

## AUTOMATIC GRAPHICAL SIMULATION OF HOW TO DETERMINE THE TRUE LENGTH OF A LINE SEGMENT BY CHANGING A PROJECTION PLAN

### SIMULAREA GRAFICĂ AUTOMATĂ A MODULUI DE DETERMINARE A ADEVĂRATEI MĂRIMI A UNUI SEGMENT DE DREAPTĂ UTILIZÂND SCHIMBAREA UNUI PLAN DE PROIECȚIE

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**Abstract.** *In Descriptive Geometry, it is noticed that when it comes about to the Methods of the Descriptive Geometry, the first theme that raises problems to the students is understanding how to determine the true length of a line segment using the methods of replacing the projection planes. Starting from the problems raised by the students, the authors have created a three-dimensional graphic model to help them understand how to determine the true length of a straight segment using the vertical projection plan change method.*

**Key words:** descriptive geometry, plan projection, graphic model, straight segment, AutoCAD

**Rezumat.** *În activitățile de prezentare a disciplinei Geometrie Descriptivă se observă că în momentul în care se ajunge la capitolul Metodele Geometriei Descriptive prima temă care ridică studenților probleme de înțelegere este cea de determinare a adevăratei mărimi a unui segment de dreaptă utilizând metodele schimbării unui plan de proiecție. Pornind de la problemele semnalate de studenți, autorii au creat un model grafic tridimensional care să-i ajute pe aceștia să înțeleagă modul de determinare a adevăratei mărimi a unui segment de dreaptă utilizând metoda schimbării planului vertical de proiecție.*

**Cuvinte cheie:** geometrie descriptivă, plan proiectant, model grafic, segment de dreaptă, AutoCAD

## INTRODUCTION

The mode of determination, classically on graphical way, of the true length of line segment using the method of replacing the projection planes is made usually using the replacement of the vertical plane [V] or horizontal plane [H] (Prună *et al.*, 2002 ; Slonovski *et al.*, 2006). From the activity with the students it was observed that in both situations the majority of them do not understand the way in that the vertical and horizontal planes are rotating, why is necessary to rotate the planes, why the OX axis rotates and how the true length of the line segment is determined.

To help the students, for that these one to understand the mode of determine of the true length of a line segment, using the replacing of the vertical

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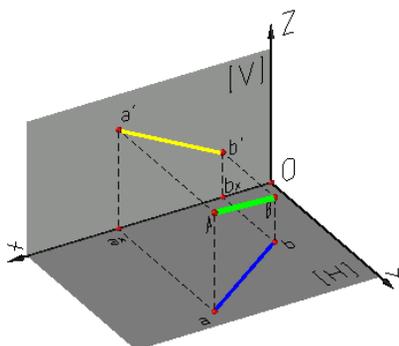
projection plane, the authors proposed the realization of some graphical tridimensional representations, computer assisted, under the AutoCAD software, to clarify the issues reported by students.

## MATERIAL AND METHOD

The issues that have arisen from the beginning concerning to the graphical tridimensional model were:

- finding the optimal alternative so that the graphical simulation shows the rotation of the vertical projection plane [V];
- choosing of an advantageous initial position for the line segment.

Thus, was chosen a position, for the line segment, such that in relation with the horizontal [H] and vertical [V] projection planes, this to be identified with a general position line (fig. 1).



**Fig. 1** The line segment AB has the position of a general position line

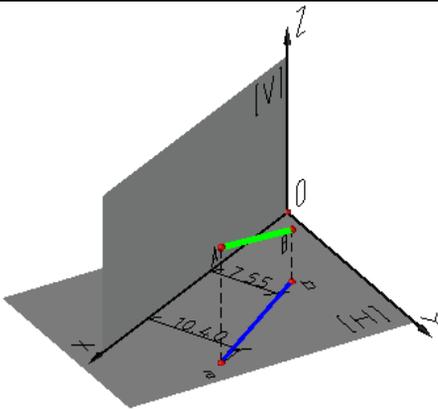
Because must be simulated the replacing of the vertical projection plane [V] it was rotated around the OZ axis of the projection system presented in figure 1, in order that the vertical plane [V] to become parallel with the line segment AB, because in that moment:

- the vertical projection  $a'b'$  will be parallel with the line segment AB and, in this moment, it will be the real length of the line segment AB;
- the horizontal projection  $ab$  of the line segment AB will be parallel with the projection axis OX.

