

Package ‘communication’

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Type Package

Title Feature Extraction and Model Estimation for Audio of Human Speech

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Description Provides fast, easy feature extraction of human speech and model estimation with hidden Markov models. Flexible extraction of phonetic features and their derivatives, with necessary preprocessing options like feature standardization. Communication can estimate supervised and unsupervised hidden Markov models with these features, with cross validation and corrections for auto-correlation in features. Methods developed in Knox and Lucas (2021) <doi:10.7910/DVN.8BTOHQ>.

Depends R (>= 3.5.0)

License GPL (>= 2)

Imports Rcpp (>= 1.0.2), purrr, magrittr, diagram, GGally, grid, useful, ggplot2, reshape2, tuneR, wrassp, gtools, signal, plyr, RColorBrewer, scales, abind, igraph, gtable

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audio	<i>Audio features from Stephen Breyer</i>
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Description

Features extracted from 100 randomly selected utterances by Stephen Breyer in Supreme Court Oral Arguments.

Usage

data(audio)

Format

An object of class preppedAudio

extractAudioFeatures	<i>Title</i>
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Description

Title

Usage

```
extractAudioFeatures(  
  wav.dir = getwd(),  
  wav.fnames = NULL,  
  windowSize = 25,  
  windowShift = 12.5,  
  windowType = "HAMMING",  
  derivatives = 2,  
  verbose = 1,  
  recursive = FALSE  
)
```

Arguments

wav.dir	Directory of wav files for featurization
wav.fnames	If wav.dir = NULL, a list of wav files for featurization
windowSize	Size of window in milliseconds
windowShift	Amount to shift window in milliseconds
windowType	Window type
derivatives	Include no (0), first (1), or first and second (2) derivatives of features
verbose	Verbose printing
recursive	Recursively traverse directory for wav files

Value

An object of class `preppedAudio`, which consists of a list of 'data', 'files', and 'control'. 'data' is a list with elements corresponding to audio features for each of the input wav files, where each element is the audio features for the respective wav file. 'files' contains metadata about each wav file for which audio features were extracted. 'control' records arguments passed to `extractAudioFeatures()`.

Examples

```
## Not run:
wav.fnames = list.files(file.path('PATH/TO/WAV/FILES'),
                        pattern = 'wav$',
                        recursive = TRUE,
                        full.names = TRUE
                      )
audio <- extractAudioFeatures(wav.fnames = wav.fnames,
                             derivatives = 0
                           )

## End(Not run)
```

hmm

Train a hidden Markov model with multivariate normal state distributions.

Description

Train a hidden Markov model with multivariate normal state distributions.

Usage

```
hmm(
  Xs,
  weights = NULL,
  nstates,
  par = list(),
  control = list(),
  labels = list()
)
```

Arguments

<code>Xs</code>	List of nsequences matrices; each matrix represents one observation sequence and is of dimension <code>nobs</code> x <code>nfeatures</code> . For a single observation sequence, a single matrix can be provided
<code>weights</code>	Optional vector of weights, one for each observation sequence
<code>nstates</code>	Integer; number of states
<code>par</code>	List of initialization parameters; see 'Details'
<code>control</code>	List of control parameters for EM steps
<code>labels</code>	List of observation labels for supervised training, with each element corresponding to an observation sequence. Element <code>i</code> can either be an vector of integer state labels in <code>1:nstates</code> or a matrix of dimension <code>nstates</code> x <code>nrow(Xs[[i]])</code> with columns summing to 1. If labels are supplied, E-step is suppressed.

Details

The `par` argument is a list of initialization parameters. Can supply any of the following components:

- `method` Name of method used to automatically initialize EM run. Currently only 'dirichlet' and 'random-spherical' are implemented. If provided, user-specified state distributions are ignored. 'dirichlet' randomly generates responsibilities which are in turn used to calculate starting distributions. 'random-spherical' randomly draws `nstates` observations and uses their features as state means; all state covariance matrices are set to a diagonal matrix with entries `method_arg` (default=1).
- `method_arg` Argument to supply to `method`. For `method='dirichlet'`, this is a scalar concentration alpha (same value used for all states). For `method='random-spherical'`, this is a scalar for diagonal entries of the spherical covariance matrices of the starting distributions (after features are standardized). 'dirichlet' is implemented. If provided, all other arguments are ignored.
- `resp` Matrix or list of nsequences matrices with rows summing to 1; each matrix represents one observation sequence and is of dimension `nobs` x `nstates`, with the (t,k)-th entry giving the initial probability that the t-th observation belongs to state k. If either `resp` or both `mus` and `Sigmas` are not provided, responsibilities are randomly initialized using `rdirichlet` with all shape parameters set to 10.
- `mus` List of `nstates` vectors with length `nfeatures`, each corresponding to the mean of a state distribution

