Ray tracer and scene builder manuals and specification

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Scene file specification

Scene files follow a very simple structure. They are a set of objects each printed one after the other. An object is described in the format shown in listing 1

```
OBJECT_NAME
<double> <double> <double>
<double> <double> <double> <double>
<double> <double> <double> <double>
<double> <double> <double> <double>
<double> <double> <double> <double>
```

Listing 1: Scene file template

"<double>" means that the value at that position would be replaced by a 64 bit floating point number. The "OBJECT_NAME" can have one of 6 values

- CAMERA
- LIGHT
- PLANE
- SPHERE
- CYLINDER
- CUBE

Each value represents one of the available objects. Then there are 3 "<double>" values present on the next line. Those are the red, green and blue values for the material colour. So "0.8 0.2 0.1" would be equivalent to 0.8 red, 0.2 green and 0.1 blue. The following 4 lines each containing 4 values correspond to the transformation matrix that this object uses. For example the description of a red sphere with the identity matrix applied (i.e without any transformations) can be seen in listing 2.

```
SPHERE
1.0 0.0 0.0
1.0 0.0 0.0 0.0
0.0 1.0 0.0 0.0
0.0 0.0 1.0 0.0
0.0 0.0 0.0 1.0
```

Listing 2: Scene file containing only a red sphere

It is important to note that the first object in a scene file must always be the camera. And, for items to be visible, we will need at least one light.

Instruction file specification

Instruction files are very similar to scene files, however the are some key differences. The first line in an instruction file must always be "OUTPUT_FILE <outputFilename>", where "<outputFilename>" can be a string that doesn't contains spaces which will be used as the output filename for the ppm file that will be produced. Then you can start describing your objects. There are 3 different object types that you can use in an instruction file. The first is a “CAMERA”, the second the “LIGHT” and the third type includes all other objects. Each type has its own unique set of properties that must be set for the scene to be set up correctly. The template to create a camera can be seen in listing 3

```
START CAMERA
    LOCATION <double> <double> <double>
    LOOK_AT <double> <double> <double>
END CAMERA
```

Listing 3: Scene file template

As we can see the camera has 2 properties. Its location and the point in the scene that it looks at. Each one take 3 “¡double¿” as parameters (64 bit floating point numbers). Lights follow a similar pattern however their second parameter is colour, which contains 3 “¡double¿” values, describing the light’s colour red, green and blue values. A template to create a light can be seen in listing 4

```
START LIGHT
    LOCATION <double> <double> <double>
    COLOUR <double> <double> <double>
END LIGHT
```

Listing 4: Scene file template

Last but not least you can then add normal objects to your scene. Those can be “PLANE”, “CUBE”, “SPHERE” and “CYLINDER”. There are 2 sections to an object type. One is the “MATERIAL” section which contains all of the material’s properties. And the other is the “TRANSFORMATION” which describes the series of transformations that you want to apply on an object. The template for an object can be seen in listing 5

```
START OBJECT <objectName>
  START MATERIAL
    COLOUR <double> <double> <double>
    AMBIENT <double>
    DIFFUSE <double>
    SPECULAR <double>
    SHININESS <double>
    REFLECTIVITY <double>
    TRANSPARENCY <double>
    RI <double>
  END MATERIAL
  START TRANSFORMATION
    <operationName> <operationParameters>
  END TRANSFORMATION
END OBJECT
```

Listing 5: Scene file template

Below is a list of all the colour properties and what they mean. Each “<double>” describes the amount we want to take this calculated property into account when computing the material for that object.

