# VISUALISATION IN CULTURAL HERITAGE

**Ondřej HOMOLA[1], Jan ZEMAN[2]**

[1] ENVIOM PRO s.r.o., DREAMWALK
Na Břevnovské pláni 1363/71
Praha 6, Czech Republic

ondrej.homola@enviom.com, jan.zeman@enviom.com

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**Abstract**: *Computer generated 3D graphics applied in culture heritage documentation experienced dramatic evolution in last 20 years. We see today wide usage of renders, pictures but trend in visualizing is more in advanced techniques as animations and interactive real-time visualization. Extended possibilities of current computer programs are allowing us to bring extra direction - emotions - that support data's or events presentation across wide public. Stereoscopic presentation might be playing important role in future in presentations to wide public. Interactive simulations will be becoming important of category. Weather, Light, Sound simulation as well as e.g. natural disasters will be more and more frequently tested, verified and visualized via 3D data models.*

## 1. ADVANCED COMPUTER GRAPHIC TECHNIGUES AND ALGORITMS

Computer generated graphic is offering us wide offer of possibilities. Besides creating exact 3D models, we could create photorealistic effects while using advance techniques.

### 1.1 Global illumination and radiosity

Global illumination algorithm is besides direct light using also reflected indirect lightning. This result to softer shades due to limited intensity based on number of reflections. This might to be visible e.g. in room corners, on relief structures in high detail or anywhere where low lightning occur. Due to limited light intensity lowered with number of reflections itself (e.g. rainy weather conditions) or combined with direct light and sharp shadows (sunny weather) create photorealistic display.

Radiosity could be described as diffused color light emitation from illuminated object to objects in nearby. Result is colored and illuminated object from reflected indirect light.

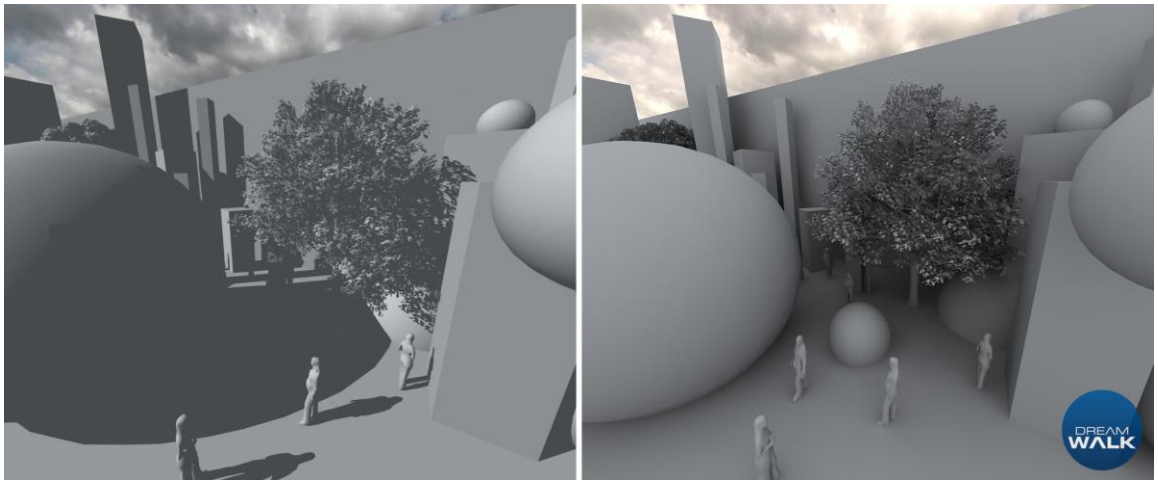

**Figure 1:** Example1: Direct lighting vs. Indirect Illumination (GI)

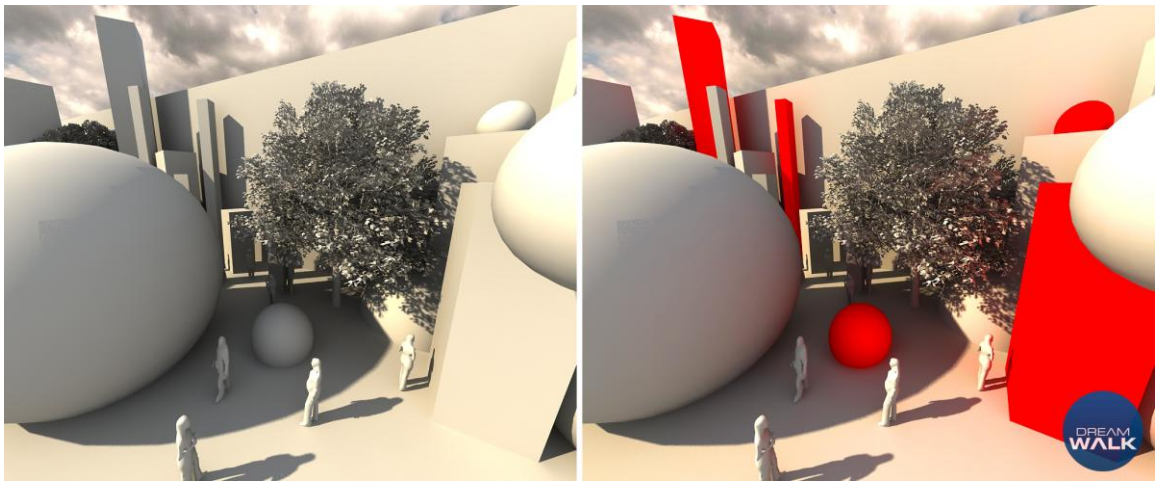

**Figure 2:** Example2: Direct lighting + Indirect Illumination (GI), Radiosity

### 1.2 Reflections and refraction

Reflection and refraction are key light effect describing materials in real life as well as in Computer generated graphics. Every single material is capable to reflect light. Reflection intensity is determined with surface capabilities, color – capability to reflect or absorb light.

Reflection intensity is also well describing different materials. Shiny surfaces like mirror, polished surfaces, metals are highly reflecting while skin, rubber are more absorbing creating glossy effect. Refraction is related to transparent and translucent materials like e.g. glass and water.

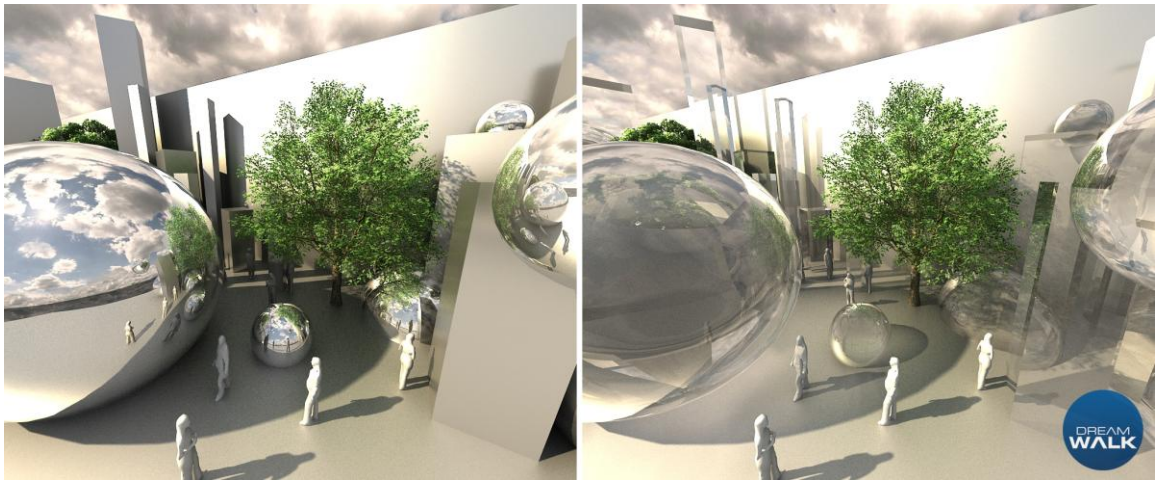

**Figure 3:** Example3: Reflections vs. Refractions

### 1.3 Ambient occlusion

Ambient occlusion is a shading method which helps add realism to local reflection models by taking into account attenuation of light due to occlusion. Ambient occlusion attempts to approximate the way light radiates in real life, especially off what are normally considered non-reflective surfaces.

