DEVELOPMENT OF ALGORITHMS TO DETERMINE ROADHEADERS ORIENTATION

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At the Department of Precision Instrument Making, the orientation and navigation system for the roadheaders is developed. The system plays a very important role in the roadheaders management in the mine construction. The idea of this system is to use two devices: ground orientation device mounted on the roof of the mine with known geographical coordinates and orientation device mounted on roadheader. These devices have mutual optical sight. Thus, if the geographical coordinates of the ground orientation device and the distance from it to the roadheader are known, the azimuth and geographical coordinates of roadheader can be easy calculated. This article considers the problem of Roadheader orientation determination.

For the solution of this problem, the analytical principle of supporting the direction structure is accepted. This principle is effective for immovable objects. So the accelerometers measure only acceleration of gravity projection. In our case, the Roadheaders move, so accelerometers will measure the apparent acceleration. This acceleration is the difference between the movement acceleration and the acceleration of gravity projection on the sensitivity axis. However, by connecting low-pass filters to the outputs of the accelerometers, one can receive the signals similar to the acceleration of gravity projection. This solution has been successfully implemented in a continuous gyroscopic inclinometer IGN100-100 / 60-A developed in Tomsk Polytechnic University.

There are three schemes for the determination of an object: the scheme with one accelerometer determines one orientation angle of an object; the scheme with two accelerometers and the scheme with three accelerometers determine two orientation angles of the object relative to the vertical. In this case, Roadheaders turn relative to the vertical by small angles, so the scheme with two accelerometers can be used (fig. 1).

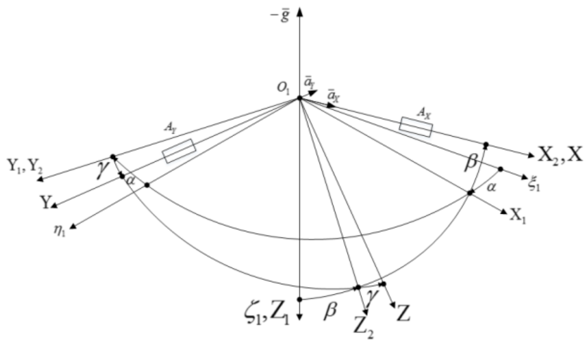

Figure 1. The support and the associated coordinate systems

Fig. 1 denotes:

$O_1\xi_1\eta_1\zeta_1$ - horizontal, geographical directional coordinate system, its origin of coordinates is the point to mount the orientation devices on Roadheader; axis $O_1\xi_1$ is directed to the North; axis $O_1\zeta_1$ is directed along true vertical of the terrain and down; axis $O_1\eta_1$ is completed so as to obtain the right coordinate system, so it is directed to the East;

O_1XYZ - coordinate system is associated with Roadheader; axis O_1X parallels to the longitudinal axis of the Roadheader in the direction of its front side; axis O_1Y perpendiculars to the axis O_1X and parallels to the caterpillar plane and right; axis O_1Z is completed to obtain the right coordinate system, so it is directed down;

$\bar{g}$ - acceleration of gravity vector;

$\bar{a}_X$, $\bar{a}_Y$ - the apparent acceleration of projections on axes O_1X and O_1Y;

For determination of the orientation of Roadheader angles Euler – Krylov are used. In the starting position the axes of coordinate system O_1XYZ coincide appropriately with the axes of coordinate system $O_1\xi_1\eta_1\zeta_1$. Firstly, system O_1XYZ turns around axis O_1Z by positive angle α. Secondly, system O_1XYZ turns around axis O_1Y by positive angle β. Lastly, system O_1XYZ turns around axis O_1X by positive angle γ.

In this article only determination tasks of the pitch and list angles of the Roadheader are considered. And azimuth of roadheader is known.

Thus, accelerometers A_X and A_Y measure the apparent acceleration projections. From fig. 1 we have:

$$a_X = g \cdot \sin\beta;$$

$$a_Y = g \cdot \cos\beta \cdot \sin\gamma.$$

After simple transformations, the following formulas are obtained:

$$\sin\beta = \frac{a_X}{g}; \cos\beta = \frac{\sqrt{g^2 - a_X{}^2}}{g}; tg\beta = \frac{a_X}{\sqrt{g^2 - a_X{}^2}};$$

$$\sin\gamma = \frac{a_Y}{\sqrt{g^2 - a_X{}^2}}; \cos\gamma = \frac{\sqrt{g^2 - \left(a_X{}^2 + a_Y{}^2\right)}}{\sqrt{g^2 - a_X{}^2}}; tg\gamma = \frac{a_Y}{\sqrt{g^2 - \left(a_X{}^2 + a_Y{}^2\right)}}.$$

Therefore, the pitch and list angles of Roadheader can be calculated using the following formulas:

$$\beta = \arcsin\frac{a_X}{g} \text{ or } \beta = \arccos\frac{\sqrt{g^2 - a_X{}^2}}{g} \text{ or } \beta = arctg\frac{a_X}{\sqrt{g^2 - a_X{}^2}};$$

$$\gamma = acr\sin\frac{a_Y}{\sqrt{g^2 - a_X{}^2}} \text{ or } \gamma = \arccos\frac{\sqrt{g^2 - \left(a_X{}^2 + a_Y{}^2\right)}}{\sqrt{g^2 - a_X{}^2}} \text{ or}$$

$$\gamma = arctg\frac{a_Y}{\sqrt{g^2 - \left(a_X{}^2 + a_Y{}^2\right)}}.$$

These values are the main values of the pitch and roll angles. However, Roadheaders turn relative to the vertical by small angles, so the main values are also values of the Roadheader’s pitch and roll angles.

Moreover, it must be noted that the function “$\arcsin$” has a high precision with the angles closed 0^o; function “$\arccos$” has a high precision with the angles closed 90^o; and function “$arctg$” has a wider high precision range. Therefore, the algorithm with function “$arctg$” will be used for pitch and roll angles determination.

$$\left.\begin{aligned} \beta &= arctg\frac{a_X}{\sqrt{g^2 - a_X{}^2}}; \\ \gamma &= arctg\frac{a_Y}{\sqrt{g^2 - \left(a_X{}^2 + a_Y{}^2\right)}}. \end{aligned}\right\}$$

In this paper, the orientation of the Roadheader is determined by the analytical method. These algorithms are simple enough for processing with a calculator.

References

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CREATION OF HARDWARE AND X-RAY PROTECTION FOR TOMOGRAPH TOLMI 150-10

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At the moment, the Institute of Non-destructive Testing is commissioning radiation tomographic systems for finding defects in industry.

"In this complex we will combine different methods of non-destructive testing, but we will offer only the set that is optimally suited for our customers' business needs. That means on our hardware we will test and define the methods which most effectively determine the defects in the products of our customers", – citation of Non-destructive Testing Institute's director, Borikov V.N., in interview for TPU News.

That means we need to improve the system of tomograph to obtain images of much more high quality with less time and reduce the size and weight of it.

The main concurrent we have in sphere of x-ray tomography is American company General Electric, supplying equipment to the European, and Russian markets.

The main problem which we ran into in process of creation the tomograph on hardware level is the low accuracy in measurement of the controlled sample's rotation angle. Used in tomographic complex rotator (Figure 1) or "turning station" allows you to rotate an object of control in increments of 1 degree. And the same minimum pitch is specified in the software for subsequent image reconstruction.