PBMath

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Contents

Introduction

PBMath is C library providing mathematical structures and functions.

The `VecFloat` structure and its functions can be used to manipulate vectors of float values.

The `Gauss` structure and its functions can be used to get values of the Gauss function and random values distributed accordingly with a Gauss distribution.

The `Smoother` functions can be used to get values of the SmoothStep and SmootherStep functions.

1 Interface

```
// ============ PBMATH.H ================

#ifndef PBMATH_H
```

```
#define PBMATH_H

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

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

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

#define PBMATH_EPSILON 0.0000001
#define PBMATH_PI 3.14159

// ================= Generic functions ==================

void VecTypeUnsupported(void*t, ...);
#define VecClone(V) _Generic((V), \
  VecFloat*: VecFloatClone, \
  VecShort*: VecShortClone, \
  default: VecTypeUnsupported)(V)
#define VecLoad(V, S) _Generic((V), \
  VecFloat**: VecFloatLoad, \
  VecShort**: VecShortLoad, \
  default: VecTypeUnsupported)(V, S)
#define VecSave(V, S) _Generic((V), \
  VecFloat*: VecFloatSave, \
  VecShort*: VecShortSave, \
  default: VecTypeUnsupported)(V, S)
#define VecFree(V) _Generic((V), \
  VecFloat**: VecFloatFree, \
  VecShort**: VecShortFree, \
  default: VecTypeUnsupported)(V)
#define VecPrint(V, S) _Generic((V), \
  VecFloat*: VecFloatPrintDef, \
  VecShort*: VecShortPrint, \
  default: VecTypeUnsupported)(V, S)
#define VecGet(V, I) _Generic((V), \
  VecFloat*: VecFloatGet, \
  VecShort*: VecShortGet, \
  default: VecTypeUnsupported)(V, I)
#define VecSet(V, I, VAL) _Generic((V), \
  VecFloat*: VecFloatSet, \
  VecShort*: VecShortSet, \
  default: VecTypeUnsupported)(V, I, VAL)
#define VecCopy(V, W) _Generic((V), \
  VecFloat*: VecFloatCopy, \
  VecShort*: VecShortCopy, \
  default: VecTypeUnsupported)(V, W)
#define VecDim(V) _Generic((V), \
  VecFloat*: VecFloatDim, \
  VecShort*: VecShortDim, \
  default: VecTypeUnsupported)(V)
#define VecNorm(V) _Generic((V), \
  VecFloat*: VecFloatNorm, \
  default: VecTypeUnsupported)(V)
#define VecNormalise(V) _Generic((V), \
  VecFloat*: VecFloatNormalise, \
  default: VecTypeUnsupported)(V)
#define VecDist(V, W) _Generic((V), \
  VecFloat*: VecFloatDist, \
```

```
  default: VecTypeUnsupported)(V, W)
#define VecIsEqual(V, W) _Generic((V), \
  VecFloat*: VecFloatIsEqual, \
  default: VecTypeUnsupported)(V, W)
#define VecOp(V, A, W, B) _Generic((V), \
  VecFloat*: VecFloatOp, \
  default: VecTypeUnsupported)(V, A, W, B)
#define VecGetOp(V, A, W, B) _Generic((V), \
  VecFloat*: VecFloatGetOp, \
  default: VecTypeUnsupported)(V, A, W, B)
#define VecRot2D(V, A) _Generic((V), \
  VecFloat*: VecFloatRot2D, \
  default: VecTypeUnsupported)(V, A)
#define VecGetRot2D(V, A) _Generic((V), \
  VecFloat*: VecFloatGetRot2D, \
  default: VecTypeUnsupported)(V, A)
#define VecDotProd(V, W) _Generic((V), \
  VecFloat*: VecFloatDotProd, \
  default: VecTypeUnsupported)(V, W)

// -------------- VecShort

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

// Vector of short values
typedef struct VecShort {
  // Dimension
  int _dim;
  // Values
  short *_val;
} VecShort;

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

// Create a new VecShort of dimension 'dim'
// Values are initalized to 0.0
// Return NULL if we couldn't create the VecShort
VecShort* VecShortCreate(int dim);

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

// Load the VecShort from the stream
// If the VecShort 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
int VecShortLoad(VecShort **that, FILE *stream);

// Save the VecShort to the stream
// Return 0 upon success, or
// 1: invalid arguments
// 2: fprintf error
int VecShortSave(VecShort *that, FILE *stream);

// Free the memory used by a VecShort
// Do nothing if arguments are invalid
void VecShortFree(VecShort **that);
```

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

// Return the i-th value of the VecShort
// Index starts at 0
// Return 0.0 if arguments are invalid
short VecShortGet(VecShort *that, int i);

// Set the i-th value of the VecShort to v
// Index starts at 0
// Do nothing if arguments are invalid
void VecShortSet(VecShort *that, int i, short v);

// Return the dimension of the VecShort
// Return 0 if arguments are invalid
int VecShortDim(VecShort *that);