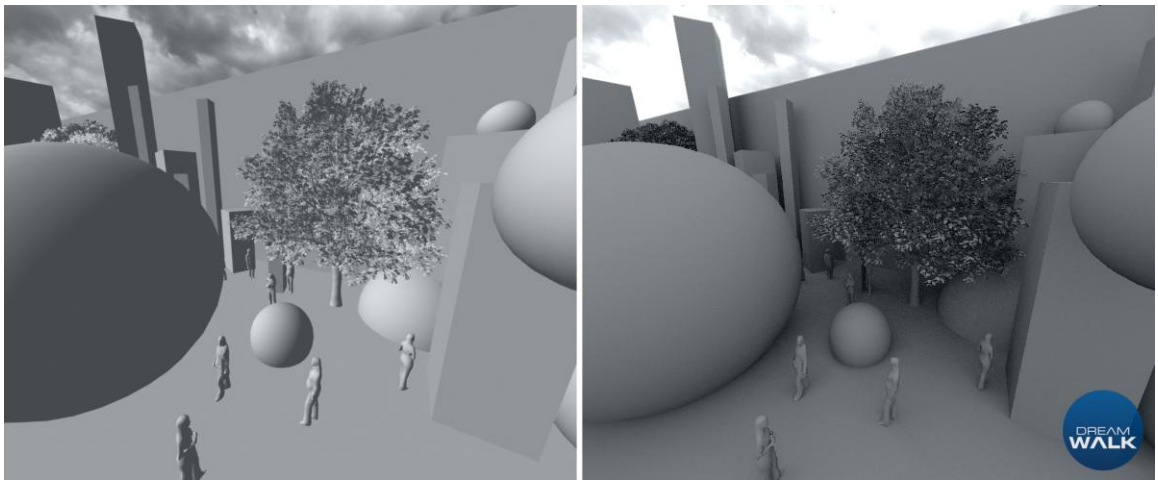

**Figure 4:** Example4: Simple lighting vs. Ambient occlusion

### 1.4 Subsurface scattering

Subsurface scattering is a mechanism of light transport in which light penetrates the surface of a translucent object, is scattered by interacting with the material, and exits the surface at a different point. The light will generally penetrate the surface and be reflected a number of times at irregular angles inside the material. Subsurface scattering is being seen on materials like marble, skin, and milk.


**Figure 5:** Example5: Subsurface scattering

## 2. VISUALISATION IN CULTURAL HERITAGE DOCUMANTATION TODAY

We see recently wide application of 3D computer generated graphic in Culture heritage documentation. Huge advantage is that due to progress on hardware side as well as development of software this tool became easily achievable for wide audience.

### 2.1 Visualization

We do understand Visualization as communication process. We have data's, information's, knowledge, achievements, many experiences and even vision on side of experts. Visualization is easy understandable way of communication most of that.

Renders (pictures) are widely used format. Renders are output of widely use 3D graphic programs. Renders are widely used from 90 s in many different segments.

**Advantages:** possibilities to display exact data**,** photorealistic visuals **,** easy to use**,** wide software offer

**Disadvantages:** Static presentation

### 2.2 Animation

Animation offers significantly better possibilities to display processes, wider areas as well as provide better description than renders. Technically animation consist of significant number of renders (average 25 – 30 per second) that create effect of continuous movie.

**Advantages:** possibilities to display exact data**,** photorealistic visuals, wider display, possibilities**,** better effect**,** better idea of presented topic compared to static visuals

**Disadvantages:** more difficult tool to manage, need to combine with other software

## 2.3 Project: The hypostyle hall of King Raneferef in Abusir (Egypt) visualization

Partners: Charles University in Prague (Jaromír Krejcí ), Enviom Pro

### Background:

Abusir is located ca 20 km to the southwest from nowadays Cairo. It is the place where a royal pyramid necropolis developed during the Fifth Dynasty (which is a part of the Old Kingdom). Beside the royal mortuary monuments, there are also non-royal necropolies dated also to the Old Kingdom and a group of large shaft tombs dated to the Saite-Persian Period. Three of the royal pyramid complexes,those of Sahure, Neferirkare and Niuserre – were excavated by German archaeologist Ludwig Borchardt at the turn of the 19th and 20th centuries. After his work, the site was thought to be fully explored and therefore remained on the periphery of interest for the Egyptological community. But the excavations of the archaeological mission of the Charles University in Prague, which started in the area of the mastaba of Ptahshepses in 1960, and especially those carried out in the new archaeological concession in the southern part of the necropolis in 1976, changed this view. These excavations underlined once again the importance of this locality for our better knowledge and understanding of ancient Egyptian architecture.

