BCurve

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Introduction

BCurve is C library to manipulate Bezier curves of any dimension and order.

1 Interface

```
// ============ BCURVE.H ================

#ifndef BCURVE_H
#define BCURVE_H

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

#include <stdlib.h>
#include <stdio.h>
#include <math.h>
#include <string.h>
#include <stdbool.h>
#include "pbmath.h"

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

// ================= Data structure ===================
typedef struct BCurve {
  // Order
  int _order;
  // Dimension
  int _dim;
  // array of (_order + 1) control points defining the curve
  VecFloat **_ctrl;
} BCurve;

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

// Create a new BCurve of order 'order' and dimension 'dim'
// Return NULL if we couldn't create the BCurve
BCurve* BCurveCreate(int order, int dim);

// Clone the BCurve
// Return NULL if we couldn't clone the BCurve
BCurve* BCurveClone(BCurve *that);

// Load the BCurve from the stream
// If the BCurve is already allocated, it is freed before loading
// Return 0 in case of success, or:
// 1: invalid arguments
// 2: can't allocate memory
// 3: invalid data
// 4: fscanf error
// 5: VecLoad error
int BCurveLoad(BCurve **that, FILE *stream);

// Save the BCurve to the stream
// Return 0 upon success, else
// 1: invalid arguments
// 2: fprintf error
// 3: VecSave error
int BCurveSave(BCurve *that, FILE *stream);

// Free the memory used by a BCurve
// Do nothing if arguments are invalid
void BCurveFree(BCurve **that);

// Print the BCurve on 'stream'
// Do nothing if arguments are invalid
void BCurvePrint(BCurve *that, FILE *stream);

// Set the value of the iCtrl-th control point to v
// Do nothing if arguments are invalid
void BCurveSet(BCurve *that, int iCtrl, VecFloat *v);

// Get the value of the BCurve at paramater 'u' (in [0.0, 1.0])
// Return NULL if arguments are invalid or malloc failed
// if 'u' < 0.0 it is replaced by 0.0
// if 'u' > 1.0 it is replaced by 1.0
VecFloat* BCurveGet(BCurve *that, float u);

// Get the order of the BCurve
// Return -1 if argument is invalid
int BCurveOrder(BCurve *that);

// Get the dimension of the BCurve
// Return 0 if argument is invalid
int BCurveDim(BCurve *that);
```

```
// Get the approximate length of the BCurve (sum of dist between
// control points)
// Return 0.0 if argument is invalid
float BCurveApproxLen(BCurve *that);

// Rotate the curve CCW by 'theta' radians relatively to the origin
// Do nothing if arguments are invalid
void BCurveRot2D(BCurve *that, float theta);

#endif
```

