Introduction

EngineA (EA) is a sector (room) based 3D game engine. A level/map is a bunch of sectors (rooms) connected by portals (openings, doorways). By calculating the visibility of the portals in the sector that the player (camera) is located it's quite easy to determine which sectors need to be rendered. If the doorway to a room is not visible, that room needn't be rendered. And if the doorway is visible, the rendering can be clipped to the bounding rectangle of the doorway. In short, sectors and portals are used to speed up rendering, which is quite crucial for an engine written entirely in an interpreted and pretty slow programming language.

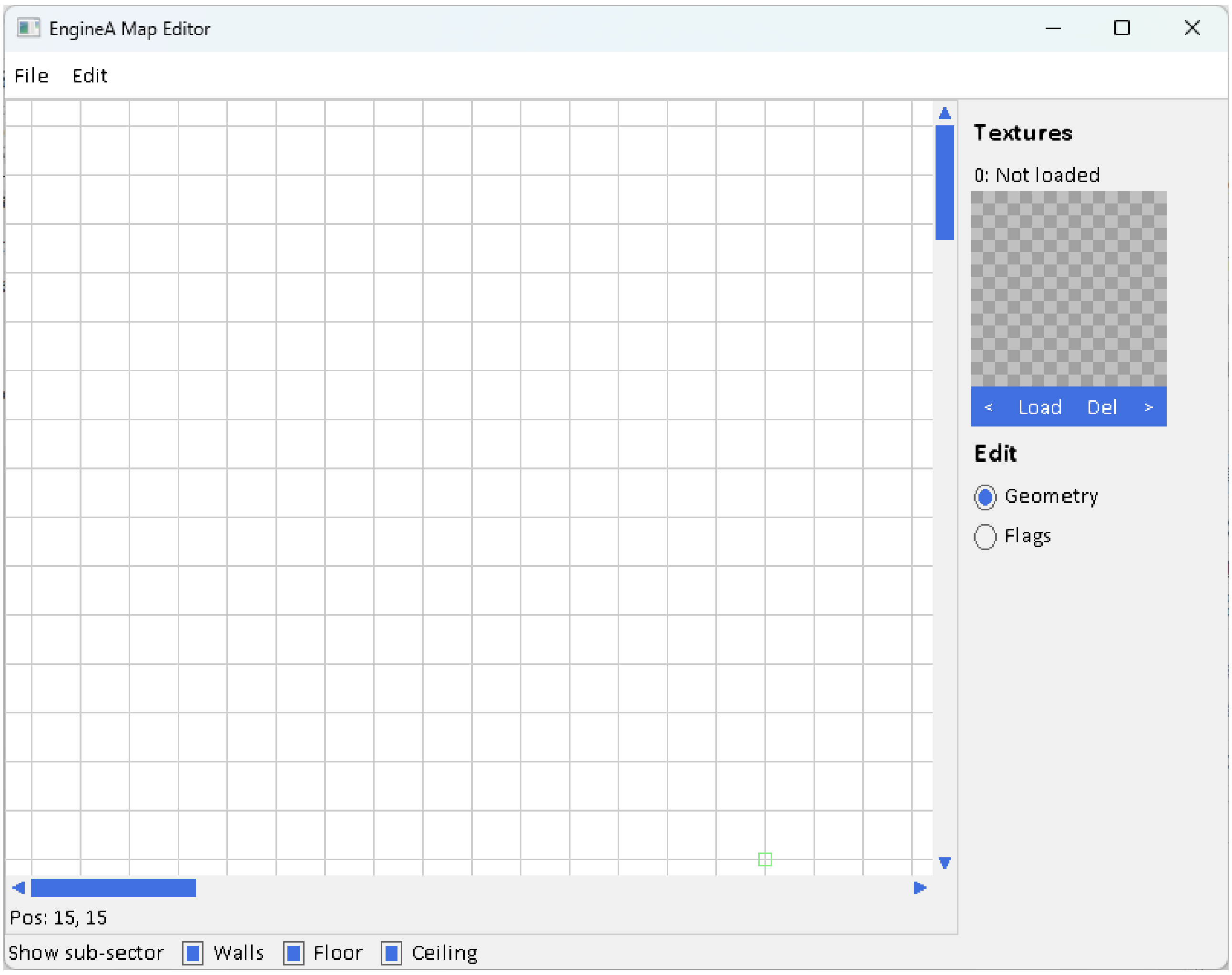
1 A single room

This example shows you how to:

- Create a map consisting of only one sector in the EngineA Editor (examples/assets/map_1.json)
- Write the n7 code to load that map and let the player move around in (examples/example_1.n7)

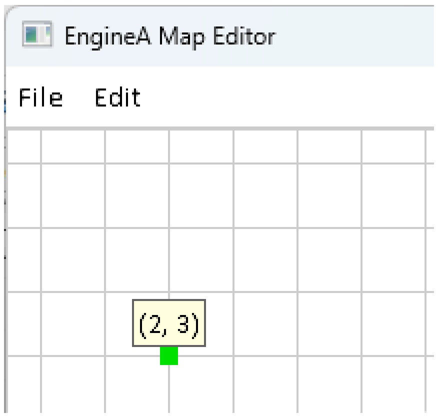
Create a folder where you can save your program and its assets (maps and images). I usually put all my assets in a sub-folder named ”assets” next to the source code. Since EngineA is not yet part of the n7 package, you should also copy the libs folder containing enginea.n7 from the examples folder to the folder you created.

Launch the EngineA Editor (enginea_editor.exe) and this is what you'll see:

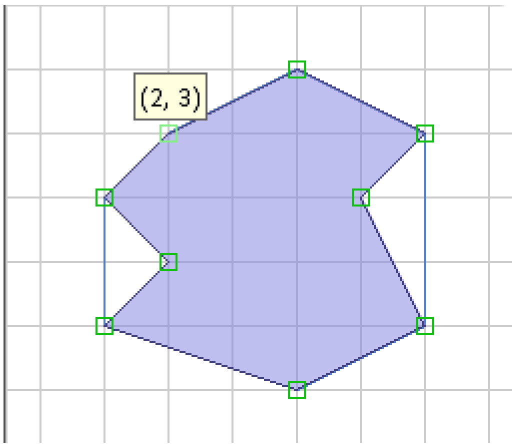


This is a topdown view of the level. The x axis (left to right) represents the x axis in the 3D world and the y axis (top to bottom) represents the z axis (actually the inverted z axis, but don't mind that for now). Just like in games such as Doom the map isn't really 3D (but creating height differences is still very possible).

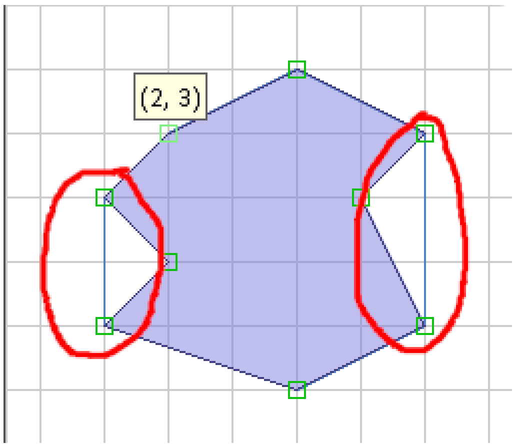
A sector is a closed polygon seen from above. Every line in the polygon is a wall and every vertex a corner. To create a new sector, click on an empty spot in the map and the sector's first vertex will appear as a green square:



Then keep adding points to the sector polygon by clicking. Close the polygon by clicking on the first point you added. A sector can be non-convex, but you shouldn't do silly things, like letting lines (walls) cross eachother – there's no error checking for that.



Now that's a fine room if I may say so! The currently selected sector (the one you just created) is always filled with a blue color. But what about those two extra blue lines?

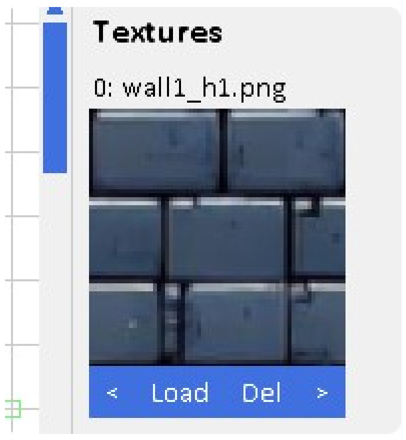


They're there to show you the convex hull of the sector. You don't need to care about the convex hull right now, but it becomes very important when connecting sectors with portals.

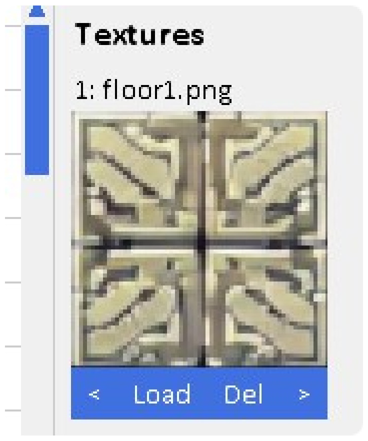
You can click on a vertex (unfilled green square) and drag it to another position if you need to.

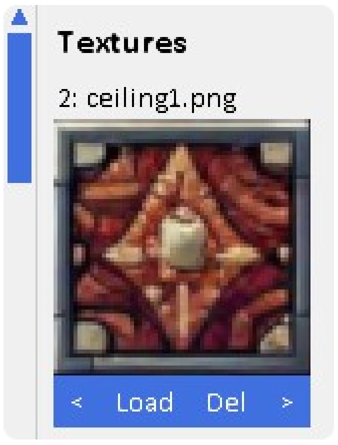
Save your masterpiece by selecting ”Save map as” in the ”File” menu!

Now it's time to load some textures (images) for the walls, floor and ceiling of your sector. For unknown reasons, a map can use no more than 32 textures.

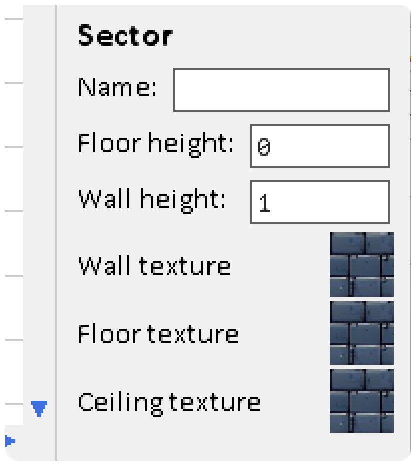


You can use the ”<” and ”>” buttons to change the texture index (0..31), and for each index you can click ”Load” to load an image from file or ”Del” to unload an image. In the image above I have loaded a texture for the walls. Then I increase the texture index and load another image for the floor and then one for the ceiling:

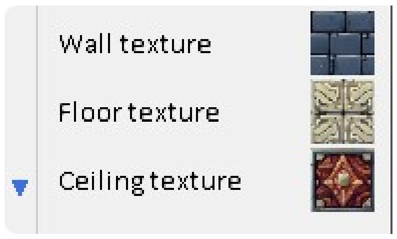




If you haven't clicked somewhere by missake the sector should still be selected (blue). If it's not selected, just click on it again. If you click on the sector when it's already selected a green square will appear where you clicked, because the editor assumes that you want to create a sub-sector. If that happens, just press the Esc key. Sub-sectors will be covered in a later example.

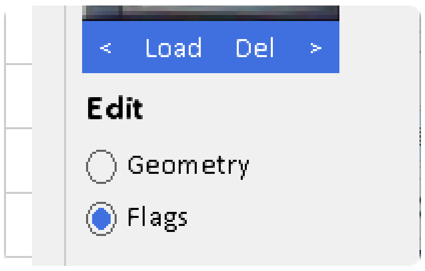

Sector
Name:
Floor height: 0
Wall height: 1
Wall texture
Floor texture
Ceiling texture

When a sector is selected, there are a couple of properties that you can set. You can give it a name by clicking on the text entry field next to ”Name:”. You can change its floor and wall height (covered later). Next to ”Wall texture”, ”Floor texture” and ”Ceiling texture” you can see small versions of the textures that are currently set for the walls, floor and ceiling. The textures default to index 0. Click on the image next to ”Floor texture” and you can select any of the images that you previously loaded from a popup:



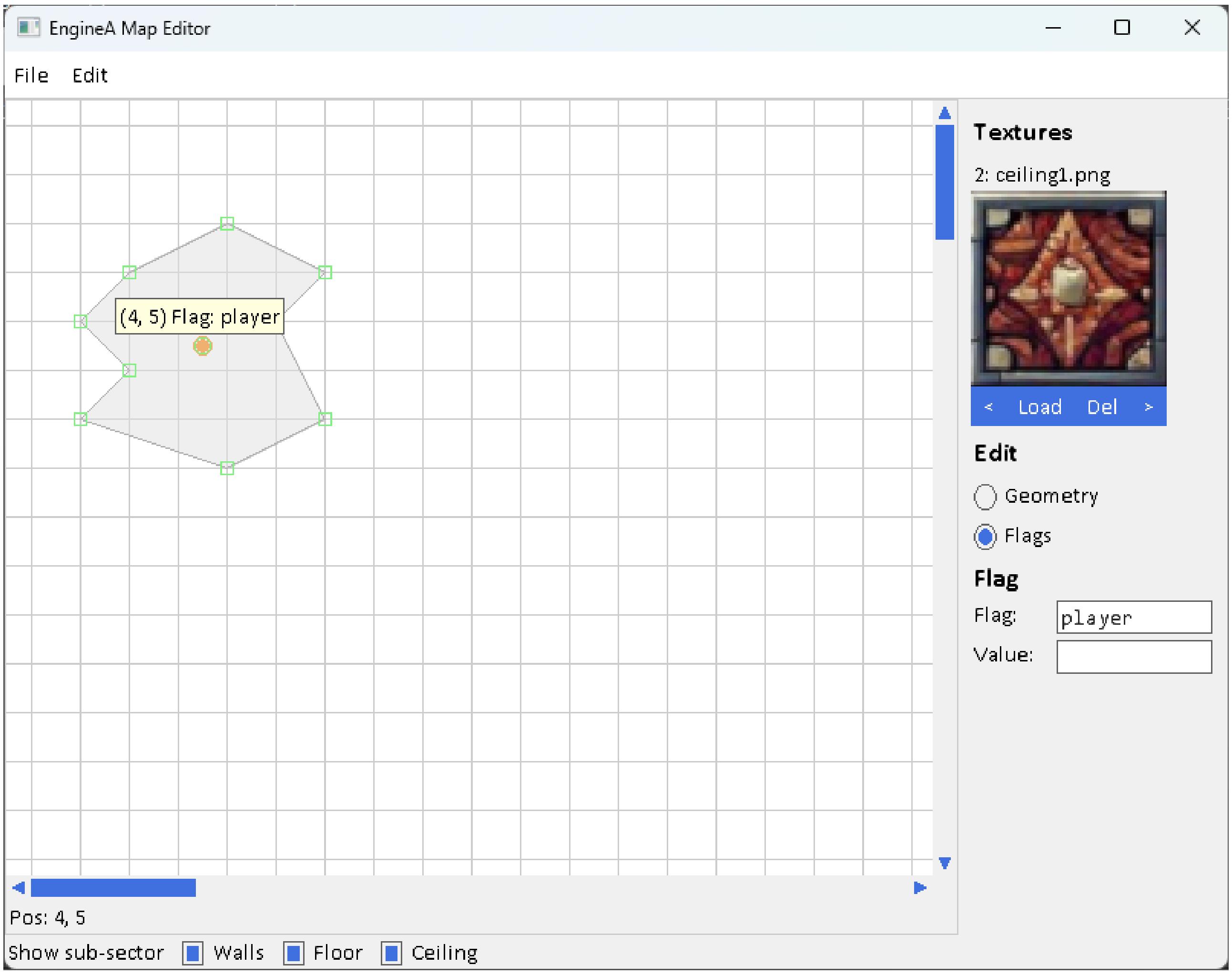
You can also set the texture used for an individual wall in a sector, but let's save that for later.

Only one thing is missing until we can launch NED and start writing code. We somehow need to mark the player's starting position on the map:



Geometry [✓ Flags]

Change the radio button under ”Edit” from ”Geometry” to ”Flags”. Then click on the position in the sector where you want the player to start:



Flag: player
Value:

An unfilled circle will appear where you clicked. Next to ”Flag:” under ”Flag”, type ”player” in the text entry field and press return. Then save the map and close the program.

Now launch NED, create a new document and save it!

Start by including the EngineA library, create a window and turning automatic redraw off:

```
include "libs/enginea.n7"

set window "Example 1", 320, 240, false, 2
set redraw off
```

Call EA_SetView(target_image, fov, z_min, z_max) to set up the renderer:

```
EA_SetView(primary, rad(65), 0.1, 6)
```

fov is the vertical field of view in radians, and you can use rad to convert from degrees to radians. z_min is the near clip plane and z_max is the far clip plane. Anything rendered closer to the camera than 0.1 or farther than 6 units will be clipped. A ”unit” is, simply put, a grid square in the EngineA editor. The larger your z_max value is, the more graphics need to be drawn.

Now use EA_LoadMap(filename) to load the map you created:

```
flags = EA_LoadMap("assets/map_1.json")
```

It returns an array with all the flags you added in the editor. If the function returns an unset variable, the map could not be loaded. So add an assert statement for that:

```
assert typeof(flags), "Map could not be loaded"
```

We just added one flag named ”player”, to tell us the player's starting position. Look for it in the array:

```
player = unset
foreach f in flags
    if f.flag = "player"
        player = EA_FpsPlayer()
        player.SetPos(f.x, f.floorY, f.z)
    endif
next
assert typeof(player), "No player flag found"
```

Each flag object in the array that EA_LoadMap returned contains these fields:

flag	flag name set in the editor
value	value set in the editor (we didn't set one, so it'll be an unset variable)
x	x coordinate of the flag
z	z coordinate of the flag
floorY	y coordinate of the floor at the flag's x and z position
ceilingY	y coordinate of the ceiling at the flag's x and z position

In the code above, when the ”player” flag is found we call EA_FpsPlayer to create a new ”game object” that contains lots of the functionality that you need for a player in a first person shooter game. Use the function SetPosition in this object to set the player's starting position to that of the flag. Later on you'll learn to configure the player object and create your own objects (enemies, bullets, decorations …).

