PBImgAnalysis

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Contents

Introduction

PBImgAnalysis is a C library providing structures and functions to perform various data analysis on images.

It implements the following algorithms:

- K-means clustering on the RGBA space of pixels in a user defined radius

It uses the `PBErr`, `PBDataAnalaysis`, `GenBrush` libraries.

1 Interface

```
// ============ PBIMGANALYSIS.H ================

#ifndef PBIMGANALYSIS_H
#define PBIMGANALYSIS_H

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

#include <stdlib.h>
#include <stdio.h>
#include <stdbool.h>
#include <execinfo.h>
#include <errno.h>
#include <string.h>
#include "pberr.h"
#include "pbdataanalysis.h"
#include "genbrush.h"

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

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

typedef struct ImgKMeansClusters {
  // Image on which the clustering is applied
  // Uses the GBSurfaceFinalPixels
  const GenBrush* _img;
  // Clusters result of the search
  KMeansClusters _kmeansClusters;
  // Size of the considered cell in the image around a given position
  // is equal to (_size * 2 + 1)
  int _size;
} ImgKMeansClusters;

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

// Create a new ImgKMeansClusters for the image 'img' and with seed 'seed'
// and type 'type' and a cell size equal to 2*'size'+1
ImgKMeansClusters ImgKMeansClustersCreateStatic(
  const GenBrush* const img, const KMeansClustersSeed seed,
  const int size);

// Free the memory used by a ImgKMeansClusters
void ImgKMeansClustersFreeStatic(ImgKMeansClusters* const that);

// Get the GenBrush of the ImgKMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
const GenBrush* IKMCImg(const ImgKMeansClusters* const that);

// Set the GenBrush of the ImgKMeansClusters 'that' to 'img'
#if BUILDMODE != 0
inline
#endif
void IKMCSetImg(ImgKMeansClusters* const that, const GenBrush* const img);

// Set the size of the cells of the ImgKMeansClusters 'that' to
// 2*'size'+1
#if BUILDMODE != 0
inline
```

```
#endif
void IKMCSetSizeCell(ImgKMeansClusters* const that, const int size);

// Get the number of cluster of the ImgKMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
int IKMCGetK(const ImgKMeansClusters* const that);

