Package ‘glmpca’

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Title Dimension Reduction of Non-Normally Distributed Data

Version 0.2.0

Description Implements a generalized version of principal components analysis (GLM-PCA) for dimension reduction of non-normally distributed data such as counts or binary matrices.


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Description

Generalized principal components analysis for dimension reduction of non-normally distributed data.

Usage

```r
glmpca(
  Y, 
  L,
  fam = c("poi", "nb", "nb2", "binom", "mult", "bern"),
  minibatch = c("none", "stochastic", "memoized"),
  optimizer = c("avagrad", "fisher"),
  ctl = list(),
  sz = NULL,
  nb_theta = NULL,
  X = NULL,
  Z = NULL,
  init = list(factors = NULL, loadings = NULL),
  ...
)
```

Arguments

- **Y**: matrix-like object of count or binary data with features as rows and observations as columns. Sparse matrices from the `Matrix` package are supported. Column-oriented sparsity is preferred.
- **L**: desired number of latent dimensions (positive integer).
- **fam**: string describing the likelihood to use for the data. Families include Poisson ('poi'), negative binomial with global overdispersion ('nb'), negative binomial with feature-specific overdispersion ('nb2'), or binomial ('binom'). Families 'mult' and 'bern' are deprecated as both are special cases of 'binom' with `sz` set to NULL and 1, respectively. They are provided only for backward compatibility. Family 'nb2' has not been thoroughly tested and is considered experimental.
- **minibatch**: string describing whether gradients should be computed with all observations ('none', the default) or a subset of observations, which is useful for larger datasets. Option 'stochastic' computes a noisy estimate of the full gradient using a random sample of observations at each iteration. Option 'memoized' computes the full data gradient under memory constraints by caching summary statistics across batches of observations.
optimizer string describing whether to use the fast AvaGrad method (`avagrad`, the default) or the slower diagonal Fisher scoring method (`fisher`) that was used in the original glmpca implementation.

c1 a list of control parameters. See 'Details'
sz numeric vector of size factors for each observation. If NULL (the default), col-
Sums are used for family `binom`, and colMeans are used for families `pois`, `nb`, and `nb2`.
nb_theta initial value for negative binomial overdispersion parameter(s). Small values
lead to more overdispersion. Default: 100. See `negative.binomial`. (nb_theta>
inf equivalent to Poisson).
X a matrix of column (observations) covariates. Any column with all same values
(eg. 1 for intercept) will be removed. This is because we force a feature-specific
intercept and want to avoid collinearity.
Z a matrix of row (feature) covariates, usually not needed.
init a list containing initial estimates for the factors (U) and loadings (V) matrices.
... additional named arguments. Provided only for backward compatibility.

Details

The basic model is $R = AX' + ZG' + VU'$, where $E[Y] = M = \text{linkinv}(R)$. Regression
coefficients are $A$ and $G$, latent factors are $U$ and loadings are $V$. The objective is to minimize the
deviance between $Y$ and $M$. The deviance quantifies the goodness-of-fit of the GLM-PCA model to
the data (smaller=better). Note that glmpca uses a random initialization, so for fully reproducible
results one may use set.seed.

The c1 argument accepts any of the following optional components:

verbose Logical. Should detailed status messages be printed during the optimization run? Default: FALSE.

batch_size Positive integer. How many observations should be included in a minibatch? Larger
values use more memory but lead to more accurate gradient estimation. Ignored if minibatch='none'.
Default: 1000.

lr Positive scalar. The AvaGrad learning rate. Large values enable faster convergence but can lead
to numerical instability. Default: 0.1. If a numerical divergence occurs, glmpca will restart
the optimization maxTry times (see below) and reduce the learning rate by a factor of five each
time.

penalty Non-negative scalar. The L2 penalty for the latent factors. Default: 1. Regression coef-
ficients are not penalized. Only used by the Fisher scoring optimizer. Larger values improve
numerical stability but bias the parameter estimates. If a numerical divergence occurs, glmpca
will restart the optimization maxTry times (see below) and increase the penalty by a factor of five
each time.

maxTry Positive integer. In case of numerical divergence, how many times should optimization be
restarted with a more stable penalty or learning rate? Default: 10.

minIter Positive integer. Minimum number of iterations (full passes through the dataset) before
checking for numerical convergence. Default: 30.
**maxIter**  Positive integer. Maximum number of iterations. If numerical convergence is not achieved by this point, the results may not be reliable and a warning is issued. Default: 1000.

