Dataset em Julia

February 11, 2016

1 Trabalho de Implementação

1.1 INF2912 - Otimização Combinatória

1.1.1 Prof. Marcus Vinicius Soledade Poggi de Aragão

1.1.2 2015-2

1.1.3 Ciro Cavani

BigData / Globo.com Algoritmos de clusterização.

1.2 Conteúdo

Esse notebook tem as seguintes seções:

1. Generator

   Algoritmo para gerar dataset baseado no código Python feito pelo Poggi.

   Na descrição do trabalho está definido como o dataset é formado. Cada grupo tem um conjunto de features próprias com uma probabilidade de ativação maior do que as features livres.

2. Visualização

   Formas de apresentar o dataset na forma de gráfico bidimensional.

   Foram testadas três algoritmos: norma das partes superior e inferior do vetor de features (recomendado em aula); norma das features do grupo contra as features livres, e; Principal Component Analysis (PCA) para redução de dimensões.

   Os dois primeiros não apresentam muita diferenciação entre os pontos dos grupos. O PCA funciona bem (boa separação) com 3 ou 4 grupos, mas fica com sobreposição para 5+.

3. Avaliação

   Métricas para avaliação de algoritmos de clusterização.

   É implementado um algoritmo de clusterização aleatório ponderado. A partir desse algoritmo, é calculada a matriz de confusão, Accuracy, Precision, Recall e etc.

4. Exportação

   Geração de datasets a serem usados para o desenvolvimento dos algoritmos desse trabalho.

1.3 1. Generator

Problema:
Propor um classificador que identifique o grupo de cada objeto.
Dados:

- g: número de grupos diferentes

- n: número de objetos (não necessariamente diferentes)
- n_{min}: número mínimo de objetos em um grupo
- n_{max}: número máximo de objetos em um grupo

Para cada Objeto:

- c: número de características binárias
- c_y: número de características de um determinado grupo
- c_n: número de características dos demais grupos ($c_n = c_y(g-1)$)
- p: probabilidade de ativação das características de um grupo ($p > 0.5$)
- $1-p$: probabilidade de ativação das características dos demais grupos
- $p' = 0.5$: probabilidade de ativação das características que não são de qualquer grupo
- (as características de cada grupo não tem interseção)

In [1]:
```
"gera a distribuição de objetos para os grupos"
function group_size(g, n, n_min, n_max)
    num_g = Array(Int, g)
    sum = 0
    for i=1:g
        num_g[i] = rand(n_min:n_max)
        sum += num_g[i]
    end
    correct = n / sum
    sum = 0
    for i=1:g
        num_g[i] = round(Int, num_g[i] * correct)
        sum += num_g[i]
    end
    if sum < n
        num_g[g] += 1
    end
    num_g
end
```

Out[1]:
```
group_size (generic function with 1 method)
```

In [2]:
```
let n = 20,
    n_min = 2,
    n_max = 5,
    g = 5

    group_size(g, n, n_min, n_max)
end
```

Out[2]:
```
5-element Array{Int64,1}:
 5
 4
 4
 4
 3
```

In [3]:
```
"máscara de características para cada grupo sem interseção"
function group_mask(g, c, c_y)
    char_g = fill(-1, c)
    index = 1
    for i=1:g, j=1:c_y
```

```
            char_g[index] = i
            index += 1
        end
        char_g
    end
```

Out[3]: group_mask (generic function with 1 method)

In [4]:
```
let g = 5,
    c = 16,
    c_y = 3

    group_mask(g, c, c_y)
end
```

Out[4]:
```
16-element Array{Int64,1}:
  1
  1
  1
  2
  2
  2
  3
  3
  3
  4
  4
  4
  5
  5
  5
 -1
```

In [5]:
```
"""gera objetos para grupos seguindo a distribuição num_g,
a máscara char_g e a probabilidade p de ativação"""
function generate_data(num_g, char_g, p)
    data = Array(Tuple{Array{Int,1},Int}, 0)
    for i=1:length(num_g),j=1:num_g[i]
        vect = zeros(Int, length(char_g))
        for k=1:length(vect)
            if char_g[k] == i
                vect[k] = rand() < p ? 1 : 0
            elseif char_g[k] != -1
                vect[k] = rand() < 1 - p ? 1 : 0
            else
                vect[k] = rand() < 0.5 ? 1 : 0
            end
        end
        push!(data, (vect, i))
    end
    data
end
```

Out[5]: generate_data (generic function with 1 method)

In [6]:
```
"gerador de instâncias para o problema de clusterização"
function instance_generator(n, c, c_y, p, g, n_min, n_max)
```

```julia
        if c < g * c_y
            error("c_y too big")
        end

        num_g = group_size(g, n, n_min, n_max)
        char_g = group_mask(g, c, c_y)
        data = generate_data(num_g, char_g, p)
        data
    end
```

Out[6]: instance_generator (generic function with 1 method)

In [7]:
```julia
let n = 20,
    n_min = 2,
    n_max = 5,
    g = 5,
    c = 16,
    c_y = 3,
    p = 0.8

    instance_generator(n, c, c_y, p, g, n_min, n_max)
end
```