Next, add the player object to the game engine and set it to act as camera:

```
EA_AddObject(player)
EA_SetCamera(player)
```

We're almost done now. When we call EA_Run() the game loop starts and we lose control. That function won't return until we call EA_Stop(). But how are we supposed to call EA_Stop if EA_Run enters a loop? Well, we do that by setting up a callback function. Start by creating a function named Update (you can name it anything you want, of course):

```
function Update(dt)
    if keydown(KEY_ESCAPE, true)  EA_Stop()
```

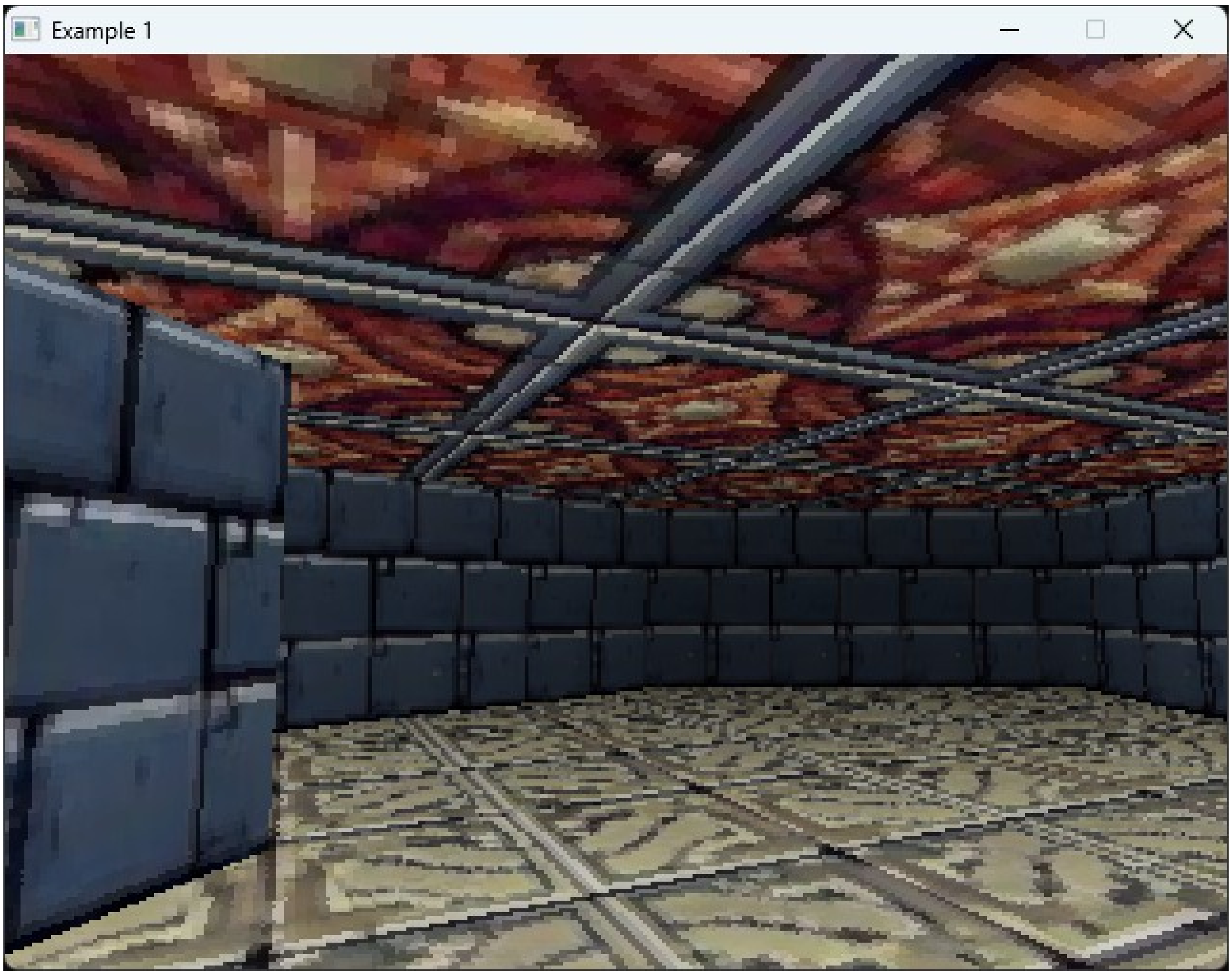
```
endfunc
```

Then use EA_SetUpdateAction(update_func) to set this function as a callback function that will be called once per frame.

```
EA_SetUpdateAction(Update)
```

When that is done, you add EA_Run() and compile and run your program.

```
EA_Run()
```



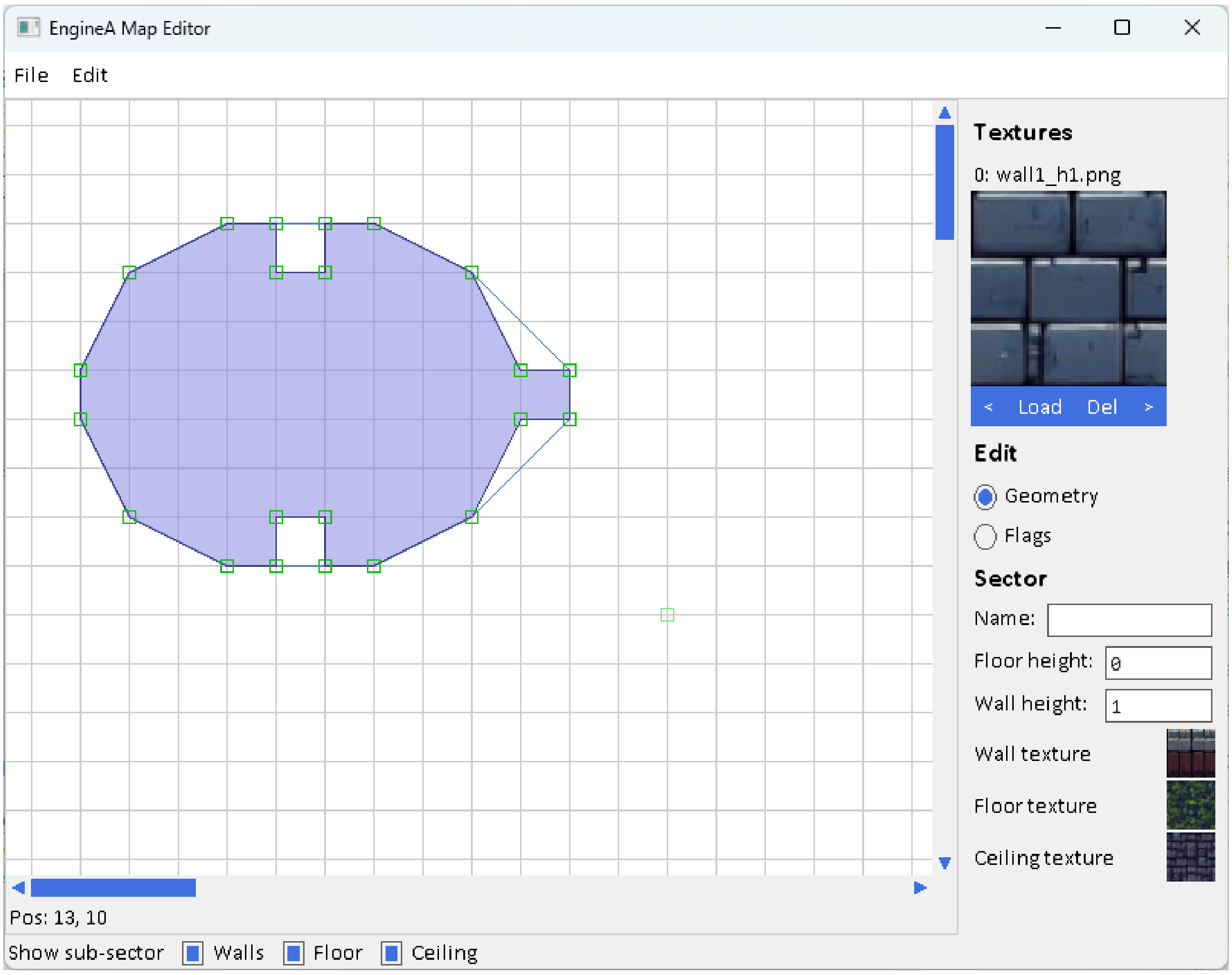
If you look at examples/example_1.n7 I also show you how to tweak the mouse sensitivity for the player and how to set up a fog effect.

2 Connecting sectors with portals

This example shows you how to:

- Create a map consisting of several sectors connected by portals (examples/assets/map_2.json)
- Implement n7 code to open doors (examples/example_2.n7)

Create a new map in the EngineA Editor, load some textures and create a nice new sector somewhere and set up its wall, ceiling and floor textures:



Geometry [✓] Flags

Name:

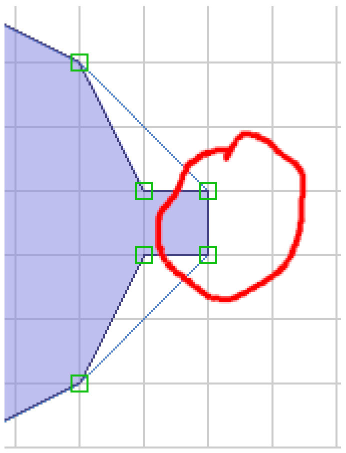
Floor height: 0

Wall height: 1

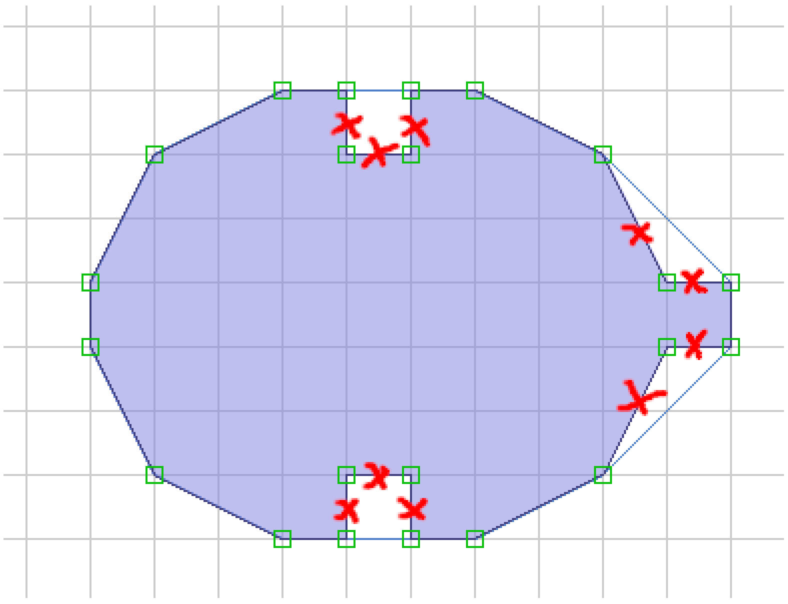
Pos: 13, 10

Show sub-sector ✓ Walls ✓ Floor ✓ Ceiling

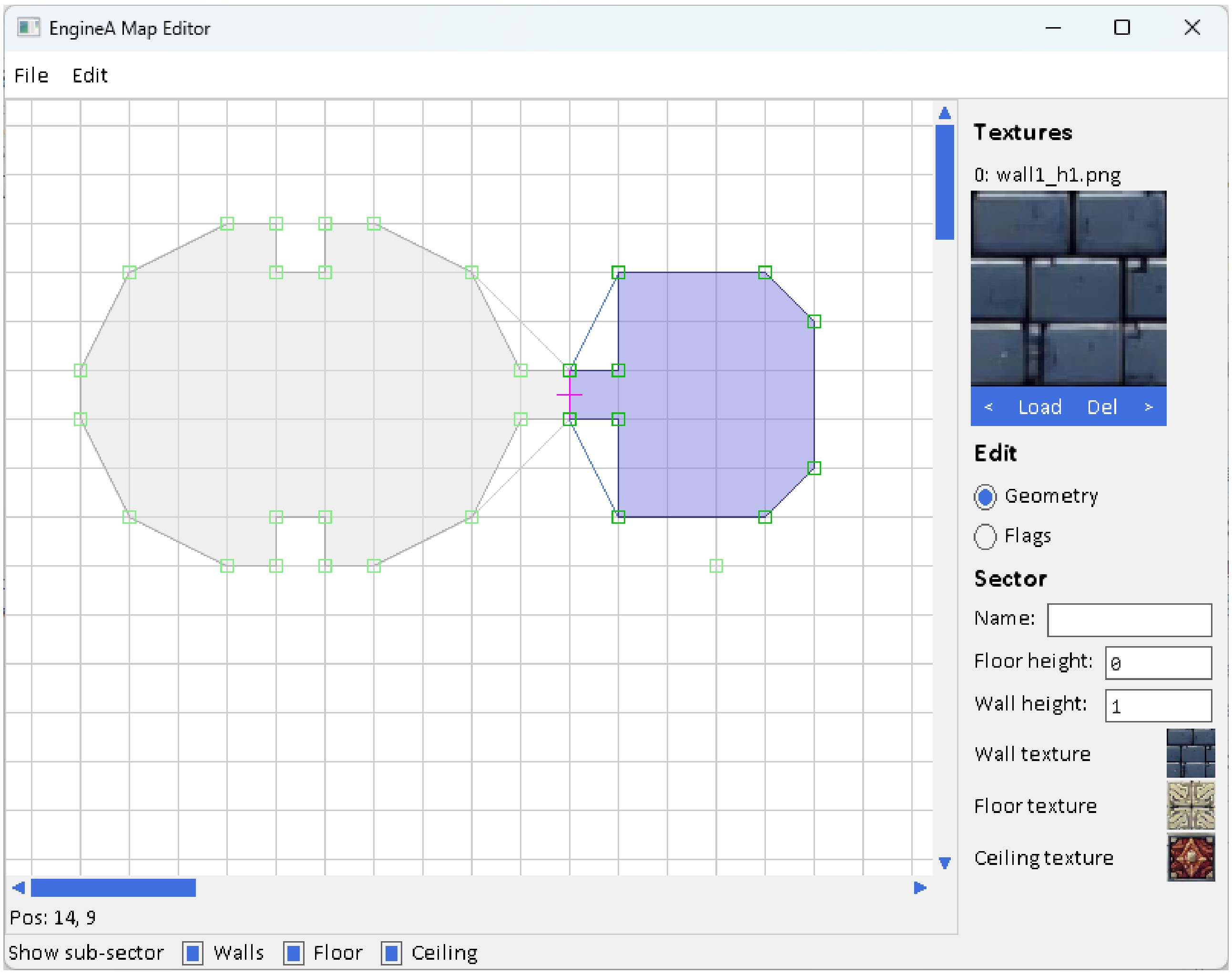
Let your sector have a wall that will serve as an opening to another sector. I will use the wall marked here:



The whole point of sectors and portals is to limit what needs to be rendered. So the wall that shall become a portal shouldn't be too long. The wall must also be part of the sector's convex hull. Remember the extra blue lines from the previous example? If you don't know what a convex hull is, those lines are there to help you see it. On this image, I've marked all the walls in the sector that can't become portals since they're not part of the convex hull:



Now click somewhere outside of the sector to unselect it. Then draw a new sector and let it share one of its walls with the intended portal in your old sector:



Name:

Floor height: 0

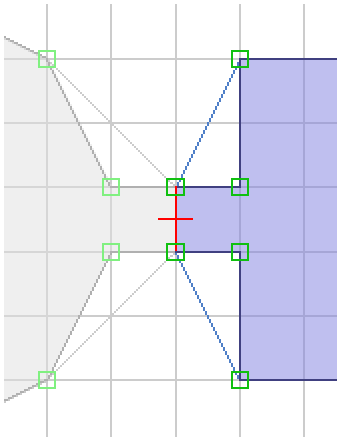
Wall height: 1

Pos: 14, 9

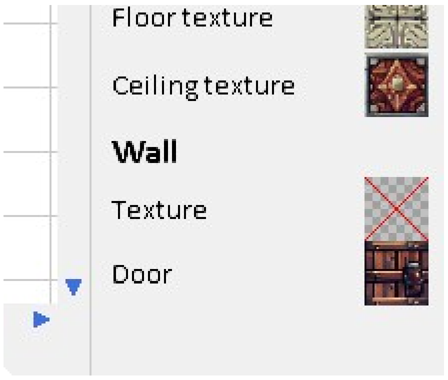
Show sub-sector ☐ Walls ☐ Floor ☐ Ceiling

When you close the polygon, the shared wall will become purple and marked with an extra line going through it. That means a portal, a doorway, has been created between the two sectors.

While you're at it, you can create a door, that can be opened and closed. With any of the two sectors selected, click on the portal. Its color will change to red:



And some settings for the wall and portal will appear under the sector properties:

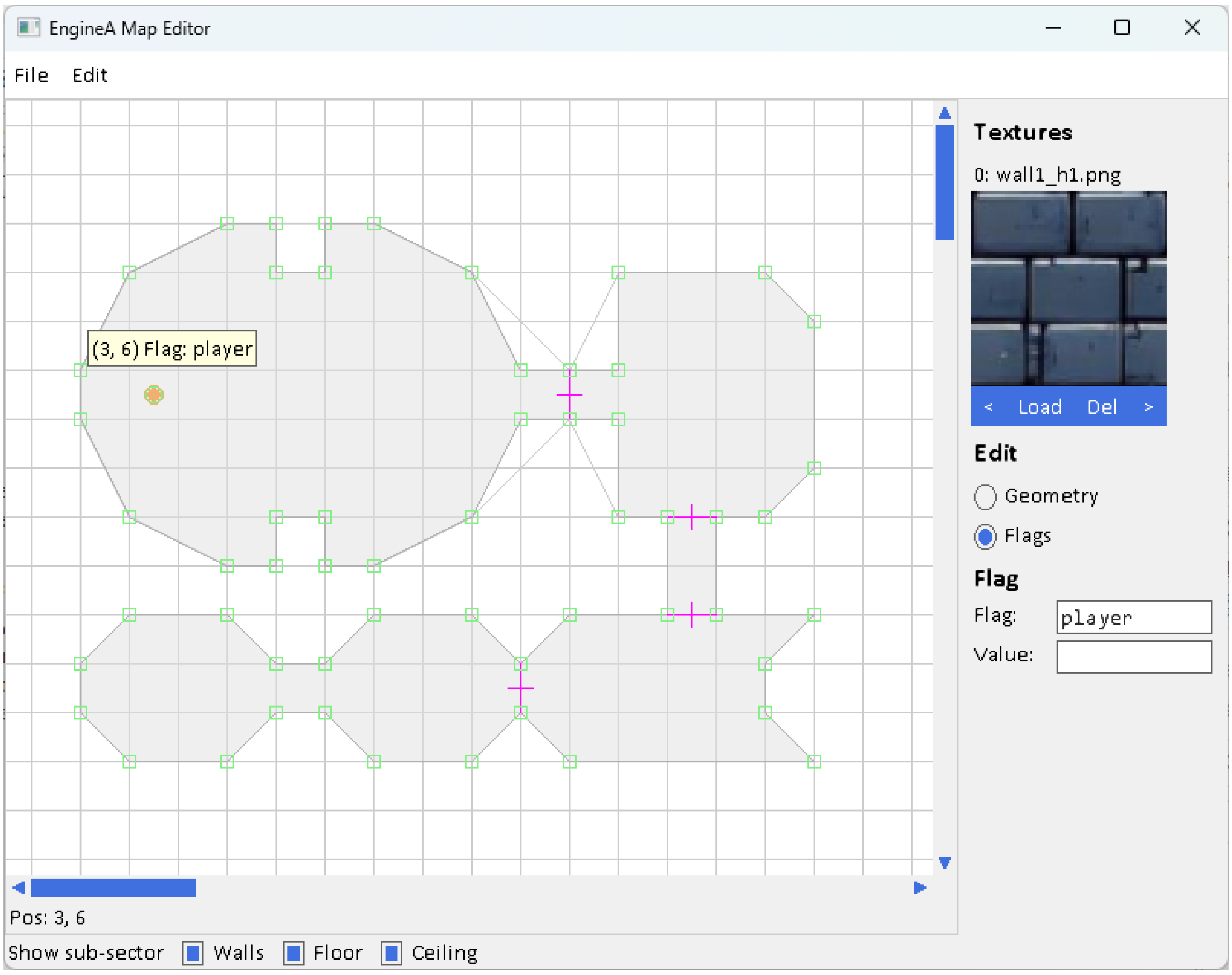


You can select any wall in a sector to set an individual texture for it by clicking on the small image next to ”Texture” under ”Wall”. The option to set a ”Door” texture only appears when you click on a portal.

