GEOMETRICAL ASPECTS OF DIGITAL PHOTOMONTAGE

Krzysztof T. Tytkowski

Silesian University of Technology
Geometry and Engineering Graphics Centre
ul. Krzywoustego 7, 44-100 Gliwice, Poland
email: Krzysztof.Tytkowski@polsl.pl

Abstract. This paper presents errors that occur in blending digital visualization with digital photos. Many examples demonstrate the ignorance of geometric relations present in perspective mapping. In some cases, it seems that there are not errors but purposeful activities aiming at such presentation of the proposed object that the project will be approved for implementation.

Keywords: digital picture, perspective, shade, reflections

1 Introduction

The principles of constructing perspective images have been known for a long time. Initial the painters imitated what they saw without knowing the exact rules of creating an image that closely resembled what a human eye perceived. The artists were able to correctly draw perspectives as their drawings were based on direct observations of a real life and assisted with various drawing instruments. Through the use of such devices, even without knowing the rules of geometry, one could draw correctly in terms of geometric perspective construction. The development of geometry has brought into life the scientific basis of perspective construction. In the nineteenth and twentieth century, when photography started to be more and more popular and ubiquitos perceiving the surrounding world in a form of are corded photographic image made the theory of perspective projection more understandable and clear to many more people.

Since the nineteenth century descriptive geometry courses have been taught at high schools and universities. Let us mention that already Silberstein [12] and Łazarski [8] included in their textbooks the chapters on creation the shades shadows, the planar representations of various solids including the solids of revolution, but also the problems containing the construction of solid’s shadows.. What is more Łazarski [9] and Wróblewski [15] added into their textbooks the lectures on the theory of central projection.

Not only in Polish literature can we find information on teaching geometry at secondary school level, as opposed to university level. Graf in [6] proves that in the 30s of the twentieth century the scope of the material was beyond the currently known syllabuses in the field of geometry (including the issues of projection with elevations, axonometric projection, theory of advanced surfaces and solids and central projection). The solid theoretical background gave the basis for perspective construction of a designed structure and served well visualization purpose to aid the future user can see the final product of a designed structure represented as real life object.

During the Second World War the analysis of aerial photographs allowed obtaining a number of highly valuable information such as the sizes of military objects which were the targets of war. Such detailed analysis was carried out based on the knowledge of geometric science.

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Many historic buildings were destroyed in Poland during the wars. Their reconstruction meant the necessity to create a technical documentation of these structures. The basis used to prepare reliable design documentation were the paintings and pre-war photos. By knowing the rules and principles of construction of a central projection it was possible to reconstruct not existing buildings and structures [4].

After the second world war, the science of geometry and the principles how to draw a perspective image were taught at high schools. For example, as evidenced by the content of [5] and [11] the principles of perspective construction were introduced.

Currently, a person who wants to learn the rules can choose among the university textbooks [1,2,7,13] or books on graphics programs, where the authors explain only some issues which they think to be important in creating rendered images [10]. Obviously, the part of the publications which you can find on the Internet is limited only to present basic analytical equations that describe the transformation between 3-D to 2-D coordinates to create a perspective image. A few years ago, the errors were of slightly different character, as evidenced by the Author [14]. Also noteworthy are the following publications Brzosko [4].

2 Visualisations

Completion of a raster image made with the use of any typical CAD software that can be used to produce visualization a rendered image of a design project requires usage of the following elements: a digital images of the environment, people, green areas, cars, etc. To create a correct render the rules of perspective must be applied. Ignorance of these rules lead to many typical mistakes. In the following we will give numerous examples of such mistakes.

2.1 Incorrect proportions and sizes of various elements

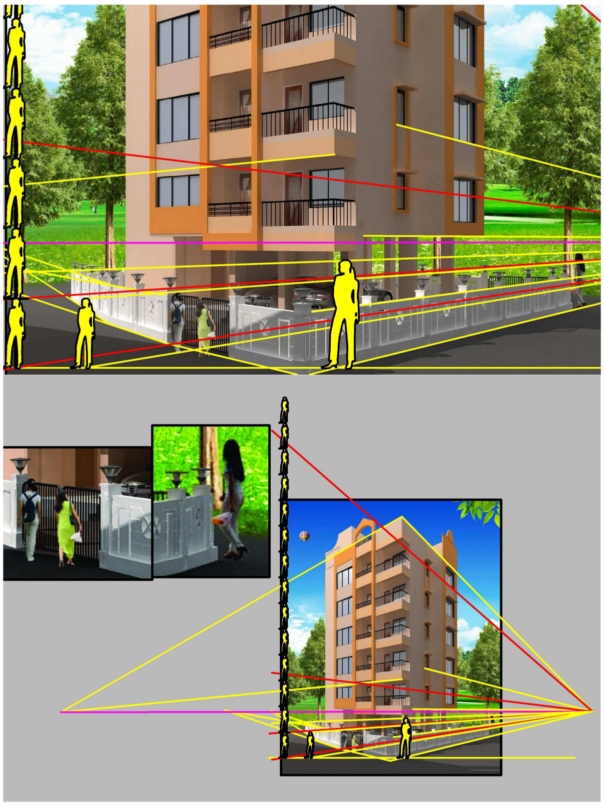

Figure 1

Figure 2

The size of elements that are added to an existing image (visualisation or digital images) must correspond to the elements occurring in the image. In the case (Figure 1) the proportions of the people inserted on the right and left are clearly distorted. Construction lines and a sample silhouette allow us to evaluate people proportions in the original. The error seems to be awkward as the people who are standing close to the wall surrounding a building are evidently too tall which is easy to see how big the difference in their height is. Two persons standing on the left-hand side of the picture (Figure 2) are somewhat shorter than the wall surrounding a building while a woman standing near the same wall but on the right-hand side of a picture has the wall extending only up to her waist. Is it not the same wall? Are the people taken from various fairytales?

Let us continue the discussion and now focus on a tree which grows next to a building. From the appearance and the proportions existing between the two trees we can conclude that the tree in the right-hand side of Figure 2 is a few or a dozen years old. However, from the fact that the branches are located at a height of only about 3.5 times the height of an adult person which makes us think that its height is about 5.6 m . The height of the tree is 12.5 times the height of an adult, which should be 20 m. What is the relation between the trees height and the human's stature? The height of a person positioned in the right-hand side of a picture does not interfere with the adjacent tree.

The distorted proportions can also be seen in Figure 2. In this case, a person who is positioned in the foreground on the right-hand side, has his eyes at the height of the horizon line (purple line).

However, the height of a man going along the pavement on the left-hand side is too short, as can be evidenced by the line drawn through the top of the head. As the person is moving on the sidewalk and as it can be assumed that both parties are moving along two parallel paths, two lines drawn through the tops of their heads have the same vanishing point. Construction red line allows specification of the proportions between the two people. Another lines, which had been inserted in yellow colour, indicate that the area is flat (curbs and skyline). Similarly, the heights of vehicles seem also to be too small in proportion if compared to the person on the right-hand side of the picture.

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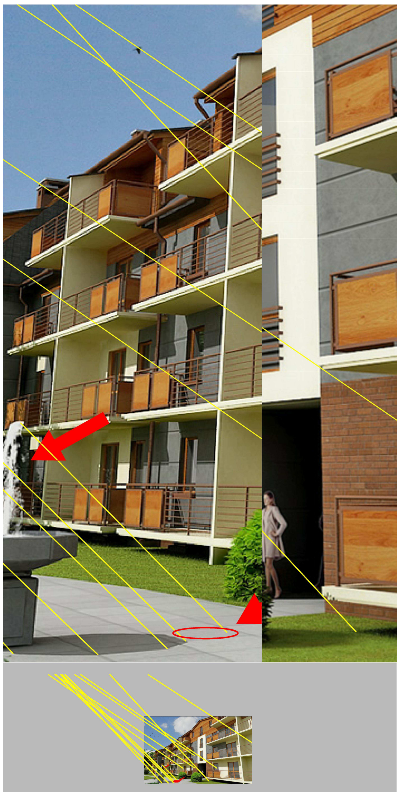
2.2 Lighting, cast shadows and one's own shadow