// Get the size of the cells of the ImgKMeansClusters 'that'
#if BUILDMODE != 0
inline
#endif
int IKMCGetSizeCell(const ImgKMeansClusters* const that);

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

// Search for the 'K' clusters in the image of the
// ImgKMeansClusters 'that'
void IKMCSearch(ImgKMeansClusters* const that, const int K);

// Print the ImgKMeansClusters 'that' on the stream 'stream'
void IKMCPrintln(const ImgKMeansClusters* const that,
  FILE* const stream);

// Get the index of the cluster at position 'pos' for the
// ImgKMeansClusters 'that'
int IKMCGetId(const ImgKMeansClusters* const that,
  const VecShort2D* const pos);

// Get the GBPixel equivalent to the cluster at position 'pos'
// for the ImgKMeansClusters 'that'
GBPixel IKMCGetPixel(const ImgKMeansClusters* const that,
  const VecShort2D* const pos);

// Convert the image of the ImageKMeansClusters 'that' to its clustered
// version
// IKMCSearch must have been called previously
void IKMCCluster(const ImgKMeansClusters* const that);

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

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

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

#endif
```

2 Code

2.1 pbimganalysis.c

```
// ============ PBIMGANALYSIS.C ================

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

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

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

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

// Get the input values for the pixel at position 'pos' according to
// the cell size of the ImgKMeansClusters 'that'
// The return is a VecFloat made of the sizeCell^2 pixels' value
// around pos ordered by (((r*256+g)*256+b)*256+a)
VecFloat* IKMCGetInputOverCell(const ImgKMeansClusters* const that,
  const VecShort2D* const pos);

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

// Create a new ImgKMeansClusters for the image 'img' and with seed 'seed'
// and type 'type' and a cell size equal to 2*'size'+1
ImgKMeansClusters ImgKMeansClustersCreateStatic(
  const GenBrush* const img, const KMeansClustersSeed seed,
  const int size) {
#if BUILDMODE == 0
  if (img == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'img' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
  if (size < 0) {
    PBImgAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBImgAnalysisErr->_msg, "'size' is invalid (%d>=0)", size);
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Declare the new ImgKMeansClusters
  ImgKMeansClusters that;
  // Set properties
  that._img = img;
  that._kmeansClusters = KMeansClustersCreateStatic(seed);
  that._size = size;
  // Return the new ImgKMeansClusters
  return that;
}

// Free the memory used by a ImgKMeansClusters
void ImgKMeansClustersFreeStatic(ImgKMeansClusters* const that) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
```

```
#endif
  // Free the memory used by the KMeansClusters
  KMeansClustersFreeStatic((KMeansClusters*)IKMCKMeansClusters(that));
}

// Search for the 'K' clusters in the image of the
// ImgKMeansClusters 'that'
void IKMCSearch(ImgKMeansClusters* const that, const int K) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
  if (K < 1) {
    PBImgAnalysisErr->_type = PBErrTypeInvalidArg;
    sprintf(PBImgAnalysisErr->_msg, "'K' is invalid (%d>0)", K);
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Create a set to memorize the input over cells
  GSetVecFloat inputOverCells = GSetVecFloatCreateStatic();
  // Get the dimension of the image
  VecShort2D dim = GBGetDim(IKMCImg(that));
  // Loop on pixels
  VecShort2D pos = VecShortCreateStatic2D();
  do {
    // Get the KMeansClusters input over the cell
    VecFloat* inputOverCell = IKMCGetInputOverCell(that, &pos);
    // Add it to the inputs for the search
    GSetAppend(&inputOverCells, inputOverCell);
  } while (VecStep(&pos, &dim));
  // Search the clusters
  KMeansClustersSearch((KMeansClusters*)IKMCKMeansClusters(that),
    &inputOverCells, K);
  // Free the memory used by the input
  while (GSetNbElem(&inputOverCells) > 0) {
    VecFloat* v = GSetPop(&inputOverCells);
    VecFree(&v);
  }
}

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

// Get the index of the cluster at position 'pos' for the
```

```
// ImgKMeansClusters 'that'
int IKMCGetId(const ImgKMeansClusters* const that,
  const VecShort2D* const pos) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
