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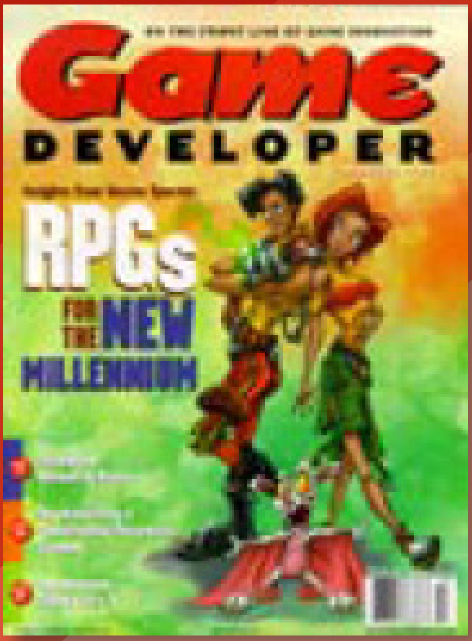
GAME DEVELOPER MAGAZINE

FEBRUARY 1999



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Landing the da Vinci Deal

Last fall, I had the fortune to find myself in a little town in France called Amboise, located about two hours outside of Paris by train. While wandering around town one day, I came upon an impressive estate which I quickly learned was Leonardo da Vinci's final residence. Da Vinci was given this residence (called Chateau du Clos-Luce, or "house of light") by King Francois I in 1516. In return, the king wanted da Vinci simply to continue his artistic and scientific explorations. If some invention suited Francois' military objectives (as some did), so much the better for the king. Essentially, da Vinci was given free creative reign to do what he was already doing, and in return his patron enjoyed the fruits of da Vinci's ideas.

While at Clos-Luce, I couldn't help but think about an analogy to this scenario within our own industry. Like Francois, today's consumer hardware manufacturers rely on the technical and creative talents of game developers. To a large extent, games are the *raison d'être* for these hardware manufacturers. That's why these hardware companies throw you parties at trade shows, send you free hardware, help you market your game, get you retail shelf space, offer bundling deals, and on occasion a hardware manufacturer will simply shower you with some cash. In short, they need your talents. But while incentives can be difficult to refuse, especially if you're a small developer in need of all of the above, Rob Wyatt of Dreamworks Interactive suggests that you ask the following questions before you sign on the dotted line.

The first question you should pose is to yourself: "Why me?" Why do you think this hardware manufacturer is so hot to get your support of its upcoming product? Sure, *you* know your game will be incredible, but does your prospective patron have the same vision for it as you? Understand what that company expects from your game before you agree to implement any changes in it. If there are differing expectations for the game, you'll have problems down the line.

Second, decide early whether the features or performance gained warrant the extra work. If what's being asked of you won't make your game better, the deal may be skewed substantially in their favor. You're lengthening your development cycle and/or cutting out the development of important features in order to implement irrelevant (or worse yet, harmful) "features" to the game. Remember that by far your most important customer is the player, and that all decisions should be made with that fact in mind.

Third, find out how exactly your patron hardware manufacturer will support your efforts. Will they actually help code certain sections of the game? Find out how much documentation and developer support will be provided before you agree to anything. If you hit a roadblock while trying to implement something for this company, you should be able to get answers to technical questions quickly and easily.

Inquire about the exclusivity of your deal. If you agree to support the Brand X API, does that preclude you from working with another hardware company? Knowing what you cannot do is as important as knowing what you must do.

If you are planning to reuse or license your game engine to others some day, how does an agreement with a hardware company affect those strategies? Find out what lasting legacies you'll have to live with after the current game ships.

Finally, in the event that you've just finished this column and thought to yourself, "I wish I had the problem of too many suitors — where's *my* patron?", take heart. Remember that the universe of game developers is far larger than the combined developer relations staffs at all of the consumer hardware companies out there. Don't wait for them to find you. After all, it was da Vinci who first introduced himself to Francois and offered his services, not the other way around. ■

Alex D

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www.gdmag.com

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BIT Blasts

News from the World of Game Development

New Products

by Wesley Hall

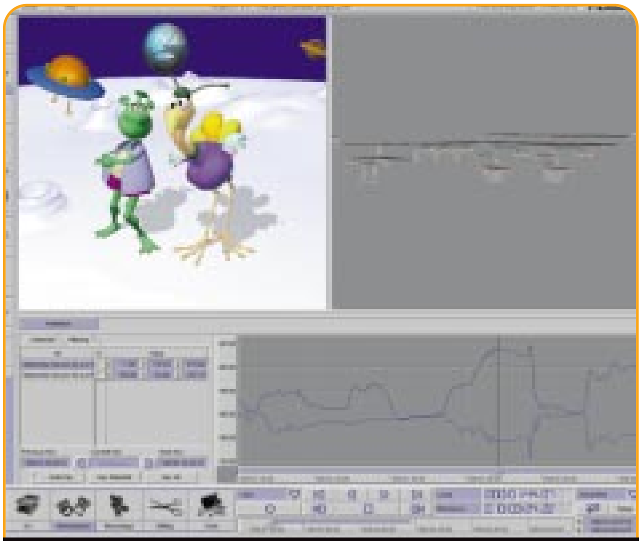
Motion Capture Made Easy

KAYDARA is shipping Filmbox 1.5, its real-time production software.

A suite of motion capture, animation, and interactive rendering tools, Filmbox is designed to simplify motion capture mapping and editing. The suite integrates into the production workflow for game, television, and film productions, and supports all major 3D packages. Feature highlights in Filmbox 1.5 include: HumanIK, Motion Sculpting, and Open Reality. HumanIK is a new tool for automatically attaching motion capture data to skeletons. It connects capture data and character joints for you. Motion Sculpting's new control curves allow you to apply offsets to captured animation, and give you a secondary level of animation control. Open Reality is a cross-platform C++ developer kit designed specifically for the creation of real-time plug-ins for Filmbox. Developers have complete access to Kaydara's performance architecture, as well as import/export access to all major 3D products such as Alias|Wavefront Power Animator/Maya, Kinetix 3D Studio Max, Newtek Lightwave, and Softimage 3D.

Available on both the Windows NT (Intel and Alpha) and Silicon Graphics IRIX operating systems, Filmbox 1.5 is immediately available with pricing starting at $4,995. The Open Reality SDK is also available separately, directly from Kaydara.

■ **Kaydara Inc.**
Montreal, Quebec, Canada
(888) 842-6842
http://www.kaydara.com



Filmbox supports a number of motion capture devices and displays the virtual character in real time. Filmbox also supports mutiple characters.

Affordable Frame Factory

NEWTEK recently launched and shipped Frame Factory, its first professional hardware and software digital video, paint, and animation solution.

Frame Factory is an affordable hardware/software integrated solution (it sells for under $4,000) that is specifically designed for 3D animation, real-time video capture and playback, 2D animation, video paint, 2D and 3D video manipulation, and video processing. It gives you complete control over modeling, texturing, painting, animating, rendering, rotoscoping, compositing, and final output from one desktop system. The package includes an uncompressed ITU-R-601 video I/O board, Lightwave 3D 5.6, and Aura, Newtek's video paint production software tool — all optimized to work together on Windows NT.

Newtek's Frame Factory for Intel is immedeately available for a suggested retail price of $3,995. Minimum system requirements are Windows NT with service pack 3, a Pentium 166MHz, 96MB RAM, drive system capable of 21MB/Sec sustained data rate, and available bus mastering PCI slots for Frame Factory board and SCSI controller.

■ **Newtek**
San Antonio, Tex.
(210) 370-8000
http://www.newtek.com

Ready-Made Models

CREDO INTERACTIVE has released Powermodels, a collection of ready-to-animate 3D character models.

The Powermodels collection includes 24 multiracial human characters from Zygote Media Group, 13 human characters from Geo-Metricks, and six original insects created by Credo Interactive. With Powermodels, Life Forms users (as well as users of Max and Lightwave) can now populate their projects with diverse characters, create multiple character interaction, and quickly create large crowd scenes — even if the crowd is a swarm of Pixar-inspired bugs and ants.

Powermodels is immediately available and sells for a suggested retail price of $249. The models are compatible with Life Forms, 3D Studio Max, and Lightwave 3D formats.

■ **Credo Interactive**
Vancouver, B.C., Canada
(604) 291-6717
http://www.credo-interactive.com

Industry Watch

by Alex Dunne

GAME GRAMMYS? For all of you composers out there who complain that you don't get enough credit for your work, maybe a Grammy Award will ease your suffering. It was recently revealed that the National Academy of Recording Arts and Sciences met with about a dozen of the game industry's top music professionals (including George Alistair Sanger, Bobby Prince, Mark Miller, Rob Hubbard, and Tommy Tallarico) in San Francisco, Calif., to discuss the feasibility of establishing a Grammy Award for our industry. Think of something along the lines of "Best Original Soundtrack from an Interactive Game." You can thank Chance Thomas, a composer at Yosemite Entertainment, for getting the ball rolling with the Grammys.

MGM INTERACTIVE AND ELECTRONIC ARTS entered into a worldwide development and distribution agreement for MGM's next slate of interactive titles. In the deal, MGM's upcoming titles, including Tomorrow Never Dies and Rollerball, will be sold, marketed and distributed by EA worldwide.

SEGA SOLD 150,000 DREAMCASTS on its first day of sales in Japan, and the company is shooting to sell one million units by the end of March.

SOFTIMAGE AND NINTENDO announced a partnership to design and create game development tools for the N64 home video game console. Under the development agreement, Nintendo and Softimage will collaborate on defining NIFF (Nintendo Intermediate File Format) 2.0 and Softimage is adding new features to Softimage 3D 3.8 to support N64 development. The Nintendo NIFF 2.0 development environment and the Softimage tools will ship concurrently to all authorized Nintendo developers in January 1999.

PSYGNOSIS AND CLOTHING FIRM DIESEL announced that they will co-promote the upcoming title, G-Police Weapons of Justice. Diesel has designed jackets, pants, T-shirts and sweatshirts based on the futuristic game world, for sale in the U.S. and Europe. A looping G-Police video, point-of-sale material, and themed areas will be present in all Diesel stores. This is the second time that the two companies have worked together to promote a game (they promoted the original G-Police together).

SENATORS Joseph Lieberman (D-Conn.) and Herb Kohl (D-Wis.) released the fourth annual "Video Game Report Card" on the state of game morality, which was conducted by the Minneapolis, Minn.-based National Institute on Media and the Family. Perhaps not surprisingly, the industry took it on the chin once again. Kohl and Lieberman simultaneously praised the industry for adhering to the five-year-old ESRB voluntary ratings system and blasted the gore found in its most violent games. In citing the worst offenders on the market this past Christmas, the report gave Duke Nukem: Time to Kill the lowest "KidScore" rating, followed closely by Bio Freaks and Mortal Kombat 4. The report, and ratings for individual games, can be found at http://www.mediaandthefamily.com.

GT INTERACTIVE signed affiliate label agreements with Sega PC and Sega Soft Networks, whereby it will handle the North American sales and distribution of PC titles from both Sega companies. The agreements cover upcoming Sega games including Enemy Zero, Vigilance, and Sega Rally 2 Championship.

DOCTORS AT THE ROYAL FREE HOSPITAL in London announced the results of a test they conducted to treat patients with stress-induced irritable bowel syndrome (which you'd be surprised to know affects almost 10 percent of the population). The patients were treated using a game developed by a company called Ultramind, which relied on sensitive sensors to monitor stress levels and provide real-time biofeedback. The more relaxed the patient, the better the progress in the game. The software developers hope that their system will be help reduce anxiety levels, improve workplace performance, train and educate children to deal with various situations, and treat a variety of psychosomatic disorders. Ah, the wonders of our craft.

Psygnosis and Diesel team up to create game fashion.

Duke Nukem: Time to Kill earned the lowest "Kidscore" from Senators.

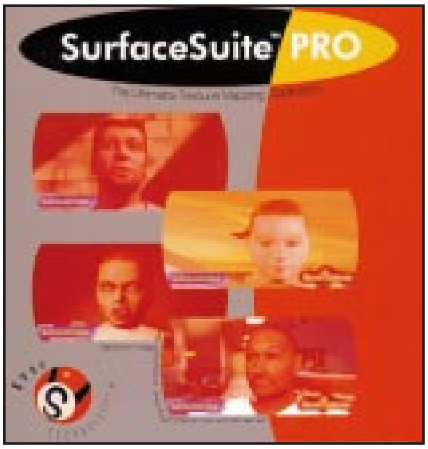
UPCOMING EVENTS CALENDAR

February 9-12, 1999

Milia 99
Palais des Festivals
Cannes, France
Cost: $655
http://www.reedmidem.milia.com

February 17-20, 1999

TED 9
Monterey Convention Center
Monterey, Calif.
Cost: $2,250
http://www.ted.com



SurfaceSuite Pro for Max

by Paul Steed

Over the past six months, I've done quite a bit of research on the manipulation of UV coordinates. My goal is to get the most effective coverage I can on a given mesh for our upcoming title, QUAKE 3: ARENA. Because I'm the animation and modeling department at id Software, speed is of the essence for me to do my job effectively.

When creating a character, I typically use a cylindrical mapping projection and make sure the texture tiles, thus avoiding any unsightly seams. If, however, the UV coverage needs tweaking, I turn to UV Unwrap (a modifier that comes free with Max). Always looking for the next better thing, I got wind of a nice little third-party plug-in for 3D Studio Max called SurfaceSuite Pro by Sven Technologies.

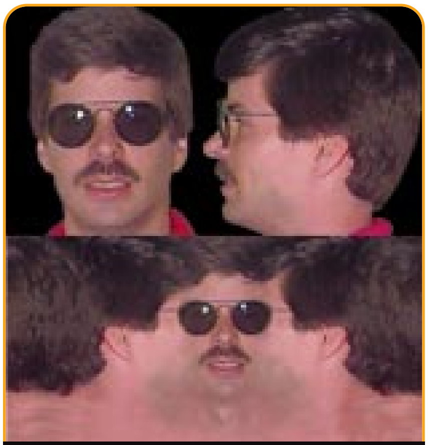


FIGURE 1. *Front- and side-views of Cash's head and the resultant seamless texture.*

Advertised as the ultimate texture-mapping application, SurfaceSuite Pro for 3D Studio Max consists of four plug-ins: Texturizer, Multimask, Gaussian Blend, and Global Map Generation. Texturizer is the main mapping plug-in and allows you to manipulate UV coordinates. Multimask and Gaussian Blend handle the texture-blending features, and Global Map Generation creates a single composite map from multiple, blended, overlapped textures. Sven also offers all these functions in a stand-alone application called simply SurfaceSuite Pro. But since Texturizer is a plug-in for the modeling and animation package that I use (Max), I decided to give it a closer look.

Installing Texturizer was easy enough. After launching Max and authorizing the plug-in with Sven, I added it to my button set of modifiers. For this exercise, I used a prebuilt mesh based on the head of John Cash, a programmer here at id. Before loading in the head, though, I had to make a material to apply to it. I used a 256×128 texture created in Adobe Photoshop from front and side shots of old Cash. I designed the texture to wrap-around the mesh, joining seamlessly at the back of the head (Figure 1).

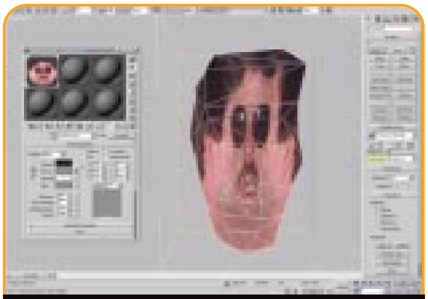


FIGURE 2. *Fitting the mapping gizmo to an object.*

Paul Steed has been making low-polygon models and animating since 1992. He's been at id for more than two years now, having worked on QUAKE 2 and the current project: QUAKE 3 ARENA. He very much enjoys being a guy and equally enjoys doing very stereotypical guy things.

Next, I loaded up Cash's head model. After assigning the texture in the Modifier menu, I assigned Texturizer to the head. A standard mapping gizmo of the planar variety immediately popped up, oriented from the top. In the manual, Sven recommends using a planar projection instead of a cylindrical or spherical one (although SurfaceSuite supports all three types). Although this is contrary to the technique that I normally use, the manual explains that a planar projection works for 95 percent of the jobs for which you'll use SurfaceSuite. Hmmm…

I rotated my viewport so that Cash's untextured head appeared straight on. The manual directs you to apply Texturizer in the perspective viewport, but I would have preferred to use a front viewport. I clicked on Subobject and brought up Projection. As planar projection is already selected by default, I clicked on Viewport Align to align the mapping gizmo to the viewport. Finally, selecting Fit expands the gizmo a little to "fit" the object's front-on dimensions (Figure 2).

So far, so good. Clicking Association under the Subobject menu beneath Projection presented me with a menu to create association points. As association points are like making your own UV points on the fly, this sounded neat.

Sven suggests laying down five points on the object's mesh and five corresponding points on the texture that will wrap around it, and then naming them (such as, "Right Eye," "Left Eye," and so on). These five markers, which should correspond to each eye, the nose, and the two corners of the mouth, are used as reference points to apply the texture onto the object properly. Naming these points in that fashion is way too time consuming so, with the Define Texture Points window open, I'd lay a couple points on the texture then a couple points on the mesh. This approach worked fine until I added a point at each ear. Ouch. Unfortunately Texturizer didn't like that too much (Figure 3).

I was pretty sure that the problem was with the planar mapping, so I thought I'd lump myself into that five percent that uses something other than the planar mapping scheme and give cylindrical mapping a poke. I changed the Projection subobject under the Texturizer modifier from Planar to

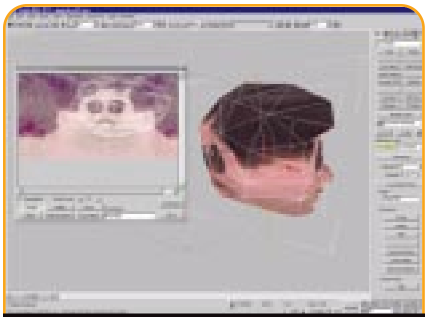


FIGURE 3. *Something's wrong with these association points.*

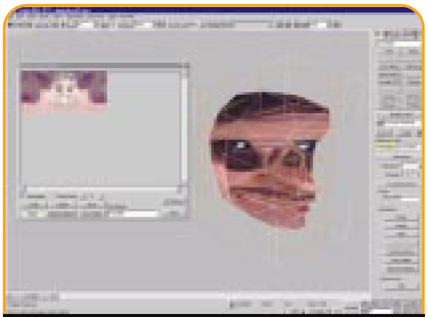


FIGURE 4. *Switching from planar to cylindrical mapping in the middle of the operation isn't advisable.*

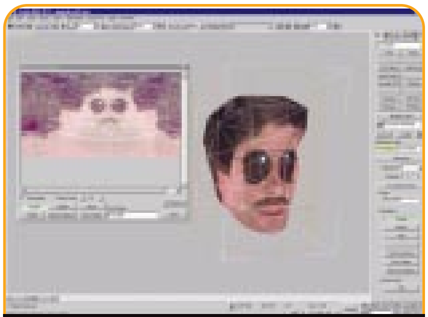


FIGURE 5. *Assigning new association points with a cylindrical mapping type works pretty well.*

Cylindrical, and as you can see, the results weren't pretty (Figure 4). So I deleted the old association points and created new ones using the new cylindrical mapping type. Starting over again, I laid down the prescribed five points in the Define Texture Points window, and did the same on the mesh. That did the trick (Figure 5).

Okay. I have a few small complaints with this process up to now. First, although the texture I was previously editing in the Define Texture Points window was still loaded when I went back to it, Texturizer didn't remember my previous window setting (I previously had a zoom factor setting of 2:1 on the source image). The second quirk I noticed was that, while I could delete editing points on the mesh using my keyboard's [Delete] button, deleting association points in the Define Texture Points window didn't support the [Delete] key. You have to use the Delete button in Texturizer. Finally, when you create a point in the Define Texture Points window, it's given a number value that is consecutive from the number value of the last point created. When a point is deleted, the numbering system still marches on. I guess this is because the random numbering is simply a temporary name for you to change. It'd be nice if the numbering tied itself directly to the association points.

Adding more association points tightens up the map-to-mesh relationship even more, but I found that knowing where to create these points is an acquired skill. I created some points at each ear, but that caused the mapping to go haywire yet again. I was more successful when I tried tightening up the forehead by creating two points at the front hairline. By creating a point at the back of the head, I was able to remove some weird texture-mapping effects at the side of the mesh. Overall, the cylindrical mapping method worked well, except at the top of the mesh, where cylindrical mapping schemes invariably have problems (Figure 6).

In an attempt to fix problems associated with the placement of the character's hairline, I moved some association points around. It's interesting to see what happens when you move these points: the entire mapping outline of the mesh seen in the window moves around and is updated in the viewport.

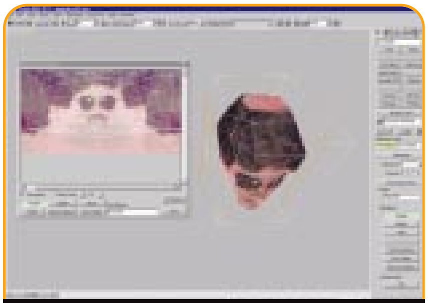


FIGURE 6. *Relative success using the cylindrical mapping method.*

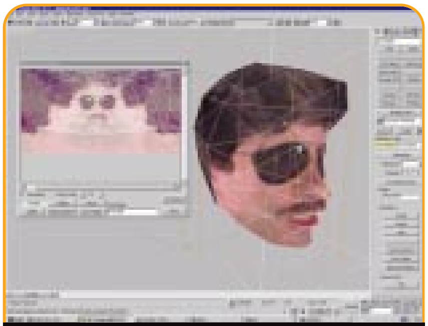


FIGURE 7. *Manipulating association points at the hairline led to problems around the glasses.*

However, I found that attempts to correct the hairline came at a cost: the glasses started looking kind of droopy. So I decided to delete the current association points at the hairline and create new ones at the different spots, but that didn't work. The glasses still drooped (Figure 7).

So I tried adding more association points around the glasses. Here, I got to play with one of the more interesting aspects of Texturizer: the Move to Surface button. When it's on, this feature lets you select and move association points while staying "glued" to the mesh. This deforms and changes the texture as the points are moved around. Unfortunately, it didn't do me much good because I couldn't figure out a comfortable correspondence between moving the association points in the Define Texture Points window and moving points on the surface of the mesh. When do you need to move one and not the other?

I decided to live with the droopy glasses for the time being and concentrate on a problem on the side of the head. In the process of wrapping the texture around the object, an ear disappeared. Because my last attempt to create an association point at the ears turned out to be a failure, I trod carefully, cursor near the Undo button. I created a point by the right ear of our texture subject, but I simply couldn't get the ear to align to the mesh properly.

At this point, I deduced that the default naming of the association points had to do with the dilemma. More specifically, the default names given to the points on the mesh had to correspond to the like-named association points on the texture. And because I'd been adding and deleting

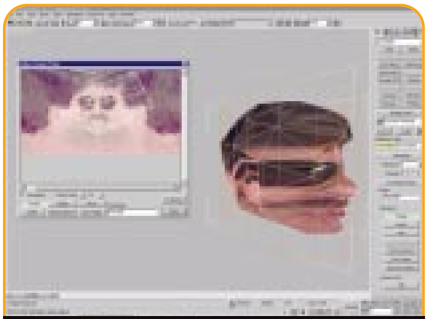


FIGURE 8. *Synching up association points still didn't fix the ear problem.*

points haphazardly during the course of fitting the texture to the object, default names for corresponding points on the mesh and texture were being assigned different numbers.

To solve the problem, I went to the mesh and created a series of points and then deleted them to resynchronize the default point names. However, even with this problem solved, the results weren't great, as you can see (Figure 8).

Finally, I decided to cut my losses and accept the fact that using Texturizer, poor Cash would have a permanent bad hair day on the right side of his head.

