libembroidery 0.1

The Embroidermodder Team

Abstract

Libembroidery is a library for manipulating, converting and creating embroidery files between all major embroidery machine formats and some graphics formats to aid the creation of designs.

Most of the supported formats are in an experimental state as the library is under active development.

The library has 3 intended user interfaces: the GUI in EmbroiderModder2, the CLI in `embroider` (see embroider-main.c) and Arduino embedded systems (libembroidery.ino). The most actively maintained user interface is the CLI `embroider`.

Contents

The Embroidermodder Team

Credits for Embroidermodder 2, libembroidery and all other related code

Please note that this file in not in alphabetical order. If you have contributed and wish to be added to this list, create a new credit section and increment the number. Fill it in with your information and submit it to us.

Here is a summary of the values used:

Name	The full name of the contributer starting with first name.
GitHub	The GitHub account name of the contributer (in parentheses).
CoreDeveloper	This is reserved for long term contributers.
Documentation	If you have contributed changes to README files or help files, set this to true.
Artwork	If you have contributed artwork or related changes, set this to true
BugFixes	If you have contributed bug fixes or added new features, set this to true.
Translation	If you have provided language translations, set this to true.
Designs	If you have contributed an embroidery design sample, set this to true.
Bindings	If you have contributed programming language bindings for libembroidery, set this to true.
Commands	If you have contributed a command for Embroidermodder 2, set this to true.

Credits

Credit 0	Jonathan Greig (`redteam316`)
	CoreDeveloper, Artwork, Documentation, Designs, Commands
Credit 1	Josh Varga (`JoshVarga`)
	CoreDeveloper
Credit 2	Jens Diemer (`jedie`)
	Documentation
Credit 3	Kim Howard (`turbokim`)
	BugFixes
Credit 4	Martin Schneider (`craftoid`)
	Documentation
Credit 5	Edward Greig (`Metallicow`)
	Artwork, BugFixes, Commands
Credit 6	Sonia Entzinger
	Translation
Credit 7	SushiTee (`SushiTee`)
	BugFixes

Credit 8 Vathonie Lufh (`x2nie`)

BugFixes, Bindings

Credit 9 Nina Paley

Designs

Credit 10 Theodore Gray

Designs

Credit 11 Jens-Wolfhard Schicke-Uffmann (`Drahflow`)

BugFixes

Credit 12 Emmett Lauren Garlitz - Some Little Sandy Rd, Elkview, West by GOD Virginia (`Oll Em`)

Credit 13 Robin Swift (`robin-swift`)

CoreDeveloper, Documentation

Features

Help Message

The user is presented with this help message when the program is given no arguments.

```
EMBROIDER
    A command line program for machine embroidery.
    Copyright 2013-2021 The Embroidermodder Team
    Licensed under the terms of the zlib license.

    https://github.com/Embroidermodder/libembroidery
    https://embroidermodder.org

Usage: embroider [OPTIONS] fileToRead...

Conversion:
    -t, -to         Convert all files given to the format specified
                    by the arguments to the flag, for example:
                        $ embroider -t dst input.pes
                    would convert \"input.pes\" to \"input.dst\"
                    in the same directory the program runs in.

                    The accepted input formats are (TO BE DETERMINED).
                    The accepted output formats are (TO BE DETERMINED).

Output:
    -h, -help       Print this message.
    -f, -format     Print help on the formats that
                    embroider can deal with.
    -q, -quiet      Only print fatal errors.
    -V, -verbose    Print everything that has reporting.
    -v, -version    Print the version.

Graphics:
    -c, -circle     Add a circle defined by the arguments
                    given to the current pattern.
    -e, -ellipse    Add a circle defined by the arguments
                    given to the current pattern.
    -l, -line       Add a line defined by the arguments
                    given to the current pattern.
    -P, -polyline   Add a polyline.
    -p, -polygon    Add a polygon.
    -s, -satin      Fill the current geometry with satin
                    stitches according
                    to the defined algorithm.
    -S, -stitch     Add a stitch defined by the arguments
                    given to the current pattern.

Quality Assurance:
        -test       Run the test suite.
```

For each of the flags described here we will go into greater detail in this manual.

To Flag

Circle Flag

Ellipse Flag

Line Flag

Polyline Flag

Polygon Flag

Satin Flag

Stitch Flag

Test Suite

Formats

Toyota Embroidery Format (.100)

- Stitch Only Format.
- Uses an external color file.

☒ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

The stitch encoding is in 4 byte chunks.

Toyota Embroidery Format (.10o)

- Stitch Only Format.
- Uses an external color file.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

The stitch encoding is in 3 byte chunks.

Bernina Embroidery Format (.art)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

We don't know much about this format. TODO: Find a source.

Bitmap Cache Embroidery Format (.bmc)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

We don't know much about this format. TODO: Find a source.

Bits and Volts Embroidery Format (.bro)

- Stitch Only Format.
- Uses an external color file.

☒ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

The header is 256 bytes. There's a series of unknown variables in the header.

The stitch list uses a variable length encoding which is 2 bytes for any stitch

Melco Embroidery Format (.cnd)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

We don't know much about this format. TODO: Find a source.

Embroidery Thread Color Format (.col)

- Stitch Only Format.

☒ Basic Read Support
☒ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Singer Embroidery Format (.csd)

- Stitch Only Format.

☒ Basic Read Support
☒ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Comma Seperated Values (.csv)

- Stitch Only Format.

☒ Basic Read Support
☒ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Barudan Embroidery Format (.dat)

- Stitch Only Format.

☒ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Melco Embroidery Format (.dem)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Barudan Embroidery Format (.dsb)

- Stitch Only Format.

☒ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Tajima Embroidery Format (.dst)

- Stitch Only Format.

☒ Basic Read Support
☒ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

.DST (Tajima) embroidery file read/write routines Format comments are thanks to tspilman@dalcoathletic.com who's notes appeared at http://www.wotsit.org under Tajima Format.

Header

The header seems to contain information about the design. Seems to be ASCII text delimited by 0x0D (carriage returns). This must be in the file for most new software or hardware to consider it a good file! This is much more important than I originally believed. The header is 125 bytes in length and padded out by 0x20 to 512 bytes total. All entries in the header seem to be 2 ASCII characters followed by a colon, then it's value trailed by a carriage return.