Now, add some more sectors and connect them with the ones you've already created.

If you need to split a wall, add another vertex, click on the wall and select ”Split wall” from the ”Edit” menu! You can also cut copy and paste sectors by selecting them and using the ”Edit” menu or the regular Ctrl+C, Ctrl+V and Ctrl+X key combinations. Portals will be created whenever two sectors share a wall.

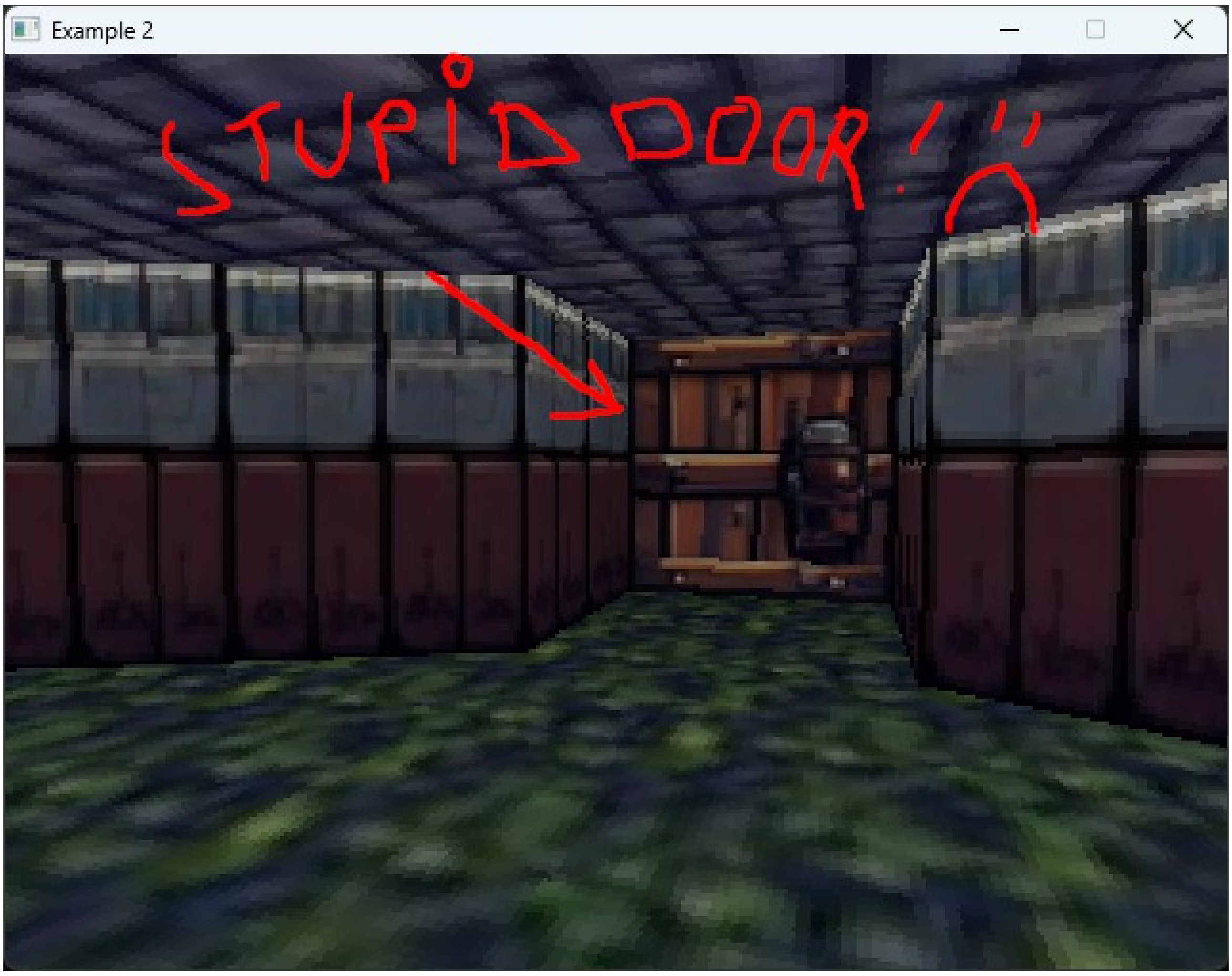
Don't forget to add a flag for the player's starting position! This is how my map turned out:



After saving your map, start NED and copy the code from the previous example. Change the parameter to EA_LoadMap to match that of your new map and compile and run the program.

```
flags = EA_LoadMap("assets/map_2.json")
```

If you've added doors to your portals, you'll notice that there's no way to open them:



The object returned by EA_FpsPlayer can't open doors. Why not? Well, because most likely you will want to control which doors can be opened with or without keys and so on. So we'll have to write some code.

Remember the Update callback function that the game engine calls once every frame? Every object you create can be assigned a function that is called every frame. Somewhere after creating the player object with EA_FpsPlayer, assign a function named Update to it:

```
player.Update = function(dt)
endfunc
```

The dt parameter is the elapsed time in seconds since the function was called the last time. That goes for the program's update callback function too.

Now, what key should be used for opening doors? Let's go with the F key, next to WASD. I post some rather nasty code here and then try to explain what you need to know about it:

```
player.Update = function(dt)
    if keydown(KEY_F, true)
```

```
        res = .Facing()
        if res and res.type = EA_DOOR and res.dist < 1 then res.data.Open()
    endif
endfunc
```

Facing is a function that all game objects can use. ”.Facing()” is short for ”this.Facing()”, in case you missed that in the relase notes some n7 versions ago. Facing returns an object with lots of information about the closest wall, door or static object (a later topic) in front of the the calling object (the player in this case). If the player is looking at the ceiling or the floor, Facing currently returns an unset variable. So we start by checking if res has a value with ”if res”. Then we check the type field. If it's EA_DOOR, the player is facing a door. The dist field is the distance to the thing the player is facing. Since the player shouldn't be able to open a door from half across the room, we make sure that dist is less than 1 unit. If all the conditions are met we call the Open function on the data field of res. When the type field is EA_DOOR, the data field is a door object, and the door object contains the following functions:

Open()	opens the door, reteurns true if the door isn't already open or opening
Close()	closes the door, returns true if the door isn't already closed or closing
GetTexture()	returns the texture index of the door, set in the editor
X()	returns the center X coordinate of the door
Y()	returns the center Y coordinate of the door
Z()	returns the center Z coordinate of the door

If you run your program now, you should be able to open doors and visit all the rooms you created.

By default, doors open by moving up into the ceiling. You can use EA_SetDoorMode(mode) to change this behavior. The possible mode values are EA_SLIDE_UP, EA_SLIDE_DOWN and EA_SLIDE_SIDE.

But wouldn't it be nice if the doors would close automatically after a while? The renderer would certainly like it, since a sector behind a closed door needn't be drawn at all. To make that work, we create a visible array at the beginning of our program. It will contain all doors that are currently open.

```
visible vOpenDoors = []
```

Then we modify the player's Update function:

```
player.Update = function(dt)
    if keydown(KEY_F, true)
        res = .Facing()
        if res and res.type = EA_DOOR and res.dist < 1 and res.data.Open()
            vOpenDoors[sizeof(vOpenDoors)] = res.data
            res.data.timer = 3
        endif
    endif
endfunc
```

We add the door to the vOpenDoors array, and we add a field, timer, to the door object that we set to 3, which is the number of seconds the door will stay open. Now change the program's Update function so that it decreases the timer of all doors in the vOpenDoors array and close any door when its timer reaches 0. When a door is closed, remove it from the array.

```
function Update(dt)
    if keydown(KEY_ESCAPE, true)  EA_Stop()

    i = 0
    while i < sizeof(vOpenDoors)
        d = vOpenDoors[i]
        d.timer = d.timer - dt
        if d.timer <= 0
            d.Close()
            free key vOpenDoors, i
        else
            i = i + 1
        endif
    wend
endfunc
```

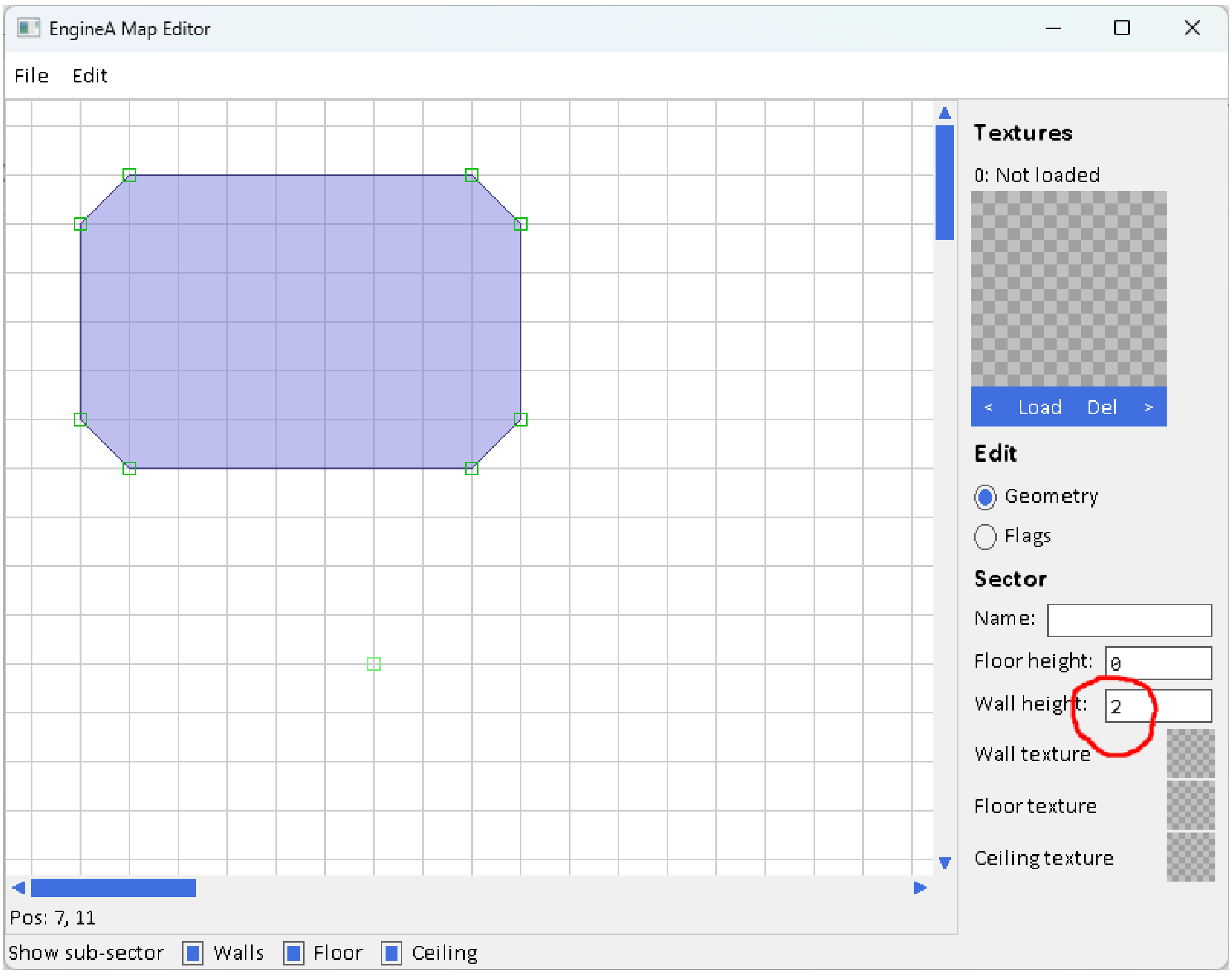
There, perfect! Run your program and the doors should automatically close. Don't forget to look at examples/example_2.n7! In that version of the code, I adjust the player movement speed and some other things not mentioned here.

3 Sub-sectors and height differences

This example shows you how to:

- Set the wall and floor heights for sectors and add sub-sectors to your sectors (examples/assets/map_3.json)
- Write code to make the player handle heights well (examples/example_3.n7)

Start the EngineA editor and create a rather large sector:



0: Not loaded

[✓ Geometry] Flags

Name:

Floor height: 0

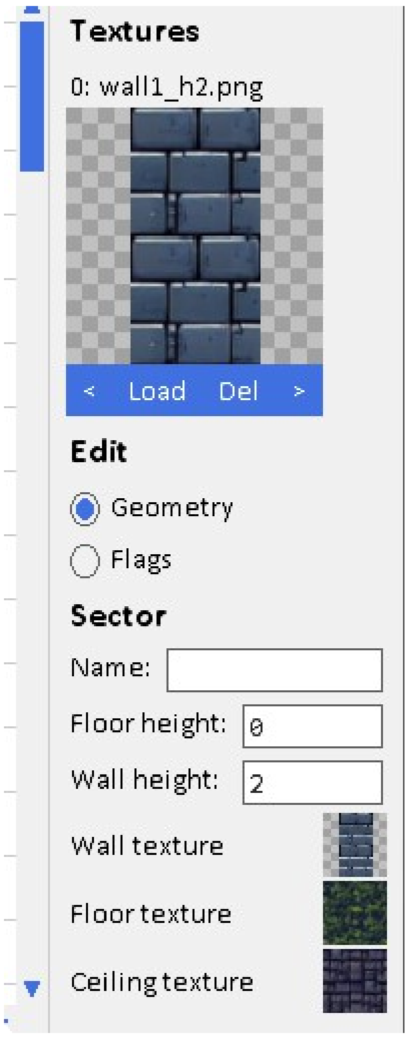
Wall height: 2

Pos: 7, 11

Show sub-sector ☑ Walls ☑ Floor ☑ Ceiling

With the sector selected, change the ”Wall height” value under ”Sector” from 1 to 2. This will make the walls of this sector 2 units tall.

When the game engine builds a 3d mesh of a sector it repeats wall texture horizontally but not vertically. This means that the wall texture you use always represents the full height of a wall. Therefor I prefer to see the width of a texture as 1 size unit in the game. So if I want a room with a wall height of 2, I use a texture with the aspect ratio 1:2. Here I've loaded such a texture (and a bunch of others) and set it as wall texture for this sector:



Textures

0: wall1_h2.png

< Load Del >

Edit

(● Geometry) ○ Flags

Sector

Name:

Floor height: 0

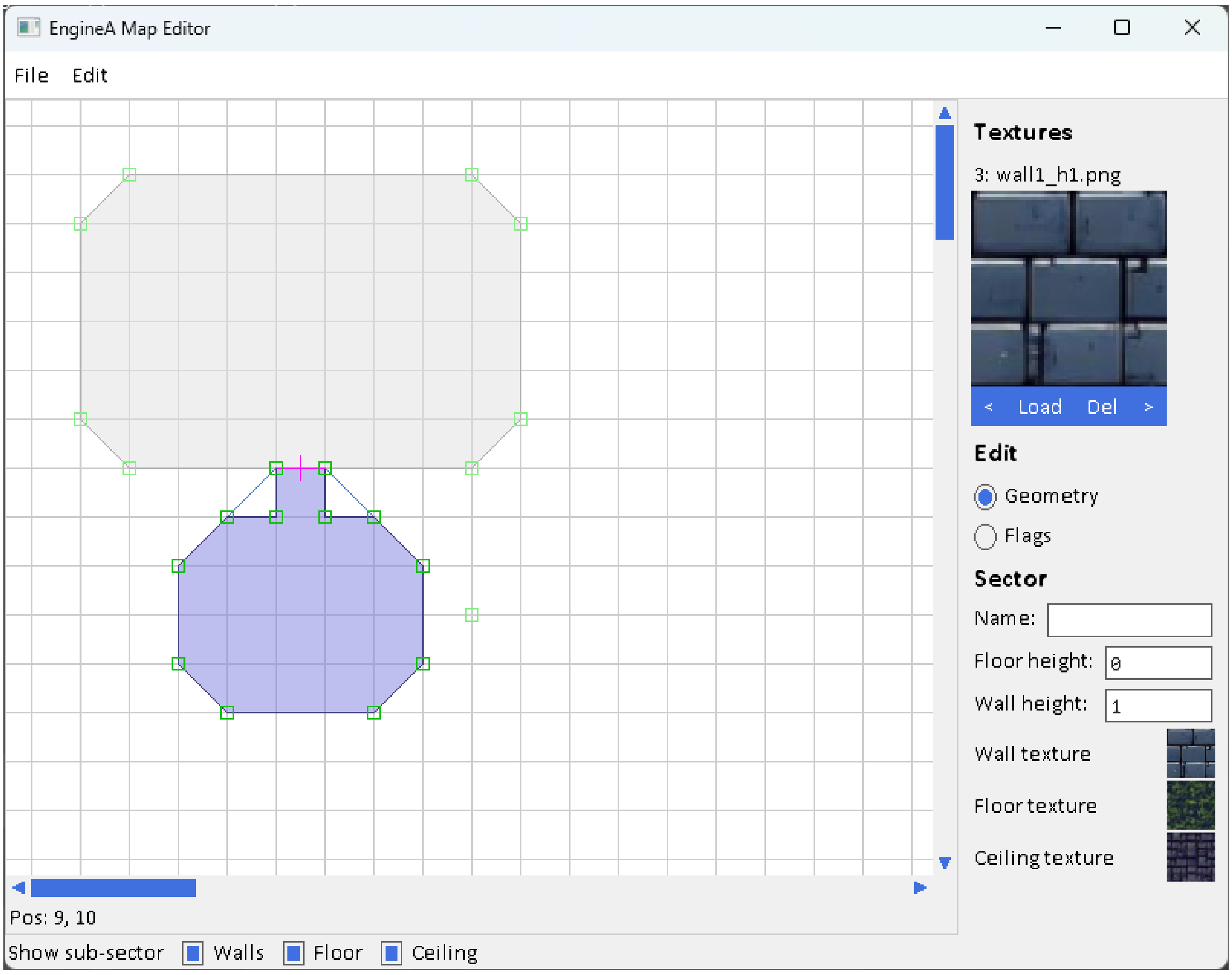
Wall height: 2

Wall texture

Floor texture

Ceiling texture

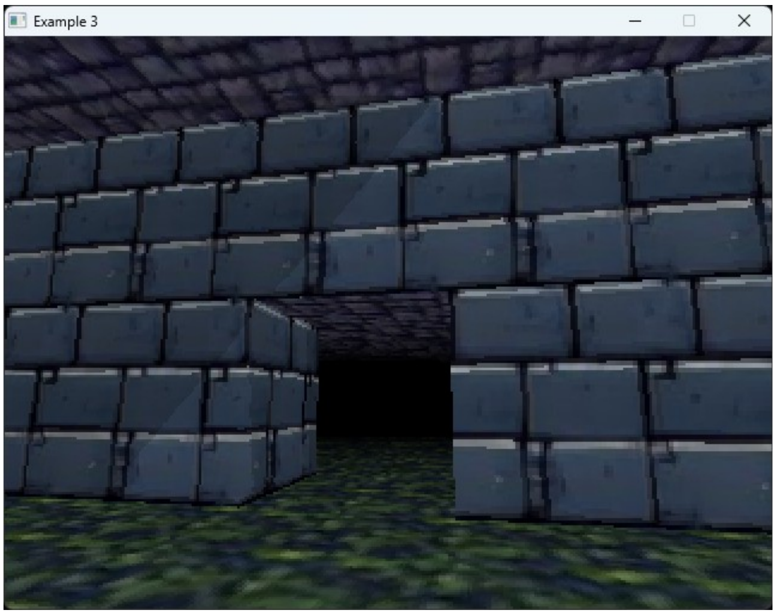
Add another sector and connect it to the first sector with a portal. Let the new sector's wall height be 1 unit. Following the logic about texture sizes that I just presented, the wall texture of this sector should have the aspect ratio 1:1:



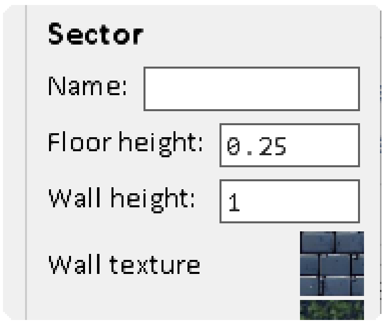
Name:
Floor height: 0
Wall height: 1
Pos: 9, 10

Note that I had to add two vertices (”Edit” → ”Split wall” twice) to the bottom wall of the first sector to form a portal to the second sector.

