MODELLING OF INDIRECT VISUAL TRANSFER COLLECTED BY CAR DRIVER

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In the paper the establishment to create mathematical model of indirect visual transfer from car surroundings, transmitting by mirrors the vehicle equipped with is shown. It served to create an analytical program in C++ programming language, using Open GL library, operating under Microsoft Windows system. Research and cognitive possibilities are discussed which elaborated the computer program. Examples of calculations' results together with the graphic illustration of the received results are presented.

Keywords: *modelling, visibility, indirect visual transfer*

INTRODUCTION

Because of existing of non-translucent elements in vehicle cabs driver is not able to observe directly the areas, which are covered by these elements and which are essential for unthreatened participation in the movement [1, 4]. Figure 1 is illustrating the problem.

Figure 1. *Real tested object – presentation of problem*

To support the driver in this range, the mirrors are used which enable to decrease the areas being around the vehicle but not possible to be observed. In Regulation No 46 EKG UN [3] the following cases are described: present binding demands and the procedure of researches of the real object in the range of assertion of indirect visibility of surroundings of the vehicle through the mirrors the vehicle is equipped with.

Figure 2. *Real tested object – inside and outside view*

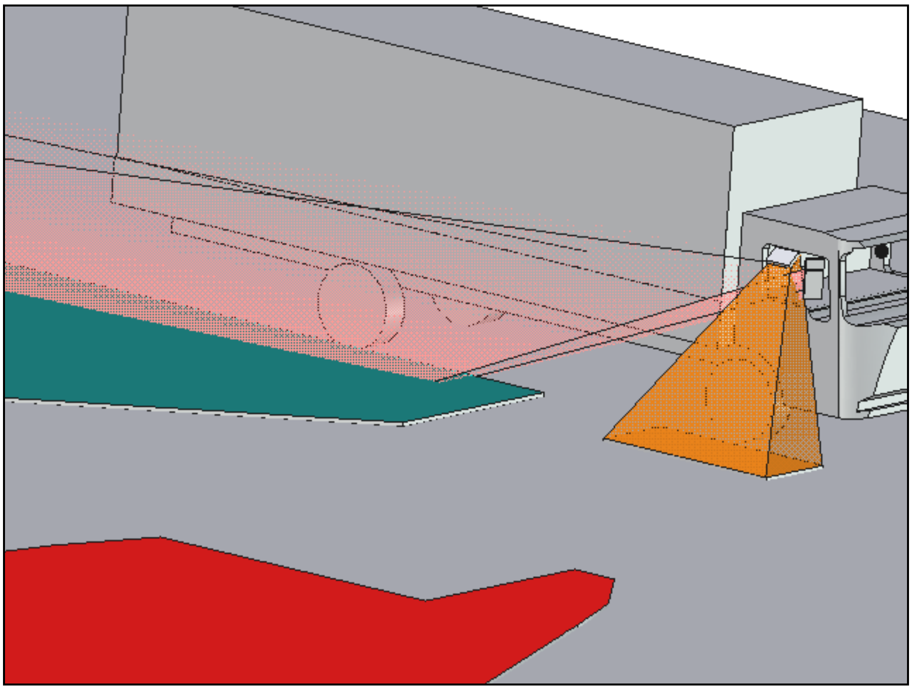


Figure 3. *Model of real tested object – monitoring minimal area*

The testing object is the scheme: Driver – Vehicle – Surroundings. The testing object is the visual (optical) indirect transfer from the vehicle surroundings in the range of lengths of waves which values corresponding with values of the light, seen by the man, transferred by mirrors the vehicle is equipped with. The testing object is presented on the Figure 1 and 2. The scheme of the testing object is presented on the Figure 3.

MODELLING OF SURROUNDINGS OBSERVATION FROM THE POST OF THE DRIVER

To make the searches the mathematical model of testing object was created. This model was used to write the computer calculation programme for the computer of the PC class. The mathematical model imitates:

- driver' s eyes by the „black points" placed in the three-dimensional space – Cartesian scheme, dextroprotatory, rectangular,
- solid of the vehicle, described in this space by the non-translucent and translucent surfaces,
- mirrors with known features, placed on the vehicle solid,
- the space surrounding the vehicle placed on the horizontal surface.

The eyes points are two points lying on the horizontal line, in the distance measured between them equals with 65 mms. Their position in the vehicle solid corresponds with situation of driver's eyes where the driver is in the normal position to drive a car.

Two points enable to imitate the real two-eye seeing.

The vehicle solid is placed inside of cuboids, which walls mark the contour of vehicle. The walls of this cuboids were led through the most moved forward elements of the vehicle (with exception of mirrors, their supports and lamps): on sides, forward, backwards, downwards, upwards.

Contour of the vehicle solid can be placed between the surfaces, where the distances between them are included in the section of values:

- on the length: 3000 mms – 18000 mms,
- on the width: 1500 mms – 2600 mms,
- on the height: 1200 mms – 4000 mms.

The front of the vehicle is placed in the opposite direction against the turn of **Ox** axis.

Transparent surfaces of vehicle solid have the coefficient of the total transparency (measured in the normal direction to surface) for the range of values if visible light – at least 70%. However, non-transparent surfaces have the value of the coefficient of total transparency below 70% and are treated as the total optical obstacles.

Mirrors are the surfaces made from the segment of sphere by cutting its fragment in the result of penetration of cuboids with sphere. Longitudinal axis of cuboids goes through the centre of the ball, from which the segment of sphere was cut. The length of sphere rays is included in the range of values: from 200 mms $\div \infty$ (till immensity).

Remaining characteristics of mirror, such as: height and width have the values equal to values of chords of bows of circles, on which the segment of the sphere was rested.

The system of coordinates (against the vehicle) is placed in the following way:

- vertical surface **Oxz** goes by the longitudinal axis of vehicle,
- vertical surface **Oyz** perpendicular to surface **Oxz** goes by „eyes points",
- horizontal surface **Oxy** lies on the road surface, on which the vehicle stands.

On the horizontal surface **Oxy** areas in the vehicle surroundings are imitated, which according to the bind rules driver should have possibility to observe them. The line of horizon is imitated on the surface **O'yz** parallel to the surface **Oyz**. The surface **O'yz** is placed behind the vehicle in the distance from the surface **Oyz** with given value.

The line of horizon is imitated by the level line marked above the surface **Oxy** on the height where its value is the same as the value of the height of the upper part of the considered mirror, measured from the surface **Oxy**. The scheme of the testing object and the model of the real object are presented on the drawings no 3 and no 4.

In the worked out model the possibility of realization of limitations fixed by present binding rules in the range of the indirect visual transfer was taken into account.

Mathematical description of the designation of area expanse (and its location), comprised by driver's eyesight, looking at the surroundings by the mirrors, in the elementary shape reduced to a rule of finding the equations of the straight lines, which are the mirror reflection of the straight lines, connecting the eyes-points with freely chosen point on the mirror surface in the three-dimensional space.

The mirror in the model can be freely set - what responds the real adjustment. It can also be freely placed against the vehicle, what enables to imitate its location such as in the real object.

The eyes-points can be also freely placed in the model solid of the vehicle.

Having given points **A**, **B**, **C** in the space which imitate:

- **A** – the centre of the sphere (sphere, on which there is the surface of the mirror),
- **B** – one of the eyes-points,
- **C** – the point on the mirror, on which the observer's eyesight was directed.

We are looking for the equations of the straight line **CE**.

On the Figure 5 location of the mentioned was illustrated. Leading the line p through the point B, perpendicularly to the line l, marked the coordinates of the point D on the line **l**. Because the vectors of the line **l** and the line **p** are not of the zero value, so on the base of characteristics of the scalar product of the vectors of these lines it appears that in the case when the scalar product of vectors gives the zero result so the line **l** and the line **p** are perpendicular.

The common cutting point of the lines **l** and **p** was marked as **D**. However the common point of lines **l** and **k** was marked as **E**. Found point **D** (x_D, y_D, z_D) permits to mark the coordinates of the point **E** (x_E, y_E, z_E) which is symmetrical to the point **B** in relation to the line **l**. Coordinates of the point E because of the symmetry towards the line **l** describe the following equations:

$$x_E = 2 \bullet x_D - x_B$$

$$y_E = 2 \bullet y_D - y_B$$

$$z_E = 2 \bullet z_D - z_B$$

Then the points **C** and **E** mark the straight-line **k** in the space.

If we know the equation of the straight-line **k** we can calculate the coordinates of the point of spiking of the surfaces Oxy or O'yz by this straight line.

