The future of the application of microcontrollers in the agriculture digitalization

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Annotation. This paper discusses the problems of agriculture digitization, shows the reasons for its appearance. One of the ways to solve these problems is proposed on the basis of the modern Arduino microcontroller platform implementation. A brief review of its capabilities for building distributed systems for collecting and processing information has been carried out. The task of training qualified IT specialists in the field of microcontroller technology is highlighted. Briefly reviewed the main aspects in the education and training of such specialists, as well as the technology of their training.

Currently, in connection with the implementation of the economy digitization programme [1,2], more and more attention is being paid to the application of information technologies in various areas of economic activity. This problem is particularly severe in the field of agriculture digitization [3].

One of the significant factors hindering the application of modern IT - technologies achievements into the agricultural activity area is the persistent belief of the heads of agricultural enterprises that this is a very expensive pleasure.

However, today there are solutions that automate many agricultural activity processes at low financial costs. These solutions are based on the use of modern microprocessor technology, and, in particular, modern microcontrollers.

One of these solutions is the use of the Arduino platform. This platform includes a number of different modules for various purposes, and essentially represents a kind of "constructor" that allows you to build monitoring and automated control systems for a variety of purposes. Most modules have interface nodes - additional nodes and blocks that simplifies the assembling of modules without the use of additional transition elements [4].

An important advantage of the Arduino platform is the freely distributed Arduino IDE, which allows you to develop your own program and write it into the microcontroller flash memory [5]. This IDE uses the language "Processing / Writing" for program development, which is essentially similar with a popular C ++ programming language, extended with built-in functions for inputting and outputting information through the contacts of microcontroller. The use of the Arduino IDE greatly facilitates and accelerates the development of programs, including through the presence of a large number of specialized libraries to perform typical (and fairly high-level) operations with specialized modules that are part of the Arduino platform.

The main computing nodes that provide the solution of applied problems and the corresponding control of peripheral modules are widely used Atmel microcontrollers based on RISC processor cores - AVR and ARM Cortex® families [6].

The top row in the figure 1 shows microcontroller modules based on 8-bit AVR ATmega processor core, which operate at clock frequency up to 16 MHz. These modules have different interface nodes and the quantity of input / output signals, as well as the type of internal devices of microcontroller devices such as timers - counters, analog - digital and digital - analog converters, etc.

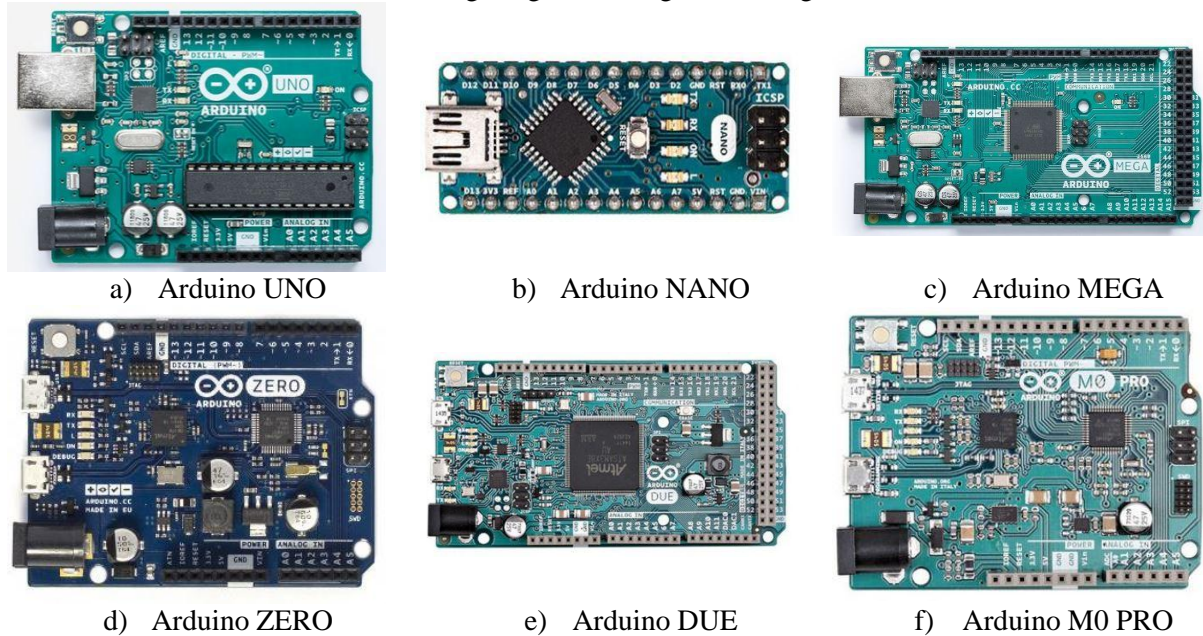|		
a) Arduino UNO	b) Arduino NANO	c) Arduino MEGA
d) Arduino ZERO	e) Arduino DUE	f) Arduino M0 PRO

