

Adding Depth to Games

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Last changed: December 23, 2009

Uses: Game Maker 8.0, Pro Edition, Advanced Mode

Level: Intermediate

Real games are 3-dimensional, aren't they? Well, actually not. All games produce a 2-dimensional image on the screen of your computer. They might look 3-dimensional but that does not mean they are 3-dimensional. So what does it mean when a game claims to be 3-dimensional? This question is difficult to answer. It is a combination of the way the game is created, the visual image the player sees, and the way the player controls the game. In this tutorial we will show how to give your games a 3-dimensional look; how to add depth in your games. But we won't use the 3D graphics functions for this. We will describe more simple techniques like parallax scaling, transparency, and isometric views. Most of this can be achieved by the drag-and-drop actions in *Game Maker* although at some places we will need a little bit of GML code. To follow the tutorial you should have some experience in the use of *Game Maker* but you do not need to know GML well. All example games we create in this tutorial are provided in the folder [Examples](#) that comes with this tutorial and can be loaded into *Game Maker*. Also all resources are provided in the folder [Resources](#).

Introduction

Modern 3-dimensional games model the game world with 3-dimensional objects. They use the 3-dimensional graphics hardware to render such scenes. Given a viewpoint, that is, the position from which the player inspects the game world, the hardware creates the correct image taking into account aspects like lighting, hidden surface removal (objects behind other objects cannot be seen and should not be drawn) and atmospheric effects. With the current hardware this can lead to spectacular experiences but there is a price to pay for this. Modeling a 3-dimensional world with 3-dimensional objects and creating the animations for the characters requires a lot of practice and is time consuming. And creating the game logics, including aspects like behavior of the game entities, 3D collision checking, camera movement, etc., is also much more difficult for than for 2-dimension games. As a result the production of a modern 3-dimensional game is a huge undertaking that involves a large team of specialized workers and typically costs millions of dollars. And still many of these games have errors, in particular in the handling of the camera and the character motions and collision checking.

Does this mean that 3-dimensional games are out of reach for you? Well, yes and no. *Game Maker* does not directly support 3-dimensional game worlds although there are functions for 3-dimensional graphics (and a separate tutorial is available on how to use that). But actually all 3-dimensional looking games produced up to 1995 and many games since don't use 3-dimensional worlds. For example games like *Age of Empires* (see Figure 1) and the *Command and Conquer* series (except for the more recent episodes) do not use a 3-dimensional game world. They are so-called isometric games. They use sprites to represent the game world and the characters, and use some relatively simple tricks to give the user a feeling of a 3-dimensional world. And in this tutorial we will explain the basics of such games.



Figure 1. The isometric world of *Age of Empires*.

Fooling your brain

How do we make something look 3-dimensional? The basic idea is that we have to fool our brain into thinking that the image we see is 3-dimensions. So why do we think that an image we see is 3-dimensional. A number of aspects play a role here.

Objects that lie behind other objects are (partially) invisible

This is an important aspect. You normally cannot look through solid objects. When for example a character is partially hidden by a rock the viewer immediately knows that the character is behind the rock. In this way the viewer gets a better insight in the 3-dimensional relationship between the objects (see Figure 2). So to make a world look 3-dimensional we should only display the (parts of) objects that are actually visible. This process is normally called *hidden-surface removal*.

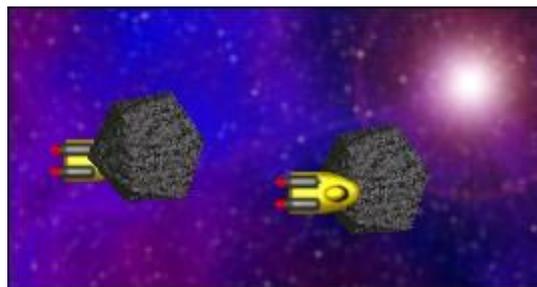


Figure 2. Hidden surface removal helps in establishing the depth relation of objects.

3-dimensional graphics hardware does hidden-surface removal automatically but, because *Game Maker* deals with a 2-dimensional world, we have to deal with this ourselves. The way to achieve this is to draw the sprites that correspond to the objects in the correct order. The object that lies furthest way is drawn first. The next object is drawn on top of it, and so on. Because closer objects are drawn on top of object behind them, they will (partially) hide the other objects. In *Game Maker* we can indicate this order by setting the depth for the different objects. Instances of objects with larger depth are drawn earlier than instances of objects with a smaller depth and, hence, appear behind them.

Translucent objects show what is behind

When objects are partially translucent, you see through them what is behind them. Using translucency combined with the correct depth order increases the feeling of depth further.

Objects that lie further away appear smaller

Clearly, the further away objects are the smaller they appear. This gives a very strong notion of distance and, hence, a better 3-dimensional feeling.

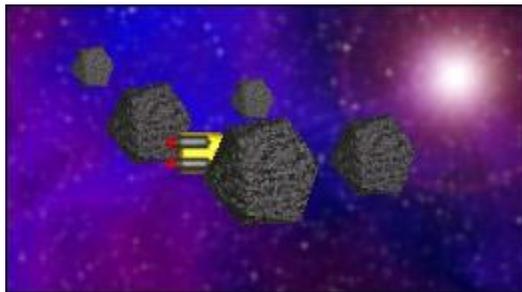


Figure 3. Distant instances appear smaller.

This can be achieved by changing the size of the sprites depending on the depth. You can either make sprites with different sizes or draw the sprites with a scale factor. (We will discuss this further below.) When an object moves towards the viewer it should become larger. This gives a very strong feeling of moving through a 3-dimensional world. Be careful though. When the scaling is wrong it gives the exact opposite effect.

Objects that lie further away appear vaguer

When objects lie further away you cannot see them so well any more. This also works the other way around. When an image appears vague we interpret it as lying further away. Hence, adding a feeling of mist and blurring images that lie further away a bit gives a good sense of distance. This can be achieved by using different sprites for the same instance, depending on its depth.

