Development of Portable Human Body Navigation System

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Abstract - **In this paper the process of development of human body navigation system is given.**

Keywords - **Rate gyro, accelerometer, human body, navigation system.**

I. INTRODUCTION

The system «PORTABLE HUMAN BODY NAVIGATION SYSTEM» is designed to measure motion parameters of human body's parts in the place of sensitive elements installation. Sensitive elements of the system are three blocks of sensors – SENSOR 1, SENSOR 2, SENSOR 3.

II. SYSTEM POSSIBILITIES

Information provided by «PORTABLE HUMAN BODY NAVIGATION SYSTEM»:

1) angular velocity of the object where blocks of sensors are installed - $\omega_x, \omega_y, \omega_z$. Angular velocity is measured in units of $[°/s]$. It characterizes the rotation around the block's axis. Block's axes are marked as a coordinates system XYZ.

2) acceleration which acting on the object where blocks of sensors are installed - a_x, a_y, a_z. The acceleration is measure in units $\left[m/s^2 \right]$.

3) orientation angles of the object – heading ψ, pitch J, roll γ. Kinematic of the block angular position is shown on Fig. 1. The measuring range of heading angle is $\pm 180^{0}$, pitch angle - $\pm 90^{0}$, roll angle - $\pm 180^{0}$.

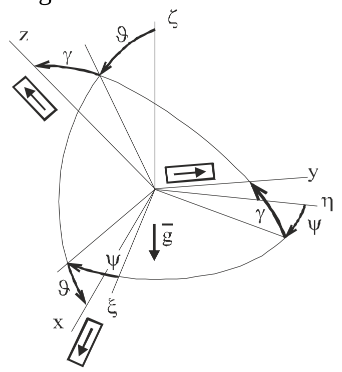

Fig. 1 Sensor's block kinematic

III. DEVELOPMENT AND DESIGN STAGES

To develop the system we used 3 inertial measurement unit, consisting of three angular rate sensors, 3 accelerometers from Analog Devices and 3-axis magnetometer. Orientation of the sensor unit is orthogonal. Information processing is conducted on a computer using specially developed software.

The main algorithmic component of system development includes:

1. The choice of mathematical models of sensors and their calibration. Mathematical model of micromechanical sensors takes into account the sensor's scale factor, the coefficients of cross-links in the other two axes and bias. Calibration is performed using the batch method of least squares.

2. Choice of navigation and body coordinate systems, process of initial alignment system. As a local inertial navigation system was selected ENU (East-North-Up) coordinate system. Zero meridian is defined in the direction on North Pole at the initial stage of the alignment.

3. Solving of the orientation problem. This problem was solved by means of Poisson kinematic equation.

4. Solving the navigation problem. This problem is solved by using the navigation algorithm analytical type.

A software package that implements algorithms micromechanical portable strapdown system was designed.

II. EXPERIMENTAL RESULTS

The tests of the system were performed. Static characteristic of designed system is shown on fig.2

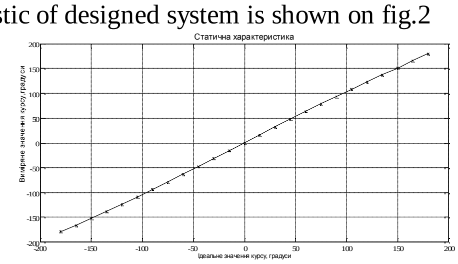

Fig. 2 Angle system static characteristic

Using experimental data were calculating the absolute errors (degrees) of the values for each pitch angle. Graphs are shown on fig.3**.**

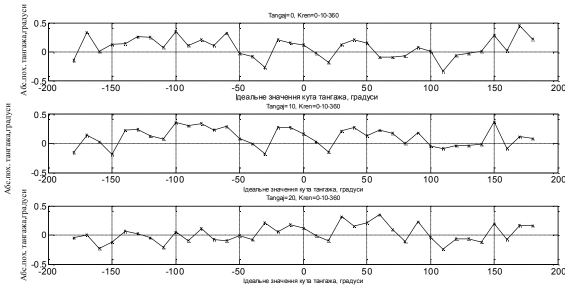

Fig. 3 Errors of measurement orientation angles

Thus, the absolute error of the system by object's roll angle measurement in dependence from pitch is: a) up to 60 degrees - 0.5 degrees; b) more than 60 degrees - 1.5 degrees. The absolute error of pitch angle over the entire range of working angles is 0.4 degrees. RMS error of the system in the entire range of angles - 0.86 degrees.

The absolute error of heading angle over the entire range of angles is 0.8 degrees.

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