The mortuary complex of King Raneferef can be certainly enumerated among the mos timportant excavations made by the Czech Institute of Egyptology. These works were done between years 1982 and 2000. Ranefer`s pyramid complex was not, due to the premature death of the young king (he died in the age of ca 20 years after 1,5-3 years of reign), finished following the original plan. The supposed pyramid was never finished and changed into a huge square mastaba and in front of it, along its eastern side, a simple stone small mortuarytemple was erected. After some time, however, this small temple was enlarged in several building stages into a large mortuary temple. During these changes mud bricks were used and the temple was not thus attacked by stone robbers in such a large scale as it was the case of the stone temples.

It was one of the main reasons why the masonry of this temple is preserved so well. Moreover, because of the nonstandard situation concerning the construction of the temple, its ground plan shows nonstandard features. One of the most interesting and intriguing finds is represented by the hypostyle hall. It is one of the oldest examples of a hypostyle in the frames of the ancient Egyptian architecture (in concern with the religious architecture, there is an example dated to the Protodynastic Period; from the profane context, we know an example from Giza dated to the Fourth Dynasty). The hypostyle hall of Raneferef is located in the southern part of the mortuary temple. The hypostyle hall was a fairly large, oblong and east-west oriented room – its dimensions were 14.78 × 10.52 m. This hall was not the only room in this part of the temple. Beside the rooms to the west and to the north of the hall, there were other (store?) rooms south of it. These rooms were connected with the hypostyle hall by means of doorways. The most important element certainly were twenty columns, set in four rows, oriented in an east-west direction. The intercolumnium varies: in the north-south direction, it was 2.10 m, in the east- west direction, it was 2.44 m. The columns stood on limestone oval bases – only eight of them were found in situ and pits in the floor of the hypostyle remained of others. The imprints of the columns on the limestone bases visible during excavation were of practical importance when reconstructing the type of columns. In one case, this imprint was reflected by the high layers of the floor's filling and lining: we are therefore able to assume that the columns were lotiform and six-stemmed and that their diameter was 0.40 m and their height can be reconstructed for 2.76 m.

The hall's ceiling was possibly supported by wooden, stuccoed and painted beams. We can assume that the beams ran in an east-west direction. This supposition is based on the fact that the intercolumnium in this direction is longer, and therefore more suitable for massive wooden beams. Wooden planks were probably laid on the beams in a north-south direction.

The hypostyle was possible used for the display of the king's sculptures which were found during the archaeological excavation. This collection, together with find of fragments of the temple's papyrus archive, one of the most important find made by the Czech archaeological mission in Abusir. We can also assume that the hall was a copy of the throne hall in the king's real royal palace in the capital of Egypt - Memphis.


**Figure 6:** Visualisation of the hypostyle hall of King Raneferef in Abusir (Egypt)

**2.4 Reconstruction:**

Reconstruction might be used for artifacts, structures, houses, urban areas, events of all kinds etc.

We see reconstruction as advanced visualization. Main difference is that we are not only testing to translate all given inputs into 3D visual but we are using those newly reconstructed reality to verify all idioms. Not only that while changing one or more axioms on digital 3D models it might bring additional learning's.

**2.5 Project: Early iron age house in East Bohemia reconstruction**

Partners: CVUT, East Bohemia Museum, Jiráň, L. and team 2008, Enviom Pro

**Background: Excavation research report, Kašpárek, F. , Vokolek, V. , Jílek, j., Jiráň, L., and team. 2008, Pavelka, K.**

"A development-led excavation was undertaken when building an overpass at the road R 35 from Sedlice to Opatovice This text was funded by the Czech Science Foundation grant GA CR GD404/09/H020, Moravian-Silesian School of Archaeological Doctoral Studies (fig. 1). The construction site stretched over the plots No. 2489, 2494, 2495, 2477, 2493, 2613, 2612, 2611,

2496, 2608, 2497, 2498, 2499, 2607, which lay less than 500 m to the southeast from the edge of the municipality Opatovice nad Labem (District of Pardubice) (fig. 2). The excavations were conducted from 13 April to 18 June 2011; in total 61 features were examined containing ceramic inventory of the Lusatian and Platenice-Silesian cultures, and from the Middle Ages.

