

DimensionalityReductionSolutions

September 11, 2018

1 Solutions to Dimensionality Reduction

2 Dimensionality Reduction Task

- Use PCA from [MultivariateStats.jl](#), to reduce 300 dimensional word embedding down to 3, 2 and 1 dimensions.
- Plot these using [Plots.jl](#), coloring according to class

2.1 Tips:

- plotly is a good backend for 3D Plotting.
- The command `scatter(xs[1,:], xs[2,:], xs[3,:]; hover=all_words, zcolor=classes)`
- will plot a 3D scatter plot
- coloring each point according to the numerical array classes
- and putting a tooltip on each point, according to the string array all_words

3 First we loadup some data

For the the example presented here, we will use a subset of some pretrained word2vec word embedding, using the [Embeddings.jl](#) package. These are 300 dimensional vectors, which encode syntactic and semantic information about words.

Example code for the loading, together with the words sorted into their original classes is below.

In [2]: `using Embeddings`

```
countries = ["Afghanistan", "Algeria", "Angola", "Arabia", "Argentina", "Australia", "I  
usa_cities = ["Albuquerque", "Atlanta", "Austin", "Baltimore", "Boston", "Charlotte", "  
world_capitals = ["Accra", "Algiers", "Amman", "Ankara", "Antananarivo", "Athens", "Ba  
animals = ["alpaca", "camel", "cattle", "dog", "dove", "duck", "ferret", "goldfish", "goose", "  
sports = ["archery", "badminton", "basketball", "boxing", "cycling", "diving", "equestrian", "  
  
words_by_class = [countries, usa_cities, world_capitals, animals, sports]  
all_words = reduce(vcat, words_by_class)  
embedding_table = load_embeddings(Word2Vec; keep_words = all_words)  
@assert Set(all_words) == Set(embedding_table.vocab)
```

```

        embeddings = embedding_table.embeddings
        all_words = embedding_table.vocab
        classes = map(all_words) do word
            findfirst(col -> word col, [countries, usa_cities, world_capitals, animals, sports])
        end;

In [ ]: using MultivariateStats
        using Plots
        plotly()

Info: Precompiling MultivariateStats [6f286f6a-111f-5878-ab1e-185364afe411]
@ Base loading.jl:1187
WARNING: Base.LinAlg is deprecated, run `using LinearAlgebra` instead
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/MultivariateStats.jl:1187
Warning: Deprecated syntax `parametric method syntax fullmean{T}(d::Int, mv::Vector{T})` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/MultivariateStats.jl:1187
Use `fullmean(d::Int, mv::Vector{T})` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/common.jl:23
Warning: Deprecated syntax `parametric method syntax preprocess_mean{T <: AbstractFloat}(X::Matrix{T}, m)` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/common.jl:23
Use `preprocess_mean(X::Matrix{T}, m)` where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/common.jl:25
Warning: Deprecated syntax `parametric method syntax extract_kv{T}(fac::Factorization{T}, ord::AbstractVector{Int}, k::Int)` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/common.jl:25
Use `extract_kv(fac::Factorization{T}, ord::AbstractVector{Int}, k::Int)` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/common.jl:34
WARNING: importing deprecated binding Base.Factorization into MultivariateStats.
WARNING: Base.Factorization is deprecated: it has been moved to the standard library package `LinearAlgebra`.
Add `using LinearAlgebra` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/common.jl:33
Warning: Deprecated syntax `parametric method syntax regularize_symmat!{T <: AbstractFloat}(A::Matrix{T}, lambda::Real)` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/common.jl:33
Use `regularize_symmat!(A::Matrix{T}, lambda::Real)` where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/common.jl:102
Warning: Deprecated syntax `parametric method syntax lrsoltype{T} (::DenseVector{T})` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/common.jl:102
Use `lrsoltype(#unused#::DenseVector{T})` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:13
Warning: Deprecated syntax `parametric method syntax lrsoltype{T} (::DenseMatrix{T})` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:13
Use `lrsoltype(#unused#::DenseMatrix{T})` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:14
Warning: Deprecated syntax `parametric method syntax _vaug{T}(X::DenseMatrix{T})` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:14
Use `_vaug(X::DenseMatrix{T})` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:16
Warning: Deprecated syntax `parametric method syntax _haug{T}(X::DenseMatrix{T})` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:16
Use `_haug(X::DenseMatrix{T})` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:17
Warning: Deprecated syntax `parametric method syntax llsq{T <: AbstractFloat}(X::DenseMatrix{T}, Y::DenseVecOrMat{T}; trans::Bool = false, bias::Bool = true)` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:17
Use `llsq(X::DenseMatrix{T}, Y::DenseVecOrMat{T}; trans::Bool = false, bias::Bool = true)` where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:24
Warning: Deprecated syntax `parametric method syntax ridge{T <: AbstractFloat}(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::Real; trans::Bool = false, bias::Bool = true)` around /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:24
Use `ridge(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::Real; trans::Bool = false, bias::Bool = true)` where T` instead.

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@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:40
Warning: Deprecated syntax `parametric method syntax ridge{T <: AbstractFloat}(X::DenseMatrix{
Use `ridge(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::DenseVector{T}; trans::Bool = false, bi
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:47
Warning: Deprecated syntax `parametric method syntax ridge{T <: AbstractFloat}(X::DenseMatrix{