Table 1: The sections of the dxf header.

C memory	Description
`char LA[16+1];`	First is the 'LA' entry, which is the design name with no path or extension information. The blank is 16 characters in total, but the name must not be longer that 8 characters and padded out with spaces (0x20).
`char ST[7+1];`	Next is the stitch count ST, this is a 7 digit number padded by leading zeros. This is the total stitch count including color changes, jumps, nups, and special records.
`char CO[3+1];`	Next, is CO or colors, a 3 digit number padded by leading zeros. This is the number of color change records in the file.

Table 1: The sections of the dxf header.

C memory	Description
`char POSX[5+1];`	Next is +X or the positive X extent in centimeters, a 5 digit non-decimal number padded by leading zeros.
`char NEGX[5+1];`	Following is the -X or the negative X extent in millimeters, a 5 digit non-decimal number padded by leading zeros.
`char POSY[5+1];`	Again, the +Y extents.
`char NEGY[5+1];`	Again, the -Y extents.
`char AX[6+1]; char AY[6+1];`	AX and AY should express the relative coordinates of the last point from the start point in 0.1 mm. If the start and last points are the same, the coordinates are (0,0).
`char MX[6+1]; char MY[6+1];`	MX and MY should express coordinates of the last point of the previous file for a multi-volume design. A multi-volume design means a design consisted of two or more files. This was used for huge designs that can not be stored in a single paper tape roll. It is not used so much (almost never) nowadays.
`char PD[9+1];`	PD is also storing some information for multi-volume design.

Uses 3 byte per stitch encoding with the format as follows:

Table 2: The 3 byte encoding for the dxf format.

Bit	7	6	5	4	3	2	1	0
Byte 0	y+1	y-1	y+9	y-9	x-9	x+9	x-1	x+1
Byte 1	y+3	y-3	y+27	y-27	x-27	x+27	x-3	x+3
Byte 2	jump	color change	y+81	y-81	x-81	x+81	set	set

T01 and Tap appear to use Tajima Ternary.

Where the stitch type is determined as:

- Normal Stitch ‘00000011 0x03‘
- Jump Stitch ‘10000011 0x83‘
- Stop/Change Color ‘11000011 0xC3‘
- End Design ‘11110011 0xF3‘

Inclusive or’ed with the last byte.

Note that:

1. The max stitch length is the largest sum of ‘1+3+9+27+81=121‘ where the unit length is 0.1mm so 12.1mm.

2. The co-ordinate system is right handed.

Sources on the Tajima dst format: [3], Edutech format description[2], KDE Liberty Description[4], ACHATINA[1].

ZSK USA Embroidery Format (.dsz)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Drawing Exchange Format (.dxf)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Embird Embroidery Format (.edr)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Elna Embroidery Format (.emd)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Melco Embroidery Format (.exp)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Eltac Embroidery Format (.exy)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Sierra Expanded Embroidery Format (.eys)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Fortron Embroidery Format (.fxy)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Smoothie G-Code Embroidery Format (.fxy)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Great Notions Embroidery Format (.gnc)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Gold Thread Embroidery Format (.gt)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Husqvarna Viking Embroidery Format (.hus)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Inbro Embroidery Format (.inb)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Embroidery Color Format (.inf)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Janome Embroidery Format (.jef)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.ksm)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.max)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Mitsubishi Embroidery Format (.mit)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Ameco Embroidery Format (.new)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Melco Embroidery Format (.ofm)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.pcd)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.pcm)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.pcq)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.pcs)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.pec)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.pel)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.pem)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.pes)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.phb)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Brother Embroidery Format (.phc)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

AutoCAD Embroidery Format (.plt)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

RGB Embroidery Format (.rgb)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Janome Embroidery Format (.sew)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Husqvarna Viking Embroidery Format (.shv)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Sunstar Embroidery Format (.sst)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Data Stitch Embroidery Format (.stx)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Scalable Vector Graphics (.svg)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.t01)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.t09)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Happy Embroidery Format (.tap)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

ThredWorks Embroidery Format (.thr)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Text File (.txt)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Barudan Embroidery Format (.u00)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Barudan Embroidery Format (.u01)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.vip)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Pfaff Embroidery Format (.vp3)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Singer Embroidery Format (.xxx)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

ZSK USA Embroidery Format (.zsk)

- Stitch Only Format.

☐ Basic Read Support
☐ Basic Write Support
☐ Well Tested Read
☐ Well Tested Write