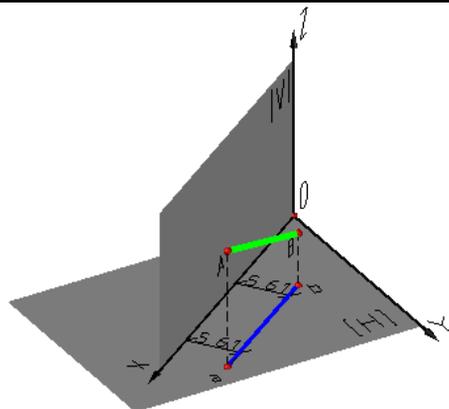
After the vertical projection plane rotation [V] it can be noted:

- the angle between the projection axes OX and OY, angle which must always has  $90^\circ$ , it progressively changes its value, the obtained values being different than  $90^\circ$  (fig. 2, fig. 3);

- at the end of the rotation, the OX axis becomes parallel with the horizontal projection  $ab$  of the line segment AB (fig. 3), thing which had to be achieved.



**Fig. 2** Intermediate position of the vertical plane [V]

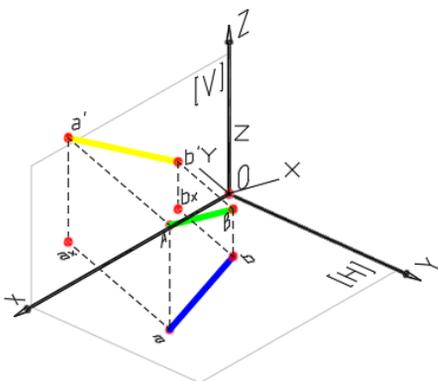


**Fig. 3** The final position of the vertical plane [V]

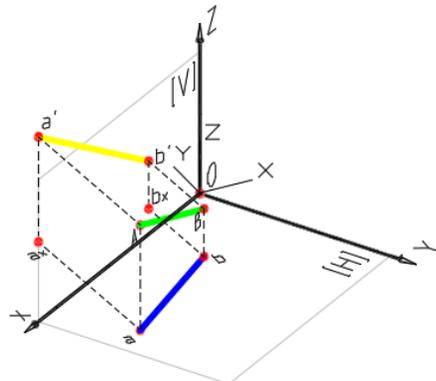
Considering the above, in order to keep the angle of  $90^\circ$  made by the OX and OY axes in the time of simulation of the vertical projection plane rotation [V], for determining of the real length of the line segment AB, the OY axis must be rotated with the same angle used at the rotation of the vertical projection plane [V].

Thus, if the Y axis and the vertical projection plane [V] rotate progressively (fig. 4, fig. 5) it may be noted, because the OX axis changes her position:

- the UCS axes must be rotated for determination the new positions of the  $a_x$  and  $b_x$  points;
- must be repositioned the  $a_x$ ,  $b_x$  points, which are situate on the OX axis;
- must be repositioned the vertical projections  $a'$  and  $b'$  of the A and B points, projections which determine the new vertical projection  $a'b'$  of the line segment AB.

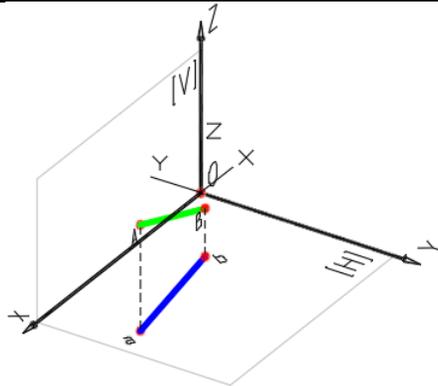


**Fig. 4** Intermediate positions of the AB line segment which highlight the fact that the UCS axes must be rotated and the points  $a_x$ ,  $b_x$ ,  $a'$  and  $b'$  repositioned



**Fig. 5** Intermediate positions of the AB line segment which highlight the fact that the UCS axes must be rotated and the points  $a_x$ ,  $b_x$ ,  $a'$  and  $b'$  repositioned

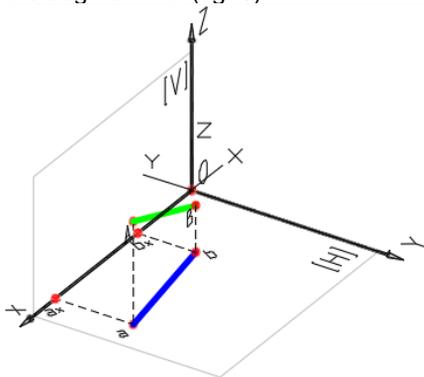
The UCS axes rotation is done so that the X, Y and Z axes are aligned with the X, Y and Z axes of the orthogonal system XYZ (fig. 6).



