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ROBOTICS AS MOTIVATION OF LEARNING TO GEOMETRY AND GRAPHICS

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Abstract. Robotics densely entered our life, penetrated into all spheres of human activity. That is why today the basics of robotics are beginning to be studied in primary school for active continuation of its development. The main task of higher education is not to interrupt the established link between school and production, but to become an intermediate step. This will allow schoolchildren at every stage of their growing to deliberately develop and make sure of the correct choice of their future profession. The article shows the possibility of solving the actual task of increasing the motivation of university students to study in the context of introducing new forms and methods of teaching. The aim of the work is to create a highly effective learning environment for students of technical universities. An example of the use of special practical tasks related to future engineering activities, which are aimed at enhancing the motivation of training, is shown. The results of the carried out experiment of the introduction of assignments focused on the future specialization of training prove not only an increase in interest in the subject «Engineering and Computer Graphics», but also demonstrate the possibility of creating a unified environment for building knowledge and skills in the process of end-to-end training.

Keywords: Interdisciplinary communication, teaching methodology, geometry, manipulator workspace, trajectory of the movement, output link

1 Introduction

To date, robotics in conjunction with mechanics, new engineering, information and intellectual technologies is a powerful tool for the development of scientific and technological progress, industry and the country's defense capability. This generally leads to an improvement in people's standard of living. Indeed, the development of robotics is designed to alleviate human labor and protect it from exposure to harmful and deadly hazards. Guided by these goals, modern robotic, mechatronic and intelligent systems have achieved great results:

- Robots already know how to deceive people. Such developments are in demand for the protection of objects.
- Robots have mastered the profession of a hacker, that is, they have learned to «crack» the protection of various software products.
- Intellectual systems through social networks try to understand our behaviour.

Externally, robots become very similar to humans.

- They already know how to feel (laugh, get angry, embarrassed).
- Some futurists are confident that nanobots will soon be implanted into the human brain.
- Robotic, mechatronic and intelligent systems became actively used for military purposes.

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However, the most important results have been achieved by replacing people in workplaces in various branches of human activity: medicine, agriculture, food industry, households, machine building, electric power, petrochemical processing, instrument making, information technology, etc.

Considering this large scale of the introduction of our assistants in many areas of production and life activity, modern education has to pay great attention to the formation of competences necessary for the design, development and operation of robotic, mechatronic and intelligent systems.

2 Problem Statement

In many educational institutions of the country there are subjects and disciplines that develop the above competences. In this case, children, schoolchildren and students are fascinated by the study of robotics. They show activity and desire to receive knowledge, express a great interest in robotics, are vigorously discussing the results of their work with peers, strive to achieve results and are conscious of themselves talented and intelligent. These observations and the experience of teaching in a technical university show that the great interest of students in robotics allows solving one of the main problems of modern education - motivation for learning and, as a consequence, to increase the development of cognitive activity.

The problem of motivation in education is quite acute in connection with many aspects of the modern way of life and the learning process. At present, the existing education system is undergoing significant changes. On the one hand, they are due to the high rates of computer technology development and the general spread of the Internet. On the other hand, this is a natural process of reorganization in accordance with the general course of Russia's scientific and technological development and the restoration of its scientific and technical potential. Reorganization in society and public consciousness, in connection with the transition to a new information age and the change in the social order, requires correction in the mind, both the student and the teacher.

3 Research Questions

Today's generation of children is completely different from what it was 20-30 years ago. Most of them are more infantile and psychologically undeveloped, more focused on entertainment, they need to be more controlled and stimulated in the learning process: a higher stipend, bonuses for work. The current teacher has to pay more attention to motivation for learning and methods of retaining attention.

The modern learning process is not standard methods, models and techniques [1, 2, 3]. Classical lecture notes are a thing of the past [4, 5, 6]. In practical exercises, experiments are conducted using virtual instruments and remote access systems [7, 8, 9]. Recently, educational institutions, including schools, have been able to significantly improve their level of equipment. Interactive whiteboards, 3D printers, powerful computers and access to the Internet, all this is now available not only to major metropolitan universities. Schools are actively included in the national educational concept, oriented not only to studying the achievements of the past, but also to the latest developments in various fields of technology and technology. The fundamentals of programming and robotics are studied in schools around the world, for example, in the UK [10], in Korea [11], in Iran [12], in Croatia [13], in Spain [14] etc. In this regard, Russia's universities cannot lag behind or impede the educational chain of the school-university-enterprise.