Threads

DraftSight DXF color table

Table 3: DraftSight DXF color table

id	label	red	green	blue
0	BYBLOCK	0	0	0
1	red	255	0	0
2	yellow	255	255	0

Table 3: DraftSight DXF color table

id	label	red	green	blue
3	green	0	255	0
4	cyan	0	255	255
5	blue	0	0	255
6	magenta	255	0	255
7	white	255	255	255
8	dark gray	128	128	128
9	light gray	192	192	192

```
{ 255, 0, 0 }, /*  '10' */
{ 255, 127, 127 }, /*  '11' */
{ 204, 0, 0 }, /*  '12' */
{ 204, 102, 102 }, /*  '13' */
{ 153, 0, 0 }, /*  '14' */
{ 153, 76, 76 }, /*  '15' */
{ 127, 0, 0 }, /*  '16' */
{ 127, 63, 63 }, /*  '17' */
{ 76, 0, 0 }, /*  '18' */
{ 76, 38, 38 }, /*  '19' */
{ 255, 63, 0 }, /*  '20' */
{ 255, 159, 127 }, /*  '21' */
{ 204, 51, 0 }, /*  '22' */
{ 204, 127, 102 }, /*  '23' */
{ 153, 38, 0 }, /*  '24' */
{ 153, 95, 76 }, /*  '25' */
{ 127, 31, 0 }, /*  '26' */
{ 127, 79, 63 }, /*  '27' */
{ 76, 19, 0 }, /*  '28' */
{ 76, 47, 38 }, /*  '29' */
{ 255, 127, 0 }, /*  '30' */
{ 255, 191, 127 }, /*  '31' */
{ 204, 102, 0 }, /*  '32' */
{ 204, 153, 102 }, /*  '33' */
{ 153, 76, 0 }, /*  '34' */
{ 153, 114, 76 }, /*  '35' */
{ 127, 63, 0 }, /*  '36' */
{ 127, 95, 63 }, /*  '37' */
{ 76, 38, 0 }, /*  '38' */
{ 76, 57, 38 }, /*  '39' */
{ 255, 191, 0 }, /*  '40' */
{ 255, 223, 127 }, /*  '41' */
{ 204, 153, 0 }, /*  '42' */
{ 204, 178, 102 }, /*  '43' */
{ 153, 114, 0 }, /*  '44' */
{ 153, 133, 76 }, /*  '45' */
{ 127, 95, 0 }, /*  '46' */
{ 127, 111, 63 }, /*  '47' */
{ 76, 57, 0 }, /*  '48' */
{ 76, 66, 38 }, /*  '49' */
{ 255, 255, 0 }, /*  '50' */
{ 255, 255, 127 }, /*  '51' */
{ 204, 204, 0 }, /*  '52' */
{ 204, 204, 102 }, /*  '53' */
```

```
{ 153, 153, 0 }, /*  '54' */
{ 153, 153, 76 }, /*  '55' */
{ 127, 127, 0 }, /*  '56' */
{ 127, 127, 63 }, /*  '57' */
{ 76, 76, 0 }, /*  '58' */
{ 76, 76, 38 }, /*  '59' */
{ 191, 255, 0 }, /*  '60' */
{ 223, 255, 127 }, /*  '61' */
{ 153, 204, 0 }, /*  '62' */
{ 178, 204, 102 }, /*  '63' */
{ 114, 153, 0 }, /*  '64' */
{ 133, 153, 76 }, /*  '65' */
{ 95, 127, 0 }, /*  '66' */
{ 111, 127, 63 }, /*  '67' */
{ 57, 76, 0 }, /*  '68' */
{ 66, 76, 38 }, /*  '69' */
{ 127, 255, 0 }, /*  '70' */
{ 191, 255, 127 }, /*  '71' */
{ 102, 204, 0 }, /*  '72' */
{ 153, 204, 102 }, /*  '73' */
{ 76, 153, 0 }, /*  '74' */
{ 114, 153, 76 }, /*  '75' */
{ 63, 127, 0 }, /*  '76' */
{ 95, 127, 63 }, /*  '77' */
{ 38, 76, 0 }, /*  '78' */
{ 57, 76, 38 }, /*  '79' */
{ 63, 255, 0 }, /*  '80' */
{ 159, 255, 127 }, /*  '81' */
{ 51, 204, 0 }, /*  '82' */
{ 127, 204, 102 }, /*  '83' */
{ 38, 153, 0 }, /*  '84' */
{ 95, 153, 76 }, /*  '85' */
{ 31, 127, 0 }, /*  '86' */
{ 79, 127, 63 }, /*  '87' */
{ 19, 76, 0 }, /*  '88' */
{ 47, 76, 38 }, /*  '89' */
{ 0, 255, 0 }, /*  '90' */
{ 127, 255, 127 }, /*  '91' */
{ 0, 204, 0 }, /*  '92' */
{ 102, 204, 102 }, /*  '93' */
{ 0, 153, 0 }, /*  '94' */
{ 76, 153, 76 }, /*  '95' */
{ 0, 127, 0 }, /*  '96' */
{ 63, 127, 63 }, /*  '97' */
{ 0, 76, 0 }, /*  '98' */
{ 38, 76, 38 }, /*  '99' */
{ 0, 255, 63 }, /* '100' */
{ 127, 255, 159 }, /* '101' */
{ 0, 204, 51 }, /* '102' */
{ 102, 204, 127 }, /* '103' */
{ 0, 153, 38 }, /* '104' */
{ 76, 153, 95 }, /* '105' */
{ 0, 127, 31 }, /* '106' */
{ 63, 127, 79 }, /* '107' */
{ 0, 76, 19 }, /* '108' */
{ 38, 76, 47 }, /* '109' */
```

```
{ 0, 255, 127 }, /* '110' */
{ 127, 255, 191 }, /* '111' */
{ 0, 204, 102 }, /* '112' */
{ 102, 204, 153 }, /* '113' */
{ 0, 153, 76 }, /* '114' */
{ 76, 153, 114 }, /* '115' */
{ 0, 127, 63 }, /* '116' */
{ 63, 127, 95 }, /* '117' */
{ 0, 76, 38 }, /* '118' */
{ 38, 76, 57 }, /* '119' */
{ 0, 255, 191 }, /* '120' */
{ 127, 255, 223 }, /* '121' */
{ 0, 204, 153 }, /* '122' */
{ 102, 204, 178 }, /* '123' */
{ 0, 153, 114 }, /* '124' */
{ 76, 153, 133 }, /* '125' */
{ 0, 127, 95 }, /* '126' */
{ 63, 127, 111 }, /* '127' */
{ 0, 76, 57 }, /* '128' */
{ 38, 76, 66 }, /* '129' */
{ 0, 255, 255 }, /* '130' */
{ 127, 255, 255 }, /* '131' */
{ 0, 204, 204 }, /* '132' */
{ 102, 204, 204 }, /* '133' */
{ 0, 153, 153 }, /* '134' */
{ 76, 153, 153 }, /* '135' */
{ 0, 127, 127 }, /* '136' */
{ 63, 127, 127 }, /* '137' */
{ 0, 76, 76 }, /* '138' */
{ 38, 76, 76 }, /* '139' */
{ 0, 191, 255 }, /* '140' */
{ 127, 223, 255 }, /* '141' */
{ 0, 153, 204 }, /* '142' */
{ 102, 178, 204 }, /* '143' */
{ 0, 114, 153 }, /* '144' */
{ 76, 133, 153 }, /* '145' */
{ 0, 95, 127 }, /* '146' */
{ 63, 111, 127 }, /* '147' */
{ 0, 57, 76 }, /* '148' */
{ 38, 66, 76 }, /* '149' */
{ 0, 127, 255 }, /* '150' */
{ 127, 191, 255 }, /* '151' */
{ 0, 102, 204 }, /* '152' */
{ 102, 153, 204 }, /* '153' */
{ 0, 76, 153 }, /* '154' */
{ 76, 114, 153 }, /* '155' */
{ 0, 63, 127 }, /* '156' */
{ 63, 95, 127 }, /* '157' */
{ 0, 38, 76 }, /* '158' */
{ 38, 57, 76 }, /* '159' */
{ 0, 63, 255 }, /* '160' */
{ 127, 159, 255 }, /* '161' */
{ 0, 51, 204 }, /* '162' */
{ 102, 127, 204 }, /* '163' */
{ 0, 38, 153 }, /* '164' */
{ 76, 95, 153 }, /* '165' */
```

```
{ 0, 31, 127 }, /* '166' */
{ 63, 79, 127 }, /* '167' */
{ 0, 19, 76 }, /* '168' */
{ 38, 47, 76 }, /* '169' */
{ 0, 0, 255 }, /* '170' */
{ 127, 127, 255 }, /* '171' */
{ 0, 0, 204 }, /* '172' */
{ 102, 102, 204 }, /* '173' */
{ 0, 0, 153 }, /* '174' */
{ 76, 76, 153 }, /* '175' */
{ 0, 0, 127 }, /* '176' */
{ 63, 63, 127 }, /* '177' */
{ 0, 0, 76 }, /* '178' */
{ 38, 38, 76 }, /* '179' */
{ 63, 0, 255 }, /* '180' */
{ 159, 127, 255 }, /* '181' */
{ 51, 0, 204 }, /* '182' */
{ 127, 102, 204 }, /* '183' */
{ 38, 0, 153 }, /* '184' */
{ 95, 76, 153 }, /* '185' */
{ 31, 0, 127 }, /* '186' */
{ 79, 63, 127 }, /* '187' */
{ 19, 0, 76 }, /* '188' */
{ 47, 38, 76 }, /* '189' */
{ 127, 0, 255 }, /* '190' */
{ 191, 127, 255 }, /* '191' */
{ 102, 0, 204 }, /* '192' */
{ 153, 102, 204 }, /* '193' */
{ 76, 0, 153 }, /* '194' */
{ 114, 76, 153 }, /* '195' */
{ 63, 0, 127 }, /* '196' */
{ 95, 63, 127 }, /* '197' */
{ 38, 0, 76 }, /* '198' */
{ 57, 38, 76 }, /* '199' */
{ 191, 0, 255 }, /* '200' */
{ 223, 127, 255 }, /* '201' */
{ 153, 0, 204 }, /* '202' */
{ 178, 102, 204 }, /* '203' */
{ 114, 0, 153 }, /* '204' */
{ 133, 76, 153 }, /* '205' */
{ 95, 0, 127 }, /* '206' */
{ 111, 63, 127 }, /* '207' */
{ 57, 0, 76 }, /* '208' */
{ 66, 38, 76 }, /* '209' */
{ 255, 0, 255 }, /* '210' */
{ 255, 127, 255 }, /* '211' */
{ 204, 0, 204 }, /* '212' */
{ 204, 102, 204 }, /* '213' */
{ 153, 0, 153 }, /* '214' */
{ 153, 76, 153 }, /* '215' */
{ 127, 0, 127 }, /* '216' */
{ 127, 63, 127 }, /* '217' */
{ 76, 0, 76 }, /* '218' */
{ 76, 38, 76 }, /* '219' */
{ 255, 0, 191 }, /* '220' */
{ 255, 127, 223 }, /* '221' */
```

```
    { 204, 0, 153 }, /* '222' */
    { 204, 102, 178 }, /* '223' */
    { 153, 0, 114 }, /* '224' */
    { 153, 76, 133 }, /* '225' */
    { 127, 0, 95 }, /* '226' */
    { 127, 63, 111 }, /* '227' */
    { 76, 0, 57 }, /* '228' */
    { 76, 38, 66 }, /* '229' */
    { 255, 0, 127 }, /* '230' */
    { 255, 127, 191 }, /* '231' */
    { 204, 0, 102 }, /* '232' */
    { 204, 102, 153 }, /* '233' */
    { 153, 0, 76 }, /* '234' */
    { 153, 76, 114 }, /* '235' */
    { 127, 0, 63 }, /* '236' */
    { 127, 63, 95 }, /* '237' */
    { 76, 0, 38 }, /* '238' */
    { 76, 38, 57 }, /* '239' */
    { 255, 0, 63 }, /* '240' */
    { 255, 127, 159 }, /* '241' */
    { 204, 0, 51 }, /* '242' */
    { 204, 102, 127 }, /* '243' */
    { 153, 0, 38 }, /* '244' */
    { 153, 76, 95 }, /* '245' */
    { 127, 0, 31 }, /* '246' */
    { 127, 63, 79 }, /* '247' */
    { 76, 0, 19 }, /* '248' */
    { 76, 38, 47 }, /* '249' */
    { 51, 51, 51 }, /* '250' */
    { 91, 91, 91 }, /* '251' */
    { 132, 132, 132 }, /* '252' */
    { 173, 173, 173 }, /* '253' */
    { 214, 214, 214 }, /* '254' */
    { 255, 255, 255 }, /* '255' */
    { 0, 0, 0 } /* '256' (BYLAYER) */


/**************************************
 * HUS Colors
 **************************************/
static const int husThreadCount = 29;

\textbf{id} & \textbf{label} & \textbf{red} & \textbf{green} & \textbf{blu
\midrule
\endhead
static const EmbThread husThreads[] = {
    { { 0, 0, 0 }, "Black", "TODO:HUS_CATALOG_NUMBER" },
    { { 0, 0, 255 }, "Blue", "TODO:HUS_CATALOG_NUMBER" },
    { { 0, 255, 0 }, "Light Green", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 0, 0 }, "Red", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 0, 255 }, "Purple", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 255, 0 }, "Yellow", "TODO:HUS_CATALOG_NUMBER" },
    { { 127, 127, 127 }, "Gray", "TODO:HUS_CATALOG_NUMBER" },
    { { 51, 154, 255 }, "Light Blue", "TODO:HUS_CATALOG_NUMBER" },
    { { 51, 204, 102 }, "Green", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 127, 0 }, "Orange", "TODO:HUS_CATALOG_NUMBER" },
```

```
    { { 255, 160, 180 }, "Pink", "TODO:HUS_CATALOG_NUMBER" },
    { { 153, 75, 0 }, "Brown", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 255, 255 }, "White", "TODO:HUS_CATALOG_NUMBER" },
    { { 0, 0, 127 }, "Dark Blue", "TODO:HUS_CATALOG_NUMBER" },
    { { 0, 127, 0 }, "Dark Green", "TODO:HUS_CATALOG_NUMBER" },
    { { 127, 0, 0 }, "Dark Red", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 127, 127 }, "Light Red", "TODO:HUS_CATALOG_NUMBER" },
    { { 127, 0, 127 }, "Dark Purple", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 127, 255 }, "Light Purple", "TODO:HUS_CATALOG_NUMBER" },
    { { 200, 200, 0 }, "Dark Yellow", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 255, 153 }, "Light Yellow", "TODO:HUS_CATALOG_NUMBER" },
    { { 60, 60, 60 }, "Dark Gray", "TODO:HUS_CATALOG_NUMBER" },
    { { 192, 192, 192 }, "Light Gray", "TODO:HUS_CATALOG_NUMBER" },
    { { 232, 63, 0 }, "Dark Orange", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 165, 65 }, "Light Orange", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 102, 122 }, "Dark Pink", "TODO:HUS_CATALOG_NUMBER" },
    { { 255, 204, 204 }, "Light Pink", "TODO:HUS_CATALOG_NUMBER" },
    { { 115, 40, 0 }, "Dark Brown", "TODO:HUS_CATALOG_NUMBER" },
    { { 175, 90, 10 }, "Light Brown", "TODO:HUS_CATALOG_NUMBER" }
};
\end{tabularx}


\textbf{id} & \textbf{label} & \textbf{red} & \textbf{green} & \textbf{blu
\midrule
\endhead
static const EmbThread jefThreads[] = {
    { { 0, 0, 0 }, "Black", "" },
    { { 0, 0, 0 }, "Black", "" },
    { { 255, 255, 255 }, "White", "" },
    { { 255, 255, 23 }, "Yellow", "" },
    { { 250, 160, 96 }, "Orange", "" },
    { { 92, 118, 73 }, "Olive Green", "" },
    { { 64, 192, 48 }, "Green", "" },
    { { 101, 194, 200 }, "Sky", "" },