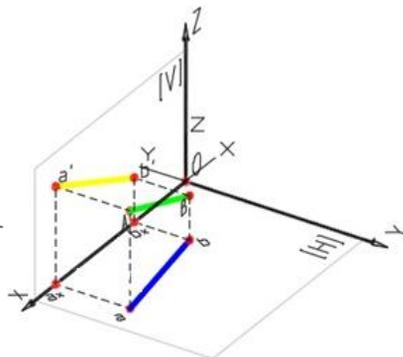
**Fig. 6** The mode in that the UCS axes must be rotated

For the determination of the  $a_x$  and  $b_x$  points which are situated on the OX axis, are drawn, from the a and b perpendicular line to the OX axis (fig. 7).

For the determination of the vertical projections  $a'$  and  $b'$  of the A and B points is drawn from  $a_x$  and  $b_x$  two lines of recall which have the lengths  $Aa$  respectively  $Bb$ . Representing a line segment from  $a'$  to  $b'$  is obtained the vertical projection  $a'b'$  of the line segment AB (fig. 8).



**Fig. 7** The way in that the  $a_x$  and  $b_x$  are determined



**Fig. 8** The way in that the  $a'$  and  $b'$  points are determined

Each of the steps listed above are repeating for each stage which permits bringing, using the replacing vertical plane [V] method, the AB line segment presented in figure 1 from a general position line to a front line.

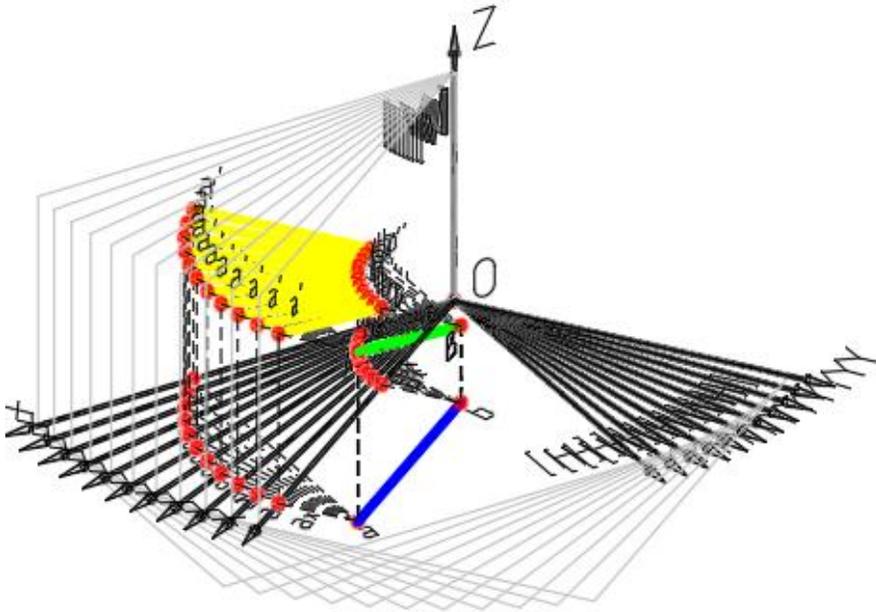
For a clearer view were built in this situation ten transformation representations (steps) of the AB line segment position from a general position line to a front line.

## RESULTS AND DISCUSSIONS

For students to view in a single representation each position of the  $a_x$ ,  $b_x$ ,  $a'$  and  $b'$  points and of the vertical projection  $a'b'$ , the overlap of these ten steps is presented in figure 9.

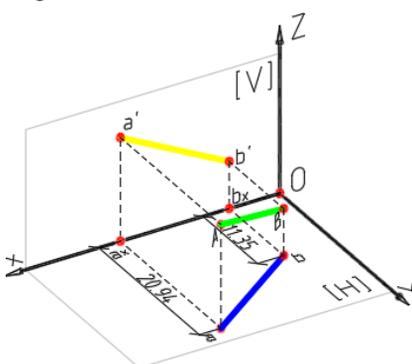
It can be noticed from this figure that this visualization mode is not advantageous because it cannot be clearly observed:

- each position of the plane [V], of the  $a_x$ ,  $b_x$ ,  $a'$ ,  $b'$  points and of the vertical projection  $a'b'$ ;
- the new positions of the recall lines which determines the points listed above;
- keeping of the  $90^\circ$  angle between OX and OY axes.

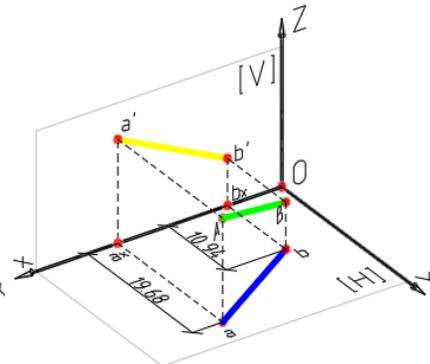


**Fig. 9** The overlapping of all positions

From this reason was proposed the presenting of these ten steps as slides (figures 10 ... 20).



**Fig. 10** Initial position



**Fig. 11** Intermediary position 1



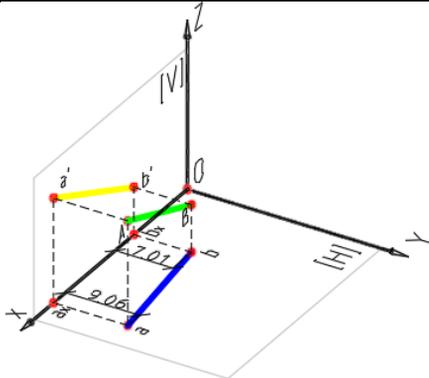


Fig. 18 Intermediary position 8

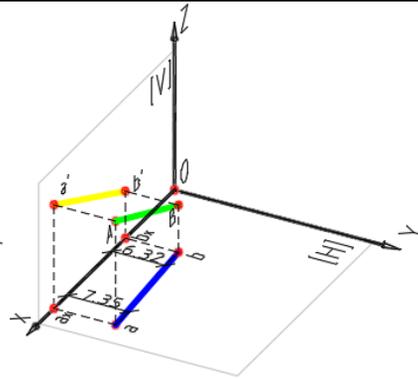


Fig. 19 Intermediary position 9

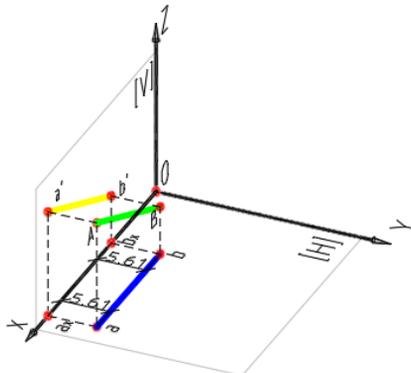


Fig. 20 Intermediary position 10 (the final position)

It can be observed from these images:

- the rotation mode of the OY axis and of the vertical projection plane [V];
- the rotation mode of the XYZ orthogonal system axes;
- the new positions of the  $a_x$ ,  $b_x$ ,  $a'$  and  $b'$  points.
- the new positions of the recall lines which determines the points listed above;
- how the distances  $aa_x$  and  $bb_x$  change until these become equal and the AB line segment occupy the position of a front line;
- the length of the  $a'b'$  line segment is identical with the length of the AB line segment (fig. 20).

The optimal alternative for step by step visualization of those ten imagines is by joining of them in a pdf file which permits rolling forward and back of the slides.

It is known that each stage which permits the vertical projection plane [V] rotation contained the next steps:

- the rotation of the plane [V] and the OY axis;

- the UCS alignment with the new XYZ axes positions;
- the determining of the  $a_x$ ,  $b_x$ ,  $a'$ ,  $b'$  points;
- the union of the  $a'$  and  $b'$  points.

Thus, can be noticed the fact that for the simulation of those ten stages, the number of steps made by the authors was forty.

Result from above that if the number of stages would be higher, for each additional stage the number of steps increase with four.

Starting from these statements the authors thought that if could automatically generate the imagines presented in figures 10 ... 20 with the help of a computer program which may run on the AutoCAD software interface, for example the AutoLISP programming language, the user could do one of the following:

- sets the number of steps desired for a finer or coarse simulation of the rotation of the vertical projection plane [V] and of the OY axis;
- could changes the descriptive coordinates of the A and B points, thing which could lead to numerous variants of theoretical problems automatically solved by the software.

From the first attempts to building of the software it was observed that the multitude of operations which referring to the drawing of the objects which must be represented and the complexity of the steps which must be followed, make the process of writing of the computer program to be complex.

The process of generating of the imagines by the authors is much easier than the process of developing the needed algorithm to build the software.

## CONCLUSIONS

The proposed method by the authors regarding to the graphical visualization of the mode to establishing of the true length of a line segment using the method of replacing of the vertical projection plane [V] which consists in the rotation of the vertical projection plane [V] and of the OY axis, the UCS rotation according to the X, Y, Z axes directions of the orthogonal system XYZ, redesigned for each step of the plane [V] rotation of the  $a_x$ ,  $b_x$ ,  $a'$  and  $b'$  points and the  $a'b'$  vertical projection of the AB line segment, highlights for each stages, the mode of transforming of a line segment, from a general position line to a front line and the determining of the true length of a line segment.

This method can be adapted and for graphical visualization of the determine mode of the true length of a line segment using the method of replacing of the horizontal projection plane [H].

## REFERENCES

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