DimensionalityReductionSolutions

November 12, 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 acording 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 dimentional 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", "
        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/MultivariateStat
 Warning: Deprecated syntax `parametric method syntax fullmean{T}(d::Int, mv::Vector{T})` arou
 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::Ma
 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
 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 `
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
 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 /
 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 /
 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
 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
 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{
 Use `llsq(X::DenseMatrix{T}, Y::DenseVecOrMat{T}; trans::Bool = false, bias::Bool = true) whe
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:24
 Warning: Deprecated syntax `parametric method syntax ridge{T <: AbstractFloat}(X::DenseMatrix
 Use `ridge(X::DenseMatrix{T}, Y::DenseVecOrMat{T}, r::Real; trans::Bool = false, bias::Bool =
```

```
 @ ~/.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, bia
 @ ~/.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, bia
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/lreg.jl:54
 Warning: Deprecated syntax `parametric method syntax _ridge{T <: AbstractFloat}(X::DenseMatri
 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/MultivariateSta
 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::Den
 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::Dens
 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::Den
 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::Dens
 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}(m
 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::DenseMatr
 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/wG
 Use `mutable struct` instead.
```

```
 @ ~/.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::In
 Use `check_pcaparams(d::Int, mean::Vector{T}, md::Int, pr::AbstractFloat) where T <: AbstractF
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:78
 Warning: Deprecated syntax `parametric method syntax choose_pcadim{T <: AbstractFloat}(v::Abst
 Use `choose_pcadim(v::AbstractVector{T}, ord::Vector{Int}, vsum::T, md::Int, pr::AbstractFloat
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:86
 Warning: Deprecated syntax `parametric method syntax pcacov{T <: AbstractFloat}(C::DenseMatrix
 Use `pcacov(C::DenseMatrix{T}, mean::Vector{T}; maxoutdim::Int = size(C, 1), pratio::AbstractF
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:103
 Warning: Deprecated syntax `parametric method syntax pcasvd{T <: AbstractFloat}(Z::DenseMatrix
 Use `pcasvd(Z::DenseMatrix{T}, mean::Vector{T}, tw::Real; maxoutdim::Int = min(size(Z)...), pr
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:117
 Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(::Type{PCA}, X::D
 Use `fit(#s20::Type{PCA}, X::DenseMatrix{T}; method::Symbol = :auto, maxoutdim::Int = size(X,
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/pca.jl:139
 Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateSta
 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
```

```
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
Use `ppcaem(S::DenseMatrix{T}, mean::Vector{T}, n::Int; maxoutdim::Int = (size(S, 1) - 1), tol
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:81
Warning: Deprecated syntax `parametric method syntax bayespca{T <: AbstractFloat}(S::DenseMatr
Use `bayespca(S::DenseMatrix{T}, mean::Vector{T}, n::Int; maxoutdim::Int = (size(S, 1) - 1), t
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:125
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(::Type{PPCA}, X::
Use `fit(#s40::Type{PPCA}, X::DenseMatrix{T}; method::Symbol = :ml, maxoutdim::Int = (size(X,
@ ~/.julia/packages/MultivariateStats/wGpiN/src/ppca.jl:181
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateSta
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:4
Warning: Deprecated syntax `immutable` at /home/wheel/oxinabox/.julia/packages/MultivariateSta
Use `struct` instead.
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:30
Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(::Type{KernelCent
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::KernelC
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::KernelPC
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::KernelPC
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::Kernel
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::Abstract
Use `pairwise!(K::AbstractVecOrMat{T}, kernel::Function, X::AbstractVecOrMat{T}, Y::AbstractVe
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:80
Warning: Deprecated syntax `parametric method syntax pairwise!{T <: AbstractFloat}(K::Abstract
Use `pairwise!(K::AbstractVecOrMat{T}, kernel::Function, X::AbstractVecOrMat{T}) where T <: Ab
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:94
Warning: Deprecated syntax `parametric method syntax pairwise{T <: AbstractFloat}(kernel::Func
Use `pairwise(kernel::Function, X::AbstractVecOrMat{T}, Y::AbstractVecOrMat{T}) where T <: Abs
@ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:98
Warning: Deprecated syntax `parametric method syntax pairwise{T <: AbstractFloat}(kernel::Func
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}
    # /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, solv
```

```
 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, solv
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/kpca.jl:116
 Warning: Deprecated syntax `type` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wG
 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::AbstractMatri
 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/wGp
 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
```

```
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/MultivariateSta
 Use `struct` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:4
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 Use `1 ./` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:24
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 Use `1 ./` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:59
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 Use `1 ./` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:68
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 Use `1 ./` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:105
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 Use `1 ./` instead.
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:128
 Warning: Deprecated syntax `1./` at /home/wheel/oxinabox/.julia/packages/MultivariateStats/wGp
 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::FactorAn
 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::Factor
 Use `reconstruct(m::FactorAnalysis{T}, z::AbstractVecOrMat{T}) where T <: AbstractFloat` inste
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:29
 Warning: Deprecated syntax `parametric method syntax faem{T <: AbstractFloat}(S::DenseMatrix{T
 Use `faem(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Re
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:51
 Warning: Deprecated syntax `parametric method syntax facm{T <: AbstractFloat}(S::DenseMatrix{T
 Use `facm(S::DenseMatrix{T}, mv::Vector{T}, n::Int; maxoutdim::Int = (size(X, 1) - 1), tol::Re
 @ ~/.julia/packages/MultivariateStats/wGpiN/src/fa.jl:92
 Warning: Deprecated syntax `parametric method syntax fit{T <: AbstractFloat}(::Type{FactorAnal
 Use `fit(#s111::Type{FactorAnalysis}, X::DenseMatrix{T}; method::Symbol = :cm, maxoutdim::Int
 @ ~/.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 axies
        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)
```