Object that lie further away appear to move slower

An object that lies far away takes longer to traverse from the left to the right through your view while an object that lies closer moves much faster through your view. You can use this to give the viewer an indication of the depth of the objects. One particular aspect of this is parallax scrolling that we will describe below. Also, objects that move away from you or towards you hardly change position on the

screen. So normally the speed in the vertical direction on the screen (which often corresponds to movement towards you or away from you) should be smaller than the horizontal speed.

Objects tend to have a shadow

Objects cast shadows. It is difficult to compute the shadows that are cast on other objects but it is relatively easy to have shadows on the floor. And even if there is no precise shadow it is good to have a little dark spot around the bottom of an object. This gives the impression that the object stands on the floor. Make sure the shadows are consistent, that is, all objects have shadows (or none) and that they have the same size and are in the same direction. For example, in Figure 4, for the left character it is unclear where she stands. The middle character clearly stands on the ground while the right one jumps above it.



Figure 4. Even a simple shadow gives position information.

Parallel lines appear to meet in a point

As you probably all know, parallel lines in a 3-dimensional world meet in the distance in a point. For example, the two sides of a road meet in the distance. Stated more precisely, our view generates a perspective projection. This in some sense deforms the objects depending on their depth but this deformation is exactly what gives the 3-dimensional feeling. Consider for example the images in Figure 5. The left image shows a projection without perspective. The vertical lines are parallel. In the right image we use a perspective transformation and as a result the lines will meet somewhere in the distance. It gives a much better 3-dimensional feeling.

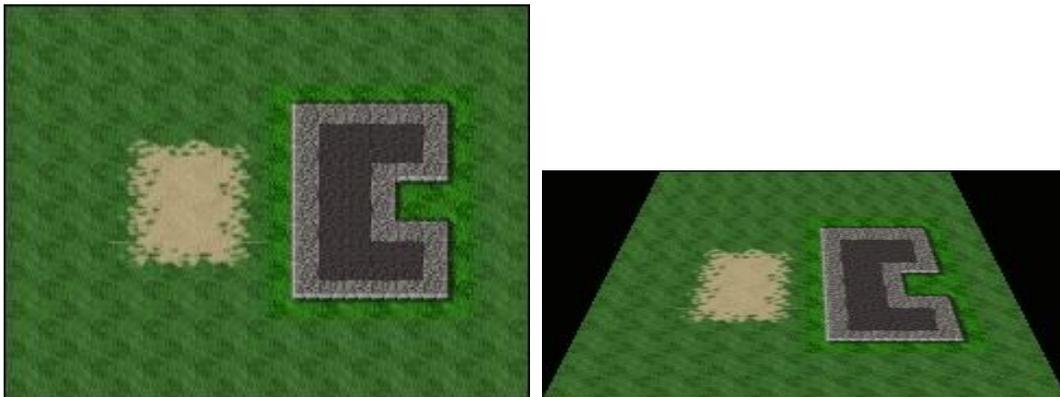


Figure 5. Using a perspective projection.

Perspective projections are important for 3-dimensional games but unfortunately they are not easy to achieve with sprites. So sprite based games normally don't use perspective transformations. To limit the effect of this they often use a projection under an angle of 45 degrees. That is, they don't look straight from the front but a bit from the side. As a result the effect of parallel lines is less prominent and, hence, the viewer is less distracted by them. This is the basis of isometric games. Figure 6 shows the same scene but now under an isometric projection. If you look careful the lines are indeed still parallel (which is wrong) but still it looks a lot more 3-dimensional than the left image above.

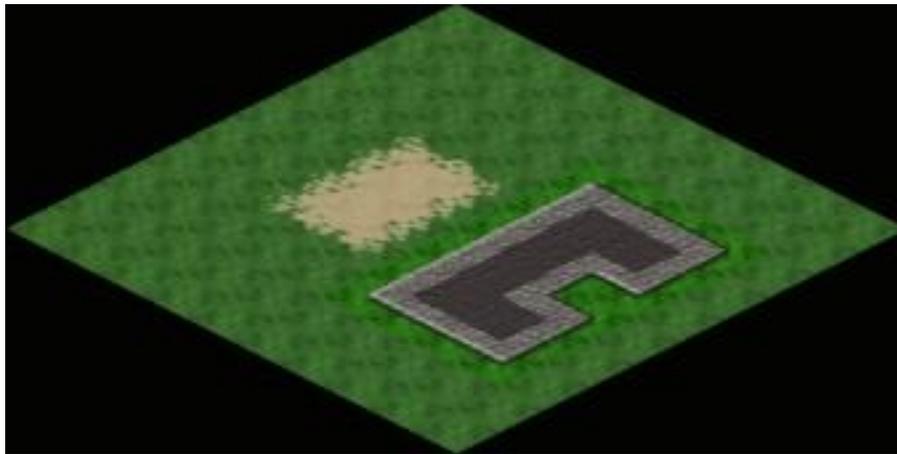


Figure 6. Using an isometric projection.

Creating isometric games is possible with *Game Maker* and below we will show how to do this.

Parallax Scrolling

As was indicated above, object that lie far away move slower than objects that are near to the viewer. In this section we will use that observation. However, we will only use it to create effective side scrolling backgrounds. You can find the example in the folder [Examples](#) with the file name [parallax.gmk](#).

As you should know you can add backgrounds to your rooms in *Game Maker*. Very often a room has just one background but it is possible to have multiple backgrounds. Clearly, to see those backgrounds they need to be partially transparent or cover just part of the room. By giving the lower backgrounds a slower horizontal speed than the higher backgrounds you give the player the impression that those backgrounds are further away. In this section we will create a small example of a car driving sideways on a road. We don't aim for graphic quality; but just want to demonstrate the effect.

First of all we use two backgrounds. The first one indicates some mountains in the distance.

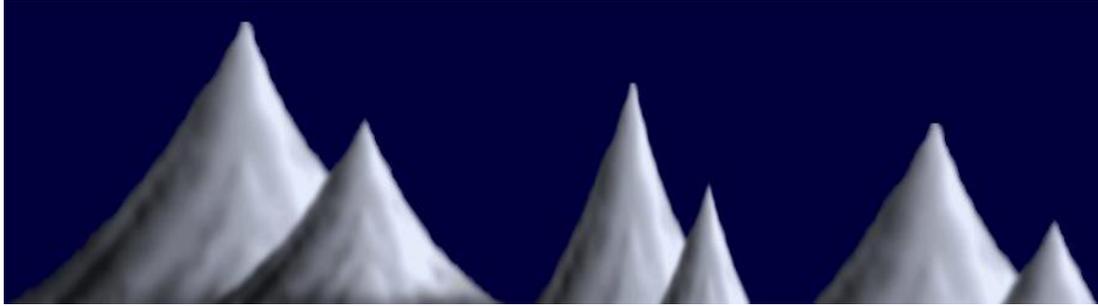


Figure 7. The distant mountains.

This background will be placed at the top of the room and scrolls left with a very small speed of -1. You can set this speed in the Room Properties. We tile it horizontally but not vertically. The second background represents the road. It is very small, is placed at the bottom of the room and moves much faster (speed -4). Again we tile it only horizontal. We place a car on the road but it does not need to move. Because the road moves under it we already get an illusion of motion. Because the road moves faster than the mountains you get the feeling that the mountains are far away.

To add a bit more depth to this demo we are going to include some trees. We use tree sprites of three different sizes as in Figure 8.



Figure 8. The same tree at three different distances.

For each of these trees we create an object. To make sure that the small tree is behind the middle tree which again must be behind the large tree we give the objects different depths. (Below we will talk more about depths.) The large tree will be placed close to the road and in the **Create** event we let it move to the left with a speed of 4, like the road. The middle tree will be placed a bit further away and we give it a speed of 3. Finally, the small tree we give a speed of 2. We place a couple of them at appropriate places in the room. To make sure that they reappear at the right if they disappear to the left we add an **Outside Room** event in which we include a **Wrap Screen** action, indicating the object should wrap horizontally. The resulting demo looks like in Figure 9.

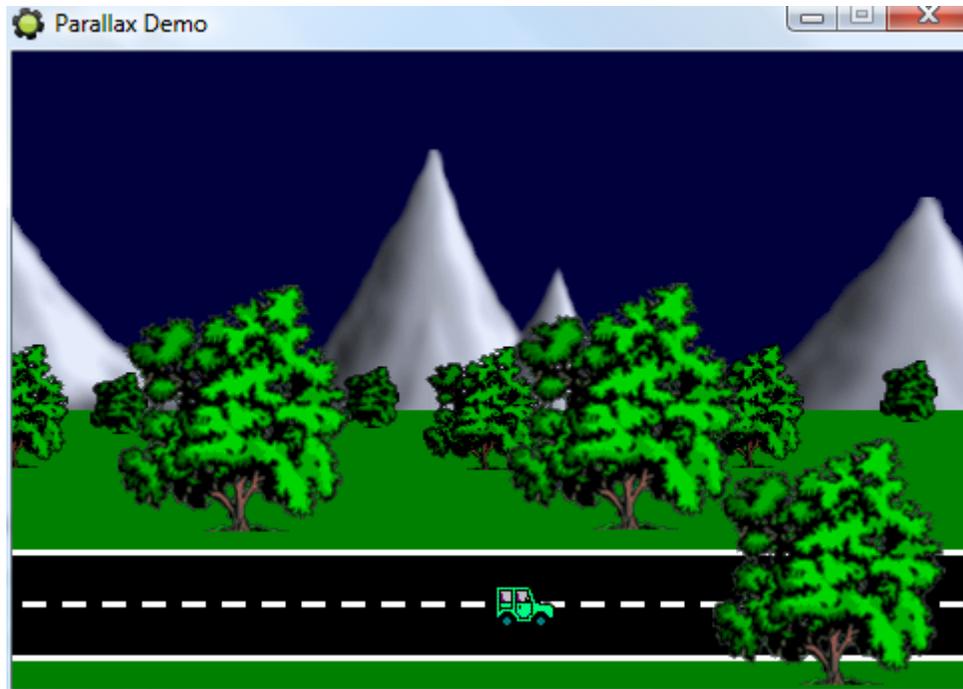


Figure 9. The parallax demo.

Clearly this demo is not a game. To turn it into a game you must give the player the opportunity to steer the car and for example add other traffic to avoid.

Parallax scrolling is very useful in for example platform games. In this case though, you should adapt the speed of the moving backgrounds to the (horizontal) speed of the character that is controlled by the player.

Parallel Projections

Even though true 3-dimensional games should use perspective projections we will first describe how parallel projections can still be used to create a feeling of depth. In a parallel projection the size of the objects stays the same independent of the distance. Also parallel lines remain parallel. This makes it a lot easier to use sprites because sprites have a fixed size (although they can be scaled). Clearly, a parallel projection gives a distortion of the view. To limit this distortion we will make sure that the player cannot see objects that are far away. So he will not really notice the errors. We achieve this by looking down on the world under an angle (normally an angle of about 45 degrees is used). So a world that consists of squares will now look like rectangles.

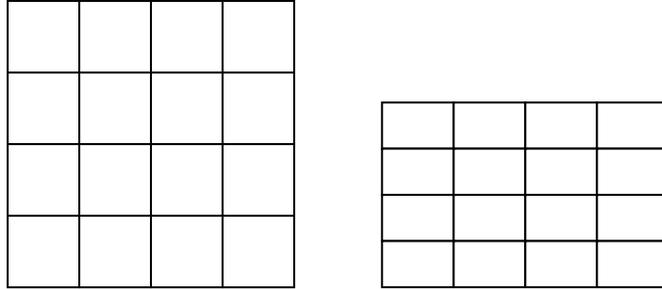


Figure 10. Looking at the square grid under an angle turns the squares into rectangles.

For a background image this will look as in Figure 11. It is easy to create such an image. We simply scale the image in the vertical direction only.

