Providing personnel for enterprises of high-tech industries of the Russian Federation in the field of artificial intelligence

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Abstract. The concept of artificial intelligence from the point of view of regulatory documents is revealed, the main areas of development of this technology are given. The current needs of the industry in highly qualified personnel in the field of artificial intelligence are considered. Technical problems are presented that can be solved with the help of artificial intelligence systems, in particular, with the use of computer vision. A generalized structure of a control system for a moving object using artificial intelligence technologies and a conditional diagram of data processing processes are given on the example of a mobile system that moves along a given trajectory. The main approaches to the training of highly qualified personnel in the field of artificial intelligence systems in leading Russian and foreign universities, as well as in the framework of specialized educational courses, are given. The connection of training in the field of artificial intelligence systems with other applied disciplines is established.

1 Introduction. The concept of an artificial intelligence system

To control complex technical objects with the required accuracy and reliability, especially in conditions of uncertainty in the external environment, a promising solution is the use of artificial intelligence technologies, which can increase the reliability of the information output signal, improve the quality of control and the speed of decisions, eliminate the possibility of emergencies due to human factor [1–3]. According to GOST R 59277-2020 "Artificial Intelligence Systems. Classification of artificial intelligence systems" any automatic system that functions without human intervention, and an automated (hybrid) system, the functioning of which is carried out under human control, is an artificial intelligence system (AIS) [4]. At the same time, there are no recommendations for separating automatica systems (with feedback, adaptive, with identification, etc.) from learners and self-learning systems. The classification procedure, the requirements for the quality of functioning, the accuracy of training, the volume of the training samples are determined only by the developer.

The importance of developing intelligent control systems that would solve a wide range of functional tasks, including an independent search for solutions under various external conditions, is emphasized, among other things, by the Decree of the President of the Russian Federation "On the Development of Artificial Intelligence in the Russian Federation", which

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states the need to develop technologies AIS in relation to various areas of knowledge and its use in the development of modern technical systems and control systems for various kinds of objects [5].

The National Strategy for the Development of Artificial Intelligence for the Period up to 2030 includes [5]:

- support for scientific research;
- development and evolution of software;
- increasing the availability and quality of data;
- increasing the availability of hardware;
- creation of an integrated system of regulation of public relations;
- increasing the level of provision of the Russian market of artificial intelligence technologies with qualified personnel.

At the same time, the last point can be noted as the most important, since the introduction of AIS in solving the priority tasks of the industry can be carried out only with the involvement of highly qualified specialists in the relevant field.

2 Industry Requests and Application of AIS

Let's consider some urgent problems, the request for the solution of which comes from high-tech industries and involves the use of AIS technologies, on the example of vision systems for moving objects.

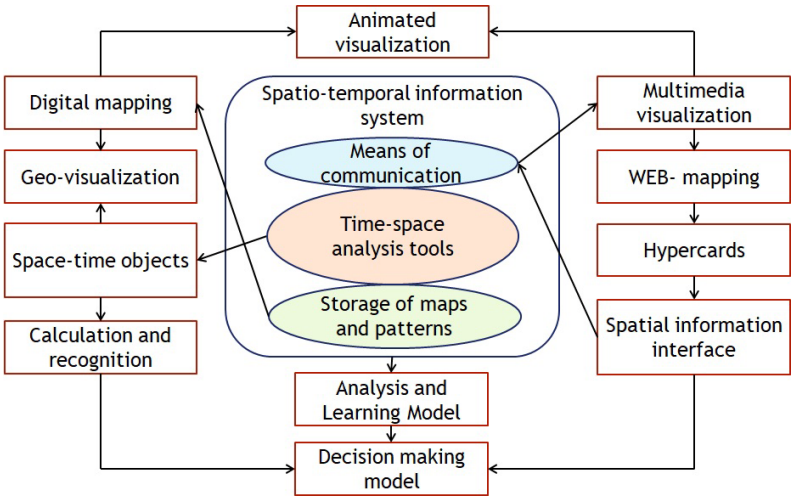

Figure 1. Generalized structure of a control system of a moving object using artificial intelligence technologies

When creating vision systems, it is necessary to solve the following algorithmic problems [2, 6–9]:

- preliminary image processing from optoelectronic sensors (changing the brightness range, highlighting the boundaries of objects, forming related fragments, etc.) in order to improve the vision systems of a technical object;

- development of algorithms for geometric alignment of images from video sensors and synthesized images in real time;
- development of algorithms for detecting and recognizing reference zones (points, lines, contours, etc.), as well as foreign objects located on the trajectory of movement, etc.

In the figure 1 shows a generalized structure of a control system of a moving object using artificial intelligence technologies.

Thus, in order to develop visual recommendations, the vision system must be able to solve the following tasks [7–10]:

- visually identify and recognize the terrain and obstacles;
- to carry out mutual referencing and integration of sensory and geospatial information;
- to carry out the synthesis of the image based on the integration of navigation information and information from the databases of the terrain and obstacles;
- to carry out photogrammetric processing of 2D and 3D data to create digital terrain models;
- to obtain an estimate of the distance from a moving object to a selected point;
- to obtain estimates of the trajectory and angular position of the moving object in space, as well as to form comparative estimates of the position of the moving object relative to a given route;
- to form the values of control signals for the timely correction of the trajectory and angular motion of the moving object;
- to carry out human-machine communication using interfaces.

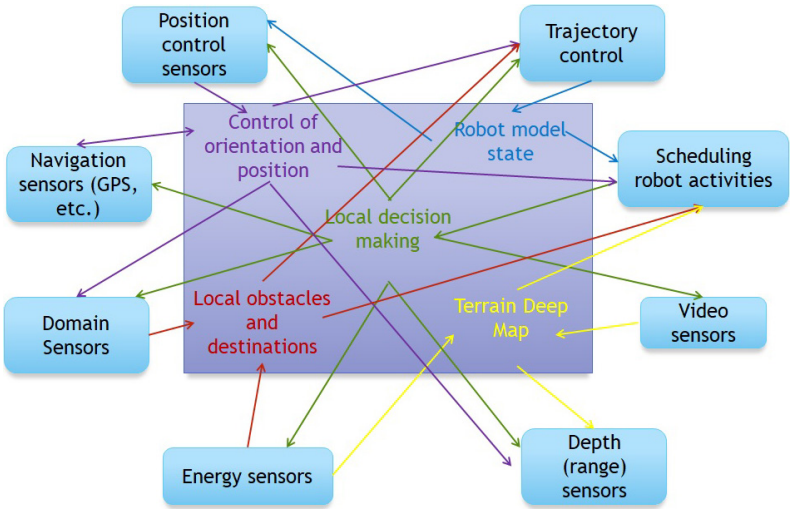

Figure 2. Schematic diagram of data processing processes in a mobile system for simultaneous position localization and terrain mapping

Simultaneous mapping of the surrounding area and assessment of the position of the robot allows, for example, to avoid collisions with obstacles or entering a danger zone. Scanning laser rangefinders (SLRs) and a visual odometry system are most commonly used as hardware for such systems. SLRs scans a sector of the surrounding space and returns a vector of distances to obstacles, for example, every degree.

To perform mapping and localization tasks, a mobile object must be equipped with an appropriate set of sensors, as well as a different set of computing facilities and software modules for data processing [2, 11]. Sensors, in fact, are operational data sources, and the corresponding buffers for the accumulation of sensory information are operational information databases [10]. In the figure 2 shows a schematic diagram of data processing processes in a mobile system for simultaneous position localization and terrain mapping.

The data from the corresponding sensors are sent to the units for controlling the orientation and position of the moving object, assessing its condition, finding local obstacles and destinations, compiling a depth map of the area, and, ultimately, in the unit for local decision making.

In the figure figure 3 shows the architecture of a typical system that implements the basic methods of visual odometry and terrain mapping.

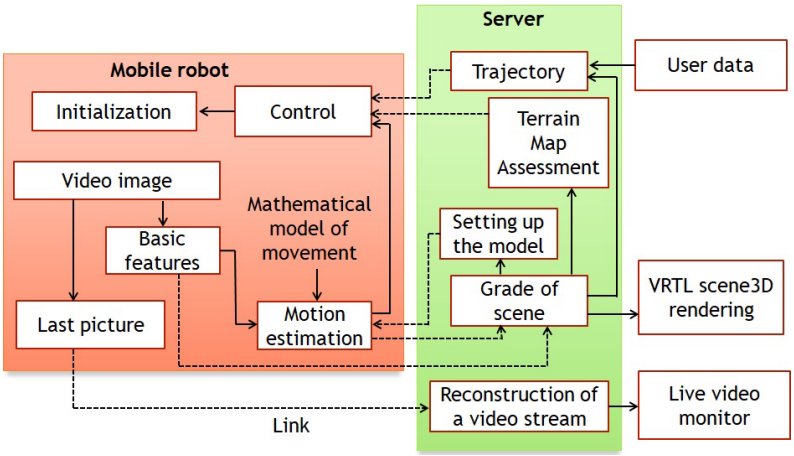

Figure 3. The architecture of a typical system that implements the basic methods of visual odometry and terrain mapping

First, preliminary processing of data on the current state of a moving technical object (for example, from a gyroscopic unit) and visual information is carried out [2]. Then one part of the data is transmitted either via a communication channel for subsequent processing (for example, to solve the tasks of planning the subsequent movement and identifying the desired objects in the search zone) to an external server, or processed by a decision-making unit, provided that it can be placed on a mobile technical object. Another part of the processed data is directly used on site to stabilize the position of a moving technical object.

3 Training of personnel in the field of AIS in the universities of the world and the Russian Federation

In accordance with the Decree of the President of the Russian Federation on the development of artificial intelligence, the directions of increasing the level of provision of the Russian market of artificial intelligence technologies with qualified personnel include [5]:

1) development and implementation of educational modules within educational programs of all levels of education, advanced training and professional retraining programs;

2) attracting organizations operating in the field of artificial intelligence to participate in activities aimed at the development of general and professional education;

3) an increase in the number and an increase in the attractiveness of competitions and olympiads aimed at developing the intellectual and creative abilities of students.

From the classification list of GOST R 59277-2020 "Artificial Intelligence Systems. Classification of artificial intelligence systems" it follows that a specialist in AIS should have a more extensive amount of knowledge, in comparison with a specialist in conventional automatic control systems [4]. Convergent knowledge, provided, among other things, through the integration of mathematics, natural science, and social and humanitarian education, is gaining priority. The relationship of training in the field of AIS with other applied disciplines is shown in figure 4.

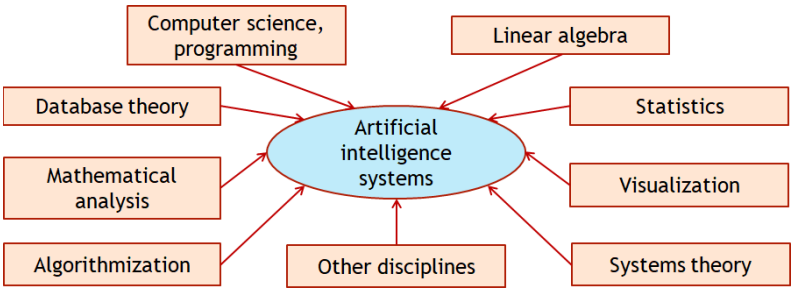

Figure 4. The relationship of training in the field of AIS with other applied disciplines

Almost all the leading technical universities in the world declare the possibility of training specialists in AIS. Moreover, artificial intelligence is being poured into completely different areas of training—business informatics, economics, information systems and technologies, applied informatics, mining, management, ecology and nature management, biology, control in technical systems, automation of technological processes and many others. At the same time, universities provide students with the opportunity to gain competencies in the most relevant areas related to artificial intelligence: computer technology, cryptography, intellectual analysis, parallel and distributed data processing, mathematical modeling, digital hardware, robotics, machine learning, and others. This makes it possible to train specialists capable of creating a technological base for ultra-fast computing, quantum computers, complex communication systems, software systems for machine learning, analyzing bigdata, predicting and calculating risks, modeling complex processes. At the same time, an important feature of the educational process is in-depth mathematical training of students, with an emphasis on the use of mathematical disciplines in the field of information technology.

However, the intensive development of AIS technologies has led to the fact that many universities are even so unable to quickly change their curricula and prepare the appropriate teaching staff for the implementation of new achievements of artificial intelligence. In this regard, a lot of commercial courses have appeared, mainly on-line, giving the necessary competencies to specialists of generally accepted profiles. Among such programs, there are a lot of courses for people who do not have the required foundation of knowledge, and only want to understand the essence of the new directions of AIS. However, in a number of cases, together with universities for which it is difficult to quickly change the curriculum, such courses allow to produce highly qualified specialists in the field of AIS. The duration of training on such courses, with appropriate software and technical support, is from 7 to 15 months.

4 Conclusions

In GOST R 59277-2020 "Artificial Intelligence Systems. Classification of artificial intelligence systems" there are no recommendations on the separation of automatic systems from learning and self-learning systems. However, an AIS specialist requires a broader body of knowledge and technical horizons than an automatic control specialist. So, more in-depth knowledge of the theory of probability and mathematical statistics, the theory of random processes, the theory of automatic systems, the theory of algorithms, mathematical logic, the main sections of the theory of computer vision and others is needed. The urgent task now is to create a comprehensive classification of methods and tools used in the creation of AIS and training in the field of AIS.

There are real practical tasks in various fields of activity that can be solved using artificial intelligence technologies (automatic visual route control, mapping of the surrounding space, estimation of the position of the robot, integration of sensory and geospatial information, etc.). In this regard, most of the leading universities in the world and in Russia offer educational programs that include the development of competencies in various aspects of artificial intelligence in a wide range of areas.

Mastering a complex body of knowledge in the field of artificial intelligence using training programs provides highly qualified specialists who are able to make sophisticated technological decisions to imitate human cognitive functions (including self-learning, finding solutions without a predetermined algorithm and achieving insight).

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