

# Understanding nlsModel in the base R nls() function

Arkajyoti Bhattacharjee, Indian Institute of Technology, Kanpur  
John C. Nash, University of Ottawa, Canada

05/06/2021

## Objective

The R function `nls()` for nonlinear least squares modeling uses a structure where a “model” object named `m` is built from an expression in the `nls` call. This object contains a great deal of functionality in the form of data and functions that different parts of the `nls` infrastructure can use. In particular, `m` contains functions to determine if the estimation of the model is “converged” (actually if the process is “terminated”) as well as computations of residuals and the search direction for the next set of parameters.

This article is an attempt to document and test the features of the `nlsModel` object `m`.

## Location of the nlsModel code

The code is found in the file `./R-devel/src/library/stats/R/nls.R`

Note that there is a version `nlsModel.plinear` for use with partially linear models (?? a ref would be helpful here). The default case and the use of bounds constraints using the `algorithm` setting “port” are handled by `nlsModel`.

Here we will at time of writing (June 2021) only deal with the default case.

## Generating an ‘m’ object

Let us use the Croucher problem and/or the Hobbs weed infestation problem (Nash (1979), page 120) again.

```
# Croucher-example1.R -- https://walkingrandomly.com/?p=5254
# construct the data vectors using c()
xdata = c(-2,-1.64,-1.33,-0.7,0,0.45,1.2,1.64,2.32,2.9)
ydata = c(0.699369,0.700462,0.695354,1.03905,1.97389,2.41143,1.91091,0.919576,-0.730975,-1.42001)

# some starting values
p1 = 1
p2 = 0.2

Cdata<-data.frame(xdata, ydata)

# do the fit
## Try numericDeriv() function
Cform <- ydata ~ p1*cos(p2*xdata) + p2*sin(p1*xdata)
Ctheta<-c("p1","p2")
Cstart<-c(p1=p1, p2=p2)
```

```
nmodc1<-nlspkg::nlsModel(form=Cform, data=Cdata, start=Cstart, wts=NULL, upper=NULL, scaleOffset = 0, n
```

```
## Registered S3 methods overwritten by 'nlspkg':
```

```
##   method      from
##   anova.nls    stats
##   coef.nls     stats
##   confint.nls  stats
##   deviance.nls stats
##   df.residual.nls stats
##   fitted.nls   stats
##   formula.nls  stats
##   logLik.nls   stats
##   nobs.nls     stats
##   plot.profile.nls stats
##   predict.nls  stats
##   print.nls    stats
##   print.summary.nls stats
##   profile.nls  stats
##   residuals.nls stats
##   summary.nls  stats
##   vcov.nls     stats
##   weights.nls  stats
```

```
print(str(nmodc1))
```

```
## List of 16
```

```
## $ resid      :function ()
## $ fitted     :function ()
## $ formula    :function ()
## $ deviance   :function ()
## $ lhs        :function ()
## $ gradient   :function ()
## $ conv       :function ()
## $ incr       :function ()
## $ setVarying:function (vary = rep_len(TRUE, np))
## $ setPars    :function (newPars)
## $ getPars    :function ()
## $ getAllPars:function ()
## $ getEnv     :function ()
## $ trace      :function ()
## $ Rmat       :function ()
## $ predict    :function (newdata = list(), qr = FALSE)
## - attr(*, "class")= chr "nlsModel"
## NULL
```

```
# Data for Hobbs problem
```

```
ydat <- c(5.308, 7.24, 9.638, 12.866, 17.069, 23.192, 31.443,
          38.558, 50.156, 62.948, 75.995, 91.972) # for testing
tdat <- seq_along(ydat) # for testing
```

```
# A simple starting vector -- must have named parameters for nlxb, nls, wrapnlr.
```

```
start1 <- c(b1=1, b2=1, b3=1)
eunsc <- y ~ b1/(1+b2*exp(-b3*tt))
str(eunsc)
```

```

## Class 'formula' language y ~ b1/(1 + b2 * exp(-b3 * tt))
##   ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
# Can we convert a string form of this "model" to a formula
ceunsc <- " y ~ b1/(1+b2*exp(-b3*tt))"
str(ceunsc)

## chr " y ~ b1/(1+b2*exp(-b3*tt))"
weeddata1 <- data.frame(y=ydat, tt=tdat)

## Now ready to try things out.
library(nlsalt) # ?? needed because base R does not export nlsModel()

## Registered S3 methods overwritten by 'nlsalt':
##   method          from
##   anova.nls        nlspkg
##   coef.nls         nlspkg
##   confint.nls      nlspkg
##   deviance.nls     nlspkg
##   df.residual.nls  nlspkg
##   fitted.nls       nlspkg
##   formula.nls      nlspkg
##   logLik.nls       nlspkg
##   nobs.nls         nlspkg
##   plot.profile.nls nlspkg
##   predict.nls      nlspkg
##   print.nls        nlspkg
##   print.summary.nls nlspkg
##   profile.nls      nlspkg
##   residuals.nls    nlspkg
##   summary.nls      nlspkg
##   vcov.nls         nlspkg
##   weights.nls      nlspkg

##
## Attaching package: 'nlsalt'

## The following objects are masked from 'package:stats':
##
##   asOneSidedFormula, getInitial, nlminb, nls, nls.control,
##   NLSstAsymptotic, NLSstClosestX, NLSstLfAsymptote, NLSstRtAsymptote,
##   numericDeriv, selfStart, setNames, sortedXyData
nmodh1<-nlsModel(form=eunsc, data=weeddata1, start=start1, wts=NULL, upper=NULL, scaleOffset = 0, nDcen

## par:1 1 1
## [1] 0.7310586 0.8807971 0.9525741 0.9820138 0.9933071 0.9975274 0.9990889
## [8] 0.9996646 0.9998766 0.9999546 0.9999833 0.9999939
## attr(,"gradient")
##           [,1]           [,2]           [,3]
## [1,] 0.7310586 -1.966119e-01 1.966119e-01
## [2,] 0.8807971 -1.049936e-01 2.099872e-01
## [3,] 0.9525741 -4.517667e-02 1.355300e-01
## [4,] 0.9820138 -1.766271e-02 7.065082e-02
## [5,] 0.9933072 -6.648056e-03 3.324027e-02
## [6,] 0.9975274 -2.466522e-03 1.479905e-02