Out[7]:
```
21-element Array{Tuple{Array{Int64,1},Int64},1}:
 ([0,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0],1)
 ([1,1,1,1,0,1,1,0,0,0,0,0,0,0,0,1],1)
 ([1,0,1,0,0,0,1,0,0,0,0,0,0,0,0,1],1)
 ([0,0,0,1,1,1,1,0,0,0,0,0,0,0,0,1],2)
 ([0,0,0,1,0,1,1,0,0,0,0,0,0,0,0,1],2)
 ([0,0,0,0,1,1,0,0,0,0,1,0,1,0,0,1],2)
 ([0,0,0,1,1,1,0,0,0,1,0,1,0,0,1,0],2)
 ([0,0,0,1,1,1,1,0,0,0,1,0,0,0,1,1],2)
 ([1,0,0,1,1,1,1,0,0,1,0,0,0,0,0,0],2)
 ([0,0,0,1,1,1,1,0,1,1,1,0,0,0,0,1],2)
 ([0,1,0,1,0,0,0,0,1,0,0,0,0,0,0,0],3)
 ([0,0,1,0,1,0,1,1,1,0,0,0,1,0,0,0],3)
 ([0,0,1,0,0,0,1,1,1,0,0,1,0,1,0,1],3)
 ([0,0,1,0,0,0,1,1,1,0,1,0,0,0,0,1],3)
 ([0,0,0,1,0,0,0,1,1,1,0,1,1,0,0,1],3)
 ([0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,1],4)
 ([0,1,1,0,0,0,0,0,1,1,1,0,1,0,0,1],4)
 ([0,0,0,0,1,0,0,0,0,1,1,1,0,0,0,0],4)
 ([0,0,0,0,0,0,0,0,0,0,0,0,1,0,1,0],5)
 ([0,0,0,0,0,0,0,0,0,0,0,0,1,0,1,1],5)
 ([0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,0],5)
```

In [8]:
```julia
type Dataset
    groups::Int
    features::Int
    slot::Int
    activation_p::Float64
    size::Int
    size_min::Int
    size_max::Int
    data::Array{Tuple{Array{Int,1}, Int}, 1}
```

```
    Dataset(; groups=3, size=10000, size_min=0, size_max=0, features=200, slot=40, activation_p=
        if size < 10
            error("minimum 10")
        end
        if groups > size
            error("too many groups")
        end
        if features < groups * slot
            error("slot too big")
        end

        if size_max == 0
            size_max = 2 * round(Int, size / groups)
        end
        if size_min == 0
            size_min = round(Int, size_max / 10)
        end
        if size_max * groups < size
            error("size_max too tight")
        end

        data = instance_generator(size, features, slot, activation_p, groups, size_min, size_ma
        shuffle!(data)

        new(groups, features, slot, activation_p, size, size_min, size_max, data)
    end
end

data(ds, k) = filter(t -> t[2] == k, ds.data)
count(ds, k) = length(data(ds, k))

"Sumário do Dataset"
function summary(io::IO, ds::Dataset)
    println(io, "Number of Groups: ", ds.groups)
    println(io, "Number of Features: ", ds.features)
    println(io, "Number of Features (group): ", ds.slot)
    println(io, "Probability of Activation: ", ds.activation_p)
    println(io, "Number of Objects (total): ", ds.size)
    println(io, "Number of Objects per Group (min): ", ds.size_min)
    println(io, "Number of Objects per Group (max): ", ds.size_max)

    for k=1:ds.groups
        println(io, "Number of Objects in ", k, ": ", count(ds, k))
    end
end

"Sumário do Dataset"
summary(ds::Dataset) = summary(STDOUT, ds)

let _dataset = Dataset()
    summary(_dataset)
    sleep(0.2)
end
```

```
Number of Groups: 3
Number of Features: 200
Number of Features (group): 40
Probability of Activation: 0.8
Number of Objects (total): 10000
Number of Objects per Group (min): 667
Number of Objects per Group (max): 6666
Number of Objects in 1: 3323
Number of Objects in 2: 2618
Number of Objects in 3: 4059
```

1.4 2. Visualization

1.4.1 Gadfly

http://gadflyjl.org/

Gadfly is a system for plotting and visualization based largely on Hadley Wickhams's ggplot2 for R, and Leland Wilkinson's book The Grammar of Graphics.

In [9]:
```
if Pkg.installed("Gadfly") === nothing
    println("Installing Gadfly...")
    Pkg.add("Gadfly")
    Pkg.add("Cairo")
end
```

In [10]:
```
using Gadfly
set_default_plot_size(24cm, 12cm)
```

In [11]:
```
dataset = Dataset()
```

Out[11]:
```
Dataset(3,200,40,0.8,10000,667,6666,[([1,1,1,1,1,1,1,1,1,0  ...  0,1,1,0,0,0,1,1,0,0],1),([1,1
```

In [12]:
```
function halfmask(n)
    mask = zeros(n)
    middle = round(Int, n / 2)
    mask[1:middle] = 1
    mask
end

halfmask(10)
```

Out[12]:
```
10-element Array{Float64,1}:
 1.0
 1.0
 1.0
 1.0
 1.0
 0.0
 0.0
 0.0
 0.0
 0.0
```