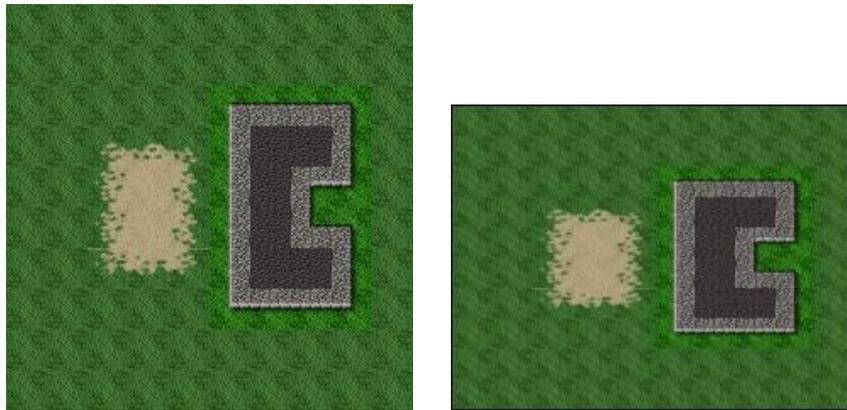


Figure 11. A parallel project of a simple world.

We will demonstrate this approach with a small demo in which the player controls a character that can walk through a world with some trees. The demo can be found in the file [parallel.gmk](#) in the [Examples](#) folder. There are three things we must handle in an application like this: We must make sure that hidden-surface removal is done correctly. So when the character is behind a tree it should be drawn before the tree is drawn to make it partially invisible. Secondly, we have to correctly deal with the speed of the character. Moving back and forth must be slower than moving left and right. Finally, and the most difficult, we must handle the collisions correctly.

Let us start with the hidden-surface removal. As you should know every sprite has an origin. Default this is the top-left corner of the sprite image. When we place an instance of an object at a particular position we actually put the corresponding sprite with its origin at that position. When we deal with a 3-dimensional world it is easiest to take as the origin of the objects the position where they stand on the ground. For all sprites we set the origin to that position. So for example for the character that walks through the forest we set the origin of the sprite at position (X16,30). We also disabled **Precise collision checking** and we modify the mask to set a small manual bounding box at the bottom of the character (see Figure 12). So collisions will not be performed with the whole sprite but only with this small

rectangle. We will use that below. Our character will be represented by 4 different sprites; one for each of the four directions in which he can walk. Clearly for each we should set the same values.

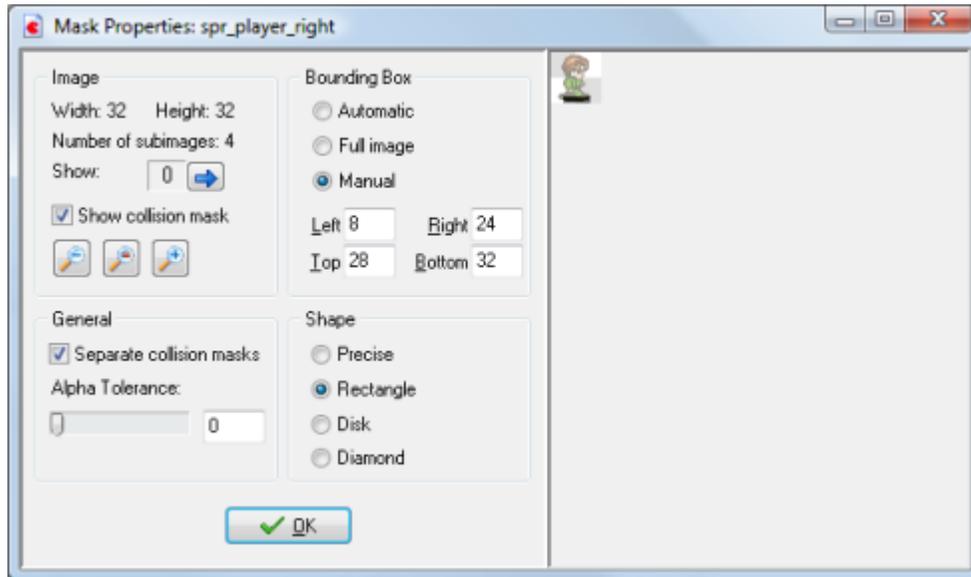


Figure 12. The Mask properties form for the player's sprite.

Now what should the depth be? In most situations the order in which the objects must be drawn is the same as the order in which they stand on the ground. So by setting the origin as indicated above, the y-coordinate of the instance determines the order. Instances with a low y-coordinate are close to the top of the window and must be drawn before the ones with a higher y-coordinate. So a higher y-coordinate must correspond to a smaller depth. This can be achieved by setting the depth to $-y$ using the **Set Variable** action as indicated in Figure 13.

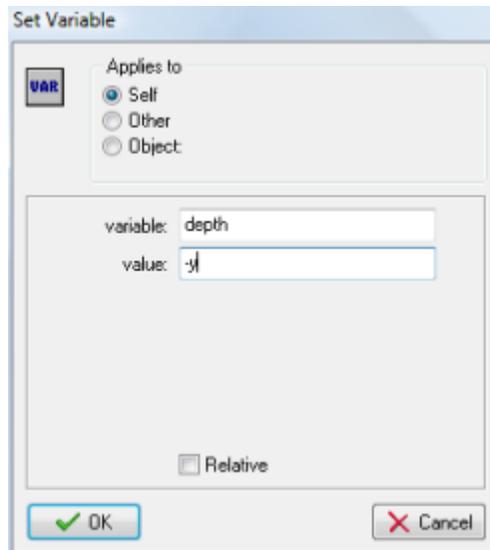


Figure 13. Setting the depth of the instance.

For the static objects, e.g. the trees in our example, we need to do this just once in the **Create** event. For the dynamic objects, the character in our example, we must do this in every step. You best use the **End Step** event for this to make sure that all other events are processed before the depth is adapted.