2 Code

```
// ============ BCURVE.C ================

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

#include "bcurve.h"

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

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

// Create a new BCurve of order 'order' and dimension 'dim'
// Return NULL if we couldn't create the BCurve
BCurve* BCurveCreate(int order, int dim) {
  // Check arguments
  if (order < 0 || dim < 1)
    return NULL;
  // Allocate memory
  BCurve *that = (BCurve*)malloc(sizeof(BCurve));
  //If we could allocate memory
  if (that != NULL) {
    // Set the values
    that->_dim = dim;
    that->_order = order;
    // Allocate memory for the array of control points
    that->_ctrl = (VecFloat**)malloc(sizeof(VecFloat*) * (order + 1));
    // If we couldn't allocate memory
    if (that->_ctrl == NULL) {
      // Free memory
      free(that);
      // Stop here
      return NULL;
    }
    // For each control point
    for (int iCtrl = 0; iCtrl < order + 1; ++iCtrl) {
      // Allocate memory
      that->_ctrl[iCtrl] = VecFloatCreate(dim);
      // If we couldn't allocate memory
      if (that->_ctrl[iCtrl] == NULL) {
        // Free memory
        BCurveFree(&that);
        // Stop here
        return NULL;
      }
    }
  }
  // Return the new BCurve
  return that;
}

// Clone the BCurve
// Return NULL if we couldn't clone the BCurve
BCurve* BCurveClone(BCurve *that) {
  // Check argument
  if (that == NULL)
    return NULL;
  // Allocate memory for the clone
  BCurve *clone = (BCurve*)malloc(sizeof(BCurve));
  // If we could allocate memory
  if (clone != NULL) {
    // Clone the properties
    clone->_dim = that->_dim;
    clone->_order = that->_order;
    // Allocate memory for the array of control points
    clone->_ctrl = (VecFloat**)malloc(sizeof(VecFloat*) *
      (clone->_order + 1));
    // If we couldn't allocate memory
    if (that->_ctrl == NULL) {
      // Free memory
      free(clone);
      // Stop here
      return NULL;
    }
    // For each control point
    for (int iCtrl = 0; iCtrl < clone->_order + 1; ++iCtrl) {
      // Clone the control point
      clone->_ctrl[iCtrl] = VecClone(that->_ctrl[iCtrl]);
      // If we couldn't clone the control point
      if (clone->_ctrl[iCtrl] == NULL) {
        // Free memory
        BCurveFree(&clone);
        // Stop here
        return NULL;
      }
    }
  }
  // Return the clone
  return clone;
}

// Load the BCurve from the stream
// If the BCurve is already allocated, it is freed before loading
// Return 0 in case of success, or:
// 1: invalid arguments
// 2: can't allocate memory
// 3: invalid data
// 4: fscanf error
// 5: VecLoad error
int BCurveLoad(BCurve **that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // If 'that' is already allocated
  if (*that != NULL) {
    // Free memory
    BCurveFree(that);
  }
  // Read the order and dimension
  int order;
  int dim;
  int ret = fscanf(stream, "%d %d", &order, &dim);
  // If we couldn't read
  if (ret == EOF) {
    return 4;
  }
  // Allocate memory
  *that = BCurveCreate(order, dim);
  // If we coudln't allocate memory
  if (*that == NULL) {
    return 2;
  }
  // For each control point
  for (int iCtrl = 0; iCtrl < (order + 1); ++iCtrl) {
    // Load the control point
    ret = VecLoad((*that)->_ctrl + iCtrl, stream);
    // If we couldn't read the control point or the conrtol point
    // is not of the correct dimension
    if (ret != 0 || VecDim((*that)->_ctrl[iCtrl]) != (*that)->_dim) {
      // Free memory
      BCurveFree(that);
      // Stop here
      return 5;
    }
  }
  // Return success code
  return 0;
}

// Save the BCurve to the stream
// Return 0 upon success, or
// 1: invalid arguments
// 2: fprintf error
// 3: VecSave error
int BCurveSave(BCurve *that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // Save the order and dimension
  int ret = fprintf(stream, "%d %d\n", that->_order, that->_dim);
  // If the fprintf failed
  if (ret < 0) {
    // Stop here
    return 2;
  }
  // For each control point
