

## Second Printing Corrections for 3DGEA.

The old book text is typeset in the color red. The new book text is typeset in the color blue.

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Page (Series). Change **Magic Software, Inc.** to **Geometric Tools, Inc.**

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Page (Title). Change **Magic Software, Inc.** to **Geometric Tools, Inc.**

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Page (About the Author). Change **Magic Software, Inc. ([www.magic-software.com](http://www.magic-software.com))** to **Geometric Tools, Inc. ([www.geometrictools.com](http://www.geometrictools.com))**. Change **then later to Magic Software, Inc.** to **then** to **Magic Software, Inc., which later became Geometric Tools, Inc.**

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Page (Table of Contents). Section 8.3.2 is now named **Maya and Max Exporters**.

---

Page 3. The directory name needs modification. Change

**MagicSoftware**/WildMagic3/BookFigures/DrawTriangle/DrawTriangle.cpp

to

**GeometricTools**/WildMagic3/BookFigures/DrawTriangle/DrawTriangle.cpp

---

Page 15. The displayed equations for rotation about up have **D'** and **R'** swapped on the first pairs of assignments. In the first displayed pair near the top of the page, change

$$\begin{aligned}\mathbf{D}' &\leftarrow \cos \theta \mathbf{R} + \sin \theta \mathbf{D} \\ \mathbf{R}' &\leftarrow -\sin \theta \mathbf{R} + \cos \theta \mathbf{D}\end{aligned}$$

to

$$\begin{aligned}\mathbf{R}' &\leftarrow \cos \theta \mathbf{R} + \sin \theta \mathbf{D} \\ \mathbf{D}' &\leftarrow -\sin \theta \mathbf{R} + \cos \theta \mathbf{D}\end{aligned}$$

In the second displayed pair near the bottom of the page, change

$$\begin{aligned}\mathbf{D}' &\leftarrow \cos \theta \mathbf{R} - \sin \theta \mathbf{D} \\ \mathbf{R}' &\leftarrow \sin \theta \mathbf{R} + \cos \theta \mathbf{D}\end{aligned}$$

to

$$\begin{aligned}\mathbf{R}' &\leftarrow \cos \theta \mathbf{R} - \sin \theta \mathbf{D} \\ \mathbf{D}' &\leftarrow \sin \theta \mathbf{R} + \cos \theta \mathbf{D}\end{aligned}$$

---

Page 17. The directory name needs modification. Change

`MagicSoftware/WildMagic3/BookFigures/DrawMesh/DrawMesh.cpp`

to

`GeometricTools/WildMagic3/BookFigures/DrawMesh/DrawMesh.cpp`

---

Page 27. Grammar. The first paragraph has the phrase `each other` (implying two) when it should be `one another` (implying more than two).

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Page 32. Grammar. Line 3 from the top of the page has “Each vertex `needs`” but should be “Each vertex `needed`”.

---

Page 35. Grammar. The phrase “different `than`” should be “different `from`”.

---

Page 42. Grammar. Line 2 from the bottom of the page has “just like TArray `does`” but is better written as “just like TArray `uses`”.

---

Page 45. The first paragraph of Section 2.1.2 has `Wm3System.{h,inl,cpp}` but should be modified to `Wm3Platform.h` and `Wm3System.{h,inl,cpp}`. The paragraph after this change must be rewritten to the following:

It is nearly impossible not to expose a small amount of platform-specific information to the engine and applications. The platform header file has conditional defines structured as shown next:

```
#if defined(MINGW)
    <items specific to the g++ compiler on the PC>
#elif defined(WIN32)
    <items specific to the Microsoft Windows platform>
#elif defined(__APPLE__)
    <items specific to the Macintosh OS X platform>
#else
    <items specific to the Linux or Unix platforms>
#endif
```

On a given platform, the appropriate preprocessor symbol is defined to give access to platform-specific information. Currently the platforms include a PC with Microsoft Windows 2000/XP, a Macintosh running Mac OS X, and a PC with some variant of Linux.

---

Page 46. The item `--MACOS--` should be replaced by the item `--APPLE--`.

---

Page 47. Section 2.1.4 needs to be rewritten to the following:

Many applications need to keep track of time, whether for sequencing purposes or for simulation. The standard programming libraries provide functions to manage a 32-bit clock, but access to the clock may vary from platform to platform. The details must be encapsulated to hide the dependencies from the application layer. The `System` member function to support this is

```
class System
{
public:
    static double GetTime ();
};
```

The returned double-precision number is 64 bits, but was constructed from integer values accessed through standard function calls. On a computer running Microsoft Windows, Linux, or Unix, the function used to access the system clock is `ftime`. On a Macintosh computer, the functions used to access the system clock are `gettimeofday` and `timersub`.

It is possible to reimplement `System::GetTime` to access a 64-bit clock. For example, on a Microsoft Windows system, you could use the operating system type `LARGE_INTEGER` that represents a 64-bit integer. The platform-dependent functions `QueryPerformanceFrequency` and `QueryPerformanceCounter` are used to create a 64-bit value representing the current time.

---

Page 48. Grammar. The phrase “different `than`” should be “different `from`”. Two occurrences on this page.

---

Page 49. I have two paragraphs highlighted with “INSERT NEW TEXT”. All I need is another sentence appended to these paragraphs:

The main client of the `System` file operations is class `Stream`. However, the file operations are simple to use in other situations as they arise. These operations include reading and writing values to preserve or modify the byte order (little endian or big endian).

---

Page 49. The pseudocode has

```
int* aaiArray = new Type[iNumRows];
```

but should be

```
int** aaiArray = new int*[iNumRows];
```

---

Page 50. The pseudocode has

```
int* aaiArray = new int*[iNumRows];
```

but should be

```
int** aaiArray = new int*[iNumRows];
```

---

Page 51. The number of calls to new or delete is listed as  $S(R + 1)$ . This should be  $S(R + 1) + 1$ . Two occurrences of the change.

---

Page 53-54. Section 2.2.1 needs most of a paragraph rewritten as follows:

Support is provided for the basic mathematics functions found in the standard C/C++ library, both for `float` and `double`. Rather than duplicate code, templates are used where the template parameter is the type of floating-point number. The template code is found in the files `Wm3Math.h`, `inl` and is automatically instantiated. The static data members need to be *explicitly instantiated* in the file `Wm3Math.cpp`. Template code itself may be explicitly instantiated, but not all compilers agree on the syntax for doing so. Some require the static data to be instantiated before the template class is instantiated while others require the static data to be instantiated after the template class is instantiated. The file `Wm3Platforms.h` contains preprocessor macros to control the order of instantiation.

---

Page 56. Change the first displayed equation from

```
#define PI 3.141259
```

to

```
#define PI 3.14159
```

Change the second displayed equation from

```
#define PI 3.14126
```

to

```
#define PI 3.1416
```

---

Page 63. The next to last line of pseudocode is the keyword `virtual`. This must be deleted.

---

Page 68. Grammar. The first line of the subsection **Member Access** has “All classes `provided`” but should be “All classes `provide`”.

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Page 71. The pseudocode for `Vector2` has `Kross` which should be `DotPerp`.

---

Page 71. The first sentence after the pseudocode has “Given a `vector (x, y)`”. Change this to “Given a `nonzero vector (x, y)`”.

---

Page 72. The first sentence of the last paragraph is better written as

Given two nonzero and nonparallel vectors  $\mathbf{V}_0 = (x_0, y_0)$  and  $\mathbf{V}_1 = (x_1, y_1)$ , we may compute from these two unit-length and perpendicular vectors, call them  $\mathbf{U}_0$  and  $\mathbf{U}_1$ .

---

Page 74. The last sentence of the last paragraph is better written as “In order to be numerically robust, the component of largest absolute magnitude is never chosen to be the one that is zeroed out.”

---

Page 75. Spelling. The comment in the top block of pseudocode has `larges-magnitude` but should have `largest-magnitude`.

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Page 76. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 83. Two problems. First, the function names occur as **atan 2**, which has a space between the ‘n’ and the ‘2’. The space should not be there, **atan2**. Second, the arguments are swapped on the right-hand side. The correctly typeset equation should be

$$\theta = \text{atan2}(\sin \theta, \cos \theta) = \text{atan2}(r_{10}, r_{00})$$

---

Page 85. The list of member functions should include another one:

```
void FromAxisAngle (const Vector3<Real>& rkAxis, Real fAngle);
```

This should be inserted *after* `ToAxisAngle` and *before* `Orthonormalize`. I have highlighted the location on the book page.