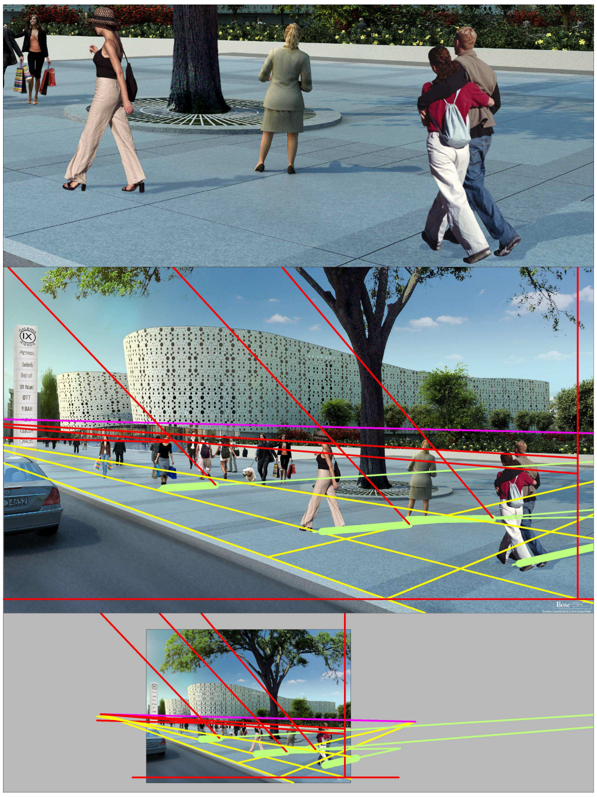


Figure 3 Figure 4

Shadows and shades must interact with the environment, especially if there are more elements that cast shadows. These shadows must be in line with the direction of light. The distance, at which the shade is cast from a subject is of great importance. In the case of shadows cast from direct sunlight, the light can be treated as a parallel source of light. On the other hand, the size of the solar disk causes the fact that the shadows tend to be slightly blurred as the distance from the object gets larger.

As shown in Figure 3, the shadow cast by the railing has very sharp edges, while the shadows cast by the persons in the picture have highly blurred edges. Blur the shadow line occurs in the case of solar lighting in a very large distances (several meters) due to the emission of light from each point of the Sun (sphere). The yellow lines indicate the directions and the spots where the shadows should be cast on the pavement. The rendered image presents inconsistency between the direction of the shadow cast by the railing and the shadow cast by the people.

The people’s own shades look also interestingly. The whole group is lit up by the sun positioned on the right-hand side of a picture, while the backs of the person standing at the left-hand-side has a lighter colour of his suit on the back. The person located on the right-hand side seems to be strongly illuminated from all the directions. The shade suggests that the person were positioned facing towards the light which can not be true if we know the position of the sun.

Similar errors occur in Figure 4. The horizon line has been indicated with a purple colour, shadow direction has been indicated with green, the bold lines indicate the shadows of selected people. As you can see, the direction of the cast shadow for each person is different while maintaining the direction of the light rays (red lines). In this case it is very easy to determine the horizon line as we can use the perspective image of a rectangular grid made of the pavement tiles which are represented here on the ground level. It let's us determine with high accuracy two intersection –points of perspective lines which are parallel in a real Actually, there are many parallel lines contained in the picture. Finally we can recognize the four persons who are standing close to the observer who are lit up from different directions. The close-up of the three people are shown in the top right-hand corner of Figure 4.

The first person on the left-hand side has been lit with the intense and 'bright' light with almost a horizontal direction if we compare the cast shadows and their directions with the perspective image orientation as it has been captured from a specified observation point. The other person (in the center) has been similarly illuminated - shown with yellow line - but evidently the light has a lower intensity if compared to the earlier described person. It seems that the light is scattered a if the picture was taken on a cloudy day. Two people on the right-hand side of the Figure 4 have been lit with a strong and 'bright' light which contradicts the shadows cast onto the ground.