So, in particular, not so long ago in schools began to appear classes on robotics. As shown by the International IT-forum held in Omsk, even younger schoolchildren actively and with pleasure comprehend the basics of designing and programming simple robots with the help of Lego designers. Classes are held in the form of a game, it is entertaining and accessible for understanding of children, but at the same time it forms a creative and cognitive impulse for the further cognitive process. Further, these children, when they move to a university, they will certainly choose engineering for their future profession. Today, there is no sphere of engineering that does not use robotic, mechatronic and (or) intelligent systems.

4 Purpose of the Study

Under these conditions, the task of the departments of general engineering training, the subjects of which students study yesterday in their first year, do not fall out of the general process of preparing future highly qualified specialists. It is necessary to preserve and support students' interest in the chosen engineering specialty by introducing special assignments. It is necessary to focus on solving problems of one subject area with the help of tools of another academic discipline.

Thus, at the department of the "Engineering geometry and CAD" of the Omsk State Technical University for students, along with the tasks aimed at studying the standards of the Unified System of Design Documentation, laboratory work on geometric modeling has been implemented. These works are related to the construction of the working space of the manipulator mechanism.

5 Research Methods

These laboratory works are designed to solve a specific problem of robotics, related to the answer to the question: Does the center of the output link of the manipulator mechanism a given point of space, or not? The reachability of the manipulator mechanism depends on its structure and geometry, on the sizes of links and on the limitations of their mobility in kinematic pairs, that is, on generalized coordinates and their maximum values. In connection with this, one of the lectures outlines such concepts as the mechanism, kinematic pairs, generalized coordinates and the output link. At the lecture the teacher explains that reachability is characterized by the location of the center of capture of mechanism of the manipulator within the working area. Therefore, the actual problem is to build a working zone according to the specified structure of the manipulator mechanism, given lengths of links and limit values of generalized coordinates. The construction of the working area for various manipulator mechanisms is considered in the works [15, 16, 17, 18, 19]. The set of points of the surrounding space for which the capture can move, determines the working area of the manipulator. Generalized coordinates show the relative position of two links connected in one kinematic pair. The specified coordinates can be given by angles or linear displacements. Their maximum and minimum values determine the maximum displacements or rotations in the hinges of the manipulator mechanism. The lengths of the links and various kinematic transducers set the geometric model of the manipulator.

The essence of the developed individual problem is to build a working zone on a given bearing mechanical system of the manipulator. Figure 1 presents the initial data of the problem defining the image of the manipulator mechanism having two rotational and one translational kinematic pairs. The same figure denotes the lengths l_i of the links of the mechanism and the limiting values of the generalized coordinates given by the angles φ_1 and φ_2^{max} and the displacement S. An example of numerical values for one of the variants of the individual problem is presented in the table. Also here are given the coordinates of two points M and N, for which it is necessary to determine their belonging to the working area. Students first build geometric objects that specify sets of locations of points (centers of the output link), first when one generalized coordinate S only changes, then, respectively, when two S and φ_2 and three S, φ_2 and φ_1 of generalized coordinates. In the first case, the set of possible positions of points is a segment, in the second case there is a sector bounded by two straight line segments and two arcs of circles, and in the third case - a region bounded by surfaces (see Figure 2 and Figure 3). Students build these geometric objects. To do this, they change a single generalized coordinate. Thus, the trajectories *d, d′, d″, c* etc. of some reference points *C, C′, C″, D , D′* etc. that determine the boundaries of the working zone are investigated.

Initial data conditions: *From the given limit values of the generalized coordinates of the spatial mechanism of the manipulator, construct a working zone. Determine the belonging of points M and N of the constructed work area.*

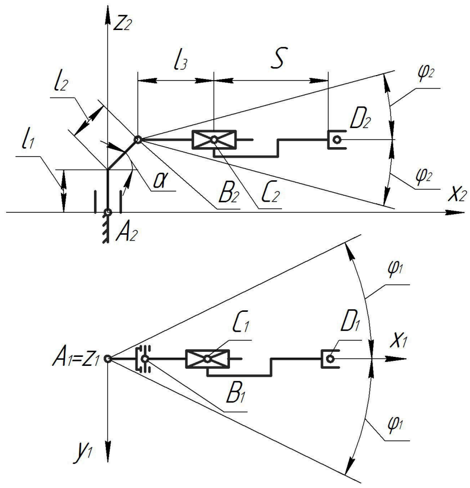

Figure 1: The initial data of the problem, which determine the structure of the kinematic chain of the manipulator mechanism

When constructing the trajectories of the motion of segments and arcs of circles, when the generalized coordinate φ_2 is changed, students construct a surface of revolution that limits the working area. Fragments of these surfaces are shown in Figure 4. As can be seen from Figures 3 and 4, the working area bounds the fragments of the two surfaces of the cones of rotations Γ' and Γ'', two surfaces of the torus and two planes.

