

# TGA

P. Baillehache

September 6, 2017

## Contents

<b>1</b>	<b>Interface</b>	<b>1</b>
<b>2</b>	<b>Code</b>	<b>7</b>
2.1	tgapaint.c . . . . .	7
2.2	tgafont.c . . . . .	29
<b>3</b>	<b>Makefile</b>	<b>43</b>
<b>4</b>	<b>Usage</b>	<b>44</b>

## Introduction

TGA library is a C library to create and manipulate pictures in TGA format.

It offers functions to create, open and save TGA files, restricted to types 2 (uncompressed true-color image) and 10 (run-length encoded true-color image), pixel depths of 16, 24, and 32, and color map 0 (no color map) and 1 (standard TGA color map). The user can access the header and pixels values, paint simple geometric shapes (point, line, curve, rectangle, filled rectangle, ellipse and filled ellipse) and print text (ascii characters) with a virtual pencil (round/square shape, solid/blend color, antialias), and apply gaussian blur to the picture.

## 1 Interface

```

// ***** TGAPaint.H *****

#ifndef TGAPaint_H
#define TGAPaint_H

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

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

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

// Maximum number of colors in a TGAPencil
#define TGA_NBCOLORPENCIL 10
// Maximum number of curves in the definition of a font's character
#define TGA_NBMAXCURVECHAR 10

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

// Header of a TGA file
typedef struct TGAHeader {
    // Origin of the color map
    short int _colorMapOrigin;
    // Length of the color map
    short int _colorMapLength;
    // X coordinate of the origin
    short int _xOrigin;
    // Y coordinate of the origin
    short int _yOrigin;
    // Width of the TGA
    short _width;
    // Height of the TGA
    short _height;
    // Length of a string located after the header
    char _idLength;
    // Type of the color map
    char _colorMapType;
    // Type of the image
    char _dataTypeCode;
    // Depth of the color map
    char _colorMapDepth;
    // Number of bit per pixel
    char _bitsPerPixel;
    // Image descriptor
    char _imageDescriptor;
} TGAHeader;

// One pixel of the TGA
typedef struct TGAPixel {
    // RGB and transparency values
    unsigned char _rgba[4];
} TGAPixel;

// Main TGA structure
typedef struct TGA {
    // Header
    TGAHeader *_header;
    // Pixels (stored by rows)
    TGAPixel *_pixels;
}

```

```

} TGA;

// Enumeration of TGAPencil's color modes
typedef enum tgaPencilModeColor {
    // Constant color
    tgaPenSolid,
    // Blend between two colors
    tgaPenBlend
} tgaPencilModeColor;

// Enumeration of TGAPencil's shapes
typedef enum tgaPencilShape {
    // Square shape
    tgaPenSquare,
    // Round shape
    tgaPenRound,
    // Pixel mode
    tgaPenPixel
} tgaPencilShape;

// Pencil to draw on a TGA
typedef struct TGAPencil {
    // List of available colors in this pencil
    TGAPixel _colors[TGA_NBCOLORPENCIL];
    // Currently active color (index in _colors)
    int _activeColor;
    // Current color mode
    tgaPencilModeColor _modeColor;
    // Current shape
    tgaPencilShape _shape;
    // The 2 colors used when color mode is tgaPenBlend (index in _colors)
    int _blendColor[2];
    // Parameter cotnroling the blend when color mode is tgaPenBlend
    // (0.0 -> _blendColor[0], 1.0 -> _blendColor[1])
    float _blend;
    // Thickness of the TGAPencil, in pixel
    float _thickness;
    // Apply antialiasing if true
    bool _antialias;
} TGAPencil;

// One character in a TGAFont
typedef struct TGACHar {
    // Number of curve defining this character
    int _nbCurve;
    // Definition of the curves
    // (1st anchor(x,y), 1st ctrl point(x,y),
    // 2nd ctrl point(x,y), 2nd anchor(x,y))
    // in pixels
    float _curve[TGA_NBMAXCURVECHAR * 8];
} TGACHar;

// Enumeration of available fonts
typedef enum tgaFont {
    // Default font
    tgaFontDefault
} tgaFont;

// Font to write on the TGA
typedef struct TGAFont {
    // Size in pixel of one character
    float _size;

```

```

    // Definition of the characters
    TGAChar _char[256];
    // Space between character, (x,y), in pixel
    // _space[0] is added to x after each character in a string
    // _space[1] is added to y when '\n' is printed
    float _space[2];
    // Scale of the characters, (x,y), multiplied to _size
    float _scale[2];
    // Tabulation size, in pixel, when '\t' is printed move x to
    // (floor(p/_tabSize)+1)*_tabSize, where p is current x position
    float _tabSize;
} TGAFont;

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

// Create a TGA of width dim[0] and height dim[1] and background
// color equal to pixel
// (0,0) is the bottom left corner, x toward right, y toward top
// Return NULL in case of invalid arguments or memory allocation
// failure
TGA* TGACreate(short *dim, TGAPixel *pixel);

// Clone a TGA
// Return NULL in case of failure
TGA* TGAClone(TGA *tga);

// Free the memory used by the TGA
void TGAFree(TGA **tga);

// Load a TGA from the file pointed to by 'fileName'
// If 'tga' already contains a TGA, it is overwritten
// return 0 upon success, else
// 1 : couldn't open the file
// 2 : malloc failed
// 3 : can only handle image type 2 and 10
// 4 : can only handle pixel depths of 16, 24, and 32
// 5 : can only handle colour map types of 0 and 1
// 6 : unexpected end of file
// 7 : invalid arguments
int TGAload(TGA **tga, char *fileName);

// Save the TGA 'tga' to the file pointed to by 'fileName'
// return 0 upon success, else
// 1 : couldn't open the file
// 2 : invalid arguments
int TGASave(TGA *tga, char *fileName);

// Print the header of 'tga' on 'stream'
// If arguments are invalid, do nothing
void TGAPrintHeader(TGA *tga, FILE *stream);

// Get a pointer to the pixel at coord (x,y) = (pos[0],pos[1])
// Return NULL in case of invalid arguments
TGAPixel* TGAGetPix(TGA *tga, short *pos);

// Set the color of one pixel at coord (x,y) = (pos[0],pos[1]) to 'pix'
// Do nothing in case of invalid arguments
void TGASetPix(TGA *tga, short *pos, TGAPixel *pix);

// Draw one stroke at 'pos' with 'pen'
// Don't do anything in case of invalid arguments
void TGASTrokePix(TGA *tga, float *pos, TGAPencil *pen);

```

```

// Draw a line between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawLine(TGA *tga, float *from, float *to, TGAPencil *pen);

// Draw a curve between 'from' and 'to' with pencil 'pen'
// and control points 'ctrlFrom' and 'ctrlTo'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawCurve(TGA *tga, float *from, float *ctrlFrom,
    float *ctrlTo, float *to, TGAPencil *pen);

// Draw a rectangle between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawRect(TGA *tga, float *from, float *to, TGAPencil *pen);

// Fill a rectangle between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGAFillRect(TGA *tga, float *from, float *to, TGAPencil *pen);

// Draw an ellipse at 'center' of radius 'r' (Rx,Ry)
// with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawEllipse(TGA *tga, float *center, float *r, TGAPencil *pen);

// Fill an ellipse at 'center' of radius 'r' (Rx, Ry) with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGAFillEllipse(TGA *tga, float *center, float *r, TGAPencil *pen);

// Apply a gaussian blur of 'strength' and 'range' perimeter on the TGA
// Do nothing if arguments are invalid
void TGAFilterGaussBlur(TGA *tga, float strength, float range);

// Print the string 's' with its (bottom, left) position at 'pos'
// and (width, height) dimension 'dim' with font 'font'
void TGAPrintString(TGA *tga, TGAPencil *pen, TGAFont *font,
    unsigned char *s, float *pos);

// Print the char 'c' with its (bottom, left) position at 'pos'
// and (width, height) dimension 'dim' with font 'font'
void TGAPrintChar(TGA *tga, TGAPencil *pen, TGAFont *font,
    unsigned char c, float *pos);

// Get a white TGAPixel
TGAPixel* TGAGetWhitePixel(void);

// Get a black TGAPixel
TGAPixel* TGAGetBlackPixel(void);

// Get a transparent TGAPixel
TGAPixel* TGAGetTransparentPixel(void);

// Free the memory used by tgapixel
void TGAFreePixel(TGAPixel **pixel);

// Return a new TGAPixel which is a blend of 'pixA' and 'pixB'
// newPix = (1 - blend) * pixA + blend * pixB

```

```

// Return NULL if arguments are invalid
TGAPixel* TGABlendPixel(TGAPixel *pixA, TGAPixel *pixB, float blend);

// Create a default TGAPencil with all color set to transparent
// solid mode, thickness = 1.0, square shape, no antialias
// Return NULL if it couldn't allocate memory
TGAPencil* TGAGetPencil(void);

// Free the memory used by the TGAPencil 'pen'
void TGAFreePencil(TGAPencil **pen);

// Clone the TGAPencil 'pen'
// Return NULL if it couldn't clone
TGAPencil* TGAPencilClone(TGAPencil *pen);

// Create a TGAPencil with 1st color active and set to black
// Return NULL if it couldn't create
TGAPencil* TGAGetBlackPencil(void);

// Select the active color of TGAPencil 'pen' to 'iCol'
// Do nothing if arguments are invalid
void TGAPencilSelectColor(TGAPencil *pen, int iCol);

// Get the index of active color of TGAPencil 'pen'
// Return -1 if arguments are invalid
int TGAPencilGetColor(TGAPencil *pen);

// Get the active color of the TGAPencil 'pen'
// Return NULL if arguments are invalid
TGAPixel* TGAPencilGetPixel(TGAPencil *pen);

// Set the active color of TGAPencil 'pen' to TGAPixel 'col'
// Do nothing if arguments are invalid
void TGAPencilSetColor(TGAPencil *pen, TGAPixel *col);

// Set the active color of TGAPencil 'pen' to 'rgba'
// Do nothing if arguments are invalid
void TGAPencilSetColRGBA(TGAPencil *pen, unsigned char *rgba);

// Set the thickness of TGAPencil 'pen' to 'v'
// Do nothing if arguments are invalid
void TGAPencilSetThickness(TGAPencil *pen, float v);

// Set the antialias of the TGAPencil 'pen' to 'v'
// Do nothing if arguments are invalid
void TGAPencilSetAntialias(TGAPencil *pen, bool v);

// Set the blend value 'v' of the TGAPencil 'pen'
// Do nothing if arguments are invalid
void TGAPencilSetBlend(TGAPencil *pen, float v);

// Set the shape of the TGAPencil 'pen' to 'tgaPenSquare'
// Do nothing if arguments are invalid
void TGAPencilSetShapeSquare(TGAPencil *pen);

// Set the shape of the TGAPencil 'pen' to 'tgaPenRound'
// Do nothing if arguments are invalid
void TGAPencilSetShapeRound(TGAPencil *pen);

// Set the shape of the TGAPencil 'pen' to 'tgaPenPixel'
// Do nothing if arguments are invalid
void TGAPencilSetShapePixel(TGAPencil *pen);

```

```

// Set the mode of the TGAPencil 'pen' to 'tgaPenSolid'
// Do nothing if arguments are invalid
void TGAPencilSetModeColorSolid(TGAPencil *pen);

// Set the mode of the TGAPencil 'pen' to 'tgaPenBlend'
// Blend is done from 'fromCol' to 'toCol'
// Do nothing if arguments are invalid
void TGAPencilSetModeColorBlend(TGAPencil *pen, int fromCol, int toCol);

// Create a TGAFont with set of character 'font',
// _fontSize = 18.0, _space[0] = _space[1] = 3.0,
// _scale[0] = 0.5, _scale[1] = 1.0
// Return NULL if it couldn't create
TGAFont* TGAFontCreate(tgaFont font);

// Free memory used by TGAFont
// Do nothing if arguments are invalid
void TGAFreeFont(TGAFont **font);

// Set the font size of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetSize(TGAFont *font, float v);

// Set the font scale of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetScale(TGAFont *font, float *v);

// Set the font spacing of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetSpace(TGAFont *font, float *v);

#endif

```

## 2 Code

### 2.1 tgapaint.c

```

// ***** TGAPAINT.C *****

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

#include "tgapaint.h"
#include "tgafont.c"

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

#define TGA_PI 3.14159
#define TGA_EPSILON 0.001

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

// Function to decode rgba values when loading a TGA file
// Do nothing if arguments are invalid
void MergeBytes(TGAPixel *pixel, unsigned char *p, int bytes);

// Function to calculate the ratio of coverage of pixel 'q' by a square
// centered on 'p' with a size of 'r'
// Return 1.0 if arguments are invalid