    { { 172, 128, 190 }, "Purple", "" },
    { { 245, 188, 203 }, "Pink", "" },
    { { 255, 0, 0 }, "Red", "" },
    { { 192, 128, 0 }, "Brown", "" },
    { { 0, 0, 240 }, "Blue", "" },
    { { 228, 195, 93 }, "Gold", "" },
    { { 165, 42, 42 }, "Dark Brown", "" },
    { { 213, 176, 212 }, "Pale Violet", "" },
    { { 252, 242, 148 }, "Pale Yellow", "" },
    { { 240, 208, 192 }, "Pale Pink", "" },
    { { 255, 192, 0 }, "Peach", "" },
    { { 201, 164, 128 }, "Beige", "" },
    { { 155, 61, 75 }, "Wine Red", "" },
    { { 160, 184, 204 }, "Pale Sky", "" },
    { { 127, 194, 28 }, "Yellow Green", "" },
    { { 185, 185, 185 }, "Silver Grey", "" },
    { { 160, 160, 160 }, "Grey", "" },
    { { 152, 214, 189 }, "Pale Aqua", "" },
    { { 184, 240, 240 }, "Baby Blue", "" },
    { { 54, 139, 160 }, "Powder Blue", "" },
    { { 79, 131, 171 }, "Bright Blue", "" },
```

```
    { { 56, 106, 145 }, "Slate Blue", "" },
    { { 0, 32, 107 }, "Nave Blue", "" },
    { { 229, 197, 202 }, "Salmon Pink", "" },
    { { 249, 103, 107 }, "Coral", "" },
    { { 227, 49, 31 }, "Burnt Orange", "" },
    { { 226, 161, 136 }, "Cinnamon", "" },
    { { 181, 148, 116 }, "Umber", "" },
    { { 228, 207, 153 }, "Blonde", "" },
    { { 225, 203, 0 }, "Sunflower", "" },
    { { 225, 173, 212 }, "Orchid Pink", "" },
    { { 195, 0, 126 }, "Peony Purple", "" },
    { { 128, 0, 75 }, "Burgundy", "" },
    { { 160, 96, 176 }, "Royal Purple", "" },
    { { 192, 64, 32 }, "Cardinal Red", "" },
    { { 202, 224, 192 }, "Opal Green", "" },
    { { 137, 152, 86 }, "Moss Green", "" },
    { { 0, 170, 0 }, "Meadow Green", "" },
    { { 33, 138, 33 }, "Dark Green", "" },
    { { 93, 174, 148 }, "Aquamarine", "" },
    { { 76, 191, 143 }, "Emerald Green", "" },
    { { 0, 119, 114 }, "Peacock Green", "" },
    { { 112, 112, 112 }, "Dark Grey", "" },
    { { 242, 255, 255 }, "Ivory White", "" },
    { { 177, 88, 24 }, "Hazel", "" },
    { { 203, 138, 7 }, "Toast", "" },
    { { 247, 146, 123 }, "Salmon", "" },
    { { 152, 105, 45 }, "Cocoa Brown", "" },
    { { 162, 113, 72 }, "Sienna", "" },
    { { 123, 85, 74 }, "Sepia", "" },
    { { 79, 57, 70 }, "Dark Sepia", "" },
    { { 82, 58, 151 }, "Violet Blue", "" },
    { { 0, 0, 160 }, "Blue Ink", "" },
    { { 0, 150, 222 }, "Solar Blue", "" },
    { { 178, 221, 83 }, "Green Dust", "" },
    { { 250, 143, 187 }, "Crimson", "" },
    { { 222, 100, 158 }, "Floral Pink", "" },
    { { 181, 80, 102 }, "Wine", "" },
    { { 94, 87, 71 }, "Olive Drab", "" },
    { { 76, 136, 31 }, "Meadow", "" },
    { { 228, 220, 121 }, "Mustard", "" },
    { { 203, 138, 26 }, "Yellow Ochre", "" },
    { { 198, 170, 66 }, "Old Gold", "" },
    { { 236, 176, 44 }, "Honeydew", "" },
    { { 248, 128, 64 }, "Tangerine", "" },
    { { 255, 229, 5 }, "Canary Yellow", "" },
    { { 250, 122, 122 }, "Vermillion", "" },
    { { 107, 224, 0 }, "Bright Green", "" },
    { { 56, 108, 174 }, "Ocean Blue", "" },
    { { 227, 196, 180 }, "Beige Grey", "" },
    { { 227, 172, 129 }, "Bamboo", "" }
};

#define HOOP_126X110 0
#define HOOP_110X110 1
#define HOOP_50X50 2
#define HOOP_140X200 3
```

```
#define HOOP_230X200 4

static const int pcmThreadCount = 65;
static const EmbThread pcmThreads[] = {
    { { 0x00, 0x00, 0x00 }, "PCM Color 1", "" },
    { { 0x00, 0x00, 0x80 }, "PCM Color 2", "" },
    { { 0x00, 0x00, 0xFF }, "PCM Color 3", "" },
    { { 0x00, 0x80, 0x80 }, "PCM Color 4", "" },
    { { 0x00, 0xFF, 0xFF }, "PCM Color 5", "" },
    { { 0x80, 0x00, 0x80 }, "PCM Color 6", "" },
    { { 0xFF, 0x00, 0xFF }, "PCM Color 7", "" },
    { { 0x80, 0x00, 0x00 }, "PCM Color 8", "" },
    { { 0xFF, 0x00, 0x00 }, "PCM Color 9", "" },
    { { 0x00, 0x80, 0x00 }, "PCM Color 10", "" },
    { { 0x00, 0xFF, 0x00 }, "PCM Color 11", "" },
    { { 0x80, 0x80, 0x00 }, "PCM Color 12", "" },
    { { 0xFF, 0xFF, 0x00 }, "PCM Color 13", "" },
    { { 0x80, 0x80, 0x80 }, "PCM Color 14", "" },
    { { 0xC0, 0xC0, 0xC0 }, "PCM Color 15", "" },
    { { 0xFF, 0xFF, 0xFF }, "PCM Color 16", "" }
};


static const int pecThreadCount = 65;
static const EmbThread pecThreads[] = {
    { { 0, 0, 0 }, "Unknown", "" }, /* Index  0 */
    { { 14, 31, 124 }, "Prussian Blue", "" }, /* Index  1 */
    { { 10, 85, 163 }, "Blue", "" }, /* Index  2 */
    { { 0, 135, 119 }, "Teal Green", "" }, /* Index  3 */ /* TODO: Verify
    { { 75, 107, 175 }, "Cornflower Blue", "" }, /* Index  4 */
    { { 237, 23, 31 }, "Red", "" }, /* Index  5 */
    { { 209, 92, 0 }, "Reddish Brown", "" }, /* Index  6 */
    { { 145, 54, 151 }, "Magenta", "" }, /* Index  7 */
    { { 228, 154, 203 }, "Light Lilac", "" }, /* Index  8 */
    { { 145, 95, 172 }, "Lilac", "" }, /* Index  9 */
    { { 158, 214, 125 }, "Mint Green", "" }, /* Index 10 */ /* TODO: Verif
    { { 232, 169, 0 }, "Deep Gold", "" }, /* Index 11 */
    { { 254, 186, 53 }, "Orange", "" }, /* Index 12 */
    { { 255, 255, 0 }, "Yellow", "" }, /* Index 13 */
    { { 112, 188, 31 }, "Lime Green", "" }, /* Index 14 */
    { { 186, 152, 0 }, "Brass", "" }, /* Index 15 */
    { { 168, 168, 168 }, "Silver", "" }, /* Index 16 */
    { { 125, 111, 0 }, "Russet Brown", "" }, /* Index 17 */ /* TODO: Verif
