Why and How to Search for Best Views

Ako a prečo hľadať najlepšie pohľady

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Abstrakt

Výber najlepších pohľadov sa v poslednej dobe stáva kľúčovým prvkom vo viacerých oblastiach počítačovej grafiky. V tomto článku analyzujeme výhody najlepších pohľadov vo virtuálnych múzeách, načrtneme niekoľko metód na ich hľadanie a diskutujeme aj možnosti rozšírenia využitia najlepších pohľadov.

Kľúčové slová:

najlepší pohľad, najhorší pohľad, klasifikácia, kvalita pohľadu, percepcia, tvarová (gestalt) psychológia, virtuálne prostredie, virtuálne múzeum, virtuálna riadená prechádzka

Abstract

Selection of good views is rapidly becoming a key issue in multiple computer graphics applications. In this paper we discuss the importance of finding the best views in virtual environment. We present several selected approaches for finding the best view and some possibilities of enhancement of the best view.

Keywords:

best view, worst view, classification, view quality, visual perception, Gestalt psychology, virtual environment, virtual museum, virtual guided tour

CR Categories: I.3.7 [Computer Graphics] Three-Dimensional: Graphics and Realism -Virtual reality; I.2.10 [Computing Methodologies] Vision and Scene:Understanding – Perceptual reasoning.

1. INTRODUCTION

"Virtual Museum is a multimedial collection of telematic available digital data and cognitive space with infinite capacity to enlarging, combination, composition and recomposition [1]." As long as we would like to make the exploration in virtual museum the most interesting we should show the museum showpieces from the best view.

What is "the best view" on a virtual object? Although the phrase "best view" is very common, it is very hard to define. We can define best view as the one that minimizes visible redundant information such as symmetry or we can maximize the visibility of interesting contents using metrics (saliency, shape distinction or viewpoint entropy) [2]. The result we get is that the term "best view" is far from having a unique definition.

Is it then possible to optimize creation of virtual museum fly-over trough best views? Generally, if we know how to count up best view for each object in the scene, could we navigate visitor of the virtual museum so that he explores the most interesting objects of museum? Because for every visitor means best view something else, we can only approximate view on showpieces in virtual museum and consider that this view will satisfy most of visitors.

2. Methods for searching for the best view

Finding the best view on virtual object became serious problem not only in computer graphics. There exist many methods for trying to find the view, which could be considered for the most similar to the observer's selection. The same holds for classification of these methods. We can split them into low level methods and high level methods, or we can choose another division: into geometrical or semantic methods. And as long as virtual museum is specific kind of virtual space (it is mostly an indoor environment with many showpieces, their textures and specific lighting) we have to carefully choose the method we use because we can obtain a great geometrical view with the biggest number of edges, but when the object is completely in the shadow from this viewpoint or it has a texture on other side of this view, it become a little bit senseless. For this short introduction we chose five of the most used methods.

Degenerated edges and faces

First publication in this area based on geometrical information is from 1988 by Kamada and Kawai [3]. They propose a method, which minimizes the number of degenerated object surfaces in orthogonal projection, i.e. surfaces which are projected as edges and edges which are projected as points (Fig 1). This method is not suitable for realistic scenes, because it does not account for visibility of individual scenes parts. Barral et al. [4] modified Kamada's coefficient in order to cope with perspective projections. Then they propose a heuristic with parameters that weight both the number of faces seen from each point and the projected area. Moreover they add an exploration parameter which accounts for the faces already visited. Plemenos and Benayada [5] brought in a method based on the number of visible surfaces and size of the projected area. Simple extension of this method based on position of light sources in the scene was presented in [6].

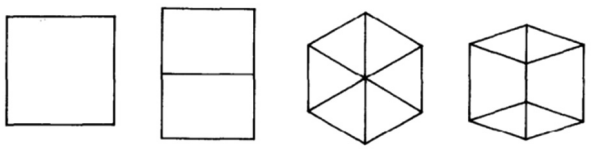

Figure 1: Four of the computed views on cube according to Kamada and Kawai

Viewpoint complexity

The term "complexity of a scene" is very intuitive [7]. Given two different scenes, people are able to say which scene is more complex than the other. The viewpoint complexity of a scene depends on the point of view. Viewpoint complexity of a scene from a given point of view is a quantity which depends on:

- The number of surfaces visible from the point of view.
- The area of visible part of each surface of the scene from the point of view.
- The orientation of each (partially) visible surface according to the point of view.
- The distance of each (partially) visible surface from the point of view.

Viewpoint entropy

Viewpoint entropy [8] is a low level method based on Shannon entropy. To define viewpoint entropy, the relative area of the projected faces over the sphere of directions centered in the viewpoint is used as probability distribution. Thus, the viewpoint entropy for scene S and viewpoint p is defined as

$$I(S,p) = -\sum_{i=0}^{N_f} \frac{A_i}{A_t} \log \frac{A_i}{A_t},$$

where N_f is the number of faces of the scene, A_i is the projected area of face i over the sphere, A_0 represents the projected area of background in open scenes, and At is the total area of the sphere. In a closed scene, or if the point does not see the background, the whole sphere is covered by the projected faces and consequently $A_0 = 0$. Hence, A_i=A_t represents the visibility of face i with respect to point p.

Silhouette length

A simple version of this descriptor measures the total length of all silhouette edges in the image plane. Since this cannot be done reliably in the image space, the visible silhouette edges are computed in object space analytically and the length of their projected versions is calculated [9].

Silhouette entropy

A more sophisticated descriptor uses silhouette entropy instead of total length. The entropy of a curve is defined as the entropy of its curvature distribution, as proposed by Page [9]. In the discrete version, the entropy of all turning angles between adjacent silhouette edges is computed. But in some cases, spurious silhouette edge crossings can make the result quite unstable.

Hence the number of existing methods for finding the best view is enormous we decided to take a brief look only on methods we study in our research. Extended list of methods can one find in [16] and [17].

3. Possibilities of enhancement

3.1 Animation

The automatic generation of in-betweens (intermediate frames) is one of the techniques used in computer animation. This technique is based on a set of key frames entered by the user. This principle is also used in computer assisted 3D animation (camera and object positions are defined only at key points) and the calculation of intermediate positions is left to the computer. When we use found sequence of views on given objects (sorted from the best to the worst one) as key frames for animation we can generate a tour around any object in virtual museum.

The objective characteristic of this approach is the lack of smoothness in the motion. Because of the sudden changes in the direction of animation can be the key frames pretty visible. But there can be also visible the discontinuities in the speed of camera motion (when we requests a different number of frames between key frames). A third common problem is the possibility deformation of the path when the movement has a rotational component. To avoid respect of these serious drawbacks of linear interpolation we assume that adequate solution for automatic path through the virtual environment is based on the Kochanek-Bartels splines [10].

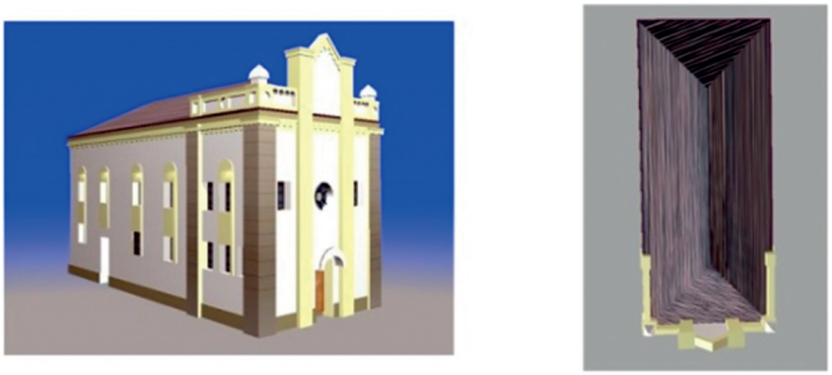

Figure 2: The best (a) and the worst view (b) computed for the church with Viewpoint entropy method

3.2 The worst view

As an ancillary commodity of finding the best view we get the worst view. Most of computer graphics users spill it or they use it just to compare the result of their recent best view finding method [11]. But what if we use these views to upgrade the visit in virtual environment? We can use them as a starting position instead of the best view to make visitors think of what they see. For finding worst views we can use any of methods mentioned above (for instance in Fig 2 we present the best and the worst view found using Viewpoint entropy method).

When we obtain the final values for the views we can line up the values uplink from the lowest to the highest one. On the top is now the worst view, which we can use as a starting for automatic path around objects. This path is made by joining views from the worst to the best by using adequate curves. We think that using worst views we can upkeep attention of visitors longer and so he may spend more time in virtual museum without feeling bored.

3.3 Classifications of objects

Is for every kind of museum showpiece adequate only one method for searching the best view? Or such as for everyone is the best view something else has every kind of objects his own special best view?

To find out, we prepared the questionnaire with dataset (25 renders of virtual objects x 13 views (Fig 3)) [12], which was available online to general public. In the questionnaire participated 145 people, aged from 11 to 56 years.

The dataset contained various types of 3D models, including colored and monochromatic, models with faces, symmetric models, models of real and fantastic objects. The respondents were supposed to select best view (according to their opinion) for each object from given 13 views of each object. Firstly, we gave the observer the view on the frontal side of object and as the last we gave them the view from the top of the object. Every object was considered separately to the others.

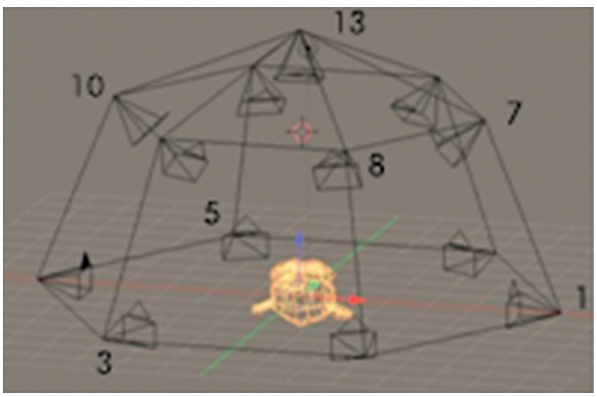

Figure 3: Camera layout in the process of computing views on object in the scene.

After evaluation of questionnaire we found out some interesting facts. If the model contained face, the people have tendency to choose the view, where the face is visible. As well as, in case of symmetric views they choose the first in row. We computed then results from three tested methods for finding best views (Fig 4): Visual attention method: Itti's approach, Geometrical method and Image based method.

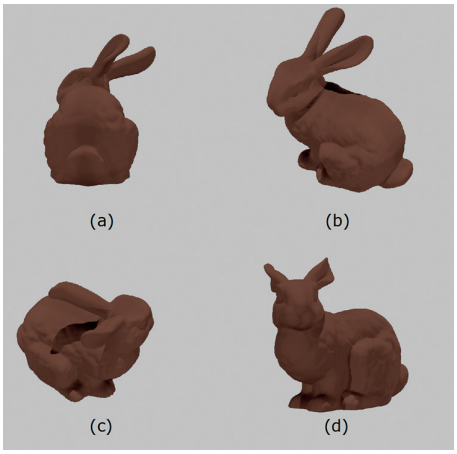

Figure 4: Examples of the selected best views for every method: (a) Geometry based method, (b) Visual attention based method, (c) Entropy based method, (d) Questionnaire.

Then we confronted these methods with the questionnaire results. Obtained results are shown in the Fig 5, where the sbest views are depicted for every method and next to it the percentage of votes from questionnaire is presented. For our surprise only in two cases all three methods selected the same or the symmetric view. The relevant objects were symmetric and colored. In 9 cases visual attention method and geometry based method performed the best and gave the same view. Visual attention based method performed better on objects with large amount of differences in color, intensity and edge orientations. The geometry based method gave the best results from all the methods on other 6 objects. The entropy based method gave good results mostly on colored objects.

	Best view		Best view		Best view		Best view	
	Visual Attention	Questionaire %	Geometry	Questionaire %	Entropy	Questionaire %	Questionaire	Questionaire %
happy buddha	1	14,08	1	14,08	7	14,08	2	45,07
Stanford dragon	2	36,88	10	0,71	2	36,88	8	53,19
hippo	8	30,99	12	15,49	2	19,01	8	30,99
gazebo	5	10,56	4	3,52	1	21,83	2	28,87
pillow	1	61,97	1	61,97	6	10,56	1	61,97
mouse	12	19,72	2	2,11	6	12,68	7	50,00
T-rex	6	47,89	6	47,89	1	3,52	6	47,89
armadillo	9	0,71	1	53,90	6	6,38	1	53,90
standford bunny	11	20,42	4	0,70	8	1,41	6	57,04
statue	3	2,13	7	38,13	11	0,72	7	38,13
bug	12	14,08	7	22,54	7	22,54	8	35,21
car	8	7,75	8	7,75	1	0,70	2	52,82

	Best view		Best view		Best view		Best view	
dragon	6	27,00	6	27,00	7	0,00	2	40,15
chessboard	12	6,34	12	6,34	6	3,52	8	28,87
knight	4	13,48	5	14,18	6	7,09	1	22,70
plane	1	0,71	7	9,22	4	0,71	8	38,30
snowman	10	0,00	1	22,70	6	32,62	6	32,62
suzie	7	7,09	1	43,79	3	1,42	1	43,79
bee	11	2,14	12	8,57	6	24,29	2	33,57
church	6	57,86	6	57,86	12	3,57	6	57,86
cube	9	8,96	9	8,96	13	0,00	7	54,48
glass	6	0,00	10	0,71	7	54,29	7	54,29
church2	10	0,00	2	45,00	6	34,29	2	45,00
crocodile	13	3,70	7	11,11	1	8,15	2	31,11
yellow submarine	8	24,29	8	24,29	6	22,14	2	42,14

Figure 5: ***Performance of the methods and results from the questionnaire. For every method, there is selected best view and next to it the percentage of votes, which obtained the selected view in the questionnaire.***

In all cases at least one of our methods correctly chose the view ranked among the three "best views" chosen by people. At the end, we can conclude that proper combining of these three methods could lead us to the results satisfying human perception.

We can then say that through experimental results we observed that each of the tested method is suitable for different type of models. It means, that it could be better to start with classification of objects according to saliency parts first and then use some of known methods for finding the best view similar to the preference of observer.

3.4 Visual perception

The main reason why are we trying to find best views for virtual objects is to give the visitor of virtual environment most information. In the [13] they assume that the observer gets most information about object from that view where from each side of object is 19 % background. So the object should be centered as much as it is possible and there should be at least some free space around it.

Moreover according to visual perception [14] it is necessary to give to observer information in such order, that he firstly gets known information and then new ones. The meaning is that he gets worse view before he gets better one. Otherwise is he trying to apply the information from the best view on another view and he sees what isn't there.

Let us consider we found best view (Fig 2a) on the church. Using Gestalt psychology rules [15], we can find the most attractive part of our object. Gestalt psychology rules attempt to describe how people tend to organize visual elements into groups or unified wholes when certain principles are applied. According this rules (Fig 6) we can assume that something different from the rest on the object can catch eye first. So we target on that detail. For this example we choose the detail of the window in the front part of the church. Now we use the premises to find a good view for whole object to his part and we get eventual worst view (Fig 7). When we have now the worst view, we can continuously get to best view (computed by some of

the methods mentioned in the chapter 2) only by ascending and again we could let visitor guess what is on the screen.

Figure 6: Dissimilarity rule in Gestalt psychology [15].

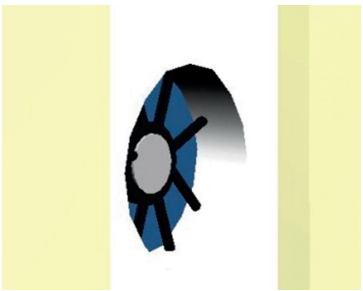

Figure 7: The worst view on church according to dissimilarity method.

4. CONCLUSION

In this paper we chalked out some methods useful for finding best views, possibilities of usability enhancement adequate mainly for virtual museum creators such as exploitation of found best views in animation presentation of the virtual museum. Our recent research is focused on classification of objects according to the best view. And in the end we briefly outlined the ways of improve searching for the best view using the perception and Gestalt psychology rules.

In the future work we would like to create automatic tool for classification the objects in virtual museum and follow-up usage of the right method for searching the best view.

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