Use `ridge(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::DenseMatrix{T}; trans::Bool = false, bi
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:54
Warning: Deprecated syntax `parametric method syntax _ridge{T <: AbstractFloat}(X::DenseMatrix{
Use `_ridge(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::Union{Real, DenseVecOrMat}, trans::Bool
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:63
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateStats
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:24
Warning: Deprecated syntax `parametric method syntax cov_whitening{T <: AbstractFloat}(C::Chol
Use `cov_whitening(C::Cholesky{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:8
Warning: Deprecated syntax `parametric method syntax cov_whitening!{T <: AbstractFloat}(C::Dense
Use `cov_whitening!(C::DenseMatrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:12
Warning: Deprecated syntax `parametric method syntax cov_whitening{T <: AbstractFloat}(C::Dense
Use `cov_whitening(C::DenseMatrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:13
Warning: Deprecated syntax `parametric method syntax cov_whitening!{T <: AbstractFloat}(C::Dense
Use `cov_whitening!(C::DenseMatrix{T}, regcoef::Real) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:15
Warning: Deprecated syntax `parametric method syntax cov_whitening{T <: AbstractFloat}(C::Dense
Use `cov_whitening(C::DenseMatrix{T}, regcoef::Real) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:18
Warning: Deprecated syntax `parametric method syntax (::Type{Whitening{T}}){T}(mean::Vector{T},
Use `(::Type{Whitening{T}})(mean::Vector{T}, W::Matrix{T}) where T` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:28
Warning: Deprecated syntax `parametric method syntax (::Type{Whitening}){T <: AbstractFloat}(
Use `(::Type{Whitening})(mean::Vector{T}, W::Matrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:35
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics`.
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:39
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(::Type{Whitening{
Use `fit(#s20::Type{Whitening}, X::DenseMatrix{T}; mean = nothing, regcoef::Real = zero(T)) wh
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:47
Warning: Deprecated syntax `parametric method syntax _invsqrtm!{T <: AbstractFloat}(C::Matrix{
Use `_invsqrtm!(C::Matrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:58
Warning: Deprecated syntax `parametric method syntax invsqrtm{T <: AbstractFloat}(C::DenseMatrix{
Use `invsqrtm(C::DenseMatrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/whiten.jl:70
Warning: Deprecated syntax `type` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/w
Use `mutable struct` instead.

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@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:5
Warning: Deprecated syntax `parametric method syntax PCA{T <: AbstractFloat}(mean::Vector{T},
Use `PCA(mean::Vector{T}, proj::Matrix{T}, pvars::Vector{T}, tvar::T) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:16
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics`.
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:31
Warning: Deprecated syntax `parametric method syntax transform{T <: AbstractFloat}(M::PCA{T},
Use `transform(M::PCA{T}, x::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:46
Warning: Deprecated syntax `parametric method syntax reconstruct{T <: AbstractFloat}(M::PCA{T},
Use `reconstruct(M::PCA{T}, y::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:47
WARNING: importing deprecated binding Base.@sprintf into MultivariateStats.
WARNING: Base.@sprintf is deprecated: it has been moved to the standard library package `Printf`.
Add `using Printf` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:51
Warning: Deprecated syntax `parametric method syntax check_pcaparams{T <: AbstractFloat}(d::Int,
Use `check_pcaparams(d::Int, mean::Vector{T}, md::Int, pr::AbstractFloat) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:78
Warning: Deprecated syntax `parametric method syntax choose_pcadim{T <: AbstractFloat}(v::AbstractVector{T},
Use `choose_pcadim(v::AbstractVector{T}, ord::Vector{Int}, vsum::T, md::Int, pr::AbstractFloat) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:86
Warning: Deprecated syntax `parametric method syntax pcacov{T <: AbstractFloat}(C::DenseMatrix{T},
Use `pcacov(C::DenseMatrix{T}, mean::Vector{T}; maxoutdim::Int = size(C, 1), pratio::AbstractFloat) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:103
Warning: Deprecated syntax `parametric method syntax pcasvd{T <: AbstractFloat}(Z::DenseMatrix{T},
Use `pcasvd(Z::DenseMatrix{T}, mean::Vector{T}, tw::Real; maxoutdim::Int = min(size(Z)...), pratio::AbstractFloat) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:117
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(:Type{PCA}, X::DenseMatrix{T},
Use `fit{#s20::Type{PCA}, X::DenseMatrix{T}; method::Symbol = :auto, maxoutdim::Int = size(X, 1)}(X, mean::Vector{T}) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:139
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:139
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:4
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics`.
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:15
WARNING: Base.var is deprecated: it has been moved to the standard library package `Statistics`.
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:17
Warning: Deprecated syntax `parametric method syntax transform{T <: AbstractFloat}(m::PPCA{T},
Use `transform(m::PPCA{T}, x::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:23
Warning: Deprecated syntax `parametric method syntax reconstruct{T <: AbstractFloat}(m::PPCA{T},
Use `reconstruct(m::PPCA{T}, z::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:30
Warning: Deprecated syntax `parametric method syntax ppcaml{T <: AbstractFloat}(Z::DenseMatrix{T},