This is a rendering where the player is standing in the first sector, looking at the second sector through the portal:



The height of the portal depends on the height of the two sectors that it connects. Now let's try changing the floor height of the second sector. Set it to 0.25:



Sector

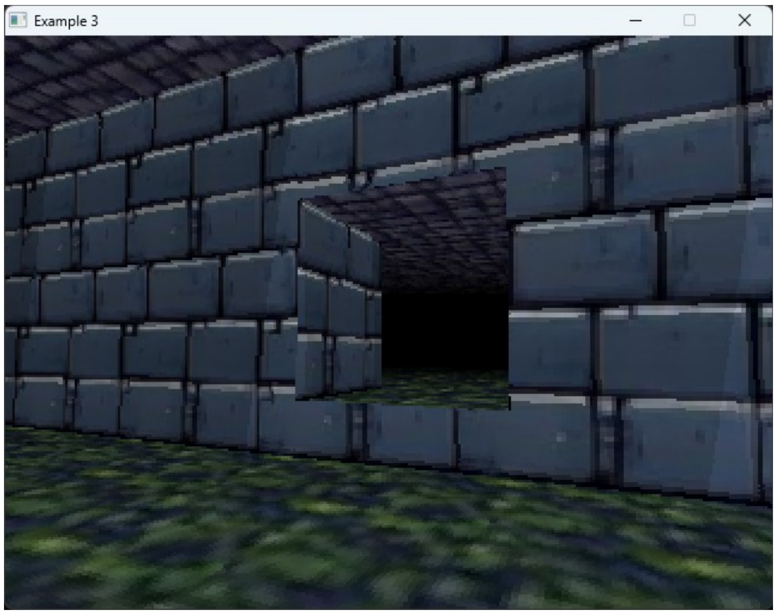
Name:

Floor height: 0.25

Wall height: 1

Wall texture

Now the view from the first sector looks like this:

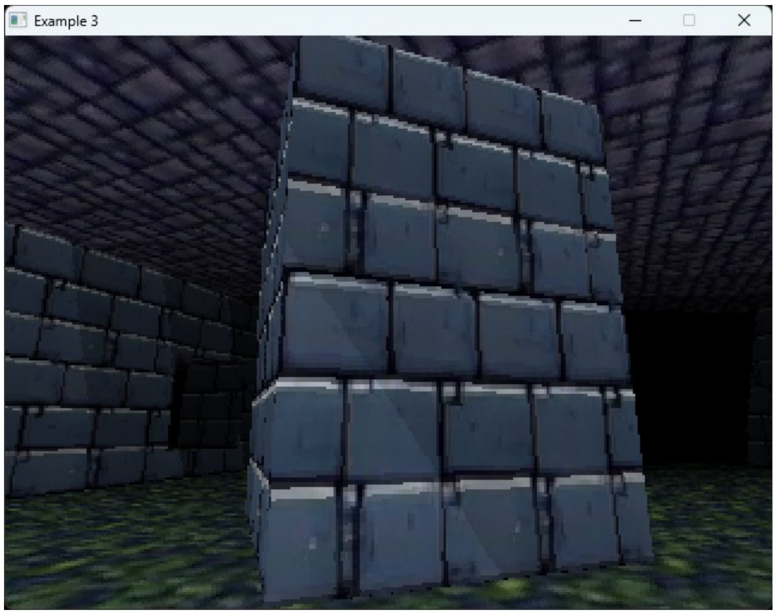


Fascinating! The height and vertical position of the portal is always adjusted to fit the floor and wall heights of its two sectors. And that is actually all there is to know about portals. So let's look at sub-sectors. They're fun.

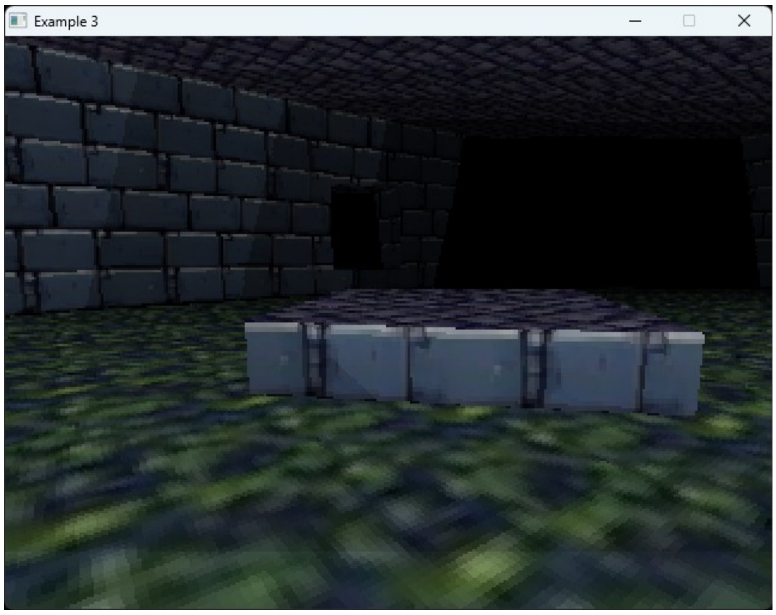
A sub-sector can be one of three things:

- Wall
- Floor elevation
- Ceiling submersion (I'm terribly sorry if ”submersion” is the wrong word, I used google to translate the Swedish word ”nedsäkning” and there were many options available …)

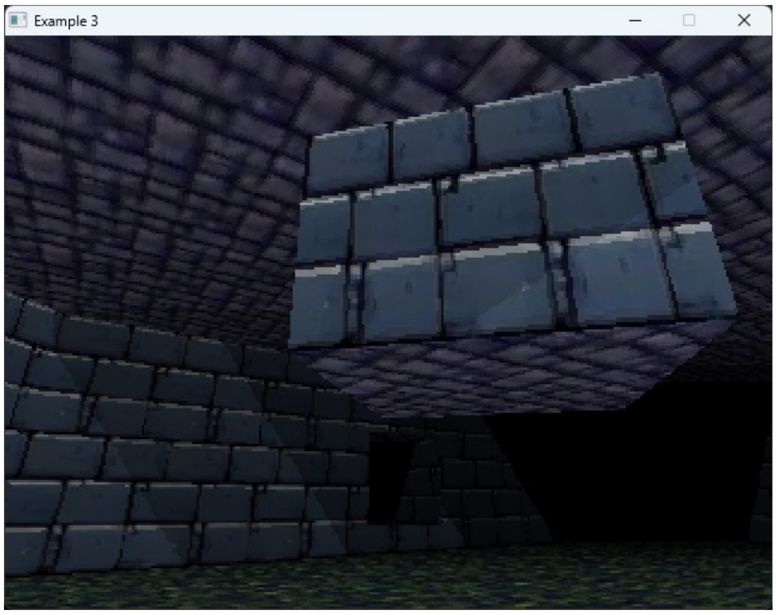
These images show the differences:



(Wall)

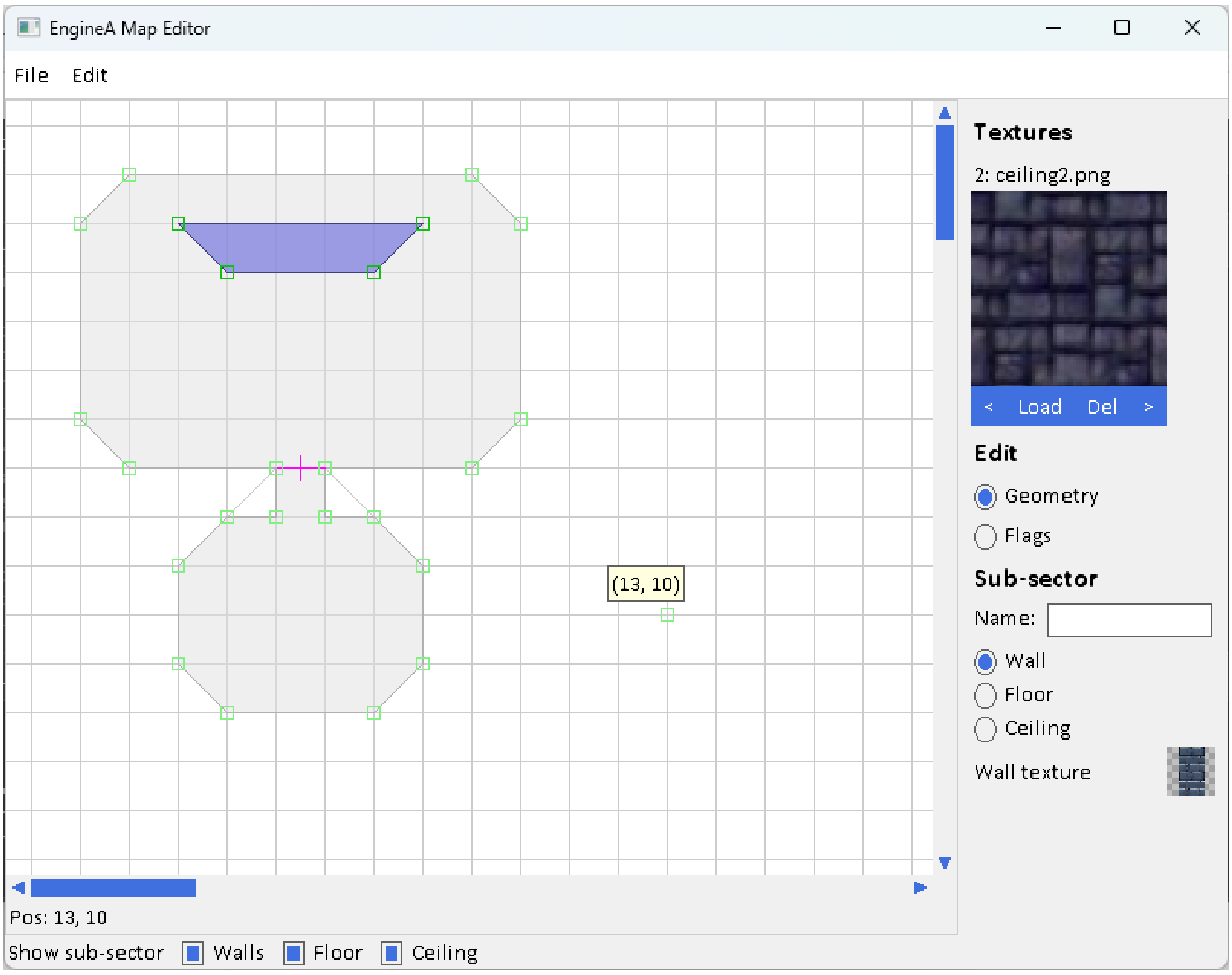


(Floor elevation)

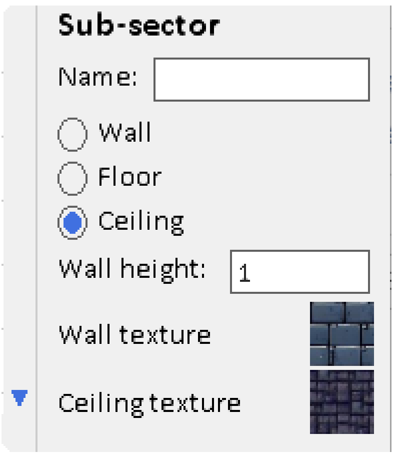


(Ceiling submersion)

Click anywhere inside a selected sector to start drawing the shape (polygon) of a new sub-sector. It works just like when you create a normal sector:

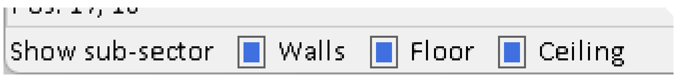


The sub-sector becomes the currently selected sector. With a sub-sector selected you can change its properties under ”Sub-sector”. Use the radio buttons to select one of the sub-sector types. ”Floor” means floor elevation, and ceiling means ceiling submersion. You can set a wall texture for any type of sub-sector. But if you select ”Floor” or ”Ceiling” you will also be able to set a floor or ceiling texture:

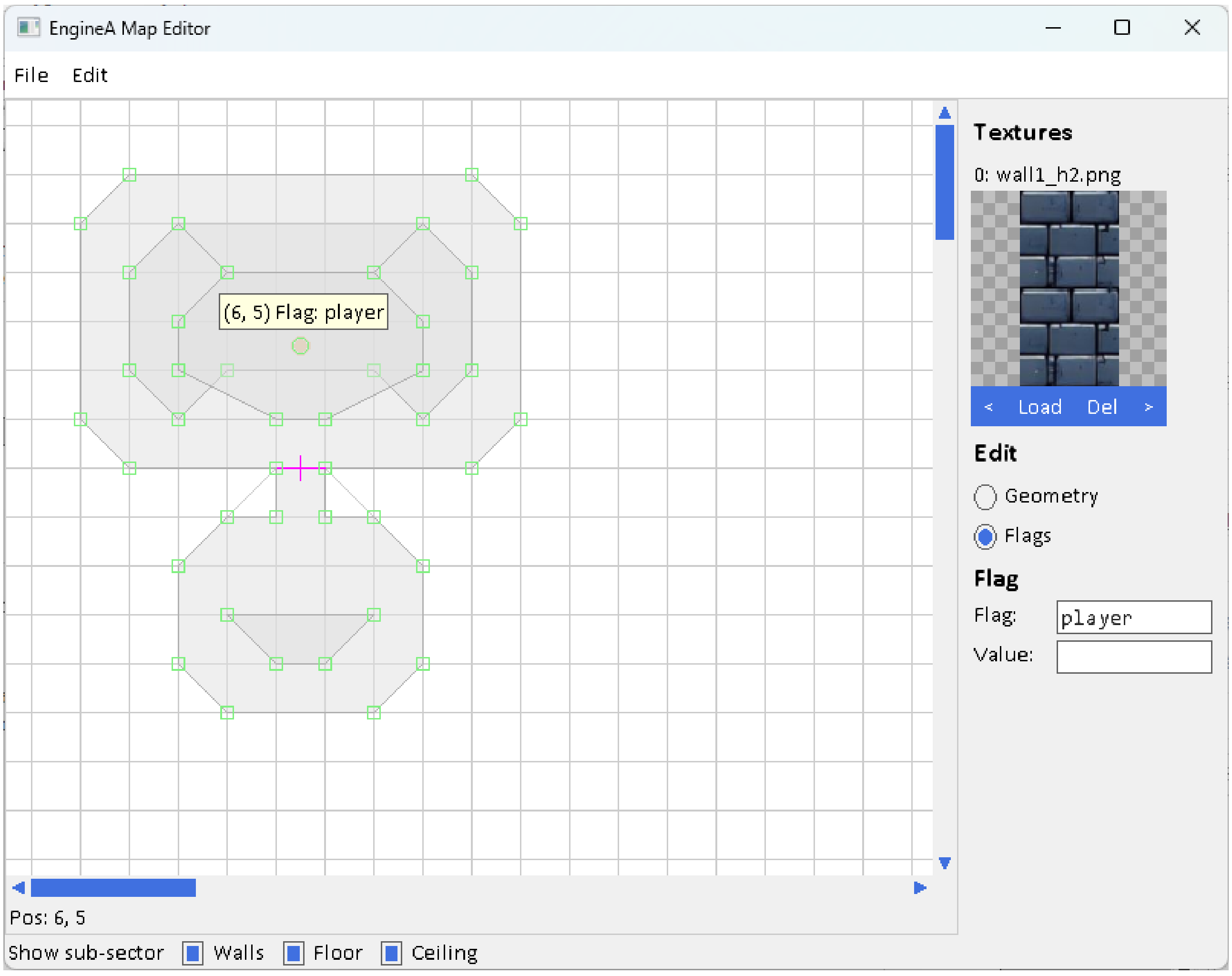


For ”Floor” and ”Ceiling” you should also enter a ”Wall height” value, that represents the height of the elevation or submersion.

Add some sub-sectors to your sectors. You can toggle the visibility (in the editor) of the different sub-sector types using the check-boxes at the bottom of the editor:



Add a ”player” flag somewhere on the map to mark the player's position and save your map. My map (examples/assets/map_3.json) looks like this:


EngineA Map Editor

Flag: player
Value:

Pos: 6, 5

Launch NED and make a copy of the code you wrote for the previous example and change the filename in your EA_LoadMap call.