- COLOUR “<double>” “<double>” “<double>” - the colour of the object, red, green, and blue values

- AMBIENT “<double>” - the ambient colour before any shading, range [0.0 - 1.0]

- DIFFUSE “<double>” - the diffuse colour, range [0.0 - 1.0]

- SPECULAR “<double>” - the specular colour, range [0.0 - 1.0]
- SHININESS “<double>” - the higher the value the more shiny the object (choose a high value >500)
- REFLECTIVITY “<double>” - how reflective the material should be, range [0.0 - 1.0]
- TRANSPARENCY “<double>” - how transparent the object is, range [0.0 - 1.0], 1.0 means invisible
- RI “<double>” - the refractive index of the material

There are also a few different operations that you can add to an object. Those are

- SCALE “<double>” “<double>” “<double>” - scale the object by “<double>” along the x, y and z axis accordingly
- TRANSLATE “<double>” “<double>” “<double>” - move the object by “<double>” on the x, y and z axis accordingly
- ROTATE_X “<double>” - rotation, in rads along the X axis
- ROTATE_Y “<double>” - rotation, in rads along the Y axis
- ROTATE_Z “<double>” - rotation, in rads along the Z axis

Listing 6 shows how to create a shiny blue cube, scaled to half the size and rotated 90 degrees ($\pi/2$ rad) along each axis.

```
START OBJECT CUBE
  START MATERIAL
    COLOUR 0.0 0.0 1.0
    AMBIENT 0.15
    DIFFUSE 0.5
    SPECULAR 0.8
    SHININESS 4000.0
    REFLECTIVITY 0.6
    TRANSPARENCY 0.0
    RI 1.0
  END MATERIAL
  START TRANSFORMATION
    SCALE 0.5 0.5 0.5
    TRANSLATE 1.0 0.5 1.0
    ROTATE_X 1.57079632679
    ROTATE_Y 1.57079632679
    ROTATE_Z 1.57079632679
  END TRANSFORMATION
END OBJECT
```

Listing 6: Scene file template

Ray tracer user manual

In this manual I will go over how to use the ray tracer executable and what arguments you can pass to it. Most of the things are done through either scene or object files, which were covered in the previous subsections of this appendix. There are really only 3 ways that you can use this program. The first is to run it without any external arguments either through the terminal "./raytracer" or by double clicking the executable. The other would be using a scene file, that can be done through the terminal using "./raytracer someScenefile.sf" or by dropping a scene file onto the executable (this will cause it to run on windows). The last way would be the same as the second way but using an instruction file instead.

Scene builder user manual

When first opening the scene builder, we are introduced with a blank screen (figure 1). New objects can be created by pressing different number on the keyboard (see the input manual on listing 7). Figure 3 shows some objects being created, by default, an object is created with the red colour. Moving the camera around is done using the mouse, press the scroll wheel to pan, and the right click to look around. Objects can be selected by left clicking on them. Once an object is selected you can scale, rotate, or move it. First press the appropriate key, as shown on listing listing 7, and then the axis that you want to perform the operation on. Light can be manipulated in the same way as object and can be created by pressing the 'L' key. Lights show up as yellow spheres. The size of the light doesn't matter. The only information that is important for the lights is their position. If you want to save your scene in a scene file you can press the 'P' key and a file will be created with all the relevant information. The filename will be in the format "Scene<number>.sf" where <number> starts from '1' when you first run the program and increments sequentially as you save more files. Refer to the detailed input manual on listing 7 for an overview of all possible inputs.

```
Keyboard input
    Creating objects
        ’1’ - create plane
        ’2’ - create cube
        ’3’ - create sphere
        ’4’ - create cylinder
        ’L’ - create a light (the light’s size doesn’t matter)
    Manipulating objects
        ’X’ - delete selected object
        ’R’ - rotate object (requires second key to be pressed, see below)
            ’X’ - rotate along the object’s x axis
            ’Y’ - rotate along the object’s y axis
            ’Z’ - rotate along the object’s z axis
        ’S’ - scale object (by default scales along all axis but a specific axis can also be specified)
            ’X’ - scale along the object’s x axis
            ’Y’ - scale along the object’s y axis
            ’Z’ - scale along the object’s z axis
        ’G’ - grab/move object (requires second key to be pressed, see below)
            ’X’ - move along the object’s x axis
            ’Y’ - move along the object’s y axis
            ’Z’ - move along the object’s z axis
    Colouring objects
        ’V’ - colour object red
        ’B’ - colour object green
        ’N’ - colour object blue
        ’M’ - colour object purple
    Creating a scene file
        ’P’ - will create a scene file with the details of the current scene
Mouse input
    clicking the scroll wheel - pan camera around while pressed
    left click - select object
    right click - look around with the camera while pressed
```

