

Warp3D_Devel

COLLABORATORS

	<i>TITLE :</i> Warp3D_Devel		
<i>ACTION</i>	<i>NAME</i>	<i>DATE</i>	<i>SIGNATURE</i>
WRITTEN BY		July 16, 2022	

REVISION HISTORY

NUMBER	DATE	DESCRIPTION	NAME

Contents

1	Warp3D_Devel	1
1.1	Warp3D_Devel	1
1.2	Warp3D_Devel/Introduction	1
1.3	Warp3D_Devel/Getting Started	3
1.4	Warp3D_Devel/Opening the library	3
1.5	Warp3D_Devel/Querying Capabilities	4
1.6	Warp3D_Devel/Opening the display	5
1.7	Warp3D_Devel/Creating a Context	7
1.8	Warp3D_Devel/Context Queries	9
1.9	Warp3D_Devel/Textures	10
1.10	Warp3D_Devel/What is it	10
1.11	Warp3D_Devel/Texture Infos	11
1.12	Warp3D_Devel/Creating Textures	12
1.13	Warp3D_Devel/Texture Images	13
1.14	Warp3D_Devel/MIP-Mapping	15
1.15	Warp3D_Devel/Using Textures	17
1.16	Warp3D_Devel/Context States	19
1.17	Warp3D_Devel/Drawing	22
1.18	Warp3D_Devel/Starting to Draw	22
1.19	Warp3D_Devel/Locking	23
1.20	Warp3D_Devel/Coordinates	24
1.21	Warp3D_Devel/Triangles	25
1.22	Warp3D_Devel/Lines	26
1.23	Warp3D_Devel/Points	27
1.24	Warp3D_Devel/Fogging	27
1.25	Warp3D_Devel/Logic Operations	28
1.26	Warp3D_Devel/Stencil Buffering	28
1.27	Warp3D_Devel/ZBuffering	28
1.28	Warp3D_Devel/Alpha Blending	30
1.29	Warp3D_Devel/Light	30

1.30 Warp3D_Devel/Hinting	31
1.31 Warp3D_Devel/Indirect Rendering	33
1.32 Warp3D_Devel/Indices	34
1.33 Warp3D_Devel/Concept Index	34
1.34 Warp3D_Devel/Function Index	36
1.35 Warp3D_Devel/Type Index	38

Chapter 1

Warp3D_Devel

1.1 Warp3D_Devel

This is the Programmer's Manual for Warp3D. It should serve as an introduction to Warp3D programming, and not as a reference for the functions (those are explained in the AutoDocs).

- Introduction
 - Introduction to Warp3D.
- Getting Started
 - How to get Warp3D going
- Textures
 - Textures and their management
- Context States
 - States
- Drawing
 - Drawing something to the Screen
- Hinting
 - Controlling output quality
- Indirect Rendering
 - Background rendering
- Indices
 - The Index

1.2 Warp3D_Devel/Introduction

Introduction

Overview

=====

Warp3D is a library for direct access to 3D Hardware in such a way that it is independent of both the graphics system as well as the hardware installed (if any). Some of the concepts are similar to those found in OpenGL, however, Warp3D is much more low-level, since it does not for example provide functions for 3D rotation or projection (1). Rather, Warp3D requires that coordinates are specified in a coordinate system that is often called Camera- or Eye- Coordinate System: The X- and Y-Coordinates are screen coordinates, and the Z-Coordinate specifies the "depth" of a vertex. There are special constraints about coordinates, which will be explained later.

Warp3D is a low-level API, meaning that it should serve as a direct interface between an application and the 3D hardware. Other than OpenGL, it has no 3D functionality, but rather is a rasterizer. A rasterizer takes descriptions of primitives and renders those to a drawing canvas, in the case of Warp3D this means a BitMap.

How to use this manual

=====

Examples in this manual will be given in the C programming language. This is done for clarity, and since C is my programming language of choice (actually it's C++, but ...). Most examples will be more or less complete with error checking, but it might be left out in some places for brevity. In the real world, however, you should always check the return values, and act accordingly.

Function descriptions may appear a bit short in some places. In general, you should always refer to the AutoDocs for more in-depth discussion of peculiarities. In any case, references to function parameters will be named exactly as in the AutoDoc description for this function, and will be written in this style. For example, the third parameter of the W3D_UpdateTexImage is called teximage.

To understand Warp3D programming, you should read this manual and cross-check with the AutoDocs as much as possible when Warp3D functions are described. The AutoDocs will always have the latest, up-to-date information, and if an AutoDoc entry contradicts this guide, the AutoDocs take precedence. This is because the AutoDocs are usually updated more frequently than this guide, although we are trying hard to keep it up-to-date.

Commonly used terms

=====

When we say Warp3D, usually this means the Warp3D.library or Warp3D as an entity.

The term 'the driver' usually refers to the active driver library,

for example, on a system with a CyberVision64/3D card, this means the W3D_Virge.library. This information is not usually necessary to understand, but in some cases it might be important to make this distinction, since even if Warp3D supports a certain feature, 'the driver' might not.

----- Footnotes -----

(1) This might change when hardware with geometry engines become available

1.3 Warp3D_Devel/Getting Started

Getting Started

Opening the library

How the Warp3D library is opened

Querying Capabilities

How to find out more about the
Environment you are running in and
how you can influence driver selection.

Opening the display

How you to provide drawing space

Creating a Context

Defining the basic drawing area

Context Queries

Finding out what the chip can do on
this display

1.4 Warp3D_Devel/Opening the library

Opening the library

=====

The first step will almost always be to open the required libraries. Besides the normal system libraries you need, you must open the Warp3D library. The following code fragment shows how this is done

```
struct Library *Warp3DBase;
// ...

Warp3DBase = OpenLibrary(`Warp3D.library', 0L);
```

```

if (!Warp3DBase) {
    fprintf(stderr, ``Error: Could not open Warp3D.library\n``);
    exit(0L);
}

```

Note for PPC/StormC: You must link with w3d.lib for PPC code.

Make sure to always check the returned base. If everything goes OK, then Warp3D is ready for use. There are numerous reasons beside memory shortage why the open could go wrong, for example, Warp3D might be unable to initialize an appropriate driver, or there might be an unsupported graphics system installed (1) and so on.

After opening the library, you might want to check what kind of driver you got. The parameterless function W3D_CheckDriver will determine this, as is illustrated in this example code:

```

ULONG flags = W3D_CheckDriver();
if (flags & W3D_DRIVER_3DHW) printf("Hardware driver available\n");
if (flags & W3D_DRIVER_CPU)  printf("Software driver available\n");
if (flags == 0) {
    printf("PANIC: no driver available!!!\n");
    doPanic();
    exit(0);
}

```

----- Footnotes -----

(1) In which case you might want to write your own driver for it. If you want to, please contact us so we can provide you with the details.

1.5 Warp3D_Devel/Querying Capabilities

Querying Capabilities

=====

It is possible that a system has more than one 3D graphics card installed, and it might be useful to find out which of those matches your requirements. Furthermore, there might be a couple of different CPU drivers that also have different capabilities, or support different destination formats.

For this purpose, Warp3D provides a library call, W3D_GetDrivers. This call returns an array of pointers to W3D_Driver structures. You may examine these read-only structures to find out the destination formats supported by this driver, and if the driver is a hardware- or CPU-Driver. Furthermore, you can obtain the name of the driver, in case there are alternatives that you want to present to the user.

If you need more information about a specific driver, there is a function W3D_QueryDriver that works exactly like the W3D_Query function, only that instead of a context, it accepts a W3D_Driver structure. Otherwise, the functions work identical.

For further details about W3D_Query, see the chapter about
Context Queries
.

1.6 Warp3D_Devel/Opening the display

Opening the display
=====

The next step is to open the display. This might depend on the graphics system software you are using. Using the Intuition standard functions OpenScreen and OpenWindow should work on all systems, but might not support special features of your software.