In the first sector on the right bank of the already abandoned western arm of the river Elbe the eastern half of a Late Bronze Age homestead was examined (fig. 4). The documented deserted river was situated only 55 m to the SE (fig. 3:B). We can try to reconstruct the examined homestead. It was enclosed by an arch-shaped fence marked out by postholes No. 10, 11, 12, 23, 25, 29, 30, 34, 35, 36, 37, 48, 49, 50, 51 and interrupted by an entrance turned inside in the NE (postholes No. 12, 14, 27, 28, 33) (fig. 4:C). In the eastern section a post-and-beam structure was identified, maybe a house making use of the enclosure, sized about 13 x 6.5 m (postholes No. 13, 15, 17, 18, 19, 20, 21, 44, 46, 47) (fig. 4:A). Inside the enclosure there was another row of postholes (Nos. 40-45), which maybe indicate some other utilitarian feature. Several posts were distinctly charred (postholes No. 49, 32), so that we can assume that the settlement complex was probably destroyed by fire. Inside the enclosure another postholes No. 4, 6-9 were detected and four of them, if not part of the medieval feature 56, may have marked out the base of a granary (fig. 4:B). According to ceramic fragments found in the postholes we can assign this homestead to stage I of the Platenice-Silesian culture (HB1-2), after V. Vokolek (Jirán a kol. 2008, 157).

Based on under mentioned information's we started to develop basic map. Always developing such project it means quite lot of questions connected with vegetation. E.G. in one of previous projects we used random vegetation (Birch). When communicated with Museum we learn that this particular species start to spread in Central Europe hundreds years after."

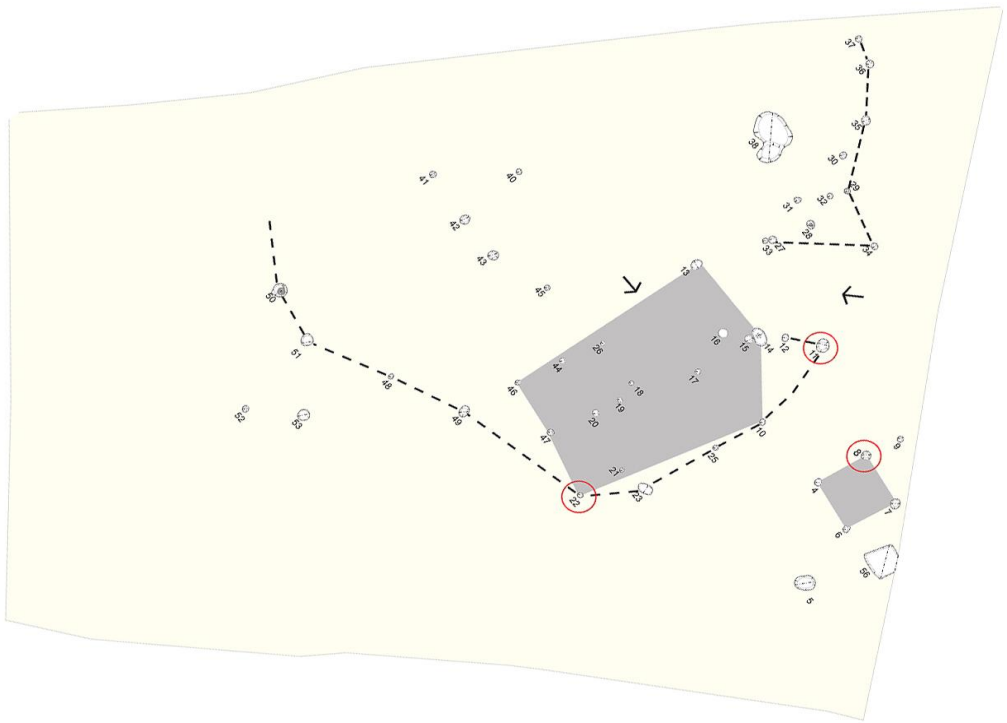

**Figure 7:** Early Iron Age house in East Bohemia – Excavation site


**Figure 8:** Visual reconstruction of early iron age house in East Bohemia


**Figure 9:** Visual reconstruction of early iron age house in East Bohemia

**2.6 Digitization:**

We see dramatic development on hardware side within 3D data excavation in last 15 years. Logically there is bigger expectation also on graphic and user side.

Very frequently are outputs from digitization processes provided to third parties – Museums, Educational partners, Public etc. Therefore there is wider expectation on graphic expression.

**We expect:** Exactness, Photorealistic quality, User friendly applications, Possibility to be connected to other information's (educational, informing etc.)

**Exactness:**

There is number of different possibilities how data are extracted. 3D laser scanners, photogrammetry etc. but finally within visualization we want to translate those data into 3D models with defined exactness. 3D models are basic tool for most of visualization techniques.

**Photorealistic quality:** As much we want to display results to public as much as photorealistic quality maters.

**User friendly applications:** While creating content is also important think about future usage. Not only output data minimization and graphic quality but also how these data will be used is playing major role.

**Possibility to be connected to other information (educational, informing etc):** Frequently is digitization used in Museum application. Therefore possibilities to connect with other information's is important and helping utilize data's in efficient way.

**Project: Pilot 3D digitization project wiz Moravian Museum Brno**

Partners: CVUT, Moravian Museum Brno

**Background:**

Moravian Museum Brno is crosschecking possibility to provide sensitive artifact also with informational part to wider audience. As very attractive possibility was chosen 3D laser scanning and real-time visualization.

Different object was chosen for pilot project. Glass made, Fabric made, Mineral .
Data acquisition had been done with Prof. Pavelka team (CVUT Prague). Data had been applied to Dreamwalk technology with same level of detail. Due to purpose of application real time mode was chosen. Due to wide spectrum of audience as well as potential application we developed "touch screen" control mode.

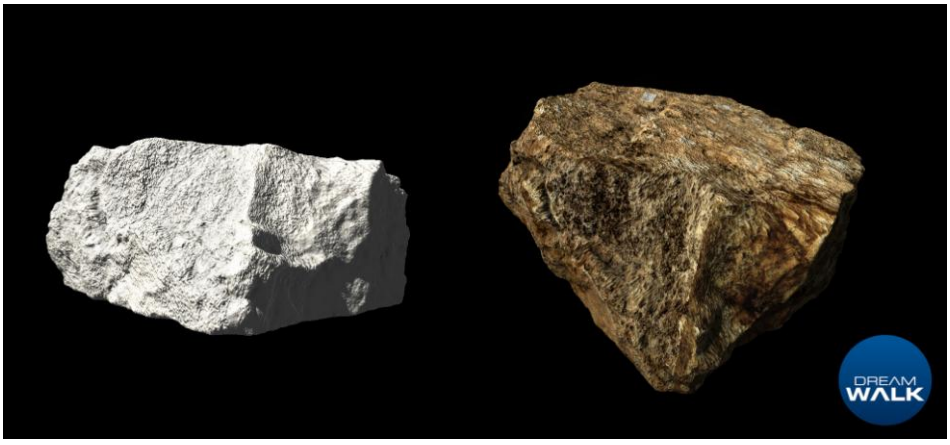


**Figure 10:** Visualisation of digitalised mineral

### 2.7 Emotions

When is decided, requested or required to present data's to wider audience as important is to present results in best possible way.
Dynamic scene, Dynamic scene we could achieve while using different dynamic aspects, Day period, Weather, Vegetation, Also using sound and music effect will bring the result.


**Figure 11:** Visualisation of baroque castle, Ostrov nad Ohří, Czech Republic

## 3. TOMORROW

### 3.1 Simulations

We are using today 3D digital models mainly for visual purposes. Nevertheless is that those digital models are carrying much more information or could be used for wider applications. Even today we could connect these data with other functions.

#### 3.1.1 Natural disasters

**Floods**

While using Neolithic household reconstruction example, we could provide floods simulation. This small example could help us to understand other habits and connections that might be influenced with this pretty frequent situation in Elbe river.

**Earthquakes**

We will be reconstructing wider urban areas in geological active areas. We might be even today simulating earthquake and results out of earthquakes.

**Volcanic eruptions**

Simulating whole process of volcanic processes and its effect on urbanized areas could be also simulated.

**Light and acoustic simulation**

We might be interested to simulate light conditions in interiors or exteriors. After light source definition this could be also provided.
Much more sophisticated will be acoustic simulations – but this request could be handled as well.

### 3.2 Real time

Real-time computer graphics is the subfield of computer graphics focused on producing and analyzing images in real time. The term is most often used in reference to interactive 3D computer graphics, typically using a GPU. The term can also refer to anything from rendering an application's GUI to real-time image processing and image analysis.
We see main advantage in using real time in all fields of application when output of specialists are presented in educational purposes for wider audience.

### 3.3 Stereoscopy

Stereoscopy (also called stereoscopic or 3-D imaging) refers to a technique for creating or enhancing the illusion of depth in an image by presenting two offset images separately to the left and right eye of the viewer. Both of these 2-D offset images are then combined in the brain to give the perception of 3D depth. Stereoscopy is next step in presentation of visual data where 3D gives more complex impression of presented object.

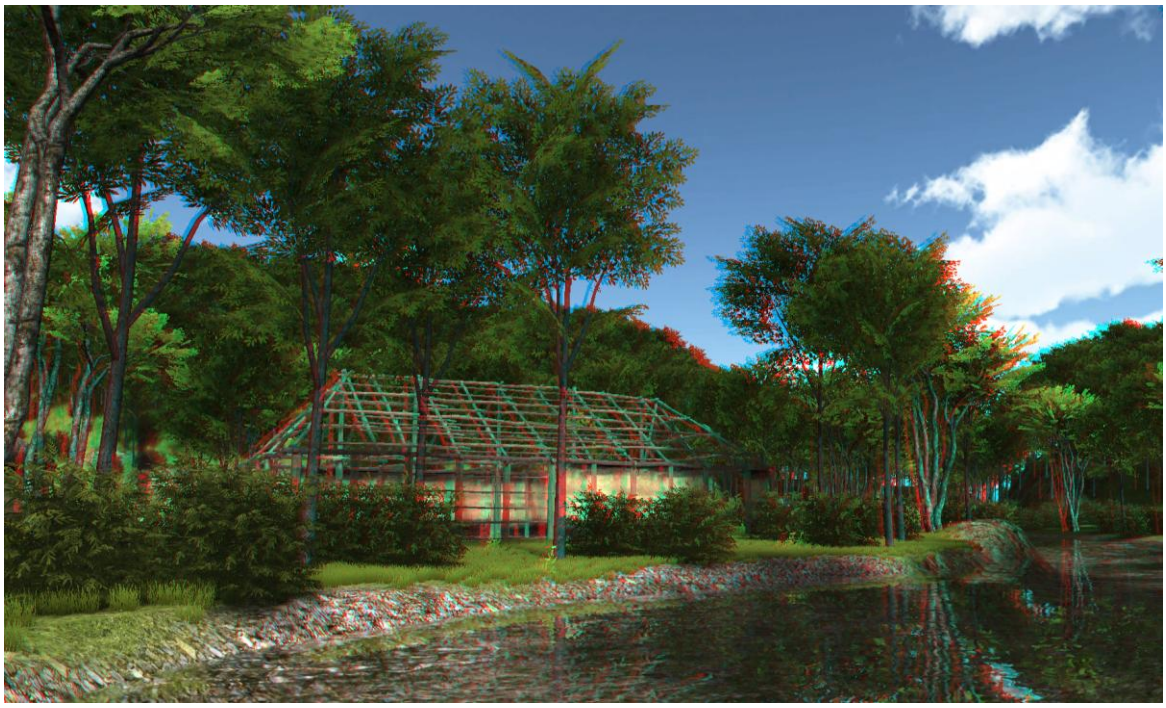

**Figure 12:** Anaglyph stereoscopy, Eneolithic village

## 4. REFERENCES


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