JUDGES SAY... In my opinion, Texturizer is a decent tool, but it has some annoying aspects to it. I found the necessity to name association points in order to get better mapping results to be a bad time sink. This product does feature some powerful multitexture blending capabilities and animatable texture mapping, but I don't find these compelling enough to switch from UV Unwrap. While SurfaceSuite possesses some pretty good functionality, it did nothing to boost my productivity.

Overall, I think SurfaceSuite's Texturizer plug-in for 3D Studio Max is promising, but ultimately outmatched by UV Unwrap. However, if you're not using Max and don't have a utility of this nature, you should check out Sven's stand-alone version of SurfaceSuite. Softimage, Lightwave, Maya, and Photoshop files can be easily brought into SurfaceSuite Pro, and the package offers the same features as the set of plug-ins — Texturizer, Multimask, Gaussian Blend, and Global Map Generation — without tying you to Max. Texturizer has promise, but for now, my money's on UV Unwrap for UV manipulation in 3D Studio Max. ■

SurfaceSuite Pro for 3D Studio Max: ★★★½

Company: Sven Technologies
Palo Alto, Calif.
(650) 852-9242
http://www.sven-tech.com

Price: $495 (stand-alone version is $595)

System Requirements: Windows 95/98/NT, 3D Studio Max, 32MB RAM and an SVGA video card

Pros

1. Easy to set up.
2. Four plug-ins instead of one.
3. Moving association points around on the mesh is very slick.

Cons

1. Tutorials are a little weak.
2. The editing window doesn't remember settings.
3. Naming infinitely numbered association points slows down the work flow.

Back

by Jeff Lander

When Two Hearts Collide

February is Valentine's month. Spring is in the air. People can meet, fall in love, and have their hearts broken all before their first cup of coffee. I don't think we've reached the point, yet, where we can adequately simulate a broken heart. However, I do think we can reasonably detect whether two people are close enough for their hearts to collide.

Last month, I discussed the use of the dot product and cross product to handle collision detection for 2D applications. This month we'll look at how to apply the same principles to 3D. Most discussions of collision detection for real-time game applications begin with bounding spheres and bounding boxes. These two tests are very rough indicators of whether or not a collision has occurred. Bounding spheres are a very fast method for testing collisions. However, as we saw last month, bounding spheres don't generally provide the best approximation of an object's extents.

Don't Box Me In

An axis-aligned bounding box (AABB) is also a very quick way of determining collisions. The fit is generally better than a bounding sphere (especially if the object you are bounding is a box itself). You can see an AABB on an object in Figure 1. However, once you rotate the object a little, the bounding box may not be nearly as efficient, as you can see in Figure 2.

This discrepancy could clearly lead to cases in which you mistakenly assume that a collision has occurred. But, as a first step, calculating an AABB may not be too bad. We could allow the original bounding box as calculated in Figure 1 to orient along with the object (Figure 3). This is called an oriented bounding box (OBB). It's definitely a better fit than Figure 2, however, I have lost the key benefit of AABBs. Aligned axes make AABBs easy to use in collision detection. Checking whether a point has entered the box involves only a trivial calculation. With OBBs, checking for collisions is more complicated. In many applications, OBBs may be worth pursuing further, but for a quick first check, I want to stick with AABBs.

So what are the main problems with coding up AABBs? Well, the biggest issue with using AABBs is that they need to be recreated every time the object changes orientation. This means that every vertex must be transformed by the object's matrix and the minimum and maximum extents must be calculated. Listing 1 contains a routine that calculates an AABB for an object.

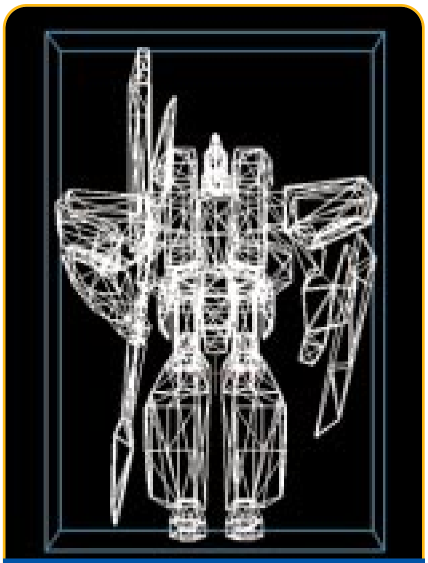


FIGURE 1. *Axis-aligned bounding box on an object.*

The noteworthy line in this code is the `MultVectorByMatrix()` call. This function transforms each vertex coordinate of

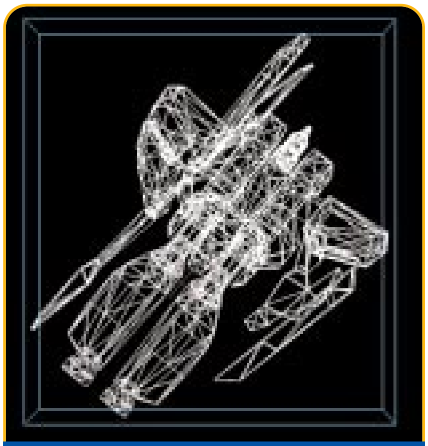


FIGURE 2. *Axis-aligned bounding box on a rotated object.*

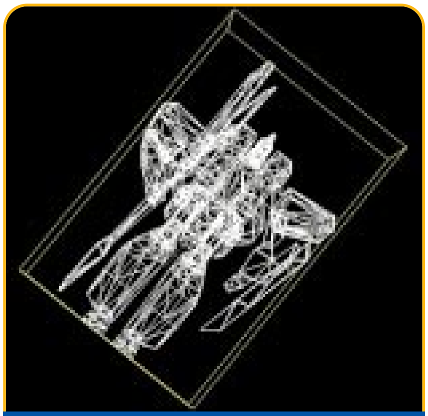


FIGURE 3. *Oriented bounding box on a rotated object.*

Jeff watches over a vast empire at Darwin 3D. He is also responsible for any collisions involving his e-mail box at jeffl@darwin3d.com. Test his collision response efficiency by sending him questions and comments.

the object into world space, given the current object orientation.

In the best case, this transformation can be reused when it comes to drawing the model. However, in the worst case, you'll be duplicating transformation work. In any case, the CPU is handling the matrix transformation for these bounding boxes. With the appearance of transformation hardware on graphics cards (such as the 3Dlabs Glint GMX and Diamond Fire GL 5000), this is a very costly operation. As this kind of hardware begins to dip into the consumer 3D hardware space, programmers need to be very careful to avoid using techniques that require vertex transformation by the CPU. Calculating a bounding box for a model with many vertices is a fairly expensive process. If your models are large, this can be a big frame-rate vampire that sucks the life right out of your game.

Getting More Bang For My Buck

You may wonder if there is any way to avoid having to transform every vertex into world space in order to find the bounding box. There is a way. However, like many things in computer game programming, there is a trade-off. Because I've already calculated the bounding box of the object in its rest position, it's possible to transform only those extreme points by the current orientation and get a new bounding box. In other words, I can take the vertices of the object's OBB and use the maximum and minimum of those positions to create a new AABB. I'm guaranteed that the new bounding box will completely contain the object because I've used the extreme extents of the initial position to create this new box. It may not be a tight fit, but it will fit. The good part is that this solution only takes eight transformations to calculate this new box — quite a bit of savings if your model contains many vertices. You can see the difference in Figure 4. The image on the right is the true AABB for the object. The image on the left is created using the yellow OBB as the source for the AABB. Listing 2 contains the code for calculating a bounding box this way.

Obviously, for some cases, this

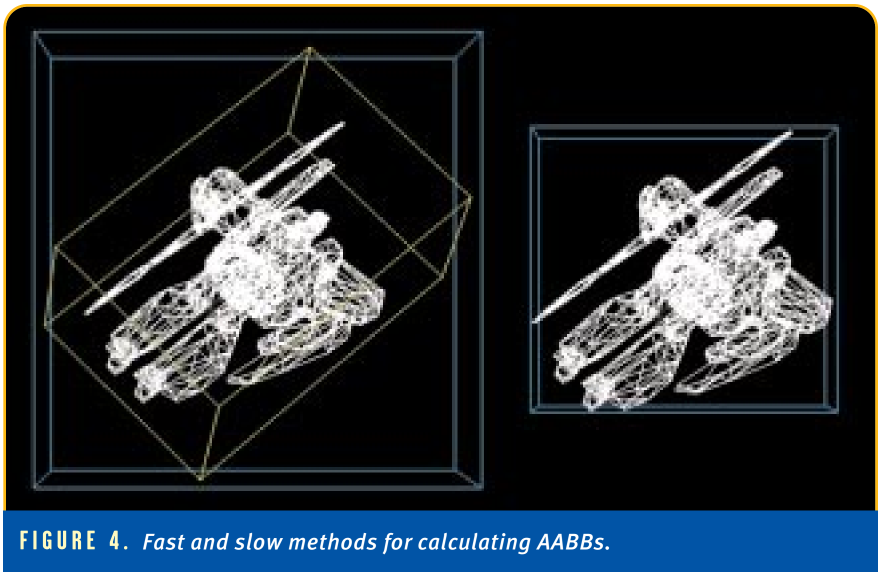


FIGURE 4. *Fast and slow methods for calculating AABBs.*

LISTING 1. *Calculate an axis-aligned bounding box for an object.*

```
////////////////////////////////////////////////////////////////////////////
// Procedure:         RecalcFullBBox
// Purpose:           Recalculates the BBox associated with a bone based on the
//                    new position for the vertices.  Tighter fit in
//                    most cases.  However, has to process all vertices
////////////////////////////////////////////////////////////////////////////
GLvoid COGLView::RecalcFullBBox(t_Bone *curBone, tVector *min,tVector *max)
{
/// Local Variables ////////////////////////////////////////////////////////
tVector               *temp,tempRes;      // X,Y,Z VECTORS
tNormalVertex         *nvData;            // VERTEX WITH NX,NY,NZ,X,Y,Z
t_Visual              *visual;
////////////////////////////////////////////////////////////////////////////
visual = curBone->visuals;                          // GET AT THE VISUAL ATTACHED TO A BONE
nvData = (tNormalVertex *)visual->vertexData;       // THE ACTUAL INTERLEAVED VERTEX DATA
for (int loop = 0; loop < visual->faceCnt * visual->vPerFace; loop++)
{
          temp = (tVector *)&nvData->x;             // POINTER TO THE VERTEX XYZ VALUES
          MultVectorByMatrix(&curBone->matrix, temp,&tempRes);  // MULT BY THE BONE MATRIX
          // FIRST VERTEX, SET IT AS THE MAX AND MIN
          if (loop == 0)
          {
          memcpy(min,&tempRes,sizeof(tVector));
          memcpy(max,&tempRes,sizeof(tVector));
          }
          else
          {
          if (tempRes.x > max->x) max->x = tempRes.x;
          if (tempRes.y > max->y) max->y = tempRes.y;
          if (tempRes.z > max->z) max->z = tempRes.z;
          if (tempRes.x < min->x) min->x = tempRes.x;
          if (tempRes.y < min->y) min->y = tempRes.y;
          if (tempRes.z < min->z) min->z = tempRes.z;
          }
          nvData++;
          }
}
```

method doesn't result in nearly as snug a fit as our original AABB calculation. However, it's certainly faster, and on a system with hardware vertex transformation, you may prefer it. Which method is right for your game? How should I know? Try them both and see. If you're using bounding boxes as a quick early check and have more sophisticated methods in follow-up tests, this quicker method may be good enough.

When creating the initial bounding box for the faster AABB method, it's easiest to calculate the AABB of the object in its initial rest position. However, the initial bounding box doesn't have to be axis-aligned. You can achieve a better fit by defining an OBB in the modeling program when the object is built. The method will then use the OBB to calculate the current AABB. Depending on the model, an initial OBB may really help. Certainly, a box built on a diagonal is a perfect candidate for an initial OBB.

When Two Boxes Collide

My nice new bounding boxes overlap in two of my objects. Chances are, I have a collision occurring between them. But I have to make sure. Also, in order to do some interesting things, I need to determine exactly where they are touching. Take a look at Figure 5.

The bounding box of the two objects clearly are colliding. It's also just as clear that the objects themselves are not. This is why being a human is great and being a game programmer is difficult. A child can easily determine that the two objects in the picture are not actually hitting each other. If a game relies solely on bounding boxes for collision detection, players may feel cheated when two objects "hit" when it appears as if they didn't. So, how can the computer determine that this is really not a hit? Notice that both of these objects are convex. This distinction is very important. I'll talk about what to do if your object is concave later, but for now, let me only consider the case where the two objects being tested are convex.

Last month, I talked about the idea of separating lines. When dealing with 3D, if I can find a plane that separates the two objects, then I know for certain that the objects are not colliding. I'll begin by considering each face of each object as the separating plane. It should be clear that the face highlighted in yellow in Figure 6 defines a plane that completely separates the two objects.

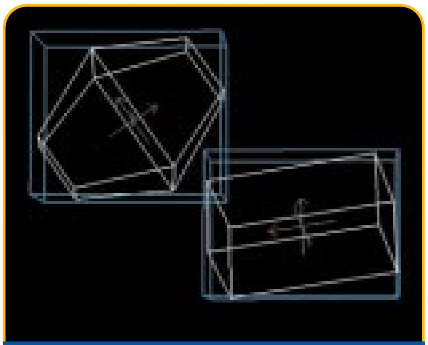


FIGURE 5. *Two objects near a collision.*

In order to test this separation plane, I need to make sure that all the vertices of the right object are on the other side of this plane from the test object on the left. It's helpful to have a normal defined for each face in the model. If you don't have face normals defined in

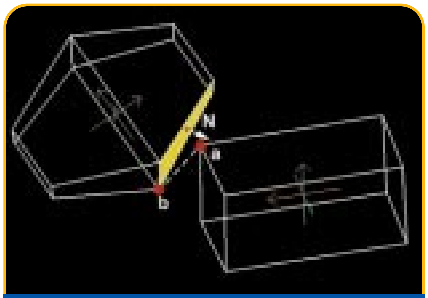


FIGURE 6. *Finding a separating plane.*

LISTING 2. *Faster AABB calculation using starting OBB.*

```
///////////////////////////////////////////////////////////////////////////////
// Procedure:       RecalcBBox
// Purpose:         Recalculates the BBox associated with a bone based on the
//                  original bounding box.  This is faster then the true BBox in
//                  most cases.  However, this BBox is not as tight a fit.
///////////////////////////////////////////////////////////////////////////////
GLvoid COGLView::RecalcBBox(t_Bone *curBone, tVector *min,tVector *max)
{
/// Local Variables ///////////////////////////////////////////////////////////
tVector   tempRes;
int       loop;
///////////////////////////////////////////////////////////////////////////////
for (loop = 0; loop < 8; loop++)          // LOOP THROUGH ALL 8 BBOX COORDS
          {
          MultVectorByMatrix(&curBone->matrix, &curBone->visuals->bbox[loop],&tempRes);
          memcpy(&curBone->visuals->transBBox[loop],&tempRes,sizeof(tVector));
          if (loop == 0)
                    {
                    memcpy(min,&tempRes,sizeof(tVector));
                    memcpy(max,&tempRes,sizeof(tVector));
                    }
                    else
                    {
                    if (tempRes.x > max->x) max->x = tempRes.x;
                    if (tempRes.y > max->y) max->y = tempRes.y;
                    if (tempRes.z > max->z) max->z = tempRes.z;
                    if (tempRes.x < min->x) min->x = tempRes.x;
                    if (tempRes.y < min->y) min->y = tempRes.y;
                    if (tempRes.z < min->z) min->z = tempRes.z;
                    }
          }
}
```

the model file, you can create them by averaging the vertex normals or by taking the cross product of two of the vectors that make up the face. I can begin once I have a face normal to test with — such as N in Figure 6. I create a vector between a vertex on the test face and each vertex on the colliding object. For example, I create a vector between points A and B in Figure 6 and call it Vector AB. Then I take the dot product of that vector and the face normal, N • Vector AB. If this value is positive, vertex A is not colliding with the object. If all the vertices in the colliding object are on the far side of the separating plane, then I definitely don't have a collision, and I'm done.

What happens if I've gone through all of the faces and cannot find a separating plane? Do I definitely have a collision? Unfortunately, no. There may be a separating plane that's not a face on either object. An infinite number of planes exist, so how can I find one that separates the two objects?

Balancing on a Polygon Edge

Luckily for me, I don't have to try arbitrary planes to see if they separate the objects. It turns out that if the separating plane is made up of a face on the object, then it must contain an edge in the object. Figure 7 displays two objects that cannot be separated by any face in either object.

In this case, I create a plane composed of edge A and vertex B. If all of the vertices of Object 1, with the exception of those that make up edge A, are on one side of the plane, and all of the vertices of Object 2, with the exception of vertex B, are on the other side, then I may have found a separating plane. One last check has to be made in order to make sure that vertex B isn't actually on edge A. If they were collinear, that would obviously be a collision. Once that possibility is ruled out, I can mark this as the separating plane.

Once I've tried every edge/vertex pair as well as all the faces, then the objects must be colliding. However, once I've found this separating plane, I can be sure that the objects are not colliding and I can move on. After the separating plane is found, it should be stored. Going through all of the faces and edges to find a plane is obviously pretty expensive to calculate. By saving the separating plane from the previous frame, I can take advantage of the fact that the separating plane tends to remain the same over several frames.

As I mentioned earlier, all of these tests only handle convex objects. It is much easier to determine collision on convex objects. If your objects are concave, you will need a method for creating a convex hull around the object. You can do this through a variety of methods. The concave object can be broken into several convex objects. There are also automatic methods of generating a convex hull around a concave object. One of the most popular methods is called QHull. You can find a link to it in the references. However, it may be much more efficient to have the artists create a convex collision object for every object in the game. That way, the artist can make the decisions about exactly what features are important to define as part of the collision boundary. This approach abides well by the game developer's philosophy: "Do as much work up front as possible, especially if it saves run time."

Boom, Boom, Out Go the Lights

That's all the time for this month. The sample application will allow you to load an object and play around with bounding boxes. When two objects have overlapping bounding boxes, a separating plane will be found, if possible. If not, a collision will be reported. Next month, I'll take up the issue of collision response so we can find out what to do once a collision has happened. ■

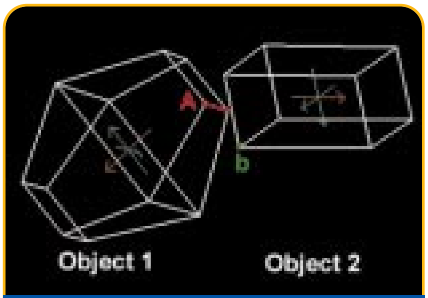


FIGURE 7. *Separating two objects by an edge-plane.*

REFERENCES:

Collision detection is a very active area of research. This method represents only one.

• Gottschalk, Lin, and Manocha. "OBBTree: A Hierarchical Representation for Rapid Interference Detection." University of North Carolina, Chapel Hill. http://www.cs.unc.edu/~geom/OBB/OBBT.html
I mentioned the use of oriented bounding boxes. This paper extends this method to include a hierarchy of OBBs. Also, several sources discuss the use of tracking the closest features of two objects in order to determine when a collision occurs.

• Gilbert, Johnson, and Keerthi. "A fast procedure for computing the distance between complex objects in three-dimensional space." *IEEE Transactions on Robotics and Automation*, April 1988, pp. 193-203.

• Lin, M. C. "Efficient Collision Detection for Animation and Robotics." Ph.D. Thesis, University of California, Berkeley, December 1993.

• Baraff, David, and Andrew Witkin, "Physically Based Modeling," *SIGGRAPH Course Notes*, July, 1998, pp. D32-D40. This paper also describes a method for using bounding box frame coherence to achieve more efficiency.

• Barber, Dobkin, and Huhdanpaa, "The Quickhull algorithm for convex hulls," *ACM Transactions on Mathematical Software*, Dec. 1996. This is the QHull library for calculating convex hulls. You can find more info at http://www.geom.umn.edu/software/qhull/

• There are also several libraries of collision routines available for use in non-commercial applications. Commercial applications may require a fee, so be sure to contact the source before using any library in a game application. These include I-Collide, V-Collide, Enhanced GJK, and others. A good link for all of these is at the University of North Carolina, Chapel Hill web site, http://www.cs.unc.edu/~geom.

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by Mel Guymon

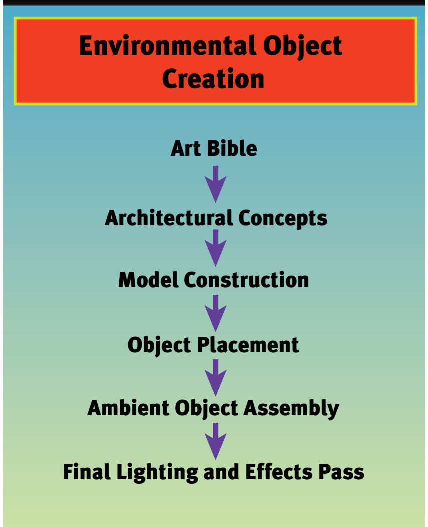
Playing God: Creating Convincing Environments in RT3D

In last-month's column, part one of the "Playing God" series, I outlined a process for streamlining the production of game-play–critical objects. This time around, we'll look at the problem on a larger scale. Instead of focusing on the creation of each individual model, we'll examine how to assemble the separate component parts so that the result is a convincing, immersive world. We'll look at ways to populate the environment with vast detail (with minimal effort), as well as go over some general tips and tricks on creating the world itself.

The Art Bible

In January, we discussed the importance of the art bible as it pertained to game-play–critical objects. We saw how the art bible served as a guide to both designers and artists when trying to apply form to function and minimize the development overhead while maintaining a coherent look-and-feel for game-play–critical objects. If the environmental art serves to define the aesthetic for the game, and the art bible outlines that aesthetic, it therefore follows that when it comes to creating convincing environments, the art bible remains the single-most critical document to which the artists will refer. Please see my column in last month's issue of *Game Developer* for more discussion about putting together a solid, evolving art bible. In short, a solid art bible should have enough information, organized intelligently, to completely familiarize new art team member with the game in only a few days.

FIGURE 1. *Environmental object creation flowchart.*



What Constitutes an Environment?

In the most general sense, environmental art includes all those resources necessary to create a graphically convincing world. It is critical to plan for and identify those items that are the minimum required for creating an immersive RT3D experience because time and personnel are both limited. These critical environmental items fall into three basic categories:

TOPOGRAPHY. Potentially the most time-intensive part of the project, this is the underlying structure within which all game play takes place. Depending on the genre of your game, the topography can be anything from a corridor-based underground maze to a string of floating islands suspended in the clouds. The important thing to remember is that you will be building your world literally from the ground up, so isolating a consistent technique early on is critical. Because the rest of your objects need to fit within this landscape, it is a good idea to spend extra time tweaking the style and composition, otherwise you may find yourself redesigning work that was based on a different aesthetic. The techniques for creating terrain are often specialized and unique to the rendering package being used, although with standardized hardware acceleration, the playing field is becoming increasingly level. This topic alone could fill an entire article, so we're going to assume uniform competency and move on to the next part of the process.

ARCHITECTURE. All artificial structures that game play takes place in or around constitute architecture. Usually, these spaces are separate from the world topography and can be developed concurrently. If the topography determines the overall atmosphere for the world, then the architecture determines its character. And because most game-play objectives depend on some sort of artificial structures to give them functionality, the architectural style for the world must be outlined before the game-play–critical items can be created.

AMBIENT OBJECTS. These are the little things that are used to fill out the environment. Though not critical to

Mel has worked in the games industry for several years, with past experience at Eidos and Zombie. Currently, he is working as the art lead on DRAKAN (http://www.surreal.com). Mel can be reached via e-mail at mel@surreal.com.

game play, these items are essential in that they make the world believable. If the architecture objects in a level are analogous to a basic set of Legos, then the ambient objects in the level are analogous to the Lego expansion sets. Sure, you could do some pretty cool stuff with the basic set, but to get your creations looking really cool and diverse, you need to bring out the expansion sets. Organizing the ambient objects in a way that is intuitive to use for artists and level designers can be a problem in itself, not to mention the mammoth task of creating all the objects themselves. To address this problem we're going to be working with object databases.

