PBDataAnalysis

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Introduction

PBDataAnalysis is a C library providing structures and functions to perform various data analysis.

It implements the following algorithms:

- K-means clustering (random, Forgy and plusplus seeds)

It uses the `PBErr`, `PBMath`, `PBJSon`, `GSet` libraries.

1 Definitions

1.1 K-means clustering

The goal of the K-means clustering algorithm is to find K Voronoi cells which clusters a data set in a way that for each cells the center of this cell is the nearest possible to the average value of the input data inside this cell.

The K-means algorithm is as follow, where 'seed' defines the way we initialise the algorithm: 'random', 'Forgy' or 'plusplus'.

As an example of use, code is provided to compute the target dimensions in the config file of YoloV3 given the target bounding boxes of the training data set, using K-means clustering.

```
if seed = random
  init the center of each cluster with a random value inside the bounds
  of the input data
else if seed = Forgy
  init the center of each cluster with one of the input data randomly
  choosen, one given input data can't be choosen twice
else if seed = pluspus
  choose one center uniformly at random from among the data points
  for each data point x, compute D(x), the distance between x and the
  nearest center that has already been chosen
  choose one new data point at random as a new center, using a weighted
  probability distribution where a point x is chosen with probability
  proportional to D(x)
  repeat the previous 2 steps until k centers have been chosen
loop until clusters' center have all converged
  init K empty sets S[]
  for each input data I
    ID = get the cluster containing I
    add I to S[ID]
  for each set S[I]
    AVG = calculate the average value of the input in S[I]
    if AVG is equal to the center of the I-th cluster
      the center of the I-th cluster has converged
    else
      set the center of the I-th cluster to AVG
```

2 Interface

```
// ============ PBDATAANALYSIS.H ================

#ifndef PBDATAANALYSIS_H
#define PBDATAANALYSIS_H

// ================= Include =================

#include <stdlib.h>
```

```c
#include <stdio.h>
#include <stdbool.h>
#include <execinfo.h>
#include <errno.h>
#include <string.h>
#include "pberr.h"
#include "pbmath.h"
#include "pbjson.h"
#include "gset.h"
#include "gdataset.h"

// ---------------- Principal component analysis --------------

// ================= Define =================

// ================= Data structure ==================

typedef struct PrincipalComponentAnalysis {
  // Principal components, stored from the most influent to the less one
  GSetVecFloat _components;
} PrincipalComponentAnalysis;

// ================ Functions declaration ===================

// Create a static PrincipalComponentAnalysis
PrincipalComponentAnalysis PrincipalComponentAnalysisCreateStatic();

// Free the memory used by the static PrincipalComponentAnalysis
void PrincipalComponentAnalysisFreeStatic(
  PrincipalComponentAnalysis* const that);

// Calculate the principal components for the 'dataset' and
// store the result into the PrincipalComponentAnalysis 'that'
void PCASearch(PrincipalComponentAnalysis* const that,
  const GDataSetVecFloat* const dataset);

// Get the 'dataset' converted through the first 'nb' components of the
// PrincipalComponentAnalysis 'that'
// Return a new data set, the dataset in arguments is not modified
// Return an empty dataset if the principal components have not yet been
// calculated (using the PCASearch function)
// Returned VecFloat have dimension 'nb'. Returned GSet has same nbsample
// as 'dataset'
// Dimension of VecFloat in 'dataset' must be equal to the size of
// components in 'that'
GDataSetVecFloat PCAConvert(const PrincipalComponentAnalysis* const that,
  const GDataSetVecFloat* const dataset, const int nb);

// Get the principal components of the PrincipalComponentAnalysis 'that'
#if BUILDMODE != 0
inline
#endif
const GSetVecFloat* PCAComponents(
  const PrincipalComponentAnalysis* const that);

// Get the number of principal components of the
// PrincipalComponentAnalysis 'that'
#if BUILDMODE != 0
inline
#endif
int PCAGetNbComponents(
  const PrincipalComponentAnalysis* const that);
```

```
// Print the principal components of the PrincipalComponentAnalysis 'that'
// on 'stream'
void PCAPrintln(const PrincipalComponentAnalysis* const that,
  FILE* const stream);

// ----------------- K-means clustering ---------------

// ================= Define ==================

// ================= Data structure ===================

typedef enum KMeansClustersSeed {
  KMeansClustersSeed_Random, KMeansClustersSeed_Forgy,
  KMeansClustersSeed_PlusPlus
} KMeansClustersSeed;
#define KMeansClustersSeed_Default KMeansClustersSeed_PlusPlus

typedef struct KMeansClusters {
  GSetVecFloat _centers;
  KMeansClustersSeed _seed;
} KMeansClusters;

// ================ Functions declaration ====================

// Create a KMeansClusters for a K-means clustering initialized
// using the 'seed' technique
KMeansClusters KMeansClustersCreateStatic(const KMeansClustersSeed seed);

// Free the memory used by a KMeansClusters
void KMeansClustersFreeStatic(KMeansClusters* const that);

// Create the set of 'K' clusters clustering the 'input' data according
// to the K-means algorithm
// 'K' must be inferior or equal to the number of input data
// srandom() must have been called before using this function
void KMeansClustersSearch(KMeansClusters* const that,
  const GSetVecFloat* const input, const int K);

// Get the set of clusters' center for the KMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
const GSetVecFloat* KMeansClustersCenters(
  const KMeansClusters* const that);

// Get the 'iCluster'-th cluster's center for the KMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
const VecFloat* _KMeansClustersCenterFromId(
  const KMeansClusters* const that, const int iCluster);

// Get the seed of the KMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
KMeansClustersSeed KMeansClustersGetSeed(const KMeansClusters* const that);

// Set the seed of the KMeansClusters 'that' to 'seed'
#if BUILDMODE != 0
inline
```

```
#endif
void KMeansClustersSetSeed(KMeansClusters* const that,
  const KMeansClustersSeed seed);

// Get the center of the cluster including the 'input' data for the
// KMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
const VecFloat* _KMeansClustersCenterFromPos(
  const KMeansClusters* const that, const VecFloat* input);

// Get the index of the cluster including the 'input' data for the
// KMeansClusters 'that'
int KMeansClustersGetId(const KMeansClusters* const that,
  const VecFloat* input);

// Get the seed of the KMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
int KMeansClustersGetK(const KMeansClusters* const that);

// Print the KMeansClusters 'that' on the stream 'stream'
void KMeansClustersPrintln(const KMeansClusters* const that,
  FILE* const stream);

// Load the KMeansClusters 'that' from the stream 'stream'
bool KMeansClustersLoad(KMeansClusters* that, FILE* const stream);

// Save the KMeansClusters 'that' to the stream 'stream'
// If 'compact' equals true it saves in compact form, else it saves in
// readable form
// Return true upon success else false
bool KMeansClustersSave(const KMeansClusters* const that,
  FILE* const stream, const bool compact);

// Function which return the JSON encoding of 'that'
JSONNode* KMeansClustersEncodeAsJSON(const KMeansClusters* const that);

// Function which decode from JSON encoding 'json' to 'that'
bool KMeansClustersDecodeAsJSON(KMeansClusters* that,
  const JSONNode* const json);

// ================= Polymorphism ==================

#define KMeansClustersCenter(Cluster, Input) _Generic(Input, \
  VecFloat*: _KMeansClustersCenterFromPos, \
  const VecFloat*: _KMeansClustersCenterFromPos, \
  int: _KMeansClustersCenterFromId, \
  const int: _KMeansClustersCenterFromId, \
  default: PBErrInvalidPolymorphism)(Cluster, Input)

// ================ Inliner ===================

#if BUILDMODE != 0
#include "pbdataanalysis-inline.c"
#endif

#endif
```

3 Code

3.1 pbdataanalysis.c

```
// ============ PBDATAANALYSIS.C ================

// ================= Include =================

#include "pbdataanalysis.h"
#if BUILDMODE == 0
#include "pbdataanalysis-inline.c"
#endif

// ----------------- Principal component analysis ---------------

// ================ Functions declaration ====================

// ================ Functions implementation ====================

// Create a static PrincipalComponentAnalysis
PrincipalComponentAnalysis PrincipalComponentAnalysisCreateStatic() {
  // Declare the PrincipalComponentAnalysis
  PrincipalComponentAnalysis that;
  // Init the properties
  that._components = GSetVecFloatCreateStatic();
  // Return the PrincipalComponentAnalysis
  return that;
}

// Free the memory used by the static PrincipalComponentAnalysis
void PrincipalComponentAnalysisFreeStatic(
  PrincipalComponentAnalysis* const that) {
  if (that == NULL)
    return;
  // Free memory
  while(GSetNbElem(PCAComponents(that)) > 0) {
    VecFloat* v = GSetPop(&(that->_components));
    VecFree(&v);
  }
}

// Calculate the principal components for the 'dataset' and
// store the result into the PrincipalComponentAnalysis 'that'
// http://setosa.io/ev/principal-component-analysis/
// https://www.dezyre.com/data-science-in-python-tutorial/principal-component-analysis-tutorial
void PCASearch(PrincipalComponentAnalysis* const that,
  const GDataSetVecFloat* const dataset) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(GSetErr);
  }
  if (dataset == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'dataset' is null");
    PBErrCatch(GSetErr);
  }
#endif
  // Create a centered and normalized version of the dataset
  GDataSetVecFloat set = GDSClone(dataset);
```

```
  GDSNormalize(&set);
  GDSMeanCenter(&set);

  // Calculate the covariance matrix
  MatFloat* covariance = GDSGetCovarianceMatrix(&set);
//MatFloatPrintln(covariance, stdout, 6);

  // Calculate the Eigen values and vectors of the covariance matrix
  that->_components = MatGetEigenValues(covariance);

  // Pop out the unused Eigen values
  VecFloat* v = GSetPop(&(that->_components));
  VecFree(&v);

  // Free memory
  MatFree(&covariance);
  GDataSetVecFloatFreeStatic(&set);
}

// Get the 'dataset' converted through the first 'nb' components of the
// PrincipalComponentAnalysis 'that'
// Return a new data set, the dataset in arguments is not modified
// Return an empty dataset if the principal components have not yet been
// calculated (using the PCASearch function)
// Returned VecFloat have dimension 'nb'. Returned GSet has same nbsample
// as 'dataset'
// Dimension of VecFloat in 'dataset' must be equal to the size of
// components in 'that'
GDataSetVecFloat PCAConvert(const PrincipalComponentAnalysis* const that,
  const GDataSetVecFloat* const dataset, const int nb) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(GSetErr);
  }
  if (dataset == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'dataset' is null");
    PBErrCatch(GSetErr);
  }
  if (nb < 1) {
    PBDataAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBDataAnalysisErr->_msg, "'nb' is invalid (%d>0)", nb);
    PBErrCatch(GSetErr);
  }
  if (VecGetDim(GSetGet(PCAComponents(that), 0)) !=
    VecGet(GDSSampleDim(dataset), 0)) {
    PBDataAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBDataAnalysisErr->_msg,
      "Size of samples in dataset doesn't match size of component "
      "(%ld=%d)", VecGetDim(GSetGet(PCAComponents(that), 0)),
      VecGet(GDSSampleDim(dataset), 0));
    PBErrCatch(GSetErr);
  }
#endif
  // Declare the result dataset
  GDataSetVecFloat res = GDSClone(dataset);

  // Create the matrix of 'nb' first transposed components
  VecShort2D dimFeatures = VecShortCreateStatic2D();
  VecSet(&dimFeatures, 0, VecGetDim(GSetGet(PCAComponents(that), 0)));
```

```
  VecSet(&dimFeatures, 1, nb);
  MatFloat* features = MatFloatCreate(&dimFeatures);
  VecShort2D pos = VecShortCreateStatic2D();
  do {
    MatSet(features, &pos, VecGet(GSetGet(PCAComponents(that),
      VecGet(&pos, 1)), VecGet(&pos, 0)));
  } while(VecStep(&pos, &dimFeatures));

  // Create the matrix of transposed vectors from the data set
  GDSNormalize(&res);
  GDSMeanCenter(&res);
  VecShort2D dimData = VecShortCreateStatic2D();
  VecSet(&dimData, 0, GDSGetSize(dataset));
  VecSet(&dimData, 1, VecGet(&dimFeatures, 0));
  MatFloat* data = MatFloatCreate(&dimData);
  VecSetNull(&pos);
  do {
    MatSet(data, &pos,
      VecGet(GSetGet(GDSSamples(&res), VecGet(&pos, 0)),
      VecGet(&pos, 1)));
  } while(VecStep(&pos, &dimData));

  // Multiply the matrices
  MatFloat* proj = MatGetProdMat(features, data);

  // Create the result data set from the resulting matrix



  // Free memory
  MatFree(&features);
  MatFree(&data);
  MatFree(&proj);

  // Return the result
  return res;
}

// Print the principal components of the PrincipalComponentAnalysis 'that'
// on 'stream'
void PCAPrintln(const PrincipalComponentAnalysis* const that,
  FILE* const stream) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(GSetErr);
  }
  if (stream == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'stream' is null");
    PBErrCatch(GSetErr);
  }
#endif
  // If the components have been computed
  if (GSetNbElem(PCAComponents(that)) > 0) {
    // Create an iterator on the set of components
    // Iterate in reverse order to display the most important
    // components first
    GSetIterBackward iter =
      GSetIterBackwardCreateStatic(PCAComponents(that));
    do {
```

```
      // Get the component
      VecFloat* v = GSetIterGet(&iter);
      // Display the component
      VecPrint(v, stream); printf("\n");
    } while (GSetIterStep(&iter));
  }
}

// ----------------- K-means clustering ---------------

// ================= Define ==================

// ================ Functions declaration ====================

void KMeansClustersInitRandom(KMeansClusters* const that,
  const GSetVecFloat* const input);

void KMeansClustersInitForgy(KMeansClusters* const that,
  const GSetVecFloat* const input);

void KMeansClustersInitPlusPlus(KMeansClusters* const that,
  const GSetVecFloat* const input);

// ================ Functions implementation ====================

// Create a KMeansClusters for a K-means clustering initialized
// using the 'seed' technique
// srandom() must have been called before using this function
KMeansClusters KMeansClustersCreateStatic(const KMeansClustersSeed seed) {
  // Declare the KMeansClusters
  KMeansClusters clusters;
  // Init the properties
  clusters._seed = seed;
  clusters._centers = GSetVecFloatCreateStatic();
  // Return the KMeansClusters
  return clusters;
}

// Free the memory used by a PBDAKMeansClusters
void KMeansClustersFreeStatic(KMeansClusters* const that) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Free the memory used by the cluster centers
  while (GSetNbElem(&(that->_centers)) > 0) {
    VecFloat* v = GSetPop((GSetVecFloat*)(KMeansClustersCenters(that)));
    free(v);
  }
}

// Create the set of 'K' clusters clustering the 'input' data according
// to the K-means algorithm
// 'K' must be inferior or equal to the number of input data
// srandom() must have been called before using this function
void KMeansClustersSearch(KMeansClusters* const that,
  const GSetVecFloat* const input, const int K) {
#if BUILDMODE == 0
  if (that == NULL) {
```

```
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (input == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'input' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (K < 1) {
    PBDataAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBDataAnalysisErr->_msg, "'K' is invalid (%d>=1)", K);
    PBErrCatch(PBDataAnalysisErr);
  }
  if (GSetNbElem(input) < K) {
    PBDataAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBDataAnalysisErr->_msg, "'K' is invalid (%d<=%ld)", K,
      GSetNbElem(input));
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // If there are alreay computed clusters,
  // free the memory used by the cluster centers
  while (GSetNbElem(&(that->_centers)) > 0) {
    VecFloat* v = GSetPop((GSetVecFloat*)(KMeansClustersCenters(that)));
    free(v);
  }
  // Allocate an array of sets used for computation
  GSetVecFloat* inputsByCluster =
    PBErrMalloc(PBDataAnalysisErr, sizeof(GSetVecFloat) * K);
  // Get the dimension of the input
  long dim = VecGetDim(GSetGet(input, 0));
  // Allocate memory for the clusters' center and sets used for
  // computation
  for (int iCenter = K; iCenter--;) {
    // The dimension of the means is the same as the one of the input
    // data
    VecFloat* v = VecFloatCreate(dim);
    GSetAppend((GSetVecFloat*)(KMeansClustersCenters(that)), v);
    inputsByCluster[iCenter] = GSetVecFloatCreateStatic();
  }
  // Initialise the means according to the seed
  switch(KMeansClustersGetSeed(that)) {
    case KMeansClustersSeed_Random:
      KMeansClustersInitRandom(that, input);
      break;
    case KMeansClustersSeed_Forgy:
      KMeansClustersInitForgy(that, input);
      break;
    case KMeansClustersSeed_PlusPlus:
      KMeansClustersInitPlusPlus(that, input);
      break;
    default:
      break;
  }
  // Create a vector used for computation
  VecFloat* w = VecFloatCreate(dim);
  // Loop until the clusters' center are aligned with their
  // real center according to input data
  float shift = 1.0;
  while (shift > PBMATH_EPSILON) {
    // Reset the shift
```

```
    shift = 0.0;
    // Loop on input data
    GSetIterForward iterInput = GSetIterForwardCreateStatic(input);
    do {
      // Get the input data
      VecFloat* v = GSetIterGet(&iterInput);
      // Get the id of the cluster containing this data
      int clusterId = KMeansClustersGetId(that, v);
      // Add the input to the corresponding set
      GSetAppend(inputsByCluster + clusterId, v);
    } while(GSetIterStep(&iterInput));
    // For each cluster
    for (int iCenter = K; iCenter--;) {
      // Reset the vector used for computation
      VecSetNull(w);
      // Memorize the number of input associated to this cluster
      int nbInput = GSetNbElem(inputsByCluster + iCenter);
      // If there are data in this cluster
      if (nbInput > 0) {
        // Loop on the input contained by this cluster
        GSetIterForward iterSet =
          GSetIterForwardCreateStatic(inputsByCluster + iCenter);
        do {
          // Get the input data
          VecFloat* v = GSetIterGet(&iterSet);
          // Sum it to the temporary vector
          VecOp(w, 1.0, v, 1.0);
        } while(GSetIterStep(&iterSet));
        // Get the center (average) of the input contained by this
        // cluster
        VecScale(w, 1.0 / (float)nbInput);
        // Update the shift
        shift += VecDist(KMeansClustersCenter(that, iCenter), w);
        // Update the cluster center with the center of the input
//VecPrint(KMeansClustersCenter(that, iCenter), stdout);printf(" ");
        VecCopy((VecFloat*)KMeansClustersCenter(that, iCenter), w);
        // Reset the sets of input data
        GSetFlush(inputsByCluster + iCenter);
      }
    }
//printf(" %f\n", shift);fflush(stdout);
  }
  // Free the memory used by the vector and sets used for computation
  free(inputsByCluster);
  VecFree(&w);
}

void KMeansClustersInitRandom(KMeansClusters* const that,
  const GSetVecFloat* const input) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (input == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'input' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Get the bounds of the input data
```

```
  GSetVecFloat bounds = GSetGetBounds(input);
  VecFloat* boundMin = GSetGet(&bounds, 0);
  VecFloat* boundMax = GSetGet(&bounds, 1);
  // Get the dimension of the data
  int dim = VecGetDim(GSetGet(input, 0));
  // For each cluster's center
  for (int iCenter = KMeansClustersGetK(that); iCenter--;) {
    // Get the iCenter-th cluster center
    VecFloat* center = (VecFloat*)KMeansClustersCenter(that, iCenter);
    // Initialize randomly the components of the iCenter-th cluster's
    // center
    for (int iDim = dim; iDim--;) {
      VecSet(center, iDim, VecGet(boundMin, iDim) +
        rnd() * (VecGet(boundMax, iDim) - VecGet(boundMin, iDim)));
    }
  }
  // Free memory
  GSetFlush(&bounds);
  VecFree(&boundMin);
  VecFree(&boundMax);
}

void KMeansClustersInitForgy(KMeansClusters* const that,
  const GSetVecFloat* const input) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (input == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'input' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Create a set to select the seeds
  GSetVecFloat forgyInp = GSetVecFloatCreateStatic();
  // Get the number of inputs
  long nbInput = GSetNbElem(input);
  // Declare a variable to pick one input randomly
  VecFloat* inp = NULL;
  // For each cluster's center
  for (int iCenter = KMeansClustersGetK(that); iCenter--;) {
    // Pick an input while avoiding picking twice the same
    // Supposes K is far less than the number of inputs
    do {
      inp = GSetGet(input, (long)round(rnd() * (nbInput - 1)));
    } while (GSetFirstElem(&forgyInp, inp) != NULL);
    // Set the center of the iCenter-th cluster to this input
    VecCopy((VecFloat*)KMeansClustersCenter(that, iCenter), inp);
  }
  // Empty the set used to select the seeds
  GSetFlush(&forgyInp);
}

void KMeansClustersInitPlusPlus(KMeansClusters* const that,
  const GSetVecFloat* const input) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
```

```
    PBErrCatch(PBDataAnalysisErr);
  }
  if (input == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'input' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (GSetNbElem(input) < KMeansClustersGetK(that)) {
    PBDataAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBDataAnalysisErr->_msg, "not enough inputs (%ld>=%d)",
      GSetNbElem(input), KMeansClustersGetK(that));
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Create a copy of the set of inputs to select the seeds
  GSetVecFloat remainInp = GSetVecFloatCreateStatic();
  // For each remaining inputs
  GSetIterForward iter = GSetIterForwardCreateStatic(input);
  do {
    GSetAppend(&remainInp, (VecFloat*)GSetIterGet(&iter));
  } while (GSetIterStep(&iter));
  // Declare a variable to pick one input randomly
  VecFloat* inp = NULL;
  // Pick one input randomly for the first cluster's center
  GSetShuffle((GSet*)&remainInp);
  inp = GSetPop(&remainInp);
  // Set the center of the 1st cluster to this input
  VecCopy((VecFloat*)KMeansClustersCenter(that, 0), inp);
  // For each following cluster
  for (int iCenter = 1; iCenter < KMeansClustersGetK(that); ++iCenter) {
    // Declare a variable to memorize the sum of square of distances
    float sumDist = 0.0;
    // For each remaining inputs
    iter = GSetIterForwardCreateStatic(&remainInp);
    do {
      // Calculate the minimum distance from this input to the center
      // of already choosen cluster's center
      inp = GSetIterGet(&iter);
      float dist = VecDist(inp, KMeansClustersCenter(that, 0));
      for (int iChoosenCluster = 1; iChoosenCluster < iCenter;
        ++iChoosenCluster) {
        float d = VecDist(inp,
          KMeansClustersCenter(that, iChoosenCluster));
        if (d < dist)
          dist = d;
      }
      GSetElemSetSortVal((GSetElem*)GSetIterGetElem(&iter),
        fsquare(dist));
      sumDist += fsquare(dist);
    } while (GSetIterStep(&iter));
    // Sort the remaining inputs by their distance
    GSetSort(&remainInp);
    // Select randomly one input according to its squared distance
    float r = rnd() * sumDist;
    GSetIterBackward iterBack = GSetIterBackwardCreateStatic(&remainInp);
    float sum = GSetElemGetSortVal(GSetIterGetElem(&iterBack));
    while (r > sum && !GSetIterIsLast(&iter)) {
      GSetIterStep(&iterBack);
      sum += GSetElemGetSortVal(GSetIterGetElem(&iterBack));
    }
    inp = GSetIterGet(&iterBack);
    GSetIterRemoveElem(&iterBack);
```

```
    // Set the center of the 1st cluster to this input
    VecCopy((VecFloat*)KMeansClustersCenter(that, iCenter), inp);
  }
  // Empty the set used to select the seeds
  GSetFlush(&remainInp);
}

// Get the index of the cluster including the 'input' data for the
// KMeansClusters 'that'
int KMeansClustersGetId(const KMeansClusters* const that,
  const VecFloat* input) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (input == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'input' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Declare variables to memorize the id and distance to the input
  float dist = 0.0;
  int id = -1;
  int iCenter = 0;
  // Loop on the clusters' center
  GSetIterForward iter =
    GSetIterForwardCreateStatic(KMeansClustersCenters(that));
  do {
    // Get the center of the cluster
    VecFloat* center = GSetIterGet(&iter);
    // Calculate the distance to the input
    float d = VecDist(center, input);
    // If it's the first considered cluster or
    // if the distance is nearer
    if (id == -1 || dist > d) {
      id = iCenter;
      dist = d;
      // TODO: we can stop if the distance is less than half the
      // shortest distance between two clusters' center to make
      // this function faster
    }
    // Increment the center index
    ++iCenter;
  } while (GSetIterStep(&iter));
  // Return the id
  return id;
}

// Print the KMeansClusters 'that' on the stream 'stream'
void KMeansClustersPrintln(const KMeansClusters* const that,
  FILE* const stream) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (stream == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
```

```
    sprintf(PBDataAnalysisErr->_msg, "'stream' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Loop on clusters' center
  GSetIterForward iter =
    GSetIterForwardCreateStatic(KMeansClustersCenters(that));
  do {
    // Get the cluster's center
    const VecFloat* v = GSetIterGet(&iter);
    // Print the cluster's center
    VecPrint(v, stream);
    printf("\n");
  } while (GSetIterStep(&iter));
}

// Load the KMeansClusters 'that' from the stream 'stream'
bool KMeansClustersLoad(KMeansClusters* that, FILE* const stream) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (stream == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'stream' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Declare a json to load the encoded data
  JSONNode* json = JSONCreate();
  // Load the whole encoded data
  if (!JSONLoad(json, stream)) {
    return false;
  }
  // Decode the data from the JSON
  if (!KMeansClustersDecodeAsJSON(that, json)) {
    return false;
  }
  // Free the memory used by the JSON
  JSONFree(&json);
  // Return success code
  return true;
}

// Save the KMeansClusters 'that' to the stream 'stream'
// If 'compact' equals true it saves in compact form, else it saves in
// readable form
// Return true upon success else false
bool KMeansClustersSave(const KMeansClusters* const that,
  FILE* const stream, const bool compact) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (stream == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'stream' is null");
    PBErrCatch(PBDataAnalysisErr);
```

```
  }
#endif
  // Get the JSON encoding
  JSONNode* json = KMeansClustersEncodeAsJSON(that);
  // Save the JSON
  if (!JSONSave(json, stream, compact)) {
    return false;
  }
  // Free memory
  JSONFree(&json);
  // Return success code
  return true;
}

// Function which return the JSON encoding of 'that'
JSONNode* KMeansClustersEncodeAsJSON(const KMeansClusters* const that) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
#endif
  // Create the JSON structure
  JSONNode* json = JSONCreate();
  // Declare a buffer to convert value into string
  char val[100];
  // Encode the seed
  sprintf(val, "%u", that->_seed);
  JSONAddProp(json, "_seed", val);
  // Encode the centers
  JSONArrayStruct setCenters = JSONArrayStructCreateStatic();
  // If there are clusters
  if (KMeansClustersGetK(that) > 0) {
    // For each cluster
    GSetIterForward iter =
      GSetIterForwardCreateStatic(KMeansClustersCenters(that));
    do {
      VecFloat* center = GSetIterGet(&iter);
      JSONArrayStructAdd(&setCenters, VecEncodeAsJSON(center));
    } while (GSetIterStep(&iter));
    JSONAddProp(json, "_centers", &setCenters);
  }
  // Free memory
  JSONArrayStructFlush(&setCenters);
  // Return the created JSON
  return json;
}

// Function which decode from JSON encoding 'json' to 'that'
bool KMeansClustersDecodeAsJSON(KMeansClusters* that,
  const JSONNode* const json) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBDataAnalysisErr);
  }
  if (json == NULL) {
    PBDataAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBDataAnalysisErr->_msg, "'json' is null");
    PBErrCatch(PBDataAnalysisErr);
```

```
  }
#endif
  // Free the memory eventually used by the clusters
  KMeansClustersFreeStatic(that);
  // Get the seed from the JSON
  JSONNode* prop = JSONProperty(json, "_seed");
  if (prop == NULL) {
    return false;
  }
  int seed = atoi(JSONLabel(JSONValue(prop, 0)));
  if (seed < 0 || seed > KMeansClustersSeed_PlusPlus) {
    return false;
  }
  that->_seed = (KMeansClustersSeed)seed;
  // Decode the centers
  prop = JSONProperty(json, "_centers");
  if (prop == NULL) {
    return false;
  }
  // For each cluster
  for (int iCluster = 0; iCluster < JSONGetNbValue(prop); ++iCluster) {
    // Decode the center of the cluster
    JSONNode* center = JSONValue(prop, iCluster);
    VecFloat* v = NULL;
    if (!VecDecodeAsJSON(&v, center))
      return false;
    GSetAppend((GSet*)KMeansClustersCenters(that), v);
  }
  // Return the success code
  return true;
}
```

4 Makefile

```
# Build mode
# 0: development (max safety, no optimisation)
# 1: release (min safety, optimisation)
# 2: fast and furious (no safety, optimisation)
BUILD_MODE?=0

all: pbmake_wget main

# Automatic installation of the repository PBMake in the parent folder
pbmake_wget:
if [ ! -d ../PBMake ]; then wget https://github.com/BayashiPascal/PBMake/archive/master.zip; unzip master.zip; rm -f

# Makefile definitions
MAKEFILE_INC=../PBMake/Makefile.inc
include $(MAKEFILE_INC)

# Rules to make the executable
repo=pbdataanalysis
$($(repo)_EXENAME): \
$($(repo)_EXENAME).o \
$($(repo)_EXE_DEP) \
$($(repo)_DEP)
$(COMPILER) `echo "$($(repo)_EXE_DEP) $($(repo)_EXENAME).o" | tr ' ' '\n' | sort -u` $(LINK_ARG) $($(repo)_LINK_ARG)
```

```
$($(repo)_EXENAME).o: \
$($(repo)_DIR)/$($(repo)_EXENAME).c \
$($(repo)_INC_H_EXE) \
$($(repo)_EXE_DEP)
$(COMPILER) $(BUILD_ARG) $($(repo)_BUILD_ARG) ‘echo "$($(repo)_INC_DIR)" | tr ’ ’ ’\n’ | sort -u‘ -c $($(repo)_DIR)/
```

5 Unit tests

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include <math.h>
#include "pbdataanalysis.h"

void UnitTestKMean() {
  srandom(3);
  GSetVecFloat input = GSetVecFloatCreateStatic();
  int K = 3;
  float mean = 0.0;
  float sigma = 3.0;
  Gauss gauss = GaussCreateStatic(mean, sigma);
  int nbData = 100;
  VecFloat2D tgtMean[3];
  FILE* csvFile = fopen("./kmeancluster.csv", "w");
  for (int iInput = 0; iInput < K; ++iInput) {
    tgtMean[iInput] = VecFloatCreateStatic2D();
    VecSet(tgtMean + iInput, 0, rnd() * 50.0);
    VecSet(tgtMean + iInput, 1, rnd() * 50.0);
    printf("Target #%d: ", iInput);
    VecPrint(tgtMean + iInput, stdout);
    printf("\n");
    fprintf(csvFile, "%f %f\n",
      VecGet(tgtMean + iInput, 0),
      VecGet(tgtMean + iInput, 1));
  }
  fprintf(csvFile, "\n");
  for (int iData = 0; iData < nbData; ++iData) {
    for (int iInput = 0; iInput < K; ++iInput) {
      VecFloat* vFloat = VecFloatCreate(2);
      GSetAppend(&input, vFloat);
      VecSet(vFloat, 0, VecGet(tgtMean + iInput, 0) +
        GaussRnd(&gauss));
      VecSet(vFloat, 1, VecGet(tgtMean + iInput, 1) +
        GaussRnd(&gauss));
      fprintf(csvFile, "%f %f ",
        VecGet(vFloat, 0), VecGet(vFloat, 1));
    }
    fprintf(csvFile, "\n");
  }
  fprintf(csvFile, "\n");
  printf("--- Seed: random\n");
  KMeansClustersSeed seed = KMeansClustersSeed_Random;
  KMeansClusters clusters = KMeansClustersCreateStatic(seed);
  KMeansClustersSearch(&clusters, &input, K);
  if (GSetNbElem(KMeansClustersCenters(&clusters)) != K) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
```

```
    sprintf(PBDataAnalysisErr->_msg, "_GetKMeansClusterFloat NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
  for (int iCenter = 0; iCenter < K; ++iCenter) {
    const VecFloat* vFloat = KMeansClustersCenter(&clusters, iCenter);
    printf("Cluster #%d: ", iCenter);
    VecPrint(vFloat, stdout);
    printf("\n");
    fprintf(csvFile, "%f %f\n",
      VecGet(vFloat, 0), VecGet(vFloat, 1));
  }
  KMeansClustersFreeStatic(&clusters);
  printf("--- Seed: forgy\n");
  seed = KMeansClustersSeed_Forgy;
  clusters = KMeansClustersCreateStatic(seed);
  KMeansClustersSearch(&clusters, &input, K);
  if (GSetNbElem(KMeansClustersCenters(&clusters)) != K) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
    sprintf(PBDataAnalysisErr->_msg, "_GetKMeansClusterFloat NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
  for (int iCenter = 0; iCenter < K; ++iCenter) {
    const VecFloat* vFloat = KMeansClustersCenter(&clusters, iCenter);
    printf("Cluster #%d: ", iCenter);
    VecPrint(vFloat, stdout);
    printf("\n");
    fprintf(csvFile, "%f %f\n",
      VecGet(vFloat, 0), VecGet(vFloat, 1));
  }
  KMeansClustersFreeStatic(&clusters);
  printf("--- Seed: plusplus\n");
  seed = KMeansClustersSeed_PlusPlus;
  clusters = KMeansClustersCreateStatic(seed);
  KMeansClustersSearch(&clusters, &input, K);
  if (GSetNbElem(KMeansClustersCenters(&clusters)) != K) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
    sprintf(PBDataAnalysisErr->_msg, "_GetKMeansClusterFloat NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
  for (int iCenter = 0; iCenter < K; ++iCenter) {
    const VecFloat* vFloat = KMeansClustersCenter(&clusters, iCenter);
    printf("Cluster #%d: ", iCenter);
    VecPrint(vFloat, stdout);
    printf("\n");
    fprintf(csvFile, "%f %f\n",
      VecGet(vFloat, 0), VecGet(vFloat, 1));
  }
  FILE* fd = fopen("./kmeancluster.txt", "w");
  if (!KMeansClustersSave(&clusters, fd, false)) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
    sprintf(PBDataAnalysisErr->_msg, "KMeansClustersSave NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
  fclose(fd);
  KMeansClusters loadClusters =
    KMeansClustersCreateStatic(KMeansClustersSeed_Default);
  fd = fopen("./kmeancluster.txt", "r");
  if (!KMeansClustersLoad(&loadClusters, fd)) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
    sprintf(PBDataAnalysisErr->_msg, "KMeansClustersLoad NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
```

```
  fclose(fd);
  if (clusters._seed != loadClusters._seed ||
    GSetNbElem(KMeansClustersCenters(&clusters)) !=
      GSetNbElem(KMeansClustersCenters(&loadClusters))) {
    PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
    sprintf(PBDataAnalysisErr->_msg, "KMeansClustersLoad NOK");
    PBErrCatch(PBDataAnalysisErr);
  }
  GSetIterForward iter =
    GSetIterForwardCreateStatic(KMeansClustersCenters(&clusters));
  GSetIterForward iterLoad =
    GSetIterForwardCreateStatic(KMeansClustersCenters(&loadClusters));
  do {
    VecFloat* u = GSetIterGet(&iter);
    VecFloat* v = GSetIterGet(&iterLoad);
    if (VecIsEqual(u, v) == false) {
      PBDataAnalysisErr->_type = PBErrTypeUnitTestFailed;
      sprintf(PBDataAnalysisErr->_msg, "KMeansClustersLoad NOK");
      PBErrCatch(PBDataAnalysisErr);
    }
  } while (GSetIterStep(&iter) && GSetIterStep(&iterLoad));
  KMeansClustersFreeStatic(&loadClusters);
  KMeansClustersFreeStatic(&clusters);
  fclose(csvFile);
  while (GSetNbElem(&input) > 0) {
    VecFloat* v = GSetPop(&input);
    VecFree(&v);
  }
  printf("UnitTestKMean OK\n");
}

void UnitTestPCA() {
  char* datasetPath = "./unitTestPCA.json";
  GDataSetVecFloat dataset =
    GDataSetVecFloatCreateStaticFromFile(datasetPath);
  PrincipalComponentAnalysis pca =
    PrincipalComponentAnalysisCreateStatic();
  PCASearch(&pca, &dataset);
  printf("Components:\n");
  PCAPrintln(&pca, stdout);
  GDataSetVecFloat convDataSet1D = PCAConvert(&pca, &dataset, 1);
  printf("Projection on 1st component:\n");
  GSetIterForward iter =
    GSetIterForwardCreateStatic(GDSSamples(&convDataSet1D));
  do {
    VecFloat* sample = GSetIterGet(&iter);
    VecPrint(sample, stdout); printf("\n");
  } while (GSetIterStep(&iter));
  GDataSetVecFloat convDataSet2D = PCAConvert(&pca, &dataset, 2);
  printf("Projection on 2nd component:\n");
  iter = GSetIterForwardCreateStatic(GDSSamples(&convDataSet2D));
  do {
    VecFloat* sample = GSetIterGet(&iter);
    VecPrint(sample, stdout); printf("\n");
  } while (GSetIterStep(&iter));
  GDataSetVecFloatFreeStatic(&convDataSet1D);
  GDataSetVecFloatFreeStatic(&convDataSet2D);
  PrincipalComponentAnalysisFreeStatic(&pca);
  GDataSetVecFloatFreeStatic(&dataset);
  printf("UnitTestPCA OK\n");
}
```

```
void UnitTestAll() {
  UnitTestKMean();
  UnitTestPCA();
}

int main(void) {
  //UnitTestAll();
  UnitTestPCA();
  return 0;
}
```

6 Unit tests output

```
Target #0: <28.069,11.249>
Target #1: <19.655,22.197>
Target #2: <14.252,7.239>
--- Seed: random
Cluster #0: <19.957,21.695>
Cluster #1: <13.881,7.343>
Cluster #2: <28.442,11.917>
--- Seed: forgy
Cluster #0: <28.442,11.917>
Cluster #1: <19.957,21.695>
Cluster #2: <13.881,7.343>
--- Seed: plusplus
Cluster #0: <28.442,11.917>
Cluster #1: <13.881,7.343>
Cluster #2: <19.957,21.695>
UnitTestKMean OK
```

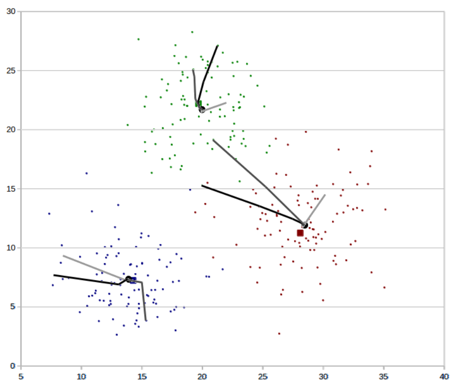
kmeancluster.csv:

```
28.069008 11.249166
19.654589 22.196920
14.252063 7.239053

28.633823 12.292907 19.235598 18.823492 12.592678 3.948273
26.052284 19.234270 18.743282 24.418528 10.458279 5.078588
26.130377 12.850240 22.535856 21.906000 10.845601 13.083977
26.455097 8.574337 18.511803 20.898256 14.739879 4.883637
28.733614 10.599995 23.665422 25.562561 14.357016 6.407752
28.550997 10.792174 15.249710 18.156441 20.529245 7.550764
29.843285 10.751228 20.759161 25.732025 9.862355 9.238699
29.386349 10.359576 22.475607 19.885624 14.946790 11.217808
28.227690 11.757756 22.867130 25.741074 14.902649 10.882385
28.538338 19.813602 18.626719 26.148878 11.498481 5.557252
23.947056 8.374683 20.750635 24.407253 13.187488 6.842857
28.845385 11.675117 22.477848 25.658518 16.712572 6.494166
28.240320 6.265765 18.270994 16.920401 12.141680 9.390920
24.723717 8.320883 22.146622 22.992455 11.246556 7.748080
26.633812 6.446450 13.803344 20.392096 18.239250 9.086374
30.953035 9.323502 21.829857 21.131969 16.259020 7.211296
31.116953 12.879289 23.409569 22.789968 14.732009 6.460821
20.959503 12.602968 17.141291 23.852451 14.999218 8.711921
27.956499 13.609019 18.733019 22.014162 15.527146 10.999743
31.872864 8.943518 18.358654 24.653770 8.360085 10.208816
26.097677 16.264061 24.531662 23.721464 12.468403 6.878686
```

26.388678	11.445029	20.422182	25.463303	14.714397	3.323504
24.513933	7.059963	18.509027	22.554037	18.467571	4.957978
29.366932	10.861627	17.426935	22.157187	14.995366	8.656789
31.595938	14.901086	19.876196	26.168688	12.279941	6.107559
27.047731	18.721298	17.749092	27.143915	17.660381	4.754192
24.668179	13.485799	21.459522	22.727383	13.219142	7.327538
30.785263	15.390684	23.087008	21.896502	11.119055	6.156090
25.330399	12.283073	18.255594	22.551985	12.758935	11.746021
24.778790	12.417658	15.977521	20.013983	17.043211	8.389001
31.640587	12.987787	17.524673	20.441366	14.605970	4.453372
29.095758	11.579761	22.153564	18.537165	14.559906	8.431289
32.779095	15.358913	20.257149	25.212011	13.068298	10.726461
35.030907	6.639762	21.238081	25.346832	16.072897	6.441304
26.896448	16.172876	14.700457	27.644926	8.433315	7.357404
32.441208	13.260548	18.330910	24.867006	14.426729	3.567520
19.391371	12.997995	15.806515	19.831161	15.215398	5.320875
28.895748	9.814054	20.318626	23.252077	7.718215	7.693003
27.068031	10.696910	16.536890	22.733471	15.396071	5.993648
32.208397	16.384439	25.096729	21.963247	11.924290	10.051946
26.491650	6.049950	20.415474	22.120098	10.869869	5.957185
26.589045	10.089059	18.382231	22.843460	14.501829	10.078506
26.485561	12.192287	19.841579	19.588705	13.052887	9.544924
24.927652	12.940019	17.671413	26.235970	15.761093	6.421089
31.238827	18.318321	19.240604	25.089767	11.164451	6.369447
28.939318	12.142779	18.180834	20.816853	12.375098	5.505887
27.630131	10.561348	22.605457	19.463205	14.375712	7.359557
27.850735	13.993544	15.209973	21.950428	14.728844	5.261156
30.143599	11.337689	15.328620	22.779089	8.273642	8.736053
30.769220	12.207006	19.299946	24.585787	17.362402	4.612987
32.244652	10.282434	17.320114	19.385283	12.901281	2.647302
24.538588	11.602779	17.704199	17.823856	18.038988	7.197000
32.762169	13.371628	17.284149	17.552122	8.941116	7.436787
22.792772	10.254848	22.606411	20.504032	16.266470	4.143282
29.497095	8.332836	20.680696	21.482531	7.318890	12.883151
25.626740	11.106087	21.263109	27.102179	13.899856	5.798704
29.959078	5.556306	17.444815	18.728331	13.491052	3.413284
29.565657	11.146928	16.102915	18.778042	12.468431	7.059418
20.874537	9.183593	20.529369	20.739050	11.255786	9.527601
28.047850	10.108035	23.392248	19.218472	16.328957	9.925616
28.980659	13.423824	25.531322	18.621786	21.656321	8.177464
23.947527	13.464624	20.417976	25.766447	13.998024	8.555392
20.401991	15.498606	20.430428	24.843374	12.270667	5.141373
28.698526	13.782323	23.226360	18.814350	18.963131	14.917116
24.172115	14.940063	20.003445	25.918982	12.409090	5.246104
28.780060	12.445168	17.376379	16.831505	10.603637	5.899348
29.091532	14.746472	17.044893	23.312666	17.813711	4.991867
29.301987	14.153702	18.020756	25.616367	11.686535	7.868994
31.022701	8.606833	22.743259	17.513430	15.340607	3.845795
29.180979	11.557543	23.135773	22.946238	16.151800	5.273566
27.930099	14.438169	22.556080	24.529539	12.015292	9.173822
33.846203	16.903858	18.179155	16.632879	12.875151	9.295219
25.154898	11.033173	23.341743	19.887142	16.519030	10.240064
35.106670	13.242561	21.428787	21.090490	12.723807	7.010818
25.209135	12.850850	25.295937	18.056234	13.486193	7.795741
29.438828	15.266409	23.976778	24.548758	9.845288	4.550106
29.725252	6.946030	18.197956	24.123976	15.505687	5.925257
27.486713	8.837636	20.891312	19.136850	13.277709	6.045727
29.519789	14.146199	23.007465	22.318642	13.021230	13.619496
26.245506	13.107677	21.434750	21.703260	13.752280	5.025379
33.955357	7.920842	19.684978	21.106571	7.609594	6.834551
27.990343	10.415890	16.665651	17.502064	14.444242	7.779035
26.135830	12.700714	22.301006	19.147243	17.841988	9.468630

```
25.933100 15.111071 22.559328 21.635067 12.447936 10.128994
27.279961 15.185240 15.790156 16.344282 15.927351 5.365943
25.760311 13.632949 20.413557 18.830910 11.671001 7.179329
31.429111 14.423276 19.958885 15.272199 17.757336 3.014699
32.629345 10.570017 18.707993 22.012554 14.535404 3.854448
28.192547 8.295099 16.633928 24.252712 16.008110 5.620173
26.773861 9.202416 23.548534 18.603050 13.867304 5.248979
29.160664 10.902171 20.796232 18.358614 11.421997 3.795157
30.813576 8.899913 23.060558 15.621967 10.409031 16.299700
20.219097 13.715732 20.710800 25.666639 17.539631 7.110938
33.206272 13.169051 21.665442 26.510429 16.426327 8.984314
33.969456 18.170853 23.012854 21.830002 15.478644 7.657965
29.226646 9.814377 22.302011 19.372135 11.912398 8.626127
26.332895 2.736907 19.141897 28.252583 17.338530 8.767639
31.999931 13.560342 18.478439 22.093273 20.308399 7.575285
24.406387 14.606756 15.232427 18.946995 14.076594 8.607273
33.677944 15.398574 16.708639 20.123032 11.821822 5.521711

19.956741 21.694563
13.880673 7.343436
28.442356 11.917128
28.442356 11.917128
19.956741 21.694563
13.880673 7.343436
28.442356 11.917128
13.880673 7.343436
19.956741 21.694563
```

random seed in grey, Forgy seed in black, plusplus in dark grey:



kmeancluster.txt:


```
{
  "_seed":"2",
  "_centers":[
    {
      "_dim":"2",
      "_val":["28.442356","11.917128"]
```

```
    },
    {
      "_dim":"2",
      "_val":["13.880673","7.343436"]
    },
    {
      "_dim":"2",
      "_val":["19.956741","21.694563"]
    }
  ]
}
```


7 YoloBoxes

main.c:

```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include <math.h>
#include "pbdataanalysis.h"

float* GetYoloBoxes(int K, int nbData, float* data) {

  // Init the random generator
  srandom(time(NULL));

  // Create the set of input data
  GSetVecFloat input = GSetVecFloatCreateStatic();
  for (int iData = 0; iData < nbData; ++iData) {
    VecFloat* vFloat = VecFloatCreate(2);
    GSetAppend(&input, vFloat);
    for (int iInput = 0; iInput < 2; ++iInput) {
      VecSet(vFloat, iInput, data[iData * 2 + iInput]);
    }
  }

  // Create the KMeansClusters
  KMeansClustersSeed seed = KMeansClustersSeed_PlusPlus;
  KMeansClusters clusters = KMeansClustersCreateStatic(seed);

  // Search the K-Means
  KMeansClustersSearch(&clusters, &input, K);

  // Store the found K-Means
  float* ret = malloc(sizeof(float) * K * 2);
  if (data == NULL) {
    printf("Failed to allocate memory\n");
    exit(1);
  }
  for (int iCenter = 0; iCenter < K; ++iCenter) {
    const VecFloat* vFloat = KMeansClustersCenter(&clusters, iCenter);
    ret[iCenter * 2] = VecGet(vFloat, 0);
    ret[iCenter * 2 + 1] = VecGet(vFloat, 1);
  }

  // Free memory
```

```
  KMeansClustersFreeStatic(&clusters);
  while (GSetNbElem(&input) > 0) {
    VecFloat* v = GSetPop(&input);
    VecFree(&v);
  }

  // Return the result
  return ret;
}

// Arguments:
// main <width image> <height image> <K, equals to 'num' in the
// yolo config file> <input file>
// where input file has the following format: first line is the
// number of boxes in input, following lines are relative width
// and relative height separated by a space of each box, one per line

int main(int argc, char** argv) {

  // Check the number of arguments
  if (argc != 5) {
    printf("Invalid number of arguments (%d)\n", argc);
    exit(1);
  }

  // Get the image dimension
  int width = atoi(argv[1]);
  int height = atoi(argv[2]);

  // Get the number of clusters
  int K = atoi(argv[3]);

  // Get the data file name
  char* filename = argv[4];
  FILE* fp = fopen(filename, "r");

  // Read the number of data
  int nbData;
  if (fscanf(fp, "%d\n", &nbData) == EOF) {
    printf("Failed to read the data\n");
    exit(1);
  }

  // Get the data
  float* data = malloc(sizeof(float) * (nbData * 2));
  if (data == NULL) {
    printf("Failed to allocate memory\n");
    exit(1);
  }
  for (int iData = 0; iData < nbData; ++iData) {
    if (fscanf(fp, "%f %f\n", data + iData * 2, data + iData * 2 + 1) == EOF) {
      printf("Failed to read the data\n");
      exit(1);
    }
  }

  // Close the input file
  fclose(fp);

  // Search the clusters
  float* ret = GetYoloBoxes(K, nbData, data);
```

```
  // Display the results
  for (int i = 0; i < K; ++i) {
    int w = (int)round(ret[2 * i] * (float)width);
    int h = (int)round(ret[2 * i + 1] * (float)height);
    printf("%d,%d ", w, h);
  }
  printf("\n");

  // Free memory
  free(data);
  free(ret);

  return 0;
}
```

example of use and output:

```
cat Data/*.txt > targets.txt; \
wc -l targets.txt | awk '{print $1}' > input.txt; \
cat targets.txt | awk '{printf "%f %f\n", $4, $5}' >> input.txt
main 250 250 9 input.txt
89,87 37,37 69,70 31,31 87,78 56,57 41,41 80,82 46,47
```