Secondly, we must deal with the motion of the character. We can do this in the usual way using the arrow keys. In each of the arrow keys event we set the motion in the correct direction and set the correct sprite for the instance. Also, to get an animation of the sprite while moving and no animation when the character is not moving we use the variable `image_speed`. This variable indicates the speed with which the subimages in the animation must be shown. Setting it to 1 plays the animation in a normal speed. Setting it to 0 will stop the animation. So whenever the user presses an arrow key we choose the correct sprite and set the image speed to 1 using the **Change Sprite** action; see Figure 14. (We use -1 for the subimage to avoid a change in subimage when we already move in the same direction.)

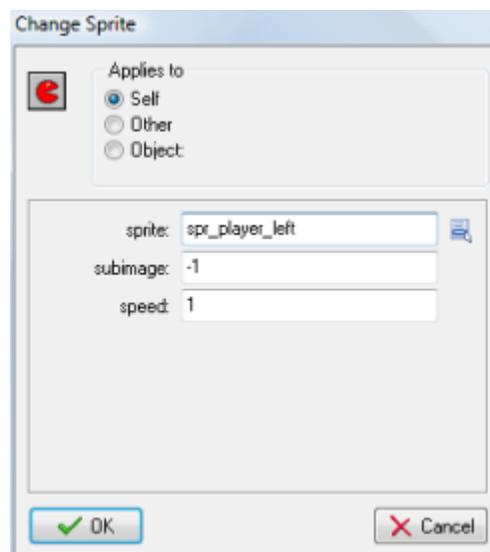


Figure 14. Changing the sprite.

When the player releases a key we set the `image_speed` to 0 using the **Set Variable** action. The same we do when a collision occur.

This all has nothing to do with 3-dimensional games. It is the usual way to handle character motion in many games. The only thing we do have to take care of in a 3-dimensional game is the difference in speed. For the horizontal motion we use a speed of 3 while for the vertical motion we use a lower speed of 2. You must experiment with these numbers to get the best effect for your game.

Finally we must deal with collisions. Normally a collision occurs when the sprites partially overlap. This is fine for 2-dimensional game but not for 3-dimensional games. When the character stands in front of a tree the sprites overlap but there is no collision. So we need another area that must define the collision. Normally this is the area of the instance on the ground. Only when the feet of the character overlap with

the bottom of the trunk of the tree there is a real collision. The easiest way to achieve this is to define a very small bounding box for all the sprites at the bottom and not use precise collision checking. A collision is only reported when the bounding boxes partially overlap, which is exactly what we want.

For more complex shapes a small rectangle at the bottom might not indicate the correct collision area. In that case we can use another feature of *Game Maker*. An object can have a different mask than the sprite used to represent the instance. So we can make a second sprite that has the shape of the required collision areas and use that as collision mask. We will use this approach below when creating an isometric game.

We now have all the ingredients for the 3-dimensional game we want to make. To make it all look a bit nicer we use a tile set of background tiles. We nicely scale them as indicated above to obtain tiles of size 48x24. With this we fill the background. We also add some walls as tiles to the background. To create collisions with these we use a standard technique in which we define an invisible solid wall object and place instances of this object on top of the walls in the background. So the character will stop because it collides with these invisible instances while the player only sees the nice background behind them. Check out the [parallel.gmk](#) file for details.

Finally we must create the room. We will use a view in the room such that the player sees only part of the world. To enhance the feeling of depth we make the view 400x200, so again scaling with a factor 1/2 in the vertical direction. In many games this proportion is achieved by adding some information panel below the scrolling world. (This is the reason why you better put the information panel at the bottom of the screen rather than at the side for this type of games.) The final demo looks as in Figure 15.



Figure 15. The parallel demo.

Scaling Sprites

In the previous section we used a parallel projection. If we keep the view high enough from the ground in a fixed orientation, and we show just a small part of the world this is good enough. But if we want to

get a first person view or a view closer to the ground we need perspective projection. The size of objects must be smaller when the objects are further away. But how do we achieve that? In the first parallax scrolling example we used three different tree sizes. This is fine when the trees stay at fixed distances but in a real 3D game the player might approach them and, hence, the size should change continuously. We could create a huge number of different sprites, one for each size, but this will use a lot of memory. You might though want to do this for really important objects because it gives the best quality. For the other instances we can use the scaling of sprites. In this section we will show how to do this using a simple example in which the player must avoid trees while moving through a forest.

So we first need a sprite for the tree. We use one sprite here. For the sprite we set the origin at the bottom in the center and we modify the mask to set a small bounding box at the trunk of the tree as above. This is the only part where we are interested in collisions with the player. So the tree sprite mask will look as follows:

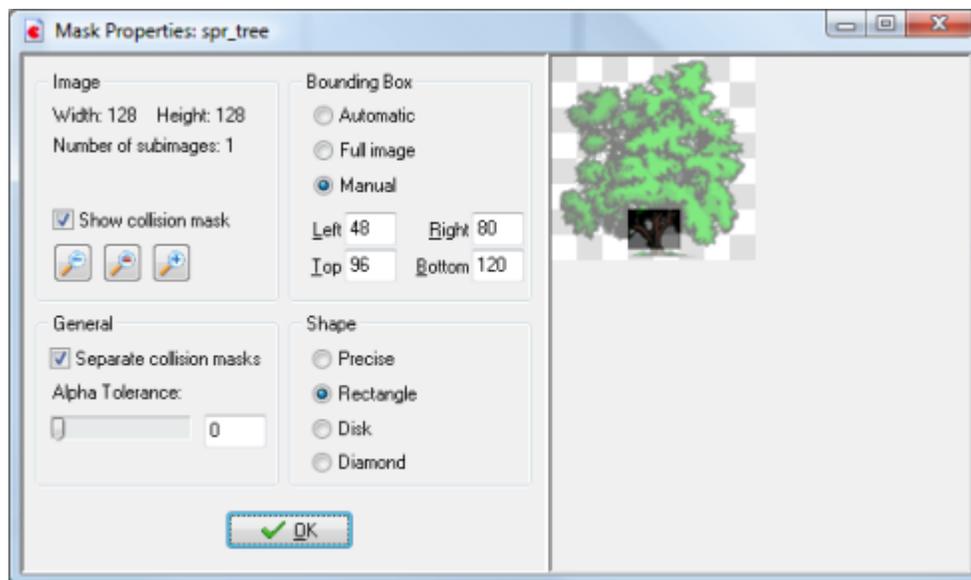


Figure 16. The tree sprite mask.