```

```
## [7,] 0.9990890 -9.102300e-04 6.371543e-03
## [8,] 0.9996646 -3.352463e-04 2.681896e-03
## [9,] 0.9998766 -1.233816e-04 1.110412e-03
## [10,] 0.9999546 -4.540384e-05 4.539490e-04
## [11,] 0.9999833 -1.670420e-05 1.837090e-04
## [12,] 0.9999939 -6.139278e-06 7.373095e-05
```

```
str(nmodh1)
```

```
## List of 16
## $ resid      :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 127 15 127 30 22 37 1668 1668
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ fitted      :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 128 16 128 29 23 36 1669 1669
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ formula     :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 129 17 129 31 24 38 1670 1670
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ deviance    :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 130 18 130 31 25 38 1671 1671
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ lhs         :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 131 13 131 26 20 33 1672 1672
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ gradient     :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 132 18 132 57 25 64 1673 1673
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ conv         :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 133 14 133 34 21 41 1674 1674
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ incr         :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 134 14 134 42 21 49 1675 1675
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ setVarying:function (vary = rep_len(TRUE, np))
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 135 20 158 7 27 14 1676 1699
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ setPars      :function (newPars)
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 159 17 166 7 24 14 1700 1707
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ getPars      :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 167 17 167 36 24 43 1708 1708
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ getAllPars:function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 168 20 168 39 27 46 1709 1709
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ getEnv       :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 169 16 169 29 23 36 1710 1710
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ trace        :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 170 15 176 7 22 14 1711 1717
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## $ Rmat         :function ()
##   ..- attr(*, "srcref")= 'srcref' int [1:8] 177 14 177 32 21 39 1718 1718
##   ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
```

```
## $ predict :function (newdata = list(), qr = FALSE)
## ..- attr(*, "srcref")= 'srcref' int [1:8] 178 17 179 56 24 56 1719 1720
## ..- attr(*, "srcfile")=Classes 'srcfilealias', 'srcfile' <environment: 0x55a54e976d00>
## - attr(*, "class")= chr "nlsModel"
```

```
ls.str(nmodh1)
```

```
## conv : function ()
## deviance : function ()
## fitted : function ()
## formula : function ()
## getAllPars : function ()
## getEnv : function ()
## getPars : function ()
## gradient : function ()
## incr : function ()
## lhs : function ()
## predict : function (newdata = list(), qr = FALSE)
## resid : function ()
## Rmat : function ()
## setPars : function (newPars)
## setVarying : function (vary = rep_len(TRUE, np))
## trace : function ()
```

```
print(nmodh1)
```

```
## $resid
## function() resid
## <bytecode: 0x55a54ea17088>
## <environment: 0x55a54ea4b040>
##
## $fitted
## function() rhs
## <bytecode: 0x55a54ea195c8>
## <environment: 0x55a54ea4b040>
##
## $formula
## function() form
## <bytecode: 0x55a54ea1acd0>
## <environment: 0x55a54ea4b040>
##
## $deviance
## function() dev
## <bytecode: 0x55a54ea1d9b8>
## <environment: 0x55a54ea4b040>
##
## $lhs
## function() lhs
## <bytecode: 0x55a54ea1c950>
## <environment: 0x55a54ea4b040>
##
## $gradient
## function() .swts * attr(rhs, "gradient")
## <bytecode: 0x55a54ea216a8>
## <environment: 0x55a54ea4b040>
```

```

##
## $conv
## function() convCrit()
## <bytecode: 0x55a54ea20b10>
## <environment: 0x55a54ea4b040>
##
## $incr
## function() qr.coef(QR, resid)
## <bytecode: 0x55a54ea20090>
## <environment: 0x55a54ea4b040>
##
## $setVarying
## function(vary = rep_len(TRUE, np)) {
##     np <- length(useParams)
##     useParams <-< useP <-
##         if(is.character(vary)) {
##             temp <- logical(np)
##             temp[unlist(ind[vary])] <- TRUE
##             temp
##         } else if(is.logical(vary) && length(vary) != np)
##             stop("setVarying : 'vary' length must match length of parameters")
##         else
##             vary # envir = thisEnv
##     gradCall[[length(gradCall) - 1L]] <-< useP
##     if(all(useP)) {
##         setPars <-< setPars.noVarying
##         getPars <-< getPars.noVarying
##         getRHS <-< getRHS.noVarying
##         npar <-< length(useP)
##     } else {
##         setPars <-< setPars.varying
##         getPars <-< getPars.varying
##         getRHS <-< getRHS.varying
##         npar <-< sum(useP)
##     }
## }
##
## <bytecode: 0x55a54ea24720>
## <environment: 0x55a54ea4b040>
##
## $setPars
## function(newPars) {
##     setPars(newPars)
##     resid <-< .swts * (lhs - (rhs <-< getRHS())) # envir = thisEnv {2 x}
##     dev <-< sum(resid^2) # envir = thisEnv
##     if(length(gr <-< attr(rhs, "gradient")) == 1L) gr <-< c(gr)
##     QR <-< qr(.swts * gr) # envir = thisEnv
##     (QR$rank < min(dim(QR$qr))) # to catch the singular gradient matrix
## }
##
## <bytecode: 0x55a54ea33df0>
## <environment: 0x55a54ea4b040>
##
## $getPars
## function() getPars()
## <bytecode: 0x55a54ea3d318>

