>
<td>0.292</td>
<td>0.249</td>
<td>0.536</td>
<td></td>
</tr>
<tr>
<td>wk:trtmnt+3</td>
<td>-0.286</td>
<td>0.718</td>
<td>0.351</td>
<td>0.223</td>
<td>0.250</td>
<td>-0.951</td>
<td>-0.573</td>
<td>-0.753</td>
<td>-0.308</td>
<td></td>
</tr>
<tr>
<td>wk:trtmntmb</td>
<td>-0.299</td>
<td>0.749</td>
<td>0.214</td>
<td>0.356</td>
<td>0.261</td>
<td>-0.565</td>
<td>-0.938</td>
<td>-0.785</td>
<td>-0.186</td>
<td></td>
</tr>
<tr>
<td>trtmnt:wk:+3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

optimizer (Nelder_Mead) convergence code: 0 (OK)

Model failed to converge with max|grad| = 0.00276087 (tol = 0.002, component 1)

> glmm.11 <- dwmw(glmm.1, verbose = TRUE)

Iteration: 1
Try solving:
Model failed to converge with max|grad| = 0.00276087 (tol = 0.002, component 1)

> summary(glmm.11)

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) [glmerMod]
Family: poisson ( log )
Formula: total_no ~ week * treatment * fzone + (1 | plot)
Data: treatments
AIC       BIC   logLik   deviance   df.resid
1558.4    1596.8 -766.2    1532.4     129

Scaled residuals:
  Min     1Q   Median     3Q    Max
-5.3750 -1.3547  -0.0084  1.1502  9.5257

Random effects:
  Groups   Name       Variance   Std.Dev.
  plot    (Intercept) 0.236       0.4858
  Number of obs: 142, groups: plot, 16

Fixed effects:
  Estimate     Std. Error      z value     Pr(>|z|)
  (Intercept)   2.79179  0.37942       7.358     1.87e-13 ***
  week          0.01591  0.02130       0.747     0.455097
  treatment+3   0.73608  0.52871       1.392     0.163854
  fzonepioneer  2.32590  0.47434       4.903     9.41e-07 ***
  week:treatment+3 -0.06711  0.02823      -2.378     0.017425 *
  week:treatmentambient -0.02522  0.02668     -0.945     0.344408
  week:fzonepioneer -0.08659  0.02323      -3.787     0.000106 ***
  treatment+3:fzonepioneer -0.01845  0.06437     -0.285     0.779508
  treatmentambient:fzonepioneer -0.02522  0.02668     -0.945     0.344408
  week:treatmentambient:fzonepioneer 0.12522  0.02967      4.220     2.44e-05 ***
  week:treatmentambient:fzonepioneer 0.06164  0.02844      2.167     0.030204 *

---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
   (Intr)   week  trtm+3  trtmnt  fznpnr  wk:t+3  wk:trt  wk:fzn  trt+3:
week         -0.399
 treatment+3 -0.718  0.286
 trtmntmbnt   -0.780  0.311  0.560
 fzonepioneer -0.800  0.319  0.574  0.624
 wk:trtm+3    0.301 -0.755 -0.369 -0.235 -0.241
 wk:trtmntmb  0.319 -0.799 -0.229 -0.380 -0.255  0.603
 week:fznpr   0.380 -0.954 -0.273 -0.297 -0.332  0.720  0.762
 trtmnt:trm+3 0.571 -0.228 -0.796 -0.445 -0.714  0.294  0.182  0.237
 trtmntmbnt:  0.600 -0.240 -0.431 -0.770 -0.751  0.181  0.292  0.249  0.536
 wk:trtm+3:   -0.286  0.718  0.351  0.223  0.250 -0.951 -0.573 -0.753 -0.308
 wk:trtmntm:  -0.299  0.749  0.214  0.356  0.261 -0.565 -0.938 -0.785 -0.186
 trtmnt:trm+3: -0.286  0.718  0.351  0.223  0.250 -0.951 -0.573 -0.753 -0.308

week
 treatment+3
A bag of tips and tricks for dealing with scale issues

In this publication, the author suggests removing the convergence failing through dividing the variable `price` by 1000. Another option is scaling (standardizing) all the continuous predictors.

```r
if(requireNamespace("ggplot2")){
  data("diamonds", package = "ggplot2")
  # Grab the priciest diamonds
  diamonds_subset <- diamonds[(nrow(diamonds)-10000):nrow(diamonds),]
  # Fit the model
  fit_1 <- lmer(carat ~ depth + table + price + x + y + z + (1 + price | cut), data = diamonds_subset)
  # Let's try dividing price by 1000
  fit_2 <- lmer(carat ~ depth + table + I(price/1000) + x + y + z + (1 + I(price/1000) | cut), data = diamonds_subset)
  fit_new <- dwmw(fit_1, scale = TRUE, verbose = TRUE)
}
```