In [13]:
```
reversemask(mask) = ones(mask) - mask

let mask = halfmask(10)
    reversemask(mask)
end
```

Out[13]: 10-element Array{Float64,1}:

```
 0.0
 0.0
 0.0
 0.0
 0.0
 1.0
 1.0
 1.0
 1.0
 1.0
```

In [14]:

```
function halfmasks(n)
    x = halfmask(n)
    y = reversemask(x)
    (x, y)
end

let a = rand(10),
    masks = halfmasks(10)
    (masks[1] .* a, masks[2] .* a)
end
```

Out[14]: ([0.4375007383708953,0.7985065523282371,0.3437691881529654,0.1584180792155101,0.500347432862236

In [15]:

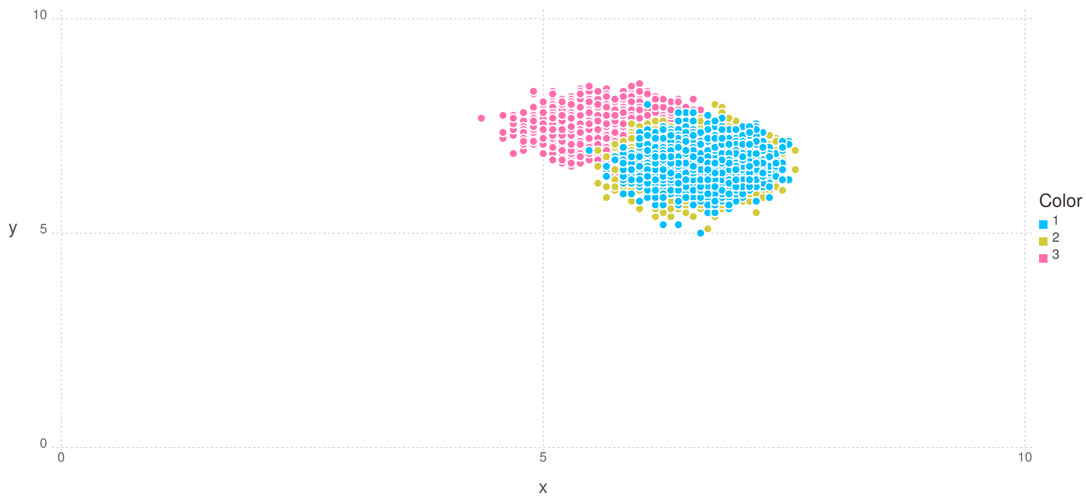
```
function reduce2d(data, masks)
    x = map(t -> norm(masks[1] .* t[1]), data)
    y = map(t -> norm(masks[2] .* t[1]), data)
    k = map(t -> string(t[2]), data)
    x, y, k
end

function plothalf(dataset)
    masks = halfmasks(dataset.features)

    g = Array(Layer, 0)

    for k=1:dataset.groups
        kdata = data(dataset, k)
        x, y, color = reduce2d(kdata, masks)
        push!(g, layer(x=x, y=y, color=color, Geom.point)...)
    end

    plot(g, Scale.x_continuous(minvalue=0, maxvalue=10), Scale.y_continuous(minvalue=0, maxvalu
end
```

Out[15]: plothalf (generic function with 1 method)

In [16]:

```
plothalf(dataset)
```

Out[16]:

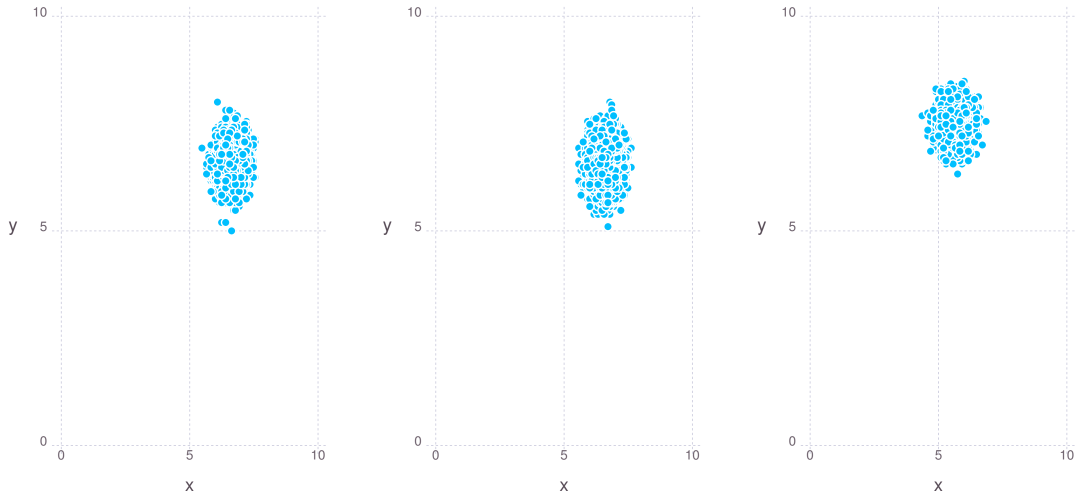



```
In [17]: function plothalf_multi(dataset)
             masks = halfmasks(dataset.features)

             g = Array(Plot, 0)

             for k=1:dataset.groups
                 kdata = data(dataset, k)
                 x, y, _ = reduce2d(kdata, masks)
                 p = plot(x=x, y=y, Scale.x_continuous(minvalue=0, maxvalue=10), Scale.y_continuous(min
                 push!(g, p)

             end

             hstack(g...)
         end
```