Points of spiking of these surfaces by the straight lines **k** which are turned aside on the whole surface of the mirror mark the place and the extensiveness of the area observed by one eye for the given location and adjustment of the mirror. In the same way we should act to mark the area observed with the second eye.

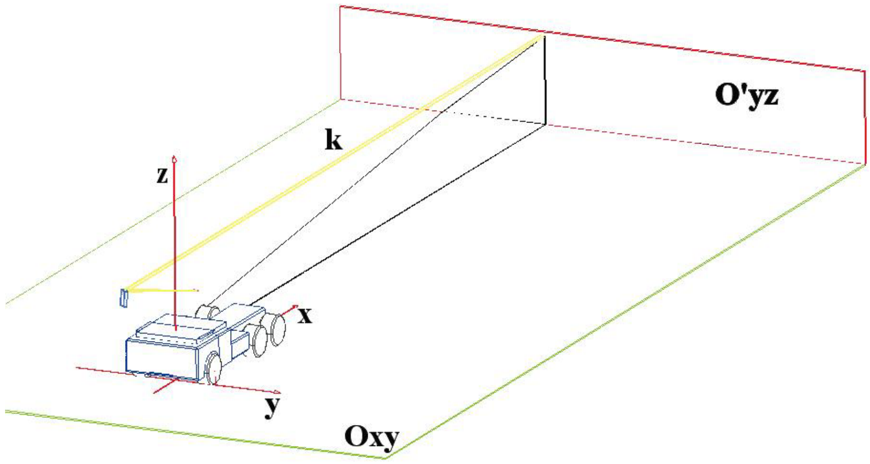


Figure 4. *Arrangements of eyes points and mirror position in coordinate system*

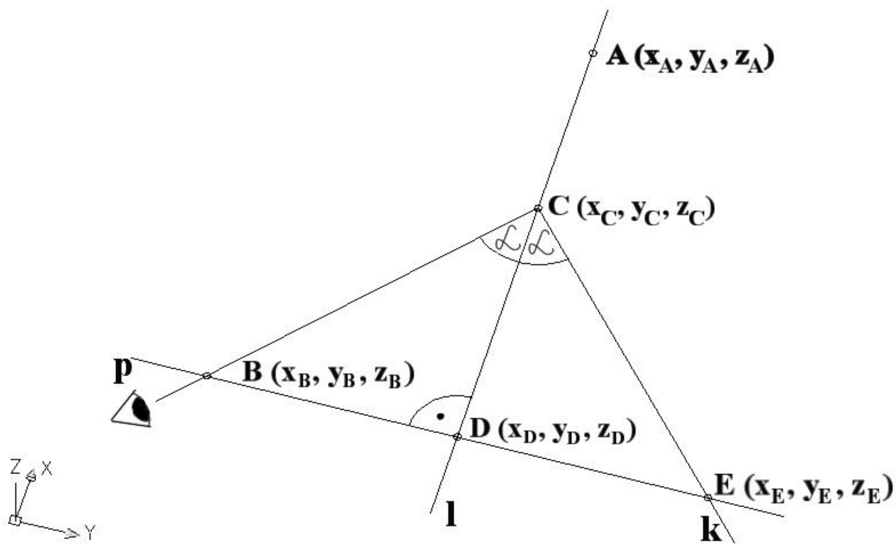


Figure 5. *Elementary problem of reflection in mirror*

Changing the value of coordinates of the point **A** in the way where the point **A** moves on the surface of the sphere and where the ray of this sphere marks the segment **AC** and the centre of this sphere marks the point **C** we direct the mirror in such a way to point the observer's eyesight to the area placed against this vehicle, which the observer wants to watch.

Marking around the vehicle the area on the surfaces Oxy and **O'yz**, for example being in agreement with the binding rules or also expectation we can define:

- if for the given mirror and its placement on the vehicle the driver can take in a view the required area,
- what conditions should be fulfilled (height, width, the ray of curvature of the mirror, the parameters of its placement on the vehicle, arrangement) to enable the driver to take in a view the given area for the definite vehicle,
- limits of possibilities to use the mirror in the indirect seeing of areas of the vehicle surroundings for the definite category of the vehicle and constructional solutions,
- sensitiveness of the testing object (which is the function of many variables) for the particular variables.

