Package 'gexp'

April 14, 2019

Title Generator of Experiments

Version 0.1-4

Date 2019-04-13

Author Ivan Bezerra Allaman <ivanalaman@gmail.com> and
José Cláudio Faria <joseclaudio.faria@gmail.com>

Maintainer Ivan Bezerra Allaman <ivanalaman@gmail.com>

Depends R (>= 3.5.0), mvtnorm, tcltk, jpeg, png

Description Generates experiments - simulating structured or experimental data as:
completely randomized design, randomized block design, latin square design,
factorial and split-plot experiments (Ferreira, 2008, ISBN:8587692526;
Naes et al., 2007 <doi:10.1002/qre.841>; Rencher et al., 2007, ISBN:9780471754985;
Montgomery, 2001, ISBN:0471316490).

Suggests knitr, rmarkdown

VignetteBuilder knitr

License GPL (>= 2)

URL https://github.com/ivanalaman/gexp

Encoding latin1

NeedsCompilation no

Repository CRAN

Date/Publication 2019-04-14 11:32:39 UTC

R topics documented:

Generator of Experiments

gexp: Generator of Experiments

Description

The package gexp was created to make it possible to plan, create and to model structured experiments, that is, under a experimental design. In the modeling it is possible to simulate results of experiments with possibility of user to report effects and random error(s). The designs are: Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD) and Latin Squares Design (LSD). The types of experiments are: Factorial Experiment (FE) and Split-plot Experiment (SPE).

The experiments can be generated with one or more response variables, In the latter case, a strict covariance structure can be imposed. It is also possible to plan experiments using the graphic functions for use in planning from pictures or pictures of the experimental area.

The possible uses are multiple: in the planning it makes possible to distribution and randomization of treatments and experimental units; in the data analysis allows to generate experiments for application in evaluations individual and can also be used to generate experiments for validations of new computational resources in the area of structured data analysis.

In summary, the package provides computational resources useful in planning and modeling of structured experiments in the R.

Details

In some situations, we are interested in simulating a variable randomized according to the experimental procedure where the differences between treatments are predetermined. In a completely randomized design with two treatments for example, we may have an interest in simulating a variable random whose treatment A will have a 1-deviation effect and treatment B a effect of 3 deviations from a given overall average. In addition, may be interested in imposing a pre-established error structure for purposes evaluation in the various analysis strategies.

Author(s)

Ivan Bezerra Allaman <ivanalaman@gmail.com> and José Cláudio Faria <joseclaudio.faria@gmail.com>.

Maintainer: Ivan Bezerra Allaman <ivanalaman@gmail.com>

gexp *Generator of Experiments*

Description

The package provides computational resources useful in planning and modeling of structured experiments in the R environment.

The generic function S3 gexp was created to enable plan, create and model structured experiments, that is, under a design experimental. In the modeling it is possible to simulate results of experiments with possibility of user informing the effects and the random error(s). The designs are: Completely Randomized Design (CRD), Randomized complete block design (RCBD) and Latin Squares Design (LSD). The types of experiments are: Factorial Experimentation (FE) and Split-plot experiment (SPE).

The experiments can be generated with one or more variable response, in the latter case, it may be important for a structure covariance between them. It is also possible to plan experiments with of graphic parts for use in planning from figures or pictures of the experimental area.

Usage

```
gexp(mu, ...)

## Default S3 method:
gexp(
     mu        = 26,
     err       = NULL,
     errp      = NULL,
     r         = 5L,
     fl        = NULL,
     blkl      = NULL,
     rowl      = NULL,
     coll      = NULL,
     fe        = NULL,
     inte      = NULL,
     blke      = NULL,
     rowe      = NULL,
     cole     = NULL,
     contrasts = NULL,
     type      = c('CRD','RCBD','LSD','FE','SPE'),
     nrand     = 1L,
     round     = 2L,
     random    = FALSE,
     ...)

## S3 method for class 'crd'
gexp(
     mu,
     err,
     r,
     fl,
     fe,
     contrasts,
     round,
```

```
     random, ...)

## S3 method for class 'rcbd'
gexp(
     mu,
     err,
     r,
     fl,
     blkl,
     fe,
     blke,
     contrasts,
     round,
     random, ...)

## S3 method for class 'lsd'
gexp(
     mu,
     err,
     fl,
     rowl,
     coll,
     fe,
     rowe,
     cole,
     nrand,
     contrasts,
     round,
     random, ...)

## S3 method for class 'fe'
gexp(
     mu,
     err,
     r,
     fl,
     blkl,
     rowl,
     coll,
     fe,
     inte,
     blke,
     rowe,
     cole,
     nrand,
     contrasts,
     round,
     random, ...)
```

```
## S3 method for class 'spe'
gexp(
     mu,
     err,
     errp,
     r,
     fl,
     blkl,
     rowl,
     coll,
     fe,
     inte,
     blke,
     rowe,
     cole,
     contrasts,
     nrand,
     round,
     random, ...)
```