Out[17]: plothalf_multi (generic function with 1 method)

```
In [18]: plothalf_multi(dataset)
```

Out[18]:



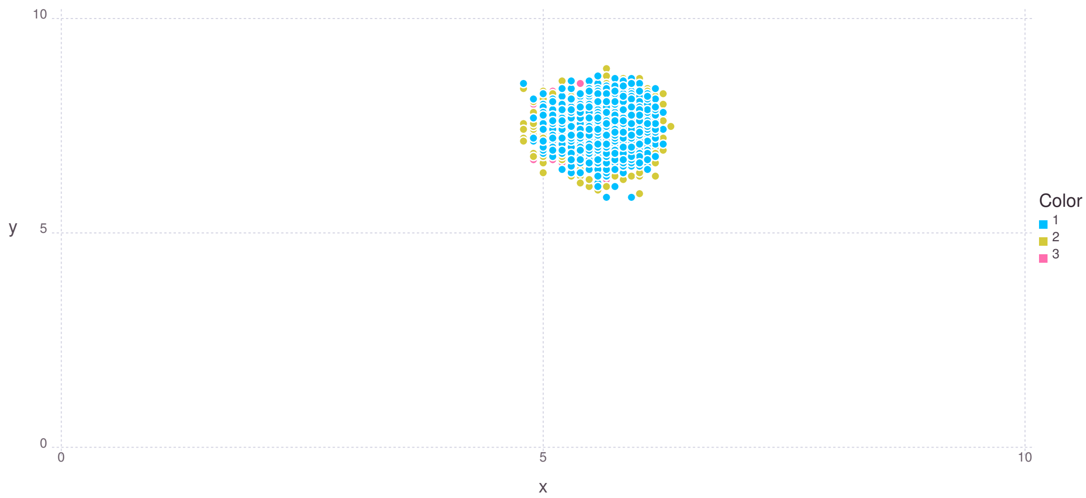

```
In [19]: function featuremask(features, slot, k)
             first = (k - 1) * slot + 1
             last = k * slot
             mask = zeros(features)
             mask[first:last] = 1
             mask
         end

         featuremask(10, 3, 1)

Out[19]: 10-element Array{Float64,1}:
          1.0
          1.0
          1.0
          0.0
          0.0
          0.0
          0.0
          0.0
          0.0
          0.0

In [20]: function featuremasks(features, slot, k)
             kmask = featuremask(features, slot, k)
             rmask = reversemask(kmask)
             (kmask, rmask)
         end

         let a = rand(10),
             masks = featuremasks(10, 3, 2)
             (masks[1] .* a, masks[2] .* a)
         end

Out[20]: ([0.0,0.0,0.0,0.45834517910600336,0.04416253139337978,0.6353298478811882,0.0,0.0,0.0,0.0],[0.0
```

In [21]:
```
function plotslot(dataset)
    g = Array(Layer, 0)

    for k=1:dataset.groups
        masks = featuremasks(dataset.features, dataset.slot, k)
        kdata = data(dataset, k)
        x, y, color = reduce2d(kdata, masks)
        push!(g, layer(x=x, y=y, color=color, Geom.point)...)
    end

    plot(g, Scale.x_continuous(minvalue=0, maxvalue=10), Scale.y_continuous(minvalue=0, maxvalu
end
```

Out[21]: plotslot (generic function with 1 method)

In [22]:
```
plotslot(dataset)
```

Out[22]:

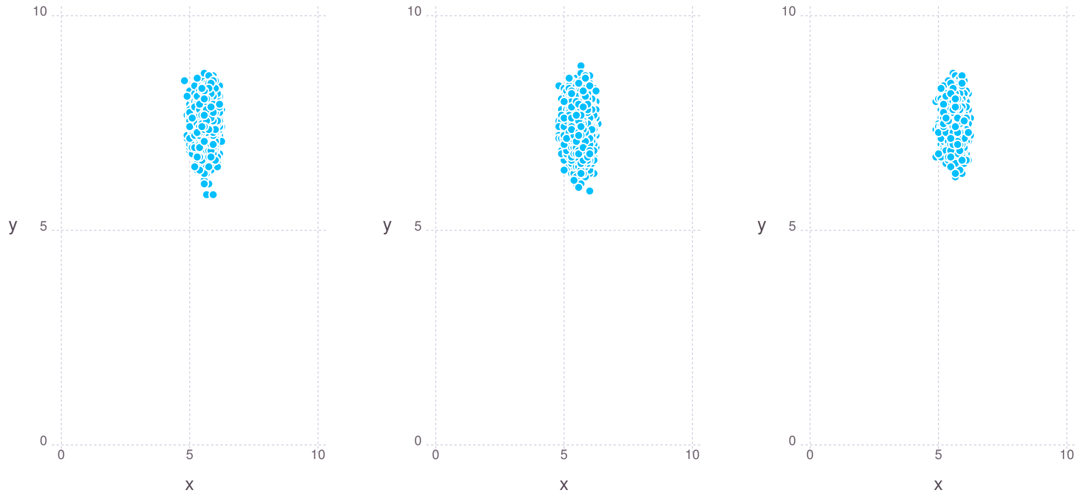


In [23]:
```
function plotslot_multi(dataset)
    g = Array(Plot, 0)

    for k=1:dataset.groups
        masks = featuremasks(dataset.features, dataset.slot, k)
        kdata = data(dataset, k)
        x, y, _ = reduce2d(kdata, masks)
        p = plot(x=x, y=y, Scale.x_continuous(minvalue=0, maxvalue=10), Scale.y_continuous(min
        push!(g, p)
    end

    hstack(g...)
end
```