---

Page 86. The change on page 85 requires a description of the newly added function, potentially causing page reflow problems. Here is my rewrite which attempts to avoid the problems. If the reflow occurs, let me know and I can attempt to modify again. I have highlighted three displayed equations on the book page. These do not have to be displayed. Also, one sentence is highlighted and needs to contain some more text. The text shown next illustrates how I think the retypesetting should go.

The method `Matrix3::ToAxisAngle` requires the matrix to be a rotation and extracts an axis and angle of rotation. The axis direction is unit length. The extraction is based on Equation (2.12). Some algebra will show that  $\cos(\theta) = (\text{Trace}(R) - 1)/2$ , where  $\text{Trace}(R)$  is the *trace* of the matrix  $R$ , the sum of the diagonal entries of  $R$ . This allows us to obtain the rotation angle  $\theta = \arccos((\text{Trace}(R) - 1)/2)$ . Also,  $R - R^T = 2 \sin(\theta)S$ , where  $S$  is formed from the rotation axis components  $(w_0, w_1, w_2)$ . As long as  $\theta$  is not a multiple of  $\pi$ , we may solve for  $w_0 = (r_{21} - r_{12})/(2 \sin(\theta))$ ,  $w_1 = (r_{02} - r_{20})/(2 \sin(\theta))$ ,  $w_2 = (r_{10} - r_{01})/(2 \sin(\theta))$ , where  $R = [r_{ij}]$ . If  $\theta = 0$ , the rotation matrix is the identity, and any choice of axis will do. My choice is  $(1, 0, 0)$ . If  $\theta = \pi$ ,  $R - R^T = 0$ , which prevents us from extracting the axis from  $S$ . Observe that  $R = I + 2S^2$ , so  $S^2 = (R - I)/2$ . The diagonal entries of  $S^2$  are  $w_0^2 - 1$ ,  $w_1^2 - 1$ , and  $w_2^2 - 1$ . We can solve these for the axis direction  $(w_0, w_1, w_2)$ . Because the angle is  $\pi$ , it does not matter which sign you choose for the square roots.

The method `Matrix3::FromAxisAngle` requires the input vector to be unit length and constructs the rotation matrix  $R$  using the identity  $R = I + (\sin \theta)S + (1 - \cos \theta)S^2$ , where  $I$  is the identity matrix and  $S = [s_{ij}]$  is a skew-symmetric matrix. If the axis vector is  $(w_0, w_1, w_2)$ , then  $s_{00} = s_{11} = s_{22} = 0$ ,  $s_{10} = -s_{01} = w_2$ ,  $s_{02} = -s_{20} = w_1$ , and  $s_{21} = -s_{12} = w_0$ .

The method `Matrix3::Orthonormalize` requires the matrix to be a rotation and applies Gram-Schmidt orthonormalization to its columns. See the discussion earlier regarding this operation applied to 2D rotation matrices and to vectors in 3D.

The discussion of eigendecomposition for  $2 \times 2$  symmetric matrices also covers  $3 \times 3$  symmetric matrices and  $N \times N$  matrices in general. The function `Matrix3::EigenDecomposition` does the decomposition for  $3 \times 3$  matrices.

The next discussion is about the methods `Matrix3::FromEulerAnglesUVW` and `Matrix3::ToEulerAnglesUVW`, where UVW is either XYZ, XZY, YXZ, YZX, ZXY, or ZYX. A popular topic for representations of rotation matrices is *Euler angles*. The idea is to represent a rotation matrix as a product of rotation matrices corresponding to the coordinate axes. For example,  $R = R_x(\alpha)R_y(\beta)R_z(\gamma)$

The remainder of page 86 remains as is.

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Page 103. The highlighted portion of the page needs a new sentence.

three points on the plane. The caller of the last constructor is responsible for ensuring that the three points are not collinear. The unit-length normal vector computed in the constructor is  $\mathbf{N} = (\mathbf{E}_1 \times \mathbf{E}_2) / |\mathbf{E}_1 \times \mathbf{E}_2|$ , where  $\mathbf{E}_1 = \mathbf{P}_1 - \mathbf{P}_0$  and  $\mathbf{E}_2 = \mathbf{P}_2 - \mathbf{P}_0$ .

---

Page 104. The last sentence before the **ColorRGBA** subsection should have additional text:

The maximum channel is found and all channels are divided by it *as long as it is not zero*.

---

Page 107. Rewrite the sentence:

The member function `IsDerived` checks to see if the caller RTTI object has the same type as the input RTTI object or if a class from which the caller RTTI object is derived has the same type as the input RTTI object.

---

Page 119. The top-most block of pseudocode has `spNode` but should have `spkNode`. The first sentence after the top-most pseudocode block has *would work just fine* but should have *is allowed by the compiler*. The second block of pseudocode should be

```
NodePtr spkNode = <some node in scene graph>;
NodePtr spkChild = new Node;           // ‘new Node’ references = 1
spkNode->AttachChild(spkChild);       // ‘new Node’ references = 2
spkChild = NULL;                       // ‘new Node’ references = 1
```

---

Page 140. The second occurrence of `Matrix2` in the pseudocode needs to be `MyClass`.

---

Page 142. Grammar. The first line of text after the top pseudocode block has “and simply notice” but should have “and will simply notice”.

---

Page 151. Grammar. The phrase “different than” should be “different from”.

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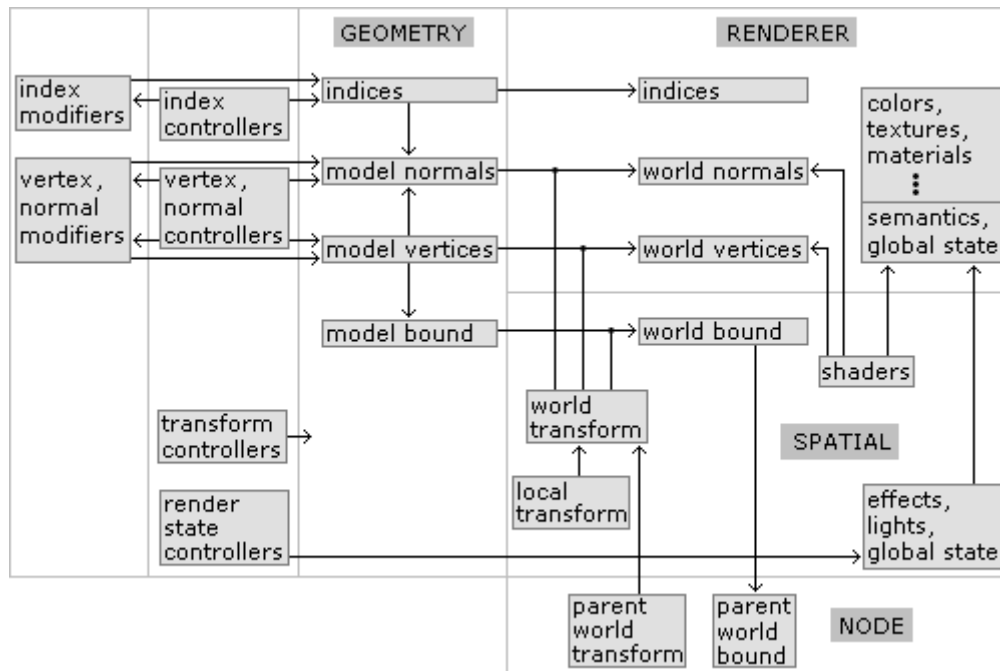
Page 151. Grammar. The footnote has “Game Developer’s Conference” but should have no apostrophe, “Game Developers Conference”.

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Page 152. The paragraph describing Section 3.1 has a 4-to-5 mapping of terms. The sentence has “which correspond to spatial decomposition, transformation, grouping” but should have “which correspond to spatial decomposition and transformation, grouping”.

---

Page 153. Figure 3.1 needs to be modified. The box with “Model scale” should be removed. The dotted box should be removed. Here is the modified figure:





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Page 156. Grammar. In the first paragraph, a colon should be placed after Wild Magic.