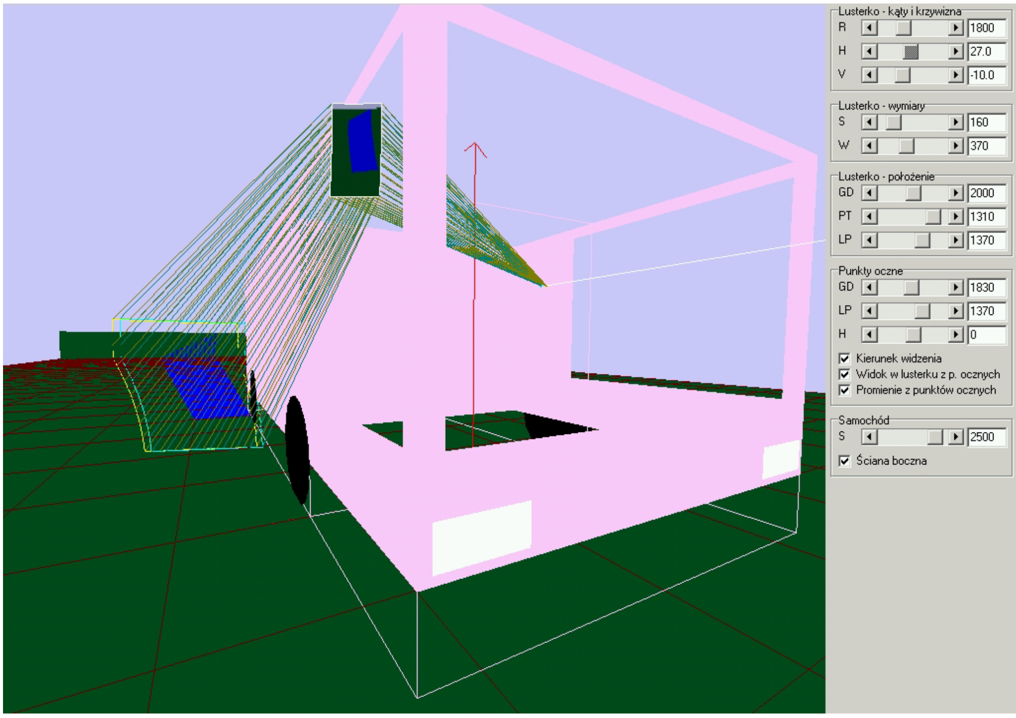


Figure 6. *Example of a screen received on the basis of software calculations*

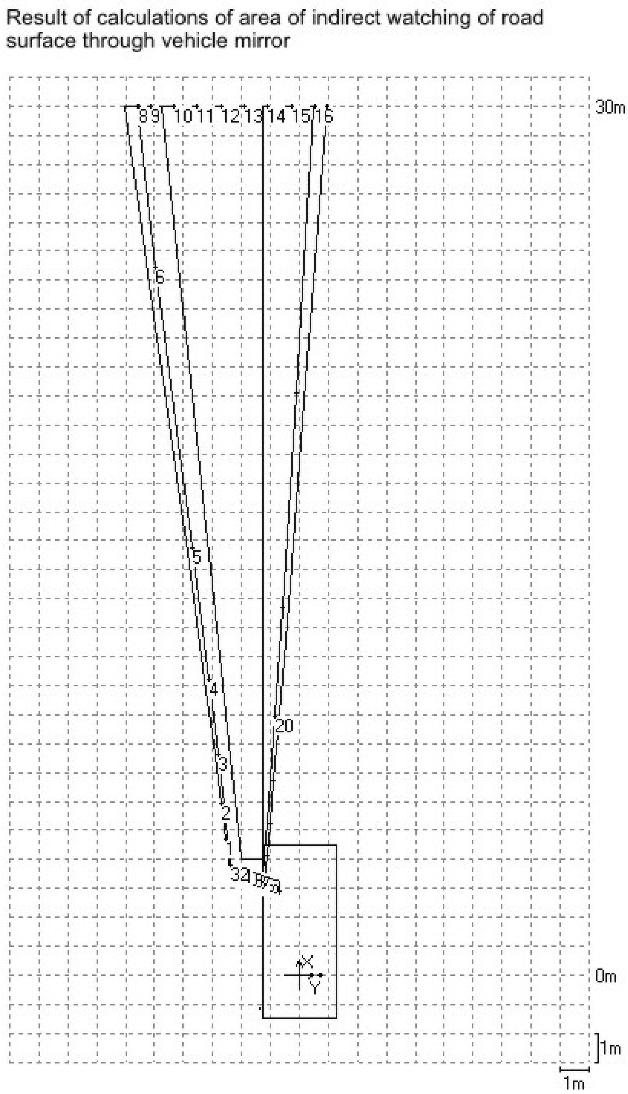
The above described mathematical model of visual transfer from the vehicle surroundings transmitted through the mirrors was used to create the calculation programme in the programming language C++, where Open GL library was used, acting under Microsoft Windows system [2]. On the Figure 6 as the example of the picture seen by the programme operator on the screen of the computer monitor was presented. In the definite range of the values it is possible to:

- increase or decrease the presented object what simplifies watching of details,
- change the direction of watching.

Attendance of the programme lies in giving the values of such sizes as for example: width of the vehicle, location and extensiveness of transparent elements. Besides below please find the list of the cases which location against the vehicle is given:

- eyes-points,
- areas which the driver should observe,
- mirror which we investigate (its width, height and the ray of curvature).

Next changing the values of angles of the mirror adjustment in the vertical and in the level we check if the area comprised by the mirrors with the driver's eyesight covers fully the area qualified by the rules or given as the result of other limitations.



Eyes points
X: 0 Y: 700 Z: 1800

Seeing angle: 0

Mirror
X: -1120 Y: -1370 Z: 2140
R: 1800 Horizontal angle: 29,5

Vertical angle: -11,5
Width: 140 Height: 300
Distance from overall dimension: 170

Points limiting watching area

Point	Eye	X	Y
1	L	4711	-2556
2	L	5916	-2699
3	P	7620	-2800
4	P	10234	-3116
5	P	14742	-3684
6	P	24445	-4945
7	P	30000	-5609
8	P	30000	-5553
9	L	30000	-5142
10	L	30000	-4334
11	L	30000	-3527
12	L	30000	-2719
13	L	30000	-1910
14	L	30000	-1099
15	L	30000	-285
16	L	30000	534
17	P	30000	940
18	L	20114	-127
19	L	12676	-590
20	L	8962	-834
21	P	6726	-874
22	P	5213	-1009
23	P	4128	-1112
24	P	3309	-1195
25	P	3370	-1335
26	P	3431	-1478
27	P	3492	-1622
28	P	3552	-1769
29	P	3611	-1919
30	P	3670	-2071
31	P	3728	-2226
32	P	3786	-2385

Figure 7. *Example of the received results of calculations and their graphic illustration*

The results of the programme calculations are presented graphically as the virtual picture of reality on the computer monitor. On Figure 6 there is an example of the received picture on the monitor, generated by the programme with the results of observation.

The programme presents in the tabular form, calculated with the given step, for the accepted parameters the values of coordinates of the points on the surfaces **Oxy** or **O'yz**. Additionally, there is possibility to draught the areas comprised with eyesight.

Figure 7 presents the example of the received results of calculations and their graphic illustration.

SUMMARY

The worked out model of the visual transfer form the vehicle surroundings transmitted by the mirror enables leading of the virtual searches of the real object. Necessary data such as: position of the eyes-points in the real vehicle, distribution of the mirrors and their features, width of vehicle, must be measured in the vehicle and brought into the programme. Estimation of the fulfilment of the demands by the vehicle is much less arduous than in the real searches.

Besides the following cases appear:

- possibilities of testing of susceptibility of the model for the particular variables,
- qualification of limits of possibilities of the mirror's use to see indirectly the areas of the vehicle surroundings.

References

[1] Olejnik K. *Doctor's trial „The research under outside visibility from a driver position in an aspect of constriction quality verifications”.* Lublin: Technical University of Lublin, 2003.

[2] Olejnik K. Lack of visual transmission and safety – operating problems of trucks. In: *Journal of International Conference „Maintenance 2004”.* Prague, 2004, pp.69-75.

[3] Regulations No46 ECE UN. *Uniform provisions concerning the approval of the rear – view mirrors of motor vehicles with regard to the installation of rear - view mirrors.*

[4] Regulations No71 ECE UN. *Uniform provisions concerning the approval of agricultural tractors with regard to the driver's field of vision.*