Figure 1. Arduino Platform Microcontroller Modules.

The bottom row in the figure 1 shows three microcontroller modules based on high-performance 32-bit ARM Cortex® architecture cores, the best of which (in terms of performance) operate at clock frequency up to 84 MHz.

As part of the Arduino platform, there are also exist modules that organize data transmission using modern information and communication technologies (Figure 2), which in turn are widely used in modern networks [6].

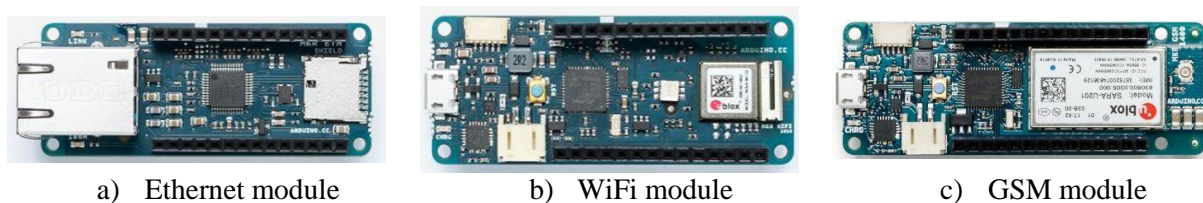|		
a) Ethernet module	b) WiFi module	c) GSM module

Figure 2. Arduino platform modules used in information and communication networks.

All the modules mentioned above are composed of one or another microcontroller. Blocks that organize data transmission using various network technologies are connected to this microcontroller.

Figure 2a shows a module that allows you to use or organize your own network based on Ethernet technology, which uses a twisted pair cable as the physical medium.

To connect systems based on the Arduino platform to wireless networks based on WiFi technology, the module shown in Figure 2b is used. Using it as an access point allows you to create your own wireless networks suitable for building distributed systems for monitoring and controlling various processes in agricultural production.

Figure 2c shows a module for transmitting data over cellular networks using GSM technology. It is used to organize the information exchange throughout the coverage area of such networks.

To solve the problem of monitoring the state of various objects, the Arduino platform contains a set of sensors [6], some of which are shown in Figure 3.

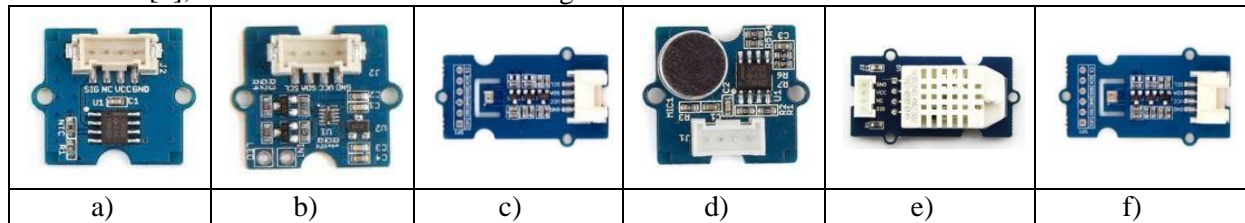| a)	b)	c)	d)	e)	f)

Figure 3. Sensors for state monitoring.

The set of such sensors includes:
- various temperature sensors (Figure 3a),
- light sensors operating in the infrared, visible and ultraviolet ranges of the spectrum (Figure 3b),
- atmospheric pressure meters (air pressure) (figure 3c),
- sound sensors (acoustic oscillations) (figure 3d).