    { { 255, 255, 179 }, "Cream Brown", "" }, /* Index 18 */
    { { 79, 85, 86 }, "Pewter", "" }, /* Index 19 */
    { { 0, 0, 0 }, "Black", "" }, /* Index 20 */
    { { 11, 61, 145 }, "Ultramarine", "" }, /* Index 21 */
    { { 119, 1, 118 }, "Royal Purple", "" }, /* Index 22 */
    { { 41, 49, 51 }, "Dark Gray", "" }, /* Index 23 */
    { { 42, 19, 1 }, "Dark Brown", "" }, /* Index 24 */
    { { 246, 74, 138 }, "Deep Rose", "" }, /* Index 25 */
    { { 178, 118, 36 }, "Light Brown", "" }, /* Index 26 */
    { { 252, 187, 197 }, "Salmon Pink", "" }, /* Index 27 */ /* TODO: Veri
    { { 254, 55, 15 }, "Vermillion", "" }, /* Index 28 */
    { { 240, 240, 240 }, "White", "" }, /* Index 29 */
    { { 106, 28, 138 }, "Violet", "" }, /* Index 30 */
```

```
    { { 168, 221, 196 }, "Seacrest", "" }, /* Index 31 */
    { { 37, 132, 187 }, "Sky Blue", "" }, /* Index 32 */
    { { 254, 179, 67 }, "Pumpkin", "" }, /* Index 33 */
    { { 255, 243, 107 }, "Cream Yellow", "" }, /* Index 34 */
    { { 208, 166, 96 }, "Khaki", "" }, /* Index 35 */
    { { 209, 84, 0 }, "Clay Brown", "" }, /* Index 36 */
    { { 102, 186, 73 }, "Leaf Green", "" }, /* Index 37 */
    { { 19, 74, 70 }, "Peacock Blue", "" }, /* Index 38 */
    { { 135, 135, 135 }, "Gray", "" }, /* Index 39 */
    { { 216, 204, 198 }, "Warm Gray", "" }, /* Index 40 */ /* TODO: Verify
    { { 67, 86, 7 }, "Dark Olive", "" }, /* Index 41 */
    { { 253, 217, 222 }, "Flesh Pink", "" }, /* Index 42 */ /* TODO: Verif
    { { 249, 147, 188 }, "Pink", "" }, /* Index 43 */
    { { 0, 56, 34 }, "Deep Green", "" }, /* Index 44 */
    { { 178, 175, 212 }, "Lavender", "" }, /* Index 45 */
    { { 104, 106, 176 }, "Wisteria Violet", "" }, /* Index 46 */
    { { 239, 227, 185 }, "Beige", "" }, /* Index 47 */
    { { 247, 56, 102 }, "Carmine", "" }, /* Index 48 */
    { { 181, 75, 100 }, "Amber Red", "" }, /* Index 49 */ /* TODO: Verify
    { { 19, 43, 26 }, "Olive Green", "" }, /* Index 50 */
    { { 199, 1, 86 }, "Dark Fuschia", "" }, /* Index 51 */ /* TODO: Verify
    { { 254, 158, 50 }, "Tangerine", "" }, /* Index 52 */
    { { 168, 222, 235 }, "Light Blue", "" }, /* Index 53 */
    { { 0, 103, 62 }, "Emerald Green", "" }, /* Index 54 */ /* TODO: Verif
    { { 78, 41, 144 }, "Purple", "" }, /* Index 55 */
    { { 47, 126, 32 }, "Moss Green", "" }, /* Index 56 */
    { { 255, 204, 204 }, "Flesh Pink", "" }, /* Index 57 */ /* TODO: Verif
    { { 255, 217, 17 }, "Harvest Gold", "" }, /* Index 58 */
    { { 9, 91, 166 }, "Electric Blue", "" }, /* Index 59 */
    { { 240, 249, 112 }, "Lemon Yellow", "" }, /* Index 60 */
    { { 227, 243, 91 }, "Fresh Green", "" }, /* Index 61 */
    { { 255, 153, 0 }, "Orange", "" }, /* Index 62 */ /* TODO: Verify RGB
    { { 255, 240, 141 }, "Cream Yellow", "" }, /* Index 63 */ /* TODO: Ver
    { { 255, 200, 200 }, "Applique", "" } /* Index 64 */
};

\section{SHV Colors}

There are 42 preprogrammed shv threads.

\begin{tabularx}{\linewidth}{l l | l l l}
\caption{SHV Color Table}\\
\textbf{}
\endhead
TODO:CATALOG_NUMBER &    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &    { { 0, 0, 255 }, "Blue", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &    { { 51, 204, 102 }, "Green", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 255, 0, 0 }, "Red", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &    { { 255, 0, 255 }, "Purple", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 255, 255, 0 }, "Yellow", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 127, 127, 127 }, "Grey", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 51, 154, 255 }, "Light Blue", "TODO:CATALOG_N
TODO:CATALOG_NUMBER &    { { 0, 255, 0 }, "Light Green", "TODO:CATALOG_NUM
TODO:CATALOG_NUMBER &    { { 255, 127, 0 }, "Orange", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 255, 160, 180 }, "Pink", "TODO:CATALOG_NUMBER
TODO:CATALOG_NUMBER &    { { 153, 75, 0 }, "Brown", "TODO:CATALOG_NUMBER"
```

```
TODO:CATALOG_NUMBER &    { { 255, 255, 255 }, "White", "TODO:CATALOG_NUMBE
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 255, 127, 127 }, "Light Red", "TODO:CATALOG_NUMBER" },
    { { 255, 127, 255 }, "Light Purple", "TODO:CATALOG_NUMBER" },
    { { 255, 255, 153 }, "Light Yellow", "TODO:CATALOG_NUMBER" },
    { { 192, 192, 192 }, "Light Grey", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 255, 165, 65 }, "Light Orange", "TODO:CATALOG_NUMBER" },
    { { 255, 204, 204 }, "Light Pink", "TODO:CATALOG_NUMBER" },
    { { 175, 90, 10 }, "Light Brown", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
    { { 0, 0, 127 }, "Dark Blue", "TODO:CATALOG_NUMBER" },
    { { 0, 127, 0 }, "Dark Green", "TODO:CATALOG_NUMBER" },
    { { 127, 0, 0 }, "Dark Red", "TODO:CATALOG_NUMBER" },
    { { 127, 0, 127 }, "Dark Purple", "TODO:CATALOG_NUMBER" },
    { { 200, 200, 0 }, "Dark Yellow", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &    { { 60, 60, 60 }, "Dark Gray", "TODO:CATALOG_NUMB
TODO:CATALOG_NUMBER &   { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &  { { 0, 0, 0 }, "Black", "TODO:CATALOG_NUMBER" },
TODO:CATALOG_NUMBER &  { { 232, 63, 0 }, "Dark Orange", "TODO:CATALOG_NUMB
TODO:CATALOG_NUMBER & Dark Pink & 255 & 102 & 122
\end{tabularx}
```