Iteration: 1
Try solving:
Model failed to converge: degenerate Hessian with 1 negative eigenvalues
unable to evaluate scaled gradient
Some predictor variables are on very different scales: consider rescaling

```
> summary(fit_1)

Linear mixed model fit by REML ['lmerMod']
Formula: carat ~ depth + table + price + x + y + z + (1 + price | cut)
  Data: diamonds_subset

REML criterion at convergence: -40082.4

Scaled residuals:
     Min      1Q  Median      3Q     Max
-10.760  -0.445  -0.106   0.374   49.847
```
Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
<th>Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>cut</td>
<td>(Intercept)</td>
<td>1.213e-03</td>
<td>3.482e-02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>price</td>
<td>5.365e-10</td>
<td>2.316e-05</td>
<td>-0.96</td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>1.049e-03</td>
<td>3.239e-02</td>
<td></td>
</tr>
</tbody>
</table>

Number of obs: 10001, groups: cut, 5

Fixed effects:

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-1.917e+00</td>
<td>2.838e-02</td>
</tr>
<tr>
<td>depth</td>
<td>1.340e-02</td>
<td>2.618e-04</td>
</tr>
<tr>
<td>table</td>
<td>2.094e-03</td>
<td>1.856e-04</td>
</tr>
<tr>
<td>price</td>
<td>9.890e-06</td>
<td>1.045e-05</td>
</tr>
<tr>
<td>x</td>
<td>2.873e-01</td>
<td>1.853e-03</td>
</tr>
<tr>
<td>y</td>
<td>2.416e-03</td>
<td>1.202e-03</td>
</tr>
<tr>
<td>z</td>
<td>-5.778e-04</td>
<td>1.116e-03</td>
</tr>
</tbody>
</table>

Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th>(Intr)</th>
<th>depth</th>
<th>table</th>
<th>price</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>depth</td>
<td>-0.736</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>table</td>
<td>-0.587</td>
<td>0.376</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>price</td>
<td>-0.501</td>
<td>-0.014</td>
<td>-0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>-0.206</td>
<td>0.144</td>
<td>-0.033</td>
<td>-0.059</td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>-0.038</td>
<td>0.041</td>
<td>0.017</td>
<td>-0.003</td>
<td>-0.593</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>0.115</td>
<td>-0.224</td>
<td>0.022</td>
<td>-0.002</td>
<td>-0.308</td>
<td>-0.073</td>
</tr>
</tbody>
</table>

fit warnings:

Some predictor variables are on very different scales: consider rescaling optimizer (nloptwrap) convergence code: 0 (OK)
unable to evaluate scaled gradient
Model failed to converge: degenerate Hessian with 1 negative eigenvalues

> summary(fit_2)

Linear mixed model fit by REML ['lmerMod']
Formula:
carat ~ depth + table + I(price/1000) + x + y + z + (1 + I(price/1000) | cut)
   Data: diamonds_subset

REML criterion at convergence: -40099.9

Scaled residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10.736</td>
<td>-0.445</td>
<td>-0.106</td>
<td>0.374</td>
<td>49.827</td>
</tr>
</tbody>
</table>
Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
<th>Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>cut</td>
<td>(Intercept)</td>
<td>0.0002811</td>
<td>0.01677</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I(price/1000)</td>
<td>0.0001138</td>
<td>0.01067</td>
<td>-0.91</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>0.0010498</td>
<td>0.03240</td>
<td></td>
</tr>
</tbody>
</table>

Number of obs: 10001, groups: cut, 5

Fixed effects:

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-1.9175113</td>
<td>0.0247826</td>
</tr>
<tr>
<td>depth</td>
<td>0.0134157</td>
<td>0.0002614</td>
</tr>
<tr>
<td>table</td>
<td>0.0021038</td>
<td>0.0001853</td>
</tr>
<tr>
<td>I(price/1000)</td>
<td>0.0094664</td>
<td>0.0049595</td>
</tr>
<tr>
<td>x</td>
<td>0.2872836</td>
<td>0.0018522</td>
</tr>
<tr>
<td>y</td>
<td>0.0024191</td>
<td>0.0012019</td>
</tr>
<tr>
<td>z</td>
<td>-0.0005757</td>
<td>0.0011167</td>
</tr>
</tbody>
</table>

Correlation of Fixed Effects:

<table>
<thead>
<tr>
<th>(Intr)</th>
<th>depth</th>
<th>table</th>
<th>I(price/1000)</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>depth</td>
<td>-0.840</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>table</td>
<td>-0.669</td>
<td>0.374</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I(price/1000)</td>
<td>-0.216</td>
<td>-0.031</td>
<td>-0.012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>-0.232</td>
<td>0.142</td>
<td>-0.035</td>
<td>-0.126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>-0.044</td>
<td>0.041</td>
<td>0.017</td>
<td>-0.005</td>
<td>-0.593</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>0.131</td>
<td>-0.224</td>
<td>0.022</td>
<td>-0.004</td>
<td>-0.308</td>
<td>-0.073</td>
</tr>
</tbody>
</table>

> summary(fit_new)

Linear mixed model fit by REML ['lmerMod']
Formula: carat ~ depth + table + price + x + y + z + (1 + price | cut)
Data: diamonds_subset-rescaled

REML criterion at convergence: -40096.8

Scaled residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10.736</td>
<td>-0.445</td>
<td>-0.106</td>
<td>0.374</td>
<td>49.827</td>
</tr>
</tbody>
</table>

Random effects:

<table>
<thead>
<tr>
<th>Groups</th>
<th>Name</th>
<th>Variance</th>
<th>Std.Dev.</th>
<th>Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>cut</td>
<td>(Intercept)</td>
<td>7.665e-05</td>
<td>0.008755</td>
<td></td>
</tr>
<tr>
<td></td>
<td>price</td>
<td>3.763e-05</td>
<td>0.006134</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>1.050e-03</td>
<td>0.032400</td>
<td></td>
</tr>
</tbody>
</table>

Number of obs: 10001, groups: cut, 5

Fixed effects:
<table>
<thead>
<tr>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.6015549</td>
<td>0.0039516</td>
</tr>
<tr>
<td>depth</td>
<td>0.0198214</td>
<td>0.0003862</td>
</tr>
<tr>
<td>table</td>
<td>0.0048810</td>
<td>0.0004300</td>
</tr>
<tr>
<td>price</td>
<td>0.0054427</td>
<td>0.0028514</td>
</tr>
<tr>
<td>x</td>
<td>0.1372493</td>
<td>0.0008849</td>
</tr>
<tr>
<td>y</td>
<td>0.0013028</td>
<td>0.0006473</td>
</tr>
<tr>
<td>z</td>
<td>-0.0002389</td>
<td>0.0004634</td>
</tr>
</tbody>
</table>

Correlation of Fixed Effects:

- `(Intr)` depth table price x y
- depth -0.038
- table -0.046 0.374
- price 0.576 -0.031 -0.012
- x -0.017 0.142 -0.035 -0.126
- y 0.002 0.041 0.017 -0.005 -0.593
- z -0.001 -0.224 0.022 -0.004 -0.308 -0.073

- SO question: how to use `update()` for random part in `lmer()`?

Function `fstruction` updates the formula of singular models according to a similar proceeding to which is explained in that SO question.

### 0.1 Session info

```r
> sessionInfo()

R version 4.2.1 (2022-06-23)
Platform: x86_64-pc-linux-gnu (64-bit)
Running under: Debian GNU/Linux 11 (bullseye)

Matrix products: default
BLAS: /usr/lib/x86_64-linux-gnu/openblas-pthread/libblas.so.3
LAPACK: /usr/lib/x86_64-linux-gnu/openblas-pthread/libopenblas-r0.3.13.so

locale:

[1] LC_CTYPE=en_GB.UTF-8 LC_NUMERIC=C
[3] LC_TIME=en_GB.UTF-8 LC_COLLATE=C
[5] LC_MONETARY=en_GB.UTF-8 LC_MESSAGES=en_GB.UTF-8
[7] LC_PAPER=en_GB.UTF-8 LC_NAME=C
[9] LC_ADDRESS=C LC_TELEPHONE=C

attached base packages:
[1] stats graphics grDevices utils datasets methods base

other attached packages:
```
loaded via a namespace (and not attached):
[1] Rcpp_1.0.9 magrittr_2.0.3 splines_4.2.1 MASS_7.3-57
[5] tidyselect_1.1.2 munsell_0.5.0 colorspace_2.0-3 lattice_0.20-45
[9] R6_2.5.1 rlang_1.0.4 minqa_1.2.4 fansi_1.0.3
[13] dplyr_1.0.9 tools_4.2.1 grid_4.2.1 gtable_0.3.0
[17] nlme_3.1-158 utf8_1.2.2 DBI_1.1.3 cli_3.3.0
[21] assertthat_0.2.1 tibble_3.1.8 lifecycle_1.0.1 purrr_0.3.4
[25] nloptr_2.0.3 ggplot2_3.3.6 vctrs_0.4.1 glue_1.6.2
[29] compiler_4.2.1 pillar_1.8.0 generics_0.1.3 scales_1.2.0
[33] boot_1.3-28 pkgconfig_2.0.3