AUTOMATION AND COMPUTER-INTEGRATED TECHNOLOGIES

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ODOMETRICAL NAVIGATION SYSTEMS

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***Abstract*—*The technology for determining the location of an object on the ground is the foundation for building vehicle navigation systems and surveillance systems after them. In general, such navigation systems make it possible to determine the coordinates of the vehicle's location and its directional angle, find the direction to the destination, and calculate the coordinates of observation objects. The technical implementation of systems can be quite diverse – from implementation on mechanical elements to their implementation using microelectronics elements. The main factors in the development of navigation systems are the transition to computer-integrated systems and resource-saving technologies. This will make it possible to increase the accuracy of navigation information, obtain a significant gain in the weight and size characteristics of the equipment, reduce its energy consumption and increase reliability. The possibility of modernization of odometrical navigation systems based on integrated computer technologies is considered.*

Index Terms—Navigation; odometer; coordinates; location; destination; steering angle; road system; course system; calculator.

I. INTRODUCTION

Location technology is the foundation for building vehicle navigation systems and surveillance systems after them. In land transport, odometric methods for determining location are most commonly used. In general, odometric navigation systems allow solving three navigation problems in accordance with well-known algorithms [1]:

- determining the coordinates *X*, *Y*, location of the vehicle and its steering angle α

$$\left.\begin{aligned} X &= X_{\text{in}} + \int_0^t v(t)\cos\left[\beta(t)\right]\cos\left[\alpha(t)\right]dt \\ Y &= Y_{\text{in}} + \int_0^t v(t)\cos\left[\beta(t)\right]\sin\left[\alpha(t)\right]dt \\ \alpha &= \alpha_{\text{in}} + \Delta\alpha \end{aligned}\right\};$$

- determining the direction α_{des} to the destination and the shortest distance to it S_{des}

$$\left.\begin{aligned} S_{\text{des}} &= \sqrt{\left(X_{\text{des}} - X\right)^2 + \left(Y_{\text{des}} - Y\right)^2} \\ \alpha_{\text{des}} &= \operatorname{arctg}\frac{\text{Y}_{\text{des}} - Y}{\text{X}_{\text{des}} - X} \end{aligned}\right\};$$

- calculating the coordinates X_{oo} and Y_{oo} of objects of observation

$$\left.\begin{aligned} X_{\text{oo}} &= X + \Delta X_{\text{oo}} = X + D_{\text{oo}}\cos\alpha_{\text{oo}} \\ Y_{\text{oo}} &= Y + \Delta Y_{\text{oo}} = Y + D_{\text{oo}}\sin\alpha_{\text{oo}} \end{aligned}\right\},$$

where are $X_{\text{in}}, Y_{\text{in}}$ is the initial coordinates of the object before the start of movement; α_{in} is the initial directional angle of the object before the start of movement; $v(t)$ is the actual speed of movement of the object; $\beta(t)$ is the angle of inclination of the terrain relative to the horizon plane; $X_{\text{des}}, \text{Y}_{\text{des}}$ are coordinates of the destination; D_{oo} is the distance from the moving object to the object of observation; α_{oo} is the directional angle of the observed object.

Note that the initial data for solving the second problem are not only the coordinates of the destination $X_{\text{in}}, Y_{\text{in}}$, but also the current coordinates of the vehicle X, Y. Without knowing the current coordinates of the vehicle, the third navigation task cannot be solved. So, the first navigation task is the main one.

II. PROBLEM STATEMENT

The functional and logical diagram for solving the first navigation problem is shown in Fig. 1. Its analysis indicates that the generalized components of an odometric navigation system are heading and track systems, a computer and information display devices.

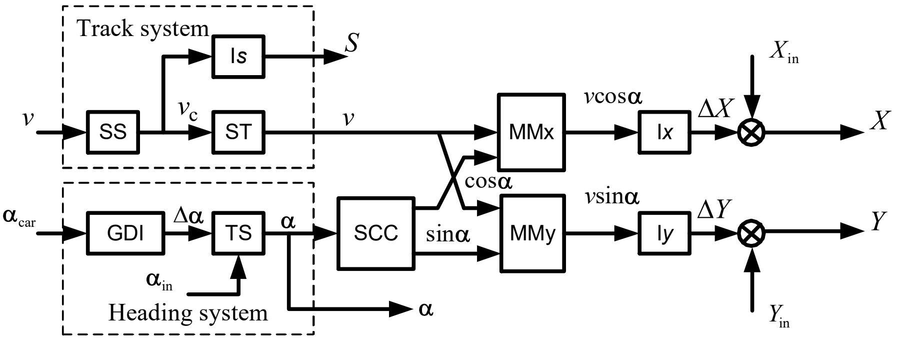

Fig. 1. Functional logic diagram with a continuous counting and solving device:
SS is the speed sensor; I is the integrator; ST is the servo transmission; GDI is the gyro direction indicator;
TS is the tracking system; SCC is the sine-cosine converter; MM is the multiplying mechanism

The technical implementation of each of these parts can be quite diverse. Thus, the first generation of navigation systems were continuous systems. In them, all elements of the functional circuit were implemented by devices with continuous input and output signals. They were performed mainly on mechanical elements. Calculators of this type were characterized by dynamic and static errors caused by the inertia of moving parts, friction in supports, slipping of friction gears and other factors.

Second generation of navigation systems work with discrete signal conversions and are designed using modern electronic-mechanical means and microelectronic elements. The functional and logical diagram of the system with a discrete computer is shown in Fig. 2.

Typically, in discrete systems, a speed sensor SS produces pulses f_{m}, the frequency of which is proportional to the speed of the machine, and their number is proportional to the distance traveled. In a sine-cosine converter SCC, pulses are generated whose transmission frequency f_x, f_y is proportional to the rate of change of coordinates X and Y. The converter C is based on pulses f_x and f_y generates coordinate increment pulses $f_{\Delta x}$, $f_{\Delta y}$ that are supplied to stepper motors EM_x and EM_y of corresponding counters. The level of modern development of automation and technology allows us to offer a computer-integrated odometric system.

III. Problem Solution

The functional and logical diagram of the computer-integrated odometric navigation system is shown in Fig. 3.

The basis of the system is a computer complex designed for entering, storing, processing and transmitting information. The variants of the latest modernizations of odometric navigation of vehicles, providing the necessary quality indicators, can be used as a course and track system. The rangefinder and sighting devices are easy to select within the framework of conversion programs. The system can be programmed to solve both the first and all three navigation tasks. In addition, it can additionally implement methods for determining and correcting initial navigation information under special conditions, set out in [2].

The results of simulation of the solution of the first navigation problem by the TNA-3 odometric navigation systems and the computer-integrated one are shown in Fig. 4.

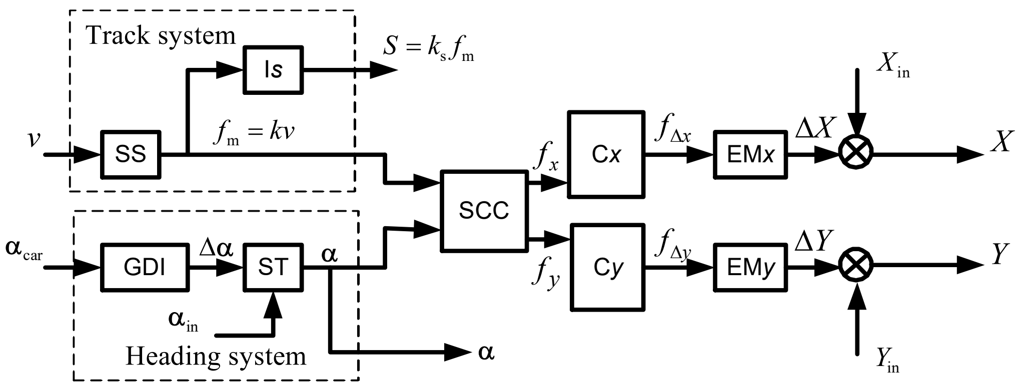

Fig. 2. Functional logic diagram with a discrete computer

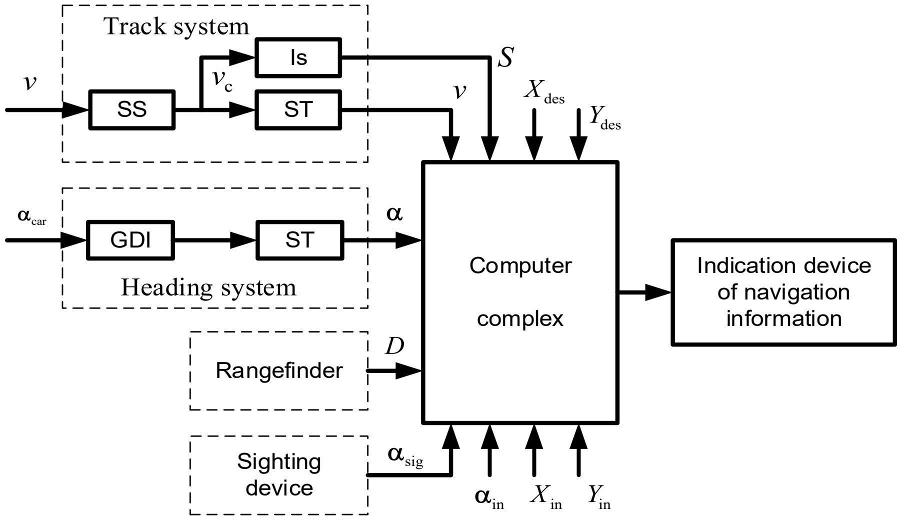

Fig. 3. Functional and logical scheme of a computer-integrated system

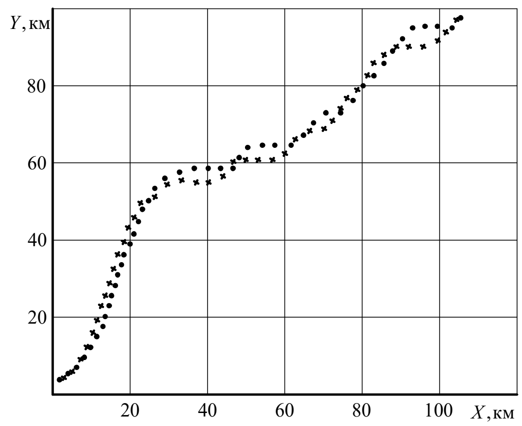

Fig. 4. Simulation results

The route of the vehicle, calculated by TNA-3 equipment, is indicated by dots, and by the computer-integrated system with crosses. On average, the discrepancy of navigation information does not exceed 7%, which confirms the possibility of using computer complexes as computing devices of odometric navigation systems. Improving the software will allow receiving high-precision navigation information.

IV. Conclusions

Modernization of odometric navigation systems based on built-in computer technologies is the beginning of the creation of third-generation systems.

The integration of a computer-integrated odometric system with a satellite one may become a priority. At the same time, its use as an autonomous one is largely justified not only from the standpoint of processing homogeneous navigation information in order to increase its reliability, but also by the need to use only it in special conditions.

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О. К. Аблесімов, О. А. Носова. Одометричні навігаційні системи
Дану роботу присвячено модернізації одометричних навігаційних систем на основі інтегрованих комп’ютерних технологій. Показано, що технологія визначення місця розташування об’єкта на місцевості є основою для побудови навігаційних систем транспортних засобів і систем спостереження за ними. Загалом навігаційні системи дозволяють визначати координати місцезнаходження автомобіля та його дирекційний кут, знаходити напрямок до пункту призначення та розраховувати координати об’єктів спостереження. Технічна реалізація систем може бути досить різноманітною – від реалізації на механічних елементах до реалізації з використанням елементів мікроелектроніки. Встановлено, що основними факторами розвитку навігаційних систем є перехід до комп’ютерно-інтегрованих систем і ресурсозберігаючих технологій. Це дасть змогу підвищити точність навігаційної інформації, отримати значний виграш у масогабаритних характеристиках обладнання, зменшити його енергоспоживання та підвищити надійність.
Ключові слова: навігація; одометр; координати; місцезнаходження; пункт призначення; кут курсу; шляхова система; курсова система; рахунково-вирішальний пристрій.

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