Other Supported Thread Brands

The thread lists that aren't preprogrammed into formats but are indexed in the data file for the purpose of conversion or fitting to images/graphics.

- Arc Polyester
- Arc Rayon
- Coats and Clark Rayon
- Exquisite Polyester
- Fufu Polyester
- Fufu Rayon
- Hemingworth Polyester
- Isacord Polyester
- Isafil Rayon
- Marathon Polyester
- Marathon Rayon
- Madeira Polyester

- Madeira Rayon
- Metro Polyester
- Pantone
- Robison Anton Polyester
- Robison Anton Rayon
- Sigma Polyester
- Sulky Rayon
- ThreadArt Rayon
- ThreadArt Polyester
- ThreaDelight Polyester
- Z102 Isacord Polyester

Development

A *right-handed co-ordinate system* is one where up is positive and right is positive. Left-handed is up is positive, left is positive. Screens often use down is positive, right is positive, including the OpenGL standard so when switching between graphics formats and stitch formats we need to use a vertical flip (`embPattern_flip`).

`0x20` is the space symbol, so when padding either 0 or space is preferred and in the case of space use the literal ' '. Use the macros:

```
#define PAD_SPACE(n) \
    embFile_pad(currentFile, ' ', n)
#define PAD_ZERO(n) \
    embFile_pad(currentFile, 0, n)
```

to save writing functions that may not inline.