2.3 Interaction of elements

Figure 5

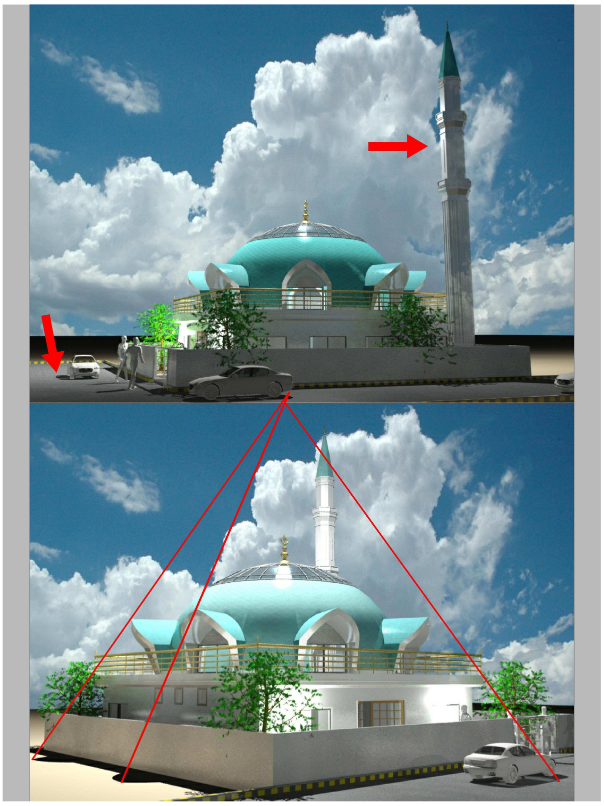


Figure 6

All elements appearing in the visualization should be tuned with each other. Let us now comment on Figure 5 which shows the perspective image of a fountain. All the directions of the light rays have been indicated with yellow colour. It is visible that the vanishing point for the rays on the fountain is different than that of the rays associated with the building. The vanishing point for the rays of the bushes is neither of those two. However, the shadow of the building balcony on the right–hand-side of the picture is clearly different.

Partially, the errors may result from the fact that the points defining this particular direction of light lie close to each other and therefore, the error might be even larger though probably not as large as the observed here. What's more, we can see the shadow cast on the pavement is only a partial image of the fountain as we do not have a shadow of a statue fixed at the top of a fountain. Also water is transparent to light and we do not have the shadow of it - the place where the shadow should be cast is empty .

For any rendered image we need to define the characteristics of the rendered environment. The sunlight has different from the spotlight characteristics. Figure 6 represents the scene of a rendered mosque. The clouds shown in the background of Figure 6 suggest that the Mosque has been illuminated with very strong sunlight. Brightly illuminated dome (the surface of revolution) indicates that the light source has been specified above the dome. However, the shadows rays (yellow) cast by the elements of the home and the car (the car's side-view mirror and its shade allow, despite a small distance, to determine precisely the direction of the light) indicate that the spotlight was placed at the intersection of the light rays. In the right-hand top picture the lighting of the tower (minaret), changes along its altitude, while its top should also be well-lit with a sunlight. Both visualizations presented in Figure 6 have the same background in the form of a raster image including the clouds, despite the fact that the images have been rendered by taking two various positions of the observer in reference to the object. Artificial lights illuminating the building are even more interesting, their intensity in comparison to the sunlight is very high, almost as big as the lighting of the dome. It is obvious that the author did not correctly set up the lighting parameters but focused his attention on the aesthetic aspect of visualization.

