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Systems of Geo Positioning of the Mobile Robot

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Abstract. Article is devoted to the analysis of opportunities of electronic instruments, such as a gyroscope, the accelerometer, the magnetometer together, the video system of image identification and system of infrared indicators during creation of system of exact positioning of the mobile robot. Results of testing and the operating algorithms are given. Possibilities of sharing of these devices and their association in a single system are analyzed. Conclusions on development of opportunities and elimination of shortcomings of the received end-to-end system of positioning of the robot are drawn.

Introduction

In modern economy special attention is paid to problems of transfer to robots of routine work, and also the works connected with the increased danger. It is for example carrying out field works, navigation in conditions of increased content of toxic agents. If to consider only agricultural machinery, then the increasing application is found by automatic control systems the movement and systems of parallel driving. Similar systems include the electronic intellect consisting of a mathematical apparatus and system of sensors and the executive mechanism allowing to transform solutions of electronic intellect to the relevant movements of the robot. The robot can independently move, but be under control of the operator. The operator can interfere with operations of the robot in situation which cannot independently process by the robot. For example, the robot does not learn the area, or the robot noticed unfamiliar objects. Use of robots during the field works allows to accelerate significantly processing of the soil and to lower costs of the energy carrier, including due to decrease in mass of the robot.

The majority of systems of automatic piloting use possibilities of satellite positioning of GLONASS or GPS [1, 2, 5]. With different degree of success, attempts of use of systems of machine vision [3, 4], and also the end-to-end systems of positioning including the different principles [6] are made. However It should be noted that in spite of the fact that high-precision systems of satellite navigation allow to position the robot with an accuracy of several centimeters use them is not always justified from the financial and technical points of view. Moreover use of systems of local positioning is a good opportunity for development of the mathematical and technical apparatus.

Proposed solutions

At development of the system of positioning it is necessary to consider hardware features of each of the making subsystems. The skeleton diagram of the received system of positioning is submitted in the figure 1. Actually the following blocks are engaged in data collection: *F_images()* image identification subsystem, *F_satellites()* positioning subsystem on the basis of satellite navigation, *F_beacons()* subsystem of definition of a position on the basis of external infrared beacons, *F_inertia()*

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positioning subsystem on the basis of inertial mechanisms and magnetic field of the earth, *F_communication()* subsystem of external control and coordination of the movement.

The *F_intel()* function obtains data from the subsystems *F_intel(F_satellites(t), F_beacons(t), F_images(t), F_inertialt(t), F_communication(t))* and makes a decision on management of the executive bodies of the robot, proceeding from an objective and indications of subsystems of information collection.

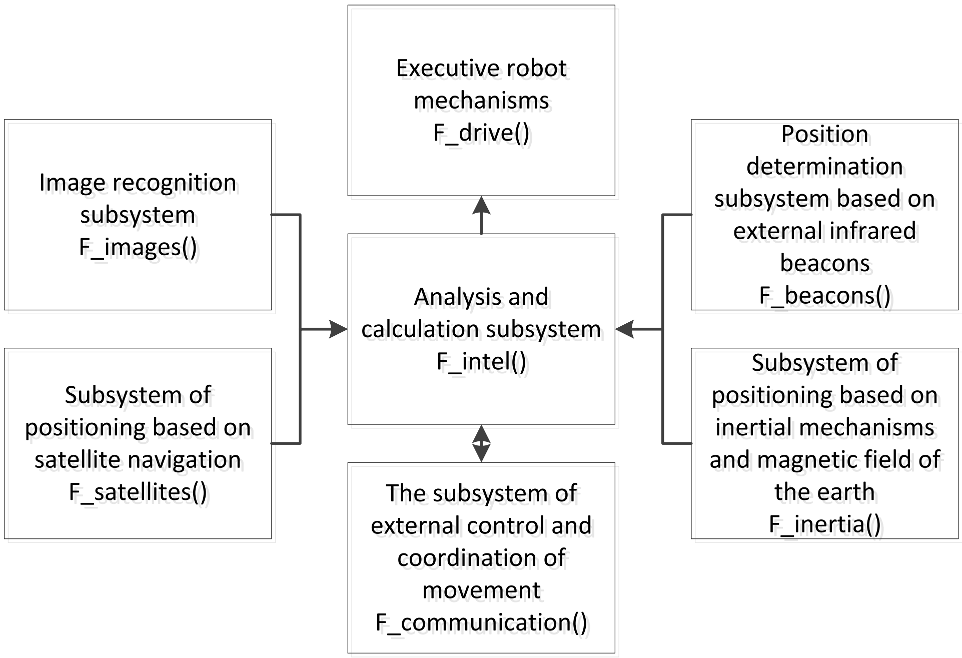

Figure 1. Structure diagram of an end-to-end system of positioning of the robot

The image identification subsystem involved on the robot is based on use of library of computer sight of OpenCV. The program processing information through OpenCV functions on the single board computer RaspberyPI which is equipped with system of video cameras. The method of recognition of graphic images on the method of Harris Corner Detection [3, 5]. The program is able to define standard obstacles, such as trees, bushes, columns, large animals and people, to select unfamiliar objects, for example, the equipment thrown in the field. Anyway information is transferred to the Subsystem of the analysis and calculations which should make a decision on processing of a regular or emergency situation. Information is transferred in the look represented in the figure 3, surely includes distance to an object, the object sizes, an object arrangement concerning the robot, the speed of its movement and a motion vector. Of course, these data cannot be considered completely reliable, they are in addition analyzed and compared to information from other subsystems and the internal map put in the robot. In necessary cases additions are made to the internal map. Use of several spaced cameras gives the chance to measure distance to objects and there's size. The history of coordinates uses to measure the speed of objects, relative in relation to the robot.

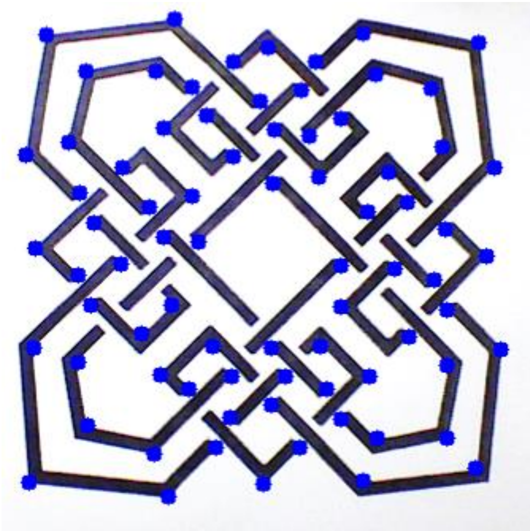

Figure 2. Matching interest points of graphic images on the method of Harris Corner Detection

It is worth noticing that the pattern recognition system has no idea of robot motion speed, but can take part in its measurement on a measurement base of characteristics of motionless objects. In other words, if it is known that an object is not mobile, but its characteristics (the size and motion vector) changes, there forms a basis for calculation of the robot speed.

Information is transferred in a matrixes I_j, where j - number of the found object.