// Copy the values of 'w' in 'that' (must have same dimensions)
// Do nothing if arguments are invalid
void VecShortCopy(VecShort *that, VecShort *w);

// -------------- VecFloat

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

// Vector of float values
typedef struct VecFloat {
  // Dimension
  int _dim;
  // Values
  float *_val;
} VecFloat;

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

// Create a new VecFloat of dimension 'dim'
// Values are initalized to 0.0
// Return NULL if we couldn't create the VecFloat
VecFloat* VecFloatCreate(int dim);

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

// Load the VecFloat from the stream
// If the VecFloat 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
int VecFloatLoad(VecFloat **that, FILE *stream);

// Save the VecFloat to the stream
// Return 0 upon success, or
// 1: invalid arguments
// 2: fprintf error
int VecFloatSave(VecFloat *that, FILE *stream);

// Free the memory used by a VecFloat
// Do nothing if arguments are invalid
```

```
void VecFloatFree(VecFloat **that);

// Print the VecFloat on 'stream' with 'prec' digit precision
// Do nothing if arguments are invalid
void VecFloatPrint(VecFloat *that, FILE *stream, int prec);
void VecFloatPrintDef(VecFloat *that, FILE *stream);

// Return the i-th value of the VecFloat
// Index starts at 0
// Return 0.0 if arguments are invalid
float VecFloatGet(VecFloat *that, int i);

// Set the i-th value of the VecFloat to v
// Index starts at 0
// Do nothing if arguments are invalid
void VecFloatSet(VecFloat *that, int i, float v);

// Return the dimension of the VecFloat
// Return 0 if arguments are invalid
int VecFloatDim(VecFloat *that);

// Copy the values of 'w' in 'that' (must have same dimensions)
// Do nothing if arguments are invalid
void VecFloatCopy(VecFloat *that, VecFloat *w);

// Return the norm of the VecFloat
// Return 0.0 if arguments are invalid
float VecFloatNorm(VecFloat *that);

// Normalise the VecFloat
// Do nothing if arguments are invalid
void VecFloatNormalise(VecFloat *that);

// Return the distance between the VecFloat 'that' and 'tho'
// Return NaN if arguments are invalid
// If dimensions are different, missing ones are considered to
// be equal to 0.0
float VecFloatDist(VecFloat *that, VecFloat *tho);

// Return true if the VecFloat 'that' is equal to 'tho'
// Return false if arguments are invalid
// If dimensions are different, missing ones are considered to
// be equal to 0.0
bool VecFloatIsEqual(VecFloat *that, VecFloat *tho);

// Calculate (that * a + tho * b) and store the result in 'that'
// Do nothing if arguments are invalid
// 'tho' can be null, in which case it is consider to be the null vector
// If 'tho' is not null it must be of same dimension as 'that'
void VecFloatOp(VecFloat *that, float a, VecFloat *tho, float b);

// Return a VecFloat equal to (that * a + tho * b)
// Return NULL if arguments are invalid
// 'tho' can be null, in which case it is consider to be the null vector
// If 'tho' is not null it must be of same dimension as 'that'
VecFloat* VecFloatGetOp(VecFloat *that, float a,
  VecFloat *tho, float b);

// Rotate CCW 'that' by 'theta' radians and store the result in 'that'
// Do nothing if arguments are invalid
void VecFloatRot2D(VecFloat *that, float theta);
```

```
// Return a VecFloat equal to 'that' rotated CCW by 'theta' radians
// Return NULL if arguments are invalid
VecFloat* VecFloatGetRot2D(VecFloat *that, float theta);

// Return the dot product of 'that' and 'tho'
// Return 0.0 if arguments are invalid
float VecFloatDotProd(VecFloat *that, VecFloat *tho);

// -------------- Gauss

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

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

// Vector of float values
typedef struct Gauss {
  // Mean
  float _mean;
  // Sigma
  float _sigma;
} Gauss;

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

// Create a new Gauss of mean 'mean' and sigma 'sigma'
// Return NULL if we couldn't create the Gauss
Gauss* GaussCreate(float mean, float sigma);

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

// Return the value of the Gauss 'that' at 'x'
// Return 0.0 if the arguments are invalid
float GaussGet(Gauss *that, float x);

// Return a random value according to the Gauss 'that'
// random() must have been called before calling this function
// Return 0.0 if the arguments are invalid
float GaussRnd(Gauss *that);

// -------------- Smoother

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

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

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

// Return the order 1 smooth value of 'x'
// if x < 0.0 return 0.0
// if x > 1.0 return 1.0
float SmoothStep(float x);

// Return the order 2 smooth value of 'x'
// if x < 0.0 return 0.0
// if x > 1.0 return 1.0
float SmootherStep(float x);

#endif
```

2 Code

```
// ============ PBMATH.C ================

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

#include "pbmath.h"

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

#define rnd() (float)(rand())/(float)(RAND_MAX)