First, you need to find out what modes are supported. The function W3D_GetDestFmt can be used to query this:

```

        ULONG format;

        format = W3D_GetDestFmt();
        if (format & W3D_FMT_CLUT)           printf("Driver supports 8 bit chunky  ←
            modes\n");
        if (format & W3D_FMT_R5G5B5)       printf("Driver supports 15 bit RGB modes\ ←
            n");

```

Note that this function doesn't take parameters and can be used directly after you are sure you have a driver.

The following code will try to open a screen suitable for a Warp3D display, but does use CyberGraphX for obtaining a ModeID:

```

        ModeID = BestCModeIDTags(
            CYBRBIDTG_Depth,          15L,
            CYBRBIDTG_NominalWidth,  640,
            CYBRBIDTG_NominalHeight, 480,
            TAG_DONE);

        if (ModeID == INVALID_ID) {
            printf("Error: No ModeID found\n");
            goto panic;
        }

        // Open Screen
        screen = OpenScreenTags(NULL,
            SA_Height,      960,
            SA_DisplayID,  ModeID,
            SA_ErrorCode,  &OpenErr,
            SA_ShowTitle,  FALSE,
            SA_Draggable,  FALSE,
            TAG_DONE);

        if (!screen) {

```

```

        printf("Unable to open screen. Reason: Error code %d\n", OpenErr);
        goto panic;
    }

    // Open window
    // While this is not strictly necessary, we use it because
    // we want to get IDCMP messages. You can also use the screen's
    // bitmap to render
    window = OpenWindowTags(NULL,
        WA_CustomScreen,    screen,
        WA_Width,           screen->Width,
        WA_Height,          screen->Height,
        WA_Left,            0,
        WA_Top,             0,
        WA_Title,           NULL,
        WA_CloseGadget,    FALSE,
        WA_Backdrop,        TRUE,
        WA_Borderless,      TRUE,
        WA_IDCMP,           IDCMP_CLOSEWINDOW|IDCMP_VANILLAKEY|IDCMP_RAWKEY| ←
        IDCMP_MOUSEBUTTONS|IDCMP_MOUSEMOVE|IDCMP_DELTAMOVE,
        WA_Flags,           WFLG_REPORTMOUSE|WFLG_RMBTRAP,
        TAG_DONE);

    if (!window) {
        printf("Unable to open window.\n");
        goto panic;
    }

```

Note that creating a suitable display might also be in the form of an `AllocBitMap` call, but you'll have to make sure that this bitmap is allocated in card memory. If you use an off-screen bitmap, or one that is attached to a window, you might use Warp3D in window mode, for example by blit-copying the drawing bitmap to a window. Also note that there is no way of ensuring that clip regions other than those defined in the context's scissor region are correctly taken into account, so a window that is in front of your drawing window might get overdrawn.

Starting with Version 2, Warp3D provides a screen mode requester. This requester can be instructed to filter screen modes according to one of three rules, specified by the following tag items:

W3D_SMR_DRIVER

The argument to this tag item is a pointer to a `W3D_Driver` structure, as provided by `W3D_GetDrivers`. If this tag is present, only screenmodes that are supported by this driver are shown in the requester. The screen modes may be filtered further (see below), but the modes are guaranteed to be supported by this driver.

W3D_SMR_DESTFMT

The argument to this tag item is a mask made up from one or more of the `W3D_FMT_#?` bits. Each screen mode is compared against this mask before it makes its way into the mode requester. You may either use this to filter directly after the destination format, or use it to further narrow down the selection of modes in conjunction with the `W3D_SMR_DRIVER` tag item.

W3D_SMR_TYPE

The argument to this tag item is one of the constants W3D_DRIVER_CPU or W3D_DRIVER_3DHW, exclusively. Before a screen mode is presented in the mode requester, it is checked against all of the screen modes supported by the CPU drivers (if the argument is W3D_DRIVER_CPU) or by the hardware drivers (if W3D_DRIVER_3DHW was specified). This tag can be used in conjunction with W3D_SMR_DESTFMT to further narrow the selection of modes.

Further filtering may be done by using the ASLSM_MIN#? tags in conjunction with W3D_SMR_SIZEFILTER. This tag is a boolean tag that specifies if you want to filter screen modes according to certain size constraints. See the WarpTest.c for more details.

To allow for further selection of a suitable driver, for example, when you want to open up on a public screen, you can use the W3D_TextMode function. This function accepts one argument, the ModeID of the screen, and returns a suitable W3D_Driver, either a HW driver if one is present, or a CPU driver (if one is available), or NULL if nothing is available.

1.7 Warp3D_Devel/Creating a Context

Creating a Context

=====

We are now ready to create a W3D_Context. But first, let us introduce the concept of a context.

A W3D_Context is a structure that stores information about the current rendering state, display state, and also driver-internal information. It serves as some kind of "anchor" or "handle" for Warp3D. The structure itself is off-limits, you should neither read or write it directly, but rather use the functions provided by the library.

A context is created with the W3D_CreateContext function. This function is fully described in the AutoDoc, we'll just look at an example call here to illustrate how the context is created for our full-screen example above (See

Opening the display
).

```
W3D_Context *context;
ULONG CError;

context = W3D_CreateContextTags(&CError,
    W3D_CC_BITMAP,      bm,
    W3D_CC_MODEID,     ModeID,
    W3D_CC_YOFFSET,    height,
    W3D_CC_DRIVERTYPE, W3D_DRIVER_BEST,
    TAG_DONE);
```

Note that there is usually no way for the programmer to influence

driver selection. The User usually has the possibility to indicate a "preferred" CPU driver, but the HW driver is always selected automatically (if W3D_DRIVER_BEST is set).

The W3D_CC_YOFFSET tag item is used for double buffering the CyberGraphX style. This specifies the top scanline used for rendering. All coordinates will be relative to this line, meaning the the offset is automatically added to the Y coordinates. When you switch display with ScrollVPort, you will need to set a new drawing area with W3D_SetDrawRegion, you can change this offset.

Please note that you should start with an Y-Offset of the second (invisible) page. This way, rendering will be directed to the invisible page, and switching the display will reveal the stuff you just drawn.

The following table summarizes the tag items for W3D_CreateContext:

W3D_CC_BITMAP

Specifies the bitmap where Warp3D should render into. This bitmap must either be allocated on the graphics card, or must be the bitmap of a screen or window.

W3D_CC_MODEID

Specifies the ModeID of the display you want to use. This tag may be omitted if you open a window on the current public screen, otherwise it is mandatory. This tag is used to select the correct driver for the display.

W3D_CC_YOFFSET

Used for 'fake' double buffering. Specifies the YOffset to add to all coordinates for drawing operations. Should generally only used if you use ScrollVPort double buffering.

W3D_CC_DRIVERTYPE

Specifies what type of driver should be active for this context. Must be one of three pre-defined symbols: W3D_DRIVER_BEST tries to obtain the best possible driver. W3D_DRIVER_3DHW makes the call fail if no suitable hardware driver was found. W3D_DRIVER_CPU will try to use a CPU driver.

W3D_CC_W3DBM

For CPU drivers, a simple bitmap might not be enough. A CPU driver might need a fastram buffer. This tagitem can be used to pass a W3D_Bitmap.

W3D_CC_INDIRECT

Sets the W3D_INDIRECT state bit on the created context. This means that all drawing operations will be queued. See

Indirect Rendering
for further details.

W3D_CC_GLOBALTEXENV

If this tagitem's value is W3D_TRUE, all texture environment changes will affect all textures, not just a single texture.

W3D_CC_DOUBLEHEIGHT

If this tagitem's value is `W3D_TRUE`, the bitmap is considered to be only half visible. This is used in conjunction with `W3D_CC_YOFFSET` to fake double buffering on older CyberGraphX systems.

`W3D_CC_FAST`

By setting this to `W3D_TRUE`, you are allowing the driver to alter the structures you pass it. This means that drawing will be slightly faster, because the structures need not be copied. This can speed things up when drawing many small triangles.