To make the player able to deal with heights, we have to add some lines of code. If you look at example_1.n7 and example_2.n7, you can see that I disabled jumping by setting the jump key to unset:

```
player.SetJumpKey(unset)
```

In example_3.n7 I remove this line, since I want the player to be able to jump. I also add these lines of code when setting up the player object:

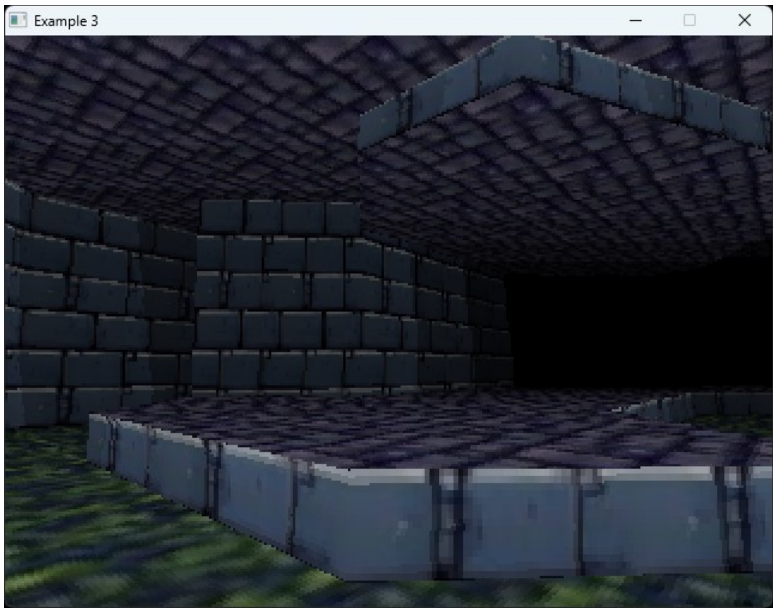
```
player.SetLeap(0.25)
player.SetHeight(0.6)
player.SetEye(0.5)
```

SetLeap makes the player able to automatically traverse heights <= 0.25 units tall. That is, the player won't need to jump to get up on them. You should keep this value low. On my map, there's a floor elevation where you can see the leap setting in action.

SetHeight sets the player's height, and SetEye sets the height of the players eyes, both default to 0.5.

Run your program and see what happens. Most likely you'll need to experiment a lot with sub-sectors to understand how they work in the game.

You can modify the player's ”jump force” with SetJumpForce(force). The default value is 3. A higher value makes the player jump higher.



4 Simple non-moving sprites

In this example you'll learn to:

- Add ”billboard” sprites to your level and check for collision with the player (examples/assets/map_4.json and examples/example_4.n7)

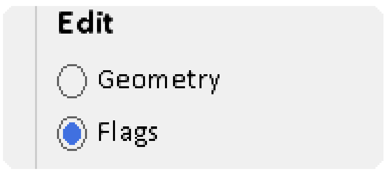
The engine makes a huge difference between static and non-static objects. The player returned by EA_FpsPlayer is a non-static object. And later on we'll use non-static objects for enemies, bullets and that kind of stuff.

Static objects can't move once added. They can be assigned polygons for collision handling, so that they behave like obstacles to moving (non-static) objects. You may not be able to construct advanced geometry in the editor, but you can get around it by using static objects and meshes created in some modelling software. Static objects are also good for things that the player can pick up, which is what this step in the tutorial is all about. We will only use ”billboard” sprites, no meshes yet.

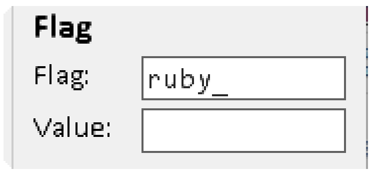
Start by drawing or downloading some sprites that look like something a player would enjoy picking up. I used the Image Creator from Microsoft Designer to create these beauties:

I personally like it when the pixel density of my sprites matches that of the textures. That is, if a unit-sized texture is 64x64 pixels large, a sprite that is half a unit tall should use an image (texture) of height 32. But that's just me, a fan of really large pixels!

Start the map editor and re-use one of your old maps or create a new one. You can settle with a single rectangular sector if you want. There's no built in support for sprites or anything like that in the editor. Instead, switch to ”Flags” under ”Edit”, just like you do when adding the ”player” flag that determines where the player should start.



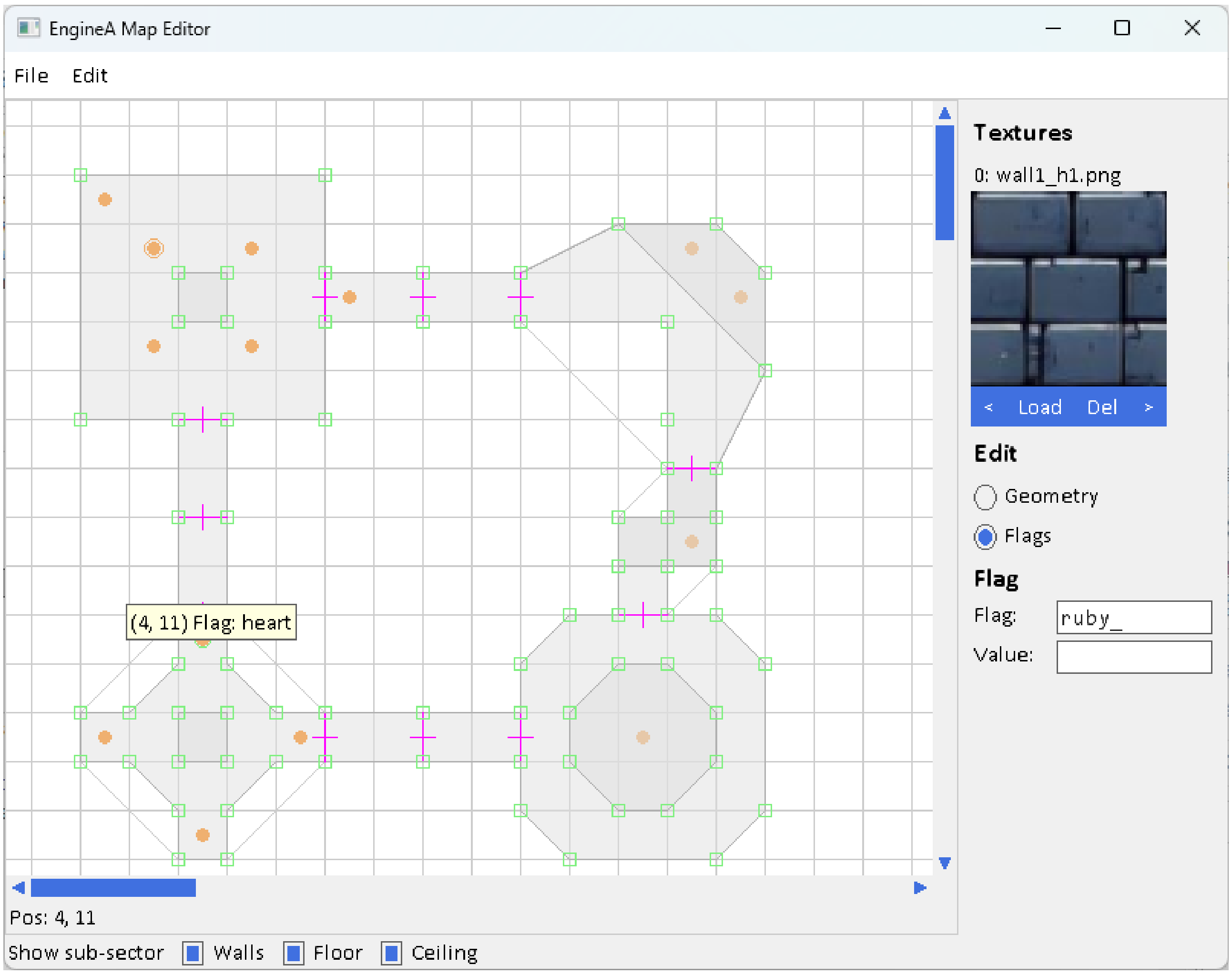
What kind of images did you decide to use? Mine are a ruby, diamond, heart and a treasure chest. Now, just as you do with the player, click on a map spot where you want to add one of your sprites. The spot will be marked with an unfilled circle (unfilled because it doesn't yet have a flag). Click on the text entry field next to ”Flag” under ”Flags” and enter the name of your item (it doesn't need to match the filename):


Flag

Flag: ruby_

Value:

Now, repeat that for every spot on your map where you want a sprite of that type. And if you've got more than one sprite image, add a couple of those too. My map is full of ”ruby”, ”diamond”, ”heart” and ”chest” flags. If you let the mouse hover over a flag on the map, information about it will appear in a tooltip:



(4, 11) Flag: heart

Flag: ruby_

Value:

Pos: 4, 11

When you're done adding flags for your sprites, save the map, shut down the editor and launch NED!

Now we must write the code for creating and adding static objects (sprites) when we find them in the flags array returned by EA_LoadMap. We also need to write code to check when the player touches any of the sprites.

Copy the source code from the previous step. Add code to load your sprite images into visible variables:

```
visible vRubyImage, vDiamondImage, vHeartImage, vChestImage

...
```

```
vRubyImage = loadimage("assets/ruby.png")
vDiamondImage = loadimage("assets/diamond.png")
vHeartImage = loadimage("assets/heart.png")
vChestImage = loadimage("assets/chest.png")
```

The code where you create and position the player looks something like this, right?

```
flags = EA_LoadMap("assets/map_3.json")
assert typeof(flags), "Map could not be loaded"
player = unset
foreach f in flags
    if f.flag = "player"
        player = EA_FpsPlayer()
        player.SetPos(f.x, f.floorY, f.z)
        player.SetLeap(0.25)
        player.SetHeight(0.6)
        player.SetEye(0.5)
        player.SetMoveSpeed(1.5)
    endif
next
```

Since we're now looking for other flags, use select instead of if, and add one case for each of your different flags:

```
foreach f in flags
    select f.flag
        case "player"
            ...
        case "ruby"
        case "diamond"
        case "heart"
        case "chest"
    endsel
next
```

Let's focus on the flag ”ruby”. To create a new static object, call EA_StaticObject()

```
case "ruby"
    ruby = EA_StaticObject()
```

Next, call the object's function SetSprite(image_id, cel, onlyYaw). image_id is the image we want to use, in my case vRubyImage. This image has no cels, so I use 0 for the cel parameter. If onlyYaw is true, the sprite will always be turned against the camera, but it will only be rotated around the y axis. If onlyYaw is false, the sprite will also be rotated around the x-axis and always face the camera completely.

```
case "ruby"
    ruby = EA_StaticObject()
    ruby.SetSprite(vRubyImage, 0, true)
```

Now we must set the size of the sprite. You do so by setting its height and a radius:

```
case "ruby"
    ruby = EA_StaticObject()
    ruby.SetSprite(vRubyImage, 0, true)
    ruby.SetHeight(height(vRubyImage)/64)
    ruby.SetRadius(0.5*width(vRubyImage)/64)
```

No one: ”Whoa! Slow down, Marcus, what the fudge are you doing here?”

Marcus: As I told you, I prefer it when my sprites use the same pixel density as the wall (and floor and ceiling) textures. Therefor, I use the width and height of the sprite image to determine the sprite's size. My unit sized textures are 64x64 pixels large. So to calculate the height of a sprite, I divide its image height by 64. And I set the radius to half the width divided by 64.

If you don't want that kind of hocus pocus in your code, you can just say: ”Nah, I want *my* ruby to be 0.4 units tall”, and adjust its radius based on that and the aspect ratio of the image. Something like:

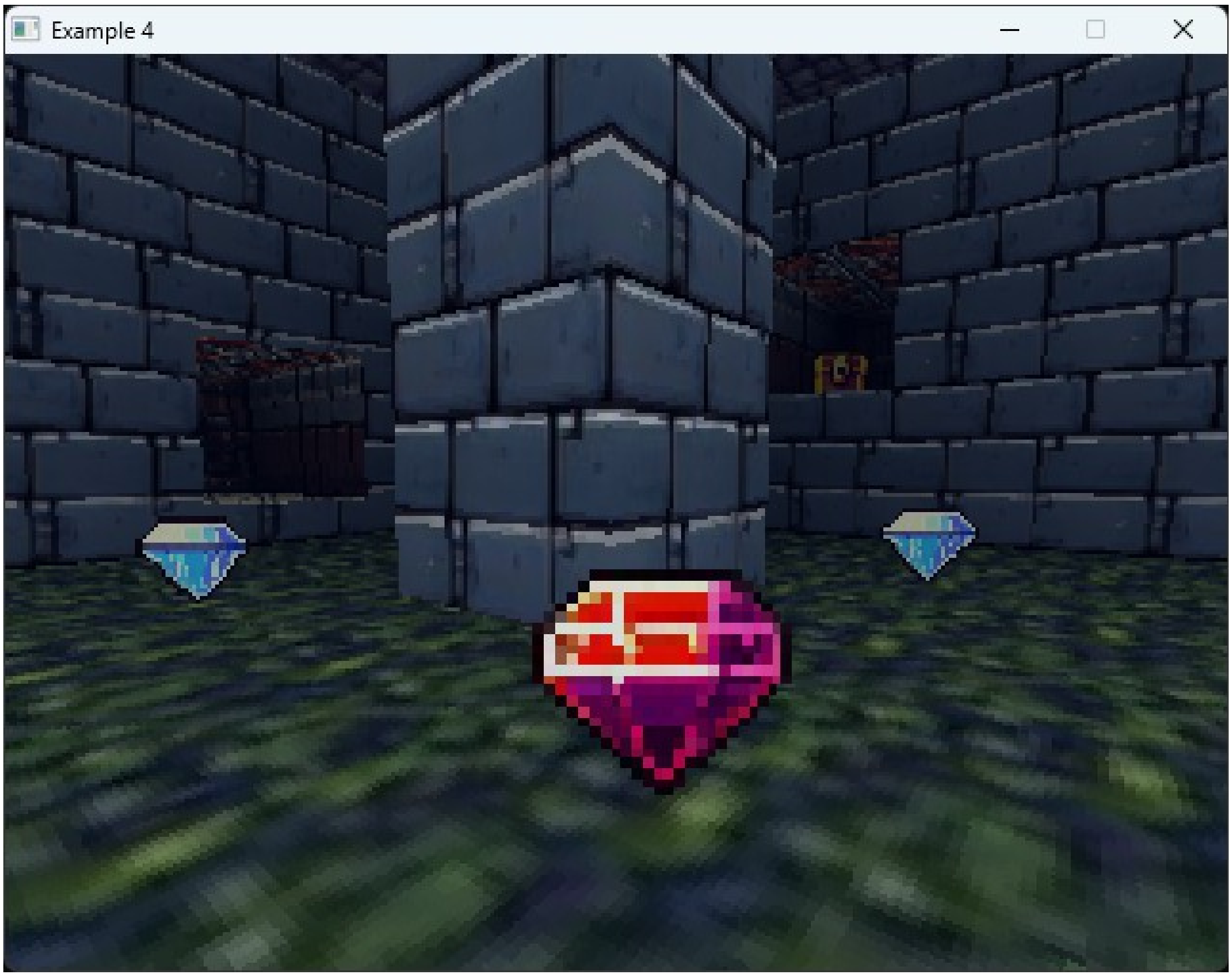
```
ruby.SetHeight(0.4)
ruby.SetRadius(0.4*0.5*width(vRubyImage)/height(vRubyImage))
```

We mustn't forget to set the sprites position using the object function SetPos(x, y, z). And then we add it to the engine with EA_AddStaticObject(object). Now my code looks like this:

```
case "ruby"
    ruby = EA_StaticObject()
    ruby.SetSprite(vRubyImage, 0, true)
    ruby.SetHeight(height(vRubyImage)/64)
    ruby.SetRadius(0.5*width(vRubyImage)/64)
    ruby.SetPos(f.x, f.floorY, f.z)
    EA_AddStaticObject(ruby)
```

You can copy and modify the code you've written for your first sprite type to the rest. In example_4.n7 I've implemented a helper function that I call for each sprite type instead.

If you launch your program now, there should be some sprites on the ground where you put them in the editor:



But how do we make the player able to pick them up? That's quite easy. You need to add some code to your player object's Update function. You put some code there in an earlier step to make the player able to open doors.

```
player.Update = function(dt)
    ...

    objs = .SectorObjects()
    if objs and sizeof(objs)
        for i = 0 to sizeof(objs) - 1
            if .CollidesWith(objs[i])

            endif
        next
    endif
endfunc
```

You can use the object function SectorObjects() to get an array that contains all the objects in the sector that the object (the player) is currently located in. This array may possibly be unset, so check if it has a type with ”if objs”. Then check if it actually contains any objects with sizeof. Actually, it should always contain atleast ONE object, the object that is calling SectorObjects, but never mind that – I've already written the code! Loop through the array with a for statement.

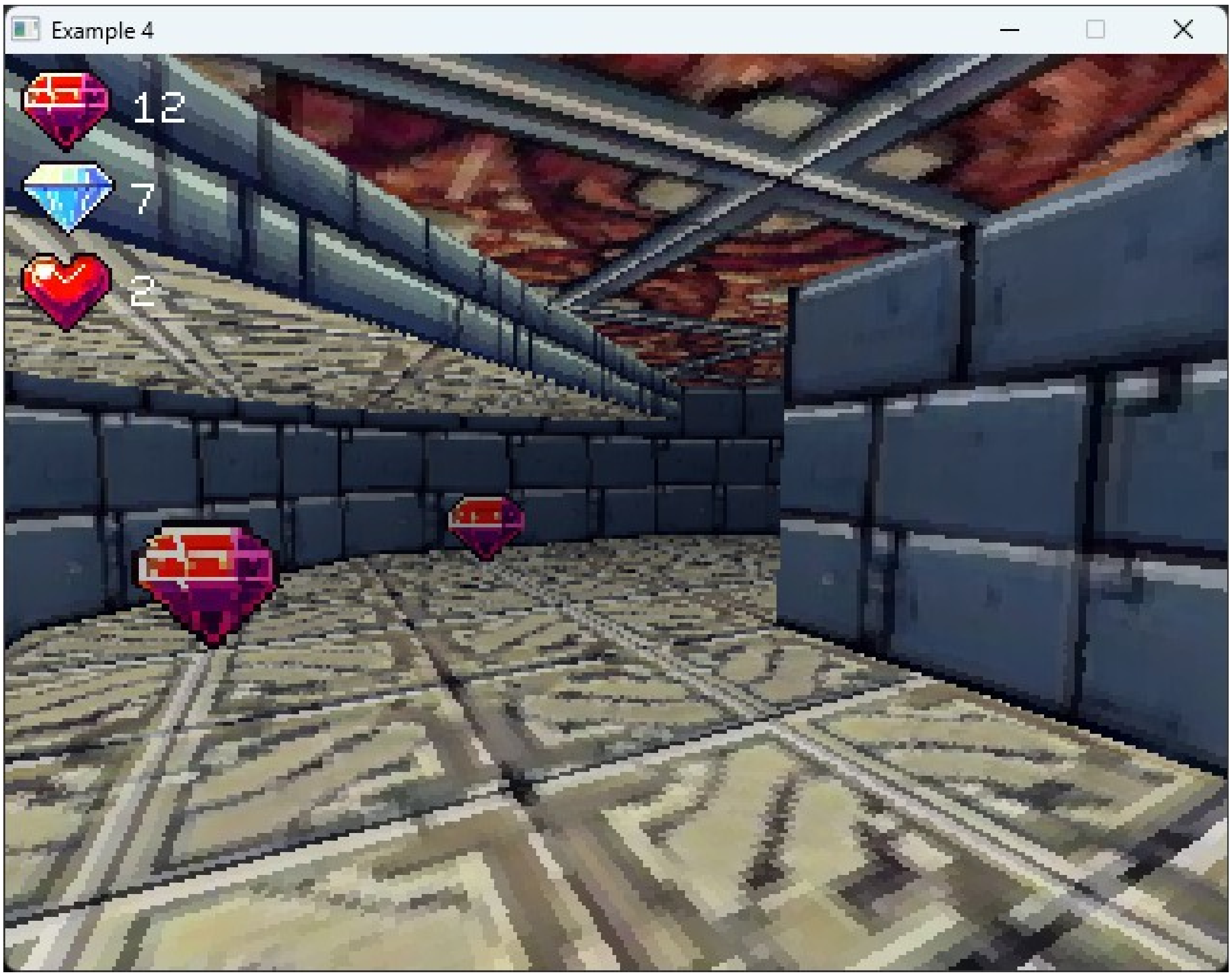
The object function CollidesWith(obj) returns true if the current object (the player) intersects with the object obj. It simply compares the bounding cylinders of the two objects (based on the their positions, radii and heights).

