International independent scientific journal

№47 2023

№47 2023
International independent scientific journal

ISSN 3547-2340

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1000 copies
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email: info@iis-journal.com
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AUDIT AS THE MAIN CONDITION FOR INCREASE OF THE TRANSPARENCY OF BUDGET PROCESS AND ESTABLISHMEMT OF EFFECTIVE ACCOUNTABILITY MECHANISM

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https://doi.org/10.5281/zenodo.7621306

Abstract

The effective organization of legal relations being the basis of public finances is one of the key and priority issues facing every country. The aspiration to control in terms of ensuring full coverage may make the issues of problem specification a subject of analysis and professional deliberations including the reliability of the alternatives to achieving goals and subprograms involving non-financial products. The possibilities of projecting of the measures that will allow to correctly rearrange the regulation of the conditions necessary for the operation of the demand-responsibility chain from the point of view of a purposeful strategy review become clear by the sum of the additional issues raised in the current period and the issues raised within the framework of the accumulated experience. In the quantitative-qualitative flow-parallel processes, the consolidation of conclusions with the qualitative advantage of audit and the use in time by necessity is definite. In the current reality, the organization of the regular budget process in line with a new model supposes the division of the work of forming an institution of responsibility and ensuring transparency, with the aim of eliminating the various gaps between separate stages in anticipation of their unification in the upcoming periods.

Keywords: *public participation, Audit Chamber, transparency, strategic reforms, effectiveness.*

The public financial relations include the widest range of public participation, so the budget system currently formed in RA, as the subject base of public finances, carries the mission of defining priorities, clarifying the various issues existing at the level of state administration and local self-government bodies, under the issue of the provision of close connection with strategic priorities, as a result of combining existing and possible financial resources. The risks of overcoming external challenges and obstacles to the stabilization of the internal environment in the context of situational budget regulation, the processing and implementation of budget policy propose necessary arrangements to identify opportunities for professional preparedness and abilities improvement, with the aim of localizing more accurate methodological provision of probabilistic calculations of forecasts in the real regime.

The purpose of the reforms of the State Finance Management System is to increase the efficiency of state expenses management, in particular, to ensure financial and budgetary discipline and thereby contribute to the establishment of macroeconomic stability.The current chronological changes in the State Finance Management System will certainly form rearrangements from the point of view of the review of the goal-result strategy, in particular, the following will be considered as important:

- The raise of main institutional and legal issues related to reforms
- The full provision of the participation process
- The outline of ways of solution of current and far-reaching issues in the matter of goal-result provision
- The assessment and monitoring of targets and indicators foreseen by the strategy[1].

The reflection of the mentioned rearrangements in the State Finance Management System is highly desirable until the continuity of the necessary steps confirms the start of their queue as a new sub-layer of the reforms implemented in RA. Since 2012, the implementation of legislative, in particular, accountability reforms has been aimed at improving internal and external control processes.However, in retrospect, the logic of the replacement of studies and analyzes with control was fixed in article 1 of the RA Law "On the Control Chamber of the RA National Assembly" since in 1999[2]. But, in fact, the replacement of traditional budgeting with a different of modern budgeting caused difficulties even in the long-term period in terms of improving control mechanisms. Taking into account that from the beginning the problems of the Control Chamber were summed up with the component of methodical and professional assistance, even today this problem is relevant at the audit level[3].

The importance of the independent audit in terms of improving the budgeting process puts a special emphasis on the performance control from the 4 types of control, considering the decision of the effectiveness of achieving the set goal[4]. At present, it is a priority to introduce the evaluation mechanisms from the goals of the budget programs to the result indicators, as well as the harmonization of individual elements in the strategic planning system[5]. Internal control processes are greatly promoted from an organizational point of view within the framework of the expansion of external control functions, constantly providing opportunities for the expansion of methodological support. At the end of the cycle of the budget process, the main actor of control-responsibility issues is the RA Audit Chamber, and in order to improve the effectiveness of external control, a sub-Committee on Accounting and Audit issues was formed in the RA National Assembly's Financial

Credit and Budget Committee, which should become a platform for cooperation with the Audit Chamber[6]. Currently, the frequency of studies and analyzes in the state audit procedures will also contribute to the above, conditioned by the positive experience of the current conclusions being rooted in the RA[7]. It should be also noted that in the continuation of the work on the introduction of the structures foreseen by the RA Law on "Accounting and Auditing Activity Regulation and Public Control" it is planned to introduce the mechanisms of public control of audit quality, which will allow to increase the quality of provided audit services and public trust[8].