Arguments

mu	Is a numeric scalar, or a vector to Multivarite Data (MD), that represent the mean of each factor.
err	It is a vector, or matrix for MD, that represents the experimental error. The default value is NULL, that is, for each response variable a normal error is added with mean 0 and variance 1 generated by rmvnorm(sigma = diag(length(mu))).
errp	It is a vector, or a matrix for MD, of the error associated with the plots if type is equal to SPE (Split-Plot Experiments). The default value is NULL, that is, for each response variable a normal error is added with mean 0 and variance 1 generated by rmvnorm(sigma = diag(length(mu))).
r	It is a scalar of the number of repetitions of the experiment.
fl	List of a vector of characters, or a matrix (MD). It's a list of factor names.
blkl	List of a vector of characters, or an array for MD, of block names.
rowl	List a vector of characters, or an array for MD, of the line names in case type is equal to LSD (Latin Square Design).
coll	List of a vector of characters, or an array for MD, of the column names in case the type is equal to LSD (Latin Square Design).
fe	It is a numerical vector, or a matrix (MD). It's a list of the effect of a factor.
inte	It is a numerical vector, or a matrix for MD, of the effects of the interaction.
blke	It is a numerical vector, or a matrix for MD, of the effects of the blocks.
rowe	It is a numerical vector, or an array for MD, of the effects of the lines in case the type is equal to LSD (Latin Square Design).
cole	Is a numeric vector, or a matrix for MD, of the effects of the columns in case the type is equal to LSD (Latin Square Design).

contrasts	A list, whose entries are values (numeric matrices or character strings naming functions) to be used as replacement values for the contrasts function and whose names are the names of the columns. See "contrasts.arg" argument of the model.matrix function to more details.
type	It is a vector of strings that contains the type of design and type of experiment to be used: Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD), Latin Squares Design (LSD), Factorial Experiment (FE) and Split-plot Experiment (SPE). CRD is the default.
nrand	It is a numerical scalar used specifically in Latin Squares Design (LSD) to shuffle treatments in rows and columns.
round	This is a numeric scalar for rounding of the response variable.
random	It is a logical argument when the purpose is to plan experiments so that randomisation of treatments occurs in the experimental units. FALSE is the default.
...	Further arguments (required by generic).

Value

The method gexp returns the list of class gexp with the slots:

X	It is the incidence matrix of the design.
Z	It is the incidence matrix of the error of the main parcel in the case of type equal to SPLIT.
Y	It is a vector, or a matrix for MD, with the values of the random variable(s).
dfm	It is a data.frame with all experiment information: treatments, repetitions, and the random response variable.

References

Ferreira, Daniel Furtado. 2008. *Estatística Multivariada*. 1 ed. Lavras: Ed. UFLA.

Aquino, Luiz Henrique. *Técnica Experimental com Animais I*. Apostila da disciplina "Técnica Experimental com Animais" da Universidade Federal de Lavras, 1992.

Rencher, Alvin C. and Schaalje, Bruce G. 2007. *Linear Models in Statistics, second edition*. Hoboken: John Wiley \& Sons.

Naes, T.; Aastveit, A.H.; Sahni, N.S. 2007. "Analysis of split-plot designs: An Overview and Comparison of Methods". *Qual. Reliab. Engng. Int.* 23, 801-820.

See Also

plot.gexp.crd

Examples

```
#!____________________________
#! Qualitative Factor(s) (QL)
#!____________________________

#! Completely Randomized Design (CRD)
```

```
#! 1 factor - CRD - QLF
# Nonsense(experimental error = 0)
# Yi = mu + fe + e
r <- 2  # (repet. number)
fln <- 3  # (factor levels number)

crd00 <- gexp(mu=0,
              r=r,
              fe=list(f1=c(1, 2, 3)),
              err=matrix(0,
                         nrow=r*fln),
              round=0)
crd00
print(crd00)
str(crd00)
summary(crd00)

#! 1 factor - CRD - QL
# Nonsense(error is 0)
# Yi = mu + fe + e
r <- 3  # (repet. number)
fln <- 5  # (factor levels number)

crd01 <- gexp(mu=1,
              r=r,
              fe=list(f1=c(0, 2, 4, 6, 8)),
              err=matrix(0,
                         nrow=r*fln),
              round=2)
summary(crd01)

#! 1 factor - CRD - QL
# Default error: rmvnorm(sigma = diag(ncol(as.matrix([[fe]]))))
crd_1f <- gexp(mu=1,
               r=3,
               fe=list(f1=c(1, 1, 5, 1, 1)),
               fl=list(Treat=LETTERS[1:5]),
               round=2)

summary(crd_1f)

#! Binomial error - CRD - QL
e_binom <- as.matrix(rbinom(n=15,
                            size=5,
                            prob=0.1))

crd_bin <- gexp(mu=20,
                err=e_binom,
                r=5,
                fe=list(f1=c(1, 4, 1)))

summary(crd_bin)
```

```
mod <- aov(Y1 ~ X1,
           data=crd_bin$dfm)

shapiro.test(mod$res)

#! Factorial Experiment (FE) - CRD - QL
crd_fe <- gexp(mu=0,
               r=2,
               fe=list(f1=c(1, 1, 5),
                       f2=c(1, 1),
                       f3=c(2, 2, 1)),
               fl=list(A=paste('a',
                               1:3,
                               sep=''),
                       B=paste('b',
                               1:2,
                               sep=''),
                       C=paste('c',
                               1:3,
                               sep='')),
               inte = rep(1,39),
               round=0,
               type = 'FE')
summary(crd_fe)

#! Factorial Experiment (FE) - Multivariated - CRD - QL
# Error = 0 - Nonsense (you can easily undertand the effects)
crd_femn <- gexp(mu=c(0, 0),
                 r=1,
                 err=mvtnorm::rmvnorm(n=3^1 * 2^1 * 1,
                                      sigma=matrix(c(0, 0,
                                                     0, 0),
                                                   ncol=2)),
                 #Y1 Y2
                 fe=list(f1=matrix(c(0, 3,  #X1  X1
                                     1, 4,  #X2  X2
                                     2, 5), #X3  X3
                                   ncol=2,
                                   byrow=TRUE),

                         #Y1 Y2
                         f2=matrix(c(0, 2,  #X1  X1
                                     1, 3), #X2  X2
                                   ncol=2,
                                   byrow=TRUE)),
                 round=1)
summary(crd_femn)

#! Factorial Experiment (FE) - Multivariated - CRD - QL
# Using default error
set.seed(30)
crd_femd <- gexp(mu=c(0, 2),
                 r=3,
```

```
                  fe=list(f1=matrix(c(1, 1,
                                      5, 1,
                                      1, 1),
                                    ncol=2,
                                    byrow=TRUE),
                          f2=matrix(c(1, 3,
                                      2, 2),
                                    ncol=2,
                                    byrow=TRUE)),
                  round=1)
summary(crd_femd)

set.seed(30)
crd_femi <- gexp(mu=c(0, 2),
                 err=mvtnorm::rmvnorm(n=3^1 * 2^1 * 3,
                                      sigma=matrix(c(1, 0,  # The same that the default error
                                                     0, 1),
                                                   ncol=2)),
                 r=3,
                 fe=list(f1=matrix(c(1, 1,
                                     5, 1,
                                     1, 1),
                                   ncol=2,
                                   byrow=TRUE),
                         f2=matrix(c(1, 3,
                                     2, 2),
                                   ncol=2,
                                   byrow=TRUE)),
                 round=1)
summary(crd_femi)

crd_femd$dfm[, 4:5] # Use of the dafault error
crd_femi$dfm[, 4:5] # Use of the user error (same as the default!)
crd_femd$dfm[, 4:5] == crd_femi$dfm[, 4:5]

#! Factorial Experiment (FE) - With interaction - CRD - QL
fe_crd <- gexp(mu=30,
               fe=list(f1=c(1, 1, 3),
                       f2=c(1, 1)),
               fl=list(A=paste('a',
                               1:3,
                               sep=''),
                       B=paste('b',
                               1:2,
                               sep='')),
               inte=c(3, 1, 1, 1, 1, 5),
               round=1,
               type='FE')
summary(fe_crd)

#! Split-plot Experiment (SPE) - CRD - QL
split_crd <- gexp(mu=30,
                  fe=list(f1=c(1, 1),
```

```
                        f2=c(2, 3)),
                   fl=list(P=paste('p',
                                   1:2,
                                   sep=''),
                           SP=paste('sp',
                                    1:2,
                                    sep='')),
                   inte=c(1, 15, 1, 1),
                   round=1,
                   type='SPE')
summary(split_crd)

#! Randomized Complete Block Design (RCBD) - QL
# 1 factor, 3 blocks
rcbd <- gexp(mu=0,
             fe=list(f1=c(5, 1, 1)),
             fl=list(TR=LETTERS[1:3]),
             blke=c(1, 2, 3),
             blkl=list(BLK=paste('B',
                                 1:3,
                                 sep='')),
             round=1,
             type='RCBD')
summary(rcbd)

#! Factorial Experiment (FE) - RCBD - QL
fe_rcbd <- gexp(mu=30,
                fe=list(f1=c(1, 1, 1),
                        f2=c(2, 3)),
                blke=c(1, 3),
                inte=c(1, 15, 1, 1, 5, 1),
                round=1,
                type='FE')
summary(fe_rcbd)

#! Multivariated - RCBD - QL
rcbd_m <- gexp(mu=c(0, 2),
               fe=list(f1= matrix(c(1, 1,
                                    5, 1,
                                    1, 1),
                                  ncol=2,
                                  byrow=TRUE)),
               blke=matrix(c(2, 1,
                             1, 2,
                             1, 1),
                           ncol=2,
                           byrow=TRUE),
               round=1,
               type='RCBD')
summary(rcbd_m)

#! Split-plot Experiment (SPE) - RCBD - QL
split_rcbd <- gexp(mu=30,
```

```
                    fe=list(f1=c(1, 1),
                            f2=c(2, 3),
                            f3=c(1, 1, 1)),
                    fl=list(A=paste('a',
                                    1:2,
                                    sep=''),
                            B=paste('b',
                                    1:2,
                                    sep=''),
                            C=paste('c',
                                    1:3,
                                    sep='')),
                    blke=c(1, 2),
                    blkl=list(BLK=paste('B',
                                        1:2,
                                        sep='')),
                    inte=c(1, 15, 1, 1, 1, 3, 4, 2, 1, 1, 4, 1,
                           1, 2, 1, 1,
                           1, 1, 1, 1, 1, 1,
                           1, 1, 3, 3, 3, 3),
                    round=1,
                    type='SPE')
summary(split_rcbd)

#! Latin Square Design (LSD) - QL
lsd <- gexp(mu=30,
            fe=list(f1=c(1, 1, 10)),
            rowe=c(1, 1, 1),
            cole=c(1, 1, 1),
            rowl=list(Row=paste('r',
                                1:3,
                                sep='')),
            coll=list(Col=paste('c',
                                1:3,
                                sep='')),
            round=1,
            type='LSD')
summary(lsd)

#! Factorial Experiment (FE) - LSD - QL
fe_lsd <- gexp(mu=30,
               fe=list(f1=c(1, 1),
                       f2=c(2, 3)),
               rowe=c(1, 3, 2, 1),
               cole=c(2, 2, 1, 1),
               rowl=list(Row=paste('r',
                                   1:4,
                                   sep='')),
               coll=list(Col=paste('c',
                                   1:4,
                                   sep='')),
               inte=c(1, 15, 1, 1),
               round=1,
```

```
               type='FE')
summary(fe_lsd)

#! Split-plot Experiment (SPE) - LSD - QL
split_lsd <- gexp(mu=30,
                  fe=list(f1=c(1, 1, 2),
                          f2=c(2, 3, 1)),
                  fl=list(P=paste('p',
                                  1:3,
                                  sep=''),
                          SP=paste('sp',
                                   1:3,
                                   sep='')),
                  inte=c(1, 15, 1, 1, 1, 1, 1, 1, 1),
                  rowe = c(1, 1, 1),
                  cole = c(1, 1, 1),
                  rowl=list(Row=paste('r',
                                      1:3,
                                      sep='')),
                  coll=list(Col=paste('c',
                                      1:3,
                                      sep='')),
                  round=1,
                  type='SPE')
summary(split_lsd)

#!____________________________
#! Quantitative Factor(s) (QT)
#!____________________________

# CRD - Orthogonal polynomials
level <- c(0, 10, 20, 30)
cont_crd <- contr.poly(length(level))

# Linear effect
crd_lo <- gexp(mu=NULL,
               r=4,
               # B0 B1 B2 B3  Linear only
               fe=list(f1=c(2, 5, 0, 0)),
               fl=list(Dose=ordered(level)),
               contrasts=list(f1=cont_crd))
summary(crd_lo)
plot(Y1 ~ Dose,
     crd_lo$dfm)

# Quadratic effect
crd_qo <- gexp(mu=NULL,
               r=4,
               # B0 B1 B2 B3  quadratic
               fe=list(f1=c(2, 0, 5, 0)),
               fl=list(Dose=ordered(c(0, 10, 20, 30))),
               contrasts=list(f1=cont_crd))
summary(crd_qo)
```

```
plot(Y1 ~ Dose,
     crd_qo$dfm)

# Cubic effect
crd_co <- gexp(mu=NULL,
               r=4,
               # B0 B1 B2 B3  cubic
               fe=list(f1=c(2, 0, 0, 5)),
               fl=list(Dose=ordered(c(0, 10, 20, 30))),
               contrasts=list(f1=cont_crd))
summary(crd_co)
plot(Y1 ~ Dose,
     crd_co$dfm)

# Not orthogonal polynomials
# Linear
cont_crd <- matrix(c(level,
                     level^2,
                     level^3),
                   ncol=3)

crd_l <- gexp(mu=NULL,
              r=4,
              fe=list(f1=c(2, 10, 0, 0)),
              fl=list(Dose=ordered(c(0, 10, 20, 30))),
              contrasts=list(f1=cont_crd))
summary(crd_l)
plot(Y1 ~ Dose,
     crd_l$dfm)

reg <- lm(Y1 ~ Dose + I(Dose^2) + I(Dose^3),
          data=crd_l$dfm)

summary(reg)

# Linear and quadratic
# When has two or more factor, to inform only Beta0 to first factor.
crd_lq <- gexp(mu=NULL,
               r=3,
               fe=list(f1=c(0, 10, 0, 0),  #linear
                       f2=c(0, 3, 4, 0)), #quadratic
               fl=list(P=ordered(level),
                       N=ordered(1:4)),
               contrasts=list(f1=cont_crd,
                              f2=cont_crd))
summary(crd_lq)

with(crd_lq$dfm,
     plot(Y1 ~ P))

with(crd_lq$dfm,
     plot(Y1 ~ N))
```

```
# Multivariated!
crd_m <- gexp(mu=NULL,
              r=4,                #L  Q
              fe=list(f1=matrix(c( 2,  2,
                                   10,  0,
                                   0, 10,
                                   0,  0),
                                 ncol=2,
                                 byrow=TRUE)),
              fl=list(Dose=ordered(level)),
              contrasts=list(f1=cont_crd))

with(crd_m$dfm,
     plot(Y1 ~ Dose))

with(crd_m$dfm,
     plot(Y2 ~ Dose))

# Orthogonal polynomios - RCBD
cont_rcbd <- contr.poly(4)

rcbd <- gexp(mu=NULL,
             fe=list(f1=c(1, 3, 0, 0)),
             blke=c(1, 2, 3),
             r=2,
             fl=list(Dose=ordered(c(0, 2, 4, 6))),
             blkl=list(Blk=c('B1', 'B2', 'B3')),
             contrasts=list(f1=cont_rcbd,
                            Blk=diag(3)),
             type='RCBD')
summary(rcbd)

#! Hibrid: qualitative and quantitative factors in the same experiment - hb
# CRD
r <- 2
(error <- matrix(rep(0,
                     4^1*3^1*r),
                 ncol=1))

crd_hb <- gexp(mu=NULL,
               err=error,
               r=r,
               fe=list(f1=c(0, 1, 0),      # Qualitative
                       f2=c(2, 1, 0, 0)),  # Quantitative linear
               fl=list(Var=LETTERS[1:3],
                       Dose=ordered(level)),
               contrasts=list(f1=diag(3),
                              f2=cont_crd))
summary(crd_hb)

# RCBD
r <- 2
blke <- c(1, 2)
```

```
(error <- matrix(rep(0,
                     4^1*3^1*r*length(blke)),
                 ncol=1))

rcbd_hb <- gexp(mu=NULL,
                err=error,
                r=r,
                fe=list(f1=c(0, 1, 0),      # Qualitative
                        f2=c(2, 1, 0, 0)),  # Quantitative linear
                fl=list(Var=LETTERS[1:3],
                        Dose=ordered(level)),
                blke=blke,
                blkl=list(Blk=c('B1', 'B2')),
                contrasts=list(f1=diag(3),
                               f2=cont_crd,
                               Blk=diag(2)),
                type='RCBD')
summary(rcbd_hb)
```

---

plot *Plot methods for* gexp *objects*

Description

These are methods for objects of class gexp.crd - Completely Randomized Design (CRD), gexp.rcbd - Randomized Complete Block Design (RCBD), gexp.lsd - Latin Squares Design (LSD), gexp.fe - Factorial Experiment (FE) and gexp.spe - Split-plot Experiment (SPE). The main objective of these methods is to produce an experimental croqui with randomized treatments according with the design and type of experiment. It can be very useful in experiment planning.

Usage

```
## S3 method for class 'gexp.crd'
plot(x,
     main= NULL,
     sub= NULL,
     colgrid='red',
     coltext='blue',
     ltygrid='dotted',
     lwdgrid=par('lwd'),
     xleftimg=par()$usr[1],
     ybottomimg=par()$usr[3],
     xrightimg=par()$usr[2],
     ytopimg=par()$usr[4],
     dynamic=FALSE, ...)

## S3 method for class 'gexp.rcbd'
plot(x,
```

```
     main=NULL,
     sub=NULL,
     colgrid='red',
     coltext='blue',
     ltygrid='dotted',
     lwdgrid=par('lwd'),
     xleftimg=par()$usr[1],
     ybottomimg=par()$usr[3],
     xrightimg=par()$usr[2],
     ytopimg=par()$usr[4],
     dynamic=FALSE, ...)

## S3 method for class 'gexp.lsd'
plot(x,
     main=NULL,
     sub=NULL,
     colgrid='red',
     coltext='blue',
     ltygrid='dotted',
     lwdgrid=par('lwd'),
     xleftimg=par()$usr[1],
     ybottomimg=par()$usr[3],
     xrightimg=par()$usr[2],
     ytopimg=par()$usr[4],
     dynamic=FALSE, ...)

## S3 method for class 'gexp.fe'
plot(x,
     main=NULL,
     sub=NULL,
     colgrid='red',
     coltext='blue',
     ltygrid='dotted',
     lwdgrid=par('lwd'),
     xleftimg=par()$usr[1],
     ybottomimg=par()$usr[3],
     xrightimg=par()$usr[2],
     ytopimg=par()$usr[4],
     dynamic=FALSE, ...)

## S3 method for class 'gexp.spe'
plot(x,
     main=NULL,
     sub=NULL,
     coltext='blue',
     srttext=30,
     colgrid='red',
     ltygrid='dotted',
```

```
     lwdgrid=par('lwd'),
     xleftimg=par()$usr[1],
     ybottomimg=par()$usr[3],
     xrightimg=par()$usr[2],
     ytopimg=par()$usr[4],
     dynamic=FALSE, ...)
```

Arguments

x	A gexp.crd, gexp.rcbd, gexp.lsd, gexp.fe or gexp.spe object.
main	An overall title for the plot.
sub	An sub title for the plot.
coltext	A color to the text on the plot.
srttext	The string rotation in degrees. See srt argument of the par function.
colgrid	A color to the grid on the plot.
ltygrid	A lty to the grid on the plot.
lwdgrid	A lwd to the grid on the plot.
xleftimg	A vector (or scalar) of left x positions.
ybottomimg	A vector (or scalar) of bottom y positions.
xrightimg	A vector (or scalar) of right x positions.
ytopimg	A vector (or scalar) of top y positions.
dynamic	A logical argument to plot experimental design using image.
...	Further arguments (required by generic).

See Also

plot.default, rasterImage

Examples

```
#! Completely Randomized Design (CRD)
#! 1 factor - CRD
crd <- gexp(mu=1,
            r=3,
            fe=list(f1=c(1, 1, 5, 1, 1)),
            fl=list(Treat=LETTERS[1:5]),
            round=2)
summary(crd)
plot(crd)  # Default

plot(crd,  # Changing some arguments
     main='',
     sub='',
     coltext='black',
     colgrid='darkred',
     ltygrid='solid',
```

```
     lwdgrid=3)

#! Factorial Experiment (FE) - CRD
# 2 factors (f1,f2, level^factor): 3^1 * 2^1 = 6 experimental units
crd_fe <- gexp(mu=0,
               r=2,
               fe=list(f1=c(1, 1, 5),
                       f2=c(1, 1)),
               fl=list(A=paste('a',
                               1:3,
                               sep=''),
                       B=paste('b',
                               1:2,
                               sep='')),
               round=0,
               inte = rep(1, 6),
               type = 'FE')
summary(crd_fe)
plot(crd_fe)

#! Split-plot Experiment (SPE) - CRD
split_crd <- gexp(mu=30,
                  fe=list(f1=c(1, 1),
                          f2=c(2, 3)),
                  fl=list(P=paste('p',
                                  1:2,
                                  sep=''),
                          SP=paste('sp',
                                   1:2,
                                   sep='')),
                  inte=c(1, 15, 1, 1),
                  round=1,
                  type='SPE')
summary(split_crd)
plot(split_crd)

#! Randomized Complete Block Design (RCBD)
# 1 factor, 3 blocks
rcbd <- gexp(mu=0,
             fe=list(f1=c(5, 1, 1)),
             fl=list(TR=LETTERS[1:3]),
             blke=c(1, 2, 3),
             blkl=list(BLK=paste('B',
                                 1:3,
                                 sep='')),
             round=1,
             type='RCBD')
summary(rcbd)
plot(rcbd)

#! Factorial Experiment (FE) - RCBD
fe_rcbd <- gexp(mu=30,
                fe=list(f1=c(1, 1, 1),
```

```
                        f2=c(2, 3)),
                 blke=c(1, 3),
                 inte=c(1, 15, 1, 1, 5, 1),
                 round=1,
                 type='FE')
summary(fe_rcbd)
plot(fe_rcbd)

fe_rcbd1 <- gexp(mu=30,
                 fe=list(f1=c(1, 1, 1),
                         f2=c(2, 3)),
                 blke=c(1, 3),
                 blkl=list(Blk=c('B1', 'B2')),
                 inte=c(1, 15, 1, 1, 5, 1),
                 round=1,
                 type='FE')
summary(fe_rcbd1)
plot(fe_rcbd1)

#! Split-plot Experiment (SPE) - RCBD
split_rcbd <- gexp(mu=30,
                   r = 2,
                   fe=list(f1=c(1, 1),
                           f2=c(2, 3),
                           f3=c(1, 1, 1)),
                   fl=list(A=paste('a',
                                   1:2,
                                   sep=''),
                           B=paste('b',
                                   1:2,
                                   sep=''),
                           C=paste('c',
                                   1:3,
                                   sep='')),
                   blke=c(1, 2, 3),
                   blkl=list(BLK=paste('B',
                                       1:3,
                                       sep='')),
                   inte=c(1, 15, 1, 1, 1, 3, 4, 2, 1, 1, 4, 1,
                          1, 2, 1, 1,
                          1, 1, 1, 1, 1, 1,
                          1, 1, 3, 3, 3, 3),
                   round=1,
                   type='SPE')
summary(split_rcbd)
plot(split_rcbd)

#! Latin Square Design (LSD)
lsd <- gexp(mu=30,
            fe=list(f1=c(1, 1, 10)),
            rowe=c(1, 1, 1),
            cole=c(1, 1, 1),
            rowl=list(Row=paste('r',
```

```
                                1:3,
                                sep='')),
            coll=list(Col=paste('c',
                                1:3,
                                sep='')),
            round=1,
            type='LSD')
summary(lsd)
plot(lsd)

#! Factorial Experiment (FE) - LSD
fe_lsd <- gexp(mu=30,
               fe=list(f1=c(1, 1),
                       f2=c(2, 3)),
               rowe=c(1, 3, 2, 1),
               cole=c(2, 2, 1, 1),
               rowl=list(Row=paste('r',
                                   1:4,
                                   sep='')),
               coll=list(Col=paste('c',
                                   1:4,
                                   sep='')),
               inte=c(1, 15, 1, 1),
               round=1,
               type='FE')
summary(fe_lsd)
plot(fe_lsd)

#! Split-plot Experiment (SPE) - LSD
split_lsd <- gexp(mu=30,
                  fe=list(f1=c(1, 1, 2),
                          f2=c(2, 3, 1)),
                  fl=list(P=paste('p',
                                  1:3,
                                  sep=''),
                          SP=paste('sp',
                                   1:3,
                                   sep='')),
                  inte=c(1, 15, 1, 1, 1, 1, 1, 1, 1),
                  rowe = c(1, 1, 1),
                  cole = c(1, 1, 1),
                  rowl=list(Row=paste('r',
                                      1:3,
                                      sep='')),
                  coll=list(Col=paste('c',
                                      1:3,
                                      sep='')),
                  round=1,
                  type='SPE')
summary(split_lsd)
plot(split_lsd)

## Not run:
```

```
#! Using images in plannig
# CRD
crd <- gexp(mu=1,
            r=2,
            fe=list(f1=c(1, 1, 5, 1, 1)),
            fl=list(Treat=LETTERS[1:5]),
            round=2)
summary(crd)
plot(crd)  # Default

# Dynamic
# Open picture 'crd.jpg' whem requested
crd_i <- update(crd,
                r=3,
                fe=list(f1=c(1, 1)),
                fl=list(Treat=LETTERS[1:2]))
summary(crd_i)
plot(crd_i)  # Default

# dynamic plot require 'jpeg' package!
plot(crd_i,
     dynamic=TRUE,
     xleftimg=0.6,
     ybottomimg=.6,
     xrightimg=1.4,
     ytopimg=1.4)

# RCBD
rcbd <- gexp(mu=0,
             fe=list(f1=c(5, 1, 1)),
             fl=list(TR=LETTERS[1:3]),
             blke=c(1, 2, 3),
             blkl=list(BLK=paste('B',
                                 1:3,
                                 sep='')),
             round=1,
             type='RCBD')
summary(rcbd)
plot(rcbd)

rcbd_i <- update(rcbd,
                 r=1,
                 fe=list(f1=c(1, 1, 1, 1)),
                 blke=c(1, 1, 1))
plot(rcbd_i,
     dynamic=TRUE)

# LSD
lsd <- gexp(mu=30,
            fe=list(f1=c(1, 1, 10)),
            rowe=c(1, 1, 1),
            cole=c(1, 1, 1),
            rowl=list(Row=paste('r',
```

```
                                1:3,
                                sep='')),
            coll=list(Col=paste('c',
                                1:3,
                                sep='')),
            round=1,
            type='LSD')
summary(lsd)

#TODO: dynamic plot require 'png' package!
plot(lsd)
plot(lsd,
     dynamic=TRUE)

## End(Not run)
```

---

print *Print for* gexp *objects.*

Description

Print gexp objects.