```

```

Use `ppcaml(Z::DenseMatrix{T}, mean::Vector{T}; maxoutdim::Int = (size(Z, 1) - 1), tol::Real =
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:48
Warning: Deprecated syntax `parametric method syntax ppcaem{T <: AbstractFloat}(S::DenseMatrix{T},
Use `ppcaem(S::DenseMatrix{T}, mean::Vector{T}, n::Int; maxoutdim::Int = (size(S, 1) - 1), tol::Real =
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:81
Warning: Deprecated syntax `parametric method syntax bayespca{T <: AbstractFloat}(S::DenseMatrix{T},
Use `bayespca(S::DenseMatrix{T}, mean::Vector{T}, n::Int; maxoutdim::Int = (size(S, 1) - 1), tol::Real =
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:125
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(:Type{PPCA}, X::DenseMatrix{T};
Use `fit(#s40::Type{PPCA}, X::DenseMatrix{T}; method::Symbol = :ml, maxoutdim::Int = (size(X, 1) - 1), tol::Real =
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:181
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:181
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:4
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:4
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:30
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(:Type{KernelCenter}, X::AbstractMatrix{T};
Use `fit(#unused#:Type{KernelCenter}, K::AbstractMatrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:11
Warning: Deprecated syntax `parametric method syntax transform!{T <: AbstractFloat}(C::KernelCenter, X::AbstractMatrix{T};
Use `transform!(C::KernelCenter{T}, K::AbstractMatrix{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:18
Warning: Deprecated syntax `parametric method syntax transform{T <: AbstractFloat}(M::KernelPCA, X::AbstractVecOrMat{T};
Use `transform(M::KernelPCA{T}, x::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:51
Warning: Deprecated syntax `parametric method syntax transform{T <: AbstractFloat}(M::KernelPCA, X::AbstractVecOrMat{T};
Use `transform(M::KernelPCA{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:57
Warning: Deprecated syntax `parametric method syntax reconstruct{T <: AbstractFloat}(M::KernelPCA, X::AbstractVecOrMat{T};
Use `reconstruct(M::KernelPCA{T}, y::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:62
Warning: Deprecated syntax `parametric method syntax pairwise!{T <: AbstractFloat}(K::AbstractMatrix{T}, X::AbstractVecOrMat{T};
Use `pairwise!(K::AbstractVecOrMat{T}, kernel::Function, X::AbstractVecOrMat{T}, Y::AbstractVecOrMat{T}) where T <: AbstractFloat`
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:80
Warning: Deprecated syntax `parametric method syntax pairwise!{T <: AbstractFloat}(K::AbstractMatrix{T}, X::AbstractVecOrMat{T};
Use `pairwise!(K::AbstractVecOrMat{T}, kernel::Function, X::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:94
Warning: Deprecated syntax `parametric method syntax pairwise{T <: AbstractFloat}(kernel::Function, X::AbstractVecOrMat{T};
Use `pairwise(kernel::Function, X::AbstractVecOrMat{T}, Y::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:98
Warning: Deprecated syntax `parametric method syntax pairwise{T <: AbstractFloat}(kernel::Function, X::AbstractVecOrMat{T};
Use `pairwise(kernel::Function, X::AbstractVecOrMat{T}) where T <: AbstractFloat` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:104
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(:Type{KernelPCA}, X::AbstractMatrix{T};
# /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl, line 110
(x' * y)
end, maxoutdim::Int = min(size(X)...), remove_zero_eig::Bool = false, atol::Real = 1e-10, solve::Bool = true)