Caution: Do not use the tagitems `W3D_CC_YOFFSET` and `W3D_CC_DOUBLEHEIGHT` for any other purpose. They might not work on certain graphics systems or drivers, and might even become deprecated in the future, so this don't try to outsmart the documentation.

1.8 Warp3D_Devel/Context Queries

Context Queries

=====

Once the context is created, you should go and find out what the chip really can do in the environment you have provided it with. For this purpose, the `W3D_Query` function also accepts the context structure as an argument.

The template for calling the `W3D_Query` function is

```
res = W3D_Query(context, query, destfmt);
```

`context` is the pointer to the `W3D_Context` structure you created, and `query` is the item you want to query. The `destfmt` parameter is ignored.

The result is one of the following three values:

`W3D_FULLY_SUPPORTED`

This feature is fully supported by the selected driver.

`W3D_PARTIALLY_SUPPORTED`

This feature is not fully supported, but may somehow still work. There might be graphics glitches, or the result might not look like you intended it to look. If possible, you should give users the possibility to bypass this feature if it can be simulated.

`W3D_NOT_SUPPORTED`

This feature is not supported, and must be emulated in software.

For a description of the supported items, refer to the AutoDocs, and to the include file `Warp3D/Warp3D.h`.

1.9 Warp3D_Devel/Textures

Textures

What is it

What exactly is a texture

Texture Infos

How to get Information on Textures

Creating Textures

How to create and destroy textures

Texture Images

How texture images are represented

MIP-Mapping

How MIP-Maps fit into this

Using Textures

How textures are used

1.10 Warp3D_Devel/What is it

What is it

=====

A Texture is a square or rectangular image map. That's about it. A texture can be used for Texture Mapping. Texture Mapping is the process of distorting the texture so that it looks as if it has been perspectively draw onto a triangle. Most 3D hardware can do texture mapping by itself, and that's what makes them so fast.

A texture in Warp3D is a combination of a structure, called W3D_Texture, and a few memory blocks. Those memory blocks hold the texture data, the MIP-Maps (See MIP-Mapping) and the converted texture data(1).

Textures can have several attributes associated with them. They can be either RESIDENT, in which case they are in the texture memory of the graphics board. They can be DIRTY, in which case the program has updated the imagery of the texture, resulting in the need to convert or upload them again. More on this is covered in the next section.

----- Footnotes -----

(1) This data is generated by the 3D Hardware driver to suit the

needs of the hardware.

1.11 Warp3D_Devel/Texture Infos

Texture Infos
=====

Different chips support different texture formats. Because of this, your textures might be in a format that the driver cannot use directly. If this is the case, your textures are automatically converted to a suitable format, without modifying the texture data you passed in. This step is handled completely transparent, without you ever noticing it.

However, this might not be desirable. For example, it might be necessary to convert your true-color textures to a chunky format because the chip can only use chunky textures. In this case, a very complicated process of finding closest matching colors must be performed, resulting in poor overall performance.

Warp3D offers a function that can determine if a texture format is directly supported by a given hardware driver. This function is called `W3D_GetTexFmtInfo`, and is called with one `ULONG` parameter, the format of the texture you want to verify.

The return value of this function is a bit mask. Currently, the following values are supported:

`W3D_TEXFMT_SUPPORTED`

The specified format is supported by the driver, although it may need to be converted to be usable by the hardware.

`W3D_TEXFMT_UNSUPPORTED`

The format is not supported by the driver, and no emulation or format conversion is defined for it.

`W3D_TEXFMT_FAST`

The given format is directly supported by the hardware, without any conversion step

`W3D_TEXFMT_CLUTFAST`

The given format is directly supported by the hardware in Chunky modes only.

`W3D_TEXFMT_ARGBFAST`

The given format is directly supported by the hardware in direct color modes only.

Consider this example: You are using Chunky textures, but want to use a True-Color 15 bit display. To find out if your active driver supports this directly, you would use something like this

```
ULONG info;
```

```

// ...
info = W3D_GetTexFmtInfo(W3D_CLUT);

if ((info & W3D_TEXFMT_ARGBFAST) || (info & W3D_TEXFMT_FAST)) {
    // ... simply load the textures, it's ok to do so
} else {
    // consider converting your textures to ARGB format once at the start
}

```

If you found out that your textures aren't directly supported, you might want to convert them to a suitable format yourself, although this step is not needed due to the on-the-fly conversion of texture formats done by Warp3D. To find a suitable format, you can also use the `W3D_GetTexFmtInfo` function.

1.12 Warp3D_Devel/Creating Textures

Creating Textures

=====

Textures must be created with the `W3D_AllocTexObj` function. The calling template for this function looks like this:

```
texture = W3D_AllocTexObj(context, error, ATOTags);
```

The `context` argument is a pointer to a context structure created with `W3D_CreateContext` (See

Creating a Context

). `error` is an `ULONG *` where

the function deposits an error code in case of failure. Finally, `ATOTags` is a taglist of one or more tagitems defined in `Warp3D/Warp3D.h`. Currently, the following tag items are supported:

W3D_ATO_IMAGE

(required) A pointer to the image data. See
Texture Images
for a

description about how the texture data should be organized

W3D_ATO_FORMAT

(required) A constant indicating the source format of the texture.
See

Texture Images

for a description of these formats

W3D_ATO_WIDTH

(required) The border width of the texture map. This must be 2^n
with an integral n .

W3D_ATO_HEIGHT

(required) The border height of the texture map. Same constraints
as with the `W3D_ATO_WIDTH`.

W3D_ATO_MIPMAP

If this tag item is specified, the texture map can be used for mipmapping. You can either provide your own mipmaps, or let Warp3D create some or all of them for you. For complete explanation of this tag item, See

MIP-Mapping

W3D_ATO_MIPMAPPTRS

This tag item must be specified if W3D_ATO_MIPMAP was used. The data of this tag item is a null-terminated array of pointers to the mipmaps you want to provide. This is described in more detail in

MIP-Mapping

W3D_ATO_PALETTE

(required for chunky textures only) This defines the color palette used for a texture. This is a pointer to an ULONG array defining 256 entries of ARGB values, packed into one ULONG, with the bits 31-24 defining Alpha, 23-16 defining red, 15-8 defining green and 7-0 defining blue.

If the return value of this function is NULL, the ULONG pointed to by error is filled with an error value. You should always take appropriate action, and not ignore the value.

After you are done with the texture, it must be freed with W3D_FreeTexObj. This frees up all associated storage, but not the texture data pointer or mipmap pointers that you passed in. It is your responsibility to free this storage. See also

Texture Images

for

further details.

1.13 Warp3D_Devel/Texture Images

Texture Images

=====

Textures are stored in one of six possible formats. The format of a texture specifies how a single pixel is represented. Textures are always stored one scanline at a time, with all scanlines successively stored in memory. Thus, a chunky texture of 128 by 128 pixels will occupy 16384 bytes of memory (if no mipmaps are used).

Supported Formats

The following formats are supported by Warp3D:

Format	Pixel Size	Description
W3D_CHUNKY1	Byte	Palettized Data. Each unit servers as an index into a color lookup table. (This lookup table must be provided on W3D_AllocTexObj with the W3D_ATO_PALETTE tag item). The palette given must match

		the screen palette, otherwise the result is undefined.
W3D_A1R5G5B52 Bytes	True color data, one word per pixel. The layout corresponds to a 15 bit screen mode, i.e. there's 5 bits for each color, but preceded by a one bit alpha. If this alpha is one, the pixel is fully opaque. If the alpha is zero, the pixel is invisible/fully transparent.	
W3D_R5G6B52 Bytes	True color data, one word per pixel. This layout corresponds to a 16 bit screen mode, with each 5 bits for red and blue, and 6 bits for green (The additional bit is used for green rather than another color because the human eye is more sensitive to green than to any other primary color). This format has no alpha channel.	
W3D_R8G8B83 Bytes	True color data, 3 bytes per pixel. Each byte corresponds to one primary color, with no alpha channel information. This format is problematic because of the uneven addresses of pixels, but can be useful for true color textures since it has no alpha channel, which might not always be needed.	
W3D_A4R4G4B42 Bytes	True color data, one word per pixel. This format is the only "narrow" true color format that supports more than just on/off alpha channels. Uses Four bits per color and alpha channel.	
W3D_A8R8G8B84 Bytes	True color data, one longword per pixel. This format uses 8 bit for each color and alpha channel.	
W3D_A81 Byte	Pure alpha data, one byte per pixel. This format uses 8 bits of alpha information.	
W3D_L81 Byte	8 bit luminance data. This format uses is similar to R8G8B8 with each component set to L, meaning that this texture specifies a gray level map.	
W3D_L8A82 Bytes	8 bit luminance and 8 bit alpha. This format is a combination of W3D_L8 and W3D_A8	
W3D_I81 Byte	8 bit Intensity. This format uses 8 bit and is similar to A8R8G8B8 with A=R=G=B=I	

The format you choose for your textures is a matter of choice, need and hardware limitations. Some hardware might not be able to use True color textures on an 8 bit screen, so if you want to use and 8 bit screen, it might be more advisable to use the W3D_CHUNKY format instead and convert your true color data to 8 bit using a dither algorithm that might be time consuming (once) but may yield better quality than Warp3D's internal texture conversion algorithms, which are mainly tuned for speed. What format you finally choose is up to you, and it is very hard to give a general suggestion.

Generally, you should only use W3D_CHUNKY textures on an 8 bit

screen, and true color texture formats on highcolor or truecolor screens.

Color Channels

As with the standard RGB model, the textures Warp3D uses do support all three color channels, including a fourth, so called Alpha channel. The Alpha Channel is not really a color, but rather the "transparency" information associated with a pixel. An Alpha value of zero means the pixel is totally transparent, while full alpha means the pixel is completely opaque.

The real outcome of the pixel depends on the alpha blending mode (see the chapter about

Alpha Blending

for more detailed information about

alpha blending modes). Alpha blending can be used for spectacular effects that are very hard to do in software.

Texture Memory and Images

Normally, when you allocate a texture, your source data is not copied. Rather, the data is used as specified, but might be internally converted to a more suitable format by the driver. This means that as long as your data pointer is associated with a texture, you may not freely modify the texture image without calling `W3D_UpdateTexImage`. Calling `W3D_UpdateTexImage` tells the driver that the image has changed.

To update only part of an image, use `W3D_UpdateTexImage`. See the AutoDoc for more information.

1.14 Warp3D_Devel/MIP-Mapping

MIP-Mapping

Introduction

A common aliasing problem is loss of detail when textures move far away from the observer. For example, a skeleton sprite in a role playing game might look even more skinny when it is away from the player. A grate might not look like a grate from a distance because the bars have disappeared. Texture mapping a large texture onto a small polygon results in loss of pixels, and hence loss of (possibly important) details.

MIP-Mapping is a way to compensate this. Technically, a MIP-Map is a sequence of arrays of decreasing size of texture maps. Each new map is half as large as the previous one; for example, a valid mipmap sequence would be 128x128, 64x64, 32x32, 16x16, 8x8, 4x4, 2x2 and 1x1. In the

case of non-square (read: rectangular) maps, this works a bit different: Each side is halved until it reaches 1, in which case it stays one. Such, a 32x16 texture would be MIP-Mapped as 32x16, 16x8, 8x4, 4x2, 2x1, 1x1.

Specifying MIP-Maps

MIP-Maps might either be programmer-supplied, or generated on the fly, or a mixture of this. The Programmer might specify any or all of the MIP-Maps.

In any case, the mechanism for this is always identical. The tag items W3D_ATO_MIPMAP and W3D_ATO_MIPMAPPTRS are used for this while allocating the texture with W3D_AllocTexObj. The first tag item W3D_ATO_MIPMAP's data is a bit mask indicating which MIP-Maps are to be generated by Warp3D. A zero bit indicates this map is user supplied, while a 1 bit indicates that this MIP map should be generated. Regardless of this tag item's value, its presence always implies that this texture is a mip map. Note also that you may provide only part of the MIP maps, and that any holes in the sequence are filled in by Warp3D. Also note that automatic MIP-Map generation decreases performance, since those maps must be generated and filtered.

The second tag item involved is W3D_ATO_MIPMAPPTRS, which must be present if W3D_ATO_MIPMAP was specified. It's data is a pointer to a NULL-terminated array with pointer to the MIP-Map data, in the same format as the texture data.

Automatic MIP-Map creation filters the images when scaling down. The filter process is only supported on true-color maps. On 8 bit, the maps are simply scaled down to half the size. This means that MIP-Mapping essentially has no effect if automatic mipmap creation is used. Of course, using pre-defined MIP-Maps still gives good results, since an artist can decide which details should be carried over to the next level of detail.

The following example illustrates the use of MIP-Maps. In this case, we consider a program that wants to create a 64x64 MIP-Map and provide two additional maps, the 16x16 and 8x8 maps. We assume that there is a function void *LoadImageMap(int size, char *name) that loads an image file.

```
void *Maps[3];
void *MainMap;
W3D_Texture *texture;
ULONG error;

extern W3D_Context *context;

MainMap = LoadImageMap(64, "main.png");
// Check for errors in the real world!

Maps[0] = LoadImageMap(16, "main_m1.png");
Maps[1] = LoadImageMap(8, "main_m2.png");
Maps[2] = NULL;
```

```

texture = W3D_AllocTexObj(context, &error,
    W3D_ATO_IMAGE,      MainMap,
    W3D_ATO_FORMAT,    W3D_A1R5G5B5,
    W3D_ATO_WIDTH,     128,
    W3D_ATO_HEIGHT,    128,
    W3D_ATO_MIPMAP,    0x0049,      // == 00111001b
    W3D_ATO_MIPMAPPTRS, Maps,
    TAG_DONE);

// --- Proceed

```

1.15 Warp3D_Devel/Using Textures

Using Textures

=====

Textures and Video Ram

In order to be used, it is not sufficient that the texture object is allocated. Rather, it must be on the graphics card's texture memory to be used. There are two possible ways to ensure this. You may either use the the W3D_AUTOTEXMANAGEMENT state (See

Context States

, or you may

manually upload the textures. The automatic texture management is the easiest to use, since this will take care of the details.

If automatic texture management is on, Warp3D will automatically upload textures when they are needed and are not resident in video memory. Otherwise, you must upload them manually, using the W3D_UploadTexture call:

```

success = W3D_UploadTexture(context,texture);

```

context is the drawing context you are using. texture is the texture object to be uploaded.

Caution: You may never use textures allocated under one context in a different context. This might lead to unpredictable behavior, including crashes

The reverse process to uploading is releasing. A (single) texture can be released with a call to the W3D_ReleaseTexture call. The call has exactly the same parameters as the W3D_UploadTexture call, only the reverse effect.

To release multiple textures, you may call the W3D_FlushTextures function with the context as a parameter. This will release all textures from the video memory

The Fate of a Texture

When you're done with a texture, it must be deallocated. This is done with a call to the `W3D_FreeTexObj` function. The texture pointer becomes invalid after you freed the texture object. This will also free any video memory associated with the texture, and deallocate all memory that Warp3D allocated, including MIP-Maps created automatically. However, all memory allocated by the programmer, including the main texture image and the provided MIP-Maps, must be freed all by yourself.

Modifying Texture Images

There might be situations where you would like to modify the image of a texture, or you might want to re-use a texture handle instead of disposing it and creating a new one if the overall parameters (size and format) match. The function `W3D_UpdateTexImage` must be used in this case. The `teximage` parameter might be either a pointer to a new image that should replace the old one, or `NULL`. In the latter case, Warp3D assumes that you have modified the original texture image and just want to inform the driver about this fact.

Caution: You must call `W3D_UpdateTexImage` when you modified your texture. Certain drivers might not need to convert your source data, and CPU drivers might directly use your memory area and directly display the correct texture without this call. This does not mean, however, that this will be the case with every other driver.

In a similar line, you might want to update only parts of a texture. There are two possibilities for this, and both use the function `W3D_UpdateTexSubImage`.

If you want to replace parts of the texture with a new image, you can give a non-`NULL` pointer for the `teximage` parameter when calling `W3D_UpdateTexSubImage`. This essentially copies the image pointed to into the texture, replacing what was originally there. The area to update is specified with a pointer to a `W3D_Scissor` region in `scissor`. The image size should match the scissor region, if it doesn't, the `srcbpr` parameter should be used to specify the bytes to skip from the first pixel of the subimage to get to the next line.

You might also want to change parts of the original image and tell Warp3D the exact area where your changes took place, so that the driver might limit conversion of the image data to the area where the actual damage was done. In this case, `teximage` should be set to `NULL`.

Texture Image Considerations

The `W3D_UpdateTexImage` function gives you the possibility to update the texture image, however, it might not always be what you want. For example, the game *Descent* uses animated textures for monitors in the mine. You might choose to use the `W3D_UpdateTexImage` function each time the monitor switches an image, but that might be wasteful. The reason for this is that your program might not use the complete texture memory, so that all monitor images might fit. Using repetitive calls to the `W3D_UpdateTexImage` function will always convert and upload the new

image.

As you can see from the above, a structured approach to texture management might be needed.

1.16 Warp3D_Devel/Context States

Context States

Introduction to Context States

=====

Like OpenGL, Warp3D uses States to inform the graphics pipeline how certain situations should be handled. Some states affect internal workings of Warp3D, for example the W3D_AUTOTEXMANAGEMENT state which make texture uploading and releasing automatic, others affect the way primitives are drawn, for example, if the W3D_PERSPECTIVE state is active, triangles are drawn with perspective-corrected texture mapping.

States are set and cleared with a call to W3D_SetState. If the newstate argument equals W3D_ENABLE, the state is set. If it equals W3D_DISABLE, the state is reset. However, not every hardware supports every state. In order to find out what is supported, use the W3D_Query function (See

Context Queries

). Alternatively, you should check the return value of the W3D_SetState. If it returns W3D_SUCCESS, the state was successfully set or reset, otherwise this state cannot be enabled (or disabled, depending on the operation you attempted).

At the start of a program, when a context was created, all states are set to a well-defined initial state, with the exception of states that cannot be set to the desired value(1). To find out what states are set, use the W3D_GetState function. This function returns W3D_ENABLED if the state is active, and W3D_DISABLED otherwise.

Supported States

=====

The following summerizes the available states, as well as the default values that are set by W3D_CreateContext.

W3D_AUTOTEXMANAGEMENT

If this state is enabled, textures are automatically uploaded to the video memory as needed, and "old" textures are released if texture memory overflows. If disabled, the drawing functions return an error message when the texture supplied is not on the card. Unless you really need full control, there's really no reason to disable this. Enabled by default.

W3D_SYNCHRON

If disabled, any drawing function starts its operation and

immediately returns, without waiting for the operation to finish. Thus, the main CPU can work in parallel with the hardware and use the extra cycles for calculations and the triangle setup stage. If enabled, all drawing functions wait until the operation completed before returning(2). Disabled by default.

W3D_INDIRECT

If enabled, no drawing is done; rather, the primitive drawing functions are queued until one of three things happen: A W3D_Flush is called by the program, the buffer overflows, or the W3D_INDIRECT is reset. See the section on
Indirect Rendering
for further
details. Disabled by default.

W3D_TEXMAPPING

If enabled, the tex field of primitives are used to texture-map the primitive. If disabled, the current state of W3D_GOURAUD determines if the primitive will be gouraud-shaded or flat-shaded. Enabled if the hardware supports texture mapping.

W3D_PERSPECTIVE

If enabled, textures are drawn with perspective correction. Otherwise, the textures are drawn with linear mapping. The latter is faster, but will look worse. Disabled by default, unless the hardware does not support linear mapping.

W3D_GOURAUD

If enabled, and texture mapping is disabled, triangles are drawn with gouraud shading. Otherwise, flat shading is used. Enabled if the hardware supports gouraud shading.

W3D_ZBUFFER

If enabled, the ZBuffer is used for depth sorting/ZBuffering (See
ZBuffering
) . If disabled, pixels are always drawn, regardless of ZBuffer value. Disabled by default, unless the hardware won't do without it.

W3D_ZBUFFERUPDATE

If enabled, the Z value of incoming pixels is used to update the ZBuffer if the ZBuffering test succeeded (See
ZBuffering
) . If
disabled, does not update the ZBuffer. Enabled by default, unless the ZBuffer cannot be updated.

W3D_BLENDING

If enabled, Alpha Blending is turned on, and pixels are alpha-blended according to the current alpha blending mode. Otherwise, alpha blending is not performed. Disabled by default, unless it can't be disabled.

W3D_FOGGING

If enabled, fogging is turned on (See
Fogging

) . Otherwise, no fogging is done. Disabled by default, unless the hardware enforces the use of fogging.

W3D_ANTI_POINT

W3D_ANTI_LINE

W3D_ANTI_POLYGON

W3D_ANTI_FULLSCREEN

If any of these is enabled, the appropriate operation is anti-aliased. The W3D_ANTI_FULLSCREEN affects the complete screen. If one is disabled, then one of the other states might still be active. All are disabled by default, unless they can't be disabled.

W3D_DITHERING

If enabled, output is dithered using the default dithering method(3). Otherwise, pixels are written "as-is". Disabled by default, unless the hardware insists on dithering(4).

W3D_LOGICOP

If enabled, Logic operations are performed (See Logic Operations) according to the currently set logic operation. Otherwise, pixels are drawn normally. Disabled by default, unless it must be enabled.

W3D_STENCILBUFFER

If enabled, stencil buffering is performed (See Stencil Buffering) as specified by the stencil buffer mode. Otherwise, pixels are always written regardless of stencil values. Disabled by default, unless it can't be disabled.

W3D_DOUBLEHEIGHT

If enabled, the bitmap pointer passed in assumed to be a double-height bitmap for faked double buffering. The ZBuffer or Stencil Buffer will be allocated with half the height of this bitmap. If disabled, the bitmap is considered to be completely used for rendering. Disabled by default, unless the W3D_CC_DOUBLEHEIGHT tag item was specified on context creation.

Note: More states may be supported. Check the AutoDoc for a description of all states.

----- Footnotes -----

(1) For example, W3D_DITHERING cannot be disabled with the ViRGE driver

(2) The hardware driver will always wait for completion of the last operation before it writes any registers.

(3) Chances are this is Ordered Dithering

(4) The ViRGE does indeed

1.17 Warp3D_Devel/Drawing

Drawing

Starting to Draw

How to start, what to do

Locking

Locking and Unlocking the display

Coordinates

X/Y/Z and U/V/W

Triangles

The essentials on Triangles

Lines

Line Drawing

Points

Point Drawing

Fogging

Fog and Depth Cueing

Logic Operations

What the LogicOp stuff means

Stencil Buffering

Cookie Cutting

ZBuffering

Using the Z Buffer

Alpha Blending

Transparency and other stuff

Light

Lighting

1.18 Warp3D_Devel/Starting to Draw

Starting to Draw

=====

Let's now get to the most important part of Warp3D programming: Drawing. In order for the user or player to see anything, we must bring our expensively calculated 3D objects to the screen.

In spite of the name, Warp3D does not really do any 3D calculation. The coordinates passed in must be in so-called Screen Space, that is, they must have been projected and clipped so that they lie on screen, or rather, in the currently visible buffer. Under Picasso96 or CyberGraphX 3, you can use the ChangeScreenBuffer call for double buffering.

To define the area on which you want to draw, you must call the W3D_SetDrawRegion function. The bm parameter is a pointer to the bit map you want the driver to draw into, that is, it must be compatible with Warp3D (W3D_CreateContext checks this). The yoffset parameter indicates the vertical offset of the top left edge of the screen, and is used to do the double buffering under CyberGraphX V2.

Basically, both the ScrollVPort trick and the normal Kick 3.x double buffering functions can be used for double buffering under Warp3D. However, the latter method has the advantage that if you do want to do direct rendering with the processor, you do not need to add an offset to determine the correct buffer. Otherwise, both functions work equally good, and with comparable speed.

The scissor parameter is a pointer to a filled-in W3D_Scissor structure. This defines the area of the screen that drawing should be restricted to. It is generally a good idea to set this, even if you don't really intent to draw into s screen section only, as it protects the memory outside your drawing area. An example for this can be found in the WarpTest.c source file.

When the selected driver is a CPU driver, it might be more reasonable to specify a RAM-Buffers instead of a bitmap for drawing. To that end, Warp3D specifies a W3D_Bitmap structure. This can be used to pass such a pointer in the dest field upon creation of the context, with the help of the W3D_CC_W3DBM tag item. Refer to the Warp3D.h include file for further details.

1.19 Warp3D_Devel/Locking

Locking

=====

In order to be able to draw anything, you must first lock the hardware. This is done with a single call to W3D_LockHardware. This call grants exclusive access to the hardware. Unless the W3D_INDIRECT state is enabled, this call must precede any drawing operation. (see See

Indirect Rendering
for details about indirect rendering).

Locking ensures that the hardware is ready to draw, and also assures that the bitmap you want to draw to is residing in graphics memory.

This can result in a certain temporal overhead. Although this is not too much, you should not lock the hardware for every primitive, This tactic should only be used if time is very unimportant for your application, or otherwise a per-frame locking is not possible(1). In this case, it might be a better idea to use indirect rendering, as discussed in

Indirect Rendering

.

Certain constraints of the graphics subsystem also affect locking. For example, CyberGraphX might have severe difficulties when a lock is held for a certain time. However, you should generally try and lock only on a frame basis, i.e. you should lock your hardware, draw your stuff, and finally release the hardware.

Other strategies include locking for a certain time only. For example, if you can predict the amount of work required for an operation, you might predict the time for which you will hold the lock. However, such things are hard to implement, so the best bet is to lock the entire frame.

----- Footnotes -----

(1) This might be the case if you are porting a 3D-Engine from another platform, or use Warp3D as a rasterizer for a 3D-Graphics library

1.20 Warp3D_Devel/Coordinates

Coordinates

=====

Coordinates are passed to Warp3D as floating point numbers of type W3D_Float. This allows for sub-pixel accuracy, i.e. it avoids "jumping" polygons, and generally looks better than using integer coordinates (of course, your 3D engine must support this). For this reason, Warp3D only runs on systems with a floating point unit.

X and Y coordinates are screen coordinates, also called device coordinates, because they reference individual pixels on the display directly. They need not be passed in any particular order (i.e. clockwise/counterclockwise), although a certain direction is almost always imposed by the 3D engine.

The Z coordinate is the vertex depth coordinate, and is used primarily for Z Buffering (See

ZBuffering

). The Z value must be normalized to a value between 0 and 1, where one is the smallest depth (i.e. 0 is directly behind the glass of the monitor).

There has been much confusion on the meaning of the W coordinate. Traditionally, the W coordinate used to be the fourth component of a 3D

vector in a homogenous coordinate system. In such a system, a point in 3-space is represented as $v = (x \ y \ z \ w)$, and for projection, this is transformed as $v' = (x/w \ y/w \ z/w \ 1)$, but this is not what it stands for in Warp3D.

In Warp3D, the W coordinate is used as the inverse of the z coordinate, i.e. $w = 1/z$. The reason for this is that for texture mapping, the z value is not linear, but $1/z$ is(1). Note that the z value we are talking about here is the z value in camera or eye space, that is, before the perspective transformation took place. This is because with some approaches, the z coordinate is also perspective foreshortened, which is not what we want here. The W coordinate should generally be set to $w = \text{scale}/z$. The scale value can be any value, you should define it in a way that all W values in your engine fit into the area [0..1]. Or, in other words: if you multiply all W values in your engine by 2, the result will be the same (unless overflow or precision errors occur). Finally, the W value has no meaning as an absolute value, it only contains information when compared to the W values of other vertices. It is finally only used for transformations between linear and perspective space. (Note to OpenGL implementors: the correct value for W is the inverse of W in clip coordinate space, eventually scaled to achieve better precision). While it is desired to scale the W values into the range [0..1], it is possible to pass values outside this range, but it may result in a slight performance loss. Often, this is necessary, for example when the world starts close to 0, or if negative Z coordinate appear (OpenGL is very flexible here). Note that you must not pass negative W values. See the example source WarpTest.c for an example on how to do this.

The texture coordinates, U and V, are always given as pixel coordinates. This means that if you are using a 128x128 texture map, the upper left pixel is at (0,0), while the lower right is at (127,127). These values are floating point, so you may even specify subpixels.

Light or color "coordinates" are given in a range of [0..1], with 0 being lowest, and 1 highest intensity. These values should be clamped to the interval to avoid errors. Also, alpha values are given in the same range, with 1 being full opaque, and 0 translucent.

----- Footnotes -----

(1) This is quite easy to see, for example, the function $f(x) = 1/x$ is not linear, while $g(x) = 1/f(x)$ is the identity, which is linear.

1.21 Warp3D_Devel/Triangles

Triangles

=====

Triangle drawing is the most essential operation in 3D graphics. Usually, objects are represented using the so-called Polygon Boundary Representation, which means that the surface of the object is

represented as a series of polygons, which usually should be planar. Since Planarity can only be guaranteed for triangles, most 3D accelerators offer triangles as a drawing primitive.

Triangles are defined by three vertices at their corner. A vertex is specified using a `W3D_Vertex` structure. Basically, this structure defines the vertex screen coordinate, it's depth and texture space coordinate as well as the vertex color. The latter is used for gouraud shading, while the depth and texture space coordinates are used for Z-Buffering, texture mapping, and fogging.

Triangles are drawn with one of three functions. `W3D_DrawTriange` draws a single triangle specified by a `W3D_Triangle` structure. The advantage of this function is that it directly returns if `W3D_SYNCHRON` is not set, giving you extra time to do other stuff while the 3D chip is busy writing the triangle to the screen.

If you want to draw more than one triangle at once, it might be more advisable to use one of the other two functions. Those can actually draw polygons, although they expect the vertices of these polygons to be in sequence. The functions are called `W3D_DrawTriFan` and `W3D_DrawTriStrip`. Since they are very similar, they are discussed here together.

Both use a `W3D_Triangles` structure. This structure contains a pointer to the vertices that define the polygon. Texture information is extracted from the `tex` field in the `W3D_Triangles` structure. The `v` field points to an array of `W3D_Vertex` structures. These need not be specially terminated, so this can also be a slice of an array, the `vertexcount` field determines the number of edges your polygon has.

The difference between the functions is that `W3D_DrawTriFan` function draws a triangle fan, while the `W3D_DrawTriStrip` draws a triangle strip. For a detailed description about these, see the OpenGL Specification.

The following image shows the order in which vertices have to be specified in the `W3D_Triangles` structure:

(press this link to see the image)

1.22 Warp3D_Devel/Lines

Lines

=====

Lines are defined by their two endpoints. These are specified using `W3D_Vertex` structures, just like in the case with triangles (See

Triangles

). On some hardware, lines can be textures; in this case, the `tex` element of the `W3D_Line` structure is used.

