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################# NON LINEAR REGRESSION ######################

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Mich<-read.table("http://user.mendelu.cz/drapela/Forest\_Biometry/Data/th.txt",sep='\t',quote='',header=TRUE)

library(nlstools)

library(nls2)

# DEFINITION OF THE FUNCTION

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model<-Mich$h~a\*exp(k/Mich$t)

# ESTIMATION OF INITIAL VALUES OF PARAMETERS

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#by command "preview"

preview(formula = h~a\*exp(k/t), data=Mich, start=list(a = 50, k = 1))

#by grid

grid.Mich<-expand.grid(list(a=seq(30,60,by=2),k=seq(-40,-10,by=2)))

est<-nls2(model, data=Mich,start=grid.Mich,algorithm="brute-force")

est

plot(Mich$t,Mich$h,xlim=c(0,140),ylim=c(0,40), xlab="age",ylab="height [m]")

curve(46\*exp(-36/x),add=TRUE,col="red")

# NON-LINEAR REGRESSION

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# with starting values based on grid - searching

mm<-nls(model,data=Mich,start=list(a=46,k=-36))

summary(mm)

overview(mm)

mm1<-nls(model,data=Mich,start=list(a=45,k=1))

summary(mm1)

overview(mm1)

plot(Mich$t,Mich$h,xlim=c(0,140),ylim=c(0,40), xlab="age",ylab="height [m]")

curve(46\*exp(-36/x),add=TRUE,col="red")

curve(coef(mm)[1]\*exp(coef(mm)[2]/x),add=TRUE,col="green")

# BASIC RESULTS OF NONLINEAR REGRESSION

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#confidence intervals of parameters (library MASS)

confint(mm)

#fitted values

fitted(mm)

#residuals

residuals(mm)

#residual plot (library nlme)

library(nlme)

plot(mm)

#predicted values

predict(mm)

#comparison of measured and modeled values

resMich<-cbind("measured"=Mich$h,"modeled"=predict(mm))

resMich<-data.frame(resMich)

resMich

#plot of measured and modeled values, regression curve and residuals

par(mfrow=c(1,1))

plot(Mich$t,Mich$h,xlim=c(0,140),ylim=c(0,40),pch=20, xlab="age",ylab="height [m]")

curve(coef(mm)[1]\*exp(coef(mm)[2]/x),add=TRUE,col="green")

points(Mich$t,resMich$modeled, col="red",pch=20)

mat<-cbind(Mich$t, Mich$h, Mich$t, resMich$modeled)

apply(mat,1,function(x) segments(x[1], x[2], x[3], x[4], lty=2, col='dodgerblue'))

#index of correlation

RSS<-sum((Mich$h-predict(mm))^2)

dev<-sum((Mich$h-mean(Mich$h))^2)

I=sqrt(1-(RSS/dev))

I2=I\*I

I

I2

# MODEL DIAGNOSTICS

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# residual plots

res<-nlsResiduals(mm)

plot(res)

#alternative way how to draw the residual plot

plot(fitted(mm), residuals(mm))

abline(h=0)

#alternative way how to draw the standardised residual plot

plot(fitted(mm), residuals(mm)/summary(mm)$sigma)

abline(h=0)

# alternative way how to draw the autocorrelation plot

plot(residuals(mm)[2:length(residuals(mm))], residuals(mm)[1:(length(residuals(mm))-1)],xlab=expression(hat(epsilon)[i]),ylab=expression(hat(epsilon)[i+1]))

abline(h=0, col="blue")

# alternative way how to draw QQ plot of residuals

library(car)

qqPlot(residuals(mm))

# test of normality of residuals

test.nlsResiduals(res)

# AIC

# AIC of nonlinear model

AIC(mm)

# comparison of AIC for nonlinear model and polynomial model (parabola)

#polynomial model and its AIC

tt<-Mich$t

hh<-Mich$h

pp<-lm(hh~tt+I(tt^2))

summary(pp)

AIC(pp)

AIC(mm)

# plot of polynomial model and nonlinear model

plot(Mich$t,Mich$h)

lines(Mich$t,coef(pp)[1]+coef(pp)[2]\*tt+coef(pp)[3]\*I(tt^2))

curve(coef(mm)[1]\*exp(coef(mm)[2]/x),add=TRUE,col="green")

legend("bottomright",c("polynomial","Michajlov"),lty=c(1,1),col=c(1,3))

# plot of polynomial model and nonlinear model for age 0 - 200 years

xx<-seq(0,200,1)

plot(Mich$t,Mich$h,xlim=c(0,210),ylim=c(0,50), xlab=("age"),ylab=("height (m)"))

lines(xx,coef(pp)[1]+coef(pp)[2]\*xx+coef(pp)[3]\*I(xx^2),col="blue")

curve(coef(mm)[1]\*exp(coef(mm)[2]/x),add=TRUE,col="green")

abline(h=coef(mm)[1],col="darkviolet",lty="dashed")

text(0,47.5,"Asymptote = 46.1 m",col="darkviolet",pos=4)

legend("bottomright",c("polynomial","Michajlov"),lty=c(1,1),col=c(4,3))