In our country, the legislative body is the main actor in forming the mechanism for reversing the inefficiency of the known version of circulation of public order in legal, political, socio-economic and other platforms, but from the point of view of realization, the main role of the Audit Chamber becomes primary in today's reality, because on the side of the experimental application being conditioned by the time factor, it is necessary to put forward a number of conditions until the starting grounds of the above scenario are visible.

It is clear that the separate outline of the necessary condition is not enough for the full clarification of the issue of transparency and responsibility of the budget process, but over the years it becomes the cornerstone of the chain continuous processes in the sense that it is the culmination of the optimization of the improvement of the further documentation of the experimental application. As we know, the field of desires is formed in the private and public sector, the latter limits it within the range of resource availability of the public order. In this case, the initiating legislative power "enforces"' the fulfillment of the public demand at the expense of the replenishing effective practices of the executive power.

The Audit Chamber, even as a result of the current control work, is unable to have a significant impact on the improvement of the ongoing works, that is why the schedule of the clarification of problems, the check-up and verification of calculations on the line of the Audit Chamber is moved to the following periods, and the responsibility for the resulting improvements is assumed from the executive to the legislative in a dialogue domain.According to this logic, ensuring the comprehensiveness of the budget process under the conditions of full public participation will ultimately move the beneficiary oriented policy to a qualitatively higher level, when the reinunerativeness will become secondary in comparison with the ideology of public benefit.

Since the strategic reforms in the budget sector have just have recently started in the local self-government system, we consider it as important to note that in the communal processes the localization of the achievements at the state management level will require a lot of time in terms of institutional reforms, but it is obvious that the practicality of realizing results can become confirmed even under the conditions of the absence of information documents circulation. The current processes in the communities, and the fundamental and complete changes of the information base in the state management system will not only become complementary processes, but will confirm the urgency and indisputability of the common-good work through the transfer regime of mutual assistance.

The investment of the program budgeting system has caused many difficulties in different countries, but having reached the necessary replenishment of public finances management reforms at the level of responsibility, it becomes realistic not only to identify, prevent and reduce the existing obstacles with the value system structure, but also to minimize the existing risks caused by these obstacles by rooting the principle of transparency.Transparency is progressive as compared with the reordering of Public Finance Management priorities from a purely temporal due to the influence of time.

Speaking in detail on the above, it should be mentioned that the visibility of the recovery of the mentioned circle with the comprehensive participation of the relevant bodies supposes at least the cessation of "double-edged striker " policy, which will make it possible not only to regulate the boundaries of the powers within the framework of the authorities, but also to pave the way to mitigate the negative perception of responsibility by the establishment of an effective consulting regime. As the second most important step, it will form an ability to convert the impossibility of visibility of problems by taking the necessary measures for their disclosure, prevention, specification of optimal solutions, and constantly rise in the hierarchy of efficiency.

From a strategic point of view, the control function is finally established at the level of monitoring, but within the framework of tactical planning, parallel initiatives to maintain the legality, effectiveness and other principles of the problems known to us will continue, and in the case of newly emerging and seemingly unsolvable problems, it will be necessary to determine the following sequence of steps in order to pass from the first level of overcoming of effectiveness to the next one:

- The identification of a problem that contains or does not contain a risk,
- The consideration of the proposed solutions for the solution of a problem at the highest possible level, setting the goal of the Program budgeting reforms as the first level,
- Outcome-based monitoring of the time-scale prevalence of financial and non-financial evaluation at the level of arrangement, and so on.

As we see, such an approach can sometimes form the exact opposite ideas regarding such compliances, whose discovery has always been justified in terms of the expectations of non- laborious processes. We think that at certain turning points in the following periods, establishing reliability and compliance can be formed as a result of the simultaneous implementation of other principles of Program budgeting.

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MEDICAL SCIENCES

THE MAIN COMPONENT OF ORTHOPEDIC TREATMENT OF PATIENTS WITH COMPLETE DENTITION

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Abstract
Orthopedic rehabilitation of patients with complete loss of teeth is always associated with a change or restoration of the interalveolar distance, the optimal value of which has a significant impact on the functioning of the organs of the dental system. Reliable stabilization of prostheses ensures the correct fixation of the interalveolar distance and is the key to the normal state of the organs of the maxillofacial region.

Keywords: *complete removable denture, individual tray, functional impression*

The absence of teeth not only causes a violation of the chewing and speech function, but also causes a disproportion in the parameters of the facial skeleton of the skull, provokes psychological and personality changes, and violates the social tolerance of people.

Good fixation and stabilization, optimal functional and aesthetic effect can be achieved with the help of qualified performance of each of the stages of manufacturing complete removable lamellar dentures [1]. In solving this problem, the leading place is occupied by the question of how to obtain functional impressions, the accuracy and correctness of which determines the quality of the future denture [4].