// -------------- VecShort

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

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

// Create a new Vec of dimension 'dim'
// Values are initalized to 0.0
// Return NULL if we couldn't create the Vec
VecShort* VecShortCreate(int dim) {
  // Check argument
  if (dim <= 0)
    return NULL;
  // Allocate memory
  VecShort *that = (VecShort*)malloc(sizeof(VecShort));
  //If we could allocate memory
  if (that != NULL) {
    // Allocate memory for values
    that->_val = (short*)malloc(sizeof(short) * dim);
    // If we couldn't allocate memory
    if (that->_val == NULL) {
      // Free memory
      free(that);
      // Stop here
      return NULL;
    }
    // Set the default values
    that->_dim = dim;
    for (int i = dim; i--;)
      that->_val[i] = 0.0;
  }
  // Return the new VecShort
  return that;
}

// Clone the VecShort
// Return NULL if we couldn't clone the VecShort
VecShort* VecShortClone(VecShort *that) {
  // Check argument
  if (that == NULL)
    return NULL;
  // Create a clone
  VecShort *clone = VecShortCreate(that->_dim);
  // If we could create the clone
  if (clone != NULL) {
    // Clone the properties
    for (int i = that->_dim; i--;)
      clone->_val[i] = that->_val[i];
  }
```

```
  // Return the clone
  return clone;
}

// Load the VecShort from the stream
// If the VecShort 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
int VecShortLoad(VecShort **that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // If 'that' is already allocated
  if (*that != NULL) {
    // Free memory
    VecShortFree(that);
  }
  // Read the number of dimension
  int dim;
  int ret = fscanf(stream, "%d", &dim);
  // If we coudln't fscanf
  if (ret == EOF)
    return 4;
  if (dim <= 0)
    return 3;
  // Allocate memory
  *that = VecShortCreate(dim);
  // If we coudln't allocate memory
  if (*that == NULL) {
    return 2;
  }
  // Read the values
  for (int i = 0; i < dim; ++i) {
    fscanf(stream, "%hi", (*that)->_val + i);
    // If we coudln't fscanf
    if (ret == EOF)
      return 4;
  }
  // Return success code
  return 0;
}

// Save the VecShort to the stream
// Return 0 upon success, or:
// 1: invalid arguments
// 2: fprintf error
int VecShortSave(VecShort *that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // Save the dimension
  int ret = fprintf(stream, "%d ", that->_dim);
  // If we coudln't fprintf
  if (ret < 0)
    return 2;
  // Save the values
  for (int i = 0; i < that->_dim; ++i) {
    ret = fprintf(stream, "%hi ", that->_val[i]);
    // If we coudln't fprintf
```

```
    if (ret < 0)
      return 2;
  }
  fprintf(stream, "\n");
  // If we coudln't fprintf
  if (ret < 0)
    return 2;
  // Return success code
  return 0;
}

// Free the memory used by a VecShort
// Do nothing if arguments are invalid
void VecShortFree(VecShort **that) {
  // Check argument
  if (that == NULL || *that == NULL)
    return;
  // Free memory
  free((*that)->_val);
  free(*that);
  *that = NULL;
}

// Print the VecShort on 'stream' with 'prec' digit precision
// Do nothing if arguments are invalid
void VecShortPrint(VecShort *that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return;
  // Print the values
  fprintf(stream, "<");
  for (int i = 0; i < that->_dim; ++i) {
    fprintf(stream, "%hi", that->_val[i]);
    if (i < that->_dim - 1)
      fprintf(stream, ",");
  }
  fprintf(stream, ">");
}

// Return the i-th value of the VecShort
// Index starts at 0
// Return 0.0 if arguments are invalid
short VecShortGet(VecShort *that, int i) {
  // Check argument
  if (that == NULL || i < 0 || i >= that->_dim)
    return 0.0;
  // Return the value
  return that->_val[i];
}

// Set the i-th value of the VecShort to v
// Index starts at 0
// Do nohting if arguments are invalid
void VecShortSet(VecShort *that, int i, short v) {
  // Check argument
  if (that == NULL || i < 0 || i >= that->_dim)
    return;
  // Set the value
  that->_val[i] = v;
}

// Return the dimension of the VecShort
```

```
// Return 0 if arguments are invalid
int VecShortDim(VecShort *that) {
  // Check argument
  if (that == NULL)
    return 0;
  // Return the dimension
  return that->_dim;
}

// Copy the values of 'w' in 'that' (must have same dimensions)
// Do nothing if arguments are invalid
void VecShortCopy(VecShort *that, VecShort *w) {
  // Check argument
  if (that == NULL || w == NULL || that->_dim != w->_dim)
    return;
  // Copy the values
  memcpy(that->_val, w->_val, sizeof(short) * that->_dim);
}

// -------------- VecFloat

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

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

// Create a new Vec of dimension 'dim'
// Values are initalized to 0.0
// Return NULL if we couldn't create the Vec
VecFloat* VecFloatCreate(int dim) {
  // Check argument
  if (dim <= 0)
    return NULL;
  // Allocate memory
  VecFloat *that = (VecFloat*)malloc(sizeof(VecFloat));
  //If we could allocate memory
  if (that != NULL) {
    // Allocate memory for values
    that->_val = (float*)malloc(sizeof(float) * dim);
    // If we couldn't allocate memory
    if (that->_val == NULL) {
      // Free memory
      free(that);
      // Stop here
      return NULL;
    }
    // Set the default values
    that->_dim = dim;
    for (int i = dim; i--;)
      that->_val[i] = 0.0;
  }
  // Return the new VecFloat
  return that;
}

// Clone the VecFloat
// Return NULL if we couldn't clone the VecFloat
VecFloat* VecFloatClone(VecFloat *that) {
  // Check argument
  if (that == NULL)
    return NULL;
  // Create a clone
  VecFloat *clone = VecFloatCreate(that->_dim);
```

```
  // If we could create the clone
  if (clone != NULL) {
    // Clone the properties
    for (int i = that->_dim; i--;)
      clone->_val[i] = that->_val[i];
  }
  // Return the clone
  return clone;
}

// Load the VecFloat from the stream
// If the VecFloat 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
int VecFloatLoad(VecFloat **that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // If 'that' is already allocated
  if (*that != NULL) {
    // Free memory
    VecFloatFree(that);
  }
  // Read the number of dimension
  int dim;
  int ret = fscanf(stream, "%d", &dim);
  // If we coudln't fscanf
  if (ret == EOF)
    return 4;
  if (dim <= 0)
    return 3;
  // Allocate memory
  *that = VecFloatCreate(dim);
  // If we coudln't allocate memory
  if (*that == NULL) {
    return 2;
  }
  // Read the values
  for (int i = 0; i < dim; ++i) {
    fscanf(stream, "%f", (*that)->_val + i);
    // If we coudln't fscanf
    if (ret == EOF)
      return 4;
  }
  // Return success code
  return 0;
}

// Save the VecFloat to the stream
// Return 0 upon success, or:
// 1: invalid arguments
// 2: fprintf error
int VecFloatSave(VecFloat *that, FILE *stream) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return 1;
  // Save the dimension
  int ret = fprintf(stream, "%d ", that->_dim);
  // If we coudln't fprintf
```

```
  if (ret < 0)
    return 2;
  // Save the values
  for (int i = 0; i < that->_dim; ++i) {
    ret = fprintf(stream, "%f ", that->_val[i]);
    // If we coudln't fprintf
    if (ret < 0)
      return 2;
  }
  fprintf(stream, "\n");
  // If we coudln't fprintf
  if (ret < 0)
    return 2;
  // Return success code
  return 0;
}

// Free the memory used by a VecFloat
// Do nothing if arguments are invalid
void VecFloatFree(VecFloat **that) {
  // Check argument
  if (that == NULL || *that == NULL)
    return;
  // Free memory
  free((*that)->_val);
  free(*that);
  *that = NULL;
}

// Print the VecFloat on 'stream' with 'prec' digit precision
// Do nothing if arguments are invalid
void VecFloatPrint(VecFloat *that, FILE *stream, int prec) {
  // Check arguments
  if (that == NULL || stream == NULL)
    return;
  // Create the format string
  char format[20] = {'\0'};
  sprintf(format, "%%.%df", prec);
  // Print the values
  fprintf(stream, "<");
  for (int i = 0; i < that->_dim; ++i) {
    fprintf(stream, format, that->_val[i]);
    if (i < that->_dim - 1)
      fprintf(stream, ",");
  }
  fprintf(stream, ">");
}
void VecFloatPrintDef(VecFloat *that, FILE *stream) {
  VecFloatPrint(that, stream, 3);
}

// Return the i-th value of the VecFloat
// Index starts at 0
// Return 0.0 if arguments are invalid
float VecFloatGet(VecFloat *that, int i) {
  // Check argument
  if (that == NULL || i < 0 || i >= that->_dim)
    return 0.0;
  // Return the value
  return that->_val[i];
}
```

```
// Set the i-th value of the VecFloat to v
// Index starts at 0
// Do nohting if arguments are invalid
void VecFloatSet(VecFloat *that, int i, float v) {
  // Check argument
  if (that == NULL || i < 0 || i >= that->_dim)
    return;
  // Set the value
  that->_val[i] = v;
}

// Return the dimension of the VecFloat
// Return 0 if arguments are invalid
int VecFloatDim(VecFloat *that) {
  // Check argument
  if (that == NULL)
    return 0;
  // Return the dimension
  return that->_dim;
}

// Copy the values of 'w' in 'that' (must have same dimensions)
// Do nothing if arguments are invalid
void VecFloatCopy(VecFloat *that, VecFloat *w) {
  // Check argument
  if (that == NULL || w == NULL || that->_dim != w->_dim)
    return;
  // Copy the values
  memcpy(that->_val, w->_val, sizeof(float) * that->_dim);
}

// Return the norm of the VecFloat
// Return 0.0 if arguments are invalid
float VecFloatNorm(VecFloat *that) {
  // Check argument
  if (that == NULL)
    return 0.0;
  // Declare a variable to calculate the norm
  float ret = 0.0;
  // Calculate the norm
  for (int iDim = that->_dim; iDim--;)
    ret += pow(that->_val[iDim], 2.0);
  ret = sqrt(ret);
  // Return the result
  return ret;
}

// Normalise the VecFloat
// Do nothing if arguments are invalid
void VecFloatNormalise(VecFloat *that) {
  // Check argument
  if (that == NULL)
    return;
  // Normalise
  float norm = VecNorm(that);
  for (int iDim = that->_dim; iDim--;)
    that->_val[iDim] /= norm;
}

// Return the distance between the VecFloat 'that' and 'tho'
// Return NaN if arguments are invalid
// If dimensions are different, missing ones are considered to
```

```
// be equal to 0.0
float VecFloatDist(VecFloat *that, VecFloat *tho) {
  // Check argument
  if (that == NULL || tho == NULL)
    return NAN;
  // Declare a variable to calculate the distance
  float ret = 0.0;
  for (int iDim = that->_dim; iDim--;)
    ret += pow(VecGet(that, iDim) - VecGet(tho, iDim), 2.0);
  ret = sqrt(ret);
  // Return the distance
  return ret;
}

// Return true if the VecFloat 'that' is equal to 'tho'
// Return false if arguments are invalid
// If dimensions are different, missing ones are considered to
// be equal to 0.0
bool VecFloatIsEqual(VecFloat *that, VecFloat *tho) {
  // Check argument
  if (that == NULL || tho == NULL)
    return false;
  // For each component
  for (int iDim = that->_dim; iDim--;)
    // If the values of this components are different
    if (fabs(VecGet(that, iDim) - VecGet(tho, iDim)) > PBMATH_EPSILON)
      // Return false
      return false;
  // Return true
  return true;
}

// Calculate (that * a + tho * b) and store the result in 'that'
// Do nothing if arguments are invalid
// 'tho' can be null, in which case it is consider to be the null vector
// If 'tho' is not null it must be of same dimension as 'that'
void VecFloatOp(VecFloat *that, float a, VecFloat *tho, float b) {
  // Check argument
  if (that == NULL)
    return;
  // Calculate
  VecFloat *res = VecFloatGetOp(that, a, tho, b);
  // If we could calculate
  if (res != NULL) {
    // Copy the result in 'that'
    VecFloatCopy(that, res);
    // Free memory
    VecFloatFree(&res);
  }
}

// Return a VecFloat equal to (that * a + tho * b)
// Return NULL if arguments are invalid
// 'tho' can be null, in which case it is consider to be the null vector
// If 'tho' is not null it must be of same dimension as 'that'
VecFloat* VecFloatGetOp(VecFloat *that, float a,
  VecFloat *tho, float b) {
  // Check argument
  if (that == NULL || (tho != NULL && that->_dim != tho->_dim))
    return NULL;
  // Declare a variable to memorize the result
  VecFloat *res = VecFloatCreate(that->_dim);
```

```
  // If we could allocate memory
  if (res != NULL) {
    // For each component
    for (int iDim = that->_dim; iDim--;) {
      // Calculate
      res->_val[iDim] = a * that->_val[iDim];
      if (tho != NULL)
        res->_val[iDim] += b * tho->_val[iDim];
    }
  }
  // Return the result
  return res;
}

// Rotate CCW 'that' by 'theta' radians and store the result in 'that'
// Do nothing if arguments are invalid
void VecFloatRot2D(VecFloat *that, float theta) {
  // Check argument
  if (that == NULL || that->_dim != 2)
    return;
  // Calculate
  VecFloat *res = VecFloatGetRot2D(that, theta);
  // If we could calculate
  if (res != NULL) {
    // Copy the result in 'that'
    VecFloatCopy(that, res);
    // Free memory
    VecFloatFree(&res);
  }
}

// Return a VecFloat equal to 'that' rotated CCW by 'theta' radians
// Return NULL if arguments are invalid
VecFloat* VecFloatGetRot2D(VecFloat *that, float theta) {
  // Check argument
  if (that == NULL || that->_dim != 2)
    return NULL;
  // Declare a variable to memorize the result
  VecFloat *res = VecFloatCreate(that->_dim);
  // If we could allocate memory
  if (res != NULL) {
    // Calculate
    res->_val[0] =
      cos(theta) * that->_val[0] - sin(theta) * that->_val[1];
    res->_val[1] =
      sin(theta) * that->_val[0] + cos(theta) * that->_val[1];
  }
  // Return the result
  return res;
}

// Return the dot product of 'that' and 'tho'
// Return 0.0 if arguments are invalid
float VecFloatDotProd(VecFloat *that, VecFloat *tho) {
  // Check arguments
  if (that == NULL || tho == NULL || that->_dim != tho->_dim)
    return 0.0;
  // Declare a variable to memorize the result
  float res = 0.0;
  // Calculate
  for (int iDim = that->_dim; iDim--;)
    res += that->_val[iDim] * tho->_val[iDim];
```