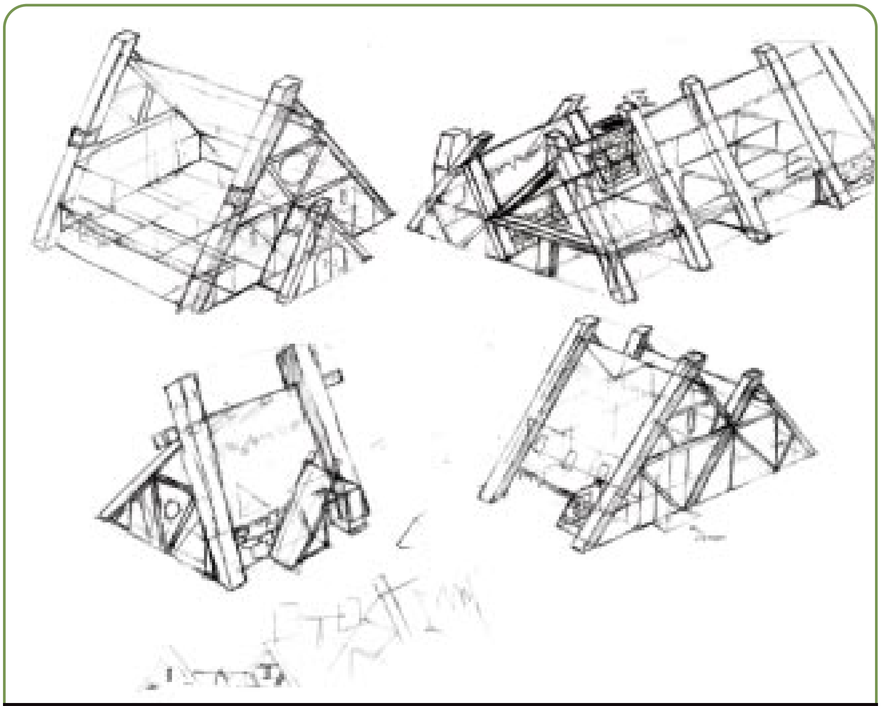


FIGURE 2. *Architectural concept sketches from DRAKAN.*

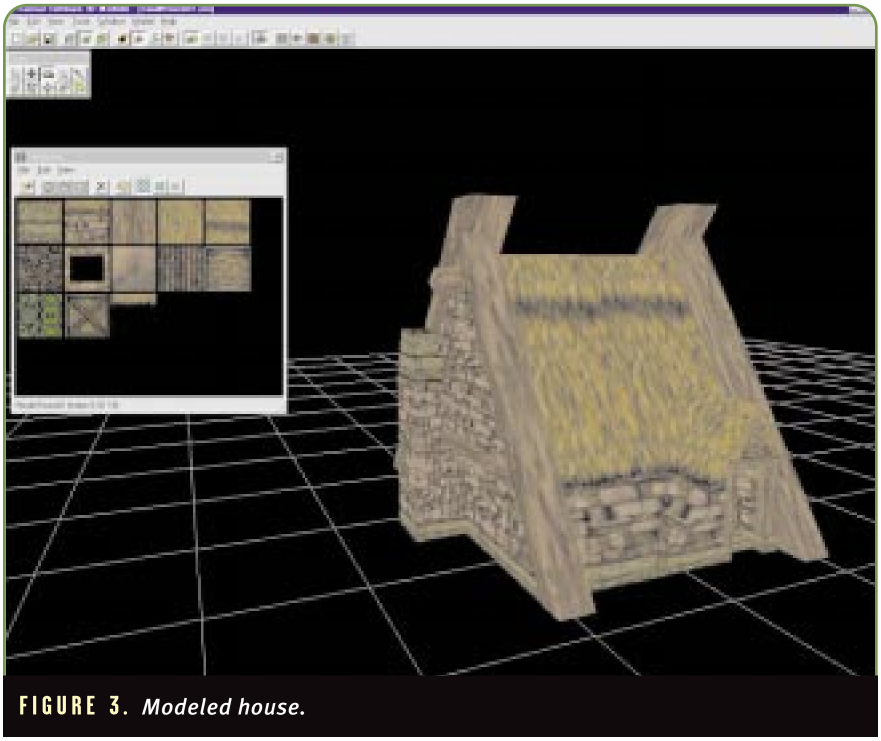


FIGURE 3. *Modeled house.*

Working with Object Databases

Creating a sufficient level of complexity in the environment is a task that can be tedious and time-consuming. One of the most efficient methods for creating detail in the environment is by means of object databases. An object database consists of a group of objects that can be used to create isolated pockets of detail, or to bring coherence to existing game-play areas. Let's say, for example, that you want to create several villages, each using the same style of architecture. The object database for the villages would contain three or four different buildings, plus an assortment of crates, barrels, woodpiles, curing sheds, outhouses, and so on. By using these objects in different combinations, a large degree of variation can be achieved with minimal overhead. The goal of the object database is to provide artists and level designers with a goody-bag full of generic building blocks with which to populate the world.

Figure 1 shows an example flowchart for the Environmental Creation Process. While these steps apply specifically to creating ambient game-play areas, the basic precepts can be applied to almost any part of the RT3D development process. The important thing is that you develop a process and stick to it. To examine the process more closely, let's look at an example, a farmhouse in the mountainous region of Surreal's world of DRAKAN.

Architectural Concepts

Once the basic architectural style is delineated in the art bible, each individual structure needs to be created on paper and then tested against the original concept. As the designs are being fleshed out, the art team can generate feedback for each individual piece. And since you are still working on paper, this is the point in the process where changes to the design can be made with rapid turnaround and little or no work loss. Figure 2 shows an example of a set of design sketches for human-based architecture.

Model Construction

After the concept has been massaged and checked against the overall aesthetic, the structures can actually be built in 3D. Figure 3 shows the model of a farmer's house based on the previous architectural concept sketches. Note that there is little deviation from the concept sketch to the completed model. This is a good benchmark against which to measure the effectiveness of your process. While each step brings an evolution of the aesthetic, if there are large style gaps between each step, you are probably not spending enough time in the early phases of the game. When a deadline looms, the processes tend to fall to the wayside due to time pressures. This can cause problems later on because as the aesthetic for each phase diverges from the original concept, the results become less predictable, reducing your ability maintain a coherent artistic vision throughout the game.

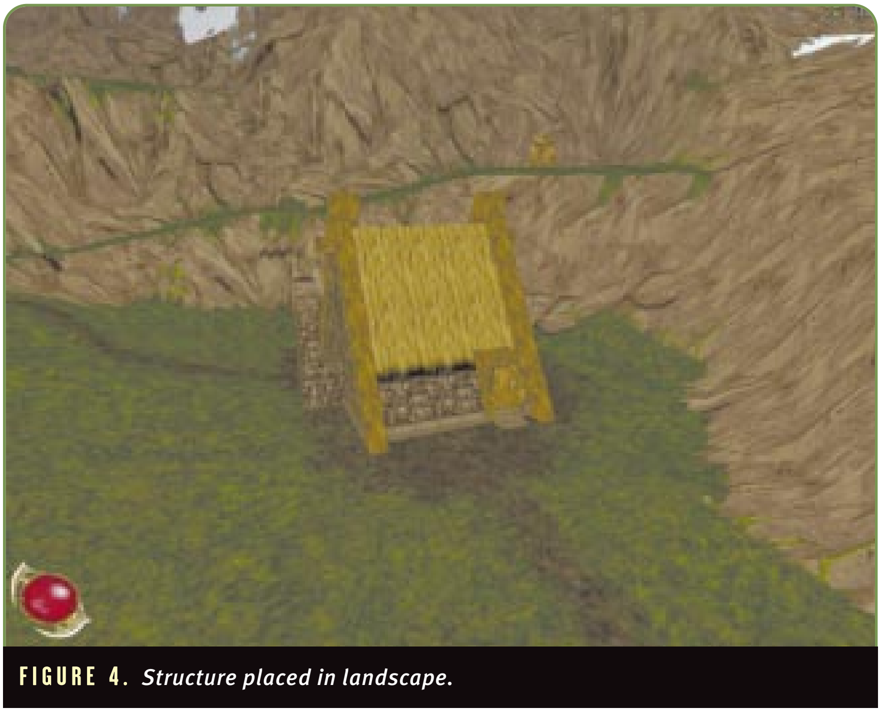


FIGURE 4. *Structure placed in landscape.*

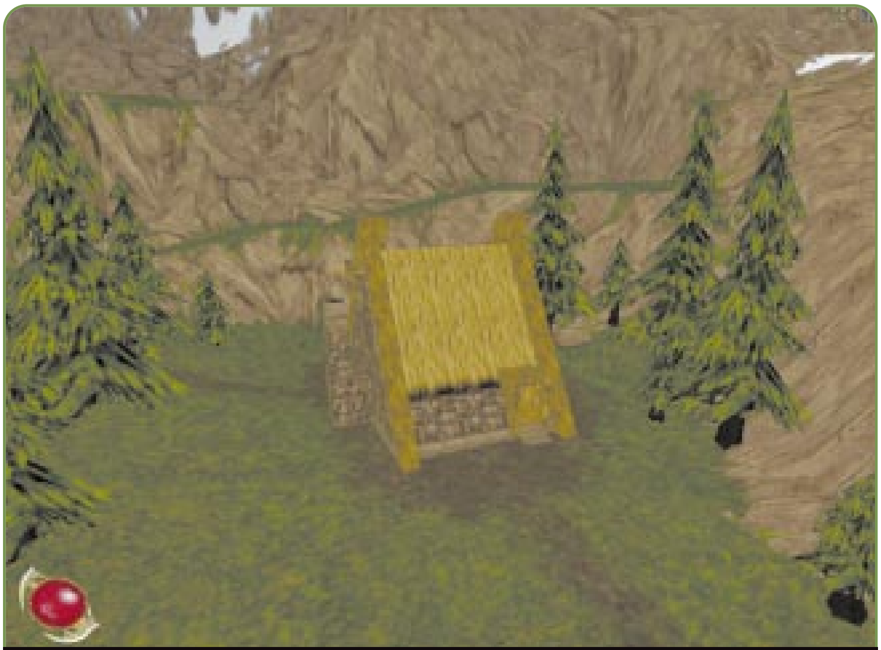


FIGURE 5. *Farmhouse with trees.*

Object Placement

In Figure 4, we can see the first pass at creating the farm. Note that the only things present at this point are the topography with its associated textures and the farmhouse. While the house is well designed and readily identifiable, the overall effect is not very convincing. The house lacks context. At this point it's time to go to the object database and begin assembling the individual pieces to add to the scene.

Ambient Object Assembly

In Figure 5, we can start to see the beginnings of a realistic outdoor scene. From our mountain world object database, some trees have been added to help achieve the effect of a mountainous forest. In this case, instancing and object redundancy have been exploited — there are, in reality, only two unique tree models in this scene, but they have been scaled and rotated to create variation and hide the similarities. Here again, we are getting the maximum amount of use out of our objects because we are using instancing. Note, also, that the farmhouse now has a better size reference, where before there was none. Still, the effect is not complete; the house appears in the scene as the only man-made object, and looks out of place.

Now it's time to dip into the farmhouse object database goody-bag and customize our farm. To do so, we will add four objects: a barrel, a crate, a cart, and a section of fence. With the addition of these ambient objects, the farmhouse is unmistakable (Figure 6). Not only do the ambient objects serve to give variation and diversity to each individual structure, the additional objects serve to cement firmly the structure's place in the landscape, while filling out the scene with interesting eye candy. This aids in game play as well because now that there is a fence, the player is funneled directly

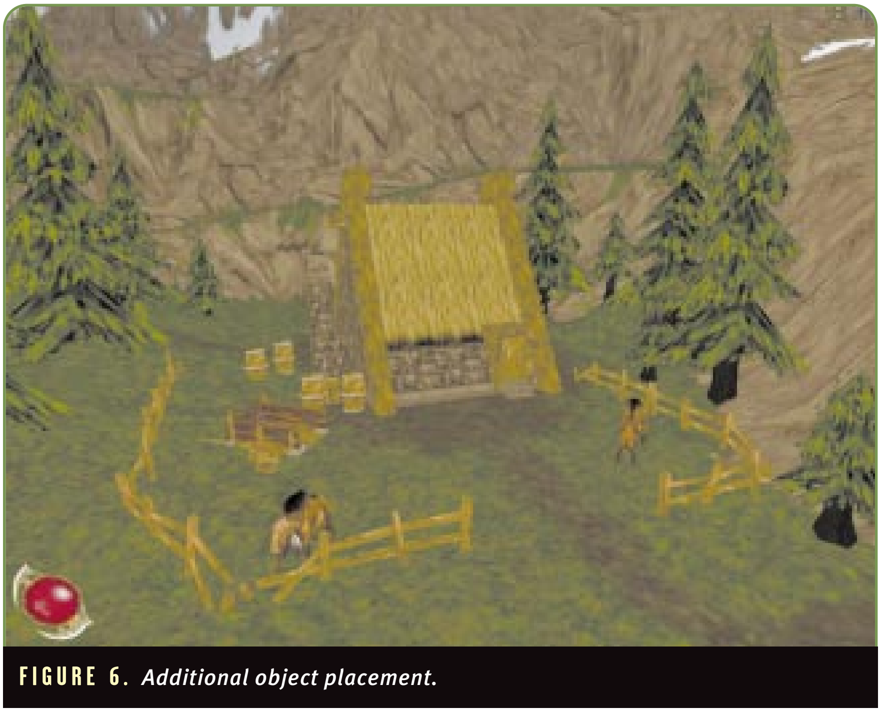


FIGURE 6. *Additional object placement.*

towards front side of the house. Finally, with the addition of a cow or two, the scale of the building becomes even more recognizable, so that the overall effect is very convincing.

Final Lighting and Effects Pass

Once you've got all the models assembled in your world, it's time to add the finishing touches to the area to give it some atmosphere (Figure 7). We've adjusted the lighting in the world to mimic the ruddy glow of a setting sun, with a small amount of blue in the shadows. We've also added a small campfire in front of the house to give it some additional character. Most engines that support hardware accelerators also support colored lighting, so it's a good bet you'll be able to get your scene looking something like this. Now, go back and compare this result with the image in Figure 4, and you can see that with just a little preparation and attention to detail, a few objects can make a huge difference.

Tips and Tricks

TEXTURES AND LIGHTING. When creating textures that are going to be lit with in-game lighting, you'll need to be careful to avoid textures that are too dark. Most lighting routines slightly modify the existing RGB values of the texture, which boosts the already existing hues. This means that dark textures tend to stay dark, which basically defeats the lighting process.

LIGHTING. As we demonstrated in the above examples, taking the time to light your levels with dynamic color combinations can yield a tremendous return on the time invested. However, this does take time to get right, so do some experimentation and schedule yourself enough time to tweak it.

OBJECT DATABASE USAGE. One of best ways to take advantage of the object database is to have a junior level designer or artist simply go over the levels and drop in objects where they see fit. This is a good experience for the artist or designer and it doesn't tie up your key people on a job that is somewhat tedious and mundane.

USE MOCKUPS WHERE POSSIBLE. If your team is coding their own engine, there will probably be some dead time until the art path is solidified and you can actually get your resources into the game. In the mean time, try setting up your environments in whatever modeling package you're using in-house (Softimage, 3D Studio Max, and so on). This works especially well when trying to come up with special effects routines in whatever engine you're using. By sitting down with an engineer and playing around with the particle system in your modeling package, for example, you can work together to visualize the effect you're trying to achieve before any time is wasted moving in the wrong direction. ■

SPECIAL THANKS:
Alan Patmore, Hans Piwenitzky, and Louise Smith.

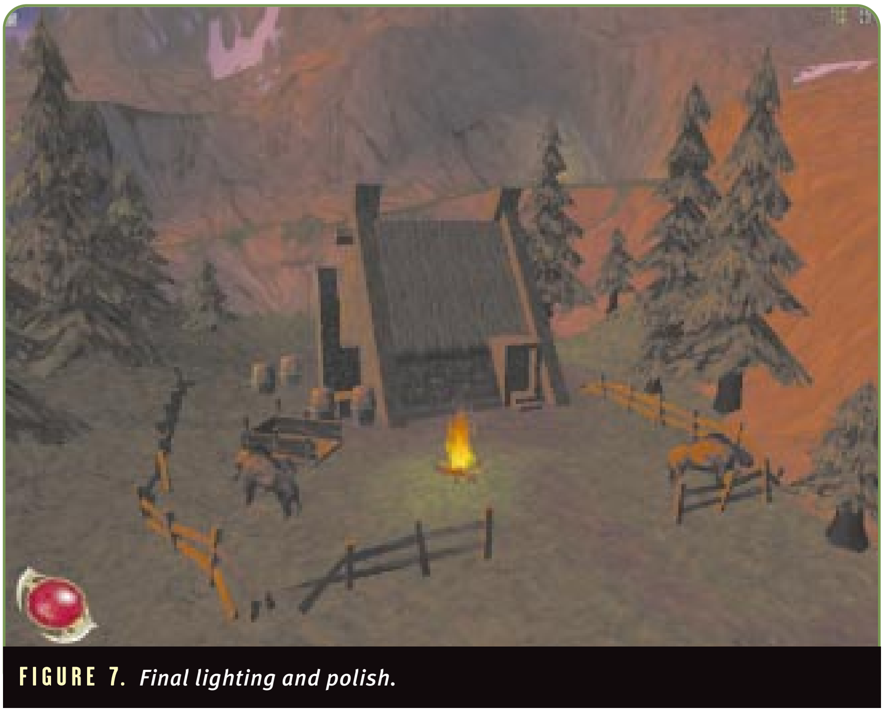


FIGURE 7. *Final lighting and polish.*

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3Dfx Against the Rest

No graphics chip or board company has reigned supreme over its competitors for very long. Usually, once a company achieves the exalted position of Number One, it can look forward to a short stay at the top. And no graphics chip or board company has built as strong a consumer brand, in as short a period of time, as 3Dfx. In 1999, 3Dfx will have to transition from a 3D-only game players' brand to a fully fledged graphics company that competes in both OEM and retail markets. How 3Dfx competes, and how the competition behaves, will define the landscape of 3D graphics for PC game developers.

Voodoo3: A Miss or a Direct Hit?

At Fall Comdex 1998, 3Dfx announced Voodoo3. In many ways, Voodoo3 is what Banshee could have been, and in some ways it's a descendant of Voodoo. However, Voodoo3 certainly isn't a clear-cut winner for the company because it puts 3Dfx in the same 2D/3D graphics chip category as everyone else in the business.

First, Voodoo3 is not one chip or chipset. It comes in two packages: the 2000 and 3000 versions. The Voodoo3 2000 is targeted at the OEM market, while the Voodoo3 3000 is a more high-end version targeted at the retail market where Voodoo and Voodoo2 have done so well. The differences between the two Voodoo3 chips and Banshee are quite straightforward. The Voodoo3 has the dual texture engines of a Voodoo2; it supports AGP 2X, with planned support for AGP 4X in the works. 3Dfx claims Voodoo3 delivers performance in excess of Voodoo2 SLI configurations, but in a 2D/3D integrated package. The Voodoo3 3000 is the much more interesting part of the two; it's capable of supporting resolutions of up to 2048×1536 at 75Hz refresh rates. However, Voodoo3 is an 8.2 million transistor titan of a chip. That makes it as complex as any high-end CPU on the market today, and 3Dfx will have its work cut out to deliver the highest performance versions of the chips by its mid-1999 deadlines. The most likely scenario is that the Voodoo3 2000 will be the first chipset to ship in full production, followed by the Voodoo3 3000. It's also likely that in the retail channels, you will find both versions of the chipset, although PC OEMs probably won't want to integrate the Voodoo3 3000 because of its higher cost.

While Voodoo and Voodoo2 gave 3Dfx a unique position in the retail market, the emergence of Voodoo3 puts them squarely in the same market as any number of other chip vendors. At one point, they could have remained aloof from the fray, but now 3Dfx must duke it out in the same mud pit with everyone else. It's a no-holds-barred contest that 3Dfx may not be equipped to win, even with the best technology.

The Competition

In direct competition with 3Dfx are Nvidia and 3Dlabs. These two companies compete via technologies that are supposed to drive their products into the mainstream from the upper end of the multimedia PC spectrum. What these companies covet most is the

*3Dfx's quarter by quarter growth. In 1996 the company made in excess of $6 million. *The company noted $13 million as income, primarily due to its successful court case against Sega and NEC/Videologic. (Source: company financial statements; figures are in thousands).*

	Q4 1996	Q1 1997	Q2 1997	Q3 1997	Q4 1997	Q1 1998	Q2 1998	Q3 1998
Revenue	$4,503	$5,247	$6,507	$10,018	$22,296	$50,008	$58,643	$33,206
Cost of product	3,404	2,582	3,278	5,352	11,399	25,730	30,443	24,971
Gross profit	1,099	2,665	3,229	4,666	10,897	24,278	28,200	8,235
Research and development	2,288	1,953	2,397	3,201	4,860	5,826	8,308	10,038
Selling, general and administrative	2,422	1,846	2,521	2,684	4,338	9,638	8,041	6,971
Net income (loss)	($3,598)	($1,161)	($1,753)	($872)	$2,704	$7,462	$9,032	$3,118*

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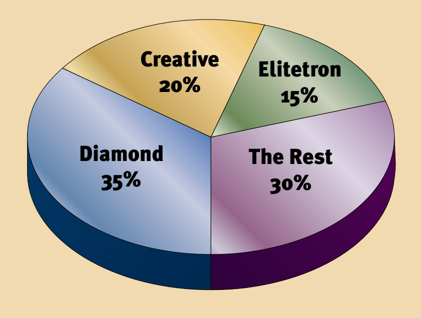
Board makers' shares of 3Dfx revenues for the first three quarters of 1998.



slot occupied by companies such as ATI and Matrox, but the technological area that they have gone after is the 3D performance of Voodoo. By contrast, Matrox, despite some poor showings in the 3D performance stakes, continues to dominate PC OEMs product segments where 2D performance is still the primary driving force. As a result, Matrox has a strong position in the entry-level Windows NT workstation lines of Compaq and Hewlett-Packard, product lines that are squarely aimed at financial markets and standard corporate users. Both ATI and Matrox, however, have enough branding to make it onto most of the major retail shelves and, as a result, they have a strong consumer following. S3, Trident, and even Intel (with its agenda to sew up the low-cost PC market) don't possess the same performance advantages of 3Dfx or Nvidia. These companies all need the volumes that PC OEMs bring in order to fuel future developments — and their ambitions. In the midst of all this, PC OEMs just want to make sure that sockets are filled in the confusing array of product segments and lines they produce.

3Dfx and Nvidia found some solace in the fourth quarter of 1998 when Matrox, ATI, S3, and 3Dlabs failed to deliver products competing products. By the time Voodoo3 is supposed to come out, the competition may be stronger. S3 has plans for a follow up to Savage3D, ATI is expected to be in full swing with the Rage 128, and 3Dlabs could still make it with Permedia 3. On paper, all these chipsets have an equal chance of succeeding against the others, and in truth, if they all work as they should, they will all find a home somewhere. No PC maker wants to sell the same components as a competitor, so there's plenty of business to go around. 3Dfx stands to gain the high ground if — much as Nvidia has to date — it can get its foot into both corporate and consumer multimedia systems on the basis of performance, reliability, and support.