2.4 Mirrored reflections

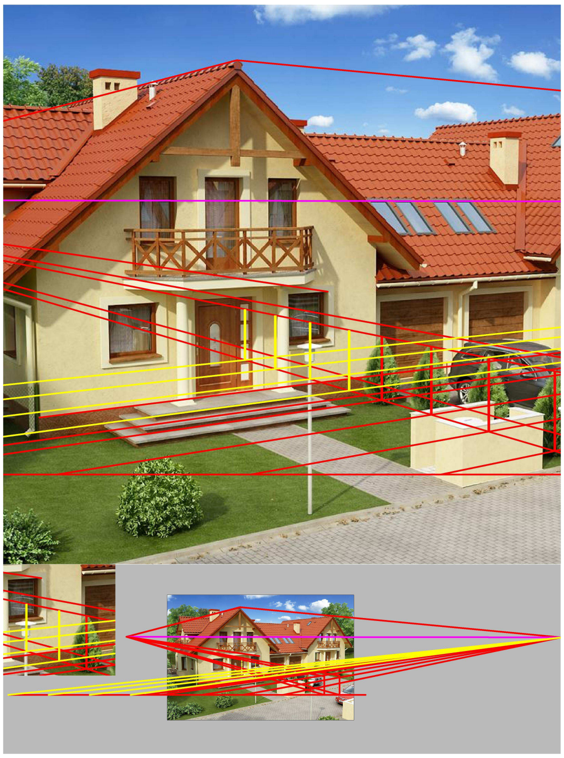


Figure 7

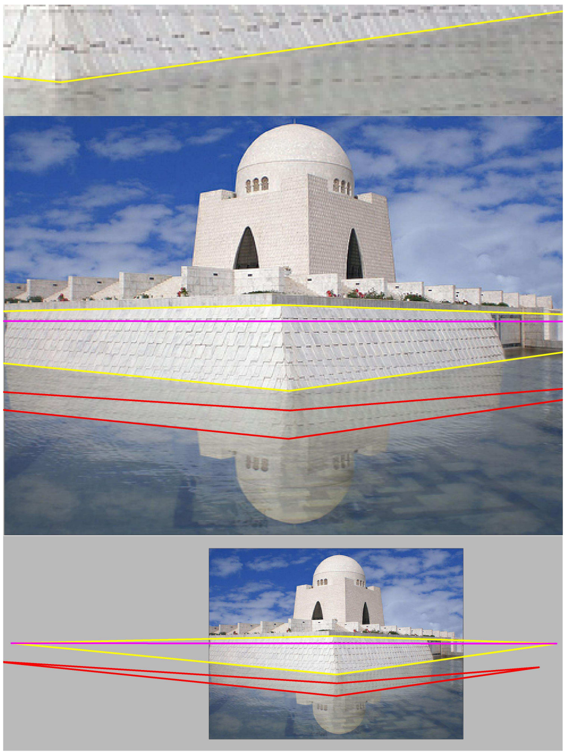


Figure 8

Mirror images, if they are not automatically generated by any visualization program, often bring problems in graphical processing. Some renderings may seem to be executed correctly but at the closer examination we are noticing significant mistakes. Let us take an example of a mirroring image of a car in Figure 7. The car is reflected in a window pane in the ground floor. The construction lines, marked red, show the location of shrubs and the car window surface which is located in the driveway to the garage.

At the bottom of Figure 7 we can see the entire system of vertical lines that indicate the axes of shrubs' reflection in the window surface (yellow lines). It might be expected that at least one of the shrubs will be reflected in the glass. There is a whole lane of them and they occur to be positioned in a plane perpendicular to the plane of the glass, closer than the plane of the side of the car, which has been included in the mirrored image. The exact construction justifies the correctness of this assumption.

The parameters such as the raytracing and reflection types of used to produce an image in any computer program need to be correctly set up so that they may be well adapted. Figure 8 shows the results of the efforts made to construct a mirror reflection of a mosque in the water. Yellow lines indicate two vanishing points (waterfront). In this way the horizon line (the purple line) together with two vanishing point have been determined. The same a elements, i.e. the horizon and two vanishing points have been determined for a mirror image. Evidenly, there exists inconsistency between the reflected image and the real life structure .