```

```

float TGA RatioCoveragePixelSquare(float *p, float r, float *q);

// Function to calculate the ratio of coverage of pixel 'q' by a circle
// centered on 'p' with a radius of 'r'
// Return 1.0 if arguments are invalid
float TGA RatioCoveragePixelRound(float *p, float r, float *q);

// Return the value of the gaussian (mean, sigma) at x
float TGA Gauss(float x, float mean, float sigma);

// Calculate the position along a Bezier curve defined by 'from',
// 'ctrlFrom', 'ctrlTo', 'to', at position 't' ([0.0, 1.0]) and memorize
// the result in 'pos'
// Return (0.0,0.0) if argument are invalid, if (pos == NULL) do nothing
void TGA CurvePos(float *from, float *to, float *ctrlFrom,
    float *ctrlTo, float t, float *pos);

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

// Create a TGA of width dim[0] and height dim[1] and background
// color equal to pixel
// (0,0) is the bottom left corner, x toward right, y toward top
// Return NULL in case of invalid arguments or memory allocation
// failure
TGA* TGA Create(short *dim, TGA Pixel *pixel) {
    // Check arguments
    if (dim == NULL || pixel == NULL) return NULL;
    // Allocate memory
    TGA *ret = (TGA*) malloc(sizeof(TGA));
    // If we couldn't allocate memory
    if (ret == NULL)
        // Return NULL
        return NULL;
    // Set the pointers to NULL
    ret->_header = NULL;
    ret->_pixels = NULL;
    // Allcoate memory for the header
    ret->_header = (TGAHeader*) malloc(sizeof(TGAHeader));
    // If we couldn't allocate memory
    if (ret->_header == NULL) {
        // Free memory for the TGA
        free(ret);
        // Return NULL
        return NULL;
    }
    // Set a pointer to the header
    TGAHeader *h = ret->_header;
    // Initialize the header values
    h->_idLength = 0;
    h->_colorMapType = 0;
    h->_dataTypeCode = 2;
    h->_colorMapOrigin = 0;
    h->_colorMapLength = 0;
    h->_colorMapDepth = 0;
    h->_xOrigin = 0;
    h->_yOrigin = 0;
    h->_width = dim[0];
    h->_height = dim[1];
    h->_bitsPerPixel = 32;
    h->_imageDescriptor = 0;
    // Allocate memory for the pixels
    ret->_pixels =

```



```

    (TGAPixel*)malloc(h->_width * h->_height * sizeof(TGAPixel));
// If we couldn't allocate memory
if (ret->_pixels == NULL) {
    // Free the memory for the TGA and its header
    free(ret->_header);
    free(ret);
    // Return NULL
    return NULL;
}
// Set a pointer to the pixels
TGAPixel *p = ret->_pixels;
// For each pixel
for (int i = 0; i < h->_width * h->_height; ++i)
    // For each value RGBA
    for (int irgb = 0; irgb < 4; ++irgb)
        // Initialize the value
        p[i]._rgba[irgb] = pixel->_rgba[irgb];
// Return the created TGA
return ret;
}

// Clone a TGA
// Return NULL in case of failure
TGA* TGAClone(TGA *tga) {
    // Check arguments
    if (tga == NULL)
        return NULL;
    // Allocate memory for the cloned TGA
    TGA *ret = (TGA*)malloc(sizeof(TGA));
    // If we could allocate memory
    if (ret != NULL) {
        // Allocate memory for the header
        ret->_header = (TGAHeader*)malloc(sizeof(TGAHeader));
        // If we couldn't allocate memory
        if (ret->_header == NULL) {
            // Free the memory for the cloned TGA
            free(ret);
            // Return NULL
            return NULL;
        }
        // Copy the header
        memcpy(ret->_header, tga->_header, sizeof(TGAHeader));
        // Allocate memory for the pixels
        ret->_pixels =
            (TGAPixel*)malloc(ret->_header->_width *
                               ret->_header->_height * sizeof(TGAPixel));
        // If we couldn't allocate memory
        if (ret->_pixels == NULL) {
            // Free the memory for the header
            free(ret->_header);
            // Free memory for the cloned TGA
            free(ret);
            // Return NULL
            return NULL;
        }
        // Copy the pixels
        memcpy(ret->_pixels, tga->_pixels,
               ret->_header->_width * ret->_header->_height * sizeof(TGAPixel));
    }
    // Return the cloned TGA
    return ret;
}

```

```

// Free the memory used by the TGA
void TGAFree(TGA **tga) {
    // Check arguments
    if (tga == NULL || *tga == NULL)
        return;
    // If the header has been allocated
    if ((*tga)->_header != NULL) {
        // Free the memory for the header
        free((*tga)->_header);
        (*tga)->_header = NULL;
    }
    // Free the pixels
    TGAFreePixel(&((*tga)->_pixels));
    // Free the TGA
    free(*tga);
    *tga = NULL;
}

// Load a TGA from the file pointed to by 'fileName'
// If 'tga' already contains a TGA, it is overwritten
// return 0 upon success, else
// 1 : couldn't open the file
// 2 : malloc failed
// 3 : can only handle image type 2 and 10
// 4 : can only handle pixel depths of 16, 24, and 32
// 5 : can only handle colour map types of 0 and 1
// 6 : unexpected end of file
// 7 : invalid arguments
int TGALoad(TGA **tga, char *fileName) {
    // Check arguments
    if (fileName == NULL) return 7;
    // If the TGA in argument is already used
    if (*tga != NULL)
        // Free memory
        TGAFree(tga);
    // Allocate memory for the TGA
    *tga = (TGA*)malloc(sizeof(TGA));
    // If we couldn't allocate memory
    if (*tga == NULL) {
        // Stop here
        TGAFree(tga);
        return 2;
    }
    // Set pointers to NULL
    (*tga)->_header = NULL;
    (*tga)->_pixels = NULL;
    // Declare variables used during decoding
    int n = 0, i = 0, j = 0;
    unsigned int bytes2read = 0, skipover = 0;
    unsigned char p[5] = {0};
    size_t ret = 0;
    // Open the file
    FILE *fptr = fopen(fileName, "r");
    // If we couldn't open the file
    if (fptr == NULL) {
        // Stop here
        TGAFree(tga);
        return 1;
    }
    // Allocate memory for the header
    (*tga)->_header = (TGAHeader*)malloc(sizeof(TGAHeader));

```

```

// If we couldn't allocate memory
if ((*tga)->_header == NULL) {
    // Stop here
    TGAFree(tga);
    fclose(fptr);
    return 2;
}
// Set a pointer to the header
TGAHeader *h = (*tga)->_header;
// Read the header's values
h->_idLength = fgetc(fptr);
h->_colorMapType = fgetc(fptr);
h->_dataTypeCode = fgetc(fptr);
ret = fread(&(h->_colorMapOrigin), 2, 1, fptr);
ret = fread(&(h->_colorMapLength), 2, 1, fptr);
h->_colorMapDepth = fgetc(fptr);
ret = fread(&(h->_xOrigin), 2, 1, fptr);
ret = fread(&(h->_yOrigin), 2, 1, fptr);
ret = fread(&(h->_width), 2, 1, fptr);
ret = fread(&(h->_height), 2, 1, fptr);
h->_bitsPerPixel = fgetc(fptr);
h->_imageDescriptor = fgetc(fptr);
// Allocate memory for the pixels
(*tga)->_pixels =
    (TGAPixel*)malloc(h->_width * h->_height * sizeof(TGAPixel));
// If we couldn't allocate memory
if ((*tga)->_pixels == NULL) {
    // Stop here
    TGAFree(tga);
    fclose(fptr);
    return 2;
}
// Set a pointer to the pixel
TGAPixel *pix = (*tga)->_pixels;
// For each pixel
for (i = 0; i < h->_width * h->_height; ++i)
    // For each value RGBA
    for (int irgb = 0; irgb < 4; ++irgb)
        // Initialize the value to 0
        pix[i]._rgba[irgb] = 0;
// If the data type is not supported
if (h->_dataTypeCode != 2 && h->_dataTypeCode != 10) {
    // Stop here
    TGAFree(tga);
    fclose(fptr);
    return 3;
}
// If the number of byte per pixel is not supported
if (h->_bitsPerPixel != 16 &&
    h->_bitsPerPixel != 24 &&
    h->_bitsPerPixel != 32) {
    // Stop here
    TGAFree(tga);
    fclose(fptr);
    return 4;
}
// If the color map type is not supported
if (h->_colorMapType != 0 &&
    h->_colorMapType != 1) {
    // Stop here
    TGAFree(tga);
    fclose(fptr);
}

```

```

    return 5;
}
// Skip the unused information
skipover += h->_idLength;
skipover += h->_colorMapType * h->_colorMapLength;
fseek(fptr, skipover, SEEK_CUR);
// Calculate the number of byte per pixel
bytes2read = h->_bitsPerPixel / 8;
// For each pixel
while (n < h->_width * h->_height) {
    // Read the pixel according to the data type, merge and
    // move to the next pixel
    if (h->_dataTypeCode == 2) {
        if (fread(p, 1, bytes2read, fptr) != bytes2read) {
            TGAFree(tga);
            fclose(fptr);
            return 6;
        }
        MergeBytes(&(pix[n]), p, bytes2read);
        ++n;
    } else if (h->_dataTypeCode == 10) {
        if (fread(p, 1, bytes2read + 1, fptr) != bytes2read + 1) {
            TGAFree(tga);
            fclose(fptr);
            return 6;
        }
        j = p[0] & 0x7f;
        MergeBytes(&(pix[n]), &(p[1]), bytes2read);
        ++n;
        if (p[0] & 0x80) {
            for (i = 0; i < j; ++i) {
                MergeBytes(&(pix[n]), &(p[1]), bytes2read);
                ++n;
            }
        } else {
            for (i = 0; i < j; ++i) {
                if (fread(p, 1, bytes2read, fptr) != bytes2read) {
                    TGAFree(tga);
                    fclose(fptr);
                    return 6;
                }
                MergeBytes(&(pix[n]), p, bytes2read);
                ++n;
            }
        }
    }
}
// Close the file
fclose(fptr);
// To avoid warning
ret = ret;
// Return success code
return 0;
}

// Save the TGA 'tga' to the file pointed to by 'fileName'
// return 0 upon success, else
// 1 : couldn't open the file
// 2 : invalid arguments
int TGASave(TGA *tga, char *fileName) {
    // Check arguments
    if (tga == NULL || fileName == NULL ||

```

```

    tga->_header == NULL || tga->_pixels == NULL)
        return 2;
// Open the file
FILE *fptr = fopen(fileName,"w");
// If we couldn't open the file
if (fptr == NULL)
    // Stop here
    return 1;
// Write the header
// Set a pointer to the header
TGAHeader *h = tga->_header;
putc(h->_idLength, fptr);
putc(h->_colorMapType, fptr);
putc(h->_dataTypeCode, fptr);
fwrite(&(h->_colorMapOrigin), 2, 1, fptr);
fwrite(&(h->_colorMapLength), 2, 1, fptr);
putc(h->_colorMapDepth, fptr);
fwrite(&(h->_xOrigin), 2, 1, fptr);
fwrite(&(h->_yOrigin), 2, 1, fptr);
fwrite(&(h->_width), 2, 1, fptr);
fwrite(&(h->_height), 2, 1, fptr);
putc(h->_bitsPerPixel, fptr);
putc(h->_imageDescriptor, fptr);
// For each pixel
for (int i = 0;
     i < tga->_header->_height * tga->_header->_width; ++i) {
    // Write the pixel values
    putc(tga->_pixels[i]._rgba[2], fptr);
    putc(tga->_pixels[i]._rgba[1], fptr);
    putc(tga->_pixels[i]._rgba[0], fptr);
    putc(tga->_pixels[i]._rgba[3], fptr);
}
// Close the file
fclose(fptr);
// Return the success code
return 0;
}

// Print the header of 'tga' on 'stream'
// If arguments are invalid, do nothing
void TGAPrintHeader(TGA *tga, FILE *stream) {
    // Check arguments
    if (tga == NULL || stream == NULL) return;
    // Set a pointer to the header
    TGAHeader *h = tga->_header;
    // If the header is not defined
    if (h == NULL)
        // Stop here
        return;
    // Print the header info
    fprintf(stream, "ID length:           %d\n", h->_idLength);
    fprintf(stream, "Colourmap type:           %d\n", h->_colorMapType);
    fprintf(stream, "Image type:               %d\n", h->_dataTypeCode);
    fprintf(stream, "Colour map offset: %d\n", h->_colorMapOrigin);
    fprintf(stream, "Colour map length: %d\n", h->_colorMapLength);
    fprintf(stream, "Colour map depth:  %d\n", h->_colorMapDepth);
    fprintf(stream, "X origin:              %d\n", h->_xOrigin);
    fprintf(stream, "Y origin:              %d\n", h->_yOrigin);
    fprintf(stream, "Width:                 %d\n", h->_width);
    fprintf(stream, "Height:                %d\n", h->_height);
    fprintf(stream, "Bits per pixel:        %d\n", h->_bitsPerPixel);
    fprintf(stream, "Descriptor:            %d\n", h->_imageDescriptor);
}

