IMPLEMENTING THE NIGHT VISION EFFECT
WITH THE USE OF A DEPTH MAP

Abstract. The article presents a method of implementing the night vision effect applied in the Jaskier image generator of the JASKIER simulator. The operating principle of a night vision device is discussed along with image processing procedures with the use of modern computer graphics techniques. The effects obtained are summarised in conclusions.

Keywords: JASKIER simulator, image generator, Jaskier IG, night vision, computer graphics, image processing, virtual reality.

1. INTRODUCTION

Night vision is the ability to see in low light conditions made possible with the use of special devices. The night vision device enables seeing in darkness by increasing the light intensity to a level observable by the human eye. For the night vision device to fulfil its function, the scattered light of stars or the moon is sufficient (residual light). The night vision device does not operate in complete darkness. In that case it is necessary to illuminate the observed object or individuals with infrared radiation, which is visible to those observed. With regard to the necessity of using an additional light source, night vision devices are classified as:

- active – these require illumination; their range of visibility is short, and they can easily be spotted by the enemy with its own night vision devices;
- passive – these operate without the infrared light sources and only use residual light intensifiers [1].

Night vision devices come in various types and categories. Night vision devices may take on the form of goggles, binoculars, telescopic sights mounted onto firearms, cameras or periscopes used in vehicles. An example of an image from night vision goggles is shown in Fig. 1.

The night vision effect developed for the purposes of the image generator of the JASKIER simulator [2] was taken from the periscope used in the KTO Rosomak vehicle (Fig. 2). This periscope was used by the Polish troops during combat in Afghanistan [3]. The PNK-72 Radomka periscope has two independent optical channels with passive image intensifiers XD4 and XR5 [5].
Image intensifier is the basic component of the night vision device. It takes advantage of the photoelectric effect, wherein individual photons entering an electron tube are converted into an avalanche of electrons that subsequently hit a screen. The night vision device does not allow to distinguish colours, therefore all objects observed on the screen are of one colour (usually green), and details can be discriminated based on their brightness only [5].
2. IMPLEMENTING THE NIGHT VISION EFFECT

When the operating principles of a night vision device are known, the night vision effect can be simulated in a graphic environment that provides programming of the graphical processes (GPU). Images in three-dimensional graphics are processed with the help of short computer programs, called shaders, which are coded in special shading languages and, depending on the tools used, can take on various forms [6]. Fig. 3 shows a shader that generates noise in Unreal Engine.

Explaination of how shaders work and discussion of their limitations and advantages would require a series of articles, therefore here we present not the used source codes of the shaders, but only the results of their operation.

The image of an example of a night scene from the Jaskier IG (Fig. 4) was processed using empirically selected post-processing techniques. Processing that included increasing colour saturation, colorization and adding grain (noise) did not produce expected results due to the lack of background light on the objects on the right-hand side of the scene (Fig. 5). Absence of visible objects on the right-hand side of the scene is caused by simplifications applied in computer graphics and by zero colour value (black) in that area. It is possible to increase light intensity to illuminate all objects. However, in the case of an image generator, where light intensity is or should be controlled by a simulator, this is not a proper approach.
The image processing method had to make use of a depth map\(^1\), i.e. an additional texture which, in short, contains information on the geometry of the scene without colours and light – the depth map is a matrix of pixels of the image which contains the Z coordinate (Fig. 6).

\(^1\) Creating an effective depth map was made possible after the "Framebuffer Object" was added to the API OpenGL in 2008 [7] and the "DepthStencilState" was added to the alternative API DirectX.
Implementing the night vision effect with the use of a depth map

The depth map now finds numerous applications in computer graphics and may be used, for instance, in the techniques of implementing shadows, fog, depth blur [6]. All image processing operations that simulate the night vision effect are listed in Table 1. The final results of applying the method are shown in Fig. 7.
Table 1 Image processing operations

<table>
<thead>
<tr>
<th>Item</th>
<th>Process description</th>
<th>Process illustration</th>
<th>Process result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increased colour saturation.</td>
<td><img src="image1.png" alt="Process illustration" /></td>
<td><img src="image2.png" alt="Process result" /></td>
</tr>
<tr>
<td>2</td>
<td>Combination of image and depth map.</td>
<td><img src="image3.png" alt="Process illustration" /></td>
<td><img src="image4.png" alt="Process result" /></td>
</tr>
<tr>
<td>3</td>
<td>Noise (graininess) generation and combination with the image.</td>
<td><img src="image5.png" alt="Process illustration" /></td>
<td><img src="image6.png" alt="Process result" /></td>
</tr>
<tr>
<td>4</td>
<td>Colorization (green)</td>
<td><img src="image7.png" alt="Process illustration" /></td>
<td><img src="image8.png" alt="Process result" /></td>
</tr>
</tbody>
</table>
3. CONCLUSIONS

The method of implementing the night vision effect, developed at the OBRUM's Centre for Military Simulations, solves the problem of the lack of background light in simplified virtual reality environments by using the depth map. The application of this method in the Jaskier image generator enabled the generation of the geometry of a scene at a distance of up to 250 metres with virtually no background light.

The developed method may be implemented in any graphics environment where shader technology is used and the range of the field of view can be modified through arithmetic operations on the depth map and adapted to the capabilities of the simulated night vision device. The method, being highly modifiable, can successfully be used in games, simulation systems and civilian training systems.

4. REFERENCES