2.5 Conscious choice on an observation point

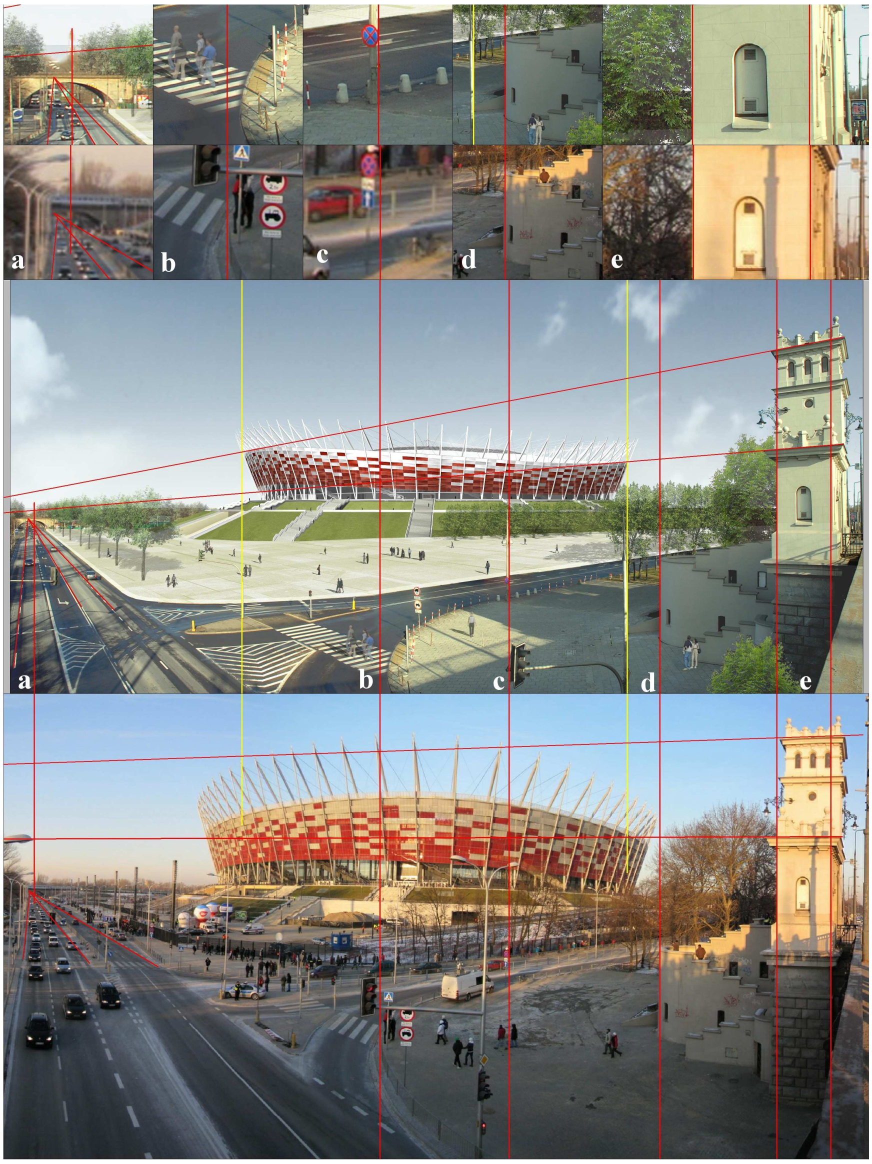


Figure 9

Major architectural structures due to their large scales, the high costs of execution and their significant visual impact on the environment undergo visualization processes. It gives an opportunity to assess the impact of a newly designed structure or facility on the existing environment and helps perception of its sizes and proportions. Sports stadiums belong to that category of objects. At the bottom of Figure 9 there is a photo of the finished structure. A little higher up we can see a rendered image of the stadium. At the top of Figure 8 we can see five pairs of images (a, b, c, d, e) which have been cut out of two lower images and which present exactly the same details as they were taken from the two lower pictures. The red vertical lines have been inserted into all the pictures to make possible that each pair of the pictures is aligned.

The direction, or rather the station point from which the picture has been taken is similar as the position of the vanishing point for the street on the left for both views. The lines labelled with a, b, d, e are passing through the same details in both pairs of images, and the photos look fairly similar. If regards line c, the red line is passing throught the post of the street light in one picture while it is positioned at quite large distance from it. One can argue that the traffic regulations demanded to place a road sign closer to the road junction, which is a good excuse to justify existing differences.

Let us discuss now the small tower on the right-hand side. If we draw two red lines which represent horizontal cornices of the tower, we can see that they intersect on the left-hand side, behind the border of the picture. It seems that the picture of a tower has been combined from two independent shots taken from various station points. The difference between the two pictures may be caused by the shift of the optical axis of the two images.

Two yellow vertical lines mark the width of the object. As it can be seen, in relation to reality, the stadium presented in a rendered image is of smaller size. Different proportions of height to width are very clearly seen. In this case, it is difficult to speak of a mistake, because the visualization shows the object much more favourably than the actual photo of the stadium. This visualization was one of many presented before the construction works started.

3 Conclusions

Some inconsistencies occurring while preparing digital photomontage images can be noticed even by those not familiar with geometric principles, but some mistakes can only be recognized by those who have appropriate geometrical knowledge and who have enough information about the object itself and its location. The reasons for such errors can be classified according to the knowledge of the rules of geometry and can be of the following character:

- unintentional mistakes due to the ignorance of the rules, or paying too little care, which can result from too little time devoted to the work done,
- purposeful, where the representation of the object is such as to be accepted by the investor. Presented image can not be verified in context of the real objects existing in the neighbourhood as the picture has been constructed from a higher elevation if compared to the typical human’s eye height or if the rendered picture doeas not have proper relations with the presented documentation regarding the sizes, its location, etc.