```

```

}

// Get a pointer to the pixel at coord (x,y) = (pos[0],pos[1])
// Return NULL in case of invalid arguments
TGAPixel* TGAGetPix(TGA *tga, short *pos) {
    // Check arguments
    if (tga == NULL || pos == NULL ||
        tga->_pixels == NULL || tga->_header == NULL)
        return NULL;
    if (pos[0] < 0 || pos[0] >= tga->_header->_width ||
        pos[1] < 0 || pos[1] >= tga->_header->_height)
        return NULL;
    // Set a pointer to the pixels
    TGAPixel *p = tga->_pixels;
    // Calculate the index of the requested pixel
    int i = pos[1] * tga->_header->_width + pos[0];
    // Return a pointer toward the requested pixel
    return &(p[i]);
}

// Set the color of one pixel at coord (x,y) = (pos[0],pos[1]) to 'pix'
// Do nothing in case of invalid arguments
void TGASetPix(TGA *tga, short *pos, TGAPixel *pix) {
    // Check arguments
    if (tga == NULL || pos == NULL || pix == NULL ||
        tga->_pixels == NULL || tga->_header == NULL)
        return;
    if (pos[0] < 0 || pos[0] >= tga->_header->_width ||
        pos[1] < 0 || pos[1] >= tga->_header->_height)
        return;
    // Set a pointer to the pixels
    TGAPixel *p = tga->_pixels;
    // Calculate the index of the requested pixel
    int i = pos[1] * tga->_header->_width + pos[0];
    // Set the value of the pixel
    memcpy(p + i, pix, sizeof(TGAPixel));
}

// Draw one stroke at 'pos' with 'pen'
// Don't do anything in case of invalid arguments
void TGAStrokePix(TGA *tga, float *pos, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || pos == NULL || pen == NULL ||
        tga->_pixels == NULL || tga->_header == NULL) return;
    // If the shape of the pencil is pixel
    if (pen->_shape == tgaPenPixel) {
        // Declare a variable for the integer position of the
        // current pixel
        short q[2] = {0};
        q[0] = (short)floor(pos[0]);
        q[1] = (short)floor(pos[1]);
        // Get the current color of the pencil
        TGAPixel *pix = TGAPencilGetPixel(pen);
        // Set the color of the current pixel
        TGASetPix(tga, q, pix);
        // Free the memory used by the pixel from the pencil
        TGAFreePixel(&pix);
    } else if (pen->_shape == tgaPenRound ||
        pen->_shape == tgaPenSquare) {
        // Set a pointer to pixels
        TGAPixel *pixels = tga->_pixels;
    }
}

```

```

// Get the current color of the pencil
TGAPixel *pix = TGAPencilGetPixel(pen);
// Declare variable for coordinates of pixel
float p[2] = {0};
// Calculate the radius of the area affected by the pencil
float r = pen->_thickness * 0.5;
// For each pixel in the area affected by the pencil
for (p[0] = pos[0] - r; p[0] < pos[0] + r + TGA_EPSILON; p[0] += 1.0) {
    for (p[1] = pos[1] - r; p[1] < pos[1] + r + TGA_EPSILON; p[1] += 1.0) {
        // Declare a variable for the integer position of the
        // current pixel
        short q[2] = {0};
        q[0] = (short)floor(p[0]);
        q[1] = (short)floor(p[1]);
        // If the current pixel is in the TGA
        if (q[0] >= 0 && q[0] < tga->_header->_width &&
            q[1] >= 0 && q[1] < tga->_header->_height) {
            // Calculate the distance of the current pixel to
            // the center of the pencil
            float l =
                sqrt(pow(pos[0] - p[0], 2.0) + pow(pos[1] - p[1], 2.0));
            // If the pencil is squared, or round and current pixel is
            // in the pencil area
            if ((pen->_shape == tgaPenRound && floor(l) <= floor(r)) ||
                pen->_shape == tgaPenSquare) {
                // Calculate the index of the current pixel
                int iPix = q[1] * tga->_header->_width + q[0];
                // If the pen doesn't use antialias
                if (pen->_antialias == false) {
                    // Set the value of the pixel
                    memcpy(pixels + iPix, pix, sizeof(TGAPixel));
                } // Else, if the pencil uses antialias
                else {
                    // Declare a variable to calculate the coverage ratio
                    float ratio = 1.0;
                    // Declare a variable to calculate the coordinates of the
                    // bottom left of the current pixel
                    float qf[2] = {0};
                    qf[0] = floor(p[0]);
                    qf[1] = floor(p[1]);
                    // If the pencil is square
                    if (pen->_shape == tgaPenSquare) {
                        // Calculate the coverage ratio
                        ratio = TGA_RatioCoveragePixelSquare(pos, r, qf);
                    } // Else, if the pencil is round
                    else if (pen->_shape == tgaPenRound) {
                        // Calculate the coverage ratio
                        ratio = TGA_RatioCoveragePixelRound(pos, r, qf);
                    }
                }
                // Get a pointer to the current pixel
                TGAPixel *curPix = TGA_GetPix(tga, q);
                // If the pointer is not null
                if (curPix != NULL) {
                    // Blend the current pixel with the pixel from
                    // the pencil
                    TGAPixel *blendPix = TGA_BlendPixel(curPix, pix, ratio);
                    // If the blended pixel is not null
                    if (blendPix != NULL) {
                        // Set the current pixel to the blended pixel
                        memcpy(pixels + iPix, blendPix, sizeof(TGAPixel));
                        // Free memory used by the blended pixel
                        TGA_FreePixel(&blendPix);
                    }
                }
            }
        }
    }
}

```

```

    }
    }
    }
    }
    }
    }
    // Free the memory used by the pixel from the pencil
    TGAFreePixel(&pix);
}
}

// Draw a line between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawLine(TGA *tga, float *from, float *to, TGAPencil *pen) {
    // Draw a curve with control points located at anchor points
    TGADrawCurve(tga, from, from, to, to, pen);
}

// Draw a curve between 'from' and 'to' with pencil 'pen'
// and control points 'ctrlFrom' and 'ctrlTo'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawCurve(TGA *tga, float *from, float *ctrlFrom,
float *ctrlTo, float *to, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || from == NULL || to == NULL || pen == NULL ||
        ctrlFrom == NULL || ctrlTo == NULL ||
        tga->_header == NULL || tga->_pixels == NULL)
        return;
    // Declare a variable to memorize the box bounding the curve
    float range[4];
    // Calculate the coordinates of the bounding box
    range[0] = from[0]; range[1] = from[1];
    range[2] = from[0]; range[3] = from[1];
    if (range[0] > to[0]) range[0] = to[0];
    if (range[1] > to[1]) range[1] = to[1];
    if (range[2] < to[0]) range[2] = to[0];
    if (range[3] < to[1]) range[3] = to[1];
    if (range[0] > ctrlTo[0]) range[0] = ctrlTo[0];
    if (range[1] > ctrlTo[1]) range[1] = ctrlTo[1];
    if (range[2] < ctrlTo[0]) range[2] = ctrlTo[0];
    if (range[3] < ctrlTo[1]) range[3] = ctrlTo[1];
    if (range[0] > ctrlFrom[0]) range[0] = ctrlFrom[0];
    if (range[1] > ctrlFrom[1]) range[1] = ctrlFrom[1];
    if (range[2] < ctrlFrom[0]) range[2] = ctrlFrom[0];
    if (range[3] < ctrlFrom[1]) range[3] = ctrlFrom[1];
    // Calculate the perimeter of the bounding box
    float l = 2.0 * (range[2] - range[0]) + 2.0 * (range[3] - range[1]);
    // The length of the curve is upper bounded by the perimeter of
    // the box, then to calculate the step of the curve parameter
    // we can divide the range of the parameter (1.0) by the perimeter,
    // and we minus epsilon to avoid jump over pixels due to float
    // approximation in the case of horizontal and vertical lines
    float dt = 1.0 / l - TGA_EPSILON;
    // Declare the parameter of the curve
    float t = 0.0;
    // Declare a variable to memorize the position on the curve
    float pos[2];
    pos[0] = from[0]; pos[1] = from[1];
    // Declare a variable to memorize the last pixel stroke to avoid

```



```

// stroking several time the same pixel as dt is underestimated
int prevPos[2];
prevPos[0] = (int)floor(from[0]);
prevPos[1] = (int)floor(from[1]);
// Stroke the first pixel
TGASTrokePix(tga, from, pen);
// While we haven't reached the end of the curve
while (t <= 1.0) {
    // Calculate the current position on the curve
    TGACurvePos(from, to, ctrlFrom, ctrlTo, t, pos);
    // If the current position is not on the same pixel as previously
    // stroke
    if ((int)floor(pos[0]) != prevPos[0] ||
        (int)floor(pos[1]) != prevPos[1]) {
        // Set the blend value of the pencil to calculate the pencil
        // current color
        TGAPencilSetBlend(pen, t);
        // Stroke the pixel
        TGASTrokePix(tga, pos, pen);
        // Update the position of the last stroke pixel
        prevPos[0] = (int)floor(pos[0]);
        prevPos[1] = (int)floor(pos[1]);
    }
    // Move along the curve by dt
    t += dt;
}
// If the last pixel hasn't been stroke
if ((int)floor(to[0]) != prevPos[0] ||
    (int)floor(to[1]) != prevPos[1])
    // Stroke the last pixel
    TGASTrokePix(tga, to, pen);
}

// Draw a rectangle between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawRect(TGA *tga, float *from, float *to, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || from == NULL || to == NULL || pen == NULL ||
        tga->_header == NULL || tga->_pixels == NULL)
        return;
    // Declare two variables to memorize the extremities of the lines
    float cornA[2];
    float cornB[2];
    // Set the coordinate of the extremities of each of the 4 lines
    // and draw them
    cornA[0] = from[0]; cornA[1] = from[1];
    cornB[0] = from[0]; cornB[1] = to[1];
    TGADrawLine(tga, cornA, cornB, pen);
    cornA[0] = from[0]; cornA[1] = from[1];
    cornB[0] = to[0]; cornB[1] = from[1];
    TGADrawLine(tga, cornA, cornB, pen);
    cornA[0] = to[0]; cornA[1] = to[1];
    cornB[0] = to[0]; cornB[1] = from[1];
    TGADrawLine(tga, cornA, cornB, pen);
    cornA[0] = to[0]; cornA[1] = to[1];
    cornB[0] = from[0]; cornB[1] = to[1];
    TGADrawLine(tga, cornA, cornB, pen);
}

// Fill a rectangle between 'from' and 'to' with pencil 'pen'
// pixels outside the TGA are ignored

```

```

// do nothing if arguments are invalid
void TGAFillRect(TGA *tga, float *from, float *to, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || from == NULL || to == NULL || pen == NULL ||
        tga->_header == NULL || tga->_pixels == NULL)
        return;
    // Declare a variable to memorize the ordered of the rectangle
    short cornA[2];
    short cornB[2];
    // Get the ordered corner of the rectangle
    if (from[0] < to[0]) {
        cornA[0] = from[0]; cornB[0] = to[0];
    } else {
        cornA[0] = to[0]; cornB[0] = from[0];
    }
    if (from[1] < to[1]) {
        cornA[1] = from[1]; cornB[1] = to[1];
    } else {
        cornA[1] = to[1]; cornB[1] = from[1];
    }
    // Declare a variable to move through pixels in the rectangle
    float p[2];
    // For each pixel in the rectangle
    for (p[0] = cornA[0]; p[0] < cornB[0]; ++(p[0]))
        for (p[1] = cornA[1]; p[1] < cornB[1]; ++(p[1]))
            // Set the color of the pixel
            TGAStrokePix(tga, p, pen);
}

// Draw a ellipse at 'center' of radius 'r' (Rx,Ry)
// with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGADrawEllipse(TGA *tga, float *center, float *r, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || center == NULL || r == NULL || pen == NULL ||
        tga->_header == NULL || tga->_pixels == NULL ||
        r[0] < 0 || r[1] < 0)
        return;
    // Declare a variable to memorize the rectangle bounding the ellipse
    float cornA[2];
    float cornB[2];
    // Calculate the coordinates of the bounding rectangle
    cornA[0] = center[0] - r[0]; cornA[1] = center[1] - r[1];
    cornB[0] = center[0] + r[0]; cornB[1] = center[1] + r[1];
    // Declare a variable to memorize the position in the
    // bounding rectangle
    float p[2];
    // Declare a variable to memorize the ratio between axis of
    // the ellipse
    float s = r[0] / r[1];
    // For each pixel in the bounding rectangle
    for (p[0] = cornA[0]; p[0] <= cornB[0]; ++(p[0])) {
        for (p[1] = cornA[1]; p[1] <= cornB[1]; ++(p[1])) {
            // Calculate the corrected distance to the center in the circle
            // of radius r[0]
            short d = (short)round(sqrt(pow(p[0] - center[0], 2.0) +
                pow(s * (p[1] - center[1]), 2.0)));
            // If the current pixel is on the circle of radius r[0]
            if (d == r[0])
                // Stroke the current pixel
                TGAStrokePix(tga, p, pen);
        }
    }
}