We will again use the mountains for the background, but this time we will not use any scrolling. Instead we use a wide room of width 2000. We place the main character, for which we also need a sprite, in the middle at the bottom of the room. We will use a view of size 480x320 and keep the character basically in the middle by setting the view borders and indicating that the view should follow the character as in Figure 17.

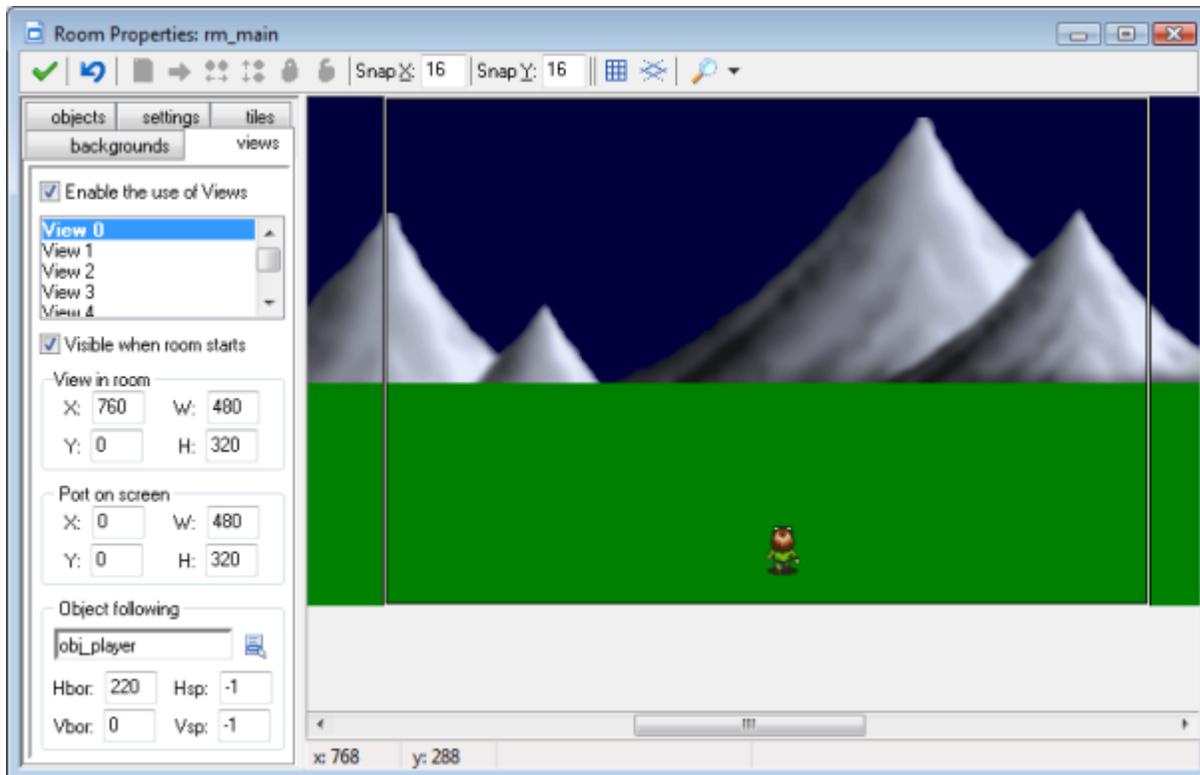


Figure 17. The view keeps the player in the center.

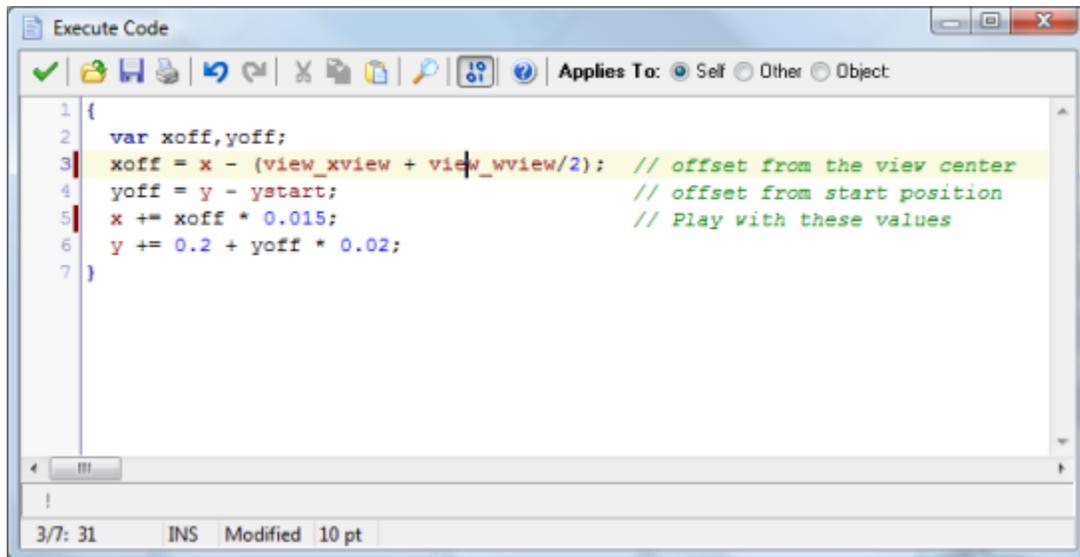
The player will move left and right when the player presses the left or right arrow key. Clearly we must avoid it to move too far to the left or too far to the right. As scoring we use the time the player survives. So in the **Step** event of the player we add 1 to the score. When the player collides with a tree we show the high-score list and restart the game.

What remains is the tree. There are three aspects we have to deal with: the size, the position on the screen, and the depth. Trees will appear at y-position 180. In the end step event we scale the sprite based on its y-position. For this we can change the variable `image_xscale` and `image_yscale`. We use a scale factor that is close to 0 when the y-position is 180 and increases when the tree moves down. To be precise, we use a scale value of $(y-178)/100$. You can play a bit with the scale factor if you like (make sure it is always positive). Alternatively you could use the **Transform Sprite** action.

The second thing to deal with is the depth. Also in the **Step** event we set the `depth` to `-y`. This means that trees closer to the bottom of the screen (with larger y-coordinate and closer to the viewer) have a smaller depth and are drawn on top of the others, as we want. We also need to give the player an appropriate depth to keep him at the correct position among the trees.

Finally we must control the movement. This is harder than it may seem. We can let the trees move down with constant speed but, as you will notice, this will visually slow them down (this is because objects close by seem to move faster than objects far away). So we must increase the vertical speed.

Also, objects move towards the sides if they get closer (because parallel lines meet in a point at infinity). So, based on the position of the tree relative to the middle of the view, we must adapt its horizontal speed. We do this using the piece of code in Figure 18 in the **Step** event.



```
1 {
2   var xoff, yoff;
3   xoff = x - (view_xview + view_wview/2); // offset from the view center
4   yoff = y - ystart; // offset from start position
5   x += xoff * 0.015; // Play with these values
6   y += 0.2 + yoff * 0.02;
7 }
```

Figure 18. Adapting the movement of the tree.

(Note the use of local variables `xoff` and `yoff`.) The numbers have been determined experimentally. You might want to change them a bit.

To finish the game we must add a few other things, like destroying trees when they disappear below the screen and adding a controller object that controls the appearing of trees (more when the score gets higher). You can find the demo game in [scaling.gmk](#). You can use it as a basis for your own games.



Figure 19. The scaling game.

You can actually use the same mechanism to create a full first person shooter game. Here the player object has a position and an orientation in the game world. For all other instances in the world you must compute their position relative to the direction the player is looking in, and their distance. The distance determines the drawing order and the size as above. (To avoid drawing too many instances you normally only draw instances if they are close enough.) For such a game it is though easier to use the functions for 3-dimensional graphics that the Pro Edition of *Game Maker* has. Another tutorial deals with this.

Isometric Games

We will finally look at a very popular type of game: isometric game. Many of the very popular games of the recent past are isometric. Examples are *Age of Empires*, *Diablo*, *Command and Conquer*, *SimCity*, and many other strategy and simulation games (see for example Figure 20).



Figure 20. *SimCity* is an isometric game.

Such games are in principle possible with *Game Maker* (but realize that these commercial games took years to create by dedicated teams of workers).

The principle of an isometric game is that the 3D world is viewed under a fixed 45-degree angle. Again parallel projection is used, that is, there is no perspective, and so objects in the distance will not become smaller. Assume the world consists of square cells as in the left picture of Figure 21 below. An isometric view will look like the right picture. Each square has become a diamond shape. To make lining up cells easy we typically use a 2x1 diamond, e.g. 32x16 pixels.

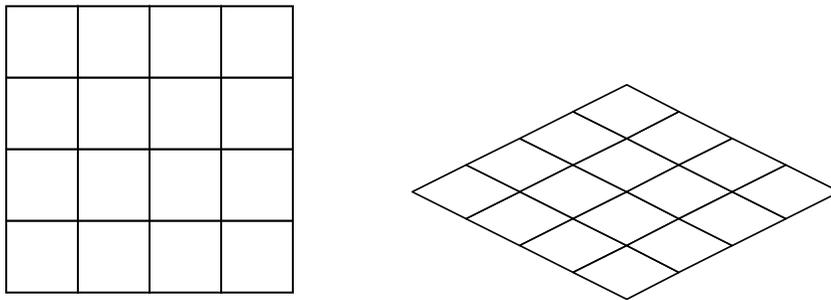


Figure 21. In isometric games squares become diamonds.

Doing the same with a background image we get the pictures in Figure 22.

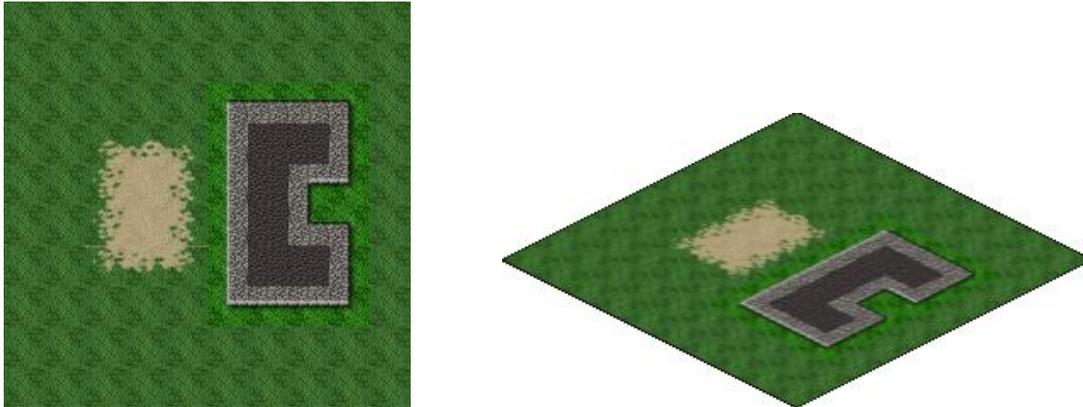


Figure 22. An isometric view on the world.

Such background images can be made rather easily with *Game Maker*. First make a tiled background. Next edit the background, enlarge the canvas, rotate it by -45 degrees, and stretch (or actually shrink) it vertically to 50%. Alternatively you can use a set of tiles that are already of the correct size and orientation. In the room editor you can indicate to use an isometric grid. Now it is relatively easy to put the tiles in the room at the correct places.