  for (int iCtrl = 0; iCtrl < that->_order + 1; ++iCtrl) {
    // Save the control point
    ret = VecSave(that->_ctrl[iCtrl], stream);
    // If we couldn't save the control point
    if (ret != 0) {
      // Stop here
      return 3;
    }
  }
  // Return success code
  return 0;
}

// Free the memory used by a BCurve
// Do nothing if arguments are invalid
void BCurveFree(BCurve **that) {
  // Check argument
  if (that == NULL || *that == NULL)
    return;
  // If there are control points
  if ((*that)->_ctrl != NULL) {
    // For each control point
    for (int iCtrl = 0; iCtrl < (*that)->_order + 1; ++iCtrl) {
      // Free the control point
      VecFree((*that)->_ctrl + iCtrl);
    }
  }
  // Free the array of control points
  free((*that)->_ctrl);
  // Free memory
  free(*that);
  *that = NULL;
}

// Print the BCurve on 'stream'
// Do nothing if arguments are invalid
void BCurvePrint(BCurve *that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return;
  // Print the order and dim
  fprintf(stream, "order(%d) dim(%d) ", that->_order, that->_dim);
  // For each control point
  for (int iCtrl = 0; iCtrl < that->_order + 1; ++iCtrl) {
    VecPrint(that->_ctrl[iCtrl], stream);
    fprintf(stream, " ");
  }
}

// Set the value of the iCtrl-th control point to v
// Do nothing if arguments are invalid
void BCurveSet(BCurve *that, int iCtrl, VecFloat *v) {
  // Check arguments
  if (that == NULL || v == NULL || iCtrl < 0 ||
    iCtrl > that->_order || VecDim(v) != BCurveDim(that))
    return;
  // Set the values
  VecCopy(that->_ctrl[iCtrl], v);
}

// Get the value of the BCurve at paramater 'u' (in [0.0, 1.0])
// Return NULL if arguments are invalid or malloc failed
// if 'u' < 0.0 it is replaced by 0.0
// if 'u' > 1.0 it is replaced by 1.0
VecFloat* BCurveGet(BCurve *that, float u) {
  // Check arguments
  if (that == NULL)
    return NULL;
  if (u < 0.0)
    u = 0.0;
  if (u > 1.0)
    u = 1.0;
  // Allocate memory for the result
  VecFloat *v = VecFloatCreate(that->_dim);
  // If we couldn't allocate memory
  if (v == NULL)
    return NULL;
  // Declare a variable for calcul
  float *val = (float*)malloc(sizeof(float) * (that->_order + 1));
  // Loop on dimension
  for (int dim = that->_dim; dim--;) {
    // Initialise the temporary variable with the value in current
    // dimension of the control points
    for (int iCtrl = 0; iCtrl < that->_order + 1; ++iCtrl)
      val[iCtrl] = VecGet(that->_ctrl[iCtrl], dim);
    // Loop on order
    int subOrder = that->_order;
    while (subOrder != 0) {
      // Loop on sub order
      for (int order = 0; order < subOrder; ++order) {
        val[order] = (1.0 - u) * val[order] + u * val[order + 1];
      }
      --subOrder;
    }
    // Set the value for the current dim
    VecSet(v, dim, val[0]);
  }
  // Free memory
  free(val);
  // Return the result
  return v;
}

// Get the order of the BCurve
// Return -1 if argument is invalid
int BCurveOrder(BCurve *that) {
  // Check arguments
  if (that == NULL)
    return -1;
  return that->_order;
}

// Get the dimension of the BCurve
// Return 0 if argument is invalid
int BCurveDim(BCurve *that) {
  // Check arguments
  if (that == NULL)
    return 0;
  return that->_dim;
}

// Get the approximate length of the BCurve (sum of dist between
// control points)
// Return 0.0 if argument is invalid
float BCurveApproxLen(BCurve *that) {
  // Check arguments
  if (that == NULL)
    return 0.0;
  // Declare a variable to calculate the length
  float res = 0.0;
  // Calculate the length
  for (int iCtrl = 0; iCtrl < that->_order; ++iCtrl)
    res += VecDist(that->_ctrl[iCtrl], that->_ctrl[iCtrl + 1]);
  // Return the length
  return res;
}

// Rotate the curve CCW by 'theta' radians relatively to the origin
// Do nothing if arguments are invalid
void BCurveRot2D(BCurve *that, float theta) {
  // Check arguments
  if (that == NULL || that->_dim != 2)
    return;
  // For each control point
  for (int iCtrl = 0; iCtrl <= that->_order; ++iCtrl) {
    // Rotate the control point
    VecRot2D(that->_ctrl[iCtrl], theta);
  }
}
```

3 Makefile

```
OPTIONS_DEBUG=-ggdb -g3 -Wall
OPTIONS_RELEASE=-O3
OPTIONS=$(OPTIONS_RELEASE)
INCPATH=/home/bayashi/Coding/Include
LIBPATH=/home/bayashi/Coding/Include

all : main

main: main.o bcurve.o $(LIBPATH)/pbmath.o Makefile
gcc $(OPTIONS) main.o bcurve.o $(LIBPATH)/pbmath.o -o main -lm

main.o : main.c bcurve.h Makefile
gcc $(OPTIONS) -I$(INCPATH) -c main.c

bcurve.o : bcurve.c bcurve.h $(INCPATH)/pbmath.h Makefile
gcc $(OPTIONS) -I$(INCPATH) -c bcurve.c

clean :
rm -rf *.o main

valgrind :
valgrind -v --track-origins=yes --leak-check=full --gen-suppressions=yes --show-leak-kinds=all ./main

install :
cp bcurve.h../Include; cp bcurve.o ../Include
```

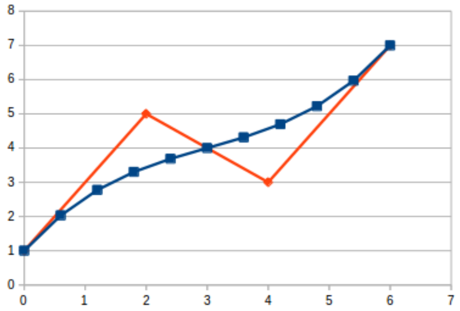
4 Usage

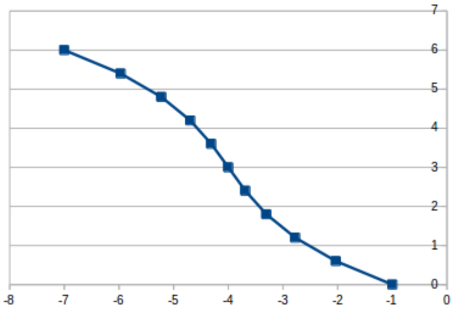
```
#include <stdlib.h>
#include <stdio.h>
#include <time.h>
#include <string.h>
#include "bcurve.h"

int main(int argc, char **argv) {
  // Create a BCurve
  int order = 3;
  int dim = 2;
  BCurve *curve = BCurveCreate(order, dim);
  // If we couldn't create the BCurve
  if (curve == NULL) {
    // Print a message
    fprintf(stderr, "BCurveCreate failed\n");
    // Stop here
    return 1;
  }
  // Print the BCurve
  BCurvePrint(curve, stdout);
  fprintf(stdout, "\n");
  // Create a VecFloat to set the values
  VecFloat *v = VecFloatCreate(dim);
  // If we couldn't create the VecFloat
  if (v == NULL) {
    // Release memory
    BCurveFree(&curve);
    // Stop here
    return 2;
  }
  // Set the control points
  float ctrlPts[8] = {0.0, 1.0, 2.0, 5.0, 4.0, 3.0, 6.0, 7.0};
  for (int iCtrl = 0; iCtrl < order + 1; ++iCtrl) {
    VecSet(v, 0, ctrlPts[2 * iCtrl]);
    VecSet(v, 1, ctrlPts[2 * iCtrl + 1]);
    BCurveSet(curve, iCtrl, v);
  }
  // Print the BCurve
  BCurvePrint(curve, stdout);
  fprintf(stdout, "\n");
  // Save the curve
  FILE *file = fopen("./curve.txt", "w");
  // If we couldn't open the file
  if (file == NULL) {
    // Print a message
    fprintf(stderr, "Can't open file\n");
    // Free memory
    VecFree(&v);
    BCurveFree(&curve);
    // Stop here
    return 3;
  }
  int ret = BCurveSave(curve, file);
  // If we couldn't save
  if (ret != 0) {
    // Print a message
    fprintf(stderr, "BCurveSave failed (%d)\n", ret);
    // Free memory
    VecFree(&v);
    BCurveFree(&curve);
    // Stop here
    return 4;
  }
  fclose(file);
  // Load the curve
  file = fopen("./curve.txt", "r");
  // If we couldn't open the file
  if (file == NULL) {
    // Print a message
    fprintf(stderr, "Can't open file\n");