Table 1: Specifying geometric parameters characterizing the manipulator mechanism

Variant	α	l_1	l_2	l_3	S	φ_2^{max}	φ_2^{min}	φ_1	G			H		
									x	y	z	x	y	z
1	45°	50	30	30	60	30°	-45°	45°	100	-50	100	120	45	115

It should be noted that when performing the task, the methods of descriptive geometry are used, related to the mapping of geometric objects on the planes of projections, the study of the trajectories of the movements of points, the determination of surfaces and the determination of the belonging of points to surfaces and given regions. Students build horizontally projecting straight lines and determine their intersection points with the boundary surfaces to determine the belonging of the points *G* and *H* to the working zone. On the basis of the study of the mutual position of the horizontally competing points (*G ′, G ″*) and (*H′, H″*) constructed, it becomes clear that the points *G* and *H* belong to the working zone. Since the point *G* is located between the points (*G ′, G ″*), then this point belongs to the working zone. Accordingly, the point *H* is not located between the points (*H′, H″*) and therefore this point does not belong to the working zone.

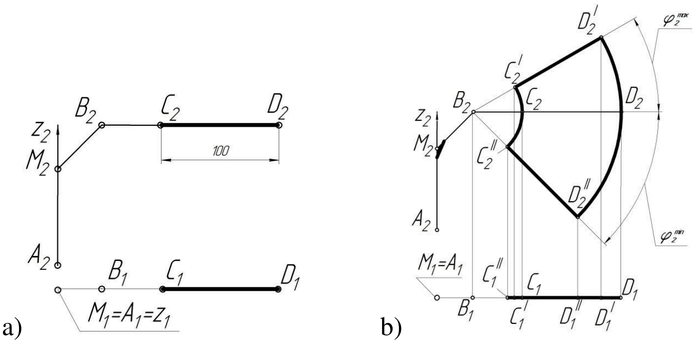

Figure 2: The stages of accomplishing an individual problem: a) determination of the positions of the capture center for $\varphi_1 = 0$, $\varphi_2 = 0$, $S - var$ (variable); b) determination of the positions of the capture center for $\varphi_1 = 0$, $\varphi_2 = var$, $S - var$

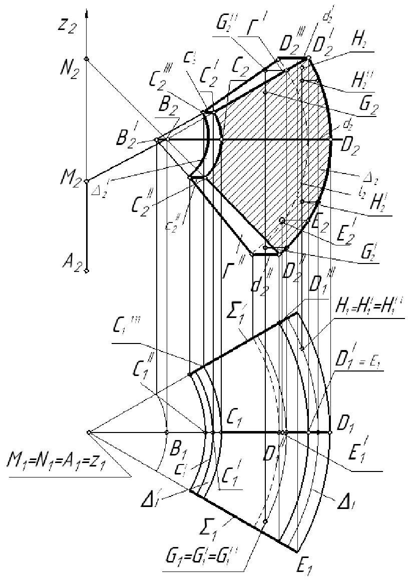

Figure 3: Construction of the manipulator working area that determines the set of positions of the capture center for $\varphi_1 = var$; $\varphi_2 = var$, $S - var$

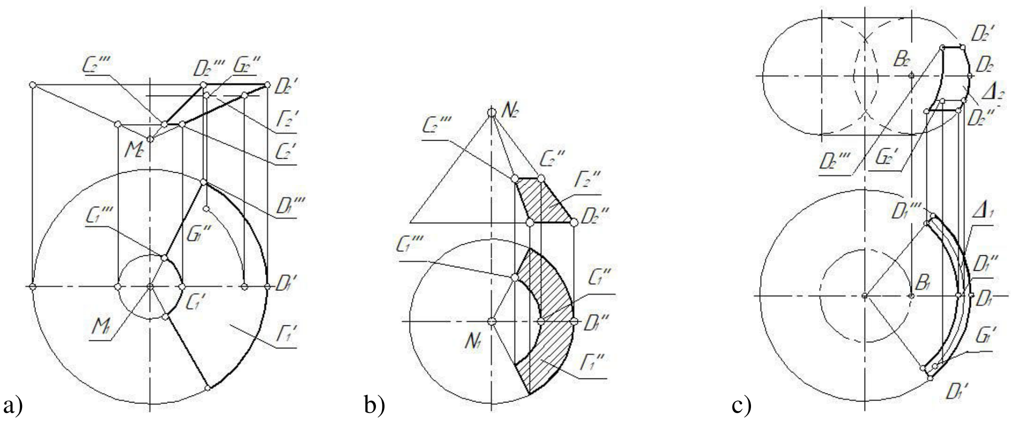

Figure 4: Some fragments of surfaces that limit the working area: a) conical surface $\Gamma^{/}$; b) conical surface $\Gamma^{//}$; c) torus surface Δ