So, how do we determine what type of object objs[i] is? We are only interested in picking up (removing) the objects that are meant to be picked up, the ones we just created. One way is to check the sprite image of objs[i], and that's just what we'll do. This is what the code looks like in example_4.n7:

```
objs = .SectorObjects()
if objs and sizeof(objs)
    for i = 0 to sizeof(objs) - 1
        if .CollidesWith(objs[i])
            select objs[i].Sprite()
                case vRubyImage
                    vRubies = vRubies + 1
                    EA_RemoveObject(objs[i])
                case vDiamondImage
                    vDiamonds = vDiamonds + 1
                    EA_RemoveObject(objs[i])
                case vHeartImage
                    vHearts = vHearts + 1
                    EA_RemoveObject(objs[i])
                case vChestImage
                    vRubies = vRubies + 10
                    vDiamonds = vDiamonds + 5
                    vHearts = vHearts + 1
                    EA_RemoveObject(objs[i])
            endsel
        endif
    next
endif
```

The object function Sprite returns the sprite image. We can compare it with the images that we assigned to our sprites. Use EA_RemoveObject(obj) to remove an object. As you can see, I'm incrementing some variables when the player picks up the different sprites. vRubies, vDiamonds and vHearts are visible variables that were initialized to 0.

We're done for now. But I suggest that you have a good look at example_4.n7! There I use EA_SetDrawAction to set a function that is called once per frame when the engine has rendered the 3D scene. In that callback function, you can draw whatever you want – in the example I use it to display the number of rubies, diamonds and hearts that the player has collected:


Example 4
12
7
2

5 A very simple enemy sprite

This example shows you how to:

- Create an animated moving object (examples/assets/map_5.json and examples/example_5.n7)

Find or create a nice enemy sprite image! I, again, used the Image Creator from Microsoft Designer. Unless I'm missing something, it's very difficult to make it create sprites with animation frames. So I settled with a spooky pumpkin and animated it myself. This is my image grid, one row with four columns:

Yes, that's what pumpkins look like when they walk.

Create a new map or copy one of the old ones in the map editor. Add some flags for your enemies' starting posisions. I use the flag ”pumpkin”. Save the map and launch NED.

Copy the code from the previous step! There's should be a new flag returned by EA_LoadMap for you to deal with. But start by loading your new sprite image into a visible variable:

```
visible vPumpkinImage
...
vPumpkinImage = loadimage("assets/pumpkin.png", 4, 1)
```

For cleaner code, I suggest that you put the construction of the new sprite in a function. This function will return a non-static game object (an object that can move), that we add with EA_AddObject. I named my constructor function CreatePumpkinEnemy:

```
flags = EA_LoadMap("assets/map_5.json")
...
foreach f in flags
    select f.flag
        ...
        case "pumpkin"
            o = CreatePumpkinEnemy(f.x, f.floorY, f.z)
            EA_AddObject(o)
    endsel
next
```

Now, let's jump into the implementation of that function. Start by creating a game object using EA_Object(). Such an object contains lots of functionality:

```
function CreatePumpkinEnemy(x, y, z)
    enemy = EA_Object()
```

You will recognize these object function calls from the previous step:

```
enemy.SetSprite(vPumpkinImage, 0, true)
enemy.SetHeight(height(vPumpkinImage)/64)
enemy.SetRadius(0.5*width(vPumpkinImage)/64)
enemy.SetPos(x, y, z)
```

The functions work exactly as they do for static objects, and by now you know my thoughts about consistent pixel density. This next function call is new though:

```
enemy.SetYaw(rad(rnd(360)))
```

Here I give the enemy a random yaw angle. We will use this angle for the enemy's movement. There's also SetPitch to set a pitch angle, but we don't need that for this creature. If you're not familiar with yaw and pitch (and roll) angles, I must advice you to look it up. Basicly, yaw is rotation around the y (vertical) axis and pitch is rotation around the x axis after applying the yaw rotation. To put it short, we give the enemy a random direction in the xz plane (top down view).

Since I'm using an image with four animation frames, a walk cycle, I then add a cel field to the enemy object:

```
enemy.cel = 0
```

Just like the player or any object, static or non-static, you can assign an Update function to the enemy. It will be called once per frame and gets the delta time in seconds as parameter:

```
enemy.Update = function(dt)
    .cel = (.cel + dt*8)%4
    .SetCel(int(.cel))
```

The first thing I do in the function is to update the cel field of the object. I use %4 to keep the value in the valid range of cels. Each second, cel will increment by 8 in total. That means that the walk animation will play twice every second. The object function SetCel(cel) sets the cel that the engine will use for the sprite.

Now it's time to move the enemy. I want the enemy to keep walking in its current direction until it hits a wall. Then it should get a new, random, direction. Let's start by moving him with the object function Move(dx, dy, dz, leap). It tries to move the object and returns lots of information about how it went:

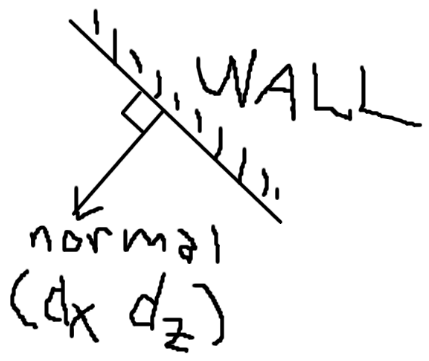
```
res = .Move(.DX()*0.75*dt, 1*dt, .DZ()*0.75*dt, 0.25)
```

Whoa, that looks super weird, right? No? Oh. We're using SetYaw to set the objects direction (that's not mandatory, you could skip the yaw thing and manage the angles and directions yourself). When using SetYaw/SetPitch, you can get the corresponding direction using DX(), DY() and DZ(). We only need to use DX() and DZ() now. The dx and dz parameters DX()*0.75*dt and DZ()*0.75*dt means that the enemy will move 0.75 units per second. So what about the dy value, 1*dt? That's just a very stupid way of managing gravity. When the enemy is not on ground, he will move down 1 unit per second. The fourth parameter, leap, does the same thing as SetLeap does for the player; internally, the player object calls Move with the leap value that you set. So we use the same leap value for the enemy that we do for the player, 0.25.

As I said, Move returns lots of information about what happened when the object moved. You can get information about what kind of wall or static object the object bumped into, if it hit the ground or the ceiling etc. But for this stupid enemy, we just need to know if it hit a wall. If it did, res.w will be true:

```
res = .Move(.DX()*0.75*dt, 1*dt, .DZ()*0.75*dt, 0.25)
if res.w
    .SetYaw(rad(deg(atan2(res.dx, res.dz)) - 90 + rnd()*180))
endif
```

Lots of code, again. You know what SetYaw does. res.dx and res.dz is the normal of the wall that the object collided with. The normal is a vector perpendicular to the wall surface. Look at this image (I drew it myself) that shows a wall and its normal from a top down perspective:



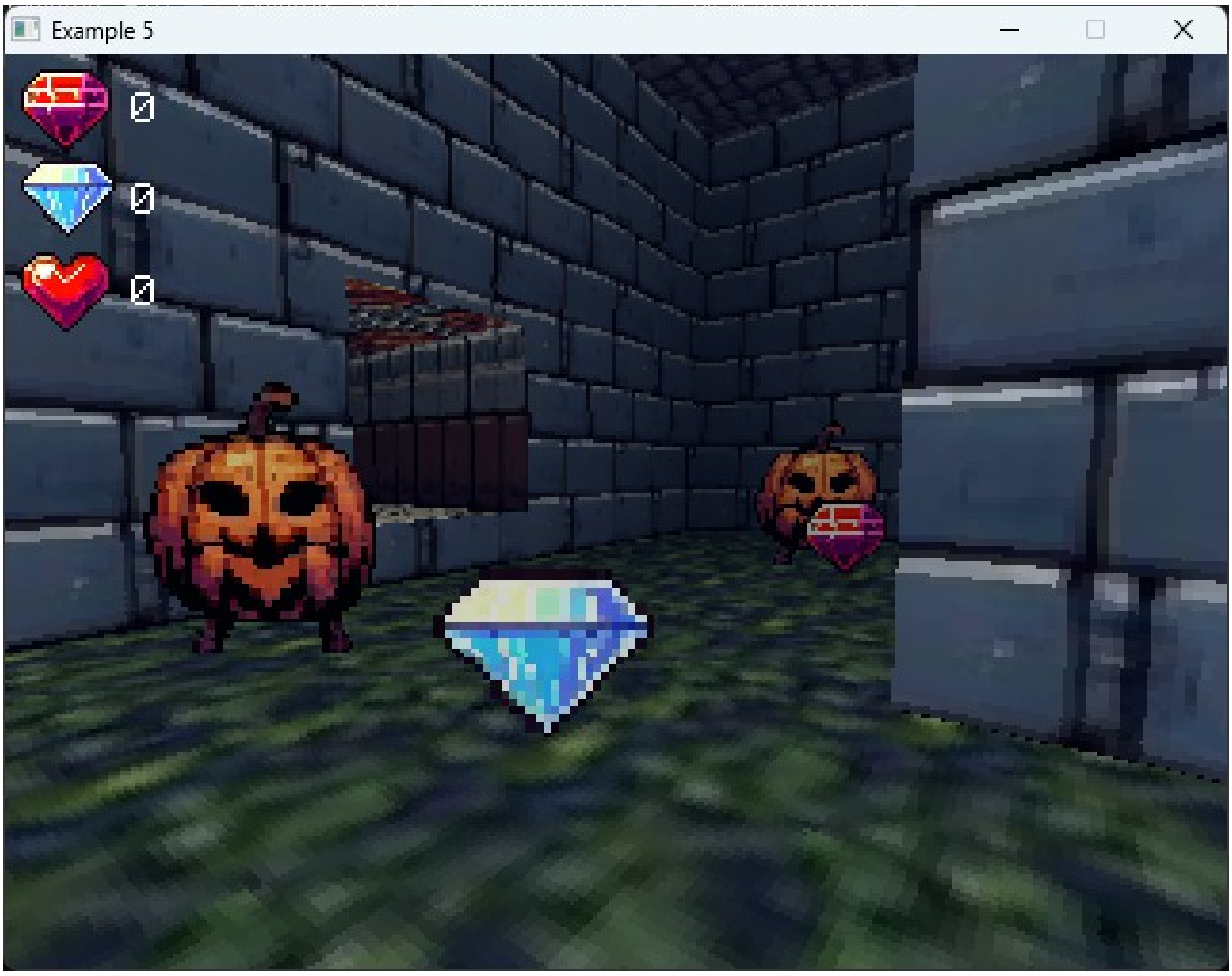
atan2(res.dx, res.dz) returns the angle (in radians) that corresponds to the normal. We want the enemy to be stupid, but not quite so stupid that he runs straight into the wall again after hitting it. So I use the angle returned by atan2, subtract 90 degrees and add 0..180 degrees by random. That way, the enemy will always walk away from the wall it just hit, but still in a random direction. If this feels like overkill, you can just skip the normal thingie and use SetYaw(rnd(360)) instead, but it's good if you try to understand what I'm doing here :)

Alright, that's the entire update function. Now my CreatePumpkinEnemy function looks like this:

```
function CreatePumpkinEnemy(x, y, z)
    enemy = EA_Object()
    enemy.SetSprite(vPumpkinImage, 0, true)
    enemy.SetHeight(height(vPumpkinImage)/64)
    enemy.SetRadius(0.5*width(vPumpkinImage)/64)
    enemy.SetPos(x, y, z)
    enemy.SetYaw(rad(rnd(360)))
    enemy.cel = 0
    enemy.Update = function(dt)
        .cel = (.cel + dt*8)%4
        .SetCel(int(.cel))
        res = .Move(.DX()*0.75*dt, 1*dt, .DZ()*0.75*dt, 0.25)
        if res.w
            .SetYaw(rad(deg(atan2(res.dx, res.dz)) - 90 + rnd()*180))
        endif
    endfunc
    return enemy
```

```
endfunc
```

That's not an aweful lot of code for an enemy, right? When I run my program (example_5.n7) this is the horror that I see:



6 Boop the pumpkins

In this example you won't really learn anything new at all. We'll clean up the code a bit and make the player able to shoot bullets that push the enemies around (without hurting them). You can copy your map and code from the previous step.

Cleaning up the code

First of all we want a nicer way of identifying our objects (bonuses, enemies, bullets and so on) than looking at what sprite image they use (GetSprite()). Looking at the sprite image would get messy if some sprites change their images as part of animation or state changes. So add a unique constant for every type of game object that you create. My list looks like this (PLAYER_BULLET_ID will soon make sense):

```
constant PLAYER_ID          = 1
constant RUBY_ID            = 2
constant DIAMOND_ID         = 3
constant HEART_ID           = 4
constant CHEST_ID           = 5
constant PUMPKIN_ID         = 6
constant PLAYER_BULLET_ID   = 7
```

In the function where you create your enemy, the pumpkin in my case, assign the proper id to a field named id. This is how my CreatePumpkinEnemy function starts now:

```
function CreatePumpkinEnemy(x, y, z)
    enemy = EA_Object()
    enemy.id = PUMPKIN_ID
    ...
```

Where and how do you create the objects that the player can pick up? Are you doing it in the flag loop, or have you followed the example code and created a function for it? Wherever you call EA_StaticObject, assign the right id to the id field. I modified my CreateItem function:

```
function CreateItem(id, img, x, y, z)
    item = EA_StaticObject()
    item.id = id
    …
```

, and added the proper id as first parameter when I look through the flags array:

```
foreach f in flags
    select f.flag
        ...
        case "ruby"
            o = CreateItem(RUBY_ID, vRubyImage, f.x, f.floorY, f.z)
            EA_AddStaticObject(o)
        case "diamond"
            o = CreateItem(DIAMOND_ID, vDiamondImage, f.x, f.floorY, f.z)
            EA_AddStaticObject(o)
        case "heart"
```

```
            o = CreateItem(HEART_ID, vHeartImage, f.x, f.floorY, f.z)
            EA_AddStaticObject(o)
        case "chest"
            o = CreateItem(CHEST_ID, vChestImage, f.x, f.floorY, f.z)
            EA_AddStaticObject(o)
        ...
```

We will soon change the code where the player picks up items so that it uses the id of the objects instead of the sprite image, but first we should clean up the creation of the player.

The setup of the player is somewhat messy in the previous examples. In example 5 we added a function to create and return an enemy object. I named the function CreatePumpkinEnemy. Let's do the same thing with the player object, put all the initialization code in one function. Start by defining a visible variable, vPlayer, where you have your other visible statements:

```
visible vPlayer
```

And when when looping through the flags from EA_LoadMap, call a new function CreatePlayer, that will return a player object:

```
vPlayer = unset
foreach f in flags
    select f.flag
        case "player"
            vPlayer = CreatePlayer(f.x, f.floorY, f.z)
            EA_AddObject(vPlayer)
            EA_SetCamera(vPlayer)
        ...
    endsel
next
assert typeof(vPlayer), "No player flag found"
```

Copy all the code that you used for setting up the player object to that function. My CreatePlayer function now looks like this:

```
function CreatePlayer(x, y, z)
    player = EA_FpsPlayer()
    player.id = PLAYER_ID
    player.SetPos(x, y, z)
    player.SetLeap(0.25)
    player.SetHeight(0.6)
    player.SetEye(0.5)
    player.SetMoveSpeed(1.5)
    player.SetMouseSens(0.5)

    player.Update = function(dt)
        if keydown(KEY_F, true)
            res = .Facing()
            if res and res.type = EA_DOOR and res.dist < 1
                if res.data.Open()
                    vOpenDoors[sizeof(vOpenDoors)] = res.data
                    res.data.timer = 3
                endif
            endif
        endif

        objs = .SectorObjects()
        if objs and sizeof(objs)
            for i = 0 to sizeof(objs) - 1
                if .CollidesWith(objs[i])
                    select objs[i].Sprite()
                        case vRubyImage
                            vRubies = vRubies + 1
                            EA_RemoveObject(objs[i])
                        case vDiamondImage
                            vDiamonds = vDiamonds + 1
                            EA_RemoveObject(objs[i])
                        case vHeartImage
                            vHearts = vHearts + 1
                            EA_RemoveObject(objs[i])
                        case vChestImage
                            vRubies = vRubies + 10
                            vDiamonds = vDiamonds + 5
                            vHearts = vHearts + 1
                            EA_RemoveObject(objs[i])
                    endsel
                endif
            next
        endif
    endfunc

    return player
endfunc
```

Much better! And while we're here, let's adjust the select statement where the player picks up items with new id system:

```
select objs[i].id
    case RUBY_ID
        vRubies = vRubies + 1
        EA_RemoveObject(objs[i])
    case DIAMOND_ID
        vDiamonds = vDiamonds + 1
        EA_RemoveObject(objs[i])
    case HEART_ID
        vHearts = vHearts + 1
        EA_RemoveObject(objs[i])
    case CHEST_ID
        vRubies = vRubies + 10
        vDiamonds = vDiamonds + 5
        vHearts = vHearts + 1
        EA_RemoveObject(objs[i])
endsel
```

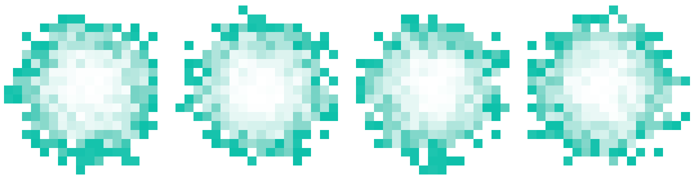
In examples/example_6.n7 I also put some settings, such as field of view and mouse sensitivity in visible variables at the top of the program so that I can change them without searching through the code. That also helps if you chose to implement a settings dialog later.