    // Free memory
    VecFree(&v);
    BCurveFree(&curve);
    // Stop here
    return 5;
  }
  BCurve *loaded = NULL;
```

```
  ret = BCurveLoad(&loaded, file);
  // If we couldn’t load
  if (ret != 0) {
    // Print a message
    fprintf(stderr, "BCurveLoad failed (%d)\n", ret);
    // Free memory
    VecFree(&v);
    BCurveFree(&curve);
    BCurveFree(&loaded);
    // Stop here
    return 6;
  }
  fclose(file);
  // Print the loaded curve
  BCurvePrint(loaded, stdout);
  fprintf(stdout, "\n");
  // Get some values of the curve
  for (float u = 0.0; u <= 1.01; u += 0.1) {
    VecFloat *w = BCurveGet(curve, u);
    // If we couldn’t get the values
    if (w == NULL) {
      // Free memory
      VecFree(&v);
      BCurveFree(&curve);
      BCurveFree(&loaded);
      // Stop here
      return 7;
    }
    fprintf(stdout, "%.1f: ", u);
    VecPrint(w, stdout);
    fprintf(stdout, "\n");
    VecFree(&w);
  }
  // Rotate the curve
  BCurveRot2D(curve, PBMATH_PI * 0.5);
  // Get some values of the curve
  fprintf(stdout, "after rotation:\n");
  for (float u = 0.0; u <= 1.01; u += 0.1) {
    VecFloat *w = BCurveGet(curve, u);
    // If we couldn’t get the values
    if (w == NULL) {
      // Free memory
      VecFree(&v);
      BCurveFree(&curve);
      BCurveFree(&loaded);
      // Stop here
      return 7;
    }
    fprintf(stdout, "%.1f: ", u);
    VecPrint(w, stdout);
    fprintf(stdout, "\n");
    VecFree(&w);
  }
  // Print the curve approximate length
  fprintf(stdout, "approx length: %.3f\n", BCurveApproxLen(curve));
  // Free memory
  VecFree(&v);
  BCurveFree(&curve);
  BCurveFree(&loaded);
  // Return success code
  return 0;
}
```

Output:

```
order(3) dim(2) <0.000,0.000> <0.000,0.000> <0.000,0.000> <0.000,0.000>
order(3) dim(2) <0.000,1.000> <2.000,5.000> <4.000,3.000> <6.000,7.000>
order(3) dim(2) <0.000,1.000> <2.000,5.000> <4.000,3.000> <6.000,7.000>
0.0: <0.000,1.000>
0.1: <0.600,2.032>
0.2: <1.200,2.776>
0.3: <1.800,3.304>
0.4: <2.400,3.688>
0.5: <3.000,4.000>
0.6: <3.600,4.312>
0.7: <4.200,4.696>
0.8: <4.800,5.224>
0.9: <5.400,5.968>
1.0: <6.000,7.000>
after rotation:
0.0: <-1.000,0.000>
0.1: <-2.032,0.600>
0.2: <-2.776,1.200>
0.3: <-3.304,1.800>
0.4: <-3.688,2.400>
0.5: <-4.000,3.000>
0.6: <-4.312,3.600>
0.7: <-4.696,4.200>
0.8: <-5.224,4.800>
0.9: <-5.968,5.400>
1.0: <-7.000,6.000>
approx length: 11.773
```





curve.txt:

```
3 2
2 0.000000 1.000000
2 2.000000 5.000000
2 4.000000 3.000000
2 6.000000 7.000000
```