```

```

    }
}
}

// Fill an ellipse at 'center' of radius 'r' (Rx, Ry) with pencil 'pen'
// pixels outside the TGA are ignored
// do nothing if arguments are invalid
void TGAFillEllipse(TGA *tga, float *center, float *r, TGAPencil *pen) {
    // Check arguments
    if (tga == NULL || center == NULL || r == NULL || pen == NULL ||
        tga->_header == NULL || tga->_pixels == NULL)
        return;
    // Declare a variable to memorize the rectangle bounding the ellipse
    float cornA[2];
    float cornB[2];
    // Calculate the coordinates of the bounding rectangle
    cornA[0] = center[0] - r[0]; cornA[1] = center[1] - r[1];
    cornB[0] = center[0] + r[0]; cornB[1] = center[1] + r[1];
    // Declare a variable to memorize the position in the
    // bounding rectangle
    float p[2];
    // Declare a variable to memorize the ratio between axis of
    // the ellipse
    float s = (float)(r[0]) / (float)(r[1]);
    // For each pixel in the bounding rectangle
    for (p[0] = cornA[0]; p[0] <= cornB[0]; ++(p[0])) {
        for (p[1] = cornA[1]; p[1] <= cornB[1]; ++(p[1])) {
            // Calculate the corrected distance to the center in the circle
            // of radius r[0]
            short d = (short)round(sqrt(pow(p[0] - center[0], 2.0) +
                pow(s * (p[1] - center[1]), 2.0)));
            // If the current pixel is inside the circle of radius r[0]
            if (d <= r[0])
                TGASTrokePix(tga, p, pen);
        }
    }
}

// Apply a gaussian blur of 'strength' and 'range' perimeter on the TGA
// Do nothing if arguments are invalid
void TGAFilterGaussBlur(TGA *tga, float strength, float range) {
    // Check arguments
    if (tga == NULL || tga->_header == NULL || strength <= 0.0)
        return;
    // Allocate memory for a temporary buffer
    float *drgb = (float*)malloc(tga->_header->_width *
        tga->_header->_height * 4 * sizeof(float));
    // If we couldn't allocate memory
    if (drgb == NULL)
        // Stop here
        return;
    // Declare variable to memorize current pixel
    short px[2] = {0, 0};
    // Declare variable to memorize index of rgba
    int irgb = 0;
    // For each pixel
    for (px[0] = tga->_header->_width; px[0]--;) {
        for (px[1] = tga->_header->_height; px[1]--;) {
            // Get index of the current pixel
            long int index = 4 * (px[1] * tga->_header->_width + px[0]);
            // For each rgba value
            for (irgb = 4; irgb--;)

```

```

        // Initilizae the value in the temporary buffer to 0
        drgb[index + irgb] = 0.0;
    }
}
// For each pixel
for (px[0] = tga->_header->_width; px[0]--;) {
    for (px[1] = tga->_header->_height; px[1]--;) {
        // Get index of the current pixel
        long int indexp = 4 * (px[1] * tga->_header->_width + px[0]);
        // For each rgba value
        for (irgb = 4; irgb--;) {
            // Declare a variable to memorize position of pixel in range
            short qx[2] = {0, 0};
            // Declare variables to calculate new value of rgba
            double sum = 0.0;
            double p = 0.0;
            // Calculate the corners positions of the area in range
            short from[2] = {0, 0};
            short to[2] = {0, 0};
            from[0] = (px[0] > range ? px[0] - range : 0);
            from[1] = (px[1] > range ? px[1] - range : 0);
            to[0] = (px[0] < tga->_header->_width - range ?
                px[0] + range : tga->_header->_width);
            to[1] = (px[1] < tga->_header->_height - range ?
                px[1] + range : tga->_header->_height);
            // For each pixel in range
            for (qx[0] = from[0]; qx[0] < to[0]; ++(qx[0])) {
                for (qx[1] = from[1]; qx[1] < to[1]; ++(qx[1])) {
                    // Calculate the distance of this pixel to the current pixel
                    double dist = sqrt(pow(qx[0] - px[0], 2.0) +
                        pow(qx[1] - px[1], 2.0));
                    // If this pixel is in range
                    if (dist < range) {
                        // Calculate the Gauss coefficient
                        double g = TGAGauss(dist, 0.0, strength);
                        // Update the values to calculate the new rgba
                        sum += g;
                        TGAPixel *pixelQ = TGAGetPix(tga, qx);
                        p += g * (double)(pixelQ->_rgba[irgb]);
                    }
                }
            }
            // Update the new value of the current pixel in the
            // temporary buffer
            drgb[indexp + irgb] = p / sum;
        }
    }
}
// For each pixel
for (px[0] = tga->_header->_width; px[0]--;) {
    for (px[1] = tga->_header->_height; px[1]--;) {
        // Get the index of the pixel
        long int index = 4 * (px[1] * tga->_header->_width + px[0]);
        // Get a pointer to the pixel
        TGAPixel *pixel = TGAGetPix(tga, px);
        // For each rgba value
        for (irgb = 4; irgb--;) {
            // Copy the new value from the temporary buffer to the tga
            pixel->_rgba[irgb] =
                (unsigned char)round(drgb[index + irgb]);
        }
    }
}

```

```

    }
    // Free memory used by the temporary buffer
    free(drgb);
    drgb = NULL;
}

// Print the string 's' with its (bottom, left) position at 'pos'
// and (width, height) dimension 'dim' with font 'font'
void TGAPrintString(TGA *tga, TGAPencil *pen, TGAFont *font,
    unsigned char *s, float *pos) {
    // Check arguments
    if (tga == NULL || pen == NULL || font == NULL || s == NULL ||
        pos == NULL)
        return;
    // Get the number of character in the string
    int nbChar = strlen((char*)s);
    // Declare a variable to memorise the position where to print
    // the next character
    float curPos[2];
    // Set the position to the start position
    curPos[0] = pos[0]; curPos[1] = pos[1];
    // for each character in the string
    for (int iChar = 0; iChar < nbChar; ++iChar) {
        // If the character is a space
        if (s[iChar] == ' ') {
            // Increment the position in absciss by one character
            // plus interspace
            curPos[0] += (font->_size * font->_scale[0] + font->_space[0]);
        } else if (s[iChar] == '\t') {
            // Increment the position in absciss to the next multiple
            // of the tab parameter
            curPos[0] =
                (floor(curPos[0] / font->_tabSize) + 1.0) * font->_tabSize;
        } else if (s[iChar] == '\n') {
            // Put the position in absciss back to the start position
            curPos[0] = pos[0];
            // Increment the position along ordinate by one character
            // plus interspace
            curPos[1] += (font->_size * font->_scale[1] + font->_space[1]);
        } else {
            // Print the character
            TGAPrintChar(tga, pen, font, s[iChar], curPos);
            // Increment the position in absciss by one character plus
            // interspace
            curPos[0] += (font->_size * font->_scale[0] + font->_space[0]);
        }
    }
}

// Print the char 'c' with its (bottom, left) position at 'pos'
// and (width, height) dimension 'dim' with font 'font'
void TGAPrintChar(TGA *tga, TGAPencil *pen, TGAFont *font,
    unsigned char c, float *pos) {
    // Check arguments
    if (tga == NULL || pen == NULL || font == NULL || pos == NULL)
        return;
    // Set a pointer to the requested character's definition
    TGAChar *ch = font->_char + c;
    // Declare variables to calculate the repositioned and scaled

```

```

// curve coefficients
float from[2];
float ctrlFrom[2];
float ctrlTo[2];
float to[2];
// For each curve in the character
for (int iCurve = 0; iCurve < ch->_nbCurve; ++iCurve) {
    // Set a pointer to the current curve
    float *curve = ch->_curve + (iCurve * 8);
    // Calculate the repositioned and scaled curve coefficients
    from[0] = pos[0] + curve[0] * font->_size * font->_scale[0];
    from[1] = pos[1] + curve[1] * font->_size * font->_scale[1];
    ctrlFrom[0] = pos[0] + curve[2] * font->_size * font->_scale[0];
    ctrlFrom[1] = pos[1] + curve[3] * font->_size * font->_scale[1];
    ctrlTo[0] = pos[0] + curve[4] * font->_size * font->_scale[0];
    ctrlTo[1] = pos[1] + curve[5] * font->_size * font->_scale[1];
    to[0] = pos[0] + curve[6] * font->_size * font->_scale[0];
    to[1] = pos[1] + curve[7] * font->_size * font->_scale[1];
    // Draw the curve
    TGADrawCurve(tga, from, ctrlFrom, ctrlTo, to, pen);
}
}

// Get a white TGAPixel
TGAPixel* TGAGetWhitePixel(void) {
    // Allocate memory for the pixel
    TGAPixel *ret = (TGAPixel*)malloc(sizeof(TGAPixel));
    // If we could allocate memory
    if (ret != NULL)
        // Set the pixel rgba values
        ret->_rgba[0] = ret->_rgba[1] = ret->_rgba[2] = ret->_rgba[3] = 255;
    // Return the pixel
    return ret;
}

// Get a black TGAPixel
TGAPixel* TGAGetBlackPixel(void) {
    // Allocate memory for the pixel
    TGAPixel *ret = (TGAPixel*)malloc(sizeof(TGAPixel));
    // If we could allocate memory
    if (ret != NULL) {
        // Set the pixel rgba values
        ret->_rgba[0] = ret->_rgba[1] = ret->_rgba[2] = 0;
        ret->_rgba[3] = 255;
    }
    // Return the pixel
    return ret;
}

// Get a transparent TGAPixel
TGAPixel* TGAGetTransparentPixel(void) {
    // Allocate memory for the pixel
    TGAPixel *ret = (TGAPixel*)malloc(sizeof(TGAPixel));
    // If we could allocate memory
    if (ret != NULL) {
        // Set the pixel rgba values
        ret->_rgba[0] = ret->_rgba[1] = ret->_rgba[2] = 255;
        ret->_rgba[3] = 0;
    }
    // Return the pixel
    return ret;
}
}

```

```

// Free the memory used by tgapixel
void TGAFreePixel(TGAPixel **pixel) {
    // Check arguments
    if (pixel == NULL || *pixel == NULL)
        return;
    // Free the memory
    free(*pixel);
    *pixel = NULL;
}

// Return a new TGAPixel which is a blend of 'pixa' and 'pixB'
// newPix = (1 - blend) * pixA + blend * pixB
// Return NULL if arguments are invalid
TGAPixel* TGABlendPixel(TGAPixel *pixA, TGAPixel *pixB, float blend) {
    // Check arguments
    if (pixA == NULL || pixB == NULL || blend < 0.0 || blend > 1.0)
        return NULL;
    // Get a transparent pixel
    TGAPixel *ret = TGAGetTransparentPixel();
    // If we could get a transparent pixel
    if (ret != NULL) {
        // For each rgba value
        for (int i = 4; i--;)
            // Calculate the blended value
            ret->_rgba[i] = (1.0 - blend) * pixA->_rgba[i] +
                blend * pixB->_rgba[i];
    }
    // Return the blend pixel
    return ret;
}

// Create a default TGAPencil with all color set to transparent
// solid mode, thickness = 1.0, square shape, no antialias
// Return NULL if it couldn't allocate memory
TGAPencil* TGAGetPencil(void) {
    // Allocate memory for the new pencil
    TGAPencil *ret = (TGAPencil*)malloc(sizeof(TGAPencil));
    // If we could allocate memory
    if (ret != NULL) {
        // Get a transparent pixel
        TGAPixel *pixel = TGAGetTransparentPixel();
        // If we couldn't get the pixel
        if (pixel == NULL) {
            // Free memory
            free(ret);
            // Return NULL
            return NULL;
        }
        // Initialise all the color of the pencil to the transparent pixel
        for (int iCol = TGA_NBCOLORPENCIL; iCol--;)
            memcpy(ret->_colors + iCol, pixel, sizeof(TGAPixel));
        // Free memory used for the pixel
        TGAFreePixel(&pixel);
        // Set the default value of the pencil
        ret->_activeColor = 0;
        ret->_modeColor = tgaPenSolid;
        ret->_shape = tgaPenSquare;
        ret->_blendColor[0] = 0;
        ret->_blendColor[1] = 1;
        ret->_blend = 0.0;
        ret->_thickness = 1.0;
    }
}

```

```

    ret->_antialias = false;
}
// Return the new pencil
return ret;
}

// Free the memory used by the TGAPencil 'pen'
void TGAFreePencil(TGAPencil **pencil) {
    // Check arguments
    if (pencil == NULL || *pencil == NULL)
        return;
    // Free memory used by the pencil
    free(*pencil);
    *pencil = NULL;
}

// Clone the TGAPencil 'pen'
// Return NULL if it couldn't clone
TGAPencil* TGAPencilClone(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return NULL;
    // Allocate memory for the cloned pencil
    TGAPencil *ret = (TGAPencil*)malloc(sizeof(TGAPencil));
    // If we could allocate memory
    if (ret != NULL) {
        // Copy the pencil in the clone
        memcpy(ret, pen, sizeof(TGAPencil));
    }
    // Return the cloned pencil
    return ret;
}

// Create a TGAPencil with 1st color active and set to black
// Return NULL if it couldn't create
TGAPencil* TGAGetBlackPencil(void) {
    // Get a default pencil
    TGAPencil *ret = TGAGetPencil();
    // If we could get a pencil
    if (ret != NULL) {
        // Select the first color
        TGAPencilSetColor(ret, 0);
        // Get a black pixel
        TGAPixel *pixel = TGAGetBlackPixel();
        // If we couldn't get the pixel
        if (pixel == NULL) {
            // Free memory
            TGAFreePencil(&ret);
            // Return NULL
            return NULL;
        }
        // Set the color to the black pixel
        TGAPencilSetColor(ret, pixel);
        // Free memory used by the pixel
        TGAFreePixel(&pixel);
    }
    // Return the new pencil
    return ret;
}

// Select the active color of TGAPencil 'pen' to 'iCol'
// Do nothing if arguments are invalid

```



```

void TGAPencilSelectColor(TGAPencil *pen, int iCol) {
    // Check arguments
    if (pen == NULL || iCol < 0 || iCol >= TGA_NBCOLORPENCIL)
        return;
    // Set the active color
    pen->_activeColor = iCol;
}

// Get the index of active color of TGAPencil 'pen'
// Return -1 if arguments are invalid
int TGAPencilGetColor(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return -1;
    // Return the active color
    return pen->_activeColor;
}

// Get the active color of the TGAPencil 'pen'
// Return NULL if arguments are invalid
TGAPixel* TGAPencilGetPixel(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return NULL;
    // Get a white pixel
    TGAPixel *ret = TGAGetWhitePixel();
    // If we couldn't get the pixel
    if (ret == NULL) {
        // Return null
        return NULL;
    }
    // If the pen's color mode is tgaPenSolid
    if (pen->_modeColor == tgaPenSolid) {
        // Set the active color to the pixel
        memcpy(ret, pen->_colors + pen->_activeColor, sizeof(TGAPixel));
    }
    // Else, if the pen's color mode is tgaPenBlend
    else if (pen->_modeColor == tgaPenBlend) {
        // Calculate the current color
        for (int irgb = 0; irgb < 4; ++irgb)
            ret->_rgba[irgb] = (unsigned char)round((1.0 - pen->_blend) *
                (float)(pen->_colors[pen->_blendColor[0]]._rgba[irgb]) +
                pen->_blend *
                (float)(pen->_colors[pen->_blendColor[1]]._rgba[irgb]));
    }
    // Return the pixel
    return ret;
}

// Set the active color of TGAPencil 'pen' to TGAPixel 'col'
// Do nothing if arguments are invalid
void TGAPencilSetColor(TGAPencil *pen, TGAPixel *col) {
    // Check arguments
    if (pen == NULL || col == NULL)
        return;
    // Set the color values
    memcpy(pen->_colors + pen->_activeColor, col, sizeof(TGAPixel));
}

// Set the active color of TGAPencil 'pen' to 'rgba'
// Do nothing if arguments are invalid
void TGAPencilSetColRGBA(TGAPencil *pen, unsigned char *rgba) {
    // Check arguments

```

```

    if (pen == NULL || rgba == NULL)
        return;
    // Set the color values
    memcpy(&(pen->_colors[pen->_activeColor]._rgba), rgba,
        sizeof(unsigned char) * 4);
}

// Set the thickness of TGAPencil 'pen' to 'v'
// Do nothing if arguments are invalid
void TGAPencilSetThickness(TGAPencil *pen, float v) {
    // Check arguments
    if (pen == NULL || v < 0.0)
        return;
    // Set the thickness
    pen->_thickness = v;
}

// Set the antialias of the TGAPencil 'pen' to 'v'
// Do nothing if arguments are invalid
void TGAPencilSetAntialias(TGAPencil *pen, bool v) {
    // Check arguments
    if (pen == NULL || (v != true && v != false))
        return;
    // Set the antialias
    pen->_antialias = v;
}

// Set the blend value 'v' of the TGAPencil 'pen'
// Do nothing if arguments are invalid
void TGAPencilSetBlend(TGAPencil *pen, float v) {
    // Check arguments
    if (pen == NULL || v < 0.0 || v > 1.0)
        return;
    pen->_blend = v;
}

// Set the shape of the TGAPencil 'pen' to 'tgaPenSquare'
// Do nothing if arguments are invalid
void TGAPencilSetShapeSquare(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return;
    // Set the shape
    pen->_shape = tgaPenSquare;
}

// Set the shape of the TGAPencil 'pen' to 'tgaPenRound'
// Do nothing if arguments are invalid
void TGAPencilSetShapeRound(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return;
    // Set the shape
    pen->_shape = tgaPenRound;
}

// Set the shape of the TGAPencil 'pen' to 'tgaPenPixel'
// Do nothing if arguments are invalid
void TGAPencilSetShapePixel(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return;
}

```

```

    // Set the shape
    pen->_shape = tgaPenPixel;
}

// Set the mode of the TGAPencil 'pen' to 'tgaPenSolid'
// Do nothing if arguments are invalid
void TGAPencilSetModeColorSolid(TGAPencil *pen) {
    // Check arguments
    if (pen == NULL)
        return;
    // Set the color mode
    pen->_modeColor = tgaPenSolid;
}

// Set the mode of the TGAPencil 'pen' to 'tgaPenBlend'
// Blend is done from 'fromCol' to 'toCol'
// Do nothing if arguments are invalid
void TGAPencilSetModeColorBlend(TGAPencil *pen, int fromCol, int toCol) {
    // Check arguments
    if (pen == NULL || fromCol < 0 || fromCol >= TGA_NBCOLORPENCIL ||
        toCol < 0 || toCol >= TGA_NBCOLORPENCIL)
        return;
    // Set the color mode
    pen->_modeColor = tgaPenBlend;
    pen->_blendColor[0] = fromCol;
    pen->_blendColor[1] = toCol;
}

// Function to decode rgba values when loading a TGA file
// Do nothing if arguments are invalid
void MergeBytes(TGAPixel *pixel, unsigned char *p, int bytes) {
    // Check arguments
    if (pixel == NULL || p == NULL)
        return;
    // Merge bytes
    if (bytes == 4) {
        pixel->_rgba[0] = p[2];
        pixel->_rgba[1] = p[1];
        pixel->_rgba[2] = p[0];
        pixel->_rgba[3] = p[3];
    } else if (bytes == 3) {
        pixel->_rgba[0] = p[2];
        pixel->_rgba[1] = p[1];
        pixel->_rgba[2] = p[0];
        pixel->_rgba[3] = 255;
    } else if (bytes == 2) {
        pixel->_rgba[0] = (p[1] & 0x7c) << 1;
        pixel->_rgba[1] = ((p[1] & 0x03) << 6) | ((p[0] & 0xe0) >> 2);
        pixel->_rgba[2] = (p[0] & 0x1f) << 3;
        pixel->_rgba[3] = (p[1] & 0x80);
    }
}

// Function to calculate the ratio of coverage of pixel 'q' by a square
// centered on 'p' with a size of 'r'
// Return 1.0 if arguments are invalid
float TGA RatioCoveragePixelSquare(float *p, float r, float *q) {
    float ratio = 1.0;
    // Check arguments
    if (p == NULL || q == NULL)
        return ratio;
}

```

```

    // Get the intersecting box
    float box[4];
    box[0] = (p[0] - r < q[0] ? q[0] : p[0] - r);
    box[1] = (p[1] - r < q[1] ? q[1] : p[1] - r);
    box[2] = (p[0] + r > q[0] + 1.0 ? q[0] + 1.0 : p[0] + r);
    box[3] = (p[1] + r > q[1] + 1.0 ? q[1] + 1.0 : p[1] + r);
    // The ratio is equal to the area of the intersecting box because the
    // pixel area is 1
    ratio = (box[2] - box[0]) * (box[3] - box[1]);
    // Return the ratio
    return ratio;
}

// Function to calculate the ratio of coverage of pixel 'q' by a circle
// centered on 'p' with a radius of 'r'
// Return 1.0 if arguments are invalid
float TGARatioCoveragePixelRound(float *p, float r, float *q) {
    float ratio = 1.0;
    // Check arguments
    if (p == NULL || q == NULL)
        return ratio;
    // Calculate the ratio by checking a grid of 100 points inside
    // the pixel
    // Declare variables for the calcul
    float delta = 0.1;
    float dp[2];
    float sum = 0.0;
    // For each point
    for (dp[0] = 0.0; dp[0] < 1.0; dp[0] += delta) {
        for (dp[1] = 0.0; dp[1] < 1.0; dp[1] += delta) {
            // Calculate the distance of this point to the center of
            // the circle
            float l = sqrt(pow(p[0] - (q[0] + dp[0]), 2.0) +
                pow(p[1] - (q[1] + dp[1]), 2.0));
            // If the point is in the circle
            if (l <= r) {
                // Increment the number of points inside the circle
                sum += 1.0;
            }
        }
    }
    // The ratio is the number of points divided by the total number of
    // points
    ratio = sum / pow(1.0 / delta, 2.0);
    // Return the ratio
    return ratio;
}

// Return the value of the gaussian (mean, sigma) at x
float TGAGauss(float x, float mean, float sigma) {
    // Calculate the Gaus value
    float a = 1.0 / (sigma * sqrt(2.0 * TGA_PI));
    float ret = a * exp(-1.0 * pow(x - mean, 2.0) /
        (2.0 * pow(sigma, 2.0)));
    // Return the value
    return ret;
}

// Calculate the position along a Bezier curve defined by 'from',
// 'ctrlFrom', 'ctrlTo', 'to', at position 't' ([0.0, 1.0]) and memorize
// the result in 'pos'
// Return (0.0,0.0) if argument are invalid, if (pos == NULL) do nothing

```

```

void TGACurvePos(float *from, float *to, float *ctrlFrom,
float *ctrlTo, float t, float *pos) {
    // Check arguments
    if (pos == NULL)
        return;
    if (from == NULL || ctrlFrom == NULL || ctrlTo == NULL || to == NULL) {
        pos[0] = pos[1] = 0.0;
        return;
    }
    // Calculate the position
    float A[2];
    A[0] = (1.0 - t) * from[0] + t * ctrlFrom[0];
    A[1] = (1.0 - t) * from[1] + t * ctrlFrom[1];
    float B[2];
    B[0] = (1.0 - t) * ctrlTo[0] + t * to[0];
    B[1] = (1.0 - t) * ctrlTo[1] + t * to[1];
    float C[2];
    C[0] = (1.0 - t) * ctrlFrom[0] + t * ctrlTo[0];
    C[1] = (1.0 - t) * ctrlFrom[1] + t * ctrlTo[1];
    float D[2];
    D[0] = (1.0 - t) * A[0] + t * C[0];
    D[1] = (1.0 - t) * A[1] + t * C[1];
    float E[2];
    E[0] = (1.0 - t) * C[0] + t * B[0];
    E[1] = (1.0 - t) * C[1] + t * B[1];
    pos[0] = (1.0 - t) * D[0] + t * E[0];
    pos[1] = (1.0 - t) * D[1] + t * E[1];
}

```

## 2.2 tgaFont.c

```

// ***** TGAFont.C *****

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

void TGAFontCreateDefault(TGAFont *font);

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

// Create a TGAFont with set of character 'font',
// _fontSize = 18.0, _space[0] = _space[1] = 3.0,
// _scale[0] = 0.5, _scale[1] = 1.0
// Return NULL if it couldn't create
TGAFont* TGAFontCreate(tgaFont font) {
    // Allocate memory
    TGAFont *ret = (TGAFont*)malloc(sizeof(TGAFont));
    // If we could allocate memory
    if (ret != NULL) {
        // Set the default size
        ret->_size = 18.0;
        // Set the default space
        ret->_space[0] = ret->_space[1] = 3.0;
        // Set the default scale
        ret->_scale[0] = 0.5; ret->_scale[1] = 1.0;
        // For each character
        for (int iChar = 256; iChar--;)
            // By default set this character definition as empty (no curves)
            ret->_char[iChar]._nbCurve = 0;
        // If the requested font is the default one
        if (font == tgaFontDefault)
            // Create the default font characters' curves
    }
}

```

```

        TGAFontCreateDefault(ret);
    }
    // Return the created font
    return ret;
}

// Free memory used by TGAFont
// Do nothing if arguments are invalid
void TGAFreeFont(TGAFont **font) {
    // If the argument are invalid, stop here
    if (font == NULL || *font == NULL)
        return;
    // Free the memory
    free(*font);
    *font = NULL;
}

// Set the font size of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetSize(TGAFont *font, float v) {
    if (font == NULL || v <= 0.0)
        return;
    font->_size = v;
}

// Set the font scale of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetScale(TGAFont *font, float *v) {
    // If the argument are invalid, stop here
    if (font == NULL || v == NULL)
        return;
    // Set the scale
    font->_scale[0] = v[0];
    font->_scale[1] = v[1];
}

// Set the font spacing of TGAFont 'font' to 'v'
// Do nothing if arguments are invalid
void TGAFontSetSpace(TGAFont *font, float *v) {
    // If the argument are invalid, stop here
    if (font == NULL || v == NULL)
        return;
    // Set the space
    font->_space[0] = v[0];
    font->_space[1] = v[1];
}

// Create the curves of each characters for the default font
void TGAFontCreateDefault(TGAFont *font) {
    TGAChar *ch = NULL;
    ch = font->_char + 'A';
    ch->_nbCurve = 3;
    memcpy(ch->_curve,
        (float[]){
            0.0,0.0,0.0,0.18,0.32,1.0,0.5,1.0,
            0.5,1.0,0.68,1.0,1.0,0.18,1.0,0.0,
            0.15,0.5,0.15,0.5,0.85,0.5,0.85,0.5
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'B';
    ch->_nbCurve = 4;
    memcpy(ch->_curve,
        (float[]){

```

```

        0.00,0.00,0.00,0.00,0.00,1.00,0.00,1.00,
        0.00,1.00,0.77,1.00,0.77,0.58,0.00,0.59,
        0.00,0.59,0.50,0.60,1.01,0.50,1.00,0.26,
        1.00,0.26,1.00,0.00,0.50,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'C';
ch->_nbCurve = 4;
memcpy(ch->_curve,
    (float[]){
        1.00,0.67,1.00,0.82,1.00,1.00,0.50,1.00,
        0.50,1.00,0.00,1.00,0.00,0.81,0.00,0.50,
        0.00,0.50,0.00,0.18,0.00,0.00,0.50,0.00,
        0.50,0.00,1.00,0.00,1.00,0.17,1.00,0.33
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'D';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        0.00,1.00,0.00,1.00,0.00,0.00,0.00,0.00,
        0.00,0.00,1.00,0.00,1.00,0.00,1.00,0.50,
        1.00,0.50,1.00,1.00,0.50,1.00,0.00,1.00,
        0.00,1.00,-0.11,1.00,0.00,0.00,0.00,0.00,
        0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'E';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        1.00,1.00,1.00,1.00,0.12,1.01,0.06,0.95,
        0.06,0.95,-0.01,0.90,0.00,0.10,0.05,0.05,
        0.05,0.05,0.11,-0.01,1.00,0.00,1.00,0.00,
        1.00,0.00,1.00,0.00,0.00,0.00,0.00,0.00,
        0.00,0.50,0.00,0.50,0.50,0.50,0.50,0.50
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'F';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        0.00,0.50,0.00,0.50,0.50,0.50,0.50,0.50,
        1.00,1.00,1.00,1.00,0.12,1.01,0.06,0.95,
        0.06,0.95,-0.01,0.90,0.00,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'G';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        1.00,0.84,1.00,1.00,0.74,1.00,0.50,1.00,
        0.50,1.00,0.00,1.00,0.00,0.81,0.00,0.50,
        0.00,0.50,0.00,0.18,0.00,0.00,0.50,0.00,
        0.50,0.00,1.00,0.00,1.00,0.50,1.00,0.50,
        1.00,0.50,1.00,0.50,0.50,0.50,0.50,0.50
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'H';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        1.00,1.00,1.00,1.00,1.00,0.00,1.00,0.00,
        0.00,0.50,0.00,0.50,1.00,0.50,1.00,0.50,
        0.00,1.00,0.00,1.00,0.00,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'I';
ch->_nbCurve = 3;

```

```

memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00,
           0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00,
           0.10,1.00,0.10,1.00,0.90,1.00,0.90,1.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'J';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.66,1.00,0.66,1.00,1.00,0.00,0.50,0.00,
           0.50,0.00,0.00,0.00,0.00,0.33,0.00,0.50,
           0.00,1.00,0.00,1.00,1.00,1.00,1.00,1.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'K';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.50,0.54,0.50,0.00,1.00,0.00,1.00,0.00,
           0.00,0.50,0.00,0.50,0.00,0.50,0.33,0.50,
           0.33,0.50,0.67,0.51,1.00,1.00,1.00,1.00,
           0.00,1.00,0.00,1.00,0.00,0.00,0.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'L';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,1.00,0.00,1.00,0.00,0.12,0.05,0.05,
           0.05,0.05,0.08,0.00,1.00,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'M';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,0.00,1.00,0.00,1.00,
           0.00,1.00,0.00,1.00,0.34,0.67,0.50,0.67,
           0.50,0.67,0.66,0.67,1.00,1.00,1.00,1.00,
           1.00,1.00,1.00,1.00,1.00,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'N';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,0.00,1.00,0.00,1.00,
           0.00,1.00,0.33,1.00,0.66,0.00,1.00,0.00,
           1.00,0.00,1.00,0.00,1.00,1.00,1.00,1.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'O';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.50,1.00,1.00,1.00,1.00,1.00,1.00,0.50,
           1.00,0.50,1.00,0.00,1.00,0.00,0.50,0.00,
           0.50,0.00,0.00,0.00,0.00,0.00,0.00,0.50,
           0.00,0.50,0.00,1.00,0.00,1.00,0.50,1.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'P';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,0.00,1.00,0.00,1.00,
           0.00,1.00,0.50,1.00,1.00,1.00,1.00,0.67,

```



```

        1.00,0.67,1.00,0.33,0.50,0.33,0.00,0.33
    }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'Q';
    ch->_nbCurve = 5;
    memcpy(ch->_curve,
        (float[]){
            0.66,0.33,0.66,0.33,1.00,0.00,1.00,0.00,
            0.50,1.00,1.00,1.00,1.00,1.00,1.00,0.50,
            1.00,0.50,1.00,0.00,1.00,0.00,0.50,0.00,
            0.50,0.00,0.00,0.00,0.00,0.00,0.00,0.50,
            0.00,0.50,0.00,1.00,0.00,1.00,0.50,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'R';
    ch->_nbCurve = 4;
    memcpy(ch->_curve,
        (float[]){
            0.00,0.33,0.33,0.00,1.00,0.00,1.00,0.00,
            0.00,0.00,0.00,0.00,0.00,1.00,0.00,1.00,
            0.00,1.00,0.50,1.00,1.00,1.00,1.00,0.67,
            1.00,0.67,1.00,0.33,0.50,0.33,0.00,0.33
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'S';
    ch->_nbCurve = 5;
    memcpy(ch->_curve,
        (float[]){
            1.00,0.83,1.00,0.99,1.00,1.00,0.50,1.00,
            0.50,1.00,0.00,1.00,0.00,0.83,0.00,0.67,
            0.00,0.67,0.00,0.50,1.00,0.67,1.00,0.50,
            1.00,0.50,1.00,0.33,1.00,0.00,0.50,0.00,
            0.50,0.00,0.00,0.00,0.00,0.16,0.00,0.33
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'T';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00,
            0.00,1.00,0.00,1.00,1.00,1.00,1.00,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'U';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,0.50,0.01,0.00,0.50,0.00,
            0.50,0.00,1.00,0.00,1.00,0.51,1.00,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'V';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,1.00,0.34,0.00,0.50,0.00,
            0.50,0.00,0.67,0.00,1.00,1.00,1.00,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'W';
    ch->_nbCurve = 4;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,1.00,0.16,0.00,0.33,0.00,
            0.33,0.00,0.50,0.00,0.50,0.50,0.50,0.50,
            0.50,0.50,0.50,0.50,0.50,0.00,0.66,0.00,
            0.66,0.00,0.82,0.00,1.00,1.00,1.00,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + 'X';

```

```

ch->_nbCurve = 4;
memcpy(ch->_curve,
(float[]){
    1.00,1.00,1.00,1.00,0.50,0.67,0.50,0.51,
    0.50,0.51,0.50,0.33,0.00,0.00,0.00,0.00,
    0.00,1.00,0.00,1.00,0.50,0.67,0.50,0.50,
    0.50,0.50,0.50,0.33,1.00,0.00,1.00,0.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'Y';
ch->_nbCurve = 3;
memcpy(ch->_curve,
(float[]){
    1.00,1.00,1.00,1.00,0.50,0.67,0.50,0.50,
    0.00,1.00,0.00,1.00,0.50,0.67,0.50,0.50,
    0.50,0.50,0.50,0.33,0.50,0.00,0.50,0.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'Z';
ch->_nbCurve = 3;
memcpy(ch->_curve,
(float[]){
    0.00,1.00,0.00,1.00,1.00,1.00,1.00,1.00,
    1.00,1.00,1.00,0.67,0.00,0.33,0.00,0.00,
    0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'O';
ch->_nbCurve = 5;
memcpy(ch->_curve,
(float[]){
    0.00,0.00,0.00,0.00,1.00,1.00,1.00,1.00,
    0.50,1.00,1.00,1.00,1.00,1.00,1.00,0.50,
    1.00,0.50,1.00,0.00,1.00,0.00,0.50,0.00,
    0.50,0.00,0.00,0.00,0.00,0.00,0.00,0.50,
    0.00,0.50,0.00,1.00,0.00,1.00,0.50,1.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '1';
ch->_nbCurve = 3;
memcpy(ch->_curve,
(float[]){
    0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00,
    0.00,0.67,0.33,0.67,0.50,1.00,0.50,1.00,
    0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '2';
ch->_nbCurve = 4;
memcpy(ch->_curve,
(float[]){
    0.00,0.67,0.00,1.00,0.34,1.00,0.50,1.00,
    0.50,1.00,0.66,1.00,1.00,1.00,1.00,0.67,
    1.00,0.67,1.00,0.50,0.00,0.33,0.00,0.00,
    0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00
}, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '3';
ch->_nbCurve = 6;
memcpy(ch->_curve,
(float[]){
    0.00,0.67,0.00,0.83,0.00,1.00,0.50,1.00,
    0.50,1.00,1.00,1.00,1.00,0.83,1.00,0.67,
    1.00,0.67,1.00,0.50,0.50,0.50,0.50,0.50,
    0.50,0.50,0.50,0.50,1.00,0.50,1.00,0.33,
    1.00,0.33,1.00,0.00,1.00,0.00,0.50,0.00,
    0.50,0.00,0.00,0.00,0.00,0.16,0.00,0.33
}, sizeof(float) * ch->_nbCurve * 8);

```

```

ch = font->_char + '4';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        1.00,0.33,1.00,0.33,0.00,0.33,0.00,0.33,
        0.00,0.33,0.50,0.50,0.66,1.00,0.66,1.00,
        0.66,1.00,0.66,1.00,0.66,0.00,0.66,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '5';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        1.00,1.00,1.00,1.00,0.33,1.00,0.33,1.00,
        0.33,1.00,0.33,1.00,0.00,0.67,0.00,0.67,
        0.00,0.67,0.00,0.67,1.00,1.01,1.00,0.33,
        1.00,0.33,1.00,0.00,0.67,0.00,0.50,0.00,
        0.50,0.00,0.33,0.00,0.00,0.16,0.00,0.33
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '6';
ch->_nbCurve = 6;
memcpy(ch->_curve,
    (float[]){
        0.00,0.33,0.00,0.50,0.33,0.50,0.50,0.50,
        0.50,0.50,0.67,0.50,1.00,0.50,1.00,0.33,
        1.00,0.33,1.00,0.16,1.00,0.00,0.50,0.00,
        0.50,0.00,0.00,0.00,0.00,0.33,0.00,0.50,
        0.00,0.50,0.00,1.00,0.50,1.00,0.50,1.00,
        0.50,1.00,0.50,1.00,1.00,1.00,1.00,0.67
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '7';
ch->_nbCurve = 2;
memcpy(ch->_curve,
    (float[]){
        0.00,1.00,0.00,1.00,1.00,1.00,1.00,1.00,
        1.00,1.00,1.00,1.00,0.33,0.67,0.33,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '8';
ch->_nbCurve = 6;
memcpy(ch->_curve,
    (float[]){
        0.50,1.00,1.00,1.00,1.00,0.67,0.50,0.67,
        0.50,0.67,0.33,0.67,0.00,0.50,0.00,0.33,
        0.00,0.33,0.00,0.00,0.33,0.00,0.50,0.00,
        0.50,0.00,0.66,0.00,1.00,0.00,1.00,0.33,
        1.00,0.33,1.00,0.50,0.66,0.67,0.50,0.67,
        0.50,0.67,0.00,0.67,0.00,1.00,0.50,1.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '9';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        0.33,0.00,0.50,0.00,1.00,0.00,1.00,0.50,
        1.00,0.50,1.00,1.00,0.66,1.00,0.50,1.00,
        0.50,1.00,0.33,1.00,0.00,1.00,0.00,0.67,
        0.00,0.67,0.00,0.50,0.33,0.50,0.50,0.50,
        0.50,0.50,0.67,0.50,1.00,0.50,1.00,0.67
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '!';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        0.50,0.18,0.44,0.18,0.44,0.07,0.50,0.07,

```

```

        0.50,0.07,0.56,0.07,0.56,0.18,0.50,0.18,
        0.50,1.00,0.50,1.00,0.50,0.33,0.50,0.33
    }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '"';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.66,1.00,0.66,1.00,0.66,0.75,0.66,0.75,
            0.33,1.00,0.33,1.00,0.33,0.75,0.33,0.75
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '\\';
    ch->_nbCurve = 1;
    memcpy(ch->_curve,
        (float[]){
            0.25,1.00,0.25,1.00,0.25,0.49,0.00,0.50
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '#';
    ch->_nbCurve = 4;
    memcpy(ch->_curve,
        (float[]){
            0.75,1.00,0.75,1.00,0.66,0.00,0.66,0.00,
            0.33,1.00,0.33,1.00,0.25,0.00,0.25,0.00,
            0.00,0.25,0.00,0.25,1.00,0.25,1.00,0.25,
            0.00,0.67,0.00,0.67,1.00,0.67,1.00,0.67
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '$';
    ch->_nbCurve = 6;
    memcpy(ch->_curve,
        (float[]){
            0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00,
            1.00,0.83,1.00,0.99,1.00,1.00,0.50,1.00,
            0.50,1.00,0.00,1.00,0.00,0.83,0.00,0.67,
            0.00,0.67,0.00,0.50,1.00,0.67,1.00,0.50,
            1.00,0.50,1.00,0.33,1.00,0.00,0.50,0.00,
            0.50,0.00,0.00,0.00,0.00,0.16,0.00,0.33
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '%';
    ch->_nbCurve = 9;
    memcpy(ch->_curve,
        (float[]){
            0.75,0.50,1.00,0.50,1.00,0.50,1.00,0.25,
            1.00,0.25,1.00,0.00,1.00,0.00,0.75,0.00,
            0.75,0.00,0.50,0.00,0.50,0.00,0.50,0.25,
            0.50,0.25,0.50,0.50,0.50,0.50,0.75,0.50,
            0.25,1.00,0.50,1.00,0.50,1.00,0.50,0.75,
            0.50,0.75,0.50,0.50,0.50,0.50,0.25,0.50,
            0.25,0.50,0.00,0.50,0.00,0.50,0.00,0.75,
            0.00,0.75,0.00,1.00,0.00,1.00,0.25,1.00,
            0.00,0.00,0.00,0.00,1.00,1.00,1.00,1.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '&';
    ch->_nbCurve = 6;
    memcpy(ch->_curve,
        (float[]){
            1.00,0.00,1.00,0.33,0.76,0.67,0.50,0.67,
            0.50,0.67,0.00,0.66,0.00,1.00,0.50,1.00,
            0.50,1.00,1.00,1.00,1.00,0.67,0.50,0.67,
            0.50,0.67,0.33,0.67,0.00,0.50,0.00,0.33,
            0.00,0.33,0.00,0.00,0.33,0.00,0.50,0.00,
            0.50,0.00,0.66,0.00,1.00,0.17,1.00,0.50
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '(';

```

```

ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           1.00,1.00,0.75,0.75,0.75,0.25,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + ')';
ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.00,1.00,0.25,0.75,0.25,0.25,0.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '=';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,0.33,0.00,0.33,1.00,0.33,1.00,0.33,
           0.00,0.67,0.00,0.67,1.00,0.67,1.00,0.67
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '~';
ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.00,0.50,0.33,0.75,0.66,0.25,1.00,0.50
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + ',';
ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.75,1.00,0.75,1.00,0.75,0.49,1.00,0.50
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '{';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           1.00,1.00,0.75,1.00,1.00,0.50,0.75,0.50,
           0.75,0.50,1.00,0.50,0.76,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '}';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,1.00,0.25,1.00,0.00,0.50,0.25,0.50,
           0.25,0.50,-0.02,0.50,0.25,0.00,0.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '*';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,1.00,1.00,1.00,1.00,
           0.00,1.00,0.00,1.00,1.00,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '+';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,0.50,0.00,0.50,1.00,0.50,1.00,0.50,
           0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '<';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){

```

```

        1.00,1.00,1.00,1.00,0.00,0.50,0.00,0.50,
        0.00,0.50,0.00,0.50,1.00,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '>';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,1.00,1.00,0.50,1.00,0.50,
            1.00,0.50,1.00,0.50,0.00,0.00,0.00,0.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '?';
    ch->_nbCurve = 5;
    memcpy(ch->_curve,
        (float[]){
            0.00,0.67,0.00,1.00,0.34,1.00,0.50,1.00,
            0.50,1.00,0.66,1.00,1.00,1.00,1.00,0.67,
            1.00,0.67,1.00,0.33,0.50,0.66,0.50,0.33,
            0.50,0.18,0.44,0.18,0.44,0.07,0.50,0.07,
            0.50,0.07,0.56,0.07,0.56,0.18,0.50,0.18
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '.';
    ch->_nbCurve = 2;
    memcpy(ch->_curve,
        (float[]){
            0.13,0.25,0.00,0.25,0.00,0.00,0.13,0.00,
            0.13,0.00,0.25,0.00,0.25,0.25,0.13,0.25
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + ',';
    ch->_nbCurve = 1;
    memcpy(ch->_curve,
        (float[]){
            0.25,0.18,0.25,0.18,0.25,-0.33,0.00,-0.32
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '/';
    ch->_nbCurve = 1;
    memcpy(ch->_curve,
        (float[]){
            1.00,1.00,1.00,1.00,0.00,0.00,0.00,0.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '\\';
    ch->_nbCurve = 1;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,1.00,1.00,0.00,1.00,0.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '[';
    ch->_nbCurve = 3;
    memcpy(ch->_curve,
        (float[]){
            1.00,1.00,1.00,1.00,0.75,1.00,0.75,1.00,
            0.75,1.00,0.75,1.00,0.75,0.00,0.75,0.00,
            0.75,0.00,0.75,0.00,1.00,0.00,1.00,0.00
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + ']';
    ch->_nbCurve = 3;
    memcpy(ch->_curve,
        (float[]){
            0.00,1.00,0.00,1.00,0.25,1.00,0.25,1.00,
            0.25,1.00,0.25,1.00,0.25,0.0,0.25,0.0,
            0.25,0.0,0.25,0.0,0.00,0.0,0.00,0.0
        }, sizeof(float) * ch->_nbCurve * 8);
    ch = font->_char + '-';

```

```

ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.00,0.50,0.00,0.50,1.00,0.50,1.00,0.50
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '|';
ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.50,1.00,0.50,1.00,0.50,0.00,0.50,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '_';
ch->_nbCurve = 1;
memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00,
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + ',';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.25,0.47,0.18,0.47,0.18,0.36,0.25,0.36,
           0.25,0.36,0.30,0.36,0.30,0.47,0.25,0.47,
           0.25,0.18,0.25,0.18,0.25,-0.33,0.00,-0.32,
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + ':';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.50,0.72,0.44,0.72,0.44,0.61,0.50,0.61,
           0.50,0.61,0.56,0.61,0.56,0.72,0.50,0.72,
           0.50,0.39,0.44,0.39,0.44,0.28,0.50,0.28,
           0.50,0.28,0.56,0.28,0.56,0.39,0.50,0.39
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'a';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.66,0.67,0.25,0.67,0.00,0.66,0.00,0.33,
           0.00,0.33,0.00,0.00,0.26,0.01,0.49,0.01,
           0.49,0.01,0.74,0.01,0.75,0.33,0.75,0.67,
           0.75,0.67,0.75,0.25,0.75,0.01,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'b';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.00,1.00,0.00,0.50,0.00,0.00,0.50,0.00,
           0.50,0.00,1.00,0.00,1.00,0.33,1.00,0.50,
           1.00,0.50,1.00,0.67,0.59,0.67,0.42,0.67,
           0.42,0.67,0.25,0.67,0.06,0.58,0.06,0.33
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'c';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           1.00,0.50,1.00,0.67,0.67,0.67,0.50,0.67,
           0.50,0.67,0.33,0.67,0.00,0.66,0.00,0.33,
           0.00,0.33,0.00,0.00,0.34,0.00,0.50,0.00,
           0.50,0.00,0.66,0.00,1.00,0.00,1.00,0.25
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'd';

```

```

ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           1.00,1.00,1.01,0.50,1.00,0.00,0.50,0.00,
           0.50,0.00,0.00,0.00,0.00,0.33,0.00,0.50,
           0.00,0.50,0.00,0.67,0.44,0.66,0.59,0.66,
           0.59,0.66,0.75,0.66,0.95,0.59,0.95,0.34
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'e';
ch->_nbCurve = 6;
memcpy(ch->_curve,
       (float[]){
           1.00,0.25,1.00,0.00,0.66,0.00,0.50,0.00,
           0.50,0.00,0.34,0.00,0.00,0.00,0.00,0.33,
           0.00,0.33,0.00,0.66,0.33,0.67,0.50,0.67,
           0.50,0.67,0.67,0.67,1.00,0.67,1.00,0.50,
           1.00,0.50,1.00,0.33,0.67,0.33,0.50,0.33,
           0.50,0.33,0.33,0.33,0.00,0.33,0.00,0.33
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'f';
ch->_nbCurve = 4;
memcpy(ch->_curve,
       (float[]){
           0.00,0.50,0.00,0.50,0.66,0.50,0.66,0.50,
           1.00,0.75,1.00,1.00,0.75,1.00,0.50,1.00,
           0.50,1.00,0.25,1.00,0.25,0.83,0.25,0.67,
           0.25,0.67,0.25,0.50,0.25,0.00,0.25,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'g';
ch->_nbCurve = 6;
memcpy(ch->_curve,
       (float[]){
           1.00,0.33,1.00,0.00,0.67,0.00,0.50,0.00,
           0.50,0.00,0.33,0.00,0.00,-0.01,0.00,0.33,
           0.00,0.33,0.00,0.67,0.25,0.67,0.50,0.67,
           0.50,0.67,0.75,0.67,1.00,0.66,1.00,0.33,
           1.00,0.33,1.00,0.00,1.00,-0.33,0.50,-0.33,
           0.50,-0.33,0.41,-0.33,0.33,-0.33,0.33,-0.33
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'h';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.00,0.33,0.25,0.67,1.00,1.00,1.00,0.50,
           1.00,0.50,1.00,0.25,1.00,0.00,1.00,0.00,
           0.00,1.00,0.00,1.00,0.00,0.00,0.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'i';
ch->_nbCurve = 5;
memcpy(ch->_curve,
       (float[]){
           0.25,0.87,0.19,0.87,0.19,0.76,0.25,0.76,
           0.25,0.76,0.31,0.76,0.31,0.87,0.25,0.87,
           0.00,0.00,0.25,0.00,0.25,0.42,0.25,0.50,
           0.25,0.50,0.25,0.25,0.26,0.00,0.50,0.00,
           0.50,0.00,0.72,0.00,1.00,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'j';
ch->_nbCurve = 5;
memcpy(ch->_curve,
       (float[]){
           0.75,0.87,0.69,0.87,0.69,0.76,0.75,0.76,

```



```

        0.75,0.76,0.81,0.76,0.81,0.87,0.76,0.87,
        0.00,0.00,0.00,-0.33,0.33,-0.33,0.50,-0.33,
        0.50,-0.33,0.75,-0.33,0.75,0.33,0.75,0.50,
        0.75,0.50,0.75,0.33,0.76,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'k';
ch->_nbCurve = 4;
memcpy(ch->_curve,
    (float[]){
        0.00,0.50,0.25,0.67,1.00,0.75,1.00,0.50,
        1.00,0.50,1.00,0.25,0.50,0.33,0.00,0.33,
        0.00,0.33,0.32,0.33,0.75,0.25,1.00,0.00,
        0.00,1.00,0.00,1.00,0.00,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'l';
ch->_nbCurve = 6;
memcpy(ch->_curve,
    (float[]){
        0.00,0.00,0.25,0.00,0.25,0.34,0.25,0.50,
        0.25,0.50,0.25,0.66,0.25,1.00,0.50,1.00,
        0.50,1.00,0.66,1.00,0.75,1.00,0.75,0.76,
        0.75,0.76,0.75,0.51,0.50,0.33,0.25,0.33,
        0.25,0.33,0.26,0.00,0.33,0.00,0.66,0.00,
        0.66,0.00,0.76,0.00,1.00,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'm';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.67,0.00,0.00,0.00,0.00,
        0.00,0.25,0.00,0.59,0.25,0.67,0.33,0.67,
        0.33,0.67,0.50,0.66,0.50,0.00,0.50,0.00,
        0.50,0.00,0.50,0.00,0.50,0.67,0.74,0.67,
        0.74,0.67,1.00,0.67,1.00,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'n';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.67,0.00,0.00,0.00,0.00,
        0.00,0.25,0.00,0.50,0.25,0.67,0.66,0.67,
        0.66,0.67,1.00,0.67,1.00,0.24,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'o';
ch->_nbCurve = 4;
memcpy(ch->_curve,
    (float[]){
        0.50,0.67,1.00,0.67,1.00,0.66,1.00,0.33,
        1.00,0.33,1.00,0.00,1.00,0.00,0.50,0.00,
        0.50,0.00,0.00,0.00,0.00,-0.01,0.00,0.33,
        0.00,0.33,0.00,0.67,0.00,0.67,0.50,0.67
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'p';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        0.00,-0.33,0.00,-0.33,0.00,0.16,0.00,0.33,
        0.00,0.33,0.00,0.50,0.00,0.67,0.50,0.67,
        0.50,0.67,1.00,0.67,1.00,0.50,1.00,0.33,
        1.00,0.33,1.00,0.16,1.00,0.00,0.50,0.00,
        0.50,0.00,0.00,0.00,0.00,0.00,0.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);

```

```

ch = font->_char + 'q';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        1.00,0.00,1.00,0.00,0.75,0.00,0.50,0.00,
        0.50,0.00,0.25,0.00,0.00,-0.01,0.00,0.33,
        0.00,0.33,0.00,0.67,0.25,0.67,0.50,0.67,
        0.50,0.67,0.75,0.67,1.00,0.66,1.00,0.33,
        1.00,0.33,1.00,0.00,1.00,-0.33,1.00,-0.33
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'r';
ch->_nbCurve = 2;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.67,0.00,0.00,0.00,0.00,
        0.00,0.33,0.25,0.67,1.00,1.00,1.00,0.50
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 's';
ch->_nbCurve = 5;
memcpy(ch->_curve,
    (float[]){
        1.00,0.50,1.00,0.66,1.00,0.67,0.50,0.67,
        0.50,0.67,0.00,0.67,0.00,0.66,0.00,0.50,
        0.00,0.50,0.00,0.33,1.00,0.50,1.00,0.33,
        1.00,0.33,1.00,0.16,1.00,0.00,0.50,0.00,
        0.50,0.00,0.00,0.00,0.00,0.08,0.00,0.25
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 't';
ch->_nbCurve = 4;
memcpy(ch->_curve,
    (float[]){
        0.00,0.00,0.25,0.00,0.25,0.17,0.25,0.25,
        0.00,0.67,0.00,0.67,0.50,0.67,0.50,0.67,
        0.25,1.00,0.25,1.00,0.25,0.33,0.25,0.25,
        0.25,0.25,0.25,0.01,0.50,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'u';
ch->_nbCurve = 3;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.33,0.00,0.00,0.50,0.00,
        0.50,0.00,1.00,0.00,1.00,0.33,1.00,0.67,
        1.00,0.67,1.00,0.33,1.00,0.00,1.00,0.00
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'v';
ch->_nbCurve = 2;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.67,0.34,0.00,0.50,0.00,
        0.50,0.00,0.66,0.00,1.00,0.67,1.00,0.67
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'w';
ch->_nbCurve = 4;
memcpy(ch->_curve,
    (float[]){
        0.00,0.67,0.00,0.67,0.16,0.00,0.33,0.00,
        0.33,0.00,0.50,0.00,0.50,0.50,0.50,0.50,
        0.50,0.50,0.50,0.50,0.50,0.00,0.66,0.00,
        0.66,0.00,0.82,0.00,1.00,0.67,1.00,0.67
    }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'x';
ch->_nbCurve = 4;

```

```

memcpy(ch->_curve,
       (float[]){
           0.00,0.00,0.25,0.00,0.51,0.24,0.50,0.33,
           0.50,0.33,0.50,0.41,0.76,0.67,1.00,0.67,
           0.00,0.67,0.25,0.67,0.50,0.41,0.50,0.33,
           0.50,0.33,0.50,0.25,0.75,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'y';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.00,0.67,0.00,0.67,0.00,0.00,0.66,0.00,
           1.00,0.67,1.00,0.67,0.82,0.33,0.66,0.00,
           0.66,0.00,0.50,-0.33,0.50,-0.33,0.25,-0.33
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + 'z';
ch->_nbCurve = 3;
memcpy(ch->_curve,
       (float[]){
           0.00,0.67,0.00,0.67,1.00,0.67,1.00,0.67,
           1.00,0.67,1.00,0.50,0.00,0.25,0.00,0.00,
           0.00,0.00,0.00,0.00,1.00,0.00,1.00,0.00
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '@';
ch->_nbCurve = 8;
memcpy(ch->_curve,
       (float[]){
           0.61,0.66,0.36,0.66,0.21,0.65,0.21,0.45,
           0.21,0.45,0.21,0.25,0.36,0.25,0.51,0.25,
           0.51,0.25,0.66,0.25,0.67,0.45,0.67,0.66,
           0.67,0.66,0.66,0.40,0.66,0.25,0.82,0.25,
           0.82,0.25,0.97,0.24,0.94,0.72,0.75,0.79,
           0.75,0.79,0.56,0.85,0.36,0.84,0.25,0.78,
           0.25,0.78,0.03,0.66,0.05,0.21,0.25,0.11,
           0.25,0.11,0.45,0.01,0.67,0.07,0.75,0.13
       }, sizeof(float) * ch->_nbCurve * 8);
ch = font->_char + '^';
ch->_nbCurve = 2;
memcpy(ch->_curve,
       (float[]){
           0.00,0.75,0.00,0.75,0.50,1.00,0.50,1.00,
           0.50,1.00,0.50,1.00,1.00,0.75,1.00,0.75
       }, sizeof(float) * ch->_nbCurve * 8);
}

```

### 3 Makefile

```

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

all : main

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

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

tgapaint.o : tgapaint.c tgafont.c tgapaint.h Makefile

```

```

gcc $(OPTIONS) -c tgapaint.c

clean :
    rm -rf *.o main

```

## 4 Usage

```

#include <stdio.h>
#include <stdlib.h>
#include "tgapaint.h"

int main(void) {
    int ret;
    TGA *theTGA;
    // Create the TGA
    short dim[2] = {120, 270};
    TGAPixel *pix = TGAGetWhitePixel();
    theTGA = TGACreate(dim, pix);
    if (theTGA == NULL) {
        fprintf(stderr, "Error while creating the tga\n");
        return 1;
    }
    // Set the color of some pixels
    short pos[2];
    pos[0] = 60; pos[1] = 50;
    TGASetPix(theTGA, pos, pix);
    pix->_rgba[0] = 255; pix->_rgba[1] = 0; pix->_rgba[2] = 0;
    pos[0] = 90; pos[1] = 50;
    TGASetPix(theTGA, pos, pix);
    pix->_rgba[0] = 0; pix->_rgba[1] = 0; pix->_rgba[2] = 255;
    pos[0] = 60; pos[1] = 25;
    TGASetPix(theTGA, pos, pix);
    pix->_rgba[0] = 0; pix->_rgba[1] = 255; pix->_rgba[2] = 0;
    pos[0] = 30; pos[1] = 75;
    TGASetPix(theTGA, pos, pix);
    // Draw some lines
    TGAPencil *pen = TGAGetBlackPencil();
    pix->_rgba[0] = 0; pix->_rgba[1] = 0; pix->_rgba[2] = 0;
    TGAPencilSetColor(pen, pix);
    float from[2];
    float to[2];
    from[0] = 50.5; from[1] = 40.5; to[0] = 50.5; to[1] = 60.5;
    TGADrawLine(theTGA, from, to, pen);
    from[0] = 50.5; from[1] = 60.5; to[0] = 70.5; to[1] = 60.5;
    TGADrawLine(theTGA, from, to, pen);
    pix->_rgba[0] = 255; pix->_rgba[1] = 0; pix->_rgba[2] = 255;
    from[0] = -10.5; from[1] = 50.5; to[0] = 60.5; to[1] = -10.5;
    TGADrawLine(theTGA, from, to, pen);
    from[0] = 60.5; from[1] = -10.5; to[0] = 130.5; to[1] = 50.5;
    TGADrawLine(theTGA, from, to, pen);
    from[0] = 130.5; from[1] = 50.5; to[0] = 60.5; to[1] = 110.5;
    TGADrawLine(theTGA, from, to, pen);
    from[0] = 60.5; from[1] = 110.5; to[0] = -10.5; to[1] = 50.5;
    TGADrawLine(theTGA, from, to, pen);
    // Apply gaussian blur
    TGAFilterGaussBlur(theTGA, 0.5, 2.0);
    // Draw a rectangle
    pix->_rgba[0] = 0; pix->_rgba[1] = 255; pix->_rgba[2] = 255;
    TGAPencilSetColor(pen, pix);
    from[0] = 70.5; from[1] = 40.5; to[0] = 100.5; to[1] = 10.5;

```

```

TGADrawRect(theTGA, from, to, pen);
// Draw a filled rectangle
pix->_rgba[0] = 255; pix->_rgba[1] = 255; pix->_rgba[2] = 0;
TGAPencilSetColor(pen, pix);
from[0] = 75.5; from[1] = 35.5; to[0] = 95.5; to[1] = 15.5;
TGAFillRect(theTGA, from, to, pen);
// Draw an ellipse
pix->_rgba[0] = 128; pix->_rgba[1] = 128; pix->_rgba[2] = 128;
TGAPencilSetColor(pen, pix);
float center[2] = {30.5, 50.5};
float radius[2] = {15.5, 20.5};
TGADrawEllipse(theTGA, center, radius, pen);
// Draw a filled ellipse
pix->_rgba[0] = 200; pix->_rgba[1] = 200; pix->_rgba[2] = 200;
TGAPencilSetColor(pen, pix);
center[0] = 60.5; center[1] = 75.5;
radius[0] = 25.5; radius[1] = 10.5;
TGAFillEllipse(theTGA, center, radius, pen);
// Draw a line using blend colors
from[0] = 30.5; from[1] = 25.5; to[0] = 90.5; to[1] = 75.5;
pix->_rgba[0] = pix->_rgba[3] = 255;
pix->_rgba[1] = pix->_rgba[2] = 0;
TGAPencilSetColor(pen, pix);
pix->_rgba[2] = pix->_rgba[3] = 255;
pix->_rgba[1] = pix->_rgba[0] = 0;
TGAPencilSelectColor(pen, 1);
TGAPencilSetColor(pen, pix);
TGAPencilSetModeColorBlend(pen, 0, 1);
TGADrawLine(theTGA, from, to, pen);
// Draw a curve
float ctrlFrom[2] = {40.5, 0.5};
float ctrlTo[2] = {80.5, 50.5};
TGAPencilSetShapeRound(pen);
TGAPencilSetAntialias(pen, true);
TGAPencilSetModeColorSolid(pen);
TGAPencilSetThickness(pen, 5.0);
TGADrawCurve(theTGA, from, ctrlFrom, ctrlTo, to, pen);
// Print some strings
TGAPencilSetThickness(pen, 1.0);
pix->_rgba[0] = pix->_rgba[1] = pix->_rgba[2] = 0;
TGAPencilSetColor(pen, pix);
TGAFont *font = TGAFontCreate(tgaFontDefault);
if (font == NULL) {
    fprintf(stderr, "Can't create the font\n");
    return 1;
}
from[0] = 5.0; from[1] = 200.0;
TGAFontSetSize(font, 12.0);
float v[2] = {0.5, 1.0};
TGAFontSetScale(font, v);
v[0] = 5.0; v[1] = 3.0;
TGAFontSetSpace(font, v);
TGAPrintString(theTGA, pen, font,
    (unsigned char *)"ABCDEFGHJ\nKLMNOPQRST\nUVWXYZ", from);
from[0] = 5.0; from[1] = 155.0;
TGAPrintString(theTGA, pen, font,
    (unsigned char *)"0123456789", from);
from[0] = 5.0; from[1] = 250.0;
TGAPrintString(theTGA, pen, font,
    (unsigned char *)"abcdefghij\nklmnopqrst\nuvwxyz^@", from);
from[0] = 5.0; from[1] = 140.0;
TGAPrintString(theTGA, pen, font,

```

```

    (unsigned char *)"!\"#$%&'()=\n~`{*+<>?,\n./\\[]-|_;;:", from);
// Save the TGA
TGASave(theTGA, "./out.tga");
//Free the tga
TGAFree(&theTGA);
// Load the TGA
ret = TGAload(&theTGA, "./out.tga");
if (ret != 0) {
    fprintf(stderr, "Error while opening the file : %d\n", ret);
    return 1;
}
// Print its header on standard output stream
TGAPrintHeader(theTGA, stdout);
// Free the memory
TGAFreeFont(&font);
TGAFree(&theTGA);
TGAFreePixel(&pix);
TGAFreePencil(&pen);
return 0;
}

```

Output:

```

ID length:      0
Colourmap type: 0
Image type:     2
Colour map offset: 0
Colour map length: 0
Colour map depth: 0
X origin:       0
Y origin:       0
Width:          120
Height:         270
Bits per pixel: 32
Descriptor:     0

```

Resulting image (enlarge):

abcdefghij  
 klmnopqrst  
 uvwxyz^@  
 ABCDEFGHIJ  
 KLMNOPQRST  
 UVWXYZ  
 0123456789  
 ! " # \$ % & ' ( ) =  
 ~ \ { } X + < > ? ,  
 . / \ [ ] - \_ ` :

