The European Proceedings of
Social & Behavioural Sciences
EpSBS

Future Academy

ISSN: 2357-1330

https://dx.doi.org/10.15405/epsbs.2018.11.02.35

ICPE 2018
International Conference on Psychology and Education

APPLIED RESEARCHES IN A FIELD OF ROBOTICS FOR TECHNICAL PERSONNEL TRAINING

Evgeny Kovshov (a)*, Vladimir Kuvshinnikov (b), Alisa Kosach (b), Vyacheslav Kravtsov (c)
*Corresponding author

(a) Moscow State University of Technology «STANKIN», 127055 Vadkovsky ln. 3a, Moscow, Russia, e.kovshov@stankin.ru
(b) Joint Stock Company "Research and Development Institute of Construction Technology - Atomstroy", 127410 Altufevskoe h. 43 bldg 2, Moscow, Russia
(c) Limited Liability Company "Era of Robots", 123060 Marshal Birjuzova st. 24, Moscow, Russia

Abstract

New scientific and technical directions in the field of assistive mobile robotics as a means of training innovative machine-building industries are considered. The market of such autonomous mobile robots is extremely wide and in addition to engineering industries covers such areas as: education, medicine, marketing and advertising, museum and library business, security and many others. As the main task of scientific research was the development of methods of precise indoor-positioning, based on the integration of information from different sources: Wi-Fi and Bluetooth LE signals, odometer of the mobile robot coming from the encoders in the process of movement, data from various sensors and cameras of the mobile device installed on the mobile platform of the robot. A set of technical and functional requirements for such assistive robots involves the use of only industrially produced, reliable and modern hardware and software platforms that have appropriate APIs for different high level programming languages. The project activity connected with real tasks forms at studying youth not only necessary practical experience in the sphere of modern technologies, but also lays the necessary base of theoretical preparation, competences and professional skills which subsequently will help them to become highly qualified specialists in the sphere of industrial production capable to solve the most various tasks at the high level and in fixed terms. The main results of the research were tested at the site of the Federal centre for technical creativity of students of the Moscow State University of Technology "STANKIN".

Keywords: Innovative projects, assistive robotics, competence, professional skills, hardware and software solutions.

https://dx.doi.org/10.15405/epsbs.2018.11.02.35
Corresponding Author: Evgeny Kovshov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Today, the market presents a wide range of robotic designers, with the use of which is actively developing educational robotics (Riadchykov et al, 2016), competitions, including international sports robotics. However, the educational tasks of creating and programming robots are far from the real application and scientific and engineering tasks, with which current studying youths will face in the future in the field of industrial production.

The software and hardware of educational robots is very different from that used in real industrial robots, is simplified and does not allow to solve, and even more so to scale up to industrial conditions, practical tasks, in particular, for service and assistive robots. The basic skills and knowledge that educational robotics provides should become the basis for work on real robotic research and development projects, using real robots, not educational robots, and the tasks solved in the course of the project should necessarily have scientific and applied importance.

In this case, applied robotics, like no other discipline, provides the acquisition of metasubject competences and creates a synergetic effect of combining engineering, research and business-oriented processes in the implementation of the project.

2. Problem Statement

One of the most important and promising areas of professional training is the involvement of studying youth and students (hereinafter – the students) in the work on innovative research and practice-oriented projects. Project activities related to real tasks, forms students not only the necessary practical experience in the field of modern technology, orients in the trends of their development, but also lays the necessary foundation for theoretical training, competencies and professional skills, which will later help them to become highly qualified specialists in the field of industrial production, able to solve a variety of problems at a high level and in a timely manner. In addition to working on important scientific and technical tasks, real projects contribute to the acquisition of skills of teamwork, communication with customers and consumers of products, educate self-demanding and perseverance in achieving the goal, the psychological experience of the winner, a sense of self-importance, a high moral level and team spirit.

In addition to high scientific and application level projects should be primarily interesting to the students to be exploratory, to be on the cutting edge of scientific-technical and technological progress. And in modern conditions there is nothing else that would be so in demand for these purposes, as robotics, which is a rapidly developing, complex scientific direction that combines, first of all, fundamental knowledge of mathematics and physics, as well as mechanics, electronics, computer science and programming, modelling, design and prototyping (Kosach & Kovshov, 2017).

3. Research Questions

The above can be illustrated by the example of the project for the development of software and hardware complex indoor-navigation, which is used as the basic intelligent software assistant mobile robot. The students' design Bureau research, which consisted of students of technical colleges and the University, was given the task of providing Autonomous movement of the mobile assistive robot in closed areas

https://dx.doi.org/10.15405/epsbs.2018.11.02.35
Corresponding Author: Evgeny Kovshov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

specified on the electronic map route, without an expensive navigation infrastructure or the installation of additional specialized sensors.

This took into account the fact that GPS navigation is very bad or almost does not work indoors, and the use of other methods of radio positioning (GSM, Wi-Fi, etc.) does not provide high accuracy and requires significant investments in the development of the supporting network infrastructure.

4. Purpose of the Study

In this regard, the task set in the framework of the project is very relevant, is not only of a promising application nature, but also involves serious research work (Kuvshinnikov & Kovshov, 2018), including the analysis of existing tools and methods of indoor navigation, the study of Russian and foreign specialized scientific sources, patent search, modelling and prototyping. It should be noted that the market of such autonomous mobile robots is extremely wide and covers such areas as: education, medicine, marketing and advertising, museum and library business, security and many others.

A set of technical and functional requirements for such assistive robots involves the use of only industrially produced, reliable and modern hardware and software platforms that have appropriate APIs for different high level programming languages. Unfortunately, the Russian market is now just beginning to appear mobile robots with the necessary sensors and capabilities of programming, adaptation and functional expansion, suitable for use in real projects by students. In general, telepresence robots that do not have developed APIs for programming new robot functions are represented on the market.

The aim of the project was to develop mathematical, algorithmic solutions and software in Java to ensure the accuracy value of indoor positioning up to 1 m. using only the standard infrastructure of the interior, including Wi-Fi access points, and the network iBeacon beacons, not significantly increasing the cost in the creation of navigation infrastructure.

The objective of the research work was the development of methods of accurate indoor positioning, on the basis of integration of information from a variety of sources: Wi-Fi signals and Bluetooth LE robot's odometry coming from the encoder during the movement, the data from different sensors and a mobile device camera installed on mobile robot platform.

5. Research Methods

As the closest prototype for the research was chosen the robot R. BOT Synergy Swan by Russian production (manufacturer – LLC "Era of Robots"). The mentioned robot is a hardware and software platform built on a hybrid scheme. As a computing device that turns the platform into a robot, stands a mobile device a smartphone or tablet running on Android OS, which is mounted at the top of the folding manipulator platform. This approach allowed the manufacturer to significantly reduce the cost of the robot, since the platform is a mechatronic device that does not contain expensive interface, radio frequency and computing components, in addition, the user can use its own mobile device as the "brain" of the robot.

To develop the Synergy Swan robot control system, the manufacturer provides a free API for the Java programming language, which in fact is the industry standard for application development.

Application of the Android platform as an OS of the mobile robot control system allows to use all the richness of the software available in its composition, including the capabilities of geographic

https://dx.doi.org/10.15405/epsbs.2018.11.02.35
Corresponding Author: Evgeny Kovshov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

information services for mobile devices. This technology is currently being actively developed for geomarketing and geotargeting in shopping centers, airports, railway stations, exhibitions, museums, universities and libraries.

6. Findings

With the recent introduction of the iBeacon standard developed by Apple for iOs 7 and the extension of this standard by Google (Eddystone), the mobile software has been able to use simple and inexpensive indoor positioning algorithms based on Bluetooth Low Energy (Bluetooth LE) beacons. But the features of iBeacon technology, which consist in the impossibility of determining the exact distance to the beacon due to the floating within a wide range of the signal power level from the beacon (RSSI) and the delay in the processing of incoming information from it, do not allow indoor positioning with an accuracy of less than 3 m, which is not enough to navigate the practically used mobile robots.

As a result of the carried out researches the problems with the use of robot odometry were revealed and solved. Thus, due to the uneven movement of the robot due to the variation in the parameters of the chassis engines and the irregularities of the surface on which the movement is carried out, the robot deviated from the given rectilinear motion, which was fixed by the odometry system.

In addition, the rotation of the robot at an angle of $\pm\pi/2$ caused it to deviate from the specified course due to friction in the rear roller wheel. The developed software and mathematical tools of the proportional regulator allowed to correct in real time the rate deviation of the robot from the given direction and to minimize the error in determining the coordinates of the electronic map. The resulting error provides positioning of the robot in the zonal squares of the electronic map, while the determination of the coordinates of the sources of the radio signal provides too large confidence interval and does not solve the problem.

The second method for a more accurate determination of the robot's coordinates was the use of markers in the form of QR-codes, which is now often used in Augmented Reality (AR) systems, but rarely for navigation of mobile devices. In closed rooms with constant artificial lighting, the use of a simple and inexpensive method for determining the coordinates of the robot by QR-markers in conjunction with other image processing methods, significantly increases the accuracy of positioning, which was proved by the results of studies. When the robot moves with an active rotating smartphone camera set to search, capture and track QR-markers located on the walls of the room, the use of a simple design transformation when finding a marker in the field of view of the robot camera allows you to determine the coordinates with an accuracy of less than 1 m.

Placing Bluetooth LE beacons on the walls of the room in various configurations allowed to reveal the essential features of indoor-positioning using iBeacon technology. The fluctuation of the signal power from the RSSI beacon varied widely, but with the immobility of the mobile device and the increase in the number of measurements had signs of normal distribution and averaged.

When changing the applications of the mobile device relative to the beacon, the signal power varied widely, and the experiments did not reveal a pattern that would allow the use of an analytical method of recalculation of the power value when changing the Z-coordinate of the device. The instability of the RSSI demonstrated the impossibility of using traditional methods of triangulation and trilateration for radio based

https://dx.doi.org/10.15405/epsbs.2018.11.02.35
Corresponding Author: Evgeny Kovshov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

navigation systems in determining the position of the receiver. To eliminate the detected instability, it was proposed to set at one point not one but three beacons for averaging RSSI and more accurate determination of the vector of motion on the beacons. But with such a technical solution, the robot often stopped, which led to a significant increase in the time of passage of a given route, and made this decision unacceptable.

In order to effectively solve the problem, a different way of navigation was proposed, called "Bluetooth fingerprint", which is rarely used in Bluetooth LE indoor navigation. With the help of the developed software, the mobile robot, moving through the squares of the electronic room card, scans the beacons and make a map of the "fingerprints" of the power of the RSSI signal, averaging its values. Recording of the coverage map can take place both in automatic mode and in controlled motion mode – "learning with the teacher". Preliminary results of the study showed a significant increase in the accuracy of positioning the robot by Bluetooth LE beacons (0.5-1 m.) (based on the method of "Bluetooth fingerprinting") in comparison with traditional methods, and the integration of information from all the above information sources allowed to achieve positioning accuracy of 0.5 m.

During the researches and work itself, elements of artificial intelligence techniques, including artificial neural networks (Kosach & Kovshov, 2018), fuzzy logic, evolutionary (genetic) algorithms and varieties of SVM classifiers (Demidova, Nikulchev, & Sokolova, 2016; Demidova et al, 2017) were used in the development of applied software.

7. Conclusion

As a result of the work on the project in the field of navigation of mobile assistive robots, the team of students showed the high efficiency of the used practice-oriented approach in the construction of innovative project educational activities. The combination of high-tech task, methods of industrial development of software for mobile devices and modern research methods, allowed forming a motivated interest of the project participants in its results, to stimulate their scientific and engineering activities, to achieve fast and high-quality results of applied importance. Obviously, the results of the project activities will be the basis, for example, master's theses, and in the future, perhaps, considered as areas of research carried out in the framework of postgraduate studies and the preparation of doctoral degree dissertation.

The experience of solving the scientific and practical problem showed the high efficiency of the educational process, built on the basis of innovative design activities of students in the field of applied robotics. A combination of engineering, scientific and business areas as a basis for building the foundation for the growth of students' competencies, work on a project that has a real practical value, stimulated the manifestation of their abilities in scientific and technical creativity, research and modelling in solving complex engineering problems with the use of modern software and electronic mobile devices. Scientific guidance with a clear step-by-step execution control allowed revealing the opportunities and potential of the project participants with a relatively deep immersion in the subject and scientific field.

The main results of the research were tested at the site of the Federal centre for technical creativity of students of the Moscow State University of Technology "STANKIN" in the process of practice-oriented training and teamwork on real projects together with industrial partners.

https://dx.doi.org/10.15405/epsbs.2018.11.02.35
Corresponding Author: Evgeny Kovshov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

Applied robotics, including mobile, as an important scientific and practical direction can become a powerful stimulus for the development of not only the infrastructure of the entire high-tech industry, but also scientific and engineering thought in general.

Acknowledgments

The authors express their deep gratitude to the leadership of the Research Institute of Design and Construction Technology (NIKIMT) for financial support throughout the entire R&D cycle and provision of laboratory facilities and classrooms.

Special thanks to the LLC "Era of Robots" for providing technical and special information on their family of assistive mobile robots and the possibility of experimental operation of hardware and software solutions for assigned research tasks and the formation of training techniques for technical personnel.

References

Demidova, L., Nikulchev, E. & Sokolova, Y. (2016). Big Data Classification Using the SVM Classifiers with the modified particle swarm optimization and the SVM ensembles, *International Journal of Advanced Computer Science and Applications*, *7*(5), 294-312

Demidova, L., Klyueva, I., Sokolova, Y., Stepanov, N. & Tyart, N. (2017). Intellectual approaches to improvement of the classification decisions quality on the base of the SVM classifier. *Procedia Computer Science*, *103*, 222-230.

Kosach, A. & Kovshov, E. (2017). Development of a computer based problem-oriented automated remote leakage detection control system, *ITM Web of Conference*, *10*, 01005

Kosach, A., Kovshov, E. (2018). Data traffic filtration of automated non-destructive testing based on an artificial neural network, *ITM Web of Conference*, *18*, 04003

Kuvshinnikov, V. & Kovshov, E. (2018). Improvement of specialized industrial manipulator movement control, *ITM Web of Conference*, *18*, 01004

Riadchykov, I., Sechenev S., Sinitsa, S., Nikulchev, E. (2016). Constructive solution of the robotic chassis AnyWalker, *ITM Web of Conference*, *6*, 01003