6 Research Methods

The basic stages of creating a 3D-model of the working zone in the system "KOMPAS" for setting the angle $\varphi_2 = \pm 45^o$ are shown in Figure 5.

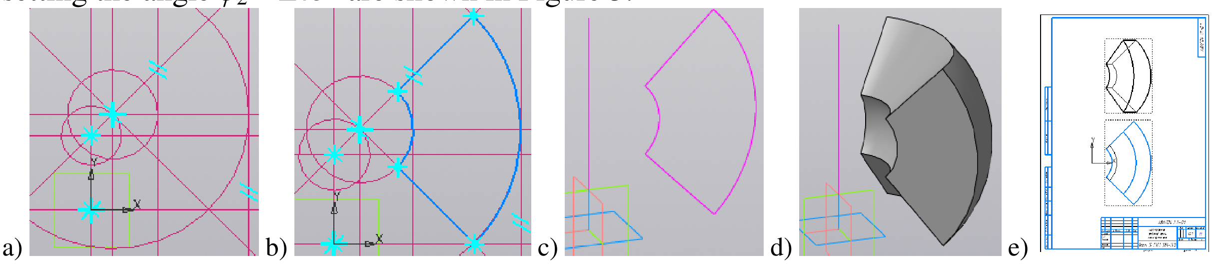

Figure 5: The construction of the region that determines the possible positions of the capture center: a) the construction of auxiliary lines in the plane *Oxz*; b) the construction of a closed contour with $\varphi_1 = 0$, $\varphi_2 = var$, $S - var$; c) setting the axis of rotation when turning a flat contour; d) the result of the "Element of rotation" command; e) an associative drawing based on the 3D-model

Observing the work of students on the performance of this task and the survey conducted lead to the conclusion that the previously studied theoretical provisions on abstract points, lines and planes become clear and logical for students and they begin to feel the importance and necessity of this discipline in their future engineering activities.

Conclusions

This assignment allows students to motivate students to study the discipline "Engineering and Computer Graphics", which includes the basics of descriptive geometry, as it demonstrates the possibility of applying the theoretical foundations of geometrical constructions to real examples in calculating the possible trajectory of the robot's movement with the aim of adjusting its software equipment . The introduction of not only gaming technologies into the learning process, but also the orientation of works and assignments for interdisciplinary communication allows not only to realize the theoretical positions of such a complex and multifaceted discipline as descriptive geometry [20, 21, 22, 23], but also to prepare a competent specialist in comfortable for the student conditions.

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All figures appearing in this work originate from the public resources available on-line.

ROBOTYKA JAKO MOTYWACJA DO NAUKI GEOMETRII I GRAFIKI INŻYNIERSKIEJ

Robotyka przeniknęła niemal wszystkie sfery ludzkiej działalności. Dlatego podstawy robotyki pojawiają się już w realizacji programów w szkole podstawowej. Pozwala to dzieciom w wieku szkolnym, a później młodzieży, na każdym etapie ich rozwoju na rozmyślne rozwijanie się i upewnienie się co do właściwego wyboru przyszłego zawodu. Zadaniem szkolnictwa wyższego jest utrzymanie relacji stworzonej między szkołą a potrzebami produkcji przemysłowej, poprzez wypełnienie kroku pośredniego treściami programowymi. W artykule pokazano możliwość zwiększenia motywacji studentów do studiowania poprzez wprowadzanie nowych form i metod nauczania studentów uczelni technicznych. W tym celu przedstawiono przykład wykorzystania specjalnych zadań praktycznych związanych z przyszłymi działaniami inżynierskimi. Wyniki przeprowadzonego eksperymentu polegające na wprowadzeniu zadań związanych z przyszłą specjalizacją dowodzą nie tylko wzrostu zainteresowania przedmiotem "Inżynieria i Grafika Komputerowa", ale także wskazują na możliwość stworzenia jednolitego środowiska dla budowania wiedzy i umiejętności w procesie „end-to-end learning".