  if (pos == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'pos' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Get the KMeansClusters input over the cell
  VecFloat* inputOverCell = IKMCGetInputOverCell(that, pos);
  // Get the index of the cluster for this pixel
  int id = KMeansClustersGetId(IKMCKMeansClusters(that), inputOverCell);
  // Free memory
  VecFree(&inputOverCell);
  // Return the id
  return id;
}

// Get the GBPixel equivalent to the cluster at position 'pos'
// for the ImgKMeansClusters 'that'
// This is the average pixel over the pixel in the cell of the cluster
GBPixel IKMCGetPixel(const ImgKMeansClusters* const that,
  const VecShort2D* const pos) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
  if (pos == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'pos' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Declare the result pixel
  GBPixel pix;
  // Get the id of the cluster for the input pixel
  int id = IKMCGetId(that, pos);
  // Get the 'id'-th cluster's center
  const VecFloat* center =
    KMeansClustersCenter(IKMCKMeansClusters(that), id);
  // Declare a variable to calculate the average pixel
  VecFloat* avgPix = VecFloatCreate(4);
  // Calculate the average pixel
  for (int i = 0; i < VecGetDim(center); i += 4) {
    for (int j = 4; j--;) {
      VecSet(avgPix, j, VecGet(avgPix, j) + VecGet(center, i + j));
    }
  }
  VecScale(avgPix, 1.0 / round((float)VecGetDim(center) / 4.0));
  // Update the returned pixel values and ensure the converted value
  // from float to char is valid
  for (int i = 4; i--;) {
    float v = VecGet(avgPix, i);
```

```
    if (v < 0.0)
      v = 0.0;
    else if (v > 255.0)
      v = 255.0;
    pix._rgba[i] = (unsigned char)v;
  }
  // Free memory
  VecFree(&avgPix);
  // Return the result pixel
  return pix;
}

// Convert the image of the ImageKMeansClusters 'that' to its clustered
// version
// IKMCSearch must have been called previously
void IKMCCluster(const ImgKMeansClusters* const that) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Get the dimension of the image
  VecShort2D dim = GBGetDim(IKMCImg(that));
  // Loop on pixels
  VecShort2D pos = VecShortCreateStatic2D();
  do {
    // Get the clustered pixel for this pixel
    GBPixel clustered = IKMCGetPixel(that, &pos);