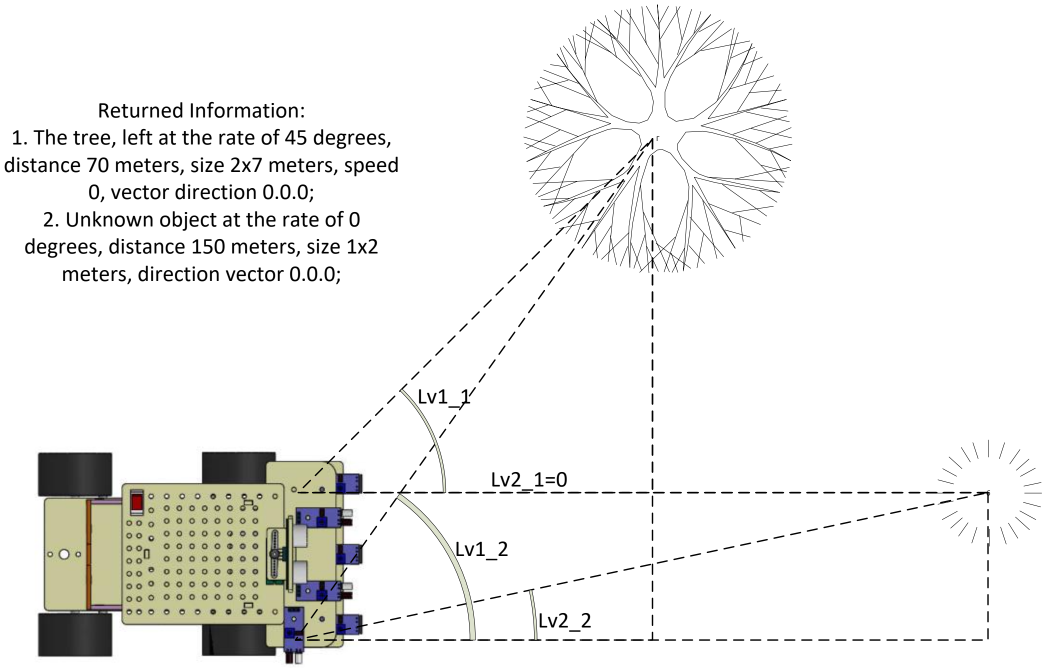

Figure 3. Work of a subsystem of image identification

The subsystem of a position definition on the basis of external Bluetooth and RFID was in details described by us in [4]. On perimeter of a field the infrared frequency-modulated beacons differing in the coded signal are installed. On the robot the system of rotary infrared sensors is installed. Corners between a motion vector of the robot and the direction to indicators are determined by sensors, and by

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the use of several sensors distance is calculated (fig. 4). Such system gives the chance to lay a route across the field and rather precisely to adhere to it.

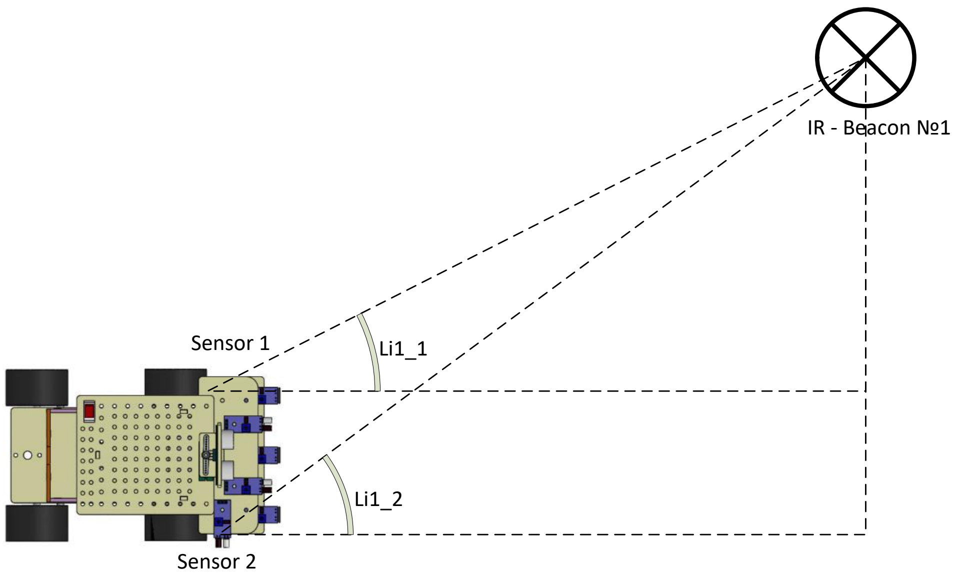

Figure 4. Robot and RFID (determination of coordinates of the beacon)

The values calculated in this subsystem include the following fields:

1. The number of the found beacons;
2. Identifiers of beacons which include the individual numbers of coded by a frequency modulated signal;
3. The distance to each of the found beacons calculated by the principle of stereosight due to use of two or more sensors of an infrared modulated signal;
4. Corners to all found beacons.

Information is transferred in a matrix IB_k where k **-** number of the found object.

The positioning subsystem on the basis of inertial mechanisms and magnetic field of the earth includes at least on one electronic instrument of the following type: gyroscope, accelerometer, compass/magnetometer. The data obtained from devices are processed therefore the matrix Pk in which the following information forms are presented:

1. Turning angle of the robot of rather initial "null value";
2. Vector of acceleration of the robot;
3. Time of measurements;
4. Estimated error.

The positioning subsystem on the basis of satellite navigation consists of the GPS/GLONASS module and the microprocessor module of primary analysis of the acquired information. The subsystem transfers the following information:

1. Geographical coordinates of the robot;
2. Direction movement of the robot;
3. Robot speed.

Information is transferred in a matrix *SN*.