```

```
## <environment: 0x55a54ea4b040>
##
## $getAllPars
## function() getPars()
## <bytecode: 0x55a54ea40690>
## <environment: 0x55a54ea4b040>
##
## $getEnv
## function() env
## <bytecode: 0x55a54ea3fc10>
## <environment: 0x55a54ea4b040>
##
## $trace
## function() {
##     d <- getOption("digits")
##     cat(sprintf("%-*s (%.2e): par = (%s)\n", d+4L+2L*(scaleOffset > 0),
##               formatC(dev, digits=d, flag="#"),
##               convCrit(),
##               paste(vapply(getPars(), format, ""), collapse=" ")))
## }
## <bytecode: 0x55a54ea429d8>
## <environment: 0x55a54ea4b040>
##
## $Rmat
## function() qr.R(QR)
## <bytecode: 0x55a54ea47890>
## <environment: 0x55a54ea4b040>
##
## $predict
## function(newdata = list(), qr = FALSE)
##     eval(form[[3L]], as.list(newdata), env)
## <bytecode: 0x55a54ea4a578>
## <environment: 0x55a54ea4b040>
##
## attr("class")
## [1] "nlsModel"
```

## Examining the nlsModel output

The output of `nlsModel` is an object of class attribute “nlsModel” with 16 elements. (??Is this always the case, or can the call cause elements to be added or not produced?)