- **Sigmas** List of `nstates` matrices with dimension `nfeatures` x `nfeatures`, each corresponding to the covariance matrix of a state distribution
- **Gamma** Matrix of transition probabilities with dimension `nstates` x `nstates`, with row `k` representing the probabilities of each transition out of `k` and summing to 1. If not supplied, each row is randomly drawn from `rdirichlet` with all shape parameters set to 10.
- **delta** Vector of initial state probabilities, of length `nstates` and summing to 1. If not supplied, `delta` is set to the stationary distribution of `Gamma`, i.e. the normalized first left eigenvector.

The `control` argument is a list of EM control parameters that can supply any of the following components

- **lambda** Ridge-like regularization parameter. `lambda` is added to each `diag(Sigmas[[k]])` to stabilize each state's covariance matrix, which might otherwise be numerically singular, before inverting to calculate multivariate normal densities. Note that regularization is applied after all features are standardized, so `diag(Sigmas[[k]])` is unlikely to contain elements greater than 1. This parameter should be selected through cross-validation.
- **tol** EM terminates when the improvement in the log-likelihood between successive steps is $< \text{tol}$. Defaults to $1e-6$.
- **maxiter** EM terminates with a warning if `maxiter` iterations are reached without convergence as defined by `tol`. Defaults to 100.
- **uncollapse** Threshold for detecting and resetting state distribution when they collapse on a single point. State distributions are uncollapsed by re-drawing `mus[[k]]` from a standard multivariate normal and setting `Sigmas[[k]]` to the `nfeatures`-dimensional identity matrix. Note that this distribution is with respect to the standardized features.
- **standardize** Whether features should be standardized. Defaults to `TRUE`. This option also adds a small amount of noise, equal to $.01 \times \text{feature standard deviation}$, to observation-features that have been zeroed out (e.g. `f0` during unvoiced periods). If set to `FALSE`, it is assumed that features have been externally standardized and zeroed-out values handled. `scaling$feature_means` and `scaling$feature_sds` are set to 0s and 1s, respectively, and no check is done to ensure this is correct. If features are in fact not standardized and zeroes handled, bad things will happen and nobody will feel sorry for you.
- **verbose** Integer in 0:1. If 1, information on the EM process is reported. Defaults to 1.

Value

An object of class `hmm`. Contains fitted values of model parameters, along with input values for hyperparameters and features.

Examples

```
data('audio')
## Not run:
mod <- hmm(audio$data, nstates = 2, control = list(verbose = TRUE))

## End(Not run)
```

llh	<i>Title</i>
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Description

Title

Usage

```
llh(Xs, mod, control = list())
```

Arguments

Xs	List of nsequences matrices; each matrix represents one observation sequence and is of dimension nobx nfeatures. For a single observation sequence, a single matrix can be provided
mod	Model object of class 'feelr.hmm', as output by hmm
control	List of control parameters

Value

List with two components. llhs is a numeric vector of log-likelihoods of each observation sequence in Xs. llh_total is the log-likelihood of all observation sequences together, i.e. sum(llhs). If Xs is the same data that generated mod, the values calculated here will be slightly lower than those output in mod\$llhs. This is because hmm estimates the starting state of each sequence, whereas here it is assumed that the starting state is drawn from the stationary distribution mod\$delta.

standardizeFeatures	<i>Title</i>
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Description

Title

Usage

```
standardizeFeatures(Xs, feature_means = NULL, feature_sds = NULL, verbose = 1)
```

Arguments

Xs	Data
feature_means	Numeric vector corresponding to columns of elements in Xs
feature_sds	Numeric vector corresponding to columns of elements in Xs. If not supplied, will be computed from Xs.
verbose	Verbose printing

Details

feature_means and feature_sds are provided to allow alignment of new datasets. For example, after a model is trained, new data for prediction must be transformed in the same way as the training data to ensure predictions are valid. If either is NULL, both will be computed from Xs and the output will be internally standardized (i.e., columns of `do.call(rbind, standardizeFeatures(Xs))` will have a mean of 0 and a standard deviation of 1).

Value

Standardizes 'data' of objects of class 'preppedAudio'. Maintains structure of original object otherwise. Is used to standardize data where the recording environment systematically shifts audio features.

Examples

```
data('audio')
audio$data <- standardizeFeatures(
  lapply(audio$data, function(x) na.omit(x))
)
```

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