The advantage of an isometric projection over a normal projection as we did before is that our mind immediately interprets the diamonds as squares viewed under an angle. This gives a 3-dimensional impression. Clearly we will still get perspective distortions because the size of objects does not change with the distance. This perspective distortion can again be limited by showing only a small part of the world. So most isometric games use a limiting view on the world.

Once you have a nice background we need to place objects on it. These objects should obviously have a 3D look from the correct 45 degree angle. Creating such isometric objects is not easy and is normally the most time consuming task when creating an isometric game.

Each object has a "shadow" on the floor. This shadow is crucial. It will be used for collision detection, or stated differently, it will be used as collision mask. So for an object you will need to make two sprites: the image of the actual object and the shadow mask. It is best to always make the origin of the sprite and the mask the center of the shadow. For example, below you see an image of a wall element we are going to use in our isometric maze, and the corresponding shadow mask (the cross is the origin).

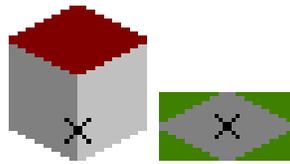


Figure 23. An isometric sprite and its collision mask.

The mask in this case has precisely the size of one tile in the image.

By doing collision detection on the shadows the sprites are allowed to overlap, as long as their shadows do not overlap. This is precisely what we want. When e.g. a ball runs among the blocks the sprites can overlap. But a collision with a wall occurs once the shadow of the ball hits the shadow of the wall.

As in the parallel case we set the depth of each instance to $-y$. In this way the instances are drawn in the correct order.

There is a problem though. When creating the rooms the sprites are not drawn in this order. This might make it difficult to create the right scenes. One advice is to always start at the top and work your way down. Also, on the toolbar there is a button to sort the instances by y-coordinate, which is just what we want.

A final word about motion. Because of the projection, horizontal motion should be twice as fast as vertical motion. Also, when for example using arrow keys to steer the motion, it is common to let them correspond to diagonal motion (along the sides of the tiles) rather than horizontal and vertical motion.

A Maze Example

As an example we are going to make a simple isometric maze game. It is not very sophisticated but it will show you the basic ideas. The game can be found in the file [isometric.gmk](#).

As a first step you better design the maze on paper. It will be very difficult to do this while creating the room. We next create a background floor for the maze that fills the whole area covered by the maze.

Next we create the sprites. As indicated above we need two sprites for each object: the actual image and the mask used for collision checking. (Actually, for many objects we can use the same mask.) Make sure that each sprite is nicely drawn on the floor and that the origin is in the middle of the shadow mask.

To make things more interesting we also add a gate. The gate consists of three parts. The left and right poles are simply a bit higher walls in a different color. They use the same mask as the normal walls and are exactly the same (so we give them the wall object as parent to give them the same behavior). The middle piece of the gate is different. It consists of a block higher in the air. It does not need a mask because the ball can move under it. But we need to make sure that its origin is still in the center of its shadow (otherwise it would not be drawn at the correct depth).

For each fixed element we set its depth in the **Create** event. For the ball we set it in the **End Step** event. For the rest the game is largely the same as a simple maze game. When you press an arrow key we move the ball a little bit in the correct diagonal direction, assuming the new position is collision free. As indicated above the horizontal distance is twice as large as the vertical distance. When the ball (that is, its shadow) collides with the flag (that is, again its shadow), the maze has been solved.

Creating the rooms is a bit more work this time. You have to place all wall elements correctly. Also, as indicated above, best work your way from the top downwards. Use the button in the toolbar to sort the instances by y-coordinate if you made a mistake. Use a 16x8 grid to align the instances correctly. You can indicate that you want to use an isometric grid to make it easier to place the instances. You might want to uncheck the box to delete underlying instances because this makes it easier to place the wall elements.

There is one more trick added to the demo. When you hold the <Space> key you can see the ball through the wall. This is useful when the moving object can completely disappear behind other objects. This is done as follows. A new object called `transparent_ball` is created. It is given a depth of `-100000`, that is, in front of everything else. When the user presses <Space> an instance of this object is created and when he releases the key the object is destroyed. We make sure the object is at the same position as the actual ball, we give it the same sprite, but set its alpha value to 0.2. As a result we see a transparent image of the ball in front of the walls. This does though give the opposite impression of the walls being partially visible.

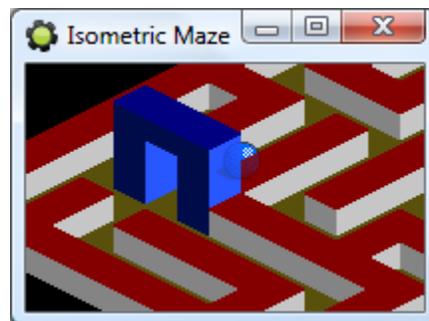


Figure 24. Using a second, translucent copy of the ball.

You might want to play a bit more with the demo. Add some nicer looking wall and gates, add some levels, etc.

More advanced isometric games

Isometric games are very well suited for many types of games. The major complication though is that you need nice looking tiles and sprites. There are though lots of resources for this on the web, including some programs that help you. Use e.g. Google and type as keywords "isometric tiles" and you will find many interesting pages. For the rest, as was hopefully made clear above, it is easier than it might seem. The only two things you have to keep in mind are the collision masks and setting the depth correctly. Here are a few more things to keep in mind:

- When you cannot walk behind certain objects (like mountains or woods) you best draw them on the background. Next you can use some invisible objects to avoid that the moving objects can stand on top of them.
- When an object spans different tiles (like e.g. a gate) split it into several pieces to avoid problems with the depth.
- Remember to always put the origin at the center of the vertical projection of the object. So for example, a flying bird will have its center quite a distance below it. Note that it is not necessary to make the sprite this long. The center can lie outside the sprite.

Conclusions

Hopefully this tutorial has convinced you that it is possible to make many different types of games with *Game Maker* that have a clear 3-dimensional look and feel. As always, only your imagination is the limit. And if you want to make some real 3-dimensional games you might want to download the *First Person Shooter* tutorial from the *YoYo Games* website <http://www.yoyogames.com>.