If the driver supports arbitrary line widths, the `linewidth` element

can be used for this. If you do not want to use this feature, or if the current driver does not support this, you should still set the linewidth to 1.0, so that your code also works on other hardware.

Vertices (v1 and v2) are used the same way as with triangles, and this applies to all of the entries in the W3D_Vertex structure. Most notably, the z coordinate is still used for Z-Buffering (if enabled) and the w coordinate is also used for fogging (if enabled) and texturing (if supported/enabled). Colors are also taken into account.

To draw the line, you call the W3D_DrawLine function.

1.23 Warp3D_Devel/Points

Points

=====

Points only take one W3D_Vertex element. They may be textured, if the driver supports this. As with lines (See

Lines

), given the right

driver, you may specify the size of the point in the pointsize entry. This must be set to 1.0 if you just wish pixel-sized dots, even if the driver does not support arbitrary point sizes, so that your code works on other drivers too.

Points are drawn with a call to the W3D_DrawPoint function.

1.24 Warp3D_Devel/Fogging

Fogging

=====

Fogging is the process of blending an incoming pixel (i.e. a pixel that is about to be drawn) with a certain amount of a specified color, the fog color. The amount of color blending is determined by the incoming pixel's W coordinate and the current fog function.

Fogging is controlled by the W3D_SetFogParams function call and the W3D_FOGGING state. The state is controlled with the W3D_SetState function (See

Context States

).

To set the fogging parameters, you'll have to fill out a W3D_Fog structure. The fog_start and fog_end elements specify where the fog starts to gather up, and where it is so thick that pixels are only drawn in the fog color (specified in the fog_color field). The start

and end values are in W-Coordinates, meaning that a fog_start of 1.0 means the fog starts right behind the glass of the monitor. The fog_density field is only used with non-linear fog (see below).

The fogmode parameter in the W3D_SetFogParams function call specifies the type of fogging you want to use (the fog function). W3D_FOG_LINEAR means that the fog should ramp up from fog_start to fog_end. The W3D_FOG_EXP and W3D_FOG_EXP_2 are called exponential fogging and square exponential fogging respectively (also sometimes called non-linear fog modes). The exact formula is given in the OpenGL specification, and since Texinfo isn't that good at math formulas, I won't give it here.

1.25 Warp3D_Devel/Logic Operations

Logic Operations

=====

This chapter has not been written yet.

1.26 Warp3D_Devel/Stencil Buffering

Stencil Buffering

=====

Stencil buffering is covered extensively in the (guess where) OpenGL specification, so I will only briefly describe it here. It is not available in the ViRGE driver.

Like the Z Buffer (See ZBuffering), the Stencil Buffer is a buffer as large as the drawing area. Each incoming pixel is assigned a stencil value if stencil buffering is enabled. This value is compared against the value in the buffer, and depending on the outcome of this comparison, the pixel is either drawn or discarded. Furthermore, the stencil value of the frame buffer may be updated in a certain way, as specified in the stencil test operation. These operations include incrementing or decrementing the buffer value, setting it to zero, replace it with the incoming value, and so on.

Stencil buffering is used (among other things) to cookie-cut shapes from an image.

1.27 Warp3D_Devel/ZBuffering

ZBuffering

=====

ZBuffering (sometimes also called depth buffering) is a method for hidden surface removal. The ZBuffer itself is a buffer with the same size as the drawing area.

Theory of Operation

When a pixel is about to be drawn, it's Z value (which is taken from the vertex structure's Z value interpolated along the primitive) is compared against the current ZBuffer Z value using the current compare function. If the test fails, the pixel is discarded. If it succeeds, the pixel is drawn. After this, if ZBuffer updating is enabled, the Z value of the pixel overwrites the value in the ZBuffer only if the pixel was also drawn.

The following table summarizes the available Z Comparison functions, along with their meaning:

W3D_Z_NEVER

The comparison never passes, the pixel is always discarded.

W3D_Z_LESS

The comparison passes if the incoming Z value is less than the ZBuffer's value

W3D_Z_EQUAL

The comparison passes if the incoming Z value is greater or equal the ZBuffer's value

W3D_Z_LEQUAL

The comparison passes if the incoming Z value is less than or equal to the ZBuffer's value

W3D_Z_GREATER

The comparison passes if the incoming Z value is greater than the ZBuffer's value

W3D_Z_NOTEQUAL

The comparison passes if the incoming Z value is not equal to the ZBuffer's value

W3D_Z_EQUAL

The comparison passes if the incoming Z value is equal to the ZBuffer's value

W3D_Z_ALWAYS

The comparison always passes, the pixel is always drawn.

Using the ZBuffer

The comparison function is set using the `W3D_SetZCompareMode` function. The mode parameter must be a value from the above table. In this context, the `W3D_Z_LESS` comparison function is what usually is

understood as ZBuffering, meaning that pixels closer to the screen are drawn, while those further away are discarded. On the other hand, the W3D_Z_EQUAL or W3D_Z_NOTQUAL modes can be used as a kind of "poor mans stencil buffering".

In order to use the ZBuffer, it must have been allocated before. This is done with a single call to the function W3D_AllocZBuffer. This makes the ZBuffer available if the return value was W3D_SUCCESS. After you are done with it, it must be freed again with a call to W3D_FreeZBuffer.

In addition to the above, there are other functions to read and write to the ZBuffer. These are only explained here in brief, please refer to the appropriate AutoDocs for more details.

W3D_ClearZBuffer clears the ZBuffer with a specified value. This value must be in the range 0 through 1.

W3D_ReadZPixel and W3D_ReadZSpan read a single pixel or a number of pixels from the ZBuffer. The result is a single or an array of floats, all in range 0 through 1.

1.28 Warp3D_Devel/Alpha Blending

Alpha Blending

=====

Alpha Blending is a process where the color of a pixel to be drawn is blended with what is already in the frame buffer at this time. The way how each pixel affects the other is defined by the blend functions on a per-texture basis.

There are two blending functions, named source and destination mode. The source function affects the alpha of the current pixel to be drawn, while the destination function affects the framebuffer pixel. For example, a destination function of W3D_ONE completely ignored the alpha value of the framebuffer pixel (assumes it to be one, i.e. opaque) and just uses the alpha from the incoming pixel.

An alpha value of 1.0 means this pixel is completely opaque, or more mathematically, this pixel's weight is 1.0. The resulting color will be a weighed average of both pixels, a linear interpolation between both pixels with the interpolation factor being the calculated alpha value.

For a deeper discussion of alpha blending, consult the OpenGL specification.

1.29 Warp3D_Devel/Light

Light

=====

Gouraud shading is an algorithm for simulating lighting of a triangle. For Gouraud shading to work, only the normals at the vertices are needed to calculate the color values. Gouraud shading has some shortcomings, especially if compared with the more complex Phong shading. Most notably, it will never catch highlights that are not on a vertex(1). Moreover, it also never takes perspective into account.

Most modern 3D hardware support gouraud shading. Gouraud shading is used either for shading untextured triangles, or for "lighting" textured polygons.

On untextured triangles, the vertex colors are linearly interpolated over the triangle. The alternative to this is flat shading, where one color is used for the entire triangle.

On textured triangles, the vertex colors are also interpolated over the triangle, but depending on the environment mode selected for the texture, the light color is combined with the texture color.

There are currently four possible environment modes for textures. These are set with a single call to `W3D_SetTexEnv`. The possible mode are(2)

`W3D_REPLACE`

The texture color is used for the triangle. No lighting whatsoever is done

`W3D_DECAL`

The texture color is blended with the light color depending on the alpha value. This means the alpha value of the texture is used as a linear interpolation factor between texture and light color.

`W3D_MODULATE`

The texture color and light color are multiplied, and the result is used as the pixel color.

`W3D_BLEND`

This mode behave much like `W3D_MODULATE`, only that the specified envcolor is blended with the result.