```
  // Return the result
  return res;
}

// -------------- Gauss

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

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

// Create a new Gauss of mean 'mean' and sigma 'sigma'
// Return NULL if we couldn't create the Gauss
Gauss* GaussCreate(float mean, float sigma) {
  // Allocate memory
  Gauss *that = (Gauss*)malloc(sizeof(Gauss));
  // If we could allocate memory
  if (that != NULL) {
    // Set properties
    that->_mean = mean;
    that->_sigma = sigma;
  }
  // REturn the new Gauss
  return that;
}

// Free the memory used by a Gauss
// Do nothing if arguments are invalid
void GaussFree(Gauss **that) {
  // Check argument
  if (that == NULL || *that == NULL)
    return;
  // Free memory
  free(*that);
  *that = NULL;
}

// Return the value of the Gauss 'that' at 'x'
// Return 0.0 if the arguments are invalid
float GaussGet(Gauss *that, float x) {
  // Check arguments
  if (that == NULL)
    return 0.0;
  // Calculate the value
  float a = 1.0 / (that->_sigma * sqrt(2.0 * PBMATH_PI));
  float ret = a * exp(-1.0 * pow(x - that->_mean, 2.0) /
    (2.0 * pow(that->_sigma, 2.0)));
  // Return the value
  return ret;
}

// Return a random value (in ]0.0, 1.0[)according to the
// Gauss distribution 'that'
// random() must have been called before calling this function
// Return 0.0 if the arguments are invalid
float GaussRnd(Gauss *that) {
  // Check arguments
  if (that == NULL)
    return 0.0;
  // Declare variable for calcul
  float v1,v2,s;
  // Calculate the value
  do {
```

```
    v1 = (rnd() - 0.5) * 2.0;
    v2 = (rnd() - 0.5) * 2.0;
    s = v1 * v1 + v2 * v2;
  } while (s >= 1.0);
  // Return the value
  float ret = 0.0;
  if (s > PBMATH_EPSILON)
    ret = v1 * sqrt(-2.0 * log(s) / s);
  return ret * that->_sigma + that->_mean;
}

// -------------- Smoother

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

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

// Return the order 1 smooth value of 'x'
// if x < 0.0 return 0.0
// if x > 1.0 return 1.0
float SmoothStep(float x) {
  if (x <= 0.0)
    return 0.0;
  else if (x >= 1.0)
    return 1.0;
  else
    return x * x * (3.0 - 2.0 * x);
}

// Return the order 2 smooth value of 'x'
// if x < 0.0 return 0.0
// if x > 1.0 return 1.0
float SmootherStep(float x) {
  if (x <= 0.0)
    return 0.0;
  else if (x >= 1.0)
    return 1.0;
  else
    return x * x * x * (x * (x * 6.0 - 15.0) + 10.0);
}
```

3 Makefile

```
OPTIONS_DEBUG=-ggdb -g3 -Wall
OPTIONS_RELEASE=-O3
OPTIONS=$(OPTIONS_DEBUG)

all : main

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

main.o : main.c pbmath.h Makefile
gcc $(OPTIONS) -c main.c

pbmath.o : pbmath.c pbmath.h Makefile
gcc $(OPTIONS) -c pbmath.c
```

```
clean :
rm -rf *.o main

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

4 Usage

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

int main(int argc, char **argv) {
  // Initialise the random generator
  srandom(time(NULL));
  // -------------- VecShort
  fprintf(stdout, "-------- VecShort\n");
  // Create a vector of dimension 3
  VecShort *a = VecShortCreate(3);
  // If we couldn't create the vector
  if (a == NULL) {
    fprintf(stderr, "VecCreate failed\n");
    return 1;
  }
  // Print the vector
  fprintf(stdout, "a: ");
  VecPrint(a, stdout);
  fprintf(stdout, "\n");
  // Set the 2nd value to 1
  VecSet(a, 1, 1);
  // Print the vector
  fprintf(stdout, "a: ");
  VecPrint(a, stdout);
  fprintf(stdout, "\n");
  // Save the vector
  FILE *f = fopen("./vecshort.txt", "w");
  if (f == NULL) {
    fprintf(stderr, "fopen failed\n");
    return 2;
  }
  int ret = VecSave(a, f);
  if (ret != 0) {
    fprintf(stderr, "VecSave failed (%d)\n", ret);
    return 3;
  }
  fclose(f);
  // Load the vector
  f = fopen("./vecshort.txt", "r");
  if (f == NULL) {
    fprintf(stderr, "fopen failed\n");
    return 4;
  }
  VecShort *b = NULL;
  ret = VecLoad(&b, f);
  if (ret != 0) {
    fprintf(stderr, "VecLoad failed (%d)\n", ret);
    return 5;
```