Let the player shoot

Maybe you have already figured out how to make the player able to shoot? No new engine functions are required for this. But, of course, I'll explain it anyway.

Start by adding a visible variable and load an image for the bullet into it. I'm using an image with four cels, because I want my bullets to be animated.

```
visible vPlayerBulletImage
...
vPlayerBulletImage = loadimage("assets/player_bullet.png", 4, 1)
```



How does a player shoot? Well, he or she clicks the mouse. Should the player be able to shoot as fast as it can click? NO! Slow clickers should not have a disadvantage! Max two clicks per second, I say. Add a field to the player object in the CreatePlayer function, perhaps after you set the id field.

```
player.stimer = 0
```

Then add some logic for the timer and a mouse button check at the bottom of your player's Update function:

```
player.Update = function(dt)
    ...
    .stimer = max(.stimer - dt, 0)
    if mousebutton(0, true) and .stimer = 0
        .stimer = 0.5
    endif
endfunc
```

Nothing strange there, right? The delta time value (dt) is subtracted from the timer every frame but we use the max function to make sure it stops at 0. And if the player clicks the left mouse button and the timer is 0 we set the timer to 0.5 seconds. We will soon create a function, CreatePlayerBullet(id, image_id, x, y, z, dx, dy, dz). Its first parameter is the id of the object that will be created (maybe we want different types of bullets with different strength later on). The second parameter is the image that the bullet sprite should use. Then comes the position, which should be right in front of the player, and the movement vector, which should be the direction in which the player is looking multiplied by the bullet speed. So:

```
player.Update = function(dt)
    ...
    .stimer = max(.stimer - dt, 0)
    if mousebutton(0, true) and .stimer = 0
        .stimer = 0.5
        EA_AddObject(CreatePlayerBullet(
                PLAYER_BULLET_ID,
                vPlayerBulletImage,
                .X() + .DX()*0.2, .Y() - 0.3 + .DY()*0.2, .Z() + .DZ()*0.2,
                .DX()*4, .DY()*4, .DZ()*4))
    endif
```

```
endfunc
```

That probably looks worse than it is. We get the player's position with the object functions X, Y and Z. But Y returns the y coordinate of the player's feet. Since the player is not kicking soccer balls at the enemies (… actually kicking soccer balls at pumpkins would have been quite fun), we need to modify the y coordinate a bit. The y axis points downwards, so to make the bullet spawn higher, we have to subtract something – 0.3 works fine. But we also want the bullet to appear slightly in front of the player. The object functions DX, DY and DZ, as explained earlier, returns the x, y and z components of the direction that the object is facing (based on the yaw and pitch angles). So to put the bullet, let's say, 0.2 units in front of the player, we simply add DX()*0.2, DY()*0.2 and DZ()*0.2 to the coordinates. The last three parameters is the movement vector of the bullet. It should travel in the direction that the player is facing at a speed of … 4 units per second.

Not to hard, right? Good, then it's time for the actual implementation of CreatePlayerBullet!

```
function CreatePlayerBullet(id, img, x, y, z, dx, dy, dz)
    b = EA_Object()
    b.id = id
    b.SetPos(x, y, z)
    b.SetSprite(img, 0, false)
    b.SetHeight(height(img)/64)
    b.SetRadius(0.5*width(img)/64)
    b.dx = dx
    b.dy = dy
    b.dz = dz
```

You know all about setting an objects position, sprite and size. But note that I now set the last parameter of SetSprite(image_id, cel, onlyYaw) to false instead of true. Because when it comes to the bullets, we want them to fully face the camera (the sprites should be rotated both around the y and x axis). You can try setting the parameter to true (as we do for the enemies and items) just to see the difference. Instead of messing with SetYaw and SetPitch and use the DX, DY and DZ functions later on, we create three fields for the direction of the bullet – dx, dy and dz. Everything fine so far? Good, let's go on with two more fields:

```
b.numCels = cels(img)
b.cel = 0
```

As I wrote earlier, I want my bullets to be animated. But the code will work for non-animated bullets too. I add one field for the number of cels in the image (a bit faster than using the cels function later on) and one for the current cel. This is all the data that the bullet object needs. Now add the bullet's Update function, where all the fun stuff happens. I'm pasting it all at once:

```
b.Update = function(dt)
    if .numCels > 1
        .cel = (.cel + dt*30)%.numCels
        .SetCel(int(.cel))
    endif

    res = .Move(.dx*dt, .dy*dt, .dz*dt, 0)
    if res.any
        EA_RemoveObject(this)
    else
```

```
        objs = .SectorObjects()
        if objs and sizeof(objs)
            for i = 0 to sizeof(objs) - 1
                if objs[i].id = PUMPKIN_ID
                    if .CollidesWith(objs[i])
                        objs[i].Hit(.dx, .dz)
                        EA_RemoveObject(this)
                        break
                    endif
                endif
            next
        endif
    endif
endfunc
```

The first thing we do is to check if the number of cels, the numCels field, is greater than 1. In that case we update the animation at 30 frames per second and set the sprite's image cel with the object function SetCel, that you've seen before.

Next we call Move using the dx, dy and dz fields and set the leap parameter to 0. If the bullet hit ANYTHING it should be removed. Earlier we have only checked the w field of the object returned by Move. w stands for wall. There is also a g field for ground and c field for ceiling. But we can check a field named any if we just want to know if there was any collision at all. If there was a collision we call EA_RemoveObject. If not, we check for collision with the enemies.

As you know from an earlier example, the object function SectorObjects returns all the objects that are in the same sector as the current object. If the returned value, objs, has a type and its size is greater than 0, we loop through the objects. And if the id of an object is the id of our enemy type, PUMPKIN_ID in my case, we check if the objects intersect. In the case of intersection, call a function, Hit, of our enemy that we have yet not implemented, remove the bullet and break out of the loop.

After the implementation of the Update function, your CreatePlayerBullet function must return the bullet object, b. Here's the entire function:

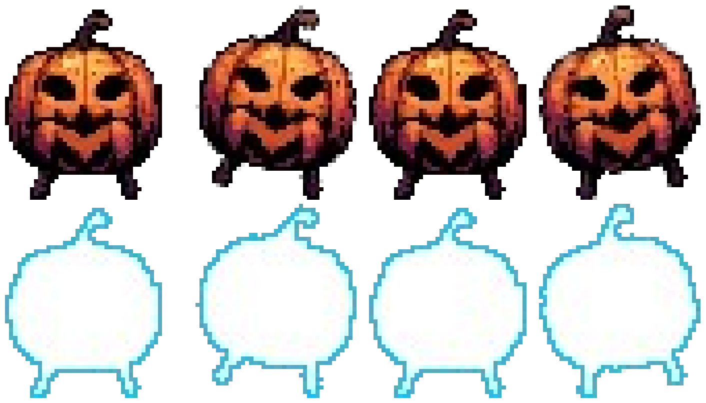
```
function CreatePlayerBullet(id, img, x, y, z, dx, dy, dz)
    b = EA_Object()
    b.id = id
    b.SetPos(x, y, z)
    b.SetSprite(img, 0, false)
    b.SetHeight(height(img)/64)
    b.SetRadius(0.5*width(img)/64)
    b.dx = dx
    b.dy = dy
    b.dz = dz
    b.numCels = cels(img)
    b.cel = 0
    b.Update = function(dt)
        if .numCels > 1
            .cel = (.cel + dt*30)%.numCels
            .SetCel(int(.cel))
        endif
        res = .Move(.dx*dt, .dy*dt, .dz*dt, 0)
        if res.any
            EA_RemoveObject(this)
        else
            objs = .SectorObjects()
            if objs and sizeof(objs)
                for i = 0 to sizeof(objs) - 1
```

```
                    if objs[i].id = PUMPKIN_ID
                        if .CollidesWith(objs[i])
                            objs[i].Hit(.dx, .dz)
                            EA_RemoveObject(this)
                            break
                        endif
                    endif
                next
            endif
        endif
    endfunc

    return b
endfunc
```

Boop the pumpkin

Only one thing is left now, and that is to make something happen with the enemy when it's hit by a player bullet. As you can see in the code above, I have already assumed the existance of a function named Hit in the enemy object. It takes two parameters, which is the movement vector in x and z of the object that caused the hit. You see, I want the enemy to be bounced away by the bullets. I also want the enemy to flash in white, so that the player gets some feedback and knows that a bullet actually hit something. So I add a new row of cels to my enemy image:



It's a bit hard to tell here, but on the second row the inside of the enemy outline is white. I change the loadimage call to inform the loader that the image has four columns and two rows:

```
vPumpkinImage = loadimage("assets/pumpkin.png", 4, 2)
```

How do we make the enemy bounce away when hit by a bullet? There are many ways to do that. I choose to add a push vector and a parameter. In each frame, the parameter will decrease towards 0. The movement of the enemy will always be affected by this vector multiplied by the parameter. When the parameter is at its max, 1, the push effect is strong, and when the parameter is 0 there is no push effect at all. Here I add the fields for pushing to the enemy object in CreatePumpkinEnemy:

```
function CreatePumpkinEnemy(x, y, z)
    enemy = EA_Object()
    ...
    enemy.push = 0
    enemy.pushDX = 0
    enemy.pushDZ = 0
```

push is the parameter and pushDX and pushDZ the vector. I also add a timer field for the flash effect:

```
enemy.htimer = 0
```

Let's jump to the implementation of the Hit function, called by the player bullet objects. Add this function to the enemy object after the update function (or before, doesn't matter):

```
enemy.Hit = function(dx, dz)
    .pushDX = .push*.pushDX + dx
    .pushDZ = .push*.pushDZ + dz
    .push = 1
    .htimer = 0.15
endfunc
```

A bit more code than expected? If there is already a push effect going on, we add ”what is left” of that effect to the new push vector by multiplying the current vector with the push parameter. Then we set the parameter to 1 and the flash timer (htimer) to 0.15 seconds.

Now, start by adding code to handle the flash effect to the enemy's Update function:

```
enemy.Update = function(dt)
    .cel = (.cel + dt*8)%4
    if .htimer > 0
        .SetCel(int(.cel) + 4)
    else
        .SetCel(int(.cel))
    endif
```

The first line, the regular animation of the enemy, is unchanged. In the if statement that follows, add 4 to the cel value to use the flash version of the animation if the htimer field is greater than 0.

Then we need to modify the call to Move in the same function, from:

```
res = .Move(.DX()*0.75*dt, 1*dt, .DZ()*0.75*dt, 0.25)
```

, to:

```
res = .Move((.DX()*0.75 + .push*.pushDX)*dt, 1*dt, (.DZ()*0.75 +
.push*.pushDZ)*dt, 0.25)
```

As you can tell, if the push field is 0, there will be no effect.

The last thing we need to do, at the bottom of the enemy's Update function, is to decrease the push and htimer fields towards 0:

```
    .push = max(.push - 1.5*dt, 0)
    .htimer = max(.htimer - dt, 0)
```

```
endfunc
```

I decrease the push parameter by 1.5 per second, so that the effect lasts for less than a second.

Even more …

I'm sorry, that was a lot of code and barely any pictures. You probably don't need to understand all of it. Was the push effect overkill? Wouldn't it have been enough with the flash? Perhaps, but it looks and ”feels” cool. If you want to, you could probably add stamina to the enemies on your own and make them go bye bye when their stamina reaches 0, am I right? Init a stamina field to, let's say, 3 and decrease it in the enemy's Hit function. When the stamina reaches 0, call EA_RemoveObject and the enemy is gone. On the other hand, an enemy couldn't possibly disappear without a cool animation! Could you pull that off?

In examples/example_6.n7 I have added even more stuff than I've shown here. The player holds a wand that bobs as the player walks. I've added sound effects and some music that will make your brains collapse. So I suggest you have a good look at the code :)

7 The last step

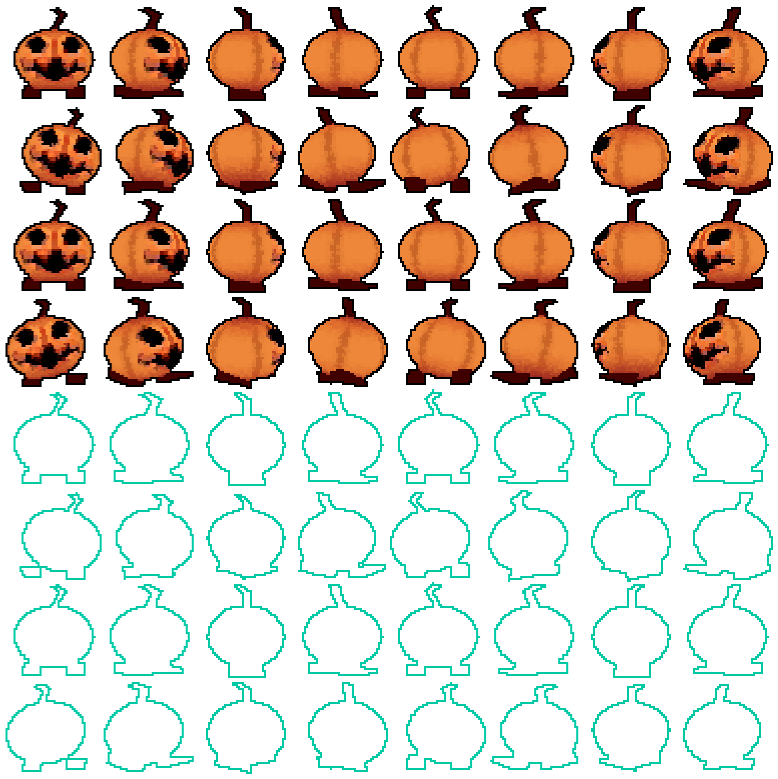
An eon has passed since I made the previous step in this tutorial, and approximately half an eon has passed since I wrote the code that I'm now going to write about. We will look at these things:

- Sprites with eight directions
- Enemies that see and chase the player
- Collision polygons for static objects

Sprites with eight directions

The pumpkin enemy sprite in the previous examples was always facing the camera (the player). Wouldn't it be better if the enemy was turned in the direction it's walking? Of course it would! But there's no support for that in the engine, since there are a thousand ways you can store your enemy's animation frames in one or multiple images. I'm simply going to give you some few lines of code here that you can use if you choose to store your sprites the same way as I do. The code assumes that your sprite has eight directions (which is the case in games such as Wolfenstein 3D and Doom).

Let's start by looking at the new pumpkin enemy image (examples/assets/pumpkin_dirs.png):



The image grid has 8x8 cells. Each row represents an animation frame, and each column represents an angle. The first column contains all the cells where the pumpkin is facing the camera. In the second column, the pumpkin has been rotated 45 degrees, then 90 degrees and so on. The first four cels in each column represents the walk animation (I'm not an artist, you just have to take my word for it). The white pumpkin cels are used as a brief effect when a pumpkin has been hit by a player bullet (just like in the previous example but in eight directions).

With this image setup I calculate and set the correct cel for the pumpkin enemy like this:

```
enemy.Update = function(dt)
```

```
    .frame = (.frame + dt*8)%4
    angle = (atan2(.X() - vPlayer.X(), .Z() - vPlayer.Z()) + rad(22.5) - .Yaw()
+ PI)%(PI*2)
    .SetCel(int((angle/(PI*2))*8) + int(.frame)*8)
    ...
```

Note that I renamed the field cel to frame. The first line of code in the pumpkin's Update function increments and wraps the animation frame, just like before. The second line calculates the angle, based on the enemy's direction and the angle between the enemy and the player, so that it matches the rotation used in the pumpkin image. And the third line sets the correct image cel for the sprite based on the animation frame and the angle. I choose not to explain this code, since it's a messy story that would require some drawing. Simply stick with the image grid layout that I use, and you'll be fine!

If you look at the source code (examples/example_7.n7), you'll notice an extra factor at the end of SetCel:

```
.SetCel(int((angle/(PI*2))*8) + int(.frame)*8 + (.htimer > 0)*32)
```

The htimer (hit timer) variable works just like in the previous example. So, (.htimer > 0)*32 means that if the htimer field is greater than 0, 32 is added to the cel value and a white pumpkin cel is used instead of a regular one. I could have written it like this instead:

```
if .htimer > 0
    .SetCel(int((angle/(PI*2))*8) + int(.frame)*8 + 32)
else
    .SetCel(int((angle/(PI*2))*8) + int(.frame)*8)
endif
```

, but obviously that doesn't look even half as cool.

Smarter pumpkins

The enemies in the previous example weren't that smart. They walked forward and turned around whenever they bumped into a wall. Now we're going to make our enemies (pumpkins in my case) see, chase and shoot at the player. And they'll also be able to jump, because it looks funny.

I'm adding a whole bunch of new fields to the pumpkin in my CreatePumpkinEnemy function:

```
enemy.spd = 0.75
enemy.dy = 0.1
enemy.onGround = false
enemy.aware = false
enemy.atimer = rnd()
enemy.shouldShoot = false
```

The speed of the enemy was previously hard coded. Now I put it in the field spd, because when the enemy chases the player we want it to change speed – move faster.

Since the enemies shall be able to jump we need better looking gravity, and for that we add the dy field, which is the enemy's vertical speed. onGround is just a flag that we set to true when the enemy is on the ground so that we know if it can jump.

aware is a flag that tells us if the enemy is aware of the player. When the enemy is aware of the player it will chase him/her, jump and shoot. The field atimer is a timer, with a value in seconds, that goes from 1 to 0 over and over again. Every time it reaches 0 the enemy's awareness of the player is updated. That is, code to check if the player is visible to the enemy is executed.

shouldShoot is a flag that swaps between true and false when an awareness check turns out positive. If shouldShoot is true the enemy shoots, and if it's false the enemy jumps instead.

Alright, that's the new data that the enemy will use. From here and on, the code I'm showing belongs in the enemy's Update function.

Let's start with the simple stuff, gravity:

```
if .onGround
    .dy = 0.1
else
    .dy = .dy + 7*dt
endif

...

res = .Move((.DX()*.spd + .push*.pushDX)*dt, .dy*dt, (.DZ()*.spd +
.push*.pushDZ)*dt, 0.25)
.onGround = res.g
```

The if statement is from the top of the function. If the onGround flag is true, we set the enemy's vertical speed to 0.1. If the onGround flag is not set, we let the speed increase by 7 units per second to simulate gravity. If I remember correctly that is also what is used for the object returned by EA_FpsPlayer (our player). Then comes the call to Move, where we actually try to move the enemy. As you can see, we now use the spd field instead of a constant, and for the vertical speed we use dy. The g field of the object returned by Move is true if there was a collision with the ground (you can also use a field named c to check if there was a collision with the ceiling). We copy that value to our onGround field. That's all the code needed for gravity!