```

```

Use `fit{#s44::Type{KernelPCA}, X::AbstractMatrix{T}}; kernel = (x, y) -> begin
  # /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl, line 110
  (x' * y)
end, maxoutdim::Int = min(size(X)...), remove_zero_eig::Bool = false, atol::Real = 1e-10, sol
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:116
Warning: Deprecated syntax `type` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/w
Use `mutable struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cca.jl:5
Warning: Deprecated syntax `parametric method syntax xtransform{T <: Real}(M::CCA, X::Abstract
Use `xtransform(M::CCA, X::AbstractVecOrMat{T}) where T <: Real` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cca.jl:53
Warning: Deprecated syntax `parametric method syntax ytransform{T <: Real}(M::CCA, Y::Abstract
Use `ytransform(M::CCA, Y::AbstractVecOrMat{T}) where T <: Real` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cca.jl:54
Warning: Deprecated syntax `parametric method syntax gram2dmat!{DT}(D::AbstractMatrix{DT}, G:
Use `gram2dmat!(D::AbstractMatrix{DT}, G::AbstractMatrix) where DT` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cmds.jl:7
Warning: Deprecated syntax `parametric method syntax gram2dmat{T <: Real}(G::AbstractMatrix{T}
Use `gram2dmat(G::AbstractMatrix{T}) where T <: Real` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cmds.jl:26
Warning: Deprecated syntax `parametric method syntax dmat2gram!{GT}(G::AbstractMatrix{GT}, D:
Use `dmat2gram!(G::AbstractMatrix{GT}, D::AbstractMatrix) where GT` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cmds.jl:32
Warning: Deprecated syntax `parametric method syntax dmat2gram{T <: Real}(D::AbstractMatrix{T}
Use `dmat2gram(D::AbstractMatrix{T}) where T <: Real` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cmds.jl:55
Warning: Deprecated syntax `parametric method syntax classical_mds{T <: Real}(D::AbstractMatr
Use `classical_mds(D::AbstractMatrix{T}, p::Int; dowarn::Bool = true) where T <: Real` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/cmds.jl:62
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wG
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/lda.jl:262
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics
Add `using Statistics` to your imports.
  likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lda.jl:73
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics
Add `using Statistics` to your imports.
  likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lda.jl:128
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics
Add `using Statistics` to your imports.
  likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/lda.jl:215
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics
Add `using Statistics` to your imports.
  likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ica.jl:12
WARNING: importing deprecated binding Base.@printf into MultivariateStats.
WARNING: Base.@printf is deprecated: it has been moved to the standard library package `Printf
Add `using Printf` to your imports.
  likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ica.jl:58

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WARNING: Base.@printf is deprecated: it has been moved to the standard library package `Printf`
Add `using Printf` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ica.jl:58
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/ica.jl:58
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:4
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:4
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:24
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:24
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:59
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:59
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:68
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:68
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:105
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:105
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:128
Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:128
Use `1 ./` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:139
WARNING: Base.mean is deprecated: it has been moved to the standard library package `Statistics`
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:13
WARNING: Base.cov is deprecated: it has been moved to the standard library package `Statistics`
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:15
WARNING: Base.var is deprecated: it has been moved to the standard library package `Statistics`
Add `using Statistics` to your imports.
    likely near /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:16
Warning: Deprecated syntax `parametric method syntax transform{T <: AbstractFloat}(m::FactorAnalysis{T}, x::AbstractVecOrMat{T}) where T <: AbstractFloat` instead
Use `transform(m::FactorAnalysis{T}, x::AbstractVecOrMat{T}) where T <: AbstractFloat` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:22
Warning: Deprecated syntax `parametric method syntax reconstruct{T <: AbstractFloat}(m::FactorAnalysis{T}, z::AbstractVecOrMat{T}) where T <: AbstractFloat` instead
Use `reconstruct(m::FactorAnalysis{T}, z::AbstractVecOrMat{T}) where T <: AbstractFloat` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:29
Warning: Deprecated syntax `parametric method syntax faem{T <: AbstractFloat}(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Real)` instead
Use `faem(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Real)` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:51
Warning: Deprecated syntax `parametric method syntax facm{T <: AbstractFloat}(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Real)` instead
Use `facm(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Real)` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:92
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(:Type{FactorAnalysis{T}}, X::DenseMatrix{T}; method::Symbol = :cm, maxoutdim::Int)` instead
Use `fit{#s111::Type{FactorAnalysis{T}}, X::DenseMatrix{T}; method::Symbol = :cm, maxoutdim::Int}` instead
@ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:164