```
}
fclose(f);
// Get the dimension and values of the loaded vector
fprintf(stdout, "b: %d ", VecDim(b));
for (int i = 0; i < VecDim(b); ++i)
  fprintf(stdout, "%d ", VecGet(b, i));
fprintf(stdout, "\n");
// Change the values of the loaded vector and print it
VecSet(b, 0, 2);
VecSet(b, 2, 3);
fprintf(stdout, "b: ");
VecPrint(b, stdout);
fprintf(stdout, "\n");
// Copy the loaded vector into the first one and print the first one
VecCopy(a, b);
fprintf(stdout, "a: ");
VecPrint(a, stdout);
fprintf(stdout, "\n");
// Free memory
VecFree(&a);
VecFree(&b);
// -------------- VecFloat
fprintf(stdout, "-------- VecFloat\n");
// Create a vector of dimension 3
VecFloat *v = VecFloatCreate(3);
// If we couldn't create the vector
if (v == NULL) {
  fprintf(stderr, "VecCreate failed\n");
  return 1;
}
// Print the vector
fprintf(stdout, "v: ");
VecPrint(v, stdout);
fprintf(stdout, "\n");
// Set the 2nd value to 1.0
VecSet(v, 1, 1.0);
// Print the vector
fprintf(stdout, "v: ");
VecPrint(v, stdout);
fprintf(stdout, "\n");
// Save the vector
f = fopen("./vecfloat.txt", "w");
if (f == NULL) {
  fprintf(stderr, "fopen failed\n");
  return 2;
}
ret = VecSave(v, f);
if (ret != 0) {
  fprintf(stderr, "VecSave failed (%d)\n", ret);
  return 3;
}
fclose(f);
// Load the vector
f = fopen("./vecfloat.txt", "r");
if (f == NULL) {
  fprintf(stderr, "fopen failed\n");
  return 4;
}
VecFloat *w = NULL;
ret = VecLoad(&w, f);
if (ret != 0) {
  fprintf(stderr, "VecLoad failed (%d)\n", ret);
```

```
  return 5;
}
fclose(f);
// Get the dimension and values of the loaded vector
fprintf(stdout, "w: %d ", VecDim(w));
for (int i = 0; i < VecDim(w); ++i)
  fprintf(stdout, "%f ", VecGet(w, i));
fprintf(stdout, "\n");
// Change the values of the loaded vector and print it
VecSet(w, 0, 2.0);
VecSet(w, 2, 3.0);
fprintf(stdout, "w: ");
VecPrint(w, stdout);
fprintf(stdout, "\n");
// Copy the loaded vector into the first one and print the first one
VecCopy(v, w);
fprintf(stdout, "v: ");
VecPrint(v, stdout);
fprintf(stdout, "\n");
// Get the norm
float norm = VecNorm(v);
fprintf(stdout, "Norm of v: %.3f\n", norm);
// Normalise
VecNormalise(v);
fprintf(stdout, "Normalized v: ");
VecPrint(v, stdout);
fprintf(stdout, "\n");
// Distance between v and w
fprintf(stdout, "Distance between v and w: %.3f\n", VecDist(v, w));
// Equality
if (VecIsEqual(v, w) == true)
  fprintf(stdout, "v = w\n");
else
  fprintf(stdout, "v != w\n");
if (VecIsEqual(v, v) == true)
  fprintf(stdout, "v = v\n");
else
  fprintf(stdout, "v != v\n");
// Op
VecFloat *x = VecGetOp(v, norm, w, 2.0);
if (x == NULL) {
  fprintf(stderr, "VecGetOp failed\n");
  return 6;
}
fprintf(stdout, "x: ");
VecPrint(x, stdout);
fprintf(stdout, "\n");
VecOp(v, norm, NULL, 0.0);
fprintf(stdout, "v: ");
VecPrint(v, stdout);
fprintf(stdout, "\n");
// Dot prod
fprintf(stdout, "dot prod v.x: %.3f\n", VecDotProd(v, x));
// Rotate
VecFree(&v);
v = VecFloatCreate(2);
if (v == NULL) {
  fprintf(stderr, "malloc failed\n");
  return 7;
}
VecSet(v, 0, 1.0);
fprintf(stdout, "v: ");
```