---

Page 157. Grammar. The phrase **each other** (implying two) should be **one another** (implying more than two).

---

Page 158. Grammar. The end of the paragraph before the subsection **Controllers and Modifiers** has the phrase “onto **the** plane” but should have “onto **a** plane”.

---

Page 160. The first paragraph has “**We could easily make all these Spatial objects, but not Geometry objects.**”, which does not convey what I wanted to say. The sentence should be replaced by “**For Room 1 to be a Geometry object, it would have to store all the geometric data for the table, chair, plate, knife, and fork. Since a Geometry object has a single world transformation, all geometric data must be transformed as a whole. Thus, the individual objects can only be moved locally by modifying the geometric data itself, which is an expensive operation when the objects have large numbers of vertices.**” If you need to make Figure 3.3 smaller to gain more space, feel free to do so.

---

Page 163. Grammar. The middle of the page has “onto the return value, **it is a smart pointer, in which case the reference**”. Better is “onto the return value (**a smart pointer**), the reference”.

---

Page 164. The bottom of the page has “**If you have any plans to** make the world”. The antecedent of “they”, which occurs later, is not clear. Instead use “**To** make the world”.

---

Page 168. Grammar. The top of the page has “three **less** multiplications” but should be “three **fewer** multiplications”.

---

Page 168. The highlighted sentence should be rewritten.

The three divisions in  $(x/\sigma_0, y/\sigma_1, z/\sigma_2) = (x', y', z')$  may be avoided by instead computing  $a = \sigma_0\sigma_1$ ,  $p = a\sigma_2$ ,  $r = 1/p$ ,  $q = r\sigma_2$ ,  $x' = q\sigma_1x$ ,  $y' = q\sigma_0y$ , and  $z' = raz$ . The three divisions cost  $3\delta$  cycles, but the alternative costs only  $9\mu + \delta$  cycles.

To make space, the two displayed equations at the bottom of the page may be placed inline.

what regularly in the Usenet computer graphics group is how to factor  $M = RS$ , where  $R$  is ...

and

The polar decomposition is  $M = UA$ , ...

---

Page 169. The term  $19\mu$  should be  $18\mu$ .

---

Page 170. The first highlighted text is **Geometry class** but should be **leaf nodes**. The second highlighted text is **in the Geometry class** but should be **at the leaf nodes**.

---

Page 170. In the highlighted place, insert the sentence “**In fact, the leaf nodes may be assigned a general matrix instead of a rotation matrix and nonuniform scales.**”

---

Page 171. The pseudocode at the top of the page has two highlighted lines. The first highlighted line should be instead

```
Matrix3f m_kMatrix;
```

and the second highlighted line should be instead

```
bool m_bIsIdentity, m_bIsRSMMatrix, m_bIsUniformScale;
```

---

Page 171. Replace “**The rotation matrix is stored as a  $3 \times 3$  matrix. The user is responsible for ensuring that the matrix really is a rotation.**” by “**The matrix represents a rotation or a general transformation.**”

---

Page 171. Change “The class has **two** additional data members, **both** Boolean variables.” to “The class has **three** additional data members, **all** Boolean variables.”

---

Page 171. I have highlighted arrow heads pointing to a location in which the following text should be inserted. That is, it is inserted after “of transformations.” and before “The default”. The sentence is “**The m\_bIsIdentity hint is set to true when the transformation is the identity. The m\_bIsRSMMatrix is set to true when m\_kMatrix is a rotation matrix and m\_kScale contains nonuniform scales. The m\_bIsUniformScale hint is set to true when the components of m\_kScale have a common value.**”

---

Page 171. Change “**The m\_bIsIdentity and m\_bIsUniformScale hints are both set to true.**” to “**The m\_bIsIdentity, m\_bIsRSMMatrix, and m\_bIsUniformScale hints are all set to true.**”

---

Page 171. The last block of pseudocode should be modified to include two new lines of code. The location is highlighted on the book page.

```
void SetMatrix (const Matrix3f& rkMatrix);
const Matrix3f& GetMatrix () const;
```

---

Page 171. At the bottom of the page, new sentences need to be inserted before the highlighted sentence “The `Get` functions have”. The new sentences are “The `SetRotate` function sets the `m_bIsRSMMatrix` hint to `true`. If the hint is `false` when `GetRotate` is called, an assertion is triggered. The `SetMatrix` function sets the `m_bIsRSMMatrix` and `m_bIsUniformScale` hints to `false`.”

---

Page 172-173. This needs a significant rewrite because my actual source code changed since the first printing of the book. If my rewrite does not take up enough space to avoid page reflow, let me know and I will try to modify it to fill the space. The pages 172 and 173 have highlighting indicating the start and end for the material to be replaced by what follows next here.

A public accessor function is provided for the convenience of determining the maximum scale associated with a transformation:

```
class Transformation
{
public:
    float GetNorm () const;
};
```

If the matrix is of the form  $M = RS$ , where  $R$  is a rotation and  $S$  is a diagonal matrix representing the scales, then `GetNorm` returns the largest magnitude scale from  $S$ . That is, if  $S = \text{Diagonal}(\sigma_0, \sigma_1, \sigma_2)$ , then `GetNorm` returns  $\max\{|\sigma_0|, |\sigma_1|, |\sigma_2|\}$ . If  $M$  is a general matrix, then `GetNorm` returns the largest sum of absolute values of column entries. That is, if  $M = [m_{rc}]$  for  $0 \leq r \leq 2$  and  $0 \leq c \leq 2$ , then `GetNorm` returns

$$\max\{|m_{00}| + |m_{10}| + |m_{20}|, |m_{01}| + |m_{11}| + |m_{21}|, |m_{02}| + |m_{12}| + |m_{22}|\}.$$

Given two matrices  $R$  and  $S$ , a matrix norm  $\|\cdot\|$  generally satisfies the inequality  $\|RS\| \leq \|R\|\|S\|$ , but equality does not have to happen. Thus, it is not necessarily the case that  $\|RS\|$  is equal to  $\|S\|$ , so multiplying  $R$  and  $S$  first before computing the norm is not guaranteed to give you the same number as the largest magnitude scale. However, the engine uses the matrix norm only to transform a bounding sphere to obtain another bounding sphere. A nonuniform scaling of a sphere produces an ellipsoid, but the engine has no capability to use ellipsoids as bounding volumes. I use the norm as a uniform scale factor to transform the sphere’s radius.

---

Page 173. In the top-most block of pseudocode, another function must be added.

```
bool IsRSMatrix () const;
```

This is to be inserted between the `IsIdentity` and `IsUniformScale` functions. In the sentence immediately following the pseudocode, change “The last **two** functions” to “The last three functions”.

---

Page 175. Change the highlighted text to the following.

and translation  $-S^{-1}R^T\mathbf{T}$ , all stored by `rkInverse`. If you were to use `rkInverse` to transform a point  $\mathbf{Y}$ , the result would be

$$\mathbf{X} = R^T S^{-1} \mathbf{Y} - S^{-1} R^T \mathbf{T}$$

which is not correct. The storage that `rkInverse` provides is for convenience only. Call the `Inverse` function, access the individual components of `rkInverse`, and then discard `rkInverse`.