----- Footnotes -----

(1) A relatively new algorithm named fence shading will catch those on edges too, but still not those that are completely inside the triangle

(2) The ViRGE only supports the first three modes, and the alpha for blending must be set to 1.0. Furthermore, `W3D_REPLACE` and `W3D_MODULATE` are treated equally

1.30 Warp3D_Devel/Hinting

Hinting

Hints are a means of controlling output quality of the Warp3D system without knowing the capability of the underlying hardware. Warp3D defines a number of categories and three different levels of quality. The function W3D_Hint is used to tell Warp3D what quality is desired for a certain category under the current context.

The following table summerizes the possible quality levels:

W3D_H_FAST

Use the fastest possible solution for this category, even if this means to downgrade the quality of output. Using this level might result in graphics glitches sometimes, but is always the fastest possible setting. This or the next mode should be used for games.

W3D_H_AVERAGE

Try to use a compromise between speed and quality.

W3D_H_NICE

With this setting, everything is optimized for maximum output quality, regardless of output speed. This mode is most suitable for interactive software that does not need all the possible speed, like modellers or some OpenGL applications.

Currently, Warp3D specifies the following categories for Hinting:

W3D_H_TEXMAPPING

Affects the quality of texture mapping.

W3D_H_MIPMAPPING

Affects the quality of mipmapping

W3D_H_BILIENARFILTER

Affects the quality of filtering. For example, there is a faster bilinear filter mode available on the ViRGE graphics processor (due to a bug, YUV textures are treated normally, but with a faster filter mode). The quality of this is a bit lower.

W3D_H_MMFILTER

Affects the quality of depth filtering

W3D_H_PERSPECTIVE

Affects the quality of perspective mapping. For example, the ViRGE processor has problems with wrapping in perspective mode, but the driver has the ability to subdivide triangles on texture wrap borders.

W3D_H_BLENDING

Affects the quality of alpha blending.

W3D_H_FOGGING

Affects the quality of fogging. For example, some graphics chips cannot have discontinuities in fogging, which means that when the fogging border is within the triangle drawn, the linear fog interpolation will not draw the triangle correctly. Again, some

drivers can subdivide the triangle to get this effect right.

W3D_H_ANTIALIASING

Affects the quality of anti-aliasing

W3D_H_DITHERING

Affects the quality of dithering. For example, some driver might be able to select ordered dithering or floyd-steinberg depending on this setting.

W3D_H_ZBUFFER

Affects the accuracy of the Z buffer, i.e. bit depth.

1.31 Warp3D_Devel/Indirect Rendering

Indirect Rendering

If the context was created with the W3D_CC_FAST tag set to W3D_TRUE, or the state W3D_FAST was set, Warp3D is in fast mode. This means that structures passed to the driver are not copied and may be modified.

In fast mode, locking the hardware is no longer necessary. All rendering calls are internally stored. Each time the queue is full, or certain functions are called, the queue is flushed (The same effect can be achieved with the W3D_Flush function).

The following table lists all functions that are queued:

- * W3D_DrawLine

- * W3D_DrawPoint

- * W3D_DrawTriangle

- * W3D_DrawTriFan

- * W3D_DrawTriStrip

- * W3D_ClearZBuffer

- * W3D_ClearStencilbuffer

- * W3D_SetCurrentColor

- * W3D_SetCurrentPen

- * W3D_Hint

These flush the queue:

- * All Stencil buffer functions except W3D_AllocStencilBuffer, and the functions that are queued.

 - * All ZBuffer functions, except W3D_AllocZBuffer, and the functions that are queued.
-

- * All functions that change the visual appearance of rendering, i.e. W3D_SetFogParams
- * All functions changing textures, i.e. W3D_UpdateTexImage

1.32 Warp3D_Devel/Indices

Indices

Concept Index
Index of concepts

Function Index
Index of functions

Type Index
Index of data-types

1.33 Warp3D_Devel/Concept Index

Concept Index

Camera Space
Coordinates

Context Queries
Context Queries

Context States
Context States

Coordinates
Coordinates

Creating a Context
Creating a Context

Creating MIP-Maps
MIP-Mapping

Creating Textures
Creating Textures

- Device Coordinates
 - Coordinates
- Eye Space
 - Coordinates
- Fogging
 - Fogging
- Getting Texture Information
 - Texture Infos
- How Textures are represented
 - Texture Images
- Introduction
 - Introduction
- Light Coordinates
 - Coordinates
- Lines
 - Lines
- Locking
 - Locking
- Making a Texture
 - Creating Textures
- MIP-Mapping
 - MIP-Mapping
- MIP-Maps <1>
 - Textures
- MIP-Maps
 - What is it
- Opening the Warp3D library
 - Opening the library
- Points
 - Points
- Querying Capabilities
 - Querying Capabilities
- Screen Coordinates
 - Coordinates
- States
 - Context States
- Texture <1>
 - Textures

- Texture
 - What is it
- Texture Creation
 - Creating Textures
- Texture Images
 - Texture Images
- Texture Mapping
 - What is it
- Texture Space
 - Coordinates
- Texture Storage
 - Texture Images
- Triangle Fan
 - Triangles
- Triangle Strip
 - Triangles
- Triangles
 - Triangles
- Using MIP-Maps
 - MIP-Mapping
- Using Textures
 - Using Textures
- ZBuffering
 - ZBuffering

1.34 Warp3D_Devel/Function Index

Function Index

- W3D_AllocTexObj <1>
 - Textures
- W3D_AllocTexObj
 - Creating Textures
- W3D_AllocZBuffer
 - ZBuffering

W3D_CheckDriver
Opening the library

W3D_ClearZBuffer
ZBuffering

W3D_CreateContext
Creating a Context

W3D_DrawLine
Lines

W3D_DrawPoint
Points

W3D_DrawTriangle
Triangles

W3D_DrawTriFand
Triangles

W3D_DrawTriStrip
Triangles

W3D_Flush
Indirect Rendering

W3D_FlushTextures
Using Textures

W3D_FreeTexObj <1>
Textures

W3D_FreeTexObj <2>
Using Textures

W3D_FreeTexObj
Creating Textures

W3D_FreeZBuffer
ZBuffering

W3D_GetDestFmt
Opening the display

W3D_GetDrivers
Querying Capabilities

W3D_GetState
Context States

W3D_GetTexFmtInfo
Texture Infos

W3D_LockHardware
Locking

W3D_Query <1>
 Querying Capabilities

W3D_Query
 Context Queries

W3D_QueryDriver
 Querying Capabilities

W3D_ReadZPixel
 ZBuffering

W3D_ReadZSpan
 ZBuffering

W3D_ReleaseTexture
 Using Textures

W3D_SetFogParams
 Fogging

W3D_SetState
 Context States

W3D_SetZCompareMode
 ZBuffering

W3D_UnLockHardware
 Locking

W3D_UpdateTexImage
 Using Textures

W3D_UpdateTexSubImage
 Using Textures

W3D_UploadTexture <1>
 Using Textures

W3D_UploadTexture
 Textures

1.35 Warp3D_Devel/Type Index

Type Index

W3D_ANTI_FULLSCREEN
 Context States

W3D_ANTI_LINE
Context States

W3D_ANTI_POINT
Context States

W3D_ANTI_POLYGON
Context States

W3D_AUTOTEXMANAGEMENT
Context States

W3D_BLENDING
Context States

W3D_Context <1>
Creating a Context

W3D_Context
Context Queries

W3D_DITHERING
Context States

W3D_FOGGING
Context States

W3D_GOURAUD
Context States

W3D_LOGICOP
Context States

W3D_PERSPECTIVE
Context States

W3D_STENCILBUFFER
Context States

W3D_SYNCHRON
Context States

W3D_TEXMAPPING
Context States

W3D_Texture <1>
Creating Textures

W3D_Texture <2>
What is it

W3D_Texture
Textures

W3D_ZBUFFER
Context States

W3D_ZBUFFERUPDATE
Context States