```
  VecPrint(v, stdout);
  fprintf(stdout, "\n");
  VecRot2D(v, 0.5 * PBMATH_PI);
  fprintf(stdout, "v: ");
  VecPrint(v, stdout);
  fprintf(stdout, "\n");
  VecFree(&x);
  x = VecGetRot2D(v, 0.5 * PBMATH_PI);
  if (v == NULL) {
    fprintf(stderr, "VecGetRot2D failed\n");
    return 8;
  }
  fprintf(stdout, "x: ");
  VecPrint(x, stdout);
  fprintf(stdout, "\n");
  // Free memory
  VecFree(&x);
  VecFree(&w);
  VecFree(&v);
  // -------------- Gauss
  fprintf(stdout, "-------- Gauss\n");
  // Create a Gauss function
  float mean = 0.0;
  float sigma = 1.0;
  Gauss *gauss = GaussCreate(mean, sigma);
  // If we couldn't create the Gauss
  if (gauss == NULL) {
    fprintf(stderr, "Couldn't create the Gauss\n");
    return 9;
  }
  // Get some values of the Gauss function
  fprintf(stdout, "Gauss function (mean:0.0, sigma:1.0):\n");
  for (float x = -2.0; x <= 2.01; x += 0.2)
    fprintf(stdout, "%.3f %.3f\n", x, GaussGet(gauss, x));
  // Change the mean
  gauss->_mean = 1.0;
  gauss->_sigma = 0.5;
  // Get some random values according to the Gauss function
  fprintf(stdout, "Gauss rnd (mean:1.0, sigma:0.5):\n");
  for (int iVal = 0; iVal < 10; ++iVal)
    fprintf(stdout, "%.3f %.3f\n", GaussRnd(gauss), GaussRnd(gauss));
  //Free memory
  GaussFree(&gauss);

  // -------------- Smoother
  fprintf(stdout, "-------- Smoother\n");
  for (float x = 0.0; x <= 1.01; x += 0.1)
    fprintf(stdout, "%.3f %.3f %.3f\n", x, SmoothStep(x),
      SmootherStep(x));

  // Return success code
  return 0;
}
```

Output:

```
-------- VecShort
a: <0,0,0>
a: <0,1,0>
b: 3 0 1 0
```

```
b: <2,1,3>
a: <2,1,3>
-------- VecFloat
v: <0.000,0.000,0.000>
v: <0.000,1.000,0.000>
w: 3 0.000000 1.000000 0.000000
w: <2.000,1.000,3.000>
v: <2.000,1.000,3.000>
Norm of v: 3.742
Normalized v: <0.535,0.267,0.802>
Distance between v and w: 2.742
v != w
v = v
x: <6.000,3.000,9.000>
v: <2.000,1.000,3.000>
dot prod v.x: 42.000
v: <1.000,0.000>
v: <0.000,1.000>
x: <-1.000,0.000>
-------- Gauss
Gauss function (mean:0.0, sigma:1.0):
-2.000 0.054
-1.800 0.079
-1.600 0.111
-1.400 0.150
-1.200 0.194
-1.000 0.242
-0.800 0.290
-0.600 0.333
-0.400 0.368
-0.200 0.391
0.000 0.399
0.200 0.391
0.400 0.368
0.600 0.333
0.800 0.290
1.000 0.242
1.200 0.194
1.400 0.150
1.600 0.111
1.800 0.079
2.000 0.054
Gauss rnd (mean:1.0, sigma:0.5):
0.469 1.519
0.646 0.955
1.101 0.403
1.452 0.832
0.451 1.199
0.865 1.120
1.093 1.150
1.416 1.465
0.229 1.400
0.842 0.459
-------- Smoother
0.000 0.000 0.000
0.100 0.028 0.009
0.200 0.104 0.058
0.300 0.216 0.163
0.400 0.352 0.317
0.500 0.500 0.500
0.600 0.648 0.683
0.700 0.784 0.837
```

```
0.800 0.896 0.942
0.900 0.972 0.991
1.000 1.000 1.000
```

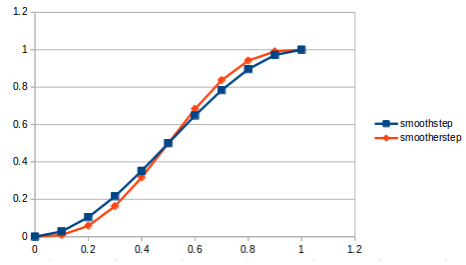
vecshort.txt:

```
3 0 1 0
```

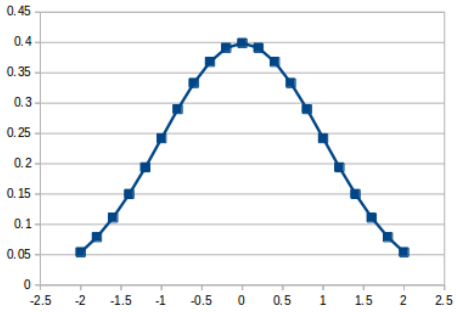
vecfloat.txt:

```
3 0.000000 1.000000 0.000000
```

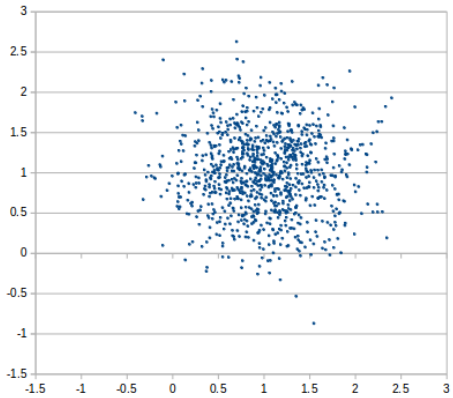
smoother functions:



gauss function (mean:0.0, sigma:1.0):



gauss rand function (mean:1.0, sigma:0.5):


3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3