Listing 7: Scene builder input manual

Figure 1: Start screen

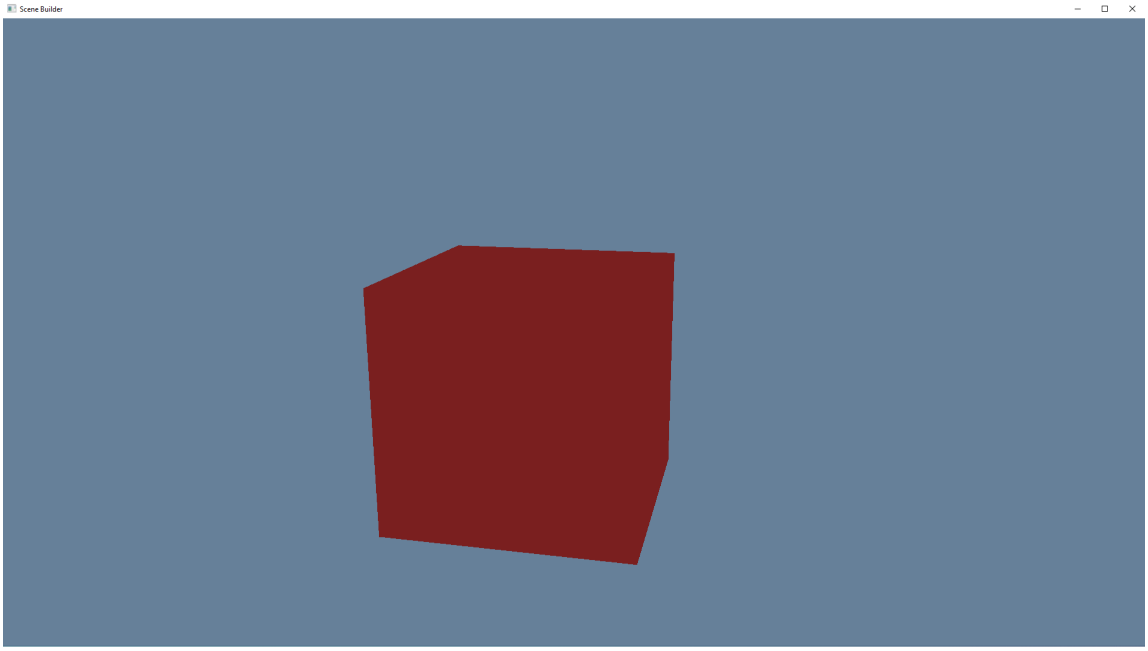

Figure 2: Moving around with the camera