Usage

```
  ## S3 method for class 'gexp'
print(x,
     digits=3L, ...)
```

Arguments

x	A gexp.crd, gexp.rcbd, gexp.lsd, gexp.fe or gexp.spe object.
digits	Number of decimal digits in the results.The default is 3.
...	Further arguments (required by generic).

See Also

gexp

Examples

```
#! Completely Randomized Design (CRD)
#! 1 factor - CRD
crd <- gexp(mu=1,
            r=3,
            fe=list(f1=c(1, 1, 5, 1, 1)),
            fl=list(Treat=LETTERS[1:5]),
            round=2)
print(crd)
```

```
crd

#! Factorial Experiment (FE) - CRD
# 5 factors (f1..f5, level^factor): 3^1 * 2^1 * 3^1 * 2^1 * 4^1 * 2 = 360 experimental units
# 5 factors (f1..f5, level^factor): 3^2 * 2^2 * 5^1 = 180 * 2 = 360 experimental units
crd_fe <- gexp(mu=0,
               r=2,
               fe=list(f1=c(1, 1, 5),
                       f2=c(1, 1),
                       f3=c(2, 2, 1),
                       f4=c(1, 5),
                       f5=c(1, 2, 3, 4, 5)),
               fl=list(A=paste('a',
                               1:3,
                               sep=''),
                       B=paste('b',
                               1:2,
                               sep=''),
                       C=paste('c',
                               1:3,
                               sep=''),
                       D=paste('d',
                               1:2,
                               sep=''),
                       E=paste('e',
                               1:5,
                               sep='')),
               inte = rep(1,848),
               type = 'FE',
               round=0)
print(crd_fe)
crd_fe

#! Split-plot Experiment (SPE) - CRD
split_crd <- gexp(mu=30,
                  fe=list(f1=c(1, 1),
                          f2=c(2, 3)),
                  fl=list(P=paste('p',
                                  1:2,
                                  sep=''),
                          SP=paste('sp',
                                   1:2,
                                   sep='')),
                  inte=c(1, 15, 1, 1),
                  round=1,
                  type='SPE')
print(split_crd)
split_crd

#! Randomized Complete Block Design (RCBD)
# 1 factor, 3 blocks
rcbd <- gexp(mu=0,
             fe=list(f1=c(5, 1, 1)),
```

```
              fl=list(TR=LETTERS[1:3]),
              blke=c(1, 2, 3),
              blkl=list(BLK=paste('B',
                                  1:3,
                                  sep='')),
              round=1,
              type='RCBD')
print(rcbd)
rcbd

#! Factorial Experiment (FE) - RCBD
fe_rcbd <- gexp(mu=30,
                fe=list(f1=c(1, 1, 1),
                        f2=c(2, 3)),
                blke=c(1, 3),
                inte=c(1, 15, 1, 1, 5, 1),
                round=1,
                type='FE')
print(fe_rcbd)
fe_rcbd

#! Split-plot Experiment (SPE) - RCBD
split_rcbd <- gexp(mu=30,
                   fe=list(f1=c(1, 1),
                           f2=c(2, 3),
                           f3=c(1, 1, 1)),
                   fl=list(A=paste('a',
                                   1:2,
                                   sep=''),
                           B=paste('b',
                                   1:2,
                                   sep=''),
                           C=paste('c',
                                   1:3,
                                   sep='')),
                   blke=c(1, 2),
                   blkl=list(BLK=paste('B',
                                       1:2,
                                       sep='')),
                   inte=c(1, 15, 1, 1, 1, 3, 4, 2, 1, 1, 4, 1,
                          1, 2, 1, 1,
                          1, 1, 1, 1, 1, 1,
                          1, 1, 3, 3, 3, 3),
                   round=1,
                   type='SPE')
print(split_rcbd)
split_rcbd

#! Latin Square Design (LSD)
lsd <- gexp(mu=30,
            fe=list(f1=c(1, 1, 10)),
            rowe=c(1, 1, 1),
            cole=c(1, 1, 1),
```

```
            rowl=list(Row=paste('r',
                                1:3,
                                sep='')),
            coll=list(Col=paste('c',
                                1:3,
                                sep='')),
            round=1,
            type='LSD')
print(lsd)
lsd

#! Factorial Experiment (FE) - LSD
fe_lsd <- gexp(mu=30,
               fe=list(f1=c(1, 1),
                       f2=c(2, 3)),
               rowe=c(1, 3, 2, 1),
               cole=c(2, 2, 1, 1),
               rowl=list(Row=paste('r',
                                   1:4,
                                   sep='')),
               coll=list(Col=paste('c',
                                   1:4,
                                   sep='')),
               inte=c(1, 15, 1, 1),
               round=1,
               type='FE')
print(fe_lsd)
fe_lsd

#! Split-plot Experiment (SPE) - LSD
split_lsd <- gexp(mu=30,
                  fe=list(f1=c(1, 1, 2),
                          f2=c(2, 3, 1)),
                  fl=list(P=paste('p',
                                  1:3,
                                  sep=''),
                          SP=paste('sp',
                                   1:3,
                                   sep='')),
                  inte=c(1, 15, 1, 1, 1, 1, 1, 1, 1),
                  rowe = c(1, 1, 1),
                  cole = c(1, 1, 1),
                  rowl=list(Row=paste('r',
                                      1:3,
                                      sep='')),
                  coll=list(Col=paste('c',
                                      1:3,
                                      sep='')),
                  round=1,
                  type='SPE')
print(split_lsd)
split_lsd
```

summary *Summary* gexp *objects.*

Description

Summary gexp objects.