Creative and Diamond at the Door

Another threat looms for 3Dfx. An outside chance exists that 3Dfx will merge or be acquired by a third party. So goes the general thinking in the industry, at least. The reason for this speculation can be traced to attempts by Diamond and 3Dfx to form a joint venture in late 1998. The story goes something like this: Diamond and 3Dfx started discussing ways of binding themselves to each other. The rumor mill spoke of mergers and joint ventures, but we may never know for sure. What is known is that Diamond initially benefited significantly from its relationship with 3Dfx, but then saw its profits from sales of Voodoo and Voodoo2 get eaten up by the force of numbers of other 3Dfx add-in board customers, particularly Creative Labs. Creative, in turn, got wind of Diamond and 3Dfx's machinations and did what any company with deep pockets would do: it voraciously consumed 3Dfx shares, making sure that any chance of a Diamond and 3Dfx partnership would raise the specter of its own bid for the company. That's the story, but it doesn't end there. Diamond knows that it needs technology and intellectual property to succeed. Creative Labs doesn't want Diamond to get its way. As a result, all chip companies are up for grabs at the right price, and consolidation in the 3D consumer graphics arena is only a matter of time. 3Dfx just happens to be the juiciest target.

Entertainment: Make it Less Fun?

3Dfx has transcended the image of other graphics chips, and firmly embedded itself in the minds of consumers. With so much brand equity built among end users, 3Dfx could quite easily do away with the middleman and sell boards into the market directly. However, there are some issues that, from the company's perspective, diminish the possibility of such an event.

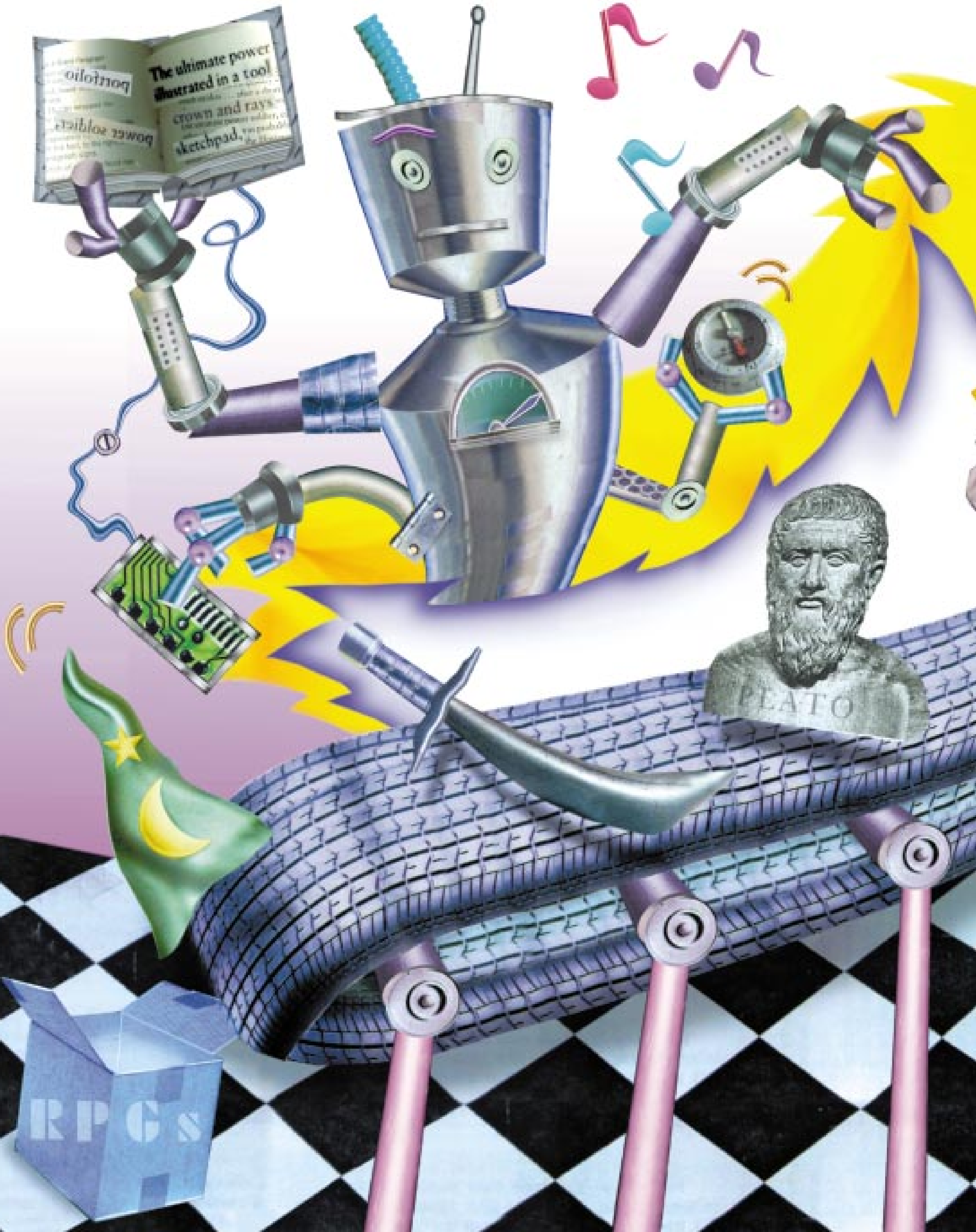
First, graphics chips still deliver better profit margins than boards. True, you can make more money with boards, but there is also the question of support, and sales and marketing through indirect channels (retailers and distributors). Presently, 3Dfx is focused on its technology and is leveraging its brand among game enthusiasts to drive its retail presence and with strong brand recognition. PC OEMs continue as customers. In the final part of 1998, only Nvidia and 3Dfx were setting the world on fire with new graphics chips. It's a sellers' market for now, and game players' appetites for 3Dfx products — diminished though they may be — are still sufficient to keep the momentum going.

News Flash

As this article was going to press, 3Dfx announced its intention to acquire STB Systems, and to become a fully-fledged provider of graphics chips and boards. This deal is expected to go through by March 1999. Among the benefits of this deal (as told by 3Dfx) are providing PC OEM and retail customers a single source for 3Dfx branded add-in-boards for greater price stability and smoother product transitions; the provision of reliable manufacturing capabilities as prequalified supplier to the top ten PC-OEM manufacturers; a more tightly integrated chip, software, and board-level layout and design for faster time-to-market and the most cost-effective graphics solutions; and a more controlled and focused brand investment for an even stronger retail presence. This stirs things up big time in the graphics industry, and confirms what the industry believed would happen to 3Dfx. The outlook for Creative and Diamond is not clear, and probably by the time you read this Nvidia and other chip vendors will have made their own strategic moves as a counterpoint. So, now we have ATI, Matrox, 3Dfx/STB, 3Dlabs/Dynamic Pictures, and Evans and Sutherland/AccelGraphics as chip and board vendors against Creative and Diamond as brand name board makers with chip agnosticism. Not too long ago, there was really only ATI and Matrox. So now, as far as game developers are concerned, the board is the platform, and whoever has the market clout reaps the accelerated titles. Should be fun to watch. ■

Back

Remodeling



RPGs for the New Millennium

by Warren Spector

Illustration by Robert Zanmarchi

Despite working in a truly remarkable medium, one that provides powerful tools for the simulation of fantastic worlds and myriad ways to immerse players in them, many RPG designers these days seem content to recreate the glories of earlier computer games. Worse, many designers seem content to recreate experiences that they (and we, as players) first enjoyed in other media.

As I stated in my recent Soapbox column ("It's ROLE-playing, Stupid!", September 1998), we RPG designers are setting our sights too low. Look at the best RPGs of the last several years. As great as Diablo, Fallout, Daggerfall, and Might & Magic VI are, they really aren't anything that we couldn't have designed ten years ago. Do they represent significant advances over Wasteland or Ultima IV or the Underworld games? And were these older games striving for much more than a recreation of the tabletop role-playing experiences of their creators? It's as if we can't see beyond our early *Dungeons & Dragons* game experiences. It's time to move beyond simply borrowing game concepts and establish computer RPGs as an independent medium.

Warren Spector runs Ion Storm's Austin, Texas, office. He is currently working on a new role-playing game, Deus Ex. In the past, he has produced such RPGs as Ultima VI, Ultima VII, Part 2: Serpent Isle, Underworld 1, Underworld 2, and System Shock for Origin and Looking Glass Technologies. You can reach him at wspector@ionstorm.com

My intent with this article is to lay out the abundant variety of choices available to would-be and practicing RPG designers. Only by analyzing the tools that we all use in the creation of our games, discussing the ways in which these tools have been and can be used, and identifying the ramifications of those uses, can we take this genre forward.

It's probably not an overstatement to say that every new medium begins, creatively and aesthetically, by defining itself in terms of previous media. So it's not surprising that we RPG developers borrow from our forebears. In fact, every RPG developer today really owes his or her job to Dave Arneson and Gary Gygax, the creators of *Dungeons & Dragons*. Our debt to these two men is worth noting here if only to force a recognition of how little we've moved beyond the realm of 20-sided dice, the concept of character class, and those familiar core attributes of strength, wisdom, dexterity, and so on.

How do we identify a computer RPG? For the purposes of this article, a computer RPG is a game in which character development and character interaction take precedence over other factors and where each player's experience of the story is determined by individual choice rather than designer fiat. Though broad, this definition clearly eliminates real-time and turn-based puzzle and strategy games (lack of character development and interaction), as well as shooters and platform action games (lack of individual choice). Of greatest importance, this definition eliminates adventure games, which share with the RPG an emphasis on story and character. What adventure games lack — and this is a critical point — is the capability for players to grow and develop their characters, and to affect, if not the outcome of the story, than the way in which the story unfolds. Without both character development and genuine choice placed within a player's control, a game cannot be called a role-playing game, as I choose to define the genre.

Someday, we will concentrate on those aspects of computer RPGs that set them apart and we *will* leave our paper gaming roots behind. To do so, we have to be more daring in our designs — or, in the terminology of this article, in our selection of design tools. And to select the right tools, we need a better understanding of these tools and how they define the genre.

The term "tool" seems, at first, odd to use in the context of game design. When I use this term, I'm talking about the conventional *elements* that are sure to appear in any work that defines itself, or is defined, as a computer RPG. Any designer contemplating an RPG must take a stance with regard to all of these tools, even if that stance is to deemphasize one or more of them. What follows are the defining characteristics that must be present in any RPG.

Story

RPGs are story driven. There's a reason for talking to or killing people and monsters, a reason to build or destroy things. Unfortunately, though it goes without saying that

RPG Commandments

1. Each player's path through the story must be unique. This doesn't mean a branching-tree structure with winning and losing paths but, rather, that players will have the freedom to decide how they'll overcome game obstacles. A world simulation must be deep enough so that each game problem is open to a variety of solution strategies, from the most thoughtful and low-key to the most obvious and violent. And the solution you choose to any given problem must have clear consequences, both immediate (killing a guard sets off an alarm, attracting more guards) and long-term (killing a guard may result in "wanted" posters being posted, causing civilians to fear you and be less cooperative).

2. Players must always have clear goals. Though free to stray from the storyline at will, players must know what they're supposed to be doing, minute to minute and, if appropriate, mission to mission. The fun of the game is in overcoming obstacles and solving problems; the fun is in *how* you solve a problem, not in guessing *what* problem you're supposed to solve.

3. The level of interactivity must be high, with NPCs about whom you really care and with a densely populated, object-rich world that looks and behaves like the real world (or, at least, a believable, internally consistent world of your own creation). A big, empty world is boring. Players must be free to explore a cool and instantly understandable world.

4. The central character must grow and change in ways that matter to players in an obvious and personal way. During the course of play, you'll become more powerful, acquire more items, and develop new skills, of course. However, you'll also make unique friends and enemies, accomplish tasks and missions differently, overhear different conversations, and see different events unfold. By game's end, each player must control an alter ego that is distinct from that of all other players.

5. The game must be about something more than killing things, solving puzzles, and maxing out a character's statistics. Remember all those hours you spent in school analyzing the underlying meaning of novels, poems, and movies? Guess what: RPGs lend themselves to the same kind of analysis. Games can and must have an impact on players. That impact may be the simple adrenaline rush of DIABLO, fleeting and soon forgotten (nothing wrong with that), or it may be the never-to-be-forgotten (and, in some cases, life-changing) experience of becoming the Avatar in ULTIMA IV. If all you're doing is throwing wave after wave of monsters at players so that they can kill lots of stuff so that they can increase some arbitrary statistics so that they can feel powerful, you're doing yourself, your players and your medium a disservice.

RPGs must tell a tale, it's unclear whether the quality of that tale has much, if anything, to do with a game's success. One would be hard-pressed to describe the Avatar vs. Guardian (a.k.a. "kill the evil foozle") stories of recent ULTIMA games as on a par with what we demand from books and movies. DIABLO's plot hardly qualifies as compelling. UNDERWORLD's story of a hero locked in a dungeon until he can rescue a kidnapped princess hardly qualifies as narrative genius.

Currently, the kinds of stories we can tell seem to be limited by the expressive capabilities of our medium — it's tough to tell a great story when you can't recreate a young lover's shy smile or allow players to tell a joke rather than bludgeon somebody. Right now, what we do most easily and best is direct, one-on-one conflict (typically combat interactions), a fact that limits our narrative range just a tad. This is not to say we shouldn't strive for greatness in our stories, but we must find greatness in the strength of universal themes and in the ways in which we tell our necessarily simple stories.

Players of RPGs must have some degree of freedom in how they follow the threads of the plot and, in some cases, how the plot resolves itself. They can often pick the order in which they accept quests or even which quests they take and which ones they ignore. Further, how they conduct themselves during a quest, and how they interact with other characters, can alter the course of the story and its outcome.

The first and, arguably, most critical decision RPG developers must make with regard to story is whether to use a branching structure or to tell a story in a more conventional, linear fashion. The temptation is strong simply to say, "We're making a computer game. Computers allow branching in a way and at a level no other medium allows. Of *course*, we should use a branching structure." This argument, one I've made myself, goes back to the moral imperative to maximize the unique capabilities of the medium and to turn away from the techniques more appropriate to other media. It's perfectly understandable that computer RPG developers would want a branching structure if for no other reason than to differentiate games from books and movies. But let's think through the implications of that decision.

Often, making one choice — picking one branch over another — means that a player can't go back to the branch not chosen. I I may be prescriptive for a moment, if picking a branch doe *not* limit players' later options in some way, the branch is unneces sary and a waste of valuable development time. The illusion c player freedom isn't worth the de opment price.

However, assuming branching real choices (meaning, choices th limit player options even as the player moves forward through the plot), the approach can be worth the cost. Done well, branching can provide a powerful illusion of freedom for players. But, that's all it can provide — an illusion. The reality is that, if we don't put something in the game, on the screen, in the mouths of nonplayer characters (NPCs), it doesn't happen — and no amount of branching can allow players to do things we don't allow them to do. What this means is that the choices available to players solely as a result of branching are false, because eventually players are forced back onto one of the paths that we've created for them.

The first factor to consider when assessing whether branching is appropriate and/or necessary for your project is whether it's worth sinking valuable development resources into the creation of content that many, if not most, players will never see. And bear in mind that you're going to be spending time and money to ensure that the game makes sense regardless of the order in which each player sees each portion of the story. That's a lot of extra flags to set and check and a lot of extra art to create on the off-chance that players will stray from the logical path.

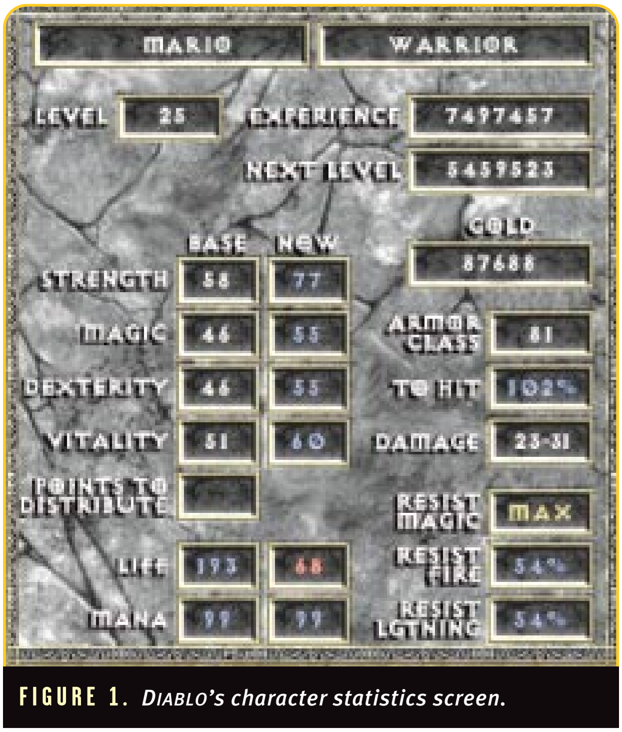
But what about replayability? Doesn't branching encourage players to keep playing a game? My first response would be, "Nah. By the time they finish your 100-hour epic, they're probably looking for The Next New Thing." Only the most zealous players replay games at all, and they're sure to see that a big percentage of their adventure differs not at all on subsequent playthroughs no matter which plot branches they follow.

extra effort. Though not vital to success (aesthetic or commercial) it's important that players talk about their experiences playing your RPG and, when they do, it's powerful when their descriptions differ, seemingly based on individual choices. As in all development-oriented decisions, it's important to weigh that power against the cost of achieving it.

It's also important to realize that once you do spend your development dollars on giving the player power over the way in which your story unfolds, that should become the emphasis of your game. You should try to give your players a big, contiguous world to explore and you should let them explore it freely and in any way they want — even at the expense of character development.

The alternative to branching is to tell a more traditional linear story. But telling a story in the way that stories have always been told isn't the answer. So what are the advantages of telling a linear story and how is this best achieved? Let's start with the biggest and most obvious advantage of the linear narrative, the story itself.

Clearly, you can tell a better story if you don't have to worry about and/or deal with all the ways in which players can screw up your carefully crafted epic narrative. It's generally accepted that a linear story in a game almost inevitably means a more powerful story. Given the cost of achieving the illusory freedom offered by branching storylines, the linear story seems to be a pretty good deal. In addition, depending on how you implement your linear story, you may find it possible to give players some genuine freedom to personalize their experience



MARIO WARRIOR

LEVEL 25 EXPERIENCE 7497457

NEXT LEVEL 5459523

GOLD 87688

	BASE	NEW		
STRENGTH	58	77		
MAGIC	46	55	ARMOR CLASS	81
DEXTERITY	46	55	TO HIT	102%
VITALITY	51	60	DAMAGE	23-31
POINTS TO DISTRIBUTE			RESIST MAGIC	MAX
LIFE	193	68	RESIST FIRE	54%
MANA	99	99	RESIST LGTNING	54%

FIGURE 1. *DIABLO's character statistics screen.*

rather than the illusion of freedom offered by branching narratives and huge worlds to explore.

What I'm getting at is that a linear story must have two characteristics. As the creator of a linear RPG, you must offer the player flexibility within episodes or narrative segments or on a single map or within a single mission. Combine this flexibility with a focus on something other than narrat (such as character development the driving principle behind yo game, and players won't notice that they're on rails, narratively speaking.

FINAL FANTASY VII does a wonderful job of allowing you to explore each of its locations with some degree of freedom. Players rarely feel constrained or stuck to a path, even though they are. The reason lies in the game's emphasis on character development. The designers recognized that freedom of movement would eventually interfere with the advancing plot, so they emphasized systems that allow players to create unique alter egos who respond to scripted events in ways that are often within the player's control. This feature allowed them to tell a better story with more interesting characters than would be present in a nonlinear game. I'm not saying that FINAL FANTASY VII is necessarily a better game than DAGGERFALL (a nonlinear game if there ever was one) — just that the designers clearly thought through the implications of the critical design decision to tell a linear story.

Here, as in most design decisions, there's no right or wrong answer. Linear narratives, expertly implemented, are no better or worse than branching narratives implemented equally well. However, it's worth pointing out that *perceived* freedom is more important than actual freedom. If the players thinks they're in control, it's as good as if they are.

Character Differentiation & Development

RPGs are character-driven. Unlike any other game genre, they rely on differentiated player characters. As unique, personal char- er growth is vital. Players ust feel that they control he destiny of their alter egos and that their choices throughout the ame result in increasing ure and a growing abili- impact the game world ts denizens. Every design decision you make when crafting an RPG should first be filtered through the following simple screens:

- Does each game system, design philosophy, or mission help the character play his or her role more effectively?
- Does each serve to differentiate one character from another?

If we as game designers allow each player's character to be unique, and thus differentiate each player's experience of the game, we have been successful. To illustrate how important the need to play a role is in role-playing games, and how controversial the subject can be, let me describe some personal experiences. In recent months, I found myself embroiled in a controversy that I never could have imagined. The issue involved the nature of role-playing and character identification.

It occurred at Ion Storm, where I'm currently working on the game DEUS EX. My development team, which is fairly united on role-playing design issues, suddenly found itself on the brink of civil war over whether players should be allowed to name their characters. My original plan had been to give the character a name and a backstory to go along with it. That would allow us to give the character significant relationships and, perhaps most important, a voice.

Half of the team felt that the predetermined name and identity offered too many dramatic advantages to pass up, particularly nowadays when full speech is expected and voice synthesis technology is still in its infancy. The other half of the team was appalled. "If you can't name your character," said one developer, "you're not making an RPG at all. You're making an adventure game." Several people commented that they find it annoying when they are forced to do or say things because the designer thinks their character would do or say that thing. To cut short this debate, I came up with a solution that, I believe, satisfied both camps. (You can tell me how successful my solution was when the game ships!) In any event, this argument about character names shows just how critical player identification with his or her character can be to the success of an RPG.

Statistics, Skills and/or Trackable Abilities

As tools, names are useful but not critical. In contrast, there are two core character identification and development tools: statistically driven and experientially driven story and world building. Regardless of whether you allow players to develop their characters through statistics or direct experience (or some combination of the two), you have to take a stance on the subject before you put the last period on your design document.

In games such as FALLOUT, DIABLO (Figure 1), DAGGERFALL, FINAL FANTASY VII, and MIGHT & MAGIC VI, numbers typically define your character's fundamental attributes (such as strength, dexterity, intelligence, and luck) and/or your character's level of accomplishment in a set of skills (such as lock picking, marksmanship, and first aid). When players run into a game problem or obstacle, they use one or more of these attributes or skills, resulting in behind-the-scenes die rolls that determine success or failure in overcoming the problem.

Development (increases in individual statistics) often comes through the expenditure of abstract skill points given by the designer for solving individual problems or for solving enough such problems to go up an arbitrary level (the rewards model). In other games, development comes through the actual use of specific capabilities in game situations (the practice model). However implemented, statistics are terrific tools for setting one character apart from another — there's a reason they've been a staple of role-playing since the birth of *D&D*.

Why are numeric systems terrific tools? For one thing, they're instantly parsable by normal human beings. Any player can tell immediately that first level isn't as good as second level, and that a strength score of 65 is better than a score of 37. In addition, die-rolls introduce tension, suspense, and variety into computer RPGs.

Statistical systems do have associated costs, though. The one that I find most damning, if only because a thoughtful designer can so
the problem, is
cally, by game'
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than different.
But the trick to avoiding this is simply to impose limits on the number of skills players can select and/or to limit the number of reward points v
hand out.

But using sta
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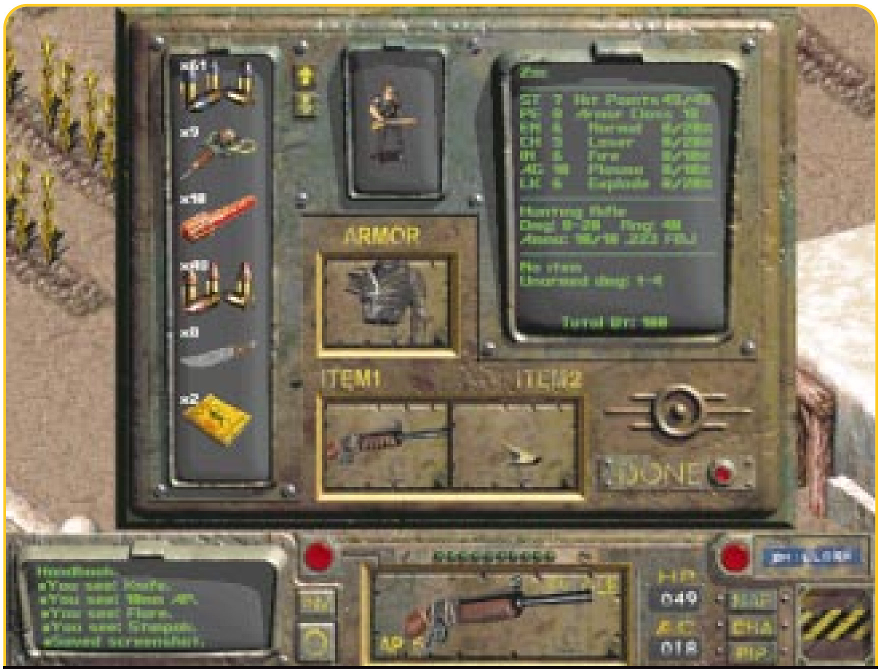


FIGURE 2. *FALLOUT's character statistics screen.*

too. As easy as it is to say two characters are different — and as easy as it is to indicate these differences on a character description screen — it is extremely difficult to communicate to players the reasons why they succeeded or failed at a given task. Can players ever really know why they succeeded or failed when behind the scenes die rolls determine success of failure? Can we make players feel their contributions to character accomplishment are significant? If you choose a statistical approach, you need to provide obvious and immediate feedback when a statistic affects problem resolution.

uch as WASTELAND and
), though separated by
any years, are extremely good examples of games that use statistics and skills effectively. In these games, statistics, in addition to being rewards, allow players to refine their characters with a great deal of control and precision and to individualize their play experience in ways the games' limited storylines don't offer. FALLOUT is a more recent example
effective use of statistics to
rentiate characters from
other (Figure 2). But FALLOUT takes the idea of tailoring experience through statistics even further than WASTELAND and DIABLO — a player who puts his or her points into stealth and communication skills, for example, is likely to solve game problems very differently than one who puts those points into weapons skills.

Looking at most games that use the statistical character definition approach, you quickly get the impression that designers like to track numerous character statistics, and like to track them to a fine degree. Logically, this seems to be the best way to differentiate one character from another. However, if you're going to track statistics based on skill values, adjustments to these values have to be meaningful enough so that changing them makes obvious changes in the game play. Hand out too many statistical improvement rewards and characters start to look more alike than different. Create enough statistics and skills and players quickly figure out which ones matter and which don't, causing characters to look more similar. My advice is to be appropriately and thoughtfully stingy with rewards and with the number and types of statistics you provide.

But are all of these statistics really necessary? Of course not. There's another way. In recent years, a small, very vocal and extremely persuasive

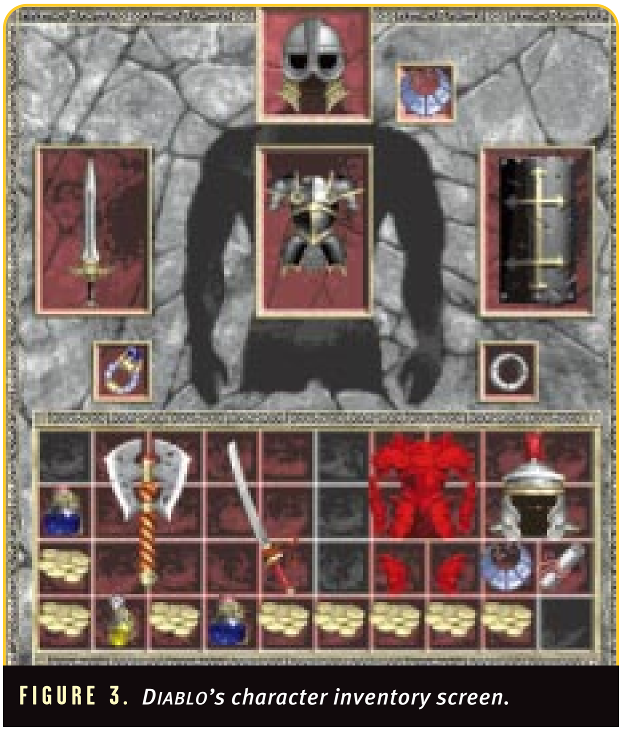


FIGURE 3. *DIABLO's character inventory screen.*

minority of the design community has begun to argue in favor of statistics-free RPGs or, as some call it, the immersive experience. They feel that hidden die rolls and finely tracked statistics are unnecessary hold-overs from paper gaming. These designers pose a number of interesting questions. Why use a crutch from another medium, one with limited simulation capabilities, in computer gaming, which has far more powerful simulation tools available? Why not let player choices determine character differences? Does anyone think the difference between a 17 and an 18 in strength or between an 89 and a 90 in lock picking should have an impact on game play?

So what do these statistics-foes offer as an alternative in terms of character differentiation and the player's ability to impact a story? The two most important alternative tools available are Inventory and Skills/Special Abilities.

Most, if not all, RPGs support the accumulation and use of items by players. In most, you can pick up anything that isn't specifically nailed down and use it later, possibly even in ways the designers never imagined. In extreme cases, you end up with characters hauling around useless candy wrappers and soda cans. In the end, problem resolution is what RPGs are all about. The more tools you give the player (useless items notwithstanding), the more solutions are likely to suggest themselves, as long as your simulation is robust enough — or your designers clever enough — to support them.

In addition to their use in problem solving, objects and weapons can be powerful tools for character differentiation. If you load up your inventory with weapons and I load mine up with keys, lockpicks, and invisosuits, our characters look, feel, and, of necessity, behave differently from one another.

The key to making inventory a character differentiation tool is to limit, in some way, the number of items that a character can carry. In a statistics-based system, this can be accomplished by giving items weight and then tying inventory capacity to strength — how much weight a character can carry therefore becomes the limiting factor. In a statistics-free system, the same goal can be accomplished by giving each item a size and then limiting the number of things a character can lug around. Clearly, combinations of these ideas work, too — witness DIABLO (Figure 3) — and there are undoubtedly several other viable schemes.

For inventory to work as a character anc experience differentiat tool, we must find way force players to make c es. Which implies limi characters' capabilities as designers must be di plined enough to parce items of increasing pow things that make chara effective — in a careful thought-out manner. I an infinite variety of w front of a character, most players would grab the most powerful one, making the inventory limitation moot. Item and weapon differentiation must be thought of in terms of economy.

In a real-world economy, more isn't always better. The same is true in gaming. Just because you can offer players 4,000 weapons doesn't mean that you should. The choice should have meaning. Ask yourself whether you can really differentiate two weapons; if the two items offer no legitimate, significant, and obvious game play difference in your game world, why bother? When pondering inventory issues, think of yourself as the game design equivalent of Alan Greenspan of the Federal Reserve Board — you have to open and close the object floodgates to match players' capabilities to the tasks at hand. Release too much "item power" and tasks become too easy. Interest in the game wanes. Release too little "item power" and tasks become too hard. Frustration sets in. Either way, players stop playing.

Not all systems of skills and abilities depend on statistical resolution; there are plenty of other ways to structure a system. In DEUS EX, we use a binary action resolution scheme in which your skill level, tracked in a gross fashion (rather than a granular one) is compared to the difficulty of the task at hand. If your skill level is higher than the difficulty factor — which, in most cases, you'll know before you attempt a task — then you succeed. If your skill level is lower than the task's difficulty factor, you have to find

d world (or even one, such as DEUS 1 should be solvays. In such a system like our olution model t sense. If you're good enough lock picker to open a vault, maybe you're a master with explosives, or aybe you can ırm a bank clerk ening it for you. till thinking in zles rather than if your world is two-dimensional rather than deeply simulated, stick with statistics.

So where does tension come into the picture? To offer levels of suspense like statistics-based systems, a statistics-free game must emphasize consequence and reward. Here's one way it can work. First, players may know in advance the outcome of a specific action (whether they do or not is largely a result of how much attention they've been paying — the designers aren't trying to hide anything). Second, players should have a fair degree of certainty about the reward for acting in a particular manner (for example, a player should know that if he or she gets through the vault door, he or she will get a million dollars). Most critically, players must not be able to do more than make an educated guess at the consequences of acting in a specific manner (for example, picking the lock on the vault door might or might not set off an alarm, blowing the door off it's hinges might attract the attention of the night watchmen or destroy the money in the vault, and charming a bank teller might allow the teller to identify you when the police show up). All actions — all choices — must reward players and, equally important, all must have consequences. There can be no right and wrong, no better and worse.

Whether statistics or experience is used to differentiate characters, some tangible measurement of character prowess and progress is necessary if a game is to be considered an RPG. In RPGs, arbitrary limitations are often placed on what your character can and cannot do. The idea of defining your character's abilities statistically is just one such arbitrary limitation.

Another is the notion of the character class. In the past, distinguishing characters using character classes has prevented mages from wearing armor, impaired warriors' use of magic, restricted clerics' use of offensive magic, and let thieves move quietly and do double damage from behind. This is the brute-force solution to the problem of differentiating characters, applicable in either statistics- or experience-based games (though fitting more easily into the former). Character classes tell players, "Here's a problem. Your character can't solve this problem in ways X, Y, and Z because those methods aren't appropriate to your class. Find another solution that takes advantage of your character class's unique and clearly defined capabilities."

Character classes are not a bad way to ensure experiential differences, but they're a little inelegant. I view them as a form of "remedial role-playing"; character classes have been a crutch for novice role-players since the 1970s. If reaching the mass market is your goal, character classes could be appropriate. If you're going for the *Dungeons & Dragons* audience, character classes are a necessity. I've noticed that the use of character classes is waning, but if the upcoming title BALDUR'S GATE proves as successful as most industry watchers expect, it could revitalize the notion of class distinctions in role-playing.

Varied Interaction

One of the defining characteristics of role-playing is the player's ability to impact the outcom the story through h her actions during game. One of the m powerful and effect ways to give player power is to offer an of interaction style

When you play an ULTIMA, or even a hack-and-slash game such as DIABLO, you meet computer-controlled people and creatures — NPCs — who don't necessarily want to kill you. In a console game such as SUIKODEN, you build a base of operations and forge alliances with the NPCs you choose. Together, these activities have a dramatic impact. In almost any RPG you can name, players can kill, talk to, buy or sell from, maybe even learn from NPCs. The interaction can come in the form of one-sided info-dumps or in complex, branching tree conversations. Whatever form it takes, some nonviolent interaction is a necessary, defining characteristic of RPGs.

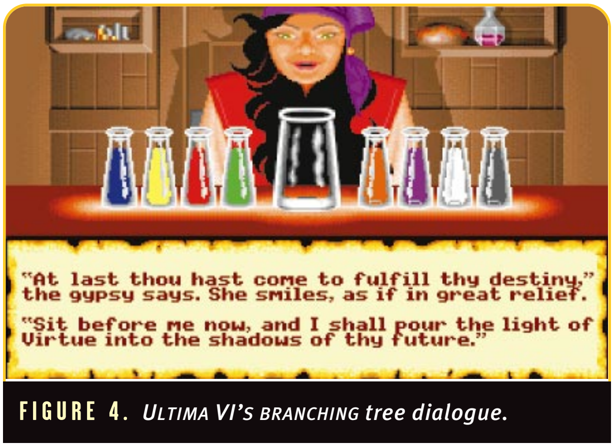
Furthermore, you can interact with the game environment in ways other than shooting weapons and opening doors. This may be as limited as picking up objects and manipulating switches and levers or it may be as limitless as, well, interactions in the real world. (I can dream, can't I?)

Finally, in the best RPGs, obstacles aren't limited to monsters or arbitrary puzzles. The solution to a particular game situation isn't as predictable as in more focused game categories and, often, more than one solution exists for each problem that you confront.

Combat

The effectiveness of your combat system depends on your understanding of the concept of "economy." Giving the player a big gun with unlimited ammo and then throwing a million hideous monsters at him or her

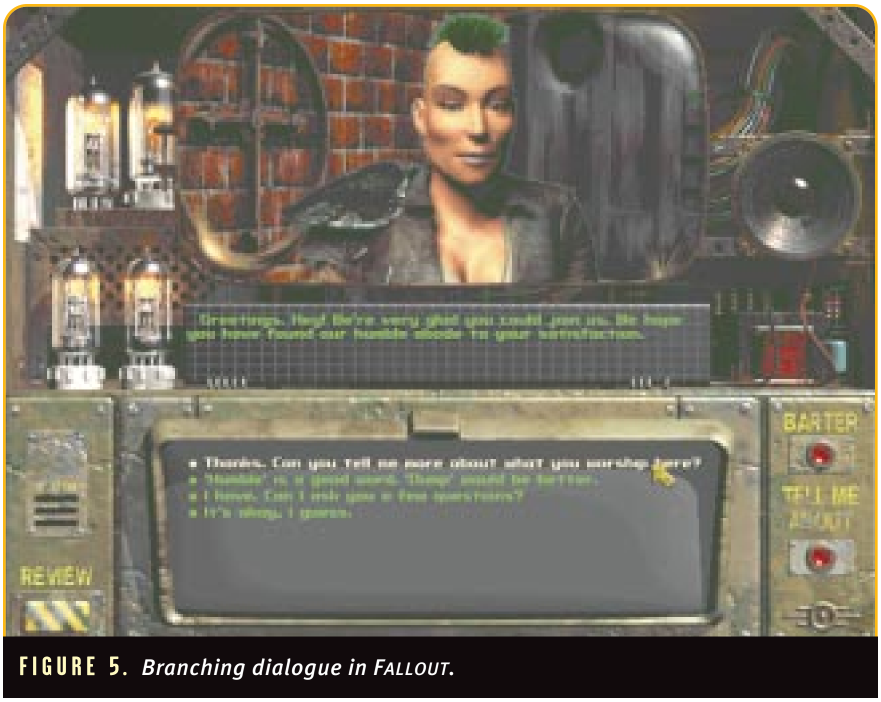
Make sure each weapon and each enemy is radically different than all others. There's no point offering a 1911 Colt, a Glock, and a Browning Hi-Power unless there's some major game play difference between them. Hey, they're all automatic pistols and serve about the same purpose in the real world. In your game, players won't know that the stocks feel different, the



"At last thou hast come to fulfill thy destiny," the gypsy says. She smiles, as if in great relief.

"Sit before me now, and I shall pour the light of Virtue into the shadows of thy future."

FIGURE 4. *ULTIMA VI's BRANCHING tree dialogue.*



Greetings. Hey! We're very glad you could join us. We hope you have found our humble abode to your satisfaction.

- Thanks. Can you tell me more about what you worship here?
- 'Humble' is a good word. 'Dump' would be better.
- I have. Can I ask you a few questions?
- It's okay, I guess.

FIGURE 5. *Branching dialogue in* FALLOUT.

weight is different, and so on. And tiny variations in accuracy and kickback and the like probably won't be noticeable even if you bother trying to simulate them. Don't bother. Just put one of them in your game and be done with it. If your game fiction can support it, make certain weapons particularly useful against certain enemies. Weapon differences must be obvious and instantly apparent.

Wherever possible, differentiate your enemies as much as (or more than) you do your player characters. If, again, your game fiction supports it, give each enemy an attack that has a specific effect (or effects) on the player's ability to move, see, hear, or otherwise interact with the game.

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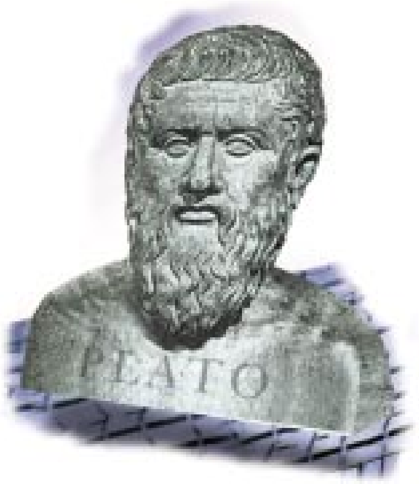

Conversing with NPCs

No one has yet devised and/or implemented an artful, compelling, interesting, or believable conversation system in a computer RPG. That includes everything I've done and everything you've done. No one has come up with a system that doesn't draw you out of the game world and remind you that you're just manipulating pixels on a screen. In the absence of anything better, let's look at some of the approaches that we've tried in the past.

First, there are branching-tree/keyword systems. If you've played just about any computer RPG of the last 15 years, you're
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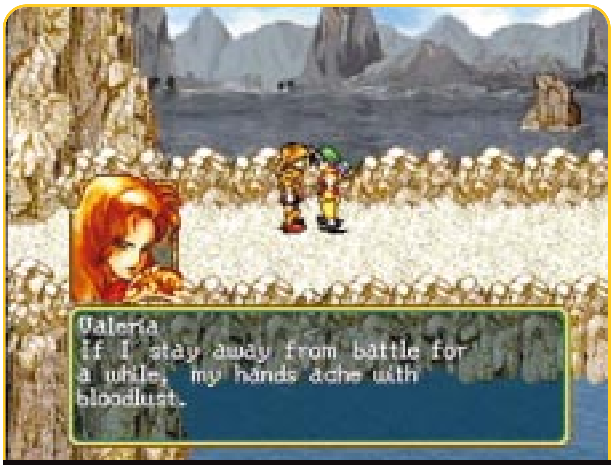
response options (or are given the opportunity to type in whatever they want). Picking one of these options or typing in a likely keyword sends the NPC into another speech. Making a selection typically prevents the player from getting the information he or she would have gotten by picking another of the available response options. Eventually, the NPC runs out of things to say along a particular branch and the conversation ends, leaving the player either to start the whole conversation over and make different response option choices in an attempt to elicit additional information from the NPC, or to go talk to someone else.

The problem is that clicking through a bunch of conversation options doesn't feel much like a conversation — an interrogation, perhaps, but not a conversation. Additionally, keywords and branching trees turn the conversations themselves into puzzles. Can you guess which branch the designer wanted you to go down? The opportunity and, more often, the necessity of talking to each NPC multiple times to be sure you ferreted out the critical nugget of information or set the one necessary conversation flag is a pain and drains conversations of their emotional impact.

Another way to handle NPC interaction is through linear conversations. This is sometimes called the "NPC as signpost" approach to conversation. It's most commonly used in console RPGs, where input options are limited and storage space for branching conversations is at a premium. Basically, this



Valeria
If I stay away from battle for a while, my hands ache with bloodlust.

FIGURE 6. *Binary decision point conversation in* SUIKODEN.

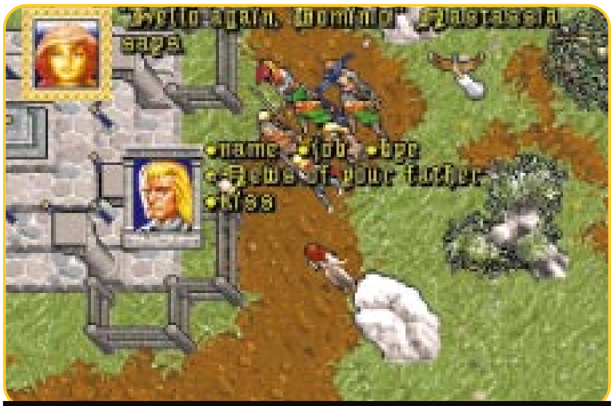


FIGURE 7. *ULTIMA VII uses a top-down, third-person perspective.*

method boils down to walking up to an NPC and having them tell you something and that's it. No interaction. Talk to them again and, unless the game state has been advanced somehow and/or the designer is particularly sharp, the NPC will simply repeat what he or she said the last time.

Linear conversations typically point you to your next goal, but they can do much more. In the best examples, NPCs can tell you about themselves and their lives. They can describe in convincing terms how you know them and how they feel about you. It's possible to evoke real emotions in a linear conversation, and about all the writer has to worry about is the role the speaker plays in the story.

A third communication solution is the use of binary decision points. This is a compromise between branching and linear conversation approaches. Most often seen in console games such as SUIKODEN (Figure 6) and just about anything developed by Square, binary decision point conversations are linear except where a yes/no decision (and associated branch) will reveal something about the character, the player, or the NPC speaking. I think this is a most promising approach.

A fourth communication method is reaction-based conversations A few designers over the years have tried a system in which NPCs speak and the player gets to pick the tone of his or her response but not the specific content (wording) of the response. This doesn't seem to offer much advantage over other, more popular systems, but it is an option.

The last communication option is simply denial. Back when Doug Church and I first started talking about SYSTEM SHOCK, we were dissatisfied with the conversation approach taken in UNDERWORLD, traditional and conventional though it may have been. And though it pained us to admit it, even to ourselves, we had no idea how to do any better. So the team designed around the unsolvable problem — we killed everyone off. The inhabitants of Citadel station would exist, for the player, only through e-mail and video logs. It was an elegant solution to an intractable problem: if we can't make you believe you're talking to a real human being, we just won't have any in our game world. (In retrospect, I think we may have gone a little overboard — it was the right decision for that game at that time, but we failed to take into account the power of consistency and convention.)

Perhaps the best thing that can be said about conversation in computer gaming is that players have grown accustomed to inelegant, unrealistic, basically unbelievable systems and cardboard cut-out NPCs. Until someone comes up with something better, you can always fall back on convention, a fact that Doug and the SYSTEM SHOCK team didn't consider very seriously. Players "get" branching-tree/keyword systems — they're so familiar with them that they don't even think about them much anymore. And that's about the best that you can hope for — that conversation won't drag players out of your carefully crafted alternate world too badly. I await the day when voice recognition, natural language processors, basic knowledge databases, and speech synthesis become realistic options.

Exploration vs. Action

Having dealt with combat and conversation, there's only one defining characteristic of role-playing left to discuss: exploration. In the typical RPG, you can fully explore a huge, contiguous world in real time. Every ULTIMA, both UNDERWORLDS, DAGGERFALL, and countless other games have taken this approach. Uncovering all of a world's secrets is fun.

Clearly, the exploration model works in RPGs, but it's both a blessing and a curse. It's great to be able to say it takes a player hours to traverse your game's world (and that's if you don't stop to interact with anything), but that begs the question of whether it's any fun to walk around for ten hours. Additionally, game players are increasingly pressed for time or anxious to finish one game so they can move on to the next. As a result, many seem to want smaller worlds, shorter play times, and more frequent pats on the back. I know there are still hardcore game players out there who always want more, but you must decide whether there are enough of these consumers to support your development budget.

Recent trends favor smaller, deeply simulated worlds over large, contiguous spaces an inch deep and miles wide, at least in terms of depth of simulation. Further, many RPGs these days — my own DEUS EX, THIEF: THE DARK PROJECT, DIABLO, and others — are adopting a mission orientation. They break the world up into more manageable sections to minimize walking

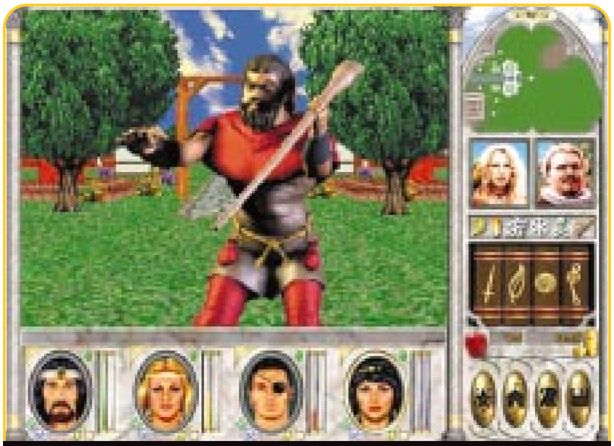


FIGURE 8. *Standard game play window in MIGHT & MAGIC VI, showing the first-person gaming experience.*

around and maximize fun. Mission structure also goes hand-in-hand with linearity and, together, they allow us to tell the best stories possible.

Variables

Now that we've cussed the defi ing characteristics – the rules of role-playing, if you will — what of the variables? There are certainly characteristics of role-playing that are not universal, that y can adopt or ignore, as you wish. Here are some of them.

Camera position. I'm the last person qualified to address technology, but camera positioning is an important enough issue to cover briefly. There are several ways to approach camera positioning and player point of view in role-playing. The most common perspectives are: first-person, three-quarters-overhead third-person (as in, an isometric viewpoint), and top-down third-person (Figure 7). For the purposes of this discussion, and for the sake of brevity, I'll treat the third-person perspectives as the same.

In a genre that, at some level, boils down to providing the player with the ultimate "I did this" experience, what could be more compelling than entering a new world and seeing it through your own eyes? The Underworld and Might & Magic series (Figure 8), not to mention many others, offer fine first-person role-playing experiences. If what you're after is simulating a world, a first-person view goes a long way toward making the player feel as though he or she is "there." You're reducing the distance between player and character to almost nothing.

One drawback to the first-person perspective is that it puts players at a tactical disadvantage by limiting their awareness of what's going on behind and to the sides of their characters. And if you're committed to turn-based, tactically challenging combat, convoluted conversations that take place on a separate conversation screen, and the video equivalent of paper game character sheets crawling with attributes, skills, and numbers, first-person could be the worst choice for your game.

If you're trying to recreate the paper gaming experience or the experience you get when you read a great novel or watch a film — the fiction experience third-person view may be just hat you need. To capture that "fiction feel," it's good to let players guide their characters rather than *be* their characters. You want a bit of distance between player and character.

A third-person perspective is also ideal for tactical decision-naking, particularly when com-ied with a turn-based combat system, a character sheet, and a separate conversation screen. Each of these elements contributes to the player's ability to make informed decisions about how to develop his or her character. The trade-off is that it's tough to care much about NPCs that are obviously nothing more than bunches of pixels an inch high when you're looking at them from a bird's perspective.

Lone adventurer or party? If you're working on an RPG, there's one question I guarantee you've been asked: "Is there gonna be multiplayer support?" Everybody seems to want to go exploring with a party. In a paper game, where players gather around a table, engage in collective acts of imagination, and push lead miniatures representing their characters around on tabletops, the party idea works just fine. Certainly, a case could be made that allowing a party of adventurers to go through your story together, linked via modem, LAN, or the Internet, is a worthy pursuit despite the problems of communication and coordination among party members.

But what of the single-player RPG? Does the party make sense in that context? Many classic RPGs indicate that it does. The early Ultimas (among many others) allow a single player to take control of a party of adventurers. However, I think controlling parties in single-player, story-based RPG is a bad idea, particularly when it's a real-time game. There are several reasons I feel this way.

First, if one of the primary goals of role-playing is to allow players to create an alter ego, you should do everything possible to increase a player's identification with his or her character. When controlling a party, player identification with a single character is history — as is role-playing, in my opinion. At that point, you're playing a boardgame. Second, AI limitations mean you're inevitably going to be slowed down by teammates who can't think quickly on their feet and, even slowly, can't respond the way real people would.

If you subscribe to the ideal that players should describe their adventures by saying "I did" something rather than "Lara Croft did" something or the "The Avatar did" something, controlling a party is a problem. In recent years, more and more designers seem to be coming around to this mode of thinking. (Recent Ultimas, Underworld, Diablo, and Daggerfall have all adopted the solo model, often to the chagrin of fans.) Solo play is simpler to implement, speeds up game play, and fosters a direct connection between player and character that seems critical to RPG success.

If you choose to include full-party control in your single-player game, recognize that you'll reduce player involvement and turn off people who value tactical thinking in games, and use it in conjunction with turn-based combat and a third-person perspective. A real-time, first-person party-based game is just asking for trouble.

It's Time to Advance the Genre

Computer role-playing games are no longer just an infant medium learning to crawl. They've been around for a while, and now we, their designers, must start figuring out what we are, and what we can do to make the most of them. I've got no beef with folks who want to continue recreating the past. Just don't count me among the people who think that's good enough. Our goal should be to create games that are simple to learn and play, accessible to the broadest possible audience, and yet offer enough depth that hardcore game players will flock to them. ■

Back

Im leme i g C di a ed M eme

by Dave C. Pottinger

Part of the fun of working in the game industry is the constant demand for technical innovations that will allow designers to create better games. In the real-time strategy (RTS) genre, most developers are focusing on improving group movement for their next round of games. I'm not talking about the relatively low-tech methods currently in use. Instead, I'm referring to coordinated group movement, where units cooperate with each other to move around the map with intelligence and cohesion. Any RTS game developer that wants to be competitive needs to look beyond simple unit movement; only the games that weigh in with solid coordinated movement systems will go the distance.

In this article, the second and final part of my coordinated unit movement series, we'll take a look at how to use the systems that we considered in the first article to satisfy our coordinated group movement goal. We'll also examine how we can use our coordinated movement fundamentals to solve some classic, complex movement problems. While we will spend most of our time talking about these features through the RTS microscope, they can easily be applied to other types of games.

Catching Up

Last month, we discussed a lot of the low-level issues of coordinated unit movement. While pathfinding (the act of finding a route from point A to point B) gets all of the press, the movement code (the execution of a unit along a path) is just as important in creating a positive game experience.

A game can have terrific pathfinding that never fails to find the optimum path. But, if the movement system isn't up to par, the overall appearance to the players is going to be that the units are stupid and can't figure out where to go.

One of the key components to any good movement system is the collision determination system. The collision system really just needs to provide accurate information about when and where units will collide. A more advanced collision system will be continuous rather than discrete. Most games scale the length of the unit movement based on the length of the game update loop. As the length of that update loop increases, the gap between point A and point B can get pretty large. Discrete collision systems ignore that gap, whereas continuous systems check the gap to make sure there isn't anything in between the two points that would have created a collision with the unit being moved.

After several close calls, Dave managed to avoid getting a "real job" and joined Ensemble Studios straight out of college a few years ago (just in time to the do the computer player AI for a little game called Age of Empires). These days, Dave spends his time either leading the development of Ensemble Studios' engines or with his lovely wife Kristen. Dave can be reached at dpottinger@ensemblestudios.com.

Continuous collision determination systems are more accurate and more realistic. They're more difficult to write, though.

Another important element for coordinated unit movement is position prediction. We need to know where our units are trying to go so that we can make intelligent decisions about how to avoid collisions. Although building a fast position-prediction system presents us with a number of issues, for this article, we can assume that our collision determination system has been augmented to tell us about future collisions in addition to current collisions. Thus, each unit in the game will know with which units it's currently in collision with and which units it will collide with in the near future. We presented several rules for getting two units out of collision in last month's article.

All of these elements work together to create the basis for a solid, first-order (single unit to single unit) coordinated movement system. The core thing to keep in mind for this article is that we have an accurate, continuous collision determination system that tells us when and where units will collide. We'll use that collision system in conjunction with the collision resolution rules to create second order (three or more units/groups in collision) coordination.

Group Movement

Looking at the definition of a group (see the sidebar, "Units, Groups, and Formations"), we can immediately see that we need to store several pieces of data. We need a list of the units that make up our group, and we need the maximum speed at which the group can move while still keeping together. Additionally, we probably want to store the centroid of the group, which will give us a handy reference point for the group. We also want to store a commander for the group. For most games, it doesn't matter how the commander is selected; it's just important to have one.

One basic question needs to be answered before we proceed, though. Do we need to keep the units together as they move across the board? If not, then the group is just a user interface convenience. Each unit will path and move as if the player had issued individual commands to each group member. As we look at how to improve on the organization of our groups, we can see that there are varying degrees of group movement cohesion.

UNITS IN A GROUP JUST MOVE AT THE SAME SPEED. Usually, this sort of organization moves the group at the maximum

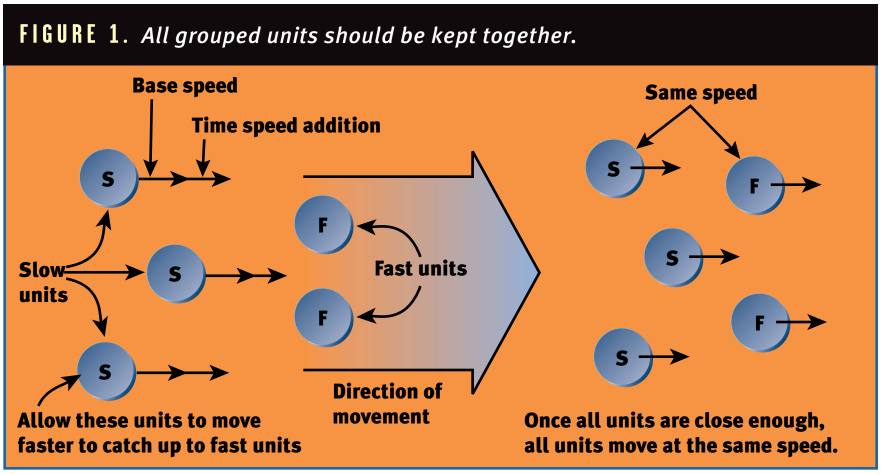
Units, Groups, and Formations

Unit. A game entity that has the ability to move around the map. Players expect their units to act intelligently.

Group. A general collection of units that have been grouped together by the user for convenience (usually to issue the same order to all of the units in the group). Other than a desire to keep its units together, groups don't place any other restrictions on unit movement.

Formation. A more complex group. A formation has an orientation (a front, a back, a right flank, and a left flank). Each unit in the formation tries to maintain a unique relative position within the formation. More complex models provide an individualized unit facing within the overall formation and support for wheeling during movement.

FIGURE 1. *All grouped units should be kept together.*


Base speed
Time speed addition
Same speed
S
F
S
F
Slow units
Fast units
S
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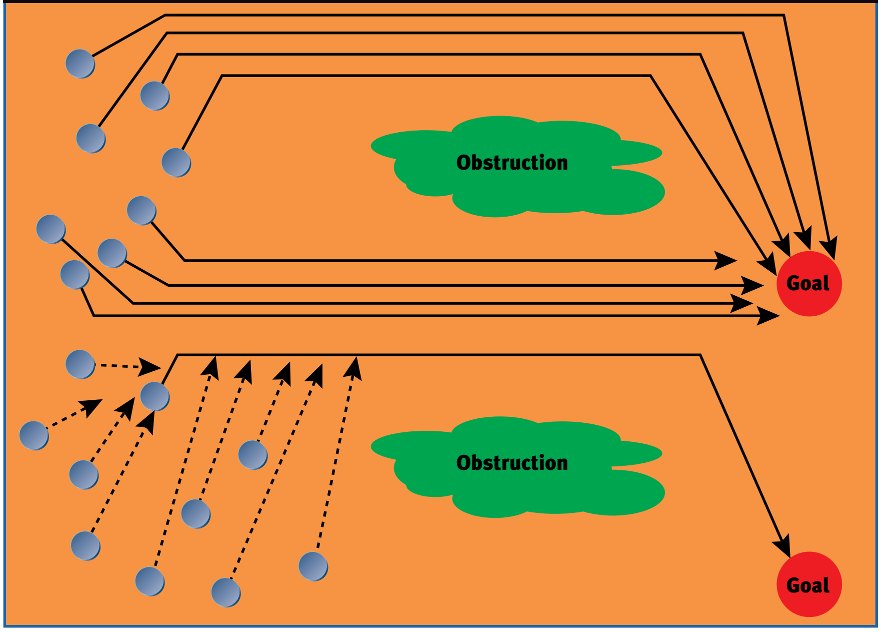
S
S
Direction of movement
Allow these units to move faster to catch up to fast units
Once all units are close enough, all units move at the same speed.

FIGURE 2. *Units in a group should follow the same path.*



speed of its slowest unit, but sometimes it's better to let a slow unit move a little faster when it's in a group (Figure 1). Designers generally give units a slow movement speed for a reason, though; altering that speed can often create unbalanced game play by allowing a powerful unit to move around the map too quickly.

UNITS IN A GROUP MOVE AT THE SAME SPEED AND TAKE THE SAME PATH. This sort of organization prevents half of the group's units from walking one way around the forest while the other half takes a completely different route (Figure 2). Later, we'll look at an easy way to implement this sort of organization.

UNITS IN A GROUP MOVE AT THE SAME SPEED, TAKE THE SAME PATH, AND ARRIVE AT THE SAME TIME. This organization exhibits the most complex behavior that we'll apply to our group definition. In addition to combining the previous two options, it also requires that units farther ahead wait for other units to catch up and possibly allows slower units to get a temporary speed boost in order to catch up.

LISTING 1. *The* BUnitGroup *class.*

```
//******************************************************************************
// BUnitGroup
//******************************************************************************
class BUnitGroup
{
   public:
      BUnitGroup( void );
      ~BUnitGroup( void );

      //Returns the ID for this group instance.
      int            getID( void ) const { return(mID); }

      //Various get and set functions.  Type designates the type of the group
      //(and is thus game specific).  Centroid, maxSpeed, and commander are
      //obvious.  FormationID is the id lookup for any formation attached to
      //the group (will be some sentinel value if not set).
      int            getType( void ) const { return(mType); }
      void           setType( int v ) { mType=v; }
      BVector&       getCentroid( void ) const { return(mCentroid); }
      float          getMaxSpeed( void ) const { return(mMaxSpeed); }
      int            getCommanderID( void ) const { return(mCommanderID); }
      BOOL           getFormationID( void ) const { return(mFormationID); }
      BOOL           setFormationID( int fID );

      //Standard update and render functions.  Update generates all of the
      //decision making within the group.  Render is here for graphical
      //debugging.
      BOOL           update( void );
      BOOL           render( BMatrix& viewMatrix );

      //Basic unit addition and removal functions.
      BOOL           addUnit( int unitID );
      BOOL           removeUnit( int unitID );
      int            getNumberUnits( void ) const { return(mNumberUnits); }
      int            getUnit( int index );

protected:
      int            mID;
      int            mType;
      BVector        mCentroid;
      float          mMaxSpeed;
      int            mCommanderID;
      int            mFormationID;
      int            mNumberUnits;
      BVector*       mUnitPositions;
      BVector*       mDesiredPositions;
};
```

So, how can we achieve the last option? By implementing a hierarchical movement system, we can manage individual unit movement in a way that allows us to consider a group of units together. If we group units together to create a group object, we can store all of the necessary data, calculate the maximum speed for the group as a whole, and provide the basic decision making regarding when units will wait for other units (Listing 1).

The `BGroup` class manages the unit interactions within itself. At any point in time, it should be able to develop a schedule for resolving collisions between its units. It needs to be able to control or modify the unit movement through the use of parameter settings and priority manipulation. If your unit system only has support for one movement priority, you'll want to track a secondary movement priority within the group for each unit in the group. Thus, to the outside world, the group can behave as a single entity with a single movement priority, but still have an internal prioritization. Essentially, the `BGroup` class is another complete, closed movement system.

The commander of the group is the unit that will be doing the pathfinding for the group. The commander will decide which route the group as a whole will take. For basic group movement, this may not mean much more than the commander being the object that generates the pathfinding call. As we'll see in the next section, though, there's a lot more that the commander can do.

Basic Formation Movement

Formations build on the group system. Formations are a more restrictive version of groups because we have to define a very specific position for each unit within the group. All of the units must stay together during group movement in terms of speed, path, and relative distance; it doesn't do any good to have a column of units if there are huge gaps in that column while it's moving around the map.

The **BFormation** class (Listing 2) manages the definition of the desired positions (the positions and orientations that we want for each unit in the formation), the orientation, and the state of the formation. Most formations that a game uses are predefined; it's useful to make these easy to edit during development (via a text file or something else that a nonprogrammer can manipulate). We do want the ability to create a formation definition on the fly, though, so we'll take the memory hit and have each formation instance in the game maintain a copy of its own definition.

Under this model, we must also track the state of a formation. The state **cStateBroken** means that the formation isn't formed and isn't trying to form. **cStateForming** signifies that our formation is trying to form up, but hasn't yet reached **cStateFormed**. Once all of our units are in their desired positions, we change the formation state to **cStateFormed**. To make the movement considerably easier, we can say that a formation can't move until it's formed.

When we're ready to use a formation, our first task is to form the formation. When given a formation, **BGroup** enforces the formation's desired positions. These positions are calculated relative to the current orientation of the formation. When the formation's orientation is rotated, then the formation's desired positions will automatically wheel in the proper direction.

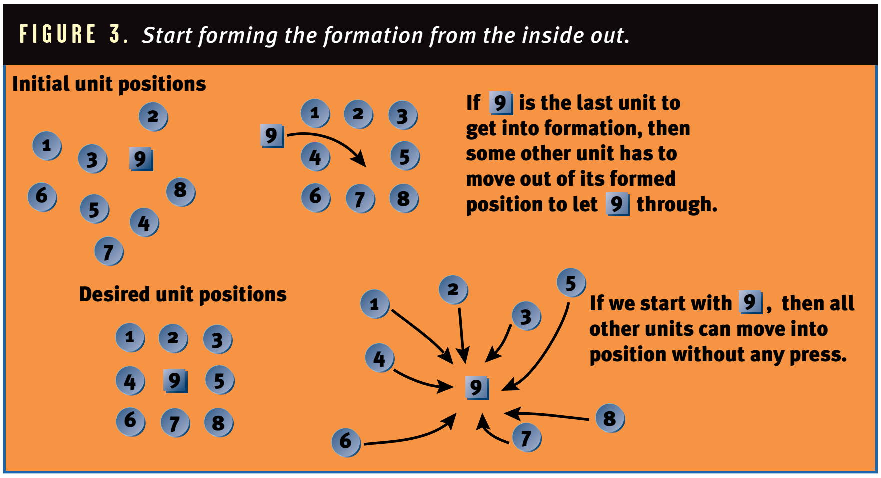
To form the units into a formation, we use scheduled positioning. Each position in the formation has a scheduling value (either by simple definition or algorithmic calculation) that will prioritize the order in which units need to form. For starters, it works well to form from the inside and work outward in order to minimize collisions and formation time (Figure 3). The group code manages the forming with the algorithm shown in Listing 3.

So, now that we have all of our swordsmen in place, what do we do with them? We can start moving them around the board. We can assume that our pathfinding has found a viable path (a path that can be followed) for our formation's current size and shape (Figure 4). If we

LISTING 2. *The* **BFormation** *class.*

```
//*****************************************************************************
// BFormation Class
//*****************************************************************************
class BFormation
{
  public:
    //The three formation states.
    enum
    {
      cStateBroken=0,
      cStateForming,
      cStateFormed
    };

    BFormation( void );
    ~BFormation( void );

    //Accessors for the formation's orientation and state.  The expectation
    //is that BFormation is really a data storage class; BGroup drives the
    //state by calling the set method as needed.
    BVector&    getOrientation( void ) { return(mOrientation); }
    void        setOrientation( BVector& v ) { mOrientation=v; }
    int         getState( void ) const { return(mState); }
    void        setState( int v ) { mState=v; }

    //The unit management functions.  These all return information for the
    //canonical definition of the formation.  It would probably be a good
    //idea to package the unit information into a class itself.
    BOOL        setUnits( int num, BVector* pos, BVector* ori, int* types );
    int         getNumberUnits( void ) const { return(mNumberUnits); }
    BVector&    getUnitPosition( int index );
    BVector&    getUnitOrientation( int index );
    int         getUnitType( int index );

protected:
    BVector     mOrientation;
    int         mState;
    int         mNumberUnits;
    BVector*    mPositions;
    BVector*    mOrientations;
    int*        mTypes;
};
```

FIGURE 3. *Start forming the formation from the inside out.*



If 9 is the last unit to get into formation, then some other unit has to move out of its formed position to let 9 through.

If we start with 9, then all other units can move into position without any press.

LISTING 3. *The formation algorithm.*

```
Set all units´ internal group movement priorities to the same low priority value.
Set state to cStateForming.
While state is cStateForming:
  {
  Find the unfilled position that´s closest to the center of the formation.
  If no unit was available
     Set the state to cStateFormed and break out of forming loop.

  Select a unit to fill that slot using a game specific heuristic that:
     Minimizes the distance the unit has to travel.
     Will collide with the fewest number of other formation members.
     Has the lowest overall travel time.

  Set unit´s movement priority to a medium priority value.
  Wait (across multiple game updates) until unit is in position.
  Set unit´s movement priority to highest possible value.  This ensures that
     subsequently formed units will not dislodge this unit.
  }
```

don't have a viable path, we'll have to manipulate our formation (we'll talk about how to do this shortly). As we move around the map, we designate one unit as the commander of our formation. As the commander changes direction to follow the path, the rest of our units will also change direction to match the commander's; this is commonly called flocking.

FIGURE 5. *Wheeling doesn't apply to every formation.*

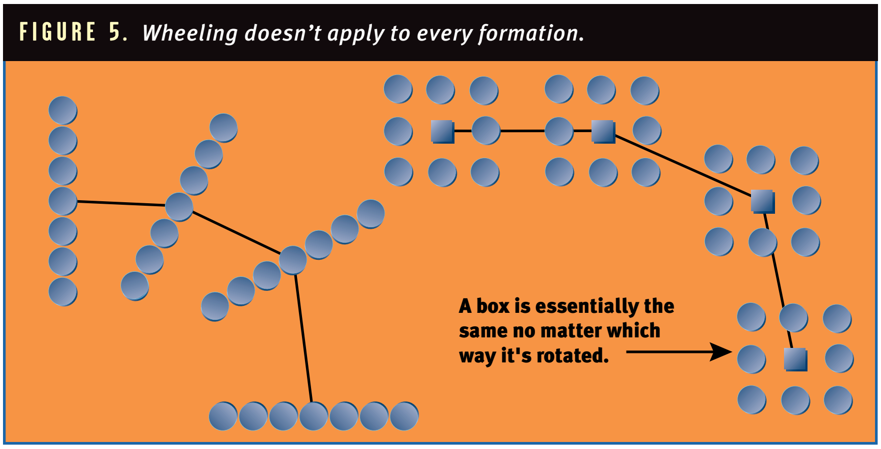

A box is essentially the same no matter which way it's rotated.

FIGURE 6. *Recalculate the desired positions after the formation's orientation has changed.*

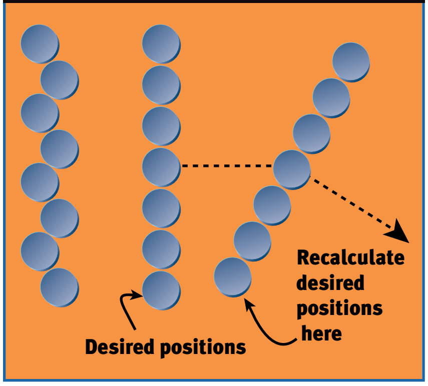


FIGURE 7. *Scaling desired positions to fit through small gaps.*

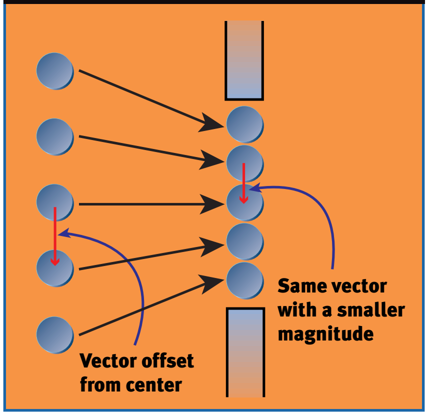
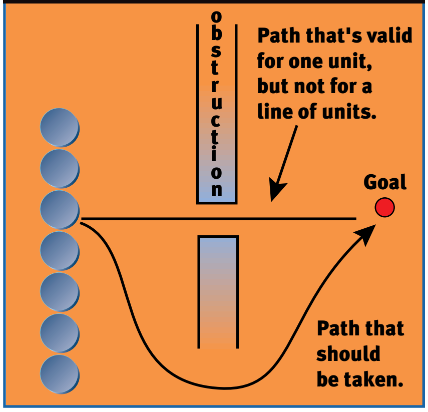

Same vector with a smaller magnitude
Vector offset from center

FIGURE 4. *The pathfinding needs to find a path that's usable given the formation's size and shape.*


obstruction
Path that's valid for one unit, but not for a line of units.
Goal
Path that should be taken.

We have a couple of ways to deal with direction changes for a formation: we can ignore the direction change or we can wheel the formation to face in the new direction. Ignoring the direction change is simple and is actually appropriate for something such as a box formation (Figure 5). Wheeling isn't much more complicated and is very appropriate for something such as a line. When we want to wheel, our first step is to stop the formation from moving. After rotating the orientation of the formation, we recalculate the desired positions (Figure 6). When that's done, we just go back to the cStateForming state, which causes the group code to move our units to their new positions and sets us back to cStateFormed when it's done (at which point, we can continue to move).

Advanced Formation Movement

So, now we've got formations moving around the map. Because our game map is dynamic and complex, it's possible that our planned path will be invalidated. If that happens, we'll need to manipulate the formation in one of three ways.

SCALING UNIT POSITIONS. Because the desired positions are really just vector offsets within a formation, we can apply a scaling factor to the entire formation to make it smaller. And a smaller formation can fit through small gaps in walls or treelines (Figure 7). This method works well for formations in which the units are spread out, but it's pretty useless for formations where the

FIGURE 8. *Reform the formation after the obstacles.*

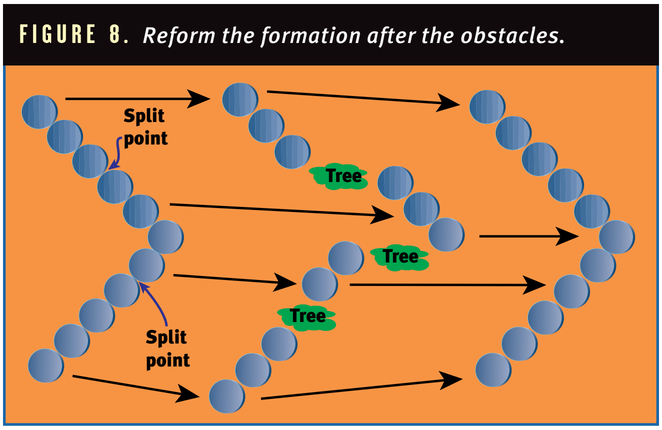
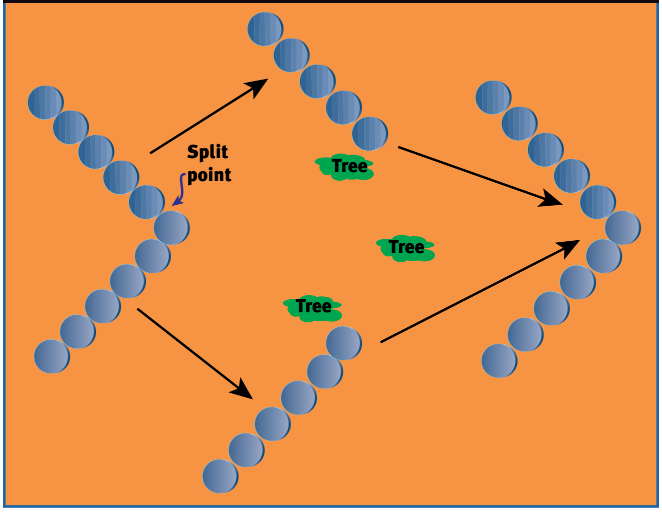


FIGURE 9. *Split the formation in two to get around an obstacle.*



units are already shoulder to shoulder (as in a line). Scaling the offsets down in that case would just make our swordsmen stand on top of each other, which isn't at all what we want.

Simple ordered obstacle avoidance. If we're moving a formation and we encounter a collision with another game entity (either a current collision or a future collision), we can assume that our path is still viable, with the exception of this entity being in the way. The simple solution is to find the first place along our formation's path where it will not be in collision with the entity and reform our formation at that spot (Figure 8). Thus, the line of infantry will break, walk around the obstacle, and reform on the other side. This solution can fall apart fairly easily, though, so it's important to realize when the reformation position is too far along the path to be of use. If the distance around the obstacle is far enough that it interferes with the reformation of your group, then you should just repath your formation.

Halving and rejoining. While simple avoidance is a good solution, it does dilute the visual impact of seeing a formation move efficiently around the map. Halving can preserve the visual impact of well-formed troops. When we encounter an obstacle that's within the front projection of the formation (Figure 9), we can pick a split point and create two formations out of our single formation. These formations then move to the rejoin position and then merge back into one formation. Halving is a simple calculation that dramatically increases the visual appeal of formations.

Path Stacks

A path stack is a simple stack-based (last in, first out) method for storing the movement route information for a unit (Figure 10). The path stack tracks information such as the path the unit is following, the current waypoint the unit is moving toward, and whether or not the unit is on a patrol. A path stack suits our needs in two significant ways.

First, it facilitates a hierarchical pathfinding setup (Figure 11). Game developers are beginning to realize that there are two distinctly different types of pathfinding: high-level and low-level. A high-level path routes a unit around major terrain obstacles and chokepoints on a map, similarly to how a human player might manually set waypoints for a unit. A low-level path deals with avoidance of smaller obstacles and is much more accurate on details. A path stack is the ideal method for storing this high- and low-level information. We can find a high-level path and stuff that into the stack. When we need to find a low-level path (to avoid a future collision with that single tree in the big field), we can stuff

FIGURE 10. *Path stack.*

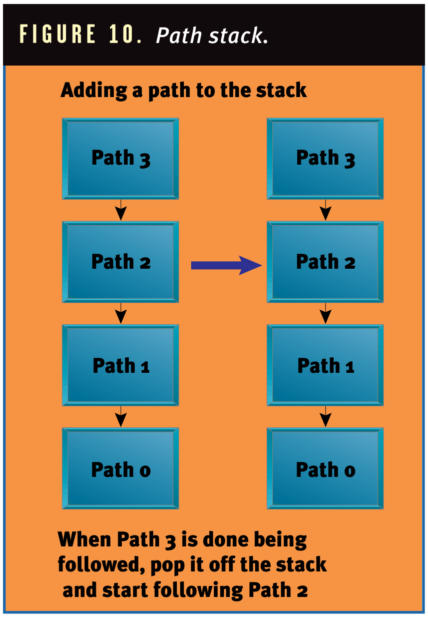

Adding a path to the stack
Path 3
Path 2
Path 1
Path 0
Path 3
Path 2
Path 1
Path 0
When Path 3 is done being followed, pop it off the stack and start following Path 2

FIGURE 11. *Hierarchical paths.*

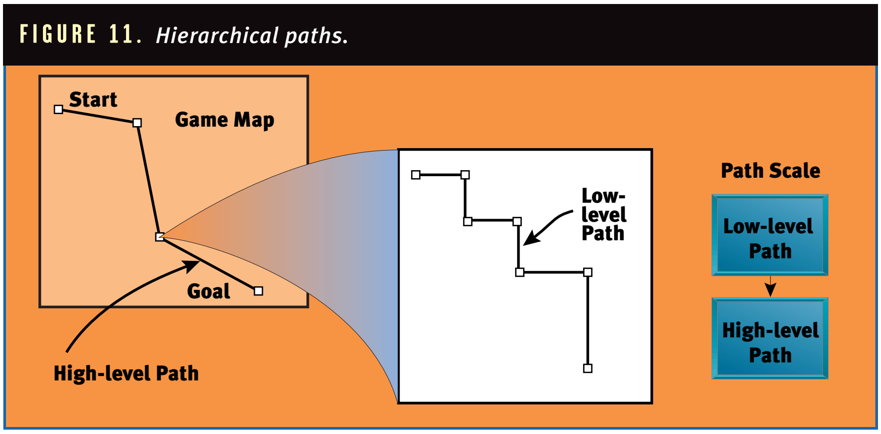
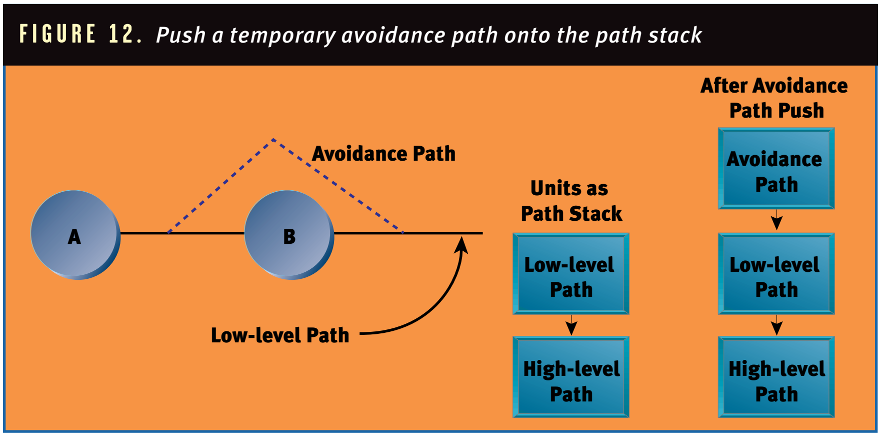


FIGURE 12. *Push a temporary avoidance path onto the path stack*



more paths onto the stack and execute those. When we're done executing a path on the stack, we pop it off the stack and continue moving along the path that's now at the top of the stack.

Second, a path stack enables high-level path reuse. If you recall, one of the key components to good group and formation movement is that all of the units take the same route around the map. If we write our path stack system so that multiple units can reference the same path, then we can easily allow units to reuse the same high-level path. A formation commander would find a high-level path and pass that path on to the rest of the units in his formation without any of them having to do any extra work.

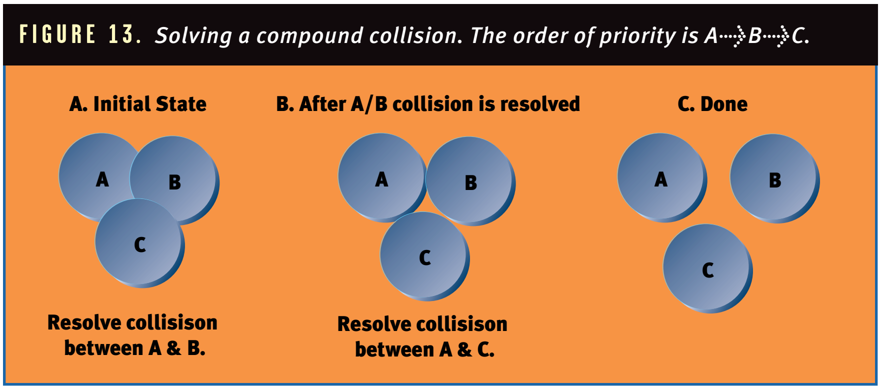
Structuring the path storage in this manner offers us several other benefits. By breaking up a high-level path into several low-level paths, we can refine future low-level segments before we execute them. We can also delay finding a future low-level path segment if we can reasonably trust that the high-level path is viable. If we're doing highly coordinated unit movement, a path stack allows us to push temporary avoidance paths onto the stack and have them easily and immediately integrated into the unit's movement (Figure 12).

Solving a Compound Collision

For our purposes, compound collisions are defined as simultaneous collisions between more than two units. Most games will have a practical upper limit to how many units can be involved in a compound collision. Still, as soon as a collision involves more than two units, programmers generally end up writing a lot of spaghetti logic that breaks way too easily. But we'll avoid that situation by reusing the movement priorities and doing some simple scheduling.

If we have a compound collision between three units (Figure 13), our first task is to find the highest-priority unit involved in the collision. Once we've identified that unit, we need to look at the other units in the collision and find the most important collision for the highest priority unit to resolve (this may or may not be a collision with the next highest-priority unit in the collision). Once we have two units, we pass those two units into the collision resolution system.

FIGURE 13. *Solving a compound collision. The order of priority is A→B→C.*


A. Initial State
B. After A/B collision is resolved
C. Done
A
B
C
A
B
C
A
B
C
Resolve collisison between A & B.
Resolve collisison between A & C.

As soon as the collision between the first two units is resolved (Figure 14), we need to reevaluate the collision and update the unit involvement. A more complex system could handle the addition of new units to the collision at this point, but you can get good results by simply removing units as they resolve their collisions with the original units. Once we've updated the units in the collision, we go back to find two more units to resolve; we repeat this process until no more units are involved in the collision (Figure 15).

You can implement this system in two different areas: the collision resolution rules or the collision determination system. The collision resolution rules would need to be changed in the way in which they units higher and lower priority; these rules aren't particularly difficult to change, but this modification does increase the complexity of that code. Alternatively, you can change the collision determination system so that it only generates collisions that involve two units at a time; you still have to find all of the units in a collision, though, before you can make this decision.

Solving the Stacked Canyon Problem

One of the ultimate goals of any movement system is to create intelligent movement. Nothing looks more intelligent than a system that solves the stacked canyon problem (Figure 16). The stacked canyon isn't a simple problem to solve upon first inspection, but we can reuse some simple scheduling to solve it once we have our coordinated unit movement in place.

The first step is to identify that you have a stacked canyon problem. This step is important because it's needed to propagate the movement priority of the driving unit (the unit trying to move through the stacked canyon) through to the rest of the units. We could just let each unit ask other units to move out of the way based on its own priority, but a better solution to use the priority of the driving unit — after all, that's the unit that we really want to get through the canyon. Identifying a stacked canyon problem can be done in a couple of ways: noticing that the driving unit will push the first unit into a second unit or looking at the driving unit's future collision list to find multiple collisions. Whichever method is used, the pushed unit should move with the same priority as the driving unit.

Once we've identified the problem, we have a fairly simple recursive execution using the coordinated movement (Figure 17). We treat the first pushed unit as the driving unit for the second pushed unit, and so on. Each unit is pushed away from its driving unit until it can move to the side. When the last unit moves to the side (Figure 18), the original driving unit has a clear path by which to move through the canyon.

A nice touch is to restore the canyon units to their original states. To do this, we simply need to track the pushing and execute the moves in the reverse order from which the units moved to the side (Figure 19). It's also useful to have the movement code recognize when the driving unit is part of a group so that the rest of the group's units can move through the canyon before the canyon units resume their original positions.

Tips

OPTIMIZE THIS GENERAL SYSTEM TO YOUR GAME. A lot of extra computation can be eliminated or simplified if you're only doing a 2D game. Regardless of whether you're doing a 2D or 3D game, your collision detection system will need a good, highly optimized object culling system; they're not just for graphics anymore.

USE DIFFERENT METHODS FOR HIGH- AND LOW-LEVEL PATHING. To date, most games have used the same system for both solutions. Using a low-level solution for high-level pathfinding generally results in high-level pathfinding that's slow and not able to find long paths. Conversely, a high-level pathfinder used for low-level pathfinding creates paths that don't take all of the obstacles into account or are forced to allow units to move completely through each other. Bite the bullet and do two separate systems.

NO MATTER WHAT YOU DO, UNITS WILL OVERLAP. Unit overlap is unavoidable or, at best, incredibly difficult to prevent in all cases. You're better off simply writing code that can deal with the problem early. Your game will be a lot more playable throughout its development.

GAME MAPS ARE GETTING MORE AND MORE COMPLEX. Random maps are going to be one of the key discriminating features in RTS games for some time to come. The better movement systems will handle random maps and also take changing map circumstances into account.

UNDERSTAND HOW THE UPDATE AFFECTS UNIT MOVEMENT. Variable update lengths are a necessary evil that your movement code will have to be able to handle. Use a simple update smoothing algorithm to make the most of the problems go away.

SINGLE UPDATE FRAMES OF REFERENCE ARE A THING OF THE PAST. It's impossible to do coordinated unit movement without planning. It's impossible to do planning if you don't track past decisions and look at what's likely to happen in the future. Any generalized coordinated unit movement system needs to be able to recall past collision information and have future collision information available at all times. Remember that minor variations during the execution of a collision resolution plan can be ignored.

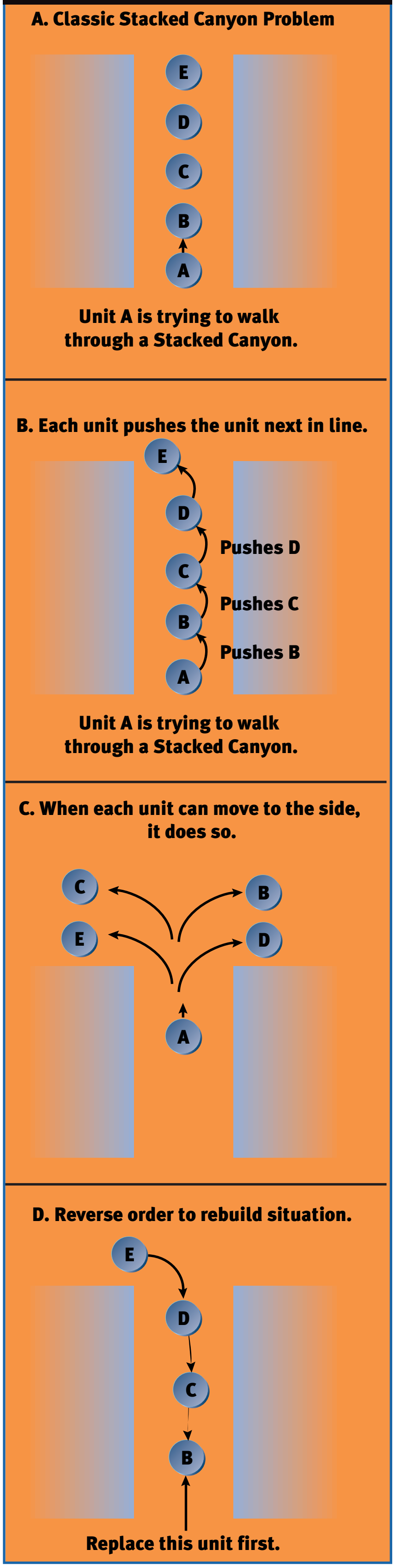
No Stupid Swordsmen

Simple unit movement is, well, simple. Good, coordinated unit movement is something that we should be working on in order to raise our games to the next level and make our players a lot happier in the process. With these articles, we've laid the foundation for a coordinated unit movement system by talking about topics such as planning across multiple updates and using a set of collision resolution rules that can handle any two-unit collision. Don't settle for stupid swordsman movement again! ■

FOR FURTHER INFO

- Archer Jones. *The Art of War in the Western World*. Oxford University Press, 1987. ISBN 0-252-01380-8. This is a great book if you're looking for information on historical formation usage.
- Bjorn Reese's page of pathfinding/navigation links is at http://www.imada.ou.dk/~breese/navigation.html

FIGURE 14. *Solving the Stacked Canyon Problem.*



A. Classic Stacked Canyon Problem

Unit A is trying to walk through a Stacked Canyon.

B. Each unit pushes the unit next in line.

Unit A is trying to walk through a Stacked Canyon.

C. When each unit can move to the side, it does so.

D. Reverse order to rebuild situation.

Replace this unit first.

Back

POSTMORTEM

Shi
E e ai me
WILD 9

by Didier Malenfant

Shiny Entertainment is well known for its successful console platform games. And yet, huge hits such as EARTHWORM JIM and its sequel have resulted in huge expectations for future projects within this genre. Game players who might forgive minor imperfections in an innovative PC title, such as Shiny's MDK, are less understanding of faults in a platform game. The Golden Age of platform games, ushered in by the NES, the Super NES, and the Megadrives consoles, established some very high standards for this genre. In this environment, our team at Shiny launched the development of WILD 9.

Didier Malenfant is a programmer at Shiny Entertainment. Even being French he is only mildly rude and enjoys snowboarding, driving his yellow car, researching in all aspects of 3D programming and running linux boxes. He can be reached at dids@shiny.com.

Like None Before

We were fortunate in that Tom Tanaka, WILD 9's lead designer, had been one of EARTHWORM JIM's designers. His experience and love for the platform genre guided the project's efforts from the beginning. During some of the early design meetings, we decided that one way to differentiate our platform game would be to come up with creative ways of getting rid of the enemies — most platform games involve some form of the player jumping onto the enemies' heads. So from the very start, we designed WILD 9 to be different in this respect. From this beginning point, we realized that the main character would have to possess some kind of weapon that could eliminate the baddies in a lot of different ways.

David Perry, Shiny's president, took an interest in our initial design and challenged us to create a weapon like none that had been attempted before in a videogame. Our first ideas centered on a female character wielding a glove that could remotely vaporize enemies or objects. This glove would deliver the same kind of actions you could perform with your own hands, only with a thousand times more strength. And then, somewhere in the early design stages, we realized that this wasn't a weapon at all. The glove evolved into a beam that came out of the back of the main character's suit. This system was to take center stage in the game's design and eventually was dubbed "The Rig." WILD 9 was to become one of the most violent games around, but ironically the main character was to have no weapon.

Kevin Munroe, character and story designer and lead animator on the project, expanded Tom's first attempts and created a whole universe and storyline for the game. The main character became Wex Major, a male teenager lost in another galaxy. Wex's encounter with The Rig gives him the opportunity to fight the evil creature controlling the planet upon which he's just landed. As Kevin described his own design, "Imagine if George Lucas co-wrote *Star Wars* with Lewis Carroll. And imagine if George Lucas then codirected it with Tex Avery." Wex soon finds allies (eight of them), and together the Wild 9 embark upon a "David vs. Goliath" battle against Karn, a 376-year-old being with the power of a god and the temperament of a toddler. Karn has set his sights on harnessing the ultimate power of The Glove and Rig, as well as the only being capable of using them: Wex Major. From his humble anti-hero beginnings as a pizza boy in earlier designs, Wex was now the planet's only hope, and the task ahead of him was nothing short of incredible.

Because Shiny had had luck with licensing its properties in the past, we created a game bible that contained the character profiles, as well as multiple sketches of all the characters in the game. This document was then used to show production studios and other interested parties the game universe from which TV shows or toy lines could eventually draw. As David had the chance to say in multiple speeches he made on the subject, a game bible is invaluable in the quest to license your game worlds and characters. In our case, it was also a useful reference to the huge database from which we were going to create a game. Kevin and Tom designed a lot of game content — to the point where we nearly had to lock them in Shiny's basement to stop them from adding anything else. In addition to the main character Wex, the designers came up with a sidekick named B'Angus; Nitro, who is allergic to everything and has a bad tendency to explode when he sneezes; Henry, who helps navigate the water levels (Wex doesn't know how to swim); Crystal and Boomer, the game's female characters; the multiple bad guys grunts Wex encounters along the way; Karn, the evil giant who faces Wex at the end of the game; the famous Little Evil Green Men (or LEGM as we later called the tiny, single-eyed green pests); Filbert the sniper; and many other characters, as well as the world they inhabit.

The WILD 9 team — Standing up from left to right: Erik Drageset, Jean-Michel Ringuet, Scott Herrington, Malachy Duffin, Tom Tanaka, Gavin James. Sitting down from left to right: Lori Perkins, Rich Neves, Kevin Munroe. Not pictured: Klaus Lyngeled, Stuart Roch, Lloyd Murphy, Didier Malenfant. And the Big Grub guys: John Alvarado, Brandon Humphreys, Mike Winfield, Ron Nakada, Neil Hong.

The initial game bible only served as WILD 9's starting point, because we added a number of elements to the design as we went along (we even managed to finish some of them). Still, this document proved to be such a valuable resource that all of Shiny's future titles will start with the development of a game bible. Many times, titles are late because certain gaps in the original design were overlooked and the full design was never really laid down on paper before development started. Writing down design details forces the designers to make all the micro-decisions that the design encompasses and leaves less room for interpretation or hesitations from the rest of the team.

WILD 9

Shiny Entertainment
Laguna Beach, Calif.
(949) 494-0772
http://www.shiny.com or http://www.wild9.com

Team Size: Thirteen full-time developers at Shiny. Five contractors from Big Grub.

Release date: October 1998.

Intended platform: Sony PlayStation

Hardware used: Loads of very powerful PCs and PSY-Q devkits.

Software used: 3D Studio Max, Photoshop, Painter, PSY-Q development system, Slick Edit, Codewright, Visual C++, Sourcesafe, and custom tools.

