Mobile robot for running exercises

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Abstract. Progress does not stand still, and machines are involved in the process of training professional athletes, where the greatest restriction is economic in nature - simulators are not available to a wide range of users. The field of running sports is currently practically not provided with robotic support in such a way that with the help of machines it was possible to implement the process of training an athlete. This article is devoted to the construction of the concept and principles of the implementation of a mobile robot for performing running exercises.

1. Introduction
Due to the intensive growth of technological progress, modern robotics as a science, in one way or another, affects most areas of society socialization. The expansion of areas of application of robotics occurs constantly, simultaneously with the growth of human needs, and today one of the most relevant branches of development is the field of sports robotics.

With the help of robots, sports equipment is tested, control and accounting processes are performed to record the results of sports competitions, and finally, competitive training is carried out, aimed at performing basic exercises that can eventually improve the performance of professional athletes.

This article does not consider the simplest mechanical devices, such as ball-serving machines in tennis and baseball, which serve with different forces and at different angles in a given range. A significant disadvantage of such robots is their one-sidedness – such a device will not respond to a counter feed. Therefore, of the already implemented solutions, manipulator robotics is usually used [1, 2] (figure 1 a, b).

Figure 1. Training robots-manipulators for: a) table tennis; b) volleyball
2. Concept

It is proposed to develop a mobile robot for novice athletes, competing with a group or individual athletic running segments with a set time when moving around the stadium. In the course of calculations of technological parameters of components of the prototype being developed, it was decided to consider the task of using a mobile runner robot as appropriate [3].

Table 1. Material development costs

| Name of materials, Ed. ed.                  | Units | Quantity | Price per unit, RUB. | The total amount of |
|--------------------------------------------|-------|----------|----------------------|---------------------|
| Arduino UNO platform                        | Pcs   | 1        | 299                  | 299                 |
| Photodiodes TEMD5080X01                      | Pcs.  | 4        | 37                   | 148                 |
| Motor driver L293D                           | Pcs   | 1        | 220                  | 220                 |
| El. Engine MY6812                            | Pcs.  | 2        | 2200                 | 4400                |
| Battery RED ENERGY DS 1205                   | Pcs.  | 1        | 2125                 | 2125                |
| ResistorS2-23 2W-0R22-5%                    | Pcs.  | 4        | 8                    | 32                  |
| Housing (aluminum 3x1200x3000 mm 1105anr)   | Pcs   | 2        | 210                  | 420                 |
| Housing treatment                            | Pcs   | 1        | 500                  | 500                 |
| Wheel 65 mm                                  | Pcs   | 4        | 160                  | 640                 |
| **Total:**                                   |       |          |                      | **8784**            |

The appearance of the mobile robot runner is a frame, lower and upper parts of the body. The frame bearing the entire load from the mass of the engine, battery, controller and sensors is shown in figure 2, the location of the components is shown in figure 3.

![Figure 2. Appearance of the prototype under developed](image-url)
The dimensions of the mobile robot are not stated in this article, because they may change during the actual process of device assembly.

The dimensions of the housing do not exceed the parameters of the DW: 276 × 197 × 126 (mm).

The fundamental principle of sports competitions is to compete with the opponent. This kind of work encourages you to improve your own performance, and the prototype you are developing acts as an opponent on the treadmill. The mobile app sets the distance and time to cover it. The speed of movement of the device on the treadmill depends on these parameters. The athlete, accordingly, follows the robot for the purpose of overtaking, or accompanies the robot in order to keep within the range of the set time. The robot's trajectory is determined by fixing the sensor dividing strip between the stadium's running tracks. At the end of the workout, the mobile app saves all parameters (distance, time, speed, and the athlete's heart rate (if you have a fitness bracelet connected to the app via Bluetooth)) it also displays summary statistics in comparison with the current standards of athletes' training [4].

The estimated power of the prototype being developed, taking into account the implementation of the process of training non-professional athletes, should allow to develop a speed sufficient to meet the standard "candidate for master of sports" inclusively at a distance of up to 600 m, as well as passing long distances of up to 5 km by athletes, inclusive [5].

Discharge standards for women and men are presented in tables 2 and 3, respectively.

![Diagram of the prototype's components](image)

**Figure 3.** Location of components of the prototype under development
### Table 2. Digit standards for men at distances up to 600 m
(Minutes: seconds, fractions of seconds)

| Distance | Circle | Kms Circle | I (u) | II (y) | III (y) |
|----------|--------|------------|-------|--------|---------|
| 30m      | -      | -          | 4,2   | 4,4    | 4,7     |
| 50m      | -      | -          | 6,1   | 6,3    | 6,6     |
| 60m      | -      | 6,8        | 7,1   | 7,4    | 7,8     |
| 100m     | -      | 10,7       | 11,2  | 11,8   | 12,6    |
| 200m     | -      | 22,0       | 23,0  | 24,3   | 26,0    |
| 200m     | 200m   | 22,4       | 23,4  | 24,7   | 26,4    |
| 300m     | -      | 34,5       | 36,2  | 38,7   | 41,6    |
| 400m     | 400m   | 49,5       | 52,0  | 56,0   | 1:00,0  |
| 400m     | 200m   | 50,3       | 52,8  | 56,4   | 1:00,8  |
| 600m     | 400m   | 1:22,5     | 1:27,5| 1:33,5 | 1:40,5  |
| 600m     | 200m   | 1:23,7     | 1:28,7| 1:34,7 | 1:41,7  |

### Table 3. Level standards for women at distances up to 600 m
(Minutes: seconds, fractions of seconds)

| Distance | Circle | Kms Circle | I (u) | II (y) | III (y) |
|----------|--------|------------|-------|--------|---------|
| 30m      | -      | -          | 4,9   | 5,1    | 5,3     |
| 50m      | -      | -          | 6,9   | 7,3    | 7,7     |
| 60m      | -      | 7,6        | 8,0   | 8,4    | 8,9     |
| 100m     | -      | 12,4       | 13,2  | 14,1   | 15,1    |
| 200m     | -      | 25,5       | 27,1  | 29,2   | 31,5    |
| 200m     | 200m   | 25,9       | 27,5  | 29,6   | 31,9    |
| 300m     | -      | 40,5       | 42,8  | 45,5   | 49,5    |
| 400m     | 400m   | 57,5       | 1:01,5| 1:06,0 | 1:11,0  |
| 400m     | 200m   | 58,3       | 1:02,3| 1:06,8 | 1:11,8  |
| 600m     | 400m   | 1:36,5     | 1:43,0| 1:50,5 | 1:59,0  |
| 600m     | 200m   | 1:37,7     | 1:44,2| 1:51,7 | 2:00,2  |

In the case of group training sessions, the robot calculates the average speed and starts moving in front of a group of athletes at the command of the mobile app. After the segment is completed, the robot stops moving.

### 3. Principle of operation

The robot moves using two motors. Turns are performed by increasing the speed on one of the engines. With the help of infrared sensors, the robot tracks, the position of the dividing line, which must remain between the sensors during all movement.

The structural diagram of the robot under development is shown in figure 4.
The robot is removed from its storage location using an application that provides a remote control (figure 5).

When the robot is put on the track and installed according to the location of the dividing lines between the sensors, the training process starts the app sets the length of the distance and the time it takes to complete it.

**Conclusion**
The advantages of design development are determined by the low cost relative to existing analogues and the versatility of its components. The device has a built-in function of automatic adjustment of the travel...
speed. The simplicity of the device reduces the risk of disabling the device and significantly increases the possibility of replacing individual elements in the event of a malfunction. Using the mobile app to control the robot makes it much easier to interact with the robot and allows you to concentrate on running. The project can be widely applied in both individual and group training sessions; the principle of competition allows you to achieve high results.

Of all the considered analogues, the best technical indicators – ease of design and programming, ease of user management, characterize the presented concept. The advantage is also economic efficiency, which is an important indicator for the development and further mass production. The project will bring innovations to sports robotics and opens up prospects for further developments in this field.

References
[1] https://futurist.ru/news/3207 (Electronic resource, last checked on 07.06.2020)
[2] https://obzor.press/hi-tech/2016032418466 (Electronic resource, last checked on 07.06.2020)
[3] https://drive.google.com/drive/folders/1xsNctjaYu6UTubq1BSi5-fxX21KtAKEg (Electronic resource, last checked on 07.06.2020)
[4] https://vitablog.ru/dvizhenie/professionalnyy-beg.html (Electronic resource, last checked on 07.06.2020)
[5] https://marathonec.ru/razryady-normativy-po-begu/ (Electronic resource, last checked on 07.06.2020)