The method of fitting an individual spoon on the edentulous lower jaw and obtaining a functional impression according to F. Herbst, who proposed to set the optimal boundaries of the spoon according to its displacement during functional tests, is widely used among orthopedic dentists. However, this method is ineffective in case of large atrophy of the alveolar process, since the functional tests proposed by Gerbst are standardized, do not take into account the individual characteristics of the patient's oral cavity and do not provide for the design of the outer polished surface of the prosthesis base in accordance with the contours of the movable anatomical structures adjacent to it.

To achieve optimal functional suction, it is necessary to accurately model the edges of the prosthesis, taking into account the anatomy of the prosthetic bed, especially in the neutral zone, which has greater compliance. Therefore, the more accurately we determine this zone and position the edges of the individual tray when obtaining a functional impression, the higher the effectiveness of orthopedic treatment [3].

It has been established that both men and women need orthopedic treatment with the same frequency, and the need for this type of dental care increases with age. It has been determined that the average shelf life of removable dentures is 2–3 years [5, 10]. One of the fundamental factors for improving the quality of life and dental health of patients with complete absence of teeth is reliable fixation and stabilization of removable dentures, the achievement of which is often associated with significant difficulties in obtaining functional impressions, especially for beginners.

At present, it should be recognized that the main method of fixing complete dentures is a method based on the use of physical laws and anatomical features of the structure of the boundaries of the prosthetic bed. This method is called biophysical. For its implementation, it is necessary to create a rarefied space on the largest possible area. This becomes possible if the suction chamber is not a limited area, but the entire basis of the prosthesis. In this case, the closing valve is formed by the edge of the prosthesis and the mucous membrane of the neutral zone, a section of the mucous membrane with significant compliance and minimal mobility. Orthopedic rehabilitation of patients with

complete loss of teeth is always associated with a change or restoration of the interalveolar distance, the optimal value of which has a significant impact on the functioning of the organs of the dental system. Reliable stabilization of prostheses ensures correct fixation of the interalveolar distance and is the key to the normal state of the organs of the maxillofacial region [10]. To achieve fixation, it is necessary to obtain a clear display of the relief of the mucous membrane of the prosthetic bed, taking into account the functional state of the soft tissues of the prosthetic field in the manufacture of an individual impression tray. For this purpose, in our opinion, polyester impression masses are the most suitable. The materials have well-pronounced mucostatic properties, which is necessary when taking impressions for removable structures, when displacement or extrusion of the mucous membrane is undesirable, as well as high hydrophilicity, thixotropy and plasticity. Monophasic and one-stage imprint eliminates the possibility of deformation due to the difference in the coefficients of elasticity of different layers, and also greatly facilitates the work of the doctor and saves time. The method of fitting an individual spoon on the edentulous lower jaw and obtaining a functional impression according to F. Herbst, who proposed to set the optimal boundaries of the spoon according to its displacement during functional tests, is widely used among orthopedic dentists. However, this method is ineffective in case of large atrophy of the alveolar process, since the functional tests proposed by Gerbst are standardized, do not take into account the individual characteristics of the patient's oral cavity and do not provide for the design of the outer polished surface of the prosthesis base in accordance with the contours of the movable anatomical structures adjacent to it. To fill this gap in the method of obtaining a functional impression from the edentulous lower jaw, P. Tanrykuliev proposed volumetric modeling of the outer polished surface of the basis of a complete removable denture of the lower jaw. Later, many techniques were proposed for the design of the edges of an individual tray and obtaining a functional impression. Thus, some authors suggest using a material for relining complete dentures to decorate the edges of an individual tray before obtaining a functional impression, which, in our opinion, can have a negative effect on the tissues of the prosthetic field [6, 7]. Other authors suggest using a hand-kneaded silicone edging mass to shape the edges of individual trays, while adhesive pads are placed on the inner surface of the individual trays to create a space between the individual tray and the mucosa. Subsequently, the pads are removed and a functional impression is obtained with a medium-fluid, and then with a high-fluid silicone impression mass [2]. Still others suggest edging a rigid individual tray with heated wax and obtaining a functional impression with alginate group impression materials using functional samples [8]. In addition, there is a technique for obtaining a functional impression with a rigid individual tray using stop stops made of composite material to position the tray during edging of the edges with thermoplastic mass. The subsequent functional impression is obtained using the Impregum 3M ESPE polyester material [9]. The above methods have a number of undoubted advantages, however, in our opinion, they are largely labor-intensive. The appearance on the dental market of innovative impression materials with improved properties and devices for taking an impression creates the conditions for a faster process of forming the edges of an individual tray and obtaining a functional impression during orthopedic rehabilitation of patients with complete absence of teeth. We have accumulated many years of experience in the use of the Express XT Penta Putty impression mass for the functional design of a peripheral closing valve in the neutral zone due to its excellent mucostatic properties, which eliminates horizontal displacement of the mucous membrane and allows the use of high mucosal compliance in the neutral zone to form a closing valve. 3M's new ESPE "Express XT Penta H" A-silicone material, featuring even lower viscosity and longer working time, makes it possible to form the ideal closing valve for a complete denture. According to the proposed method, an individual spoon pre-fitted with Herbst samples is shortened along the borders by 3–4 mm and the edge thickness is reduced to 1–2 mm. Thanks to the Pentamix automated mixing system, high-quality and uniform preparation of the impression mass is carried out, as well as fast and uniform application to the borders of the impression tray. In this case, it is necessary to preliminarily apply an adhesive to the surface of an individual impression tray. After placing the spoon on the prosthetic bed, it is pressed against the mucous membrane and its edges are passively formed until the impression mass is structured, while functional tests are added to form the lingual edge, which makes it possible, under difficult clinical conditions, for prosthetics on the edentulous lower jaw to always achieve adequate boundaries of the basis prosthesis and optimal design of its outer surface. After structuring, the layer of the impression mass on the outer surface of the individual tray follows the contours of the movable anatomical structures adjacent to it, and the inner layer acts as a limiter-stopper for further positioning and creating a space between the individual tray and the mucous membrane of the prosthetic bed. To obtain a refining functional impression, we use the corrective material "Express Ultra-light body", which has excellent fluidity and is distributed over the surface in a thin layer. The mass is produced in cartridges designed for convenient dosing and mixing with a Garant dispenser gun, which facilitates and speeds up its application to the impression tray. The applied corrective mass "Express Ultra-light body" flows well under pressure, filling the thinnest cavities when obtaining a corrective impression, while due to its good mucostatic properties, the need to perforate the impression tray to obtain decompression is eliminated.

CONCLUSION

This method of obtaining a functional impression minimizes the traumatic effect of the prosthesis on the oral mucosa, reduces the number of corrections, and therefore contributes to a faster adaptation of the patient to the prosthesis. In conclusion, it can be noted that despite the fact that the success of orthopedic treatment of patients with a complete absence of teeth depends on

the qualified implementation of all stages of prosthetics, the decisive role belongs to the creation of an effective closing valve, which is certainly achieved by obtaining a functional impression taking into account the neutral zone.

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OBTAINING A FUNCTIONAL IMPRESSION DURING PROSTHETICS OF PARTIAL ADENTIA

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Abstract

Functional impressions are widely used in prosthetics of patients with complete loss of teeth. However, the advantages of a functional impression over an anatomical one turned out to be so obvious and effective that this was the reason for the development of a technique for obtaining it in patients with partial loss of teeth:

a) a functional impression allows you to determine the optimal relationship between the edge of the base of the prosthesis and the adjacent soft tissues;

b) it contributes to better fixation and stabilization of a partial removable denture;

c) it provides a more rational distribution of masticatory pressure between different parts of the prosthetic bed;

d) it can provide the necessary compression of the mucous membrane of the prosthetic bed, corresponding to the masticatory pressure.

Keywords: *individual tray, functional cast, Partial edentulous.*

The impression is an information link between the doctor and the dental technician, and the accuracy of the impression largely determines the quality of orthopedic treatment. Currently, one-piece cast combined (consisting of fixed and removable parts) prostheses are widely used. Their production is traditionally carried out in two stages. At the first stage, a fixed part of the cast structure is made to obtain a refined impression and a working model cut into fragments. On such a model it is impossible to make a removable part. In addition, when taking an impression, the underlying soft tissues of the prosthetic bed are pressed out, which leads to their distortion. Therefore, after the manufacture of a non-removable structure, the stage of re-obtaining an impression and manufacturing a new working model with a non-removable part installed on it is mandatory. Such a repetition of the clinical and laboratory stages is inconvenient, stretched in time and requires an increase in the number of visits to the dental clinic by the patient.

PURPOSE OF THE WORK

In connection with the foregoing, there was a need for a method for obtaining an impression simultaneously for both the fixed and removable parts of the combined prosthesis. The impression in this case should perfectly display the elements of the abutment teeth, the gingival margin and the ledge, the relief of the mucous membrane of the prosthetic bed and the functional state of the mobile tissues of the oral cavity adjacent to the prosthesis. This can be solved by taking an impression using an individual tray [1].

The variety of clinical situations encountered in the oral cavity dictates the need for a differentiated approach to the choice of material and technique for obtaining an impression. Traditionