Package mactivate
Examples II

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1 Example: Medium Data, Numerical Inputs, Numerical Response

```
library(mactivate)
set.seed(777)
d <- 56
N <- 100000
X <- matrix(rnorm(N*d, 0, 1), N, d) ####
colnames(X) <- paste0("x", I(1:d))
#############  primary effects
b <- rep_len( c(-1/4, 1/4), d )
###########

ystar <-
  X %*% b +
  1/3 * (X[ , 11]+1) * (X[ , 12]-1) * (X[ , 33]+1) -
  1/2 * (X[ , 30]+0) * (X[ , 44]+1) * (X[ , 45]-0) * (X[ , 56]-1) +
  1/3 * (X[ , 6]+1) * (X[ , 47]-1) -
  1/2 * (X[ , 1]-1) * (X[ , 32]+0) * (X[ , 33]+1) * (X[ , 34]-0) *
  (X[ , 45]-0) * (X[ , 51]-1)
m_tot <- 12
#############




xs1 <-
```

```
  "y ~ . + x11:x12:x33 + x30:x44:x45:x56 + x6:x47 + x1:x32:x33:x34:x45:x51"
xs2 <-
  "y ~ . + x11*x12*x33 + x30*x44*x45*x56 + x6*x47 + x1*x32*x33*x34*x45*x51"
xnotQuiteTrue_formula <- eval(parse(text=xs1))
xtrue_formula <- eval(parse(text=xs2))
xnoint_formula <- eval(parse(text="y ~ ."))
yerrs <- rnorm(N, 0, 3)
y <- ystar + yerrs
## y <- (y - mean(y)) / sd(y)


########## standardize X
Xall <- t( ( t(X) - apply(X, 2, mean) ) / apply(X, 2, sd) )
yall <- y
Nall <- N
####### fold index
xxfoldNumber <- rep_len(1:2, N)
ufolds <- sort(unique(xxfoldNumber)) ; ufolds
############### predict
############### predict

dfx <- data.frame("y"=yall, Xall)
################### incorrectly fit LM: no interactions

xlm <- lm(xnoint_formula , data=dfx)
summary(xlm)
yhat <- predict(xlm, newdata=dfx)
sqrt( mean( (yall - yhat)^2 ) )
################### incorrectly fit LM: no lower-order interactions
xlm <- lm(xnotQuiteTrue_formula , data=dfx)
summary(xlm)
yhat <- predict(xlm, newdata=dfx)
sqrt( mean( (yall - yhat)^2 ) )
################### correctly fit LM
xlm <- lm(xtrue_formula, data=dfx)
summary(xlm)
yhat <- predict(xlm, newdata=dfx)
sqrt( mean( (yall - yhat)^2 ) )
################ fit using hybrid m-activation
```

```
###### takes about 1.5-3 hours

xcmact_hybrid <-
  f_control_mactivate(
  param_sensitivity = 10^12,
  bool_free_w = TRUE,
  w0_seed = 0.01,
  w_col_search = "alternate",
  max_internal_iter = 500, #####
  ss_stop = 10^(-14), ###
  escape_rate = 1.003,  #### 1.002,
  Wadj = 1/1,
  force_tries = 0,
  lambda = 0/10000, ### hybrid only
  tol = 10^(-14) ### hybrid only
  )
#### Fit


Uall <- Xall
xthis_fold <- ufolds[ 1 ]
xndx_test <- which( xxfoldNumber %in% xthis_fold )
xndx_train <- setdiff( 1:Nall, xndx_test )