    // Replace the original pixel
    GBSetFinalPixel((GenBrush*)IKMCImg(that), &pos, &clustered);
  } while (VecStep(&pos, &dim));
}

// Get the input values for the pixel at position 'pos' according to
// the cell size of the ImgKMeansClusters 'that'
// The return is a VecFloat made of the sizeCell^2 pixels' value
// around pos ordered by (((r*256+g)*256+b)*256+a)
VecFloat* IKMCGetInputOverCell(const ImgKMeansClusters* const that,
  const VecShort2D* const pos) {
#if BUILDMODE == 0
  if (that == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'that' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
  if (pos == NULL) {
    PBImgAnalysisErr->_type = PBErrTypeNullPointer;
    sprintf(PBImgAnalysisErr->_msg, "'pos' is null");
    PBErrCatch(PBImgAnalysisErr);
  }
#endif
  // Create two vectors to loop on the cell
  VecShort2D from = VecShortCreateStatic2D();
  VecSet(&from, 0, -that->_size);
  VecSet(&from, 1, -that->_size);
  VecShort2D to = VecShortCreateStatic2D();
  VecSet(&to, 0, that->_size + 1);
  VecSet(&to, 1, that->_size + 1);
  // Get the pixel at the center of the cell, will be used as default
  // if the cell goes over the border of the image
```

```
  const GBPixel* defaultPixel = GBFinalPixel(IKMCImg(that), pos);
  // Declare a set to memorize the pixels in the cell
  GSet pixels = GSetCreateStatic();
  // Loop over the pixels of the cell
  VecShort2D posCell = from;
  VecShort2D posImg = VecShortCreateStatic2D();
  do {
    // If the position in the cell is inside the radius of the cell
    VecFloat2D posCellFloat = VecShortToFloat2D(&posCell);
    if ((int)round(VecNorm(&posCellFloat)) <= that->_size) {
      // Get the position in the image
      posImg = VecGetOp(pos, 1, &posCell, 1);
      // Get the pixel at this position
      const GBPixel* pix = GBFinalPixelSafe(IKMCImg(that), &posImg);
      if (pix == NULL)
        pix = defaultPixel;
      // Get the value to sort this pixel
      float valPix = 0.0;
      for (int iRgba = 4; iRgba--;)
        valPix += 256.0 * valPix + (float)(pix->_rgba[iRgba]);
      // Add the pixel to the set of pixels in the cell
      GSetAddSort(&pixels, pix, valPix);
    }
  } while (VecShiftStep(&posCell, &from, &to));
  // Declare the result vector
  VecFloat* res = VecFloatCreate(GSetNbElem(&pixels) * 4);
  // Loop over the sorted pixels of the cell
  int iPix = 0;
  while (GSetNbElem(&pixels)) {
    const GBPixel* pix = GSetDrop(&pixels);
    // Set the result value
    for (int i = 0; i < 4; ++i)
      VecSet(res, iPix * 4 + i, (float)(pix->_rgba[i]));
    ++iPix;
  }
  // Return the result
  return res;
}
```

3 Makefile

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

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=pbimganalysis
$($(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)/$
```

4 Unit tests

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

void UnitTestImgKMeansClusters() {
  srandom(1);
  for (int size = 0; size < 6; ++size) {
    for (int K = 2; K <= 6; ++K) {
      char* fileName = "./imgkmeanscluster.tga";
      GenBrush* img = GBCreateFromFile(fileName);
      ImgKMeansClusters clusters = ImgKMeansClustersCreateStatic(
        img, KMeansClustersSeed_Forgy, size);
      IKMCSearch(&clusters, K);
      printf("%s size K=%d cell=%d:\n",
        fileName, K, IKMCGetSizeCell(&clusters));
      IKMCPrintln(&clusters, stdout);
      IKMCCluster(&clusters);
      char fileNameOut[50] = {'\0'};
      sprintf(fileNameOut, "./imgkmeanscluster%02d-%02d.tga", K, size);
      GBSetFileName(img, fileNameOut);
      GBRender(img);
      GBFree(&img);
      ImgKMeansClustersFreeStatic(&clusters);
    }
  }
  printf("UnitTestImgKMeansClusters OK\n");
}

void UnitTestAll() {
  UnitTestImgKMeansClusters();
}

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

5 Unit tests output

```
./imgkmeanscluster02.tga size K=2 cell=1:
<190.271,188.622,189.519,255.874>
<57.922,71.614,92.852,255.544>
./imgkmeanscluster02.tga size K=3 cell=1:
<197.903,195.060,194.940,255.852>
<46.857,55.700,72.989,255.384>
<129.141,141.318,156.154,255.440>
./imgkmeanscluster02.tga size K=4 cell=1:
<49.314,59.658,46.134,255.156>
<156.342,159.087,163.036,255.568>
<56.903,76.562,152.418,255.000>
<201.616,198.516,198.111,255.828>
./imgkmeanscluster02.tga size K=5 cell=1:
<42.357,54.043,156.886,255.000>
<47.936,59.604,46.270,255.149>
<119.585,133.399,145.312,255.076>
<177.630,176.173,177.662,255.664>
<206.329,203.216,202.496,255.772>
./imgkmeanscluster02.tga size K=6 cell=1:
<210.086,207.070,206.155,255.687>