Out[23]: plotslot_multi (generic function with 1 method)

```
In [24]: plotslot_multi(dataset)
```

Out[24]:



1.4.2 MultivariateStats Package

https://github.com/JuliaStats/MultivariateStats.jl
http://multivariatestatsjl.readthedocs.org/en/latest/index.html
A Julia package for multivariate statistics and data analysis (e.g. dimension reduction)

Principal Component Analysis (PCA) http://multivariatestatsjl.readthedocs.org/en/latest/pca.html

```
In [25]: if Pkg.installed("MultivariateStats") === nothing
             println("Installing MultivariateStats...")
             Pkg.add("MultivariateStats")
             Pkg.checkout("MultivariateStats")
         end
```

```
In [26]: matrix(data) = float(hcat(map(first, data)...))

         matrix([([1,2], 1), ([3,4], 2), ([5,6], 3)])
```

```
Out[26]: 2x3 Array{Float64,2}:
          1.0  3.0  5.0
          2.0  4.0  6.0
```

```
In [27]: using MultivariateStats
```

```
In [28]: let train = matrix(dataset.data)
             fit(PCA, train; maxoutdim=2)
         end
```

```
Out[28]: PCA(indim = 200, outdim = 2, principalratio = 0.19494)
```

In [29]:
```
let train = matrix(dataset.data),
    model = fit(PCA, train; maxoutdim=2)

    sample = data(dataset, 1)
    transform(model, matrix(sample))
end
```

Out[29]:
```
2x3157 Array{Float64,2}:
 2.90348  2.52256  2.80591   2.98064  ...  3.09083  3.34821  2.74889  2.64308
 1.50803  1.64484  0.698902  1.6003        1.09301  2.07549  1.66346  1.70987
```

In [30]:
```
let train = matrix(dataset.data),
    model = fit(PCA, train; maxoutdim=2)

    sample = data(dataset, 1)
    points = transform(model, matrix(sample))
    vec(points[1,:])
end
```

Out[30]:
```
3157-element Array{Float64,1}:
 2.90348
 2.52256
 2.80591
 2.98064
 3.23991
 2.7537
 2.86279
 2.84578
 3.57327
 1.34105
 2.49099
 3.12914
 2.18843
 ⋮
 2.75908
 2.08887
 2.36002
 3.00488
 2.8451
 2.93136
 2.48775
 2.74521
 3.09083
 3.34821
 2.74889
 2.64308
```

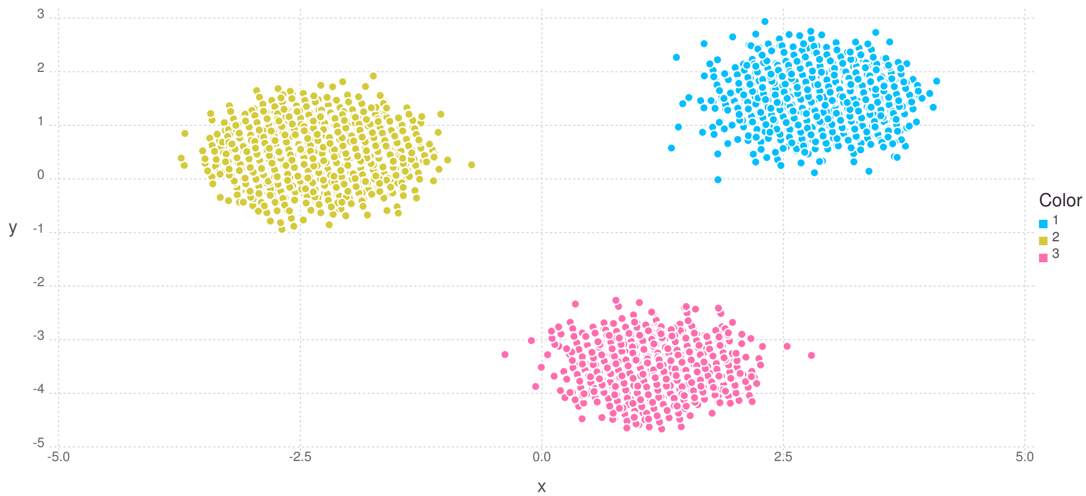
In [31]:
```
function plotpca(dataset)
    train = matrix(dataset.data)
    model = fit(PCA, train; maxoutdim=2)

    g = Array(Layer, 0)

    for k=1:dataset.groups
        kdata = data(dataset, k)
```

```
            kpoints = transform(model, matrix(kdata))
            x = vec(kpoints[1,:])
            y = vec(kpoints[2,:])
            color = fill(string(k), size(kpoints, 2))
            push!(g, layer(x=x, y=y, color=color, Geom.point)...)
        end

        plot(g)
    end
```

Out[31]: plotpca (generic function with 1 method)

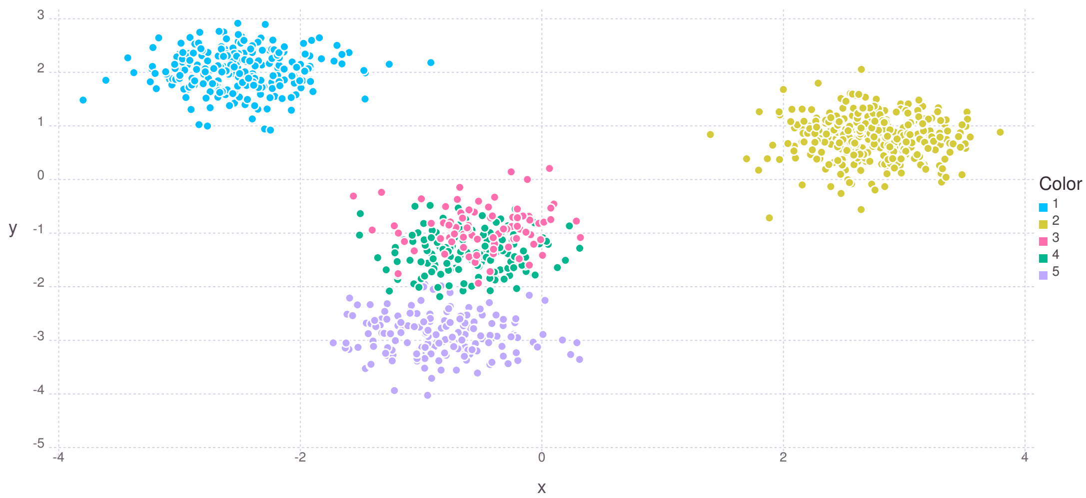
In [32]: `plotpca(dataset)`

Out[32]:



In [33]:
```
let _dataset = Dataset(groups=5, size=1000, features=200, slot=40)
    plotpca(_dataset)
end
```

Out[33]:



1.5 3. Evaluation

In [34]:
```
function distribution(dataset)
    groups = Array(Float64, dataset.groups)
    size = 0
    for k=1:dataset.groups
        size += count(dataset, k)
        groups[k] = size
    end
    groups /= size
    groups
end

distribution(dataset)
```

Out[34]:
```
3-element Array{Float64,1}:
 0.3157
 0.798
 1.0
```

In [35]:
```
function choosek(distribution)
    r = rand()
    for k=1:length(distribution)
        if r <= distribution[k]
            return k
        end
    end
    return 0
end

let
    d = [0.3, 0.5, 1.0]
    k = zeros(d)
```

```
    n = 100000
    for _=1:n
        i = choosek(d)
        k[i] += 1
    end
    k / n
end
```

Out[35]: 3-element Array{Float64,1}:

```
 0.29959
 0.20094
 0.49947
```

In [36]:

```
function random_clustering(dataset)
    cdf = distribution(dataset)
    clusters = Array(Int, length(dataset.data))
    for i=1:length(clusters)
        clusters[i] = choosek(cdf)
    end
    clusters
end

random_clustering(dataset)
```

Out[36]: 10000-element Array{Int64,1}:

```
 3
 2
 1
 2
 1
 1
 2
 2
 1
 2
 2
 1
 3
 ⋮
 2
 1
 1
 3
 1
 3
 1
 2
 3
 1
 1
 1
```

1.5.1 Confusion Matrix

https://en.wikipedia.org/wiki/Confusion_matrix

In [37]:
```
function evaluate(dataset, prediction)
    matrix = zeros(Int, dataset.groups, dataset.groups)
    for p=1:length(prediction)
        i = dataset.data[p][2]
        j = prediction[p]
        matrix[i,j] += 1
    end
    matrix
end

let
    prediction = random_clustering(dataset)
    evaluate(dataset, prediction)
end
```

Out[37]:
```
3x3 Array{Int64,2}:
  983  1567  607
 1474  2383  966
  646   950  424
```

In [38]:
```
evaluate(dataset, map(t -> t[2], dataset.data))
```

Out[38]:
```
3x3 Array{Int64,2}:
 3157     0     0
    0  4823     0
    0     0  2020
```

In [39]:
```
function evaluation_summary(io::IO, dataset, prediction)
    matrix = evaluate(dataset, prediction)

    n = sum(matrix)
    tp = sum(diag(matrix))
    fn = sum(triu(matrix)) - tp
    fp = sum(tril(matrix)) - tp

    precision = tp / (tp + fp)
    recall = tp / (tp + fn)
    fscore = 2 * precision * recall / (precision + recall)

    println(io, "Precision: ", round(100 * precision, 2), "%")
    println(io, "Recall: ", round(100 * recall, 2), "%")
    println(io, "F-score: ", round(fscore , 2))
    println(io)
    println(io, "Número de predições: ", n)
    println(io, "Acertos: ", tp, " (", round(100 * tp / n, 2), "%)")
    println(io, "Falso negativo: ", fn, " (", round(100 * fn / n, 2), "%)")
    println(io, "Falso positivo: ", fp, " (", round(100 * fp / n, 2), "%)")

    for k=1:dataset.groups
        kn = sum(matrix[k,:])
        ktp = matrix[k,k]
        kfn = kn - ktp
        kfp = sum(matrix[:,k]) - ktp
        ktn = n - kfn - kfp - ktp
        kacc = (ktp + ktn) / n
```

```julia
                kprecision = ktp / (ktp + kfp)
                krecall = ktp / (ktp + kfn)
                kfscore = 2 * kprecision * krecall / (kprecision + krecall)
                println(io)
                println(io, "Cluster ", k)
                println(io)
                println(io, "Objetos: ", kn)
                println(io, "Accuracy: ", round(100 * kacc, 2), "%")
                println(io, "Precision: ", round(100 * kprecision, 2), "%")
                println(io, "Recall: ", round(100 * krecall, 2), "%")
                println(io, "F-score: ", round(kfscore , 2))
                println(io)
                println(io, "Acerto positivo: ", ktp, " (", round(100 * ktp / kn, 2), "%)")
                println(io, "Acerto negativo: ", ktn, " (", round(100 * ktn / (n - kn), 2), "%)")
                println(io, "Falso negativo: ", kfn, " (", round(100 * kfn / fn, 2), "%)")
                println(io, "Falso positivo: ", kfp, " (", round(100 * kfp / fp, 2), "%)")
            end
        end

        evaluation_summary(dataset, prediction) = evaluation_summary(STDOUT, dataset, prediction)

        let
            prediction = random_clustering(dataset)
            evaluation_summary(dataset, prediction)
            sleep(0.2)
        end
```

```
Precision: 53.98%
Recall: 54.24%
F-score: 0.54

Número de predições: 10000
Acertos: 3709 (37.09%)
Falso negativo: 3129 (31.29%)
Falso positivo: 3162 (31.62%)

Cluster 1

Objetos: 3157
Accuracy: 56.63%
Precision: 31.57%
Recall: 32.02%
F-score: 0.32

Acerto positivo: 1011 (32.02%)
Acerto negativo: 4652 (67.98%)
Falso negativo: 2146 (68.58%)
Falso positivo: 2191 (69.29%)

Cluster 2

Objetos: 4823
Accuracy: 49.89%
Precision: 48.04%
```

```
Recall: 47.69%
F-score: 0.48

Acerto positivo: 2300 (47.69%)
Acerto negativo: 2689 (51.94%)
Falso negativo: 2523 (80.63%)
Falso positivo: 2488 (78.68%)

Cluster 3

Objetos: 2020
Accuracy: 67.66%
Precision: 19.8%
Recall: 19.7%
F-score: 0.2

Acerto positivo: 398 (19.7%)
Acerto negativo: 6368 (79.8%)
Falso negativo: 1622 (51.84%)
Falso positivo: 1612 (50.98%)
```

```
In [40]: evaluation_summary(dataset, map(t -> t[2], dataset.data))
         sleep(0.2)
```

```
Precision: 100.0%
Recall: 100.0%
F-score: 1.0

Número de predições: 10000
Acertos: 10000 (100.0%)
Falso negativo: 0 (0.0%)
Falso positivo: 0 (0.0%)

Cluster 1

Objetos: 3157
Accuracy: 100.0%
Precision: 100.0%
Recall: 100.0%
F-score: 1.0

Acerto positivo: 3157 (100.0%)
Acerto negativo: 6843 (100.0%)
Falso negativo: 0 (NaN%)
Falso positivo: 0 (NaN%)

Cluster 2

Objetos: 4823
Accuracy: 100.0%
Precision: 100.0%
Recall: 100.0%
F-score: 1.0

Acerto positivo: 4823 (100.0%)
```

```
Acerto negativo: 5177 (100.0%)
Falso negativo: 0 (NaN%)
Falso positivo: 0 (NaN%)

Cluster 3

Objetos: 2020
Accuracy: 100.0%
Precision: 100.0%
Recall: 100.0%
F-score: 1.0

Acerto positivo: 2020 (100.0%)
Acerto negativo: 7980 (100.0%)
Falso negativo: 0 (NaN%)
Falso positivo: 0 (NaN%)
```

```
In [41]: let
             n = 100
             k = 3
             c = 16
             c_y = 3

             tiny = Dataset(size=n, groups=k, features=c, slot=c_y)
             summary(tiny)

             assignments = map(t -> rand() <= 0.7 ? k - t[2] + 1 : rand(1:k), tiny.data)

             centermap = zeros(Int, k)
             groups = map(v -> v[2], tiny.data)
             for i=1:k
                 g_index = findin(groups, i)
                 centers = map(i -> assignments[i], g_index)
                 counts = hist(centers, 0:k)[2]
                 center_key = indmax(counts)
                 if centermap[center_key] != 0
                     error("Center already mapped: $(center_key) -> $(centermap[center_key]), now $i?")
                 end
                 centermap[center_key] = i
             end
             println(collect(enumerate(centermap)))
             sleep(0.2)
         end
```

```
Number of Groups: 3
Number of Features: 16
Number of Features (group): 3
Probability of Activation: 0.8
Number of Objects (total): 100
Number of Objects per Group (min): 7
Number of Objects per Group (max): 66
Number of Objects in 1: 12
Number of Objects in 2: 35
Number of Objects in 3: 53
[(1,3),(2,2),(3,1)]
```

```
In [42]: function mapping(dataset, assignments, k)
             centermap = zeros(Int, k)
             groups = map(v -> v[2], dataset.data)
             for i=1:dataset.groups
                 g_index = findin(groups, i)
                 centers = map(i -> assignments[i], g_index)
                 counts = hist(centers, 0:k)[2]
                 center_key = indmax(counts)
                 if centermap[center_key] != 0
                     error("Center already mapped: $(center_key) -> $(centermap[center_key]), now $i?")
                 end
                 centermap[center_key] = i
             end
             centermap
         end

         let
             assignments = map(t -> rand() <= 0.7 ? dataset.groups - t[2] + 1 : rand(1:dataset.groups),
             centermap = mapping(dataset, assignments, dataset.groups)
             collect(enumerate(centermap))
         end
```

```
Out[42]: 3-element Array{Tuple{Int64,Int64},1}:
          (1,3)
          (2,2)
          (3,1)
```

1.6 4. Export / Load

1.6.1 JLD

https://github.com/JuliaLang/JLD.jl

Saving and loading julia variables while preserving native types

```
In [55]: if Pkg.installed("JLD") === nothing
             println("Installing JLD...")
             Pkg.add("JLD")
         end
```

```
In [56]: using JLD
```

```
In [57]: save("dataset.jld", "large", dataset)
```

```
In [58]: stat("dataset.jld")
```

```
Out[58]: StatStruct(mode=100644, size=23790496)
```

```
In [59]: let ds = load("dataset.jld", "large")
             summary(ds)
             sleep(0.2)
         end
```

```
Number of Groups: 3
Number of Features: 200
Number of Features (group): 40
Probability of Activation: 0.8
```

```
Number of Objects (total): 10000
Number of Objects per Group (min): 667
Number of Objects per Group (max): 6666
Number of Objects in 1: 3157
Number of Objects in 2: 4823
Number of Objects in 3: 2020
```

In [60]:
```
rm("dataset.jld")
```

In [61]:
```
function export_dataset(name, dataset)
    path = "../dataset/" * name
    isdir(path) && rm(path, recursive=true)
    mkdir(path)
    open(path * "/summary.txt", "w") do f
        summary(f, dataset)
    end
    open(path * "/baseline.txt", "w") do f
        prediction = random_clustering(dataset)
        evaluation_summary(f, dataset, prediction)
    end
    save(path * "/dataset.jld", "dataset", dataset)
    draw(PNG(path * "/plothalf.png", 24cm, 16cm), plothalf(dataset))
    draw(PNG(path * "/plothalf_multi.png", 24cm, 16cm), plothalf_multi(dataset))
    draw(PNG(path * "/plotslot.png", 24cm, 16cm), plotslot(dataset))
    draw(PNG(path * "/plotslot_multi.png", 24cm, 16cm), plotslot_multi(dataset))
    draw(PNG(path * "/plotpca.png", 24cm, 16cm), plotpca(dataset))
end

export_dataset("test", dataset)
readdir("../dataset/test")
```

Out[61]:
```
8-element Array{ByteString,1}:
 "baseline.txt"
 "dataset.jld"
 "plothalf_multi.png"
 "plothalf.png"
 "plotpca.png"
 "plotslot_multi.png"
 "plotslot.png"
 "summary.txt"
```

In [62]:
```
function load_dataset(name)
    path = "../dataset/" * name
    load(path * "/dataset.jld", "dataset")
end

load_dataset("test")
```

Out[62]:
```
Dataset(3,200,40,0.8,10000,667,6666,[([1,1,1,1,1,1,1,1,1,0  ...  0,1,1,0,0,0,1,1,0,0],1),([1,1
```

In [63]:
```
rm("../dataset/test", recursive=true)
```

In [64]:
```
function create_large_dataset()
    dataset = Dataset(groups=3, size=1000, features=200, slot=40)
    export_dataset("large", dataset)
end
```

```
create_large_dataset()

readdir("../dataset/large")
```

Out[64]:

```
8-element Array{ByteString,1}:
 "baseline.txt"
 "dataset.jld"
 "plothalf_multi.png"
 "plothalf.png"
 "plotpca.png"
 "plotslot_multi.png"
 "plotslot.png"
 "summary.txt"
```

In [65]:

```
function create_small_dataset()
    dataset = Dataset(groups=3, size=100, features=200, slot=40)
    export_dataset("small", dataset)
end

create_small_dataset()

readdir("../dataset/small")
```

Out[65]:

```
8-element Array{ByteString,1}:
 "baseline.txt"
 "dataset.jld"
 "plothalf_multi.png"
 "plothalf.png"
 "plotpca.png"
 "plotslot_multi.png"
 "plotslot.png"
 "summary.txt"
```