```

```
Info: Precompiling Plots [91a5bcdd-55d7-5caf-9e0b-520d859cae80]
@ Base loading.jl:1187
```

```
In [ ]: #Direct projection -- no DR -- just throw away the information in the other axes
        xs=embeddings
        scatter(xs[1,:], xs[2,:], xs[3,:]; hover=all_words, zcolor=classes)
```

3.0.1 PCA

```
In [ ]: M = fit(PCA, embeddings; maxoutdim=3)
        xs = transform(M, embeddings)
        scatter(xs[1,:], xs[2,:], xs[3,:]; hover=all_words, zcolor=classes)
```

```
In [ ]: M = fit(PCA, embeddings; maxoutdim=2)
        xs = transform(M, embeddings_mat)
        scatter(xs[1,:], xs[2,:]; hover=all_words, zcolor=classes)
```

```
In [ ]: M = fit(PCA, embeddings; maxoutdim=1)
        xs = transform(M, embeddings)
        scatter(xs[1,:], ones(length(xs)); hover=all_words, zcolor=classes)
```

4 ICA

```
In [ ]: M = fit(ICA, embeddings, 3)
        xs = transform(M, embeddings)
        scatter(xs[1,:], xs[2,:], xs[3,:]; hover=all_words, zcolor=classes)
```

5 Extension: T-SNE

- Use [TSne.jl](#), to perform similar dimentionality reduction, and to produce plots.

T-SNE is another popluar DR method.

Be warned: it is sideways -- it is row major, so tanspose the inputs and outputs

You may have to play with the perplexity to get it to work well.

If you look at the resulting plots, you may note that countries are often paired uo with their captical city.

```
In [ ]: using TSne
```

```
In [ ]: xs = tsne(embeddings', 3, 500, 1000, 20.0)'
```

```
In [ ]: scatter(xs[1,:], xs[2,:], xs[3,:]; hover=all_words, zcolor=classes)
```