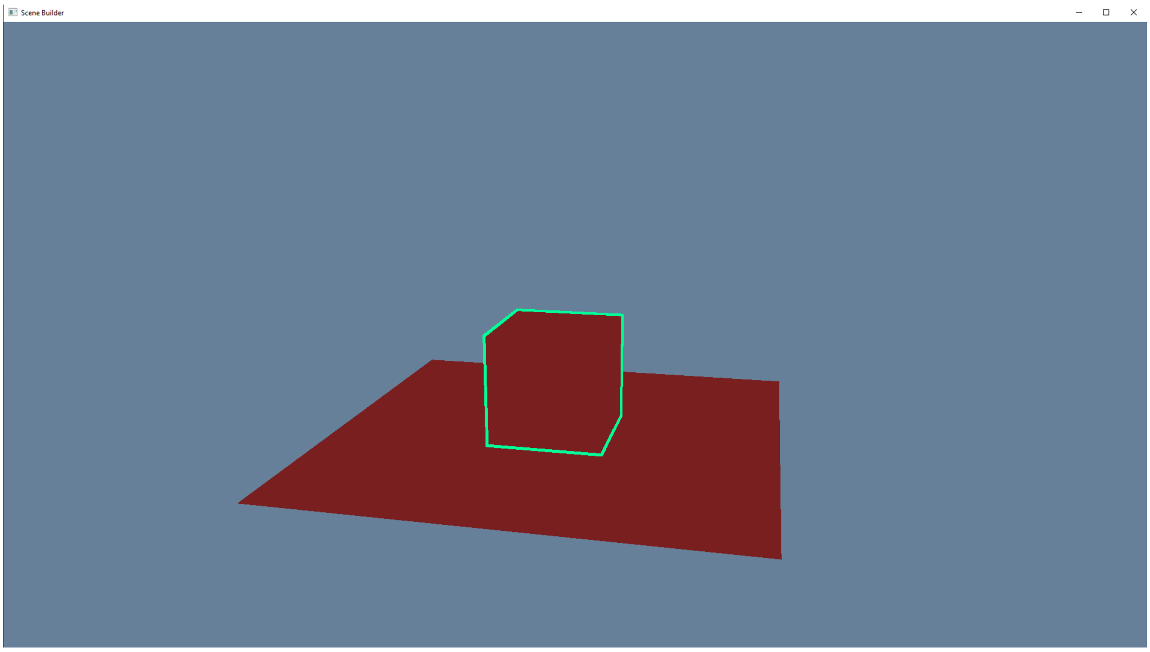

Figure 3: Creating objects

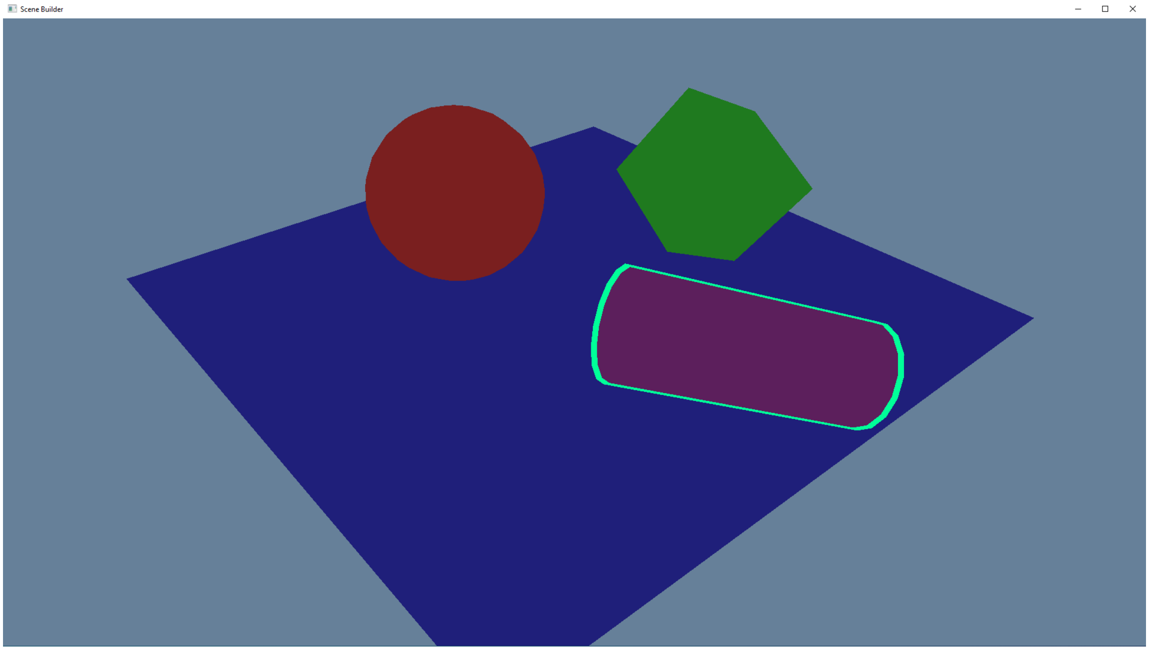

Figure 4: Colouring and positioning objects