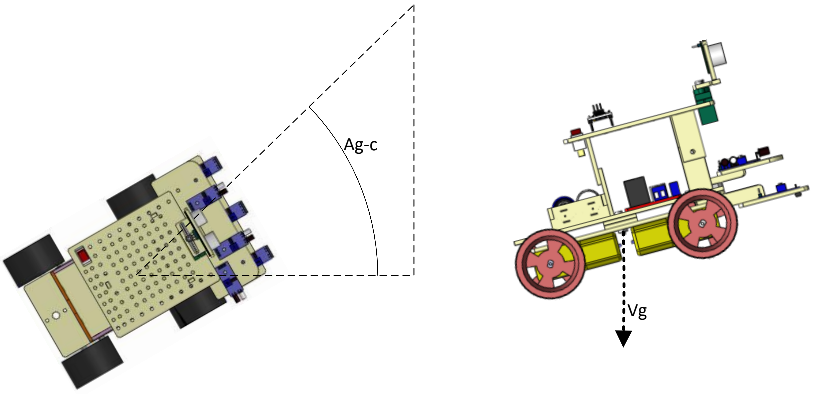

Figure 5. The robot (inertial, gravitational, magnetic sensors), where Ag-c - a turning angle of the robot, Vg - an acceleration vector

The subsystem of external control and coordination of the movement *F_communication()* can execute several functions, one of which is visual observation of the robot in the automatic mode, visual tracking of its characteristics and transfer of the calculated information to a subsystem of the analysis and calculations. In this case the block of visual observation in the form of a complex of video cameras and the microprocessor block of calculation on the basis of visual images is in a subsystem. Let's notice that this subsystem can be stationary or to have "moving bases", for example, in the form of the flying device (balloon) which can conduct simultaneous observation at once or in turn behind several mobile robots.

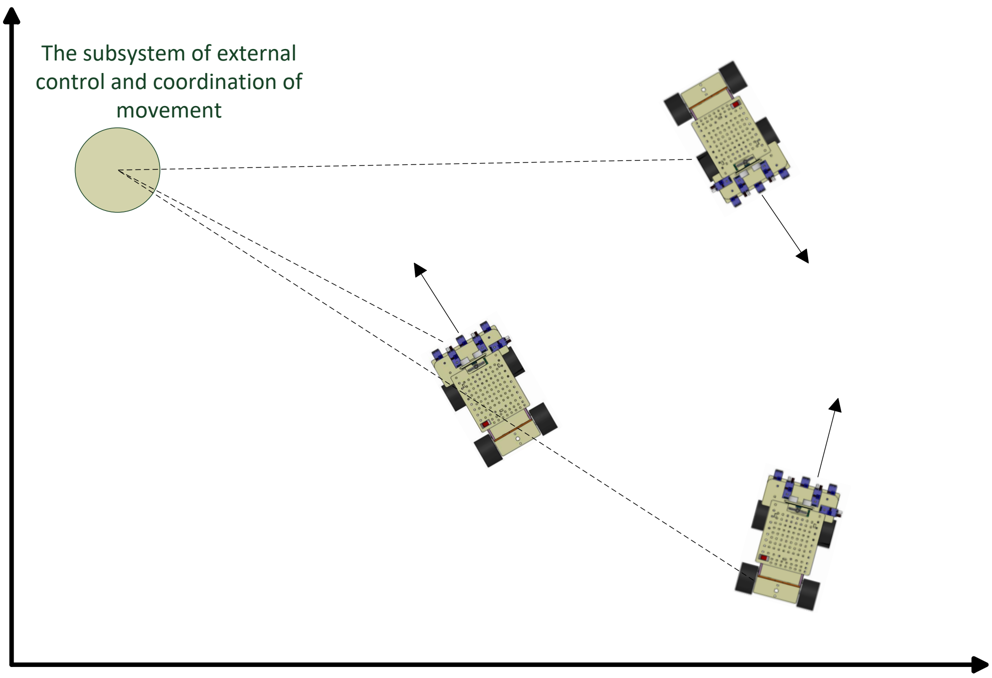

Figure 6. Demonstration of external observation of robots

The subsystem transfers the following information:

1. Coordinates of the robot of rather local section;
2. Direction movement of the robot;
3. Robot speed;
4. Probable obstacles.

Information is transferred in a matrix *EO*.

Accuracy of indications of the above described subsystems has some error, and during certain time frames of the indication can be absent or be less informative, for example, during fog, smoke, at failure of a part of the equipment – satellite system of positioning. Therefore, the algorithm for mixing data and calculating the "reliable" coordinates of the robot and the vector of its movement must be flexible enough and work with incomplete information.

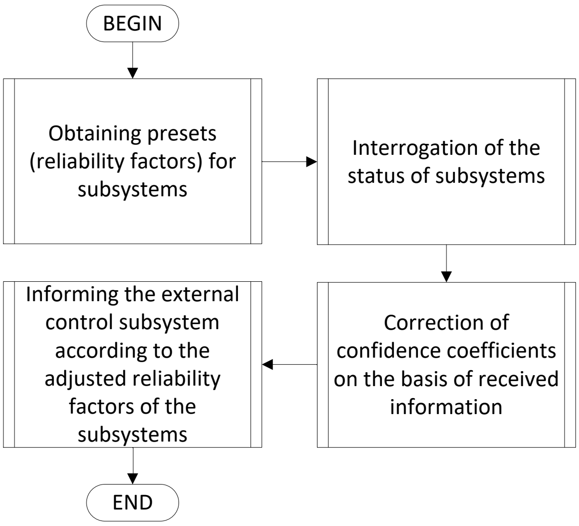

Figure 7. Formation of coefficients of subsystems reliability

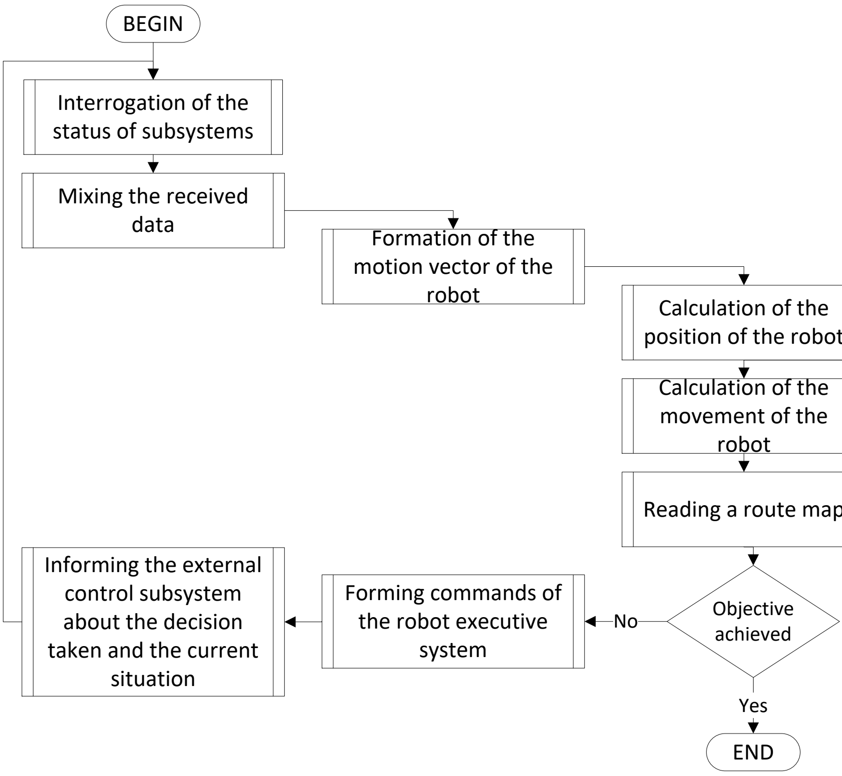

Figure 8. An algorithm of work of a subsystem of the analysis and calculations at the movement of the robot on the set trajectory

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Conclusions

As a result of use of the above-stated solutions the system of positioning of robots of agricultural purpose which allows to carry out field works with high accuracy without obligatory binding to high-precision system of positioning on the basis of GPS/GLONASS is created. The system has the small cost and high rates of quality. Integration of the specified system in a complex makes possible to receive the most effective structure from the point of possession cost.

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