### `resid()`

This function computes the residuals in the current environment. (?? Is this `.GlobalEnv`? Can that environment be changed i.e., is it an argument to `resid()`?)

```
cat("Display Croucher residuals from nmodc1 as currently set:\n")
```

```
## Display Croucher residuals from nmodc1 as currently set:
```

```
print(nmodc1$resid())
```

```
## [1] -0.03983251 -0.04670526 -0.07524643 0.17767754 0.97389000 1.32848416
## [7] 0.75316421 -0.22663381 -1.77169083 -2.30432252
```

```
cat("Display Hobbs residuals from nmodc1 as currently set:\n")
```

```
## Display Hobbs residuals from nmodc1 as currently set:
```

```
print(nmodh1$resid())
```

```
## [1] 4.576941 6.359203 8.685426 11.883986 16.075693 22.194473 30.443911  
## [8] 37.558335 49.156123 61.948045 74.995017 90.972006
```

## fitted()

This function computes the fitted values of the nonlinear model in the current environment. The output includes an attribute, "gradient," which is actually the Jacobian matrix of which the k, j element is the

```
cat("Display Croucher fitted model values from nmodc1 as currently set:\n")
```

```
## Display Croucher fitted model values from nmodc1 as currently set:
```

```
print(nmodc1$fitted())
```

```
## [1] 0.7392015 0.7471673 0.7706004 0.8613725 1.0000000 1.0829458 1.1577458  
## [8] 1.1462098 1.0407158 0.8843125  
## attr("gradient")  
##      [,1]      [,2]  
## [1,] 1.0875197 -1.6881341  
## [2,] 0.9693692 -1.5259328  
## [3,] 0.9013955 -1.3207711  
## [4,] 0.8831381 -0.7418979  
## [5,] 1.0000000 0.0000000  
## [6,] 1.0769930 0.3945202  
## [7,] 1.0583038 0.6467959  
## [8,] 0.9240078 0.4692800  
## [9,] 0.5782596 -0.3060353  
## [10,] 0.2733069 -1.3500201
```

```
cat("Display Hobbs fitted model values from nmodc1 as currently set:\n")
```

```
## Display Hobbs fitted model values from nmodc1 as currently set:
```

```
print(nmodh1$fitted())
```

```
## [1] 0.7310586 0.8807971 0.9525741 0.9820138 0.9933071 0.9975274 0.9990889  
## [8] 0.9996646 0.9998766 0.9999546 0.9999833 0.9999939  
## attr("gradient")  
##      [,1]      [,2]      [,3]  
## [1,] 0.7310586 -1.966119e-01 1.966119e-01  
## [2,] 0.8807971 -1.049936e-01 2.099872e-01  
## [3,] 0.9525741 -4.517667e-02 1.355300e-01  
## [4,] 0.9820138 -1.766271e-02 7.065082e-02  
## [5,] 0.9933072 -6.648056e-03 3.324027e-02  
## [6,] 0.9975274 -2.466522e-03 1.479905e-02  
## [7,] 0.9990890 -9.102300e-04 6.371543e-03  
## [8,] 0.9996646 -3.352463e-04 2.681896e-03  
## [9,] 0.9998766 -1.233816e-04 1.110412e-03  
## [10,] 0.9999546 -4.540384e-05 4.539490e-04  
## [11,] 0.9999833 -1.670420e-05 1.837090e-04  
## [12,] 0.9999939 -6.139278e-06 7.373095e-05
```



## formula()

```
cat("Display Croucher formula from nmodc1 as currently set:\n")

## Display Croucher formula from nmodc1 as currently set:
print(nmodc1$formula())

## ydata ~ p1 * cos(p2 * xdata) + p2 * sin(p1 * xdata)
cat("Display Hobbs formula from nmodc1 as currently set:\n")

## Display Hobbs formula from nmodc1 as currently set:
print(nmodh1$formula())

## y ~ b1/(1 + b2 * exp(-b3 * tt))
```