Classification by the type of error:

- Inconsistency in the scale of objects,
- Inconsistency of the taken image combined with the image obtained from the visualization process,
- Improper interaction between objects, e.g. reflections, shadows, shades

- Incorrectly set up the types of lights and positions of lamps (e.g. different lights applied in various parts of the image),
- The lack of correlations between the direction of light and the cast of shadows,
- Improper distribution of shades, depending on the distance,
- Mirror images do not correspond to the existed objects in the image.

3.1 Reasons for the present 'state of art'

Nowadays, even though the students of architecture (specialties of architecture and urban planning or interior design) get acquainted with the issues of perspective projection in a very symbolic way. Due to the limitation of the numbers of teaching hours the topic of perspective construction have been limited to the short entries. Besides this, the students enter the universities to study technical contents with neither the knowledge of Euclidean geometry nor with the knowledge of basic properties of various projection methods. Let us mention here that only about 20 years ago the number of hours dedicated to descriptive geometry was twice as much as it is today while the scope of the geometry syllabus covered all the issues including the construction of perspective images and such problems as the mirror reflections, the shades and shadows, etc.) [3]. It is sad to say that the high schools today do not teach the subjects that can provide a proper level of knowledge in geometry.

In various colleges, there also do not exist such subjects which are addressed to the future designers studying at the computer graphic specialties . The term of a "graphic designer" is associated with a person elaborating graphically the games, with the use of a parametric design procedures rather than being a designer dealing with the creation of raster graphics.

3.2 Consequences

It is common that young architects deal with processing of raster graphics. The huge burden of design work which must be done on a project forces the architects to outsource renderings to external offices which do not have enough qualifications .

Rendered visualization of a structure is usually prepared before the final decision on the investment is being made. It must serve as an argument and a support during the business talks to convince the investor that a specific project should be financed. The investors are usually not able to spot any discrepancies existing between a design project and a rendered image. They only get a general impression on the architectural idea and the future shape of the designed structure. Thus, it is possible to present any design project in a way that it is acceptable.

The specialists who work in computer graphics choose the station point of a camera or the center of projection in such a way that the least interesting or the most overwhelming views or elements of a structure is omitted. The recipient is not able to verify the rendered images because he/she is not able to climb up to the height of several feet above the ground and to take a look from such height on a real object. Similar effects can be obtained if we reduced a number of building elements. This may be possible by making visualization of an object from a different view-point than the actual image of the captured elements.

3.3 Remedies

In many countries visualization accuracy and fidelity plays a crucial role when a design project is the subject of evaluation within the initial stage of the investment process. The final decision made by the investor depends not only on the proposed solutions presented in a form of rendered images but also the layouts are evaluated in contextual form by answering the question how the structure fits to a surrounding environment To give an example we can take a “Dresden” example, where the conservation officer of Dresden required a visual presentation of historic backyards which survived through the World War II. In the 90s of the last century, after having received the rendered images of the old city, the decision was made to restore further elements of the old city structure. Visualization of Dresden was performed with great devotion. The issues such as orientation and the sizes of clinker bricks were taken into account. The sandstone reliefs were inserted in a form of a digital photomontage. Within the approving procedure, the images were compared with effects derived from a combination of visualization model of digital images. Today Dresden makes impression if you think in terms of conservatory and restoration works which have been done there.

Another example can be taken from the UK. It is strongly required that the architect places his/her signature underneath each of such a work while the investor verifies the rendered images delivered for visualization with the final product of reconstruction works.

It seems that some forms of accountability should be introduced to make the work done by the constructors and the architects with the full responsibility both in terms of the used materials and execution of construction works.

Another aspect of a problem is that the designers should be equipped with a good background knowledge in descriptive geometry if the rendering engines were to be used effectively. Realism of the visualization images is based on the knowledge of geometry which should be popularised not only among engineers but also among the engineers who enhance the knowledge with their practice and experience. It is important to provide more chances to present visual images for verification. It would be useful to introduce the courses in visualization techniques into each of a curriculum at technical studies.

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ASPEKTY GEOMETRYCZNE FOTOMONTAŻU

Streszczenie. W pracy przedstawiono błędy występujące w wykonywanych łączeniach wizualizacji otrzymanej z programu komputerowego ze zdjęciami cyfrowymi. Wiele przykładów świadczy o nieznajomości związków geometrycznych występujących w odwzorowaniu perspektywicznym. W niektórych przypadkach wydaje się, że nie są to błędy a celowe działania mające na celu takie przedstawienie projektowanego obiektu, by projekt był zaakceptowany do realizacji.