Usage

```
  ## S3 method for class 'gexp'
summary(object,
     digits=3L, ...)
```

Arguments

object	A gexp.crd, gexp.rcbd, gexp.lsd, gexp.fe or gexp.spe object.
digits	Number of decimal digits in the results.The default is 3.
...	Further arguments (required by generic).

Examples

```
#! Completely Randomized Design (CRD)
#! 1 factor - CRD
crd <- gexp(mu=1,
            r=3,
            fe=list(f1=c(1, 1, 5, 1, 1)),
            fl=list(Treat=LETTERS[1:5]),
            round=2)
summary(crd)

#! Factorial Experiment (FE) - CRD
# 5 factors (f1..f5, level^factor): 3^1 * 2^1 * 3^1 * 2^1 * 4^1 * 2 = 360 experimental units
# 5 factors (f1..f5, level^factor): 3^2 * 2^2 * 5^1 = 180 * 2 = 360 experimental units
crd_fe <- gexp(mu=0,
               r=2,
               fe=list(f1=c(1, 1, 5),
                       f2=c(1, 1),
                       f3=c(2, 2, 1),
                       f4=c(1, 5),
                       f5=c(1, 2, 3, 4, 5)),
               fl=list(A=paste('a',
                               1:3,
                               sep=''),
                       B=paste('b',
                               1:2,
                               sep=''),
                       C=paste('c',
                               1:3,
                               sep=''),
```

```
                        D=paste('d',
                                1:2,
                                sep=''),
                        E=paste('e',
                                1:5,
                                sep='')),
                inte = rep(1,848),
                type = 'FE',
                round=0)
summary(crd_fe)

#! Split-plot Experiment (SPE) - CRD
split_crd <- gexp(mu=30,
                  fe=list(f1=c(1, 1),
                          f2=c(2, 3)),
                  fl=list(P=paste('p',
                                  1:2,
                                  sep=''),
                          SP=paste('sp',
                                   1:2,
                                   sep='')),
                  inte=c(1, 15, 1, 1),
                  round=1,
                  type='SPE')
summary(split_crd)

#! Randomized Complete Block Design (RCBD)
# 1 factor, 3 blocks
rcbd <- gexp(mu=0,
             fe=list(f1=c(5, 1, 1)),
             fl=list(TR=LETTERS[1:3]),
             blke=c(1, 2, 3),
             blkl=list(BLK=paste('B',
                                 1:3,
                                 sep='')),
             round=1,
             type='RCBD')
summary(rcbd)

#! Factorial Experiment (FE) - RCBD
fe_rcbd <- gexp(mu=30,
                fe=list(f1=c(1, 1, 1),
                        f2=c(2, 3)),
                blke=c(1, 3),
                inte=c(1, 15, 1, 1, 5, 1),
                round=1,
                type='FE')
summary(fe_rcbd)

#! Split-plot Experiment (SPE) - RCBD
split_rcbd <- gexp(mu=30,
                   fe=list(f1=c(1, 1),
                           f2=c(2, 3),
```

```
                        f3=c(1, 1, 1)),
                fl=list(A=paste('a',
                                1:2,
                                sep=''),
                        B=paste('b',
                                1:2,
                                sep=''),
                        C=paste('c',
                                1:3,
                                sep='')),
                blke=c(1, 2),
                blkl=list(BLK=paste('B',
                                    1:2,
                                    sep='')),
                inte=c(1, 15, 1, 1, 1, 3, 4, 2, 1, 1, 4, 1,
                       1, 2, 1, 1,
                       1, 1, 1, 1, 1, 1,
                       1, 1, 3, 3, 3, 3),
                round=1,
                type='SPE')
summary(split_rcbd)

#! Latin Square Design (LSD)
lsd <- gexp(mu=30,
            fe=list(f1=c(1, 1, 10)),
            rowe=c(1, 1, 1),
            cole=c(1, 1, 1),
            rowl=list(Row=paste('r',
                                1:3,
                                sep='')),
            coll=list(Col=paste('c',
                                1:3,
                                sep='')),
            round=1,
            type='LSD')
summary(lsd)

#! Factorial Experiment (FE) - LSD
fe_lsd <- gexp(mu=30,
               fe=list(f1=c(1, 1),
                       f2=c(2, 3)),
               rowe=c(1, 3, 2, 1),
               cole=c(2, 2, 1, 1),
               rowl=list(Row=paste('r',
                                   1:4,
                                   sep='')),
               coll=list(Col=paste('c',
                                   1:4,
                                   sep='')),
               inte=c(1, 15, 1, 1),
               round=1,
               type='FE')
summary(fe_lsd)
```

```
#! Split-plot Experiment (SPE) - LSD
split_lsd <- gexp(mu=30,
                  fe=list(f1=c(1, 1, 2),
                          f2=c(2, 3, 1)),
                  fl=list(P=paste('p',
                                  1:3,
                                  sep=''),
                          SP=paste('sp',
                                   1:3,
                                   sep='')),
                  inte=c(1, 15, 1, 1, 1, 1, 1, 1, 1),
                  rowe = c(1, 1, 1),
                  cole = c(1, 1, 1),
                  rowl=list(Row=paste('r',
                                      1:3,
                                      sep='')),
                  coll=list(Col=paste('c',
                                      1:3,
                                      sep='')),
                  round=1,
                  type='SPE')
summary(split_lsd)
```

Index