## deviance()

```
cat("Display Croucher deviance from nmodc1 as currently set:\n")

## Display Croucher deviance from nmodc1 as currently set:
print(nmodc1$deviance())

## [1] 11.82174
cat("Display Hobbs deviance from nmodc1 as currently set:\n")

## Display Hobbs deviance from nmodc1 as currently set:
print(nmodh1$deviance())

## [1] 23520.58
```

## lhs()

```
cat("Display Croucher lhs from nmodc1 as currently set:\n")

## Display Croucher lhs from nmodc1 as currently set:
print(nmodc1$lhs())

## [1] 0.699369 0.700462 0.695354 1.039050 1.973890 2.411430 1.910910
## [8] 0.919576 -0.730975 -1.420010
cat("Display Hobbs lhs from nmodc1 as currently set:\n")

## Display Hobbs lhs from nmodc1 as currently set:
print(nmodh1$lhs())

## [1] 5.308 7.240 9.638 12.866 17.069 23.192 31.443 38.558 50.156 62.948
## [11] 75.995 91.972
```

## gradient()

```
cat("Display Croucher gradient from nmodc1 as currently set:\n")
```

```
## Display Croucher gradient from nmodc1 as currently set:
```

```
print(nmodc1$gradient())
```

```
##           [,1]      [,2]
## [1,] 1.0875197 -1.6881341
## [2,] 0.9693692 -1.5259328
## [3,] 0.9013955 -1.3207711
## [4,] 0.8831381 -0.7418979
## [5,] 1.0000000  0.0000000
## [6,] 1.0769930  0.3945202
## [7,] 1.0583038  0.6467959
## [8,] 0.9240078  0.4692800
## [9,] 0.5782596 -0.3060353
## [10,] 0.2733069 -1.3500201
```

```
cat("Display Hobbs gradient from nmodc1 as currently set:\n")
```

```
## Display Hobbs gradient from nmodc1 as currently set:
```

```
print(nmodh1$gradient())
```

```
##           [,1]      [,2]      [,3]
## [1,] 0.7310586 -1.966119e-01 1.966119e-01
## [2,] 0.8807971 -1.049936e-01 2.099872e-01
## [3,] 0.9525741 -4.517667e-02 1.355300e-01
## [4,] 0.9820138 -1.766271e-02 7.065082e-02
## [5,] 0.9933072 -6.648056e-03 3.324027e-02
## [6,] 0.9975274 -2.466522e-03 1.479905e-02
## [7,] 0.9990890 -9.102300e-04 6.371543e-03
## [8,] 0.9996646 -3.352463e-04 2.681896e-03
## [9,] 0.9998766 -1.233816e-04 1.110412e-03
## [10,] 0.9999546 -4.540384e-05 4.539490e-04
## [11,] 0.9999833 -1.670420e-05 1.837090e-04
## [12,] 0.9999939 -6.139278e-06 7.373095e-05
```

**conv()**

```
cat("Display Croucher conv from nmodc1 as currently set:\n")
```

```
## Display Croucher conv from nmodc1 as currently set:
```

```
print(nmodc1$conv())
```

```
## [1] 0.680674
```

```
cat("Display Hobbs conv from nmodc1 as currently set:\n")
```

```
## Display Hobbs conv from nmodc1 as currently set:
```

```
print(nmodh1$conv())
```

```
## [1] 2.076871
```

**incr()**

```
cat("Display Croucher incr from nmodc1 as currently set:\n")
```

```

## Display Croucher incr from nmodc1 as currently set:
print(nmodc1$incr())

## [1] 0.4951056 0.6604326
cat("Display Hobbs incr from nmodc1 as currently set:\n")

## Display Hobbs incr from nmodc1 as currently set:
print(nmodh1$incr())

## [1] 49.97713 -248.39739 -379.03452

setVarying(vary = rep_len(TRUE, np))

{r tsetVarying(vary = rep_len(TRUE, np)) cat("Display Croucher setVarying from nmodc1
as currently set:\n") print(nmodc1$setVarying()) cat("Display Hobbs setVarying from
nmodc1 as currently set:\n") print(nmodh1$setVarying())

setPars(newPars)

{r tsetPars(newPars) cat("Display Croucher setPars(newPars) from nmodc1 as currently
set:\n") print(nmodc1$setPars(newPars)()) cat("Display Hobbs setPars(newPars) from nmodc1
as currently set:\n") print(nmodh1$setPars(newPars)())

getPars()

cat("Display Croucher getPars from nmodc1 as currently set:\n")

## Display Croucher getPars from nmodc1 as currently set:
print(nmodc1$fitted())

## [1] 0.7392015 0.7471673 0.7706004 0.8613725 1.0000000 1.0829458 1.1577458
## [8] 1.1462098 1.0407158 0.8843125
## attr(,"gradient")
## [,1] [,2]
## [1,] 1.0875197 -1.6881341
## [2,] 0.9693692 -1.5259328
## [3,] 0.9013955 -1.3207711
## [4,] 0.8831381 -0.7418979
## [5,] 1.0000000 0.0000000
## [6,] 1.0769930 0.3945202
## [7,] 1.0583038 0.6467959
## [8,] 0.9240078 0.4692800
## [9,] 0.5782596 -0.3060353
## [10,] 0.2733069 -1.3500201

cat("Display Hobbs getPars from nmodc1 as currently set:\n")

## Display Hobbs getPars from nmodc1 as currently set:
print(nmodh1$getPars())

## b1 b2 b3
## 1 1 1

```

## getAllPars()

```
cat("Display Croucher getAllPars from nmodc1 as currently set:\n")
```

```
## Display Croucher getAllPars from nmodc1 as currently set:
```

```
print(nmodc1$getAllPars())
```

```
## p1 p2
```

```
## 1.0 0.2
```

```
cat("Display Hobbs getAllPars from nmodc1 as currently set:\n")
```

```
## Display Hobbs getAllPars from nmodc1 as currently set:
```

```
print(nmodh1$getAllPars())
```

```
## b1 b2 b3
```

```
## 1 1 1
```

## getEnv()

```
cat("Display Croucher fitted model values from nmodc1 as currently set:\n")
```

```
## Display Croucher fitted model values from nmodc1 as currently set:
```

```
print(nmodc1$getEnv())
```

```
## <environment: 0x55a54cc1a3a0>
```

```
cat("Display Hobbs fitted model values from nmodc1 as currently set:\n")
```

```
## Display Hobbs fitted model values from nmodc1 as currently set:
```

```
print(nmodh1$getEnv())
```

```
## <environment: 0x55a54ea4ac88>
```

## trace()

```
cat("Display Croucher trace from nmodc1 as currently set:\n")
```

```
## Display Croucher trace from nmodc1 as currently set:
```

```
print(nmodc1$trace())
```

```
## 11.82174 (6.81e-01): par = (1 0.2)
```

```
## NULL
```

```
cat("Display Hobbs trace from nmodc1 as currently set:\n")
```

```
## Display Hobbs trace from nmodc1 as currently set:
```

```
print(nmodh1$trace())
```

```
## 23520.58 (2.08e+00): par = (1 1 1)
```

```
## NULL
```

## Rmat()

```
cat("Display Croucher Rmat from nmodc1 as currently set:\n")
```

```
## Display Croucher Rmat from nmodc1 as currently set:
```

```
print(nmodc1$Rmat())
```

```
##           [,1]      [,2]
## [1,] -2.873607  1.448954
## [2,]  0.000000  2.843251
```

```
cat("Display Hobbs Rmat from nmodc1 as currently set:\n")
```

```
## Display Hobbs Rmat from nmodc1 as currently set:
```

```
print(nmodh1$Rmat())
```

```
##           [,1]      [,2]      [,3]
## [1,] -3.340785  0.09192216 -0.1753546
## [2,]  0.000000  0.20888840 -0.2499881
## [3,]  0.000000  0.00000000 -0.1193344
```

## predict(newdata = list(), qr = FALSE)

```
{r tpredict(newdata = list(), qr = FALSE) cat("Display Croucher predict from nmodc1
as currently set:\n") print(nmodc1$predict()) cat("Display Hobbs predict from nmodc1 as
currently set:\n") print(nmodh1$predict())
```

Nash, John C. 1979. *Compact Numerical Methods for Computers : Linear Algebra and Function Minimisation*. Book. Hilger: Bristol.