X_train <- Xall[ xndx_train, , drop=FALSE ]
y_train <- yall[ xndx_train ]
xxnow <- Sys.time()
xxls_out <-
  f_fit_hybrid_01(
  X = X_train,
  y = y_train,
  m_tot = m_tot,
  U = X_train,
  m_start = 1,
  mact_control = xcmact_hybrid,
  verbosity = 1
  )
cat( difftime(Sys.time(), xxnow, units="mins"), "\n" )
######### check test error
```

```
U_test <- Xall[ xndx_test, , drop=FALSE ]
X_test <- Xall[ xndx_test, , drop=FALSE ]
y_test <- yall[ xndx_test ]
yhatTT <- matrix(NA, length(xndx_test), m_tot+1)
for(iimm in 0:m_tot) {
      yhat_fold <- predict(object=xxls_out, X0=X_test, U0=U_test, mcols=iimm )
      yhatTT[ , iimm + 1 ] <- yhat_fold
  }
errs_by_m <- NULL
for(iimm in 1:ncol(yhatTT)) {
      yhatX <- yhatTT[ , iimm]
      errs_by_m[ iimm ] <- sqrt(mean( (y_test - yhatX)^2 ))
      cat(iimm, "::", errs_by_m[ iimm ])
  }
##### plot test RMSE vs m

plot(0:(length(errs_by_m)-1), errs_by_m, type="l", xlab="m", ylab="RMSE Cost")
#### 11 best




################## known 'true' for non zero-centered is
xtrue_formula_use <- xtrue_formula
xthis_fold <- ufolds[ 1 ]
xndx_test <- which( xxfoldNumber %in% xthis_fold )
xndx_train <- setdiff( 1:Nall, xndx_test )
xlm <- lm(xtrue_formula_use , data=dfx[ xndx_train, ])
yhat <- predict(xlm, newdata=dfx[ xndx_test, ])
sqrt( mean( (y_test - yhat)^2 ) )
###############




####### Let's dig in
####### We can use train W to construct test Xstar
####### Check which columns drive our response, y
```

```
X_test <- Xall[ xndx_test, ]
y_test <- yall[ xndx_test ]
Xstar_test <- f_mactivate(U=X_test, W=xxls_out[[ length(xxls_out) ]][[ "What" ]])
Xi <- cbind(X_test, Xstar_test)
xlm <- lm(y_test ~ Xi)
sumxlm <- summary(xlm)
```

print(sumxlm)

```
Call:
lm(formula = y_test ~ Xi)

Residuals:
     Min       1Q   Median       3Q      Max
-12.6721  -2.0218  -0.0189   2.0268  17.8341

Coefficients:
              Estimate Std. Error  t value Pr(>|t|)
(Intercept)  2.706e+00  3.882e+00    0.697 0.485760
Xix1        -2.529e-01  5.311e-02   -4.762 1.92e-06 ***
Xix2         2.928e-01  4.076e-02    7.183 6.93e-13 ***
Xix3        -2.394e-01  6.772e-02   -3.535 0.000409 ***
Xix4         2.901e-01  5.291e-02    5.482 4.22e-08 ***
Xix5        -1.933e-01  8.021e-02   -2.409 0.015983 *
Xix6        -5.480e-02  3.740e-02   -1.465 0.142835
Xix7        -2.412e-01  5.105e-02   -4.725 2.31e-06 ***
Xix8         2.832e-01  4.973e-02    5.694 1.25e-08 ***
Xix9        -2.380e-01  4.192e-02   -5.677 1.38e-08 ***
Xix10        2.814e-01  4.999e-02    5.629 1.82e-08 ***
Xix11       -3.069e-01  6.118e-02   -5.017 5.27e-07 ***
Xix12        3.381e-01  4.511e-02    7.495 6.74e-14 ***
Xix13       -2.237e-01  5.192e-02   -4.308 1.65e-05 ***
Xix14        2.723e-01  3.932e-02    6.924 4.46e-12 ***
Xix15       -2.244e-01  4.134e-02   -5.427 5.75e-08 ***
Xix16        2.955e-01  5.092e-02    5.803 6.54e-09 ***
Xix17       -2.419e-01  4.757e-02   -5.085 3.69e-07 ***
Xix18        2.535e-01  6.801e-02    3.728 0.000193 ***
Xix19       -2.004e-01  8.207e-02   -2.442 0.014614 *
Xix20        3.012e-01  4.416e-02    6.821 9.12e-12 ***
Xix21       -2.099e-01  5.010e-02   -4.190 2.79e-05 ***
Xix22        2.854e-01  6.367e-02    4.482 7.42e-06 ***
Xix23       -2.280e-01  5.350e-02   -4.261 2.04e-05 ***
Xix24        2.858e-01  4.097e-02    6.975 3.09e-12 ***
Xix25       -2.216e-01  4.775e-02   -4.642 3.46e-06 ***
Xix26        2.855e-01  4.316e-02    6.615 3.77e-11 ***
Xix27       -1.908e-01  7.456e-02   -2.560 0.010482 *
```

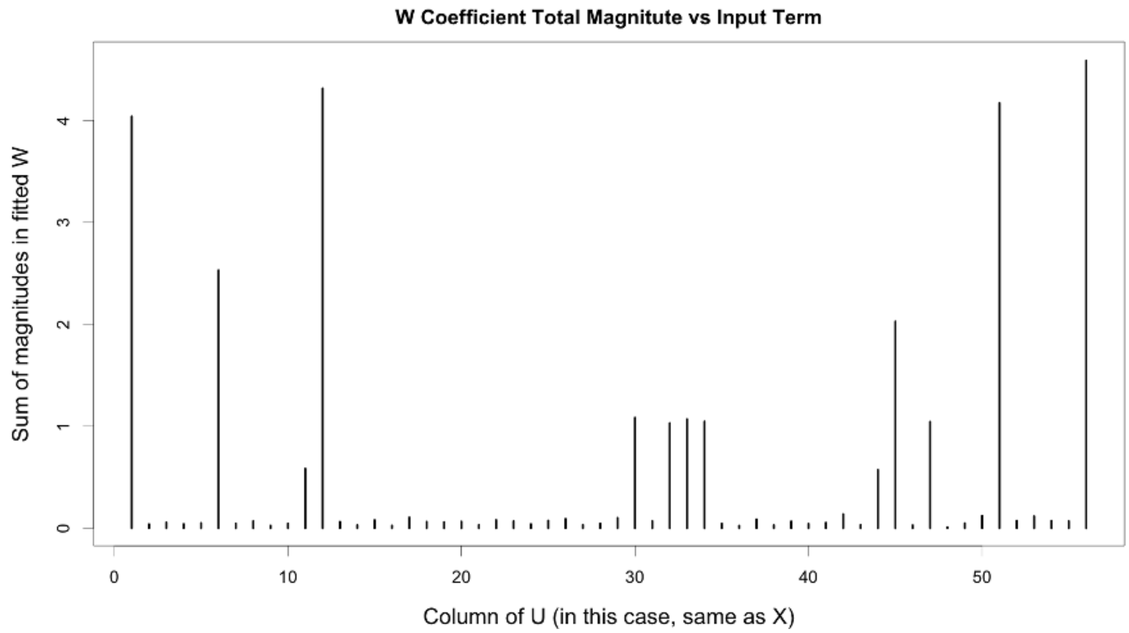
Xix28	3.146e-01	6.579e-02	4.781	1.75e-06	***
Xix29	-2.218e-01	4.379e-02	-5.065	4.09e-07	***
Xix30	2.936e-01	5.358e-02	5.480	4.26e-08	***
Xix31	-2.128e-01	4.253e-02	-5.003	5.65e-07	***
Xix32	2.775e-01	3.978e-02	6.977	3.06e-12	***
Xix33	-3.369e-01	3.928e-02	-8.576	< 2e-16	***
Xix34	2.802e-01	4.295e-02	6.524	6.91e-11	***
Xix35	-2.099e-01	6.172e-02	-3.401	0.000672	***
Xix36	2.902e-01	5.601e-02	5.180	2.22e-07	***
Xix37	-2.130e-01	6.445e-02	-3.305	0.000951	***
Xix38	3.002e-01	8.099e-02	3.707	0.000210	***
Xix39	-2.601e-01	5.574e-02	-4.666	3.08e-06	***
Xix40	2.896e-01	6.015e-02	4.815	1.48e-06	***
Xix41	-2.460e-01	4.160e-02	-5.913	3.38e-09	***
Xix42	3.086e-01	5.391e-02	5.725	1.04e-08	***
Xix43	-2.435e-01	4.662e-02	-5.222	1.77e-07	***
Xix44	2.848e-01	5.467e-02	5.209	1.91e-07	***
Xix45	-2.204e-01	5.974e-02	-3.689	0.000225	***
Xix46	2.473e-01	5.917e-02	4.179	2.93e-05	***
Xix47	5.280e-01	6.007e-02	8.791	< 2e-16	***
Xix48	2.576e-01	4.636e-02	5.557	2.76e-08	***
Xix49	-2.533e-01	6.713e-02	-3.774	0.000161	***
Xix50	2.834e-01	5.838e-02	4.855	1.21e-06	***
Xix51	-2.187e-01	4.951e-02	-4.417	1.00e-05	***
Xix52	2.511e-01	4.219e-02	5.952	2.67e-09	***
Xix53	-2.323e-01	4.953e-02	-4.691	2.73e-06	***
Xix54	2.729e-01	5.590e-02	4.881	1.06e-06	***
Xix55	-2.274e-01	3.979e-02	-5.714	1.11e-08	***
Xix56	2.814e-01	5.066e-02	5.554	2.81e-08	***
Xi	1.746e-01	2.384e-03	73.242	< 2e-16	***
Xi	2.684e-01	5.615e-03	47.809	< 2e-16	***
Xi	-1.977e-04	8.386e-04	-0.236	0.813601	
Xi	-1.414e-01	5.993e-03	-23.589	< 2e-16	***
Xi	2.328e-04	7.586e-03	0.031	0.975514	
Xi	-4.343e-02	4.186e-04	-103.753	< 2e-16	***
Xi	-2.076e-02	1.866e-02	-1.113	0.265808	
Xi	3.501e-03	8.045e-03	0.435	0.663476	
Xi	3.621e+04	3.032e+05	0.119	0.904920	
Xi	-8.776e+04	9.212e+05	-0.095	0.924103	

```
Xi           5.259e+04  8.601e+05    0.061 0.951251
Xi          -1.046e+03  2.450e+05   -0.004 0.996593
Xi          -4.014e-03  1.411e-02   -0.284 0.776060
Xi           1.569e-02  1.524e-02    1.030 0.302984
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.019 on 49929 degrees of freedom
Multiple R-squared:  0.4611,        Adjusted R-squared:  0.4603
F-statistic: 610.2 on 70 and 49929 DF,  p-value: < 2.2e-16
```

```
########### Looks like cols 1,2,4,6 are where all the action is
########### (in other word, mactivate didn't track signal on passes 3 and 5)

bWhat <- xxls_out[[ length(xxls_out) ]][[ "What" ]][ ,  c(1,2,4,6) ]
bWhat
wwmag <- apply(bWhat, 1, function(x) { return(sum(abs(x)))} ) ; wwmag
plot(wwmag, type="h", lwd=4,
  main="W Coefficient Total Magnitute vs Input Term",
  xlab="Column of U (in this case, same as X)",
  ylab="Sum of magnitudes in fitted W",
  cex.lab=1.3
  )
```




```
###########################

########## these are the terms in X that
########## appear to have a polynomial contribution
########## to our response, y

xxhigh <- which(wwmag > 0.5) ; xxhigh

######################
```

2 Example: Orthopedic Sales Data, Numerical Inputs, Numerical Response, 10-Fold CV

```
data(df_hospitals_ortho)
xvars <- attr(df_hospitals_ortho, "modelvars")
xmx <- as.matrix(df_hospitals_ortho[ , xvars])
old_par <- par(mfrow=c(3,4))
for(jj in 1:ncol(xmx)) {
      hist(xmx[ ,jj], main=colnames(xmx)[jj])
```

```
  }
######## pause and look

################ transform

xlog_list <-
  c(
  "tot_sales",
  "tot_knee",
  "tot_hip",
  "beds",
  "rehab_beds",
  "outpatient_visits",
  "adm_costs",
  "revenue_inpatient"
  )
ymx <- xmx
for(jj in 1:ncol(xmx)) {
      ymx[ ,jj] <- log( xmx[ ,jj] + 1 )
  }
for(jj in 1:ncol(ymx)) {
      hist(ymx[ ,jj], main=colnames(ymx)[jj])
  }
######## pause and look



#### standardize

ymx_stnd <- t( ( t( ymx ) - apply(ymx, 2, mean)) / apply(ymx, 2, sd) )
for(jj in 1:ncol(ymx_stnd)) {
      hist(ymx_stnd[ ,jj], main=colnames(ymx_stnd)[jj])
  }
######## pause and look



############ let's fit an MLR model (in place, no train-test)
ydf_stnd <- as.data.frame(ymx_stnd)
```

```
xlm <- lm( tot_sales ~ . , data=ydf_stnd )
summary(xlm)
yhat <- xlm$fitted
yy <- ydf_stnd[ , "tot_sales" ]
rmse <- sqrt( mean( (yy - yhat)^2 ) ) ; rmse
1 - rmse^2 / 1  #### r-squared
######## now let's break out m-activation using 10-fold CV


library(mactivate)
yall <- ymx_stnd[ , "tot_sales" ]
Xall <- ymx_stnd[ , -1 ]
Uall <- Xall
xfolds <- rep_len( 1:10, length(yall) ) ## 10-fold CV
m_tot <- 5
xmcont <-
  f_control_mactivate(
  param_sensitivity = 10^11,
  w0_seed = 0.1,
  max_internal_iter = 500,
  w_col_search = "one",
  bool_headStart = FALSE,
  ss_stop = 10^(-11),
  escape_rate = 1.001,
  step_size = 1/100,
  Wadj = 1/1,
  force_tries = 0,
  lambda = 0,
  tol = 10^(-8)
  )
ufolds <- sort(unique(xfolds))
yout <- numeric(length(yall))
#### takes about 5-10 minutes

for(iif in 1:length(ufolds)) {

      xmask_fold <- xfolds %in% ufolds[ iif ]

      xxls_out <-
```

```
        f_fit_hybrid_01(
        X=Xall[ !xmask_fold, ],
        y=yall[ !xmask_fold ],
        m_tot=m_tot,
        U = Xall[ !xmask_fold, ],
        m_start = 1,
        mact_control = xmcont,
        verbosity = 0
        )

        xxls_out

        yhatG <- predict(
            object=xxls_out,
            X0=Xall[ xmask_fold, ],
            U0=Uall[ xmask_fold, ],
            mcols=m_tot
            )

        yout[ xmask_fold ] <- yhatG

        cat("Done this fold:", iif, "\n\n")

  }
mact_rmse <- sqrt( mean( (yall  -  yout)^2 ) ) ; mact_rmse
cat("TT R2:", 1 - mact_rmse^2 / 1, "\n") #### m-activation R^2
par(old_par)
```

3 Example: Medium Data, Numerical Inputs, Dichotomous Response

```
library(mactivate)
set.seed(777)
d <- 25
N <- 100000
X <- matrix(rnorm(N*d, 0, 1), N, d) ####
colnames(X) <- paste0("x", I(1:d))
```

```
############# primary effects
b <- rep_len( c(-1/4, 1/4), d )
ystar <-
  X %*% b +
  1/3 * (X[ , 1]+1) * (X[ , 2]-1) * (X[ , 3]+1) -
  1/2 * (X[ , 3]+0) * (X[ , 4]+1) * (X[ , 5]-0) * (X[ , 6]-1) +
  1/3 * (X[ , 6]+1) * (X[ , 7]-1) -
  1/2 * (X[ , 1]-1) * (X[ , 2]+0) * (X[ , 3]+1) * (X[ , 4]-0) *
  (X[ , 5]-0) * (X[ , 7]-1)
m_tot <- 10
#############


xs1 <- "y ~ . + x1:x2:x3 + x3:x4:x5:x6 + x6:x7 + x1:x2:x3:x4:x5:x7"
xs2 <- "y ~ . + x1*x2*x3 + x3*x4*x5*x6 + x6*x7 + x1*x2*x3*x4*x5*x7"
xnotQuiteTrue_formula <- eval(parse(text=xs1))
xtrue_formula <- eval(parse(text=xs2))
xnoint_formula <- eval(parse(text="y ~ ."))
ysigmoid <- 1 / (1 + exp(-ystar))
range(ysigmoid)
y <- rbinom(size=1, n=N, prob=ysigmoid)
########## standardize X
Xall <- t( ( t(X) - apply(X, 2, mean) ) / apply(X, 2, sd) )
yall <- y
Nall <- N
####### fold index
xxfoldNumber <- rep_len(1:2, N)
ufolds <- sort(unique(xxfoldNumber)) ; ufolds
############### predict
############### predict

dfx <- data.frame("y"=yall, Xall)
###################

xglm <- glm(xnoint_formula , data=dfx, family=binomial(link="logit"))
summary(xglm)
yhat <- predict(xglm, newdata=dfx, type="response")
mean( f_logit_cost(y=yall, yhat=yhat) )
####### known true when zero centered
```

```
xglm <- glm(xnotQuiteTrue_formula , data=dfx, family=binomial(link="logit"))
summary(xglm)
yhat <- predict(xglm, newdata=dfx, type="response")
mean( f_logit_cost(y=yall, yhat=yhat) )
####### known true when not zero centered
xglm <- glm(xtrue_formula , data=dfx, family=binomial(link="logit"))
summary(xglm)
yhat <- predict(xglm, newdata=dfx, type="response")
mean( f_logit_cost(y=yall, yhat=yhat) )
################################ alternate
################################ alternate -- about 1.5 hours

xcmact_gradient <-
  f_control_mactivate(
  param_sensitivity = 10^9,
  bool_free_w = TRUE,
  w0_seed = 0.05,
  w_col_search = "alternate",
  bool_headStart = TRUE,
  ss_stop = 10^(-9), ###
  escape_rate = 1.003,
  Wadj = 1/1,
  force_tries = 0
  )
Uall <- Xall
xthis_fold <- ufolds[ 1 ]
xndx_test <- which( xxfoldNumber %in% xthis_fold )
xndx_train <- setdiff( 1:Nall, xndx_test )
X_train <- Xall[ xndx_train, , drop=FALSE ]
y_train <- yall[ xndx_train ]
xxnow <- Sys.time()
xxls_out <-
  f_fit_gradient_logistic_01(
  X = X_train,
  y = y_train,
  m_tot = m_tot,
  U = X_train,
  m_start = 1,
  mact_control = xcmact_gradient,
```

```
  verbosity = 1
  )
cat( difftime(Sys.time(), xxnow, units="mins"), "\n" )
U_test <- Xall[ xndx_test, , drop=FALSE ]
X_test <- Xall[ xndx_test, , drop=FALSE ]
y_test <- yall[ xndx_test ]
yhatTT <- matrix(NA, length(xndx_test), m_tot+1)
for(iimm in 0:m_tot) {
      yhat_fold <- predict(object=xxls_out, X0=X_test, U0=U_test, mcols=iimm )
      yhatTT[ , iimm + 1 ] <- yhat_fold[[ "p0hat" ]]
  }
errs_by_m <- NULL
for(iimm in 1:ncol(yhatTT)) {
      yhatX <- yhatTT[ , iimm]
      errs_by_m[ iimm ] <- mean( f_logit_cost(y=y_test, yhat=yhatX) )
      cat(iimm, "::", errs_by_m[ iimm ])
  }
##### plot test Logit vs m

plot(0:(length(errs_by_m)-1), errs_by_m, type="l", xlab="m", ylab="Logit Cost")
################## use known 'true' in glm()

xglm <- glm(xtrue_formula , data=dfx[ xndx_train, ], family=binomial(link="logit"))
yhat <- predict(xglm, newdata=dfx[ xndx_test, ], type="response")
mean( f_logit_cost(y=y_test, yhat=yhat) )
```