<188.060,185.241,185.757,255.701>
<90.991,116.830,139.485,255.000>
<46.868,57.760,44.244,255.109>
<37.108,37.526,155.019,255.000>
<153.019,156.372,160.882,255.265>
./imgkmeanscluster02.tga size K=2 cell=3:
<196.476,194.722,195.635,255.874,194.379,192.612,193.523,255.874,192.848,191.093,192.012,255.874,191.376,189.680,190
<70.561,84.186,107.671,255.546,66.415,80.028,103.270,255.546,63.722,77.315,100.200,255.546,60.385,74.097,95.695,255.5
./imgkmeanscluster02.tga size K=3 cell=3:
<142.267,153.344,167.998,255.445,138.511,149.808,164.556,255.445,135.723,147.234,162.003,255.445,132.033,143.971,158
<203.108,200.359,200.281,255.851,201.244,198.444,198.356,255.851,199.906,197.080,196.987,255.851,198.732,195.894,195
<58.046,67.067,87.513,255.383,54.053,62.941,83.006,255.383,51.554,60.343,79.943,255.383,48.753,57.583,75.451,255.383
./imgkmeanscluster02.tga size K=4 cell=3:
<166.321,168.400,172.509,255.561,163.232,165.432,169.521,255.561,160.871,163.233,167.332,255.561,158.048,160.752,164
<70.162,89.174,164.837,255.000,65.785,84.909,161.050,255.000,63.053,82.167,158.272,255.000,59.666,79.014,154.477,255
<59.902,70.791,61.053,255.151,55.989,66.727,56.274,255.151,53.496,64.141,53.107,255.151,50.658,61.260,48.356,255.151
<206.331,203.363,203.001,255.829,204.541,201.518,201.148,255.829,203.264,200.202,199.827,255.829,202.160,199.067,198
./imgkmeanscluster02.tga size K=5 cell=3:
<210.420,207.434,206.768,255.779,208.729,205.682,205.001,255.779,207.507,204.426,203.748,255.779,206.477,203.349,202
<50.209,62.203,167.101,255.000,46.743,58.512,163.959,255.000,44.835,56.378,161.714,255.000,43.170,54.670,158.697,255
<59.032,70.967,60.922,255.146,55.106,66.935,56.215,255.146,52.602,64.363,53.094,255.146,49.762,61.509,48.493,255.146
<183.893,182.408,184.051,255.650,181.493,180.014,181.653,255.650,179.745,178.301,179.954,255.650,178.076,176.728,178
<134.728,147.284,160.113,255.070,130.219,143.112,155.970,255.070,126.814,140.019,152.823,255.070,121.763,135.616,148
./imgkmeanscluster02.tga size K=6 cell=3:
<162.431,165.080,170.039,255.241,159.193,161.986,166.967,255.241,156.704,159.677,164.713,255.241,153.771,157.139,162
<213.719,210.815,209.984,255.706,212.075,209.117,208.270,255.706,210.884,207.889,207.039,255.706,209.881,206.837,205