B'Angus

WILD 9's development began around the time that the first all-around 3D platform games had started to appear. Faced with this emerging trend, we had to make a choice whether to follow it or to stick to more traditional 2D-based game play, even if it meant evolving in a 3D environment. The second solution was chosen mainly because of The Rig. We wanted full freedom for the beam to move, and that meant using the full range of joypad inputs just to achieve that goal, never mind running around in 3D. So we decided that the main character would travel on a predefined path that would roam through a 3D universe, involving changes of direction and multiple camera angles. This decision also allowed the level designers to carefully place camera angles along the character's path, thus enabling dramatic scenes and varied views of the scenery. Later, we used the camera to give players more awareness of their surroundings and warn them of the dangers ahead by panning the camera one way or another.

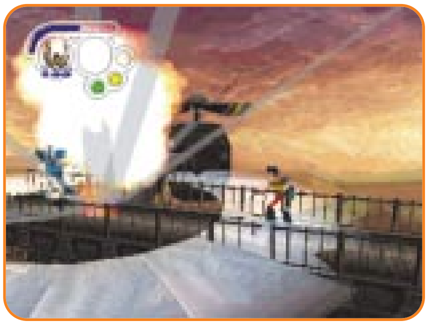
While WILD 9's design was challenging from the start, we also wanted the game to push new limits on the technical front. We wanted to deliver not only great and innovative game play, but also amazing visuals. The results were a mixed bag, and our technological effort was probably the most tumultuous part of the game's development.

The Tools and the Talent

WILD 9 was originally targeted at two platforms; the Sony PlayStation and the Sega Saturn. We eventually dropped the Saturn version, much to the disappointment of many Sega fans worldwide. Still, our original plan influenced the technical side of the project throughout the course of the game's development.

Characters and levels in the game were modeled in 3D Studio Max and then exported using a proprietary plug-in that Malachy Duffin wrote. In order to account for both platforms, Malachy first wrote the export plug-in to handle both output formats, and the scripts that drove the export process contained lines referring to both the PlayStation and the Saturn. When we dropped the Saturn version, half of the data in these scripts became obsolete; from that point on, only the PlayStation side continued to evolve.

The export plug-in handles the character's geometry, which is stored as a certain number of limbs, and animation, which is stored as translation and rotations of those limbs. This system has a small memory footprint while remaining flexible enough for our purposes. (We didn't use single skin meshes in the game because the on-screen size of our characters would have rendered this refinement invisible.) One of the game engine's features was the ability to hide and unhide specific limbs, which was pretty handy in optimizing the game's rendering time. One of the tricks we used was to produce multiple level of detail (LOD) models of certain objects, and store those LODs as separate limbs within the same character file. We could then hide and unhide LOD limbs depending on an object's distance from the viewpoint; once again, the small size of our objects on the screen made the popping from one LOD to another minimal.



The levels and characters also contain various invisible bits of information, such as trigger points, reference points, and collision boxes. A level's trigger points generate monsters and powers ups. A model's reference points provide anchors for multiple effects. If a character, such as the alien beast in the Beast Engine level, has smoke coming out of its nostrils, then these will be generated from a reference point placed on the character model. The reference point can be hidden and shown according to a visibility track placed in the model's animation in 3D Studio Max, which makes editing them simple. Of course, things are never too simple. We encountered some problems toward the end of the project when time came to get the PAL version of WILD 9 going. The game's final level, which features an encounter between Wex and Karn, involves Karn trying to catch up to a running Wex. Because Karn is such an imposing fellow, his

Filbert

footsteps generate a puff of smoke and a loud bang; we generated these footsteps with reference points placed on Karn's feet. A problem arose with the PAL version because the animations played at a different speed to compensate for the 50Hz frame rate. Some of the reference points were skipped altogether, and Karn would appear to limp as only one leg would make a sound. We solved this problem by making the reference points active for multiple frames and preventing the game engine from processing those two frames in a row. If one reference point was skipped, we were sure to catch at least one another from the same group. It wasn't a very elegant solution, but it served its purpose late in the project.

All in all, 3D Studio Max was a decent editing environment for Stuart Roch, Lori Perkins, and Rich Neves to work with, although a dedicated editor would probably have been better in some cases. 3D Studio Max offered near-total layout freedom, but was lacking in the ease-of-use department, considering that we weren't even using a tenth of its features for our level-building and real-time character purposes. One feature that was very useful to us, however, was the user-defined properties it allows you to input for each object. By including a lot of keywords and properties within each game object, we could easily pass on the information that the export plug-in needed to and process its output accurately and efficiently.

My assignment for the project was to program the game's intermediate levels, which consisted of jetbike races chasing bad guys in various landscapes, falling down a huge tube trying to avoid projectiles, and the game's final encounter between Wex and Karn.

The tools and the game engine also allowed for animated textures and particles, which the team's artists used extensively. Jean-Michel Ringuet used animated textures in the Crystal Maze level, for example, to give crystals a extremely realistic glow. Erik Drageset provided levels such as Drench, which featured a series of multiple water falls and water effects — it had us all in awe the first time we saw it. In the meantime, Lloyd Murphy was working on Wreckage with the secret intention of making it the most graphically intensive level in the whole game. He kept that record to the end of the project with only a few kilobytes of memory and a few bytes of video memory left when this level was running. However, toward the end of the project, when we'd add a game element that would appear on all the levels (such as the in-game information panel), Wreckage would be the first level to break and run out of memory. We used the particle system extensively throughout the game for explosions and various pyrotechnics. Here too, unexpected usage of the particle system proved very effective in the Drench level, where raindrops fall and create very realistic ripples into the water — all done using different types of particles.

Two factors led to the literal flourishing of particles everywhere in the game. Gregg Tavares, who started as a programmer but left the project midway through development, added the ability to create and use particles from inside the game's scripting language. Furthermore, John Alvarado built his now famous Particle Studio module. This module allowed us to preview the effects of the particle system's many parameters while modifying them in real-time using the joypad.

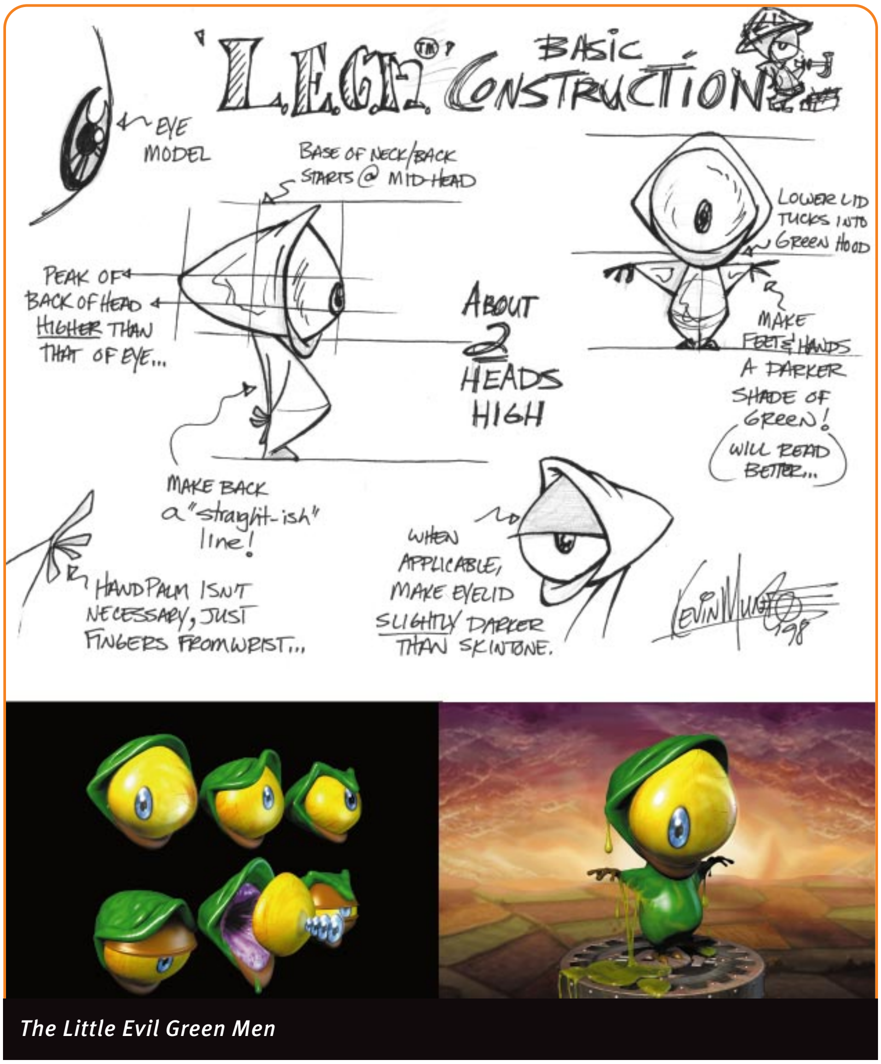
These kinds of tools, together with our scripting language, offered our artists a creative freedom that paid off for us in a big way; it's likely to serve as a model for our future development efforts. Great and unexpected things resulted when the artists were able to try out new ideas out without involving the programmers. A typical scene involved a bunch of programmers looking at the artist's screen and saying something along the lines of, "I didn't know it could even do that."

On the other side, every time a task required the programmers' help, synchronization became a major problem, with the programmers trying to fit these extra tasks into an already busy schedule and artists waiting around for a very long time before they could wrap up their levels. One perfect example of this was the game's enemy AI. Even though the artists could place enemy actors anywhere in their levels, they always needed a programmer to code at least a place holder AI routine so that the artists could preview their work. As a solution, we built a test level that we could use as an object viewer. Artists could drop their models into this test level to get a preview of what they would look like in their final, real-time, PlayStation form. While the test level helped, it didn't solve completely solve our work synchronization problem. Enemy behavior still needed to be coded in for the level to be fully tested and polished.

Still, a really effective solution to many of the problems that we experienced involved not only extra organization and proper scheduling, but also better communication. If a programmer is unaware that another team member is waiting on a certain feature, then the process would end up in a gridlock situation. So, while the organization we chose worked, it was never perfect. We used Microsoft Sourcesafe to share code between the programmers, but the only trusted version of the game was always living on Gavin James's computer. Gavin personally made sure that he'd incorporated every change we made to the game by keeping track of everybody's progress and updates. For future projects, we hope to implement some kind of registry or database where all the game elements can be recorded. Our hope is that such a system would allow us to better see how changing some part affects all of the other parts.

Our programmers developed a scripting language to enable easy implementation of the characters' AI. The language is based on a byte code, which is interpreted in real-time during the game and specifies three main threads for each character. The intelligence, animation, and movement threads control the actor's behavior and also have the ability to spawn additional threads, if necessary. The scripting language also handles collision events using a table that contains all the different classes of characters in the game and the corresponding collision types allowed to occur between them. The system can thus trivially reject collision tests between objects that should never collide with each other, such as two static objects.

As Gavin continued to improve the game engine, we kept extending the scripting, adding new features and allowing access to just about any low-level function through C function calls. Though imperfect, the scripting language was fairly easy to use once all its loopholes were known, and it enabled faster prototyping than straight C. A testament to the versatility of the scripting language is the fact that even the menu system that Malachy wrote is, in fact, treated as a normal game level by the engine. Every menu item that the players see on the screen is a game actor and the background is a huge game level.


L.E.G.M.™? BASIC CONSTRUCTION
EYE MODEL
BASE OF NECK/BACK STARTS @ MID-HEAD
PEAK OF BACK OF HEAD HIGHER THAN THAT OF EYE...
ABOUT 2 HEADS HIGH
LOWER LID TUCKS INTO GREEN HOOD
MAKE FEET & HANDS A DARKER SHADE OF GREEN!
WILL READ BETTER...
MAKE BACK a "straight-ish" line!
HAND PALM ISN'T NECESSARY, JUST FINGERS FROM WRIST...
WHEN APPLICABLE, MAKE EYELID SLIGHTLY DARKER THAN SKINTONE.
'98

The Little Evil Green Men

Progress

WILD 9's development was divided into two relatively distinct periods (more on the reasons for this later). The first team that worked on WILD 9 had most of the game engine written, a few levels started, and some game play mechanics implemented, but the game itself was not what we could call playable. When the second team took over, Gavin spend most of his time cleaning up the engine, while the artists and level designers focused on finishing one level. This was the long birthing of Gulag, which took a full two months to finish; more than any other level in the game.

To the team's credit, a second level, called Bombopolis, was started during the last few weeks of Gulag. Then things started to really snowball. People were getting used to the tools and the limitations of the engine, and we spent the remainder of the project making progress at an extremely scary pace. At this point, the engine was getting pretty stable, and we were able to start adding new features. Levels started popping out of nowhere, and before we knew it, we were playing a full-blown game.

What Went Right

1. **THE SECOND TEAM.** Shiny had originally wanted to release WILD 9 last year. Back then, another team was working on the project. But following a major staff upheaval, the only people left from the original staff were Tom and Kevin; the rest of the first WILD 9 team, in one way or another, left Shiny. I'll elaborate on this in the "What Went Wrong" section, but needless to say, inheriting a project, engine, graphical work, and early levels from another team is indeed not an easy task. A constant tension exists between trying to work with old stuff and wanting to redo it all over again.

Most credits must go to Gavin, who had to abide by technical decisions made by other programmers before him; he spent a lot of time trying to make sense of the game engine's features and inner workings. Word is that even though the game is now finished, he's still somewhere back there trying to make sense of part of it.

In truth, he spent a lot of time trying to anticipate what people would need in order to be productive and gave, where possible, top priority to other people's needs to avoid gridlock and keep things moving. He also helped a lot by sorting out small and easily definable tasks and handing them to people who were learning parts of the system, thus making their learning curve easier.

If the first team's working atmosphere was not perfect, that of the second team was a completely different story. People were gradually added to the team as development progressed, and the last few months were spent under incredible pressure and extremely tight deadlines. And yet through all this, we get along well with one another, and no homicides took place. Joking aside, the chemistry among the second team was incredible, and I think I can safely say that everyone had a great time working on this title. A great atmosphere meant suggestions on each other's work were well-taken, spirits were up, and productivity was positively influenced.

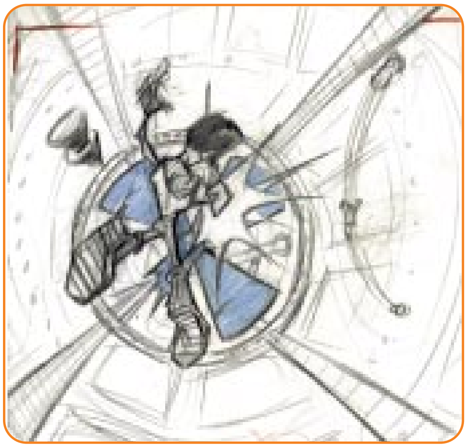
2. **THE SCRIPTING LANGUAGE.** As I mentioned earlier, we used the scripting language for just about everything

in the game. In fact, the language turned out to be rather easy to learn, and it was very powerful once some key features were added to it. It was a great way to prototype certain actors very quickly and work with the animator and the level designer to polish up behaviors and attack patterns. The interpretation of the byte code wasn't the fastest thing around, but it turned out to be a positive trade-off for flexibility and ease of use. Also, most of the low-level functions were performed by straight C code that was triggered by scripting commands from within the actors' AI code.

3. Stuart Roch stepping up as a producer. During a rough patch in the second team's initiation, when we thought things couldn't get much worse, Wild 9 lost Scott Herrington (it's producer), who had to replace the departing Simon Cox as Shiny's PR manager. Stuart Roch had been hired initially as an assistant designer, but he quickly stepped up to full-blown producer, even though he only officially earned the title later on in the project. Stuart's attention truly helped keep the project on track, as he did an awesome job at keeping everything together, organizing schedules, and making sure that we as the team had everything we needed. It's no surprise that now, after Wild 9, Stuart will go on to produce other Shiny titles.

4. The addition of Big Grub. Toward the end of the project, it became clear that we weren't going to finish all the ideas that we had had for this game if we didn't get serious help in the form of extra manpower. We needed art for the menu system, a closing movie for the end of the game, and a dozen programmers to implement the behavior of all the actors that the level designers had in mind for their levels. We didn't get a dozen programmers, but we did decide to flout Brook's Law and add more people to the project. Learning from past mistakes, we looked for people who were not only talented, but work well with the rest of the team. Nobody fit this bill better than the Big Grub guys.

Big Grub is a small company from Irvine, Calif., whose talents we contracted to help us out with all the content ideas we had for the game. John Alvarado, Ron Nakada, and Mike Winfield helped program the AI for



many of the game's characters, Brandon Humphreys worked on the interface art and the end movie, while Neil Hong designed the second falling level and helped with the end movie. We couldn't have finished the game in time without them, but we also took a big risk bringing on new people toward the end of the project.

5. Keeping everybody in close quarters. Shiny is housed in a three-floor building. The first floor is mainly administrative, the third floor houses the Messiah and Sacrifice teams, which leaves the second floor for Wild 9 and Stunt RC Copter. Shiny has no private offices, so to speak; both development floors are organized in an open space layout, with separating half-walls in some cases. Stunt RC Copter is only a three-person team, so the rest of the space was occupied by the Wild 9 team. While we weren't cramped, it's safe to say that some people got to know their neighboring coworkers rather well.

This proximity became invaluable because it enhanced communications among us ten-fold. One early problem with the project involved assigning tasks to the individual team members and keeping abreast of who was up to what. Weekly meetings going over everybody's schedules and a lot of direct and constant communication among us (most of the time without even leaving our desks) directly addressed this problem.

What Went Wrong

1. The first team. I once heard David Perry say that the first Wild 9 team was a great collection of talented individuals, while the second was a talented team. This statement alone sums up the main problem encountered by the first team. As we found out later in the project, communication and good atmosphere were two factors that made this project move forward; it's now obvious that the best thing to do was to start over rather than try to salvage a situation that was going nowhere.

2. A lack of existing documentation. I've already sung the praises of our scripting language, but not everything was totally perfect in this picture. Although it ended up being very useful, it became clear early on that the language and its op-codes had massive loopholes and "gotchas" waiting to jump on us. To help other programmers with their first steps, Gregg started maintaining a document as he was learning the AI system. This document described all the major problems that he'd encountered and ways around them that he'd discovered. When Gregg left the project , Gavin and the rest of the programmers took over the responsibility of updating this document as new problems appeared or new solutions were found.

This process continued until the very end of the project. The document was invaluable in getting somebody up to speed on the system, such as when the new programmers from Big Grub came to the rescue. Overall, the language's design was, in some places, questionable; for instance, the actor registers were called **params** and the virtual processor's variables were called **regs**, which was greatly confusing.

3. The physics engine. The physics engine turned out to be one of Gavin's biggest nightmares during the Wild 9's development. He inherited

this code from the previous programmers, and he spent more time trying to unravel, optimize, and just get that part of the code functioning than on any other identifiable part of the game. His advice to engine inheritors: unless the physics are perfect and written exactly as you want them, grow your own.

4. Deal me in. Our tools programmer and resident Irish person Malachy once decided to bring us a little multiplayer game he was working on in his spare time. The game was called Deal Me In, and he wanted us to help him beta test it. Deal Me In is best described as a very addictive cross between Scrabble and Poker. Actually, "addictive" doesn't even begin to describe the darn thing.

Everyone at Shiny plays games. So when it comes to testing a very addictive game, we are very thorough. The game became an obsession, to the point where it was affecting our productivity. It turns out, after extensive research, that there is no such thing as a "quick game of Deal Me In."

5. Things that did not make it. Tom and Kevin are two very creative fellows. The material they came up with is enough to fill up three or four games like this one. In addition, the whole team took this game to heart and ended up coming up with suggestions of their own. We were thus faced with a situation toward the end of the project: we could not fit everything into the game.

Wex's weapon, The Rig, is normally blue. But it possesses a red mode, which is greatly under-used in the game. The red mode was initially meant to be a more powerful blue beam, but this created game play issues, as a player will sometimes want to transport enemies in the beam from one point of the level to another. The red beam would vaporize just about everything on contact, which was obviously a problem. This is one of the only design issues that was never truly fixed and the red beam, even though it made it into the game, isn't used to its full potential.

Many other great actor ideas never made it into Wild 9: for instance, the 3D cow that was intended as a reference to Earthworm Jim, or the tank that Lloyd Murphy modeled that was supposed to populate the Wreckage level. In fact, Lloyd's tank became sort of a myth, which we would bring up at various meetings: "So we don't have time to fit even a tiny little tank then? Are you sure? What if I pretend it's a background?" The need to stop development at some point made it impossible to use it all the ideas and content that we had, although I hear from reliable sources that the cow did eventually make it in there somewhere.

We Did Our Best

It's an amazing feeling after working so hard on a game to sit back and start playing it. In our case, the general feeling was that Wild 9 turned out amazingly well, especially in light of its rocky development history. One of the best feelings was to see the press reaction at E3 this year, and to hear the comments that Wild 9 had come a long way. If you ever saw anything from Wild 9 a year ago, go and check out the final version. We did our best to make sure you will have a pleasant surprise. ■

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SOAPBOX

by Luke Ahearn

Garage Developers are Not Dead

Let me start by clarifying some terms, particularly "Garage Developer" and "Suit." Do not confuse a "Garage Developer" with a "Geek." Likewise, do not mistake a good "Businessman" for "Suit." These terms are about opposing mindsets.

Those of the Garage Developer mindset, given any limits, would rather work their asses off and achieve something than do nothing and achieve nothing. Garage Developer, as I use the term, describes the innovative, self-starting, and hard-working mindset of the individual who has a strong inner vision and follows it. A Geek lacks these qualities.

The Suit mindset, as I use the term, would rather rip-off an idea than innovate. He is not like the honorable Businessman, as his goal is to crank out crap (such as all the MYST rip-offs), dump it in a box, and sell it. This mindset believes that pulling ads is saving money, and that lying on the box will promote sales. This mindset has a short-term view of things.

What we have in the industry now is a great number of Geeks and Suits creating rip-off garbage, screwing each other over, and filling the bargain bins to critical capacity. What we need are Garage Developers and Businessmen working together to create innovative and profitable games.

So, I am sick to death of the statement "Garage Developers are dead." I think the statement was originally intended to mean that the days of one guy developing an entire game by himself are over (and I don't even agree with that). You'd be surprised at the number of two- and three-person shops out there that are responsible for huge chunks of the development process on some major titles. And it's not just programmers. An informal survey of mine revealed that many (who wish to remain anonymous for fear of appearing "unprofessional") are active in the production of 3D models, animation, music, and even design. The small guys are always rising to the top. It's a cycle; the small guy succeeds, becomes a big guy, and another small guy pops up to do things even better.

People will latch on to a statement such as "Garage Developers are dead" and misconstrue it for their own purposes — usually to justify their own failings. People have been echoing this sentiment about garage developers and other innovators for hundreds of years. The American patent office declared that everything that could be invented, had been, in the late 1800s.Obviously, a few new inventions have appearedon the horizon since that time.

This statement reflects more than just a pessimistic view of our industry, but a core problem of humanity. It says to me that some people believe that all innovation, individual achievement, and accomplishment is over. That people believe that there will be no more daring startup businesses based solely on a grand vision and some elbow grease. That people believe that there will be no more technological breakthroughs based on imagination and perspiration. In short, that there will be no more great works by great people. Everything has been done, discovered, and dared — so why try? "So why try?" is the pure essence of the loser mindset.

So what's my advice for making it as a Garage Developer? It's easy to detail. 1. Write your game idea on paper. 2. Build a prototype. 3. Submit it to a publisher. 4. Develop the game. 5. Detail everything you did right and wrong in steps one through four and write a Postmortem for *Game Developer*. 6. Start at step one and repeat this process until you succeed.

Dare to take these steps and repeat them until you succeed. Each time around you will make progress towards producing a successful game. This goes for the professional game developers as well. Is your company or development team reinventing itself, stretching itself, and daring new heights each time you start a new project? If not, then you are moving backwards. Whether you're a true Garage Developer or not, have a mindset of quality and innovation. It's a mindset vital to the game development community. If you decide to take this daring journey, you will not be alone. You'll find plenty of help and information online, in news groups and web sites. The Internet has hooked all of our garages together. We now have tools and information at our disposal undreamed of only a few years ago. Garage Developers have never been more powerful. ■

3D scene by Nicholas Marks of Goldtree

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