**tol**  Positive scalar. Relative tolerance for assessing convergence. Convergence is determined by comparing the deviance at the previous iteration to the current iteration. Default: 1e-4.


**betas**  Numeric vector of length two. AvaGrad hyperparameters. See Savarese et al (2020). Default: c(0.9, 0.999).

**minDev**  Scalar. Minimum deviance threshold at which optimization is terminated. Useful for comparing different algorithms as it avoids the need to determine numerical convergence. Default: NULL.

**Value**

An S3 object of class `glmpca` with copies of input components `optimizer`, `minibatch`, `ctl`, `X`, and `Z`, along with the following additional fitted components:

- **factors**  a matrix U whose rows match the columns (observations) of Y. It is analogous to the principal components in PCA. Each column of the factors matrix is a different latent dimension.

- **loadings**  a matrix V whose rows match the rows (features/dimensions) of Y. It is analogous to loadings in PCA. Each column of the loadings matrix is a different latent dimension.

- **coefX**  a matrix A of coefficients for the observation-specific covariates matrix X. Each row of coefX corresponds to a row of Y and each column corresponds to a column of X. The first column of coefX contains feature-specific intercepts which are included by default.

- **coefZ**  a matrix G of coefficients for the feature-specific covariates matrix Z. Each row of coefZ corresponds to a column of Y and each column corresponds to a column of Z. By default no such covariates are included and this is returned as NULL.

- **dev**  a vector of deviance values. The length of the vector is the number of iterations it took for GLM-PCA's optimizer to converge. The deviance should generally decrease over time. If it fluctuates wildly, this often indicates numerical instability, which can be improved by decreasing the learning rate or increasing the penalty, see `ctl`.

- **dev_smooth**  a locally smoothed version of `dev` that may be easier to visualize when `minibatch='stochastic'`.

- **glmpca_family**  an S3 object of class `glmpca_family`. This is a minor extension to the `family` or `negative.binomial` object used by functions like `glm` and `glm.nb`. It is basically a list with various internal functions and parameters needed to optimize the GLM-PCA objective function. For the negative binomial case, it also contains the final estimated value of the overdispersion parameter (`nb_theta`).

- **offsets**  For Poisson and negative binomial families, the offsets are the logarithmically transformed size factors. These are needed to compute the predicted mean values.

**References**


predict.glmpca


See Also

predict.glmpca, prcomp, glm, logisticSVD, scry::devianceFeatureSelection, scry::nullResiduals

Examples

# create a simple dataset with two clusters
mu<-(rep(c(.5,3),each=10)
mu<-matrix(exp(rnorm(100*20)),nrow=100)
mu[,1:10]<-mu[,1:10]*exp(rnorm(100))
clust<-(rep(c("red","black"),each=10)
Y<-matrix(rpois(prod(dim(mu)),mu),nrow=nrow(mu))
# visualize the latent structure
res<-(glmpca(Y, 2)
factors<-(res$factors
plot(factors[,1],factors[,2],col=clust,pch=19)

predict.glmpca

Predict Method for GLM-PCA Fits

Description

Predict the mean matrix from a fitted generalized principal component analysis model object.

Usage

## S3 method for class 'glmpca'
predict(object, ...)

Arguments

object a fitted object of class inheriting from glmpca.
... additional named arguments. Currently ignored.

Details

Let $Y$ be the data matrix originally used to estimate the parameters in fit. The GLM-PCA model regards each element of $Y$ as a random sample from an exponential family distribution such as a Poisson, negative binomial, or binomial likelihood. The components of a GLM-PCA fit are combined to produce the predicted mean of this distribution at each entry of $Y$. This matrix may be regarded as a 'denoised' version of the original data.
Value

a dense matrix of predicted mean values.

Warning

The predicted mean matrix returned by this function will have the same dimensions as the original data matrix and it will be dense even if the original data were sparse. This can exhaust available memory for large datasets, so use with caution.

See Also

glmpca, predict.glm with type='response'
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