Design Philosophy and Coding Standards

- No GUI code will be present here.
- The library will be written in pedantic ANSI C/C90, aiming for no compiler warnings under GCC for compatibility with the most possible platforms.
- The command line program 'embroider' targets 32-bit and 64 bit systems that comply to POSIX or current Windows/MacOS standards. Practically, this means we only call C99 standard library functions.

Image Fitting

A currently unsolved problem in development that warrants further research is the scenario where a user wants to feed embroider an image that can then be .

To Do

1. Basic features.
    1. Incorporate `#if 0`ed parts of `emb-stitch-fill.c`.
    2. Interpret how to write formats that have a read mode from the source code and vice versa.
    3. Identify sources that break down the binary formats we currently don't understand.
    4. Better documentation of the structure of the headers for the formats we do understand.
2. Code quality and user friendliness.
    1. Document all structs, macros and functions (will contribute directly on the web version).
    2. Make a texinfo/PDF user manual for embroider.
    3. Incorporate experimental code, improve support for language bindings.
    4. Make stitch x, y into an EmbVector.
3. embroider CLI
    1. Make -circle flag to add a circle to the current pattern.
    2. Make -rect flag to add a rectangle to the current pattern.
    3. Make -fill flag to set the current satin fill algorithm for the current geometry. (for example "-fill crosses -circle 11,13,10" fills a circle with center 11mm, 13mm with radius 10mm with crosses).
    4. Make -ellipse flag to add to ellipse to the current pattern.
    5. Make -bezier flag to add a bezier curve to the current pattern.
4. Improve embedded compatibility.
    1. Remove reliance on slower, memory expensive parts of the C Standard Library that are in the main library, for example, not using printf, sprintf, fprintf etc. (Use embFile_puts.)
    2. Share heavy memory usage between functions, for example use embBuffer for buffering headers rather than having a seperate `char header[]` variables.
    3. Reduce calls to malloc when we know the total usage as dynamic memory may not be present and we may need to get rid of malloc entirely.
    4. Consider using an alternative C standard library for the remaining functions like uclibc.

Finding fixes

To find jobs marked within the source code rather than the list above, use:

```
grep "TODO" *.c *.h
```

Testing

Build `embroider` then run:

```
./embroider -test &> report.txt
```

If any of the tests return a fail in the summary (see `tail report.txt`) then it would help the project to send us an issue attatching the file to your message along with a description of the system you ran the program on.

On Embedded Systems

The library is designed to support embedded environments, so it can be used in CNC applications.

Compatible Boards

We recommend using an Arduino Mega 2560 or another board with equal or greater specs. That being said, we have had success using an Arduino Uno R3 but this will likely require further optimization and other improvements to ensure continued compatibility with the Uno. See below for more information.

Arduino Considerations

There are two main concerns here: Flash Storage & SRAM.

libembroidery continually outgrows the 32KB of Flash storage on the Arduino Uno and every time this occurs, a decision has to be made as to what capabilities should be included or omitted. While reading files is the main focus on arduino, writing files may also play a bigger role in the future. Long term, it would be most practical to handle the inclusion or omission of any feature via a single configuration header file that the user can modify to suit their needs.

SRAM is in extremely limited supply and it will deplete quickly so any dynamic allocation should occur early during the setup phase of the sketch and sparingly or not at all later in the sketch. To help minimize SRAM consumption on Arduino and ensure libembroidery can be used in any way the sketch creator desires, it is required that any sketch using libembroidery must implement event handlers. See the ino-event source and header files for more information.

There is also an excellent article by Bill Earl on the Adafruit Learning System which covers these topics in more depth: http://learn.adafruit.com/memories-of-an-arduino?view=all.

Space

Since a stitch takes 3 bytes of storage and many patterns use more than 10k stitches, we can't assume that the pattern will fit in memory. Therefore we will need to buffer the current pattern on and off storage in small chunks. By the same reasoning, we can't load all of one struct beore looping so we will need functions similar to binaryReadInt16 for each struct.

This means the EmbArray approach won't work since we need to load each element and dynamic memory management is unnecessary because the arrays lie in storage.

TODO: Remove all malloc/realloc/free from souce.

TODO: Replace EmbArray functions with embPattern load functions.

Tables

All thread tables and large text blocks are too big to compile directly into the source code. Instead we can package the library with a data packet that is compiled from an assembly program in raw format so the specific padding can be controlled.

TODO: Reformat tables as `libembroidery_data.bin`.

In the user section above we will make it clear that this file needs to be loaded on the pattern USB/SD card or the program won't function.

TODO: Keep EmbFile* datfile open, use an init library function for the library to open it and a close libarary function to close it.

TODO: Start file with a list of offsets to data with a corresponding table to load into with macro constants for each label needed.

Current Pattern Memory Management

It will be simpler to make one file per EmbArray so we keep an EmbFile* and a length, so no malloc call is necessary. So there needs to be a consistent tmpfile naming scheme.

TODO: For each pattern generate a random string of hexidecimal and append it to the filenames like `stitchList_A16F.dat`. Need to check for a file which indicates that this string has been used already.

Special Notes

Due to historical reasons and to remain compatible with the Arduino 1.0 IDE, this folder must be called "utility". Refer to the arduino build process for more info: https://arduino.github.io/arduino-cli/0.19/sketch-build-process/

libembroidery relies on the Arduino SD library for reading files. See the ino-file source and header files for more information.

Experimental Projects

Anything contained within the experimental/ folder is unstable and unsupported. Items in here may eventually be moved elsewhere or may not. If you have an interesting concept or prototype that you would like us to add, contact us and we may add it here.

Dependencies

To build additional language bindings for libembroidery from source you will need at least:

Ubuntu repository packages:

```
sudo apt-get install swig python-dev
```

Mac

```
brew install swig
```

An example for building for use in C#

```
swig -csharp -o ./csharp/binding/swig_wrap.c -I../ swig.i
```

References

[1] Technical Info, Feb 2005. [Online; accessed 28. Sep. 2021].

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