There are also combined sensors, such as the temperature and humidity (air) sensor shown in Figure 3e, the temperature, humidity and pressure sensor shown in Figure 3f.

The Arduino platform also does not exclude the possibility of connecting other third-party devices, which makes it very versatile and attractive for developing automation systems for various fields of agricultural activity.

An additional advantage of the Arduino platform is the low cost of components: for the modules shown in Figures 1, 2, it is measured in hundreds of rubles; the cost of sensors is several times less.

Thus, the considered platform provides opportunities for the development of inexpensive systems for various purposes and scale, which is especially important for agricultural enterprises.

After using the Arduino platform in the agro-industrial complex, the following positive prospects are expected:

Firstly, many young graduates and specialists will be attracted to work in rural areas. One of the main problems of the outflow of professional personnel from rural areas is that they do not want to make great efforts to perform routine and physically hard work, which is associated with agriculture. This situation is aggravated by the fact that automation of work and improvement of working conditions is going very slowly compared to European and American farms. The use of structures and mechanisms based on the Arduino platform will solve almost all these problems. This will make work in the village much more attractive for young people, as well as enhance the prestige of posts related to agriculture.

Secondly, the productivity of rural farms will increase. Automatic execution of many important processes will reduce the number of errors, inaccuracies and other manifestations of the human factor, which negatively affect the quality and volume of the crop. People will spend less effort on various heavy, monotonous, but necessary procedures, such as watering, airing or fertilizing. People will act as managers; they will have the opportunity to evaluate the results of labor in appropriate conditions.

Thirdly, workers at automated agricultural facilities will be able to obtain more useful information required for analysis or decision making. For example, it will be possible to monitor the growth rate of crops during different irrigation cycles, select the most appropriate irrigation frequency for a given area and climatic conditions. And at the same time they will not need to rely on generalized information from open sources, because the data collected with sensors will be available.

Fourthly, the use of the Arduino platform requires the relatively low monetary costs, which is beneficial for small farms. Currently, the production of automated equipment for agriculture in Russia is not well developed. Most of these structures and mechanisms are imported, which leads to higher costs for the purchase of such devices for individual entrepreneurs or farms of small settlements with a small budget. And designs based on the Arduino platform will save a lot of money.

Unfortunately, the implementation of such projects faces the problem of a shortage of qualified personnel needed to develop specialized systems based on microcontrollers. This problem should be solved precisely by agricultural universities, which have in their staffs qualified specialists in the field of agricultural activity.

The use of the Arduino platform and the automation of agricultural production requires the expansion of the training of IT specialists at universities in the use of microcontroller and microprocessor technology, and, in fact, this task has been set for agricultural universities [7-12].

The low price allows the Arduino platform to be widely used in the educational process due to the clear programming environment and the ability to monitor physical processes in real time, as well as to design various automated systems and robots. More powerful Arduino boards can be used to research and solve complex technical problems related to the development of large projects and integrated automation.

In addition, the use of this platform in practical classes in the process of preparing future IT specialists for the agro-industrial sector, allows not only to engage students in their specialty, but also leads to improving their practical skills in designing, developing information systems, and allows to improve knowledge and programming level. The use of the Arduino platform in the educational process expands the knowledge of IT students in areas of the purely agricultural sciences such as agronomy, soil science, animal husbandry, and so on. This leads to the strenghtening of interdisciplinary relations and contributes to improving the quality of education.

Practical training of students in the form of internship in actually functioning enterprises is one of the main tasks of training future specialists. Carrying out the installation, configuration, maintenance and work with devices based on the Arduino platform directly on the territory of farms will provide the knowledge and experience necessary for further employment, will increase the motivation to acquire knowledge. In addition, practical developments and innovations will convince people of the real demand for this type of inventions.

The application of these automated devices in agriculture creates separate units for certain tasks, as well as complete and complex systems, for example, whole greenhouses or poultry houses, fully serviced in an automatic way. The prospect of full automation of some processes will positively affect the productivity of farms and the salary scale for trained specialists.

Thus, the use of the Arduino platform seems promising in many aspects. Low cost of products and the possibility of a wide range of applications in real conditions of agriculture and in personnel training is one of the ways to solve the tasks set by the Digital Economy Programme.

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