<107.498,132.241,155.378,255.000,102.122,127.262,150.460,255.000,98.306,123.685,146.780,255.000,92.555,118.440,141.39
<192.867,190.218,190.870,255.688,190.799,188.111,188.753,255.688,189.313,186.613,187.259,255.688,188.002,185.310,185
<56.646,67.997,57.533,255.094,52.988,64.197,53.064,255.094,50.691,61.814,50.148,255.094,48.147,59.221,45.884,255.094
<44.721,45.847,165.918,255.000,41.315,42.113,162.715,255.000,39.486,40.058,160.372,255.000,37.977,38.626,156.902,255
./imgkmeanscluster02.tga size K=2 cell=5:
<199.430,197.609,198.528,255.874,197.521,195.689,196.598,255.874,196.238,194.395,195.310,255.874,195.197,193.361,194
<78.934,92.056,117.044,255.548,75.278,88.404,113.260,255.548,72.596,85.783,110.397,255.548,69.885,83.286,106.888,255
./imgkmeanscluster02.tga size K=3 cell=5:
<149.809,159.522,173.907,255.455,146.579,156.494,170.976,255.455,144.233,154.351,168.862,255.455,141.879,152.364,166
<205.448,202.802,202.692,255.851,203.748,201.041,200.928,255.851,202.615,199.870,199.765,255.851,201.748,198.969,198
<64.703,73.812,96.796,255.376,61.085,70.068,92.790,255.376,58.466,67.395,89.768,255.376,55.886,64.901,85.866,255.376
./imgkmeanscluster02.tga size K=4 cell=5:
<66.243,77.243,71.372,255.136,62.701,73.569,67.060,255.136,60.104,70.905,63.742,255.136,57.409,68.284,59.158,255.136
```

<171.552,172.993,177.353,255.555,168.834,170.341,174.682,255.555,166.914,168.507,172.824,255.555,165.089,166.896,171
<79.445,97.444,170.074,255.000,75.572,93.734,166.962,255.000,72.750,91.111,164.705,255.000,70.150,88.822,162.500,255
<208.325,205.503,205.109,255.830,206.690,203.810,203.413,255.830,205.603,202.684,202.297,255.830,204.781,201.817,201
./imgkmeanscluster02.tga size K=5 cell=5:
<54.882,67.031,171.555,255.000,51.444,63.486,168.824,255.000,49.247,61.151,166.998,255.000,47.545,59.373,165.387,255
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UnitTestImgKMeansClusters OK
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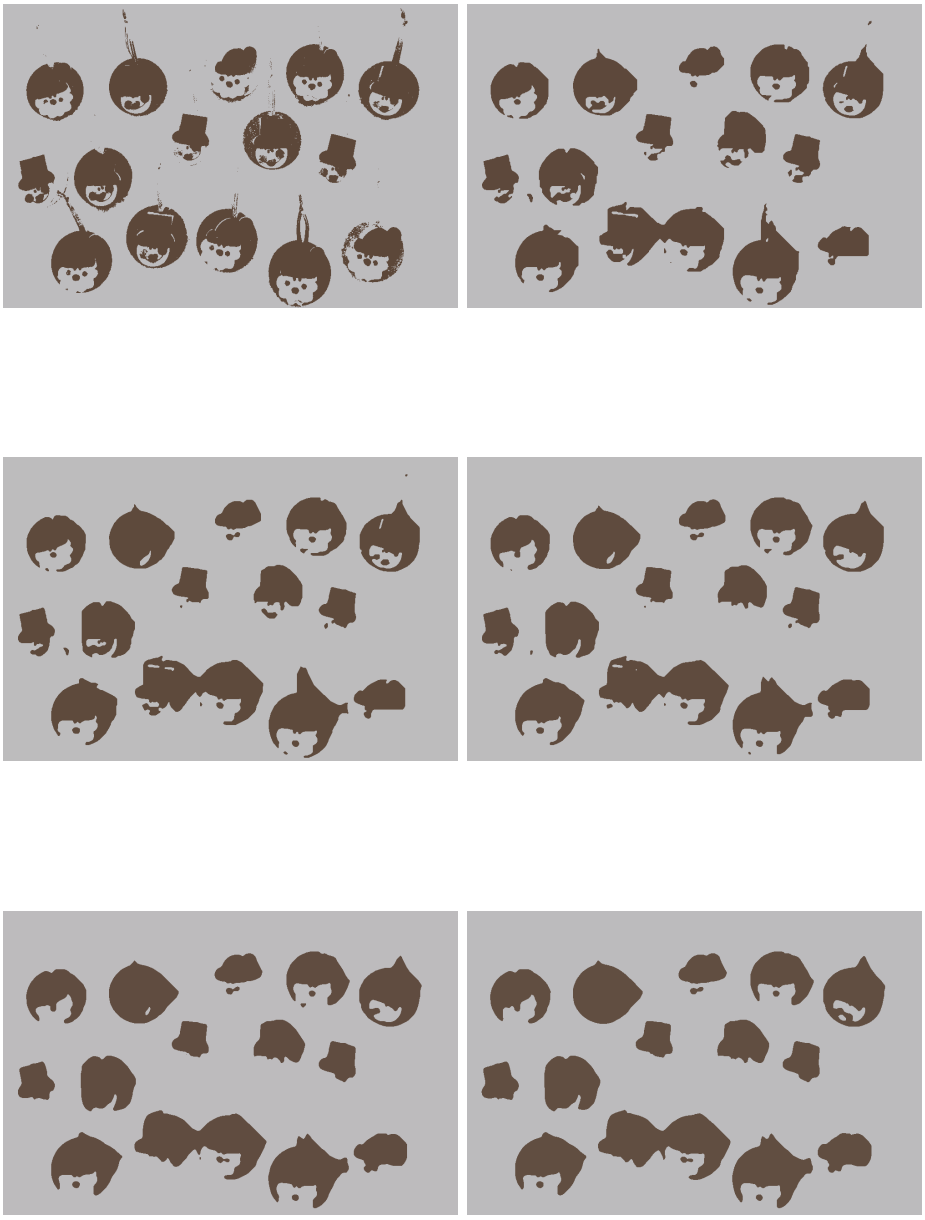
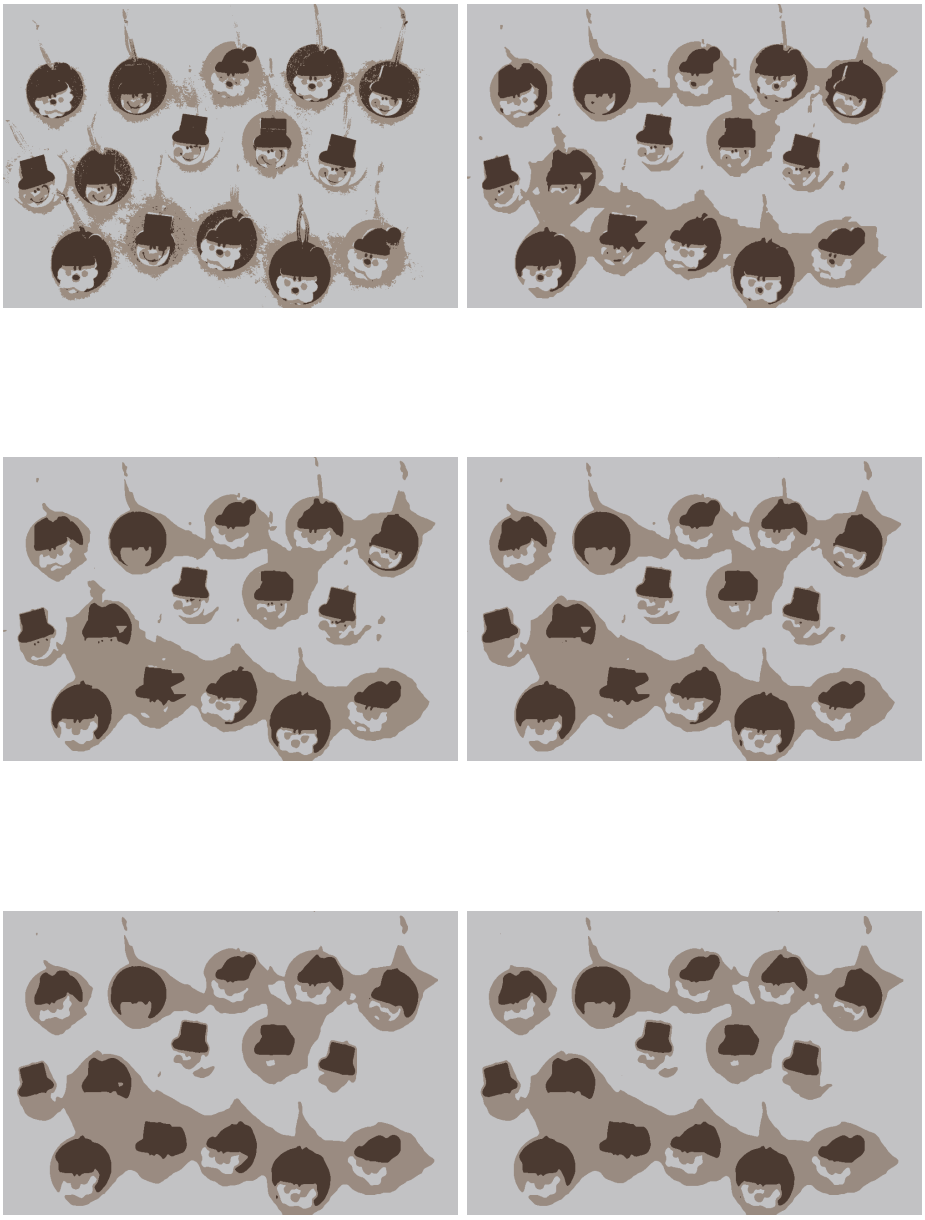
5.1 K-Means clustering on RGBA space

imgkmeanscluster.tga:

clustering for K equals 2 to 6 and radius equals 0 to 5:
K=2:



K=3:



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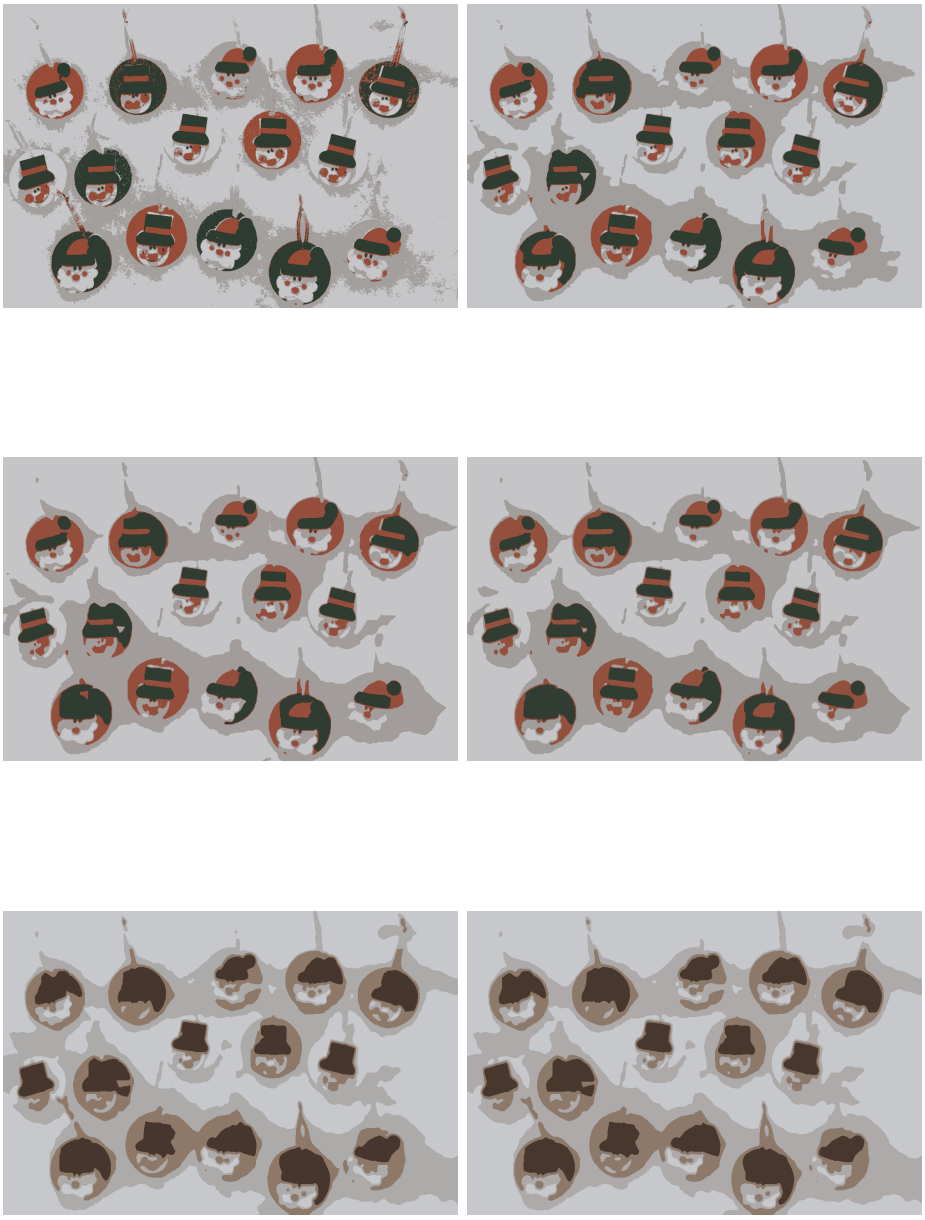

K=5:

K=6: