ALGORITHM FOR GENERATION OF REFLECTIONS ON 'FLAT' ELEMENTS FOR VISUALISATION PURPOSES (E.G. GLASS SHEETS)

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ABSTRACT

In real model inaccuracy connected with surface making must be taken into account It has been assumed that reflections from real surface will not be calculated and thus only 'shifts' of a picture will be determined. The suggested algorithm includes/ takes into consideration the distance of an object and the observer.

Keywords: reflection, real surface, rendering, visualisation

1. INTRODUCTION

Visualisation always aims at presenting a model rendered with the aid of computer so that it looks as closely to reality as possible. Computer methods derived from geometrical generalisations quite often fail to give effects resembling reality. Generation of reflections is an interesting issue here. Reality observations give the following remarks. Reflections from flat surfaces e.g. glass in case of short distance observation, are of compatible character with what

Reflection from flat surface – short distance
Figure 1

can be expected from geometrical generalisation of reality. (Fig 1). This reflection matches the view of original exactly. In case of long distance observation even deformations resulting from inaccuracy of glass making are important (Fig.2). It results from the fact

Reflection from flat surface – long distance
Figure 2

that the bigger distance from an object the bigger deformations/distortions since they result from the difference of theoretical and real angle at which the

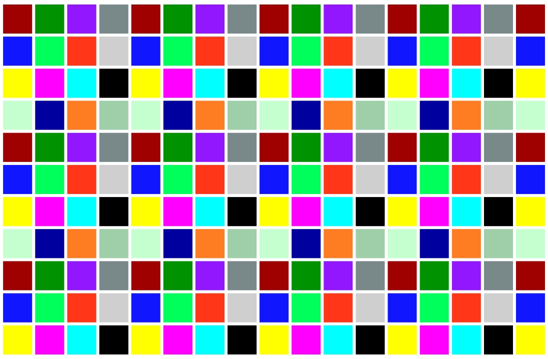
Specific deformations
Figure 3

ray is reflected. The bigger distance the more visible deformations of a picture (Fig.3). These deformations are of a specific kind:

- there are no straight lines or regular shapes on reflections
- deformations are of stochastic character
- there are places where the picture seems to be stretched or squeezed
- there are places where parts of picture are repeated

2. METHODS OF SIMULATION OF REFLECTIONS ON 'FLAT' ELEMENTS

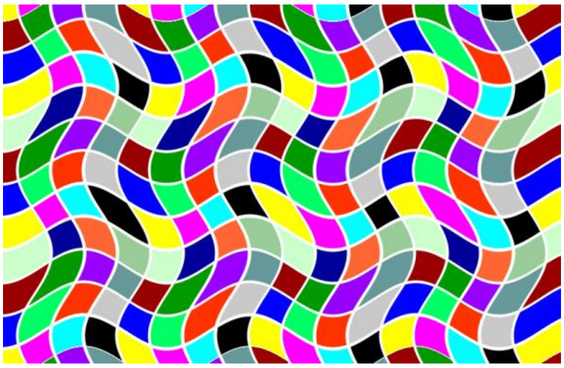
It is possible to use already existing effects but then picture is without features characteristic of



Used bitmap

Figure 4

reflection. A rendered photorealistic picture can undergo filtration in order to achieve effects close to reality. A filter from PhotoShop program, Wave, can



Wave filter - PhotoShop

Figure 5

be used here (in order to investigate the principle of

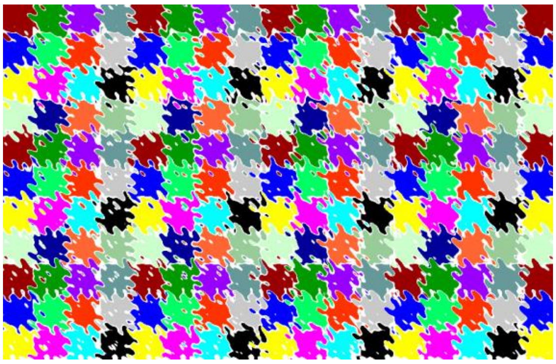
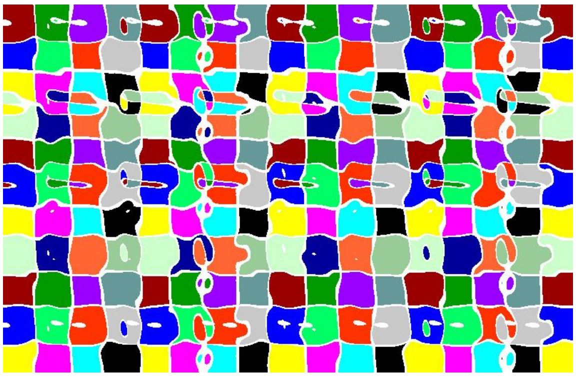


Figure 6

operation of filters bitmap has been used (Fig 4). A test drawing has been tested with this filter (Fig 5).

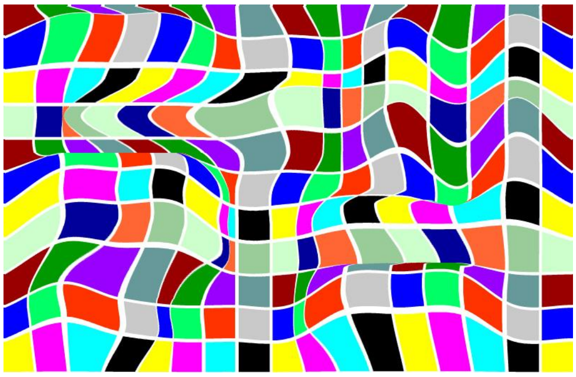


Glass filter - PhotoShop

Figure 7

With Wave filter it can be seen distinctly that repeated deformations are clearly visible.

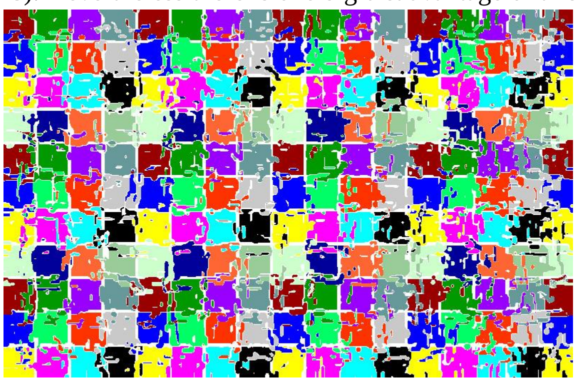
With reflection of irregular elements the effect of



Warp filter – HiRes QFX

Figure 8

repeatability can be less clearly seen. Filters of Ripple (Fig 6) type give less regular shapes but still deformation is of repeated character. Filters of glass type (Fig 7) give in some fragments effects similar to photo image. There are characteristic, random repeated elements. However, these repetitions are not very regular. Various programs give different solutions and thus HiRes QFX program offers Warp filter where a picture is deformed manually but it is not regular deformation although with a single use of a filter it is impossible to create repeated areas (Fig 8). Nevertheless there is one big disadvantage of this



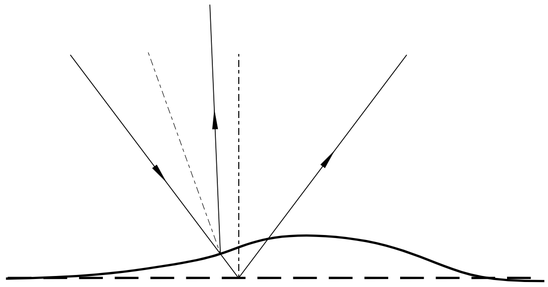
Combination glass and ocean filter - PhotoShop

Figure 9

type of simulation. When an element is not seen as a whole then filtration is carried in a previously prepared mask and it can be really time consuming with small elements e.g. railing.
The usage of photographs is a common practice with visualisation. Snapshots of existing surrounding of a building are taken. If it is done by an experienced graphic expert then they are filtered. They can be filtered many times and with different filters e.g. those, which have been presented above (Fig 9).

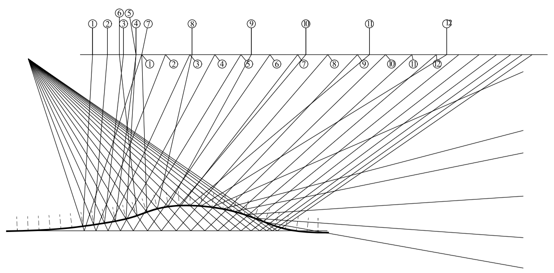
3. REAL MODEL

In real model inaccuracy connected with surface making must be taken into account. It has been



Theoretic and real reflection rays
Figure 10

presented with exaggeration on picture (Fig 10) where it has been shown how reflection from this



Theoretic and real reflection
Figure 11

surface starts. The succeeding rays have been numbered so that they can be easily distinguishable. The picture made in this way can be characterised by no straight lines or regular shapes on the reflections (deformation is non-linear). Stochastic character of a deformation appears due to surface shape. There will

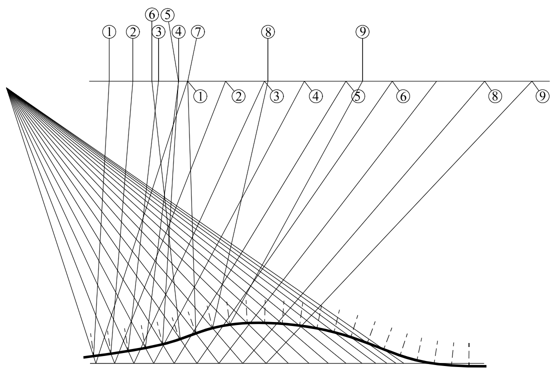
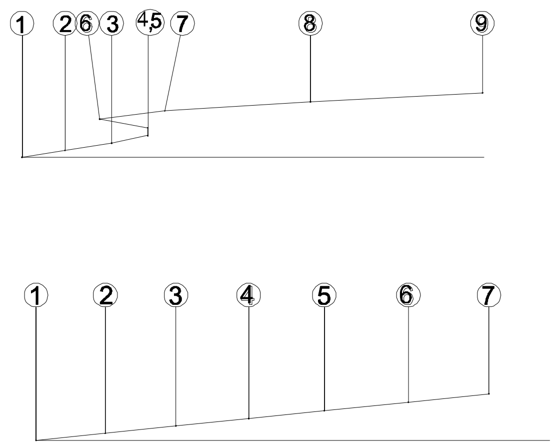


Figure 12

be places where the picture will seem to be stretched (rays 8 and 9 Fig 12) or squeezed (rays 5 and 6). In some places the picture will be repeated (rays 4 and 5). Deformations depend on the difference between reflection angle of theoretical and real surface. That is why the distance is so essential for the size of deformation. With small distances these angle differences are too little to be noticed. But a few meters distance makes deformations visible.
These effects can be simulated either by programs for snapshot processing or visualisation programs. However in both cases this task is difficult and does not give satisfying results. In case of one picture visualisation it can be improved manually but with animation there is no possibility of manual correction of generated images.

4. SUGGESTED ALGORITHM

Almost all visualisation programs allow generation of reflections from flat surfaces. They quite often generate reflections from cylinder or sphere surfaces. These possibilities can be used at generating reflections from real surfaces. In order to understand the idea of the suggested method let us assume a certain theoretical surface which is flat (a part of a surface) and real surface. The position of reflected rays is fixed with already known rules. Numbered



Numbered rays - real and theoretical surface
Figure 13

rays give us an idea of how that reflection is done on a real (Fig 13) and theoretical surface. The suggested algorithm uses generated reflection from a flat surface and then such a picture is further processed.
These are not transformations which are of noise character. If we assume that filter of noise type will do, then each change of observer's position would not change a picture or the changes would be of bound character with the change of camera position. In case of animation this disadvantage makes the whole method useless. The method should give the same results with repeated parameters. It is essential when we do animation in a given time periods or take additional pictures. If we do not want to have jumping objects then a generated picture with

unchanged parameters should be the same. Besides, significant increase in file size, which represents a model, is out of question. The algorithm should be simple so that calculations do not constitute too big percent of the whole time of rendering.

That is why for real surface representation only node points will be used. They are placed on a surface and the reflection of that surface is going to be simulated. The assumed points form a net. The distances between the points of the net determine the deformation density. Two parameters are allocated to the points. They are components of a deformation which can be assumed as representing deviation/distortion of a picture from reflection in theoretical plane. It can be assumed as a representation of inaccuracy of surface making, which reflects rays.

The size of assumed distortion is random from a range $\Delta x_{min} \div \Delta x_{max}$ and for the second direction $\Delta y_{min} \div \Delta y_{max}$. The size of these distortions from theoretical surface will influence on how big picture distortion is (Fig 14).

l=10m l=20m

Figure 14

It has been assumed that reflections from real surface will not be calculated and thus only 'shifts' of a picture will be determined. Generated point of reflection from real surface it is a point of a picture reflected from theoretical surface and shifted by a given value. Generally, it is a different point from a calculated point. This shift can be accepted instead of generating a real reflection when we only want to simulate real surface. This approach does not require calculation of a real reflected ray for each point. The proposed method simplifies calculation procedures significantly.

The suggested algorithm includes/ takes into consideration the distance of an object and the observer. A matrix [R] is built reflecting distortion from theoretical surface.

$$[R] = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1p} \\ r_{21} & r_{22} & \dots & r_{2p} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mp} \end{bmatrix}$$

$$r_{i,k} = \{\Delta x_{i,k}, \Delta y_{i,k}\}$$

Vectors $\{r\}_k$ are the matrix elements and the choice of the matrix size m,p depends on the size of the element which is to reflect rays, as well as from the size of the picture of this element on the rendered scene. It seems optimal if values m and p are selected so that the distance of consecutive points on the rendered picture are 15-60 pixels. Values of components are taken as random. After generating the reflection from theoretical surface deformation in particular points of the surface is found as interpolation of matrix points [R]. In order to include the distance from the observer, the distance $l_{m,p}$ from the observer to matrix points [R] is calculated. Shifts Δu and Δv are calculated in the following way:

$$\Delta u_{i,j} = \Delta x_{i,j} l_{i,j}$$
$$\Delta v_{i,j} = \Delta y_{i,j} l_{i,j}$$

After the value of $r_{i,k} = \{\Delta x_{i,k}, \Delta y_{i,k}\}$

$$u_{i,j} = x_{i,j} + \Delta u_{i,j}$$
$$v_{i,j} = y_{i,j} + \Delta v_{i,j}$$

Having a given pixel of u,v co-ordinates it is possible to take the colour of a point which will be allocated to point P(x,y)

5. CONCLUSIONS

This approach has the following advantages:

1. Generation of pictures more close to reality
2. Generation of repetitions of parts of picture and pieces of picture, characteristic for reflections, which are stretched and squeezed
3. model is not enlarged in a significant way
4. generated pictures are repeated i.e. if the parameters do not change the pictures generated at any time would be the same
5. simple rule allows high speed of generating a picture as compared to rendering

We can mention the following disadvantages:

1. generation of pictures which are not reflections but should only imitate them
2. no possibility of applying this method to complex surfaces

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