---

Page 176. The middle block of pseudocode should be replaced by

```
Vector3f Transformation::ApplyForward (
    const Vector3f& rkInput)
{
    if ( m_bIsIdentity )
    {
        // Y = X
        return rkInput;
    }

    if ( m_bIsRSMMatrix )
    {
        // Y = R*S*X + T
        Vector3f kOutput(
            m_kScale.X()*rkInput.X(),
            m_kScale.Y()*rkInput.Y(),
            m_kScale.Z()*rkInput.Z());
        kOutput = m_kMatrix*kOutput + m_kTranslate;
        return kOutput;
    }

    // Y = M*X + T
    Vector3f kOutput = m_kMatrix*rkInput + m_kTranslate;
    return kOutput;
}
```

---

Page 176-177. The block of pseudocode starting at the bottom of page 176 and continuing onto page 177 should be replaced by

```
Vector3f Transformation::ApplyInverse (
    const Vector3f& rkInput) const
{
    if ( m_bIsIdentity )
    {
        // X = Y
        return rkInput;
    }

    Vector3f kOutput = rkInput - m_kTranslate;
    if ( m_bIsRSMMatrix )
    {
        //  $X = S^{-1} * R^t * (Y - T)$ 
        kOutput = kOutput * m_kMatrix;
        if ( m_bIsUniformScale )
        {
            kOutput /= GetUniformScale();
        }
        else
        {
            float fSXY = m_kScale.X() * m_kScale.Y();
            float fSXYZ = fSXY * m_kScale.Z();
            float fInvSXYZ = 1.0f / fSXYZ;
            float fInvSXY = fInvSXYZ * m_kScale.Z();
            kOutput.X() *= fInvSXY * m_kScale.Y();
            kOutput.Y() *= fInvSXY * m_kScale.X();
            kOutput.Z() *= fInvSXYZ * fSXY;
        }
    }
    else
    {
        //  $X = M^{-1} * (Y - T)$ 
        kOutput = m_kMatrix.Inverse() * kOutput;
    }

    return kOutput;
}
```

---

Page 178. Grammar. At the end of the second paragraph, replace **sphere** by **sphere's**.

---

Page 181-182. A rewrite is needed for the material highlighted between the start and end labels.

At the lowest level, you need to know *where* a bounding volume is located (*center*) and what its *size* is (*radius*). The abstract interface provides set and get accessors for these values. The actual values of the center and radius depend on the type of bounding volume. The center and radius for a sphere are as you expect. The values for an oriented bounding box are naturally the box center and the maximum distance from the center to a vertex. The values for a convex polyhedron may be selected as the average of the vertices and the maximum distance from that average to any vertex. Other types of bounding volumes can define center and radius similarly.

The abstract class is `BoundingBox` and has the following initial skeleton:

```
class BoundingBox : public Object
{
public:
    virtual ~BoundingBox ();

    virtual void SetCenter (const Vector3f& rkCenter) = 0;
    virtual void SetRadius (float fRadius) = 0;
    virtual Vector3f GetCenter () const = 0;
    virtual float GetRadius () const = 0;

    static BoundingBox* Create ();

protected:
    BoundingBox ();
};
```

The constructor is protected and the set and get accessors are pure virtual functions, so the class is abstract.

---

Page 183. The pseudocode block at the top of the page needs another function inserted where the highlighting indicates.

```
virtual bool Contains (const Vector3f& rkPoint) const = 0;
```

---

Page 183. The phrase “The last two member functions, `CopyFrom` and `GrowToContain`,” should be changed to “The member functions `CopyFrom` and `GrowToContain`”.

---

Page 183-184. The last sentence on page 183 and the first sentence on page 184 need to be rewritten as

For a node with multiple children, `CopyFrom` makes a copy of the bounding volume of the first nonnull child, and `GrowToContain` creates a bounding volume that contains that copy as well as the bounding volume of the second nonnull child. The resulting bounding volume is grown further to contain each of the remaining nonnull children.

---

Page 184. A new paragraph should be added before the one starting with “A brief warning”. It is

The member function `Contains` is a simple test whether the input point is inside the bounding volume.

---

Page 184. The highlighted sentences in the paragraph starting with “A brief warning” are rewritten to make space for the new paragraph that is listed in the next change item.

It is possible to extend the bounding volume system to handle mixed types. Each bounding volume pair requires you to implement a test-intersection query function. The semantics of `CopyFrom` must change. How do you copy a bounding sphere to an oriented bounding box? The semantics of `GrowToContain` must also change. If you have a sphere and a box, should the containing volume be a sphere or a box? I chose to limit the complexity of Wild Magic by disallowing mixing of bounding volume types.



---

Page 184. Insert a new paragraph just before Section 3.2.3.

Another warning is that the merging of bounding volumes two at a time is a greedy algorithm. The final bounding volume is not usually optimal, leading to less precise culling. A joint merge of bounding volumes will usually produce a better fit, but the run-time cost of a joint merge is typically more than that for a greedy algorithm. This is a trade off you will need to consider when designing a hierarchical culling system.

If you need more space to fit these changes on the page, modify

```
class Spatial : public Object
{
public:
    Transformation Local;
    Transformation World;
    bool WorldIsCurrent;

    BoundingBoxPtr WorldBound;
    bool WorldBoundIsCurrent;
};
```

to

```
class Spatial : public Object
{
public:
    Transformation Local, World;
    bool WorldIsCurrent, WorldBoundIsCurrent;
    BoundingBoxPtr WorldBound;
};
```

---

Page 187. Change `void UpdateMS ();` to `void UpdateMS (bool bUpdateNormals);`

---

Page 190. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 193. The second line of text after the pseudocode has “set WorldBoundIsCurrent to **false**” but should have “set WorldBoundIsCurrent to **true**”.

---

Page 194. Grammar. The first sentence has **smallest volume of two spheres**. Clearer is **smallest-volume sphere containing two spheres**.

---

Page 196. The last paragraph has a sentence ending with “by at most two **lines**” but should end with “by at most two **line segments**”.

---

Page 197. At the end of the first paragraph, append **The enumerant `GT_POLYLINE_CLOSED` is used for a line loop.**”

---

Page 198. In the middle of the page, the sentence starting with “If it is **not**, no reallocation” should be rewritten as “If it is **larger**, no reallocation”.

---

Page 200. Grammar. The phrase **smaller or equal to** should be **smaller than or equal to**.

---

Page 201. The constructor for `TriMesh` has a new parameter. Change the highlighted line

```
bool bGenerateNormals);
```

to

```
bool bGenerateNormals, bool bCachedNormals);
```

---

Page 201. The paragraph starting with “The constructor” should have a sentence appended: **The fourth parameter specifies whether the normals should be stored for caching in VRAM.**

---

Page 203. Grammar. The sentence ending with “is **one**” should end with “is **1**” since I am referring to the numerical value assigned to a variable.

---

Page 203. The sentence immediately before Section 3.4 has “active quantity of **end points**”. This should be “active quantity of **particles**”.

---

Page 203. Grammar. The phrase **smaller or equal to** should be **smaller than or equal to**.

---

Page 208. The first displayed equation should be

$$\begin{aligned}(r_f, g_f, b_f) &= a_s(r_s, g_s, b_s) + (1 - a_s)(r_d, g_d, b_d) \\ &= (a_s r_s + (1 - a_s) r_d, a_s g_s + (1 - a_s) g_d, a_s b_s + (1 - a_s) b_d)\end{aligned}$$

The second displayed equation should be

$$a_f = a_s a_s + (1 - a_s) a_d$$

---

Page 209. The first displayed equation should be

$$\begin{aligned}(r_f, g_f, b_f, a_f) &= (a_s r_s + (1 - a_s) r_d, a_s g_s + (1 - a_s) g_d, \\ &\quad a_s b_s + (1 - a_s) b_d, a_s a_s + (1 - a_s) a_d)\end{aligned}$$

---

Page 211. Modify “The default constructor for `AlphaState` sets `SrcBlend` and `DstBlend`, so only” to “The default constructor for `AlphaState` sets `SrcBlend` and `DstBlend`, as shown in the previous pseudocode, so only”.

---

Page 214. Grammar. The sentence “Consider if you did not do this.” is better written as “Consider [what would happen](#) if you did not do this.”

---

Page 217. The final sentence of the first paragraph has “Fog is applied after transformations, lighting, and texturing are performed, [so such objects are affected by the inclusion of fog](#).”. Change it to “Fog is applied after transformations, lighting, and texturing are performed [on objects](#).”

---

Page 218. The first displayed equation has the color coefficients swapped. It should be

$$(r_2, g_2, b_2, a_2) = (1 - f)(r_0, g_0, b_0, a_0) + f(r_1, g_1, b_1, a_1)$$

---

Page 218. The fragment “where [z is the depth measured from the camera position to the vertex or pixel location](#).” should be “where  $z = \mathbf{D} \cdot (\mathbf{P} - \mathbf{E})$  for camera origin  $\mathbf{E}$ , camera view direction  $\mathbf{D}$ , and vertex or pixel location  $\mathbf{P}$ .”

---

Page 218. The paragraph ending with “its value is irrelevant.” should have a sentence appended: [The z values may be outside the interval \[Start,End\], in which case the fog factor is clamped to \[0, 1\].](#)”

---

Page 219. The sentence starting with “If the mesh is closed, the triangles can **still be partitioned into two subsets**” should be changed to “If the mesh is closed, the triangles can **always be partitioned into two nonempty subsets**”.

---

Page 227. For clarification, insert another sentence after “The spot light angle ... cone of the light.” The new sentence is **This angle is measured from the axis of the cone to the cone surface.**

---

Page 228. Grammar. The first sentence has **class** but should be **class’s**.

---

Page 238. The middle of the first paragraph has “it until the result is **0 or larger.**” Better is “it until the result is **in the interval  $[0, 1)$ .**”

---

Page 239. Grammar. At the bottom of the page, “illustrates with” should be “illustrates **this** with”.

---

Page 240. Figure 3.14 mentions **squares** twice. These should be **rectangles**. The corresponding color plates require the same changes.

---

Page 240. The middle of the page has “The **left** edge of the texture on the left duplicates the **right** edge of the texture on the right.” This should say “The **right** edge of the texture on the left duplicates the **left** edge of the texture on the right.”

---

Page 243. Grammar. The first paragraph has “I already **discussed**”. Better is “I already **mentioned**”.

---

Page 249. Grammar. At the top of the page. Change to “The dilemma was which” to “The dilemma was **in** which”.

---

Page 250. Grammar. At the top of the page. Change “traversing **through** portions” to “traversing portions”. (Delete the word “through”.)

---

Page 251. Grammar. In Section 3.4.6, change “required the **object** to” to “required the **objects** to”.

---

Page 252. Spelling. Next to last paragraph. The word **hierarhcy** should be **hierarchy**.

---

Page 255. Grammar. Change “smart pointers to **those**” to “smart pointers to **it**”.

---

Page 259. The pseudocode at the top of the page is missing a line of code. It should occur immediately after the “`int iQuantity =`” line.

```
Lights.RemoveAll();
```

---

Page 266. Grammar. The aspect ratios in the first paragraph are written as  $4/3$  and  $16/9$  but should be written as  $4:3$  and  $16:9$ .

---

Page 271. Grammar. Top of the page. Change “`bNoCull` is set to **true, if**” to “`bNoCull` is set to **true and if**”.

---

Page 273. The pseudocode loop has `iP-` which should be `iP--`. Note that the change has two dashes with a small amount of space between them. That space must occur!

---

Page 276. I used **U** for the up vector and for the pick ray direction. Change the picking ray from  $\mathbf{E} + t\mathbf{U}$  to  $\mathbf{E} + t\mathbf{V}$ . The last occurrence “and **U** is” should be “and **V** is”. The displayed equation starts with  $\mathbf{U} = d_{\min}$  but should instead start with  $\mathbf{V} = d_{\min}$ .

---

Page 281. Grammar. Top of the page. Change “**updated, Spatial::UpdateGS**” to “**updated via Spatial::UpdateGS**”.

---

Page 292. Change “**The relevant interface for the Texture class is**” to “**The supporting classes are listed next. The Texture class has a BindInfoArray member:**”.

---

Page 292-293. The pseudocode should be replaced by the following pseudocode.

```
class BindInfo
{
public:
    BindInfo ();
    Renderer* User;
    char ID[8];
};

class BindInfoArray
{
public:
    BindInfoArray (int iQuantity, int iGrowBy);
    const TArray<BindInfo>& GetArray () const;
    void Bind (Renderer* pkUser, int iSize, const void* pvID);
    void Unbind (Renderer* pkUser);
    void GetID (Renderer* pkUser, int iSize, void* pvID);
private:
    TArray<BindInfo> m_kBind;
};
```

---

Page 293. The first sentence after the pseudocode has “The **nested** class” but should have “The class”.

---

Page 294. The pseudocode in the middle of the page has a for loop which should be replaced by the following pseudocode.

```
const TArray<BindInfo>& rkArray = BIArray.GetArray();
for (int i = 0; i < rkArray.GetQuantity(); i++)
    rkArray[i].User->ReleaseTexture(this);
```

---

Page 294. The paragraph after the middle block of pseudocode has “function **Texture::Unbind**” but should have “function **Unbind**”.

---

Page 295. The second paragraph has “the **BindInfo nested** class” but should have “the **BindInfo** class”.

---

Page 302. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestBillboardNode`

to

`GeometricTools/WildMagic3/SampleGraphics/BillboardNodes`

---

Page 306. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestParticles`

to

`GeometricTools/WildMagic3/SampleGraphics/ParticleSystems`

---

Page 306. Grammar. First paragraph of Section 4.1.3. The two occurrences of “model is selected” should be “model selected”.

---

Page 308. Delete the sentence “If the picking had to do with firing . . . picking to the active child.”

---

Page 309. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestDlodMesh`

to

`GeometricTools/WildMagic3/SampleGraphics/DlodNodes`

---

Page 310. A clarification at the top of the page. Change “weight is zero” to “weight  $w_i$  is zero”.

---

Page 311. Grammar. The phrase `smaller or equal to` should be `smaller than or equal to`.

---

Page 312. Grammar. The phrase `smaller or equal to` should be `smaller than or equal to`.

---

Page 317. Grammar. The phrase `smaller or equal to` should be `smaller than or equal to`.

---

Page 322. Grammar. First paragraph on page. Change “but also increase” to “but also `to` increase”.

---

Page 327. Grammar. Next to last paragraph. Change “`figure: upside down, it folded over.`” to “`figure because it folded over.`”

---

Page 333. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestClodMesh`

to

`GeometricTools/WildMagic3/SampleGraphics/ClodMeshes`

---

Page 333. Spelling. Middle of the page. Change `further` to `farther`.

---

Page 336. At the beginning of Section 4.2.1, delete the starting phrase “`As I have mentioned a few times,`”.

---

Page 337. Grammar. First paragraph at top of page, third line. Change “can draw” to “can `then` draw”.

---

Page 343. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestBspNode`

to

`GeometricTools/WildMagic3/SampleGraphics/BspNodes`

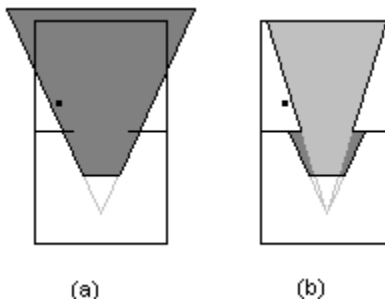
---

Page 343. Spelling. Middle of the page. Change `torii` to `tori`.



---

Page 346 I missed proofing the Figure 4.31. The portal “gaps” were filled in, but should not be. In (b), the visible region should not have extended all the way to the corners of the room since that occurs only coincidentally. The original figure I submitted is shown below.



---

Page 349. Grammar. In the first paragraph, replace “it cannot be shared” by “the array cannot be shared”.

---

Page 349. Grammar. In the paragraph before the pseudocode for UpdateWorldData, change “by UpdateGS pass” to “by the UpdateGS pass”.

---

Page 352. Grammar. In the first paragraph, replace “Once pushed” by “Once the planes are pushed”.

---

Page 353. In the first paragraph, replace the sentence “The maximum number of planes is arbitrarily chosen to be 32.” by “The maximum number of planes is 32, which allows you to use a 32-bit mask for keeping track of active planes.”

---

Page 354. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestPortals`

to

`GeometricTools/WildMagic3/SampleGraphics/Portals`

---

Page 354. The first bulleted item in Section 4.2.3. Change “able to see it when positioned on either side of the face.” to “able to see it from either the front or the back.”

---

Page 354. The second bulleted item in Section 4.2.3. Change “For the cube only” to “If the cube is the only object in the scene”.

---

Page 355. The second line has “the outer normal is larger than”. Change this to “the outer normal is 180 degrees, which is larger than”.

---

Page 355. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestSortFaces`

to

`GeometricTools/WildMagic3/SampleGraphics/SortFaces`

---

Page 360. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestDeferredDraw`

to

`GeometricTools/WildMagic3/SampleGraphics/DeferredDraw`

---

Page 369. Grammar. Middle of the page. Change “guarantees a forward” to “guarantees that a forward”.

---

Page 369. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestSurfaceMesh`

to

`GeometricTools/WildMagic3/SampleGraphics/SurfaceMeshes`

---

Page 372. Grammar. Next to last paragraph. Change “It is essential to compute  $E_1'$  first and store it before” to “It is essential to compute and store  $E_1'$  before”.

---

Page 373. The second paragraph has a typographical error and states that “the initial number of triangles is  $T_1$ .” This should be “the initial number of triangles is  $T_0$ .”

---

Page 373. Next to last paragraph. Change “the new number of vertices is  $E_0$ ” to “the number of new vertices is  $E_0$ .” Also change “adding  $2E_0$  edges to the triangulation” to “adding  $E_0$  edges to the triangulation”. Both phrases were meant to refer to the increase in vertices/edges, not to the total numbers after the increase.

---

Page 377. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestSurfaceMesh`

to

`GeometricTools/WildMagic3/SampleGraphics/SurfaceMeshes`

---

Page 378. Grammar. First paragraph. Change “Realizing that large chunks of terrain will be stitched together, height fields” to “Large chunks of terrain will be stitched together, so height fields”.

---

Page 388. Grammar. First line. Change “is needed” to “would be needed”.

---

Page 389. Grammar. The phrase “different than” should be “different from”.

---

Page 393. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestTerrain`

to

`GeometricTools/WildMagic3/SampleGraphics/Terrains`

---

Page 393. The directory names need modification. Change

```
MagicSoftware/WildMagic3/Test/TestTerrain/Height32  
MagicSoftware/WildMagic3/Test/TestTerrain/Height64  
MagicSoftware/WildMagic3/Test/TestTerrain/Height128
```

to

```
GeometricTools/WildMagic3/Data/Terrain/Height32  
GeometricTools/WildMagic3/Data/Terrain/Height64  
GeometricTools/WildMagic3/Data/Terrain/Height128
```

---

Page 393. The directory names need modification. Change

```
MagicSoftware/WildMagic3/Test/TestTerrain/Image32  
MagicSoftware/WildMagic3/Test/TestTerrain/Image64  
MagicSoftware/WildMagic3/Test/TestTerrain/Image128
```

to

```
GeometricTools/WildMagic3/Data/Terrain/Image32  
GeometricTools/WildMagic3/Data/Terrain/Image64  
GeometricTools/WildMagic3/Data/Terrain/Image128
```

---

Page 393. The pairs of single quotes on the height and image prefixes should be typeset as double quotes instead. Change

```
‘‘Height128/height’’  
‘‘Image128/image’’
```

to

```
"Height128/height"  
"Image128/image"
```

---

Page 394. The first line has “the value 32 in” but should have “the value 33 in”.

---

Page 394. Grammar. First paragraph. Change “*C* columns, the” to “*C* columns of pages, the”

---

Page 394. The pairs of single quotes on the height prefix should be typeset as double quotes instead. Also, the *r* and *c* portions of the name should be italicized to indicate they are placeholders for the actual numbers for the files on disk. Change

‘ ‘Height32/height.*r.c*.wmhf’ ’

to

"Height32/height.*r.c*.wmhf"

---

Page 394. First paragraph. Change “there are 64 height fields” to “there are 64 height files” to be consistent with the remainder of the paragraph. (There really are 64 height fields.)

---

Page 394. The pairs of single quotes on the image prefix should be typeset as double quotes instead. Also, the *r* and *c* portions of the name should be italicized to indicate they are placeholders for the actual numbers for the files on disk. Change

‘ ‘Image32/image.*r.c*.wmhf’ ’

to

"Image32/image.*r.c*.wmhf"

---

Page 396. Grammar. First paragraph. Change “algorithms assumes camera” to “algorithms assume camera”.

---

Page 397. Two statements in the pseudocode are indented too deeply. They should be typeset as shown next.

```
int iCMinP = iCMin0 % m_iCols;
if ( iCMinP < 0 )
    iCMinP += m_iCols;
```

and

```
int iRMinP = iRMin0 % m_iRows;
if ( iRMinP < 0 )
    iRMinP += m_Rows;
```

---

Page 399. Grammar. The paragraph before Section 4.5. Change “places of low probability that a character might see.” to “places that a character might rarely see.”

---

Page 399. Grammar. The first paragraph of Section 4.5. Change “You name it.” to “Your choices are limitless.”

---

Page 401. Grammar. The phrase “different than” should be “different from”. Two occurrences on this page.

---

Page 401. The last paragraph has “If the repeat type is *clamp*” but should have “If the repeat type is *cycle*”

---

Page 402. The first paragraph of Section 4.5.1. Change “assigned a time for the animation to “assigned a time value”

---

Page 403. Grammar. The next to last line. Change “pair of keys bound” to “pair of keys bounds”

---

Page 404. The directory name needs modification. Change

```
MagicSoftware/WildMagic3/Test/TestSkinnedBiped
```

to

```
GeometricTools/WildMagic3/SampleGraphics/SkinnedBiped
```

---

Page 404. Grammar. First paragraph of Section 4.5.2. Change “there are corresponding vertices on all the other objects” to “there is a corresponding vertex on each of the other objects”

---

Page 406. The equation in the first line is  $w_{T-1} = 1 - \sum_{i=0}^{T-2} w_i$  but should be  $w_0 = 1 - \sum_{i=1}^{T-1} w_i$ .

---

Page 406. Grammar. Second line after the displayed equation. Change “three less multiplications” to “three fewer multiplications”.

---

Page 406. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestMorphController`

to

`GeometricTools/WildMagic3/SampleGraphics/MorphControllers`

---

Page 408. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestPolypoint`

to

`GeometricTools/WildMagic3/SampleGraphics/PointSystems`

---

Page 410. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestParticles`

to

`GeometricTools/WildMagic3/SampleGraphics/ParticleSystems`

---

Page 414. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestSkinnedBiped`

to

`GeometricTools/WildMagic3/SampleGraphics/SkinnedBiped`

---

Page 415. Grammar. First paragraph, fourth line. Change “you either” to “either you”.

---

Page 419. The bottom of the page. Change “perpendicular to the line” by “perpendicular to **U**”.

---

Page 424. A typesetting problem, middle of page. The function `atan 2` needs not to have space between the ‘n’ and ‘2’. It should be one word `atan2`.

---

Page 425. A typesetting problem, middle of page. The function `atan 2` needs not to have space between the ‘n’ and ‘2’. It should be one word `atan2`.

---

Page 429. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestInverseKinematics`

to

`GeometricTools/WildMagic3/SampleGraphics/InverseKinematics`

---

Page 432. Grammar. The phrase “different than” should be “different from what”.

---

Page Color Plate 3.14. The word `squares` occurs twice and should be `rectangles`.



---

Page 436. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestMultitexture`

to

`GeometricTools/WildMagic3/SampleGraphics/Multitexture`

---

Page 440. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestGlossMap`

to

`GeometricTools/WildMagic3/SampleGraphics/GlossMaps`

---

Page 440. Second paragraph of Section 5.1.6. Change “which can be mapped to intervals `[0, 255]` and rounded so that components are integer valued.” to “which can be mapped to intervals `[0, 1]`.”

---

Page 440. Second paragraph of Section 5.1.6. Change “components can be stored” to “components are stored”.

---

Page 441. First line. Change “interval `[0, 255]`” to “interval `[0, 1]`”

---

Page 441. Grammar. The last line. Change “store in” to “store `it` in”.

---

Page 445. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestBumpMap`

to

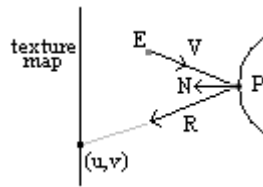
`GeometricTools/WildMagic3/SampleGraphics/BumpMaps`

---

Page 445. The last paragraph. Change `appearance` to `illusion`.

---

Page 446. Figure 5.4 is associated with environment mapping but is placed immediately after Figure 5.3 for bump mapping. To make it clear Figure 5.4 is associated with environment mapping, change the caption from “The mapping of a texture” to “The `environment` mapping of a texture”. Also, the vector  $\mathbf{N}$  in the Figure 5.4 is supposed to be normal to the surface at point  $\mathbf{P}$ , but the figure does not show this. It should look like this.



---

Page 446. The first paragraph of Section 5.1.7. Change “the `appearance of the surface` reflecting” to “the `illusion that the surface is very shiny and` reflecting”.

---

Page 447. A typesetting problem, near top of page. The function `atan 2` needs not to have space between the ‘n’ and ‘2’. It should be one word `atan2`. Two occurrences.

---

Page 449. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestEnvironmentMap`

to

`GeometricTools/WildMagic3/SampleGraphics/EnvironmentMaps`

---

Page 454. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestProjectedTexture`

to

`GeometricTools/WildMagic3/SampleGraphics/ProjectedTextures`

---

Page 455. The second paragraph has `Renderer:DrawPlanarShadow` but is missing another colon. It should be `Renderer::DrawPlanarShadow`.

---

Page 455. Grammar. The last line has `them` but should have `it`.

---

Page 456. Grammar. Last paragraph. Change “`those pixels affected by the plane.`” to “`which pixels the plane spans.`”.

---

Page 457. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestPlanarShadow`

to

`GeometricTools/WildMagic3/SampleGraphics/PlanarShadows`

---

Page 457. First paragraph of Section 5.1.10. Before “The class that encapsulates”, insert the sentence “`The reflectance value is used to blend the surface color and the reflection.`”

---

Page 459. At the end of the first paragraph, insert “`This class does not support reflections of reflections. All reflecting planes are opaque.`”

---

Page 461. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestPlanarReflection`

to

`GeometricTools/WildMagic3/SampleGraphics/PlanarReflections`

---

Page 465. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestCharcoalEffect`

to

`GeometricTools/WildMagic3/SampleShaders/CharcoalEffects`

---

Page 469. Grammar. Next to last paragraph. Change “engine **has the responsibility** for” to “engine **is responsible** for”.

---

Page 473. The top-most pseudocode has two changes. Change `virtual int GetShaderType () const = 0;` to `int GetShaderType () const;`. The second change is to insert `int m_eShaderType` before the line of code “`const char* m_acProgram;`”

---

Page 473. The paragraph after the top-most pseudocode should be rewritten to

The class is abstract since the only constructor is protected. The only two derived classes are `VertexShader` and `PixelShader`. Each of these derived classes sets the variable `m_eShaderType` to the correct enumerant of the `Shader` base class.

---

Page 473. The two following pseudocode lines should be deleted.

```
virtual int GetShaderType () const { return ST_VERTEX_SHADER; }  
virtual int GetShaderType () const { return ST_PIXEL_SHADER; }
```

---

Page 488. Grammar. The last sentence in item 2. Change “at the **first** time is called” to “at the **contact** time is called”.

---

Page 491. Grammar. Last paragraph. Change “If **both objects are not linear components**” to “If **neither object is a linear component**”

---

Page 492. Grammar. First line after equation (6.6). Change “for which  $f(t_{\text{first}}) = 0$ , **but**  $f(t) > 0$ ” to “for which  $f(t_{\text{first}}) = 0$  **and**  $f(t) > 0$ ”.

---

Page 492. Grammar. First sentence after equation (6.7). Change “from the second” to “from **that** of the second”.

---

Page 492. Grammar. Last sentence. Change “if you **compute** the contact set” to “if you **want to know** the contact set”.

---

Page 494. Second paragraph. Change “but that  $t$ -value is not  $t_{\text{first}}$ ” to “but that  $t$ -value is not **necessarily**  $t_{\text{first}}$ ”.

---

Page 494. Grammar. The paragraph before the last displayed equation. Change “The actual function **value** used” to “The actual function **values** used”.

---

Page 497. Second paragraph. Change “derivatives at  $t_0$  and  $t_1$  are **all positive**” to “derivatives at  $t_0$  and  $t_1$  are **both positive or both negative**”.

---

Page 497-490. An entire rewrite of Section 6.1.5 starting after the first paragraph. Here it is.

```
template <class Real, class TVector>
class Distance
{
public:
    // abstract base class
    virtual ~Distance ();

    // static distance queries

    virtual Real Get () = 0;    // distance
    virtual Real GetSquared () = 0; // squared distance

    // function calculations for dynamic distance queries

    virtual Real Get (Real fT,
        const TVector& rkVelocity0,
        const TVector& rkVelocity1) = 0;

    virtual Real GetSquared (Real fT,
        const TVector& rkVelocity0,
        const TVector& rkVelocity1) = 0;

    // Derivative calculations for dynamic distance queries. The
    // defaults use finite difference estimates
    //  $f'(t) = (f(t+h)-f(t-h))/(2*h)$ 
    // where h = DifferenceStep. A derived class may override
    // these and provide implementations of exact formulas that
    // do not require h.

    virtual Real GetDerivative (Real fT,
        const TVector& rkVelocity0,
        const TVector& rkVelocity1);

    virtual Real GetDerivativeSquared (Real fT,
        const TVector& rkVelocity0,
        const TVector& rkVelocity1);

    // Dynamic distance queries. The function computes the
    // smallest distance between the two objects over the time
    // interval [tmin,tmax].

    virtual Real Get (Real fTMin, Real fTMax,
        const TVector& rkVelocity0,
        const TVector& rkVelocity1);
```

```

virtual Real GetSquared (Real fTMin, Real fTMax,
    const TVector& rkVelocity0,
    const TVector& rkVelocity1);

// for Newton's method and inverse parabolic interpolation
int MaximumIterations; // default = 8
Real ZeroThreshold;    // default = ZERO_TOLERANCE

// for derivative approximations
void SetDifferenceStep (Real fDiffStep); // default = 1e-03
Real GetDifferenceStep () const;

// The time at which minimum distance occurs for the dynamic queries.
Real GetContactTime () const;

// Closest points on the two objects. These are valid for
// static or dynamic queries. The set of closest points on a
// single object need not be a single point. In this case, the
// Boolean member functions return 'true'. A derived class
// may support querying for the full contact set.
const TVector& GetClosestPoint0 () const;
const TVector& GetClosestPoint1 () const;
bool HasMultipleClosestPoints0 () const;
bool HasMultipleClosestPoints1 () const;

protected:
    Distance ();

    Real m_fContactTime;
    TVector m_kClosestPoint0;
    TVector m_kClosestPoint1;
    bool m_bHasMultipleClosestPoints0;
    bool m_bHasMultipleClosestPoints1;
    Real m_fDifferenceStep, m_fInvTwoDifferenceStep;
};

```

The only constructor is protected, so the class is abstract. The function `Get()` computes the true distance between the objects. The function `GetSquared()` computes the squared distance between the objects. In most implementations, the squared distance is computed first, and the true distance obtained by a square root operation.

The functions `Get` and `GetSquared` that take the three inputs are used for dynamic distance queries. The maximum time for the interval is the first input. The velocities of the two objects are the second and third inputs. The minimum of  $f(t)$  is computed by solving for  $t_{\min} \in [0, t_{\max}]$ , the time at which the one-sided derivatives of  $f'$  multiply to a nonpositive number.

---

Page 501. Grammar. Fourth paragraph from the top. Change “If you **are to** move the objects” to “If you move the objects”.

---

Page 503. Grammar. Third paragraph of Section 6.3. Change “**of** which most of the scene graph” to “**from** which most of the scene graph”.

---

Page 508. Grammar. Second paragraph of the **Spheres** section. Change “**replace** the parametric line” by “**substitute** the parametric line”.

---

Page 508. Grammar. The phrase **smaller or equal to** should be **smaller than or equal to**.

---

Page 510. Grammar. First sentence. Change “either of the  $t$ -values **are** nonnegative” to “either of the  $t$ -values **is** nonnegative”.

---

Page 513. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 514. Item (e) has “The function is monotonic **increasing**” but should have “The function is monotonic **decreasing**”.

---

Page 520. Second paragraph. Change “the origin is against each face” to “the origin is **tested** against each face”.

---

Page 520. Last paragraph. Change “**Eight** of the OBB edges” to “**Four** of the OBB edges”.

---

Page 525. Spelling. The caption for Figure 6.12 has **segmet** but should have **segment**.

---

Page 533. The directory name needs modification. Change

**MagicSoftware/WildMagic3/Test/TestCastle**

to

**GeometricTools/WildMagic3/SampleGraphics/Castle**



---

Page 534. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestMorphController`

to

`GeometricTools/WildMagic3/SampleGraphics/MorphControllers`

---

Page 534. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestCastle`

to

`GeometricTools/WildMagic3/SampleGraphics/Castle`

---

Page 536. The directory name needs modification. Change

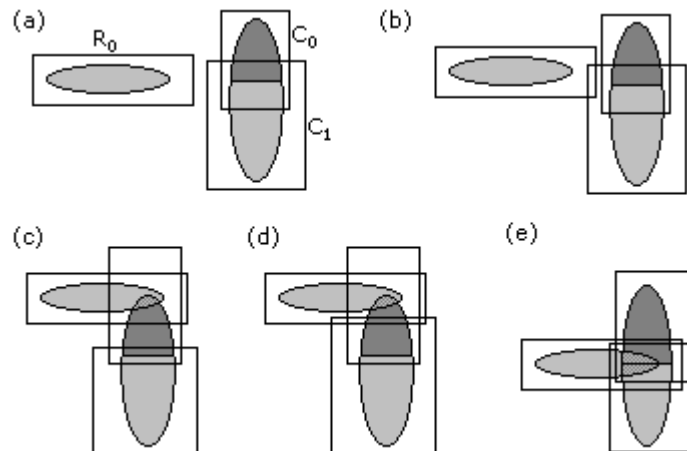
`MagicSoftware/WildMagic3/Test/TestCastle`

to

`GeometricTools/WildMagic3/SampleGraphics/Castle`

---

Page 541. The artwork for Figure 6.15 (d) was not redrawn correctly from my originals. The original figure is shown next. Notice that the top edge of the bottom rectangle must extend farther up the page.



---

Page 546. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 546. Grammar. The phrase **smaller or equal to** should be **smaller than or equal to**.

---

Page 552. Grammar. The first paragraph has the phrase **each other** (implying two) when it should be **one another** (implying more than two).

---

Page 553. The directory name needs modification. Change

**MagicSoftware/WildMagic3/Test/TestCollision**

to

**GeometricTools/WildMagic3/SampleGraphics/Collisions**

---

Page 563. The directory name needs modification. Change

**MagicSoftware/WildMagic3/Test/TestIntersectingBoxes**

to

**GeometricTools/WildMagic3/SamplePhysics/IntersectingBoxes**

---

Page 565. The first paragraph, last sentence has “initial time  $t \geq 0$ ” but should have “initial time  $t = 0$ ”.

---

Page 566. First paragraph. Change ‘class, OdeSolver,’ to “class, OdeSolver (“Ode” stands for “ordinary differential equation”)”.

---

Page 569. The last displayed equation for is missing a closing right parenthesis. Change  $(h/2)\mathbf{F}(t_0, \mathbf{X}_0)$  to  $(h/2)\mathbf{F}(t_0, \mathbf{X}_0)$ .

---

Page 570 The last line of pseudocode has

```
OdeEuler OdeMidpoint(iDim,fStep,F,afData);
```

but should have

```
OdeMidpoint kSolver(iDim,fStep,F,afData);
```

---

Page 571. The displayed equation after the one for  $\mathbf{K}_3$  has  $\mathbf{K}$  but should have  $\mathbf{K}_4$ .

---

Page 583. The directory name needs modification. Change

```
MagicSoftware/WildMagic3/Test/TestRope
```

to

```
GeometricTools/WildMagic3/SamplePhysics/Rope
```

---

Page 586. The directory name needs modification. Change

```
MagicSoftware/WildMagic3/Test/TestCloth
```

to

```
GeometricTools/WildMagic3/SamplePhysics/Cloth
```

---

Page 586. The first paragraph of Section 7.3.3. Change “An interior particle has **eight** neighbors” to “An interior particle has **six** neighbors. The last sentence on the page has a similar error. Change “has **eight** force” to “has **six** force”.

---

Page 589. The directory name needs modification. Change

```
MagicSoftware/WildMagic3/Test/TestGelatinCube
```

to

```
GeometricTools/WildMagic3/SamplePhysics/GelatinCube
```

---

Page 591. The directory name needs modification. Change

`MagicSoftware/WildMagic3/Test/TestGelatinBlob`

to

`GeometricTools/WildMagic3/SamplePhysics/GelatinBlob`

---

Page 591. The directory names need modification. Change

`MagicSoftware/WildMagic3/Test/TestBouncingBalls`  
`MagicSoftware/WildMagic3/Test/TestBouncingTetrahedra`

to

`GeometricTools/WildMagic3/SamplePhysics/BouncingBalls`  
`GeometricTools/WildMagic3/SamplePhysics/BouncingTetrahedra`

---

Page 609. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 624. Grammar. First paragraph. Change “camera **parallel to the** plane” to “camera **in a** plane”.  
Change “the **observer is looking down at** that” to “the **view direction is not parallel to** that”.

---

Page 624. The pseudocode in the middle of the page has **MoveBackward** but should have **MoveDown**.

---

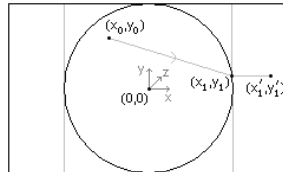
Page 625. Grammar. The sentence starting with “**You might think**” should start with “**In the second blocks, you might think**”.

---

Page 626. Grammar. Next to last paragraph. Change “a rate that is much **larger** than” to “a rate that is much **greater** than”.

---

Page 630. Figure 8.1 needs a small modification. The line segment connecting the points  $(x_1, y_1)$  and  $(x'_1, y'_1)$  should be perpendicular to the circle. The image shown next illustrates this.



---

Page 646. Grammar. First paragraph of Section 8.2.4, last sentence. Change “the eye point **using the distance** to” to “the eye point to”.

---

Page 649. Grammar. The caption of Figure 8.6. Change “the **distance wall** clicked to place **it** in” to “the **walls** clicked to place **them** in”.

---

Page 654. First paragraph. Change “intersections of triangles **on the circular ends of cylinder 0 and the sides of cylinder 1.**” to “intersections of triangles **forming the cylinders.**”

---

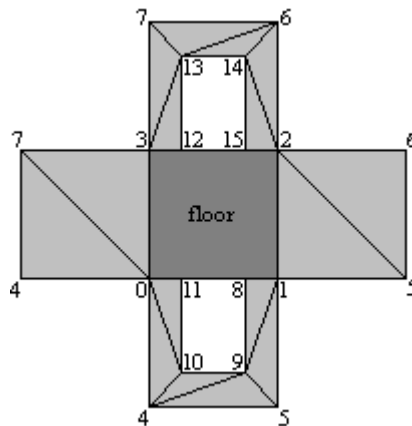
Page 657. Grammar. Next to last paragraph. Change “tell you **the** normal” to “tell you a **(not necessarily unit-length)** normal”.

---

Page 660. Grammar. The phrase “different **than**” should be “different **from**”.

---

Page 661. The wrong original image was included in Figure 8.12. The correct image is



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Page 671. Grammar. Middle of the page. The term “*distant assumption*” needs both words italicized, “*distant assumption*”.

---

Page 673. The book is missing a description of the Max exporter. To keep the section numbering the same in Chapter 8, I have modified the title of Section 8.3.2 to MAYA AND MAX EXPORTERS. The section rewrite is

Also on the CD-ROM are exporters for Maya version 6 and Max versions 4, 6, and 7. These exporters have a good number of features and do support keyframe animation and skin-and-bones. The Maya scene graph structures are sufficiently similar to those of Wild Magic, which reduces some of the pain of writing an exporter for that package.

---

Page 696. The semicolon after the include of ClassC.h should be deleted. That is, the line of pseudocode should be

```
#include "ClassC.h"
```

---

Page 734-736. These are “About the CD-ROM” pages. My Software License Agreement has changed. Replace the text of that subsection by the contents in the new file `AboutTheCDROM.pdf`.

---

Page 736. The paragraph starting with “For convenience” and the four lines of displayed text should be deleted. Change “Copy the files from the **directory of your choice.**” to “Copy the files from the **CD-ROM to your hard drive.**” Change “The directions for installing and compiling are found in the **PDF file.**” to “The directions for installing and compiling are found in the file `WildMagic3p4ReleaseNotes.pdf`.”

---

Page 736. Last paragraph. Change `www.wild-magic.com` to `www.geometrictools.com`.

---

Page (End Papers). See the file `EndPapers.pdf` for the changes.