We created a timer field named atimer. Let's decrease it and do something when it reaches 0. What we add now belongs in the "..." area in the code above.

```
.atimer = max(.atimer - dt, 0)
if .atimer = 0
    .atimer = 1
    if not .aware
        Check if the player is visible and start the chase if so ...
    else
        Shoot or jump if the player is still visible, stop chasing if not ...
    endif
    if .aware
        .SetYaw(atan2(vPlayer.X() - .X(), vPlayer.Z() - .Z()))
    endif
endif
```

As you can see, there's some code to be implemented here. I just want to show you this as an overview. When the timer, atimer, reaches 0 we set it to 1, which means a new awareness check will be made when another second has passed. If the enemy is not aware of the player, according to the aware flag, we will make some ”advanced” calculations to deterime if the enemy can see the player. If the enemy is already aware of the player, we'll make a simpler check to determine if the enemy has lost track of the player and make it jump or shoot if not. Before the end of the outer if statement, we again check the aware flag of the enemy. If it's true, we use the atan2 function and SetYaw to make the enemy face the player.

So, how do we determine if the enemy can see the player? Every game object created with EA_Object actually has a function named Visible(obj) that returns true if an object is visible from the current object. What it does is to calculate the distance between the two objects. Then it calls EA_Facing to see if any geometry (wall, floor, ceiling or static object) is closer than the object passed to Visible. If not, it returns true. But this function only solves half our problem! Our enemy (atleast my pumpkin) has eyes and therefor some sort of field of view. If the enemy is standing with its back against the player, it shouldn't see the player no matter what the Visible function says. We need to consider the enemy's direction and its field of view. And we do that before calling Visible, since Visible is a pretty ”expensive” function call:

```
...
if not .aware
    dx = vPlayer.X() - .X()
    dz = vPlayer.Z() - .Z()
    d = dx*dx + dz*dz
    if d > 0 and d < 36
        k = 1/sqr(d)
        if dx*k*.DX() + dz*k*.DZ() > 0.71
            if .Visible(vPlayer)
                .aware = true
                .spd = 2
                .shouldShoot = true
            endif
        endif
    endif
else
...
```

How's your linear algebra? A bit rusty? No problems! To determine if the player is within the enemy's field of view we can look at the dot product between the enemy's direction, which is the vector (.DX() .DZ()), and the vector between the enemy and the player. We start by calculating the vector between the enemy and the player and its square size:

```
dx = vPlayer.X() - .X()
dz = vPlayer.Z() - .Z()
d = dx*dx + dz*dz
```

If the square size, d, is 0 or greater than 36 we abort. If it's 0, we can't do any meaninful calculations without causing a division by 0, and if it's greater than 36 the player is too far away. ”Too far away?” you wonder. Well, yeah, in my game I have set the far clip plane to 6 units, meaning that the player can't see anything that's further away than that. And it wouldn't be fair if a bloody pumpkin had better vision than the player. d is the square distance, and $6^2 = 36$.

Then we normalize the vector (dx dz) and calculate the dot product between it and the enemy's direction:

```
k = 1/sqr(d)
if dx*k*.DX() + dz*k*.DZ() > 0.71
```

”Ah. Dot product. Greater than 0.71. Good.”

The dot product of two unit vectors is the cosine of the angle between them. So what angle does cosine 0.71 represent? The answer is about ±45 degrees. This gives our enemy a 90 degree field of view, which I think is a fair value. If that if statement evaluates to true, we use Visible to make sure there aren't any obstacles between the enemy and the player:

```
if .Visible(vPlayer)
    .aware = true
    .spd = 2
    .shouldShoot = true
endif
```

We set the aware flag to true and the spd field to 2, so that the enemy starts running. shouldShoot is set to true, meaning that if the enemy is still aware during the next awareness check it will launch a fire ball.

We have now written the code that is executed when the awareness timer reaches 0 and the enemy is not yet aware of the player. It's time for the code that runs when the enemy is already aware of the player. It's not quite as complicated as the things we just did:

```
...
if not .aware
    All the things we just did ...
else
    if not .Visible(vPlayer)
        .aware = false
        .spd = 0.75
    else
        if .shouldShoot
            .shouldShoot = false
            EA_AddObject(CreateEnemyBullet(ENEMY_BULLET_ID, vEnemyBulletImage,
                    .X() + .DX()*0.1, .Y() -0.25, .Z() + .DZ()*0.1,
                    .DX()*3, 0, .DZ()*3))
        else
            .shouldShoot = true
            if .onGround then .dy = -2.5
        endif
    endif
endif
...
```

To determine if the player is no longer visible, we just use the object function Visible. But why not do the cool field of view and dot product thingies? Because we can assume that the enemy has ”greater awareness” now when it has already spotted the player. It shouldn't stop chasing the player just because the player takes a step to the left and is no longer in the enemy's field of view. But if the player hides behind something, the chase stops. That is, if Visible returns false, we set the aware flag to false and the speed back to 0.75. If it returns true, we make the enemy shoot or jump depending on the shouldShoot flag.

```
if .shouldShoot
    .shouldShoot = false
    EA_AddObject(CreateEnemyBullet(ENEMY_BULLET_ID, vEnemyBulletImage,
            .X() + .DX()*0.1, .Y() -0.25, .Z() + .DZ()*0.1,
            .DX()*3, 0, .DZ()*3))
else
    ...
```

If shouldShoot is true we set it to false and add an object returned by CreateEnemyBullet to the engine. CreateEnemyBullet is a slightly modified version of CreatePlayerBullet, so have a look at the previous step to understand how it works. You can see that I've added another object identifier named ENEMY_BULLET_ID and loaded asuitable image into vEnemyBulletImage. The Update function of the object returned by CreateEnemyBullet looks like this:

```
b.Update = function(dt)
    if .numCels > 1
        .cel = (.cel + dt*30)%.numCels
        .SetCel(int(.cel))
    endif
    res = .Move(.dx*dt, .dy*dt, .dz*dt, 0)
    if res.any
        EA_RemoveObject(this)
    else
        if .CollidesWith(vPlayer)
            vPlayer.Hit(10)
            EA_RemoveObject(this)
        endif
    endif
endfunc
```

Here we just check for collision with the player, using the object function CollidesWith. In the player bullet's Update function we fetched a list of all objects in the bullet's sector and checked for collision with every object with the id PUMPKIN_ID. That's the only difference between the two functions. If the bullet does collide with the player, we call a new function in the player object named Hit that takes a damage value as parameter. It's a simple function that will be explained when we're done with all the new enemy code. As you can see, we also remove the enemy bullet if it hits the player.

Let's get back to the enemy's Update function. If shouldShoot is true, we add a bullet. If shouldShoot is false we set shootShoot to true, so that the enemy shoots during the next awareness check, and make it jump with the statement:

```
if .onGround then .dy = -2.5
```

2.5 is a value chosen by trial and error and it makes the pumpkin do a cute little jump that serves no purpose what so ever.

As it is now, the enemy can only hurt the player with the bullets it shoots. It would also be nice if the enemy could hurt the player by running into him/her. So at the end of the enemy's Update function we add:

```
if .CollidesWith(vPlayer)
    vPlayer.Hit(15)
    dx = .X() - vPlayer.X(); dz = .Z() - vPlayer.Z()
    d = dx*dx + dz*dz
    if d > 0
        k = 2/sqr(d)
        dx = dx*k; dz = dz*k
        .Push(dx, dz)
    endif
endif
```

Again, we call the unexplained Hit function in the player object. Then we create a vector between the player and the enemy, (dx dz), change its size to 2 and call a new object function named Push. If you remember the enemy Hit function in the previous example, it added a push effect to the enemy when hit (by a bullet). Well, the new Push function just implements the pushing part of that function:

```
enemy.Push = function(dx, dz)
    .pushDX = .push*.pushDX + dx
    .pushDZ = .push*.pushDZ + dz
    .push = 1
endfunc
```

So, when the enemy runs into the player, it kind of bounces away while applying some damage to the player.

Before we leave the enemy alone, there's one more change we should make. I just mentioned the enemy's Hit function. In the previous example the enemy couldn't die. For that to be possible, we can add a new field to the enemy object when it's constructed (in my CreatePumpkinEnemy function). Let's name the field stamina and set it to 4:

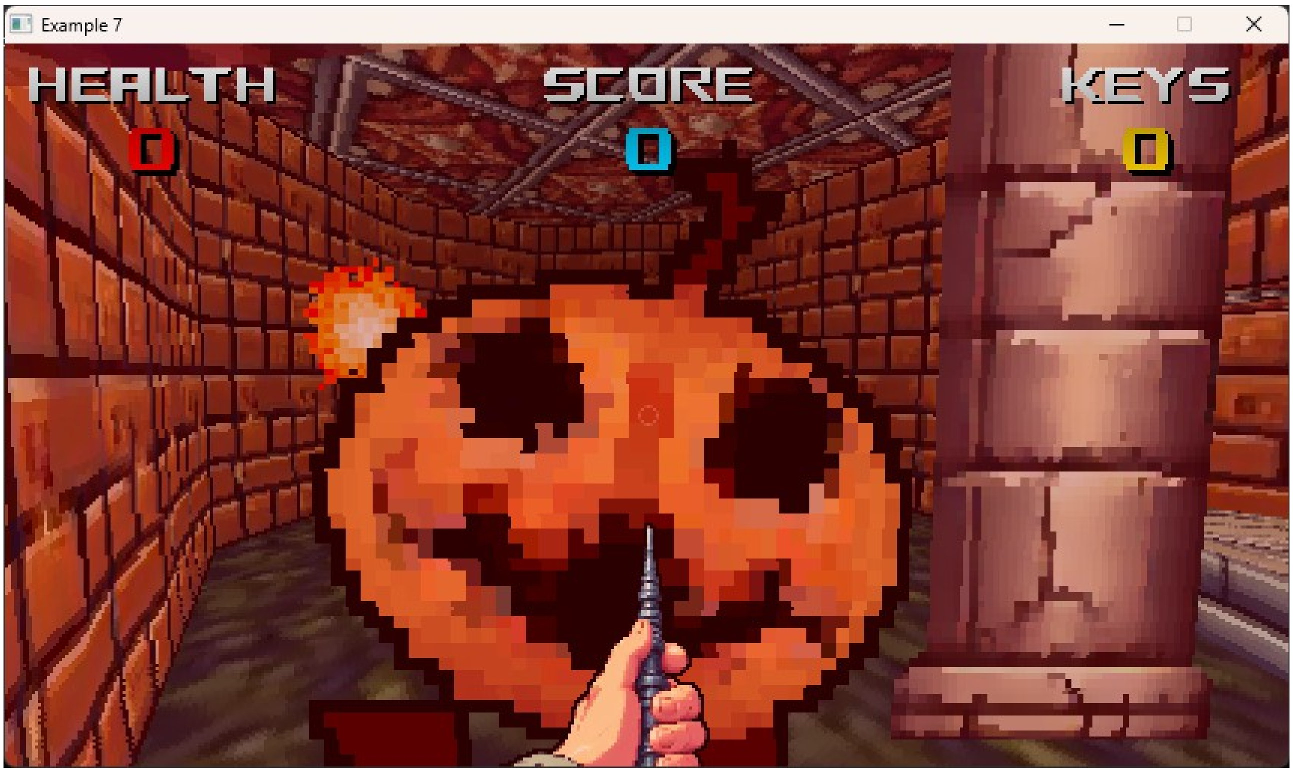
```
enemy.stamina = 4
```

When should this field be used, you think? In the enemy's Hit function, of course. It's called when a player bullet collides with the enemy. I'm pasting a whole blob of code here:

```
enemy.Hit = function(dx, dz)
    .stamina = .stamina - 1
    if .stamina > 0
        .Push(dx, dz)
        .htimer = 0.15
        .aware = true
        .atimer = min(.atimer, 0.1)
    else
        EA_RemoveObject(this)
    endif
endfunc
```

Decrease the stamina by 1. If the stamina is still greater than 0, call the new Push function, make the enemy flash white for 0.15 seconds and … make the enemy instantly aware of the player! We also set the awareness timer to 0.1, meaning that the enemy will turn towards the player in 0.1 seconds. If stamina is 0, remove the enemy.

That's it for the enemy. And here's a picture to lighten things up:



But wait, there's this one function for the player that we still need to implement for our enemies to function. At two places, the enemy code assumes that there's a function in the player object named Hit that takes a damage number as parameter. First, let's add some new fields to the player object (I do so in my CreatePlayer function):

```
player.stamina = 100
player.htimer = 0
```

From start, the player stamina is 100. The htimer, hit timer, field is used for controlling how often the player can get hit. htimer is decreased in the player's Update function:

```
.htimer = max(.htimer - dt, 0)
```

, and the player can only get hit when it's 0. In the player's Hit function we simply do this:

```
player.Hit = function(damage)
    if .htimer = 0
        .htimer = 1
        .stamina = max(.stamina - damage, 0)
    endif
endfunc
```

We set htimer to 1, meaning that a second will have to pass before the player can take damage again. The stamina is decreased, but that's all we do here. I have not added any code for the player's death in the example (examples/example_7.n7), but here's a start for you in the games Update callback function (where we check if escape is pressed and update the doors):

```
function Update(dt)
    if vPlayer.stamina = 0  EA_Stop()
    ...
```

It will give the control back to your program, meaning that any code you add after EA_Run() will execute.

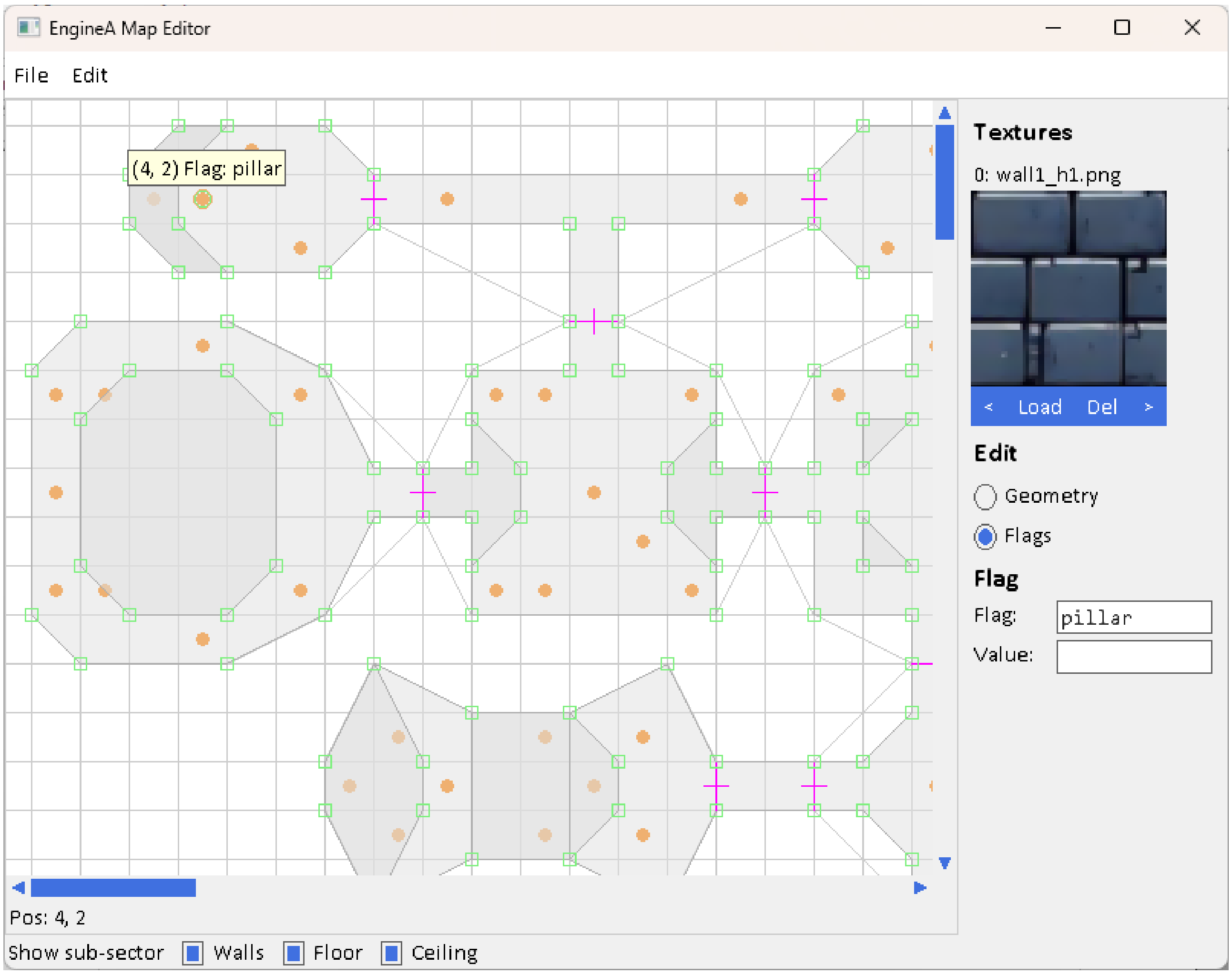
Making obstacles of static objects

The difference, as explained so far, between static objects and regular objects is that static objects can't move. You may have wondered why there exists such a distinction. The answer is that there's a cool thing that you can do with non-moving objects that wouldn't be possible with moving ones (because it would require too many heavy calculations that n7, a slow interpreted language, couldn't handle in ”real time”). You can assign collision properties to a static object, meaning that the object can act as a complex wall and even something that the player can stand on.

I asked the Image Creator from Microsoft Designer for a pixel art stone pillar and got this beauty:

, and a barrel:

I then added a couple of ”pillar” and ”barrel” flags to my map (examples/assets/map_7.json) in the editor.



Two new object identifiers are to my game, and the new images are loaded into visible variables.

```
constant PILLAR_ID          = 11
constant BARREL_ID          = 12
...
visible vPillarImage, vBarrelImage
...
vPillarImage = loadimage("assets/pillar.png")
vBarrelImage = loadimage("assets/barrel.png")
```

When loading the map and looping through the flags I do this:

```
flags = EA_LoadMap("assets/map_7.json")
...
pillarPoly = CreateCirclePoly(0.4, 5)
barrelPoly = CreateCirclePoly(0.2, 5)
foreach f in flags
    select f.flag
        ...
        case "pillar"
            obj = CreateItem(PILLAR_ID, vPillarImage, f.x, f.floorY, f.z)
            obj.SetColPoly(pillarPoly)
            EA_AddStaticObject(obj)
        case "barrel"
```

```
            obj = CreateItem(BARREL_ID, vBarrelImage, f.x, f.floorY, f.z)
            obj.SetColPoly(barrelPoly)
            EA_AddStaticObject(obj)
    endsel
next
```

The CreateCirclePoly function is a helper function that returns a circular polygon with the specified radius and number of vertices:

```
function CreateCirclePoly(r, vertices)
    p = []
    astep = 2*PI/vertices
    for i = 0 to vertices - 1
        p[sizeof(p)] = r*cos(i*astep)
        p[sizeof(p)] = r*sin(i*astep)
    next
    return p
endfunc
```

The polygon passed to SetColPoly will be centered around the object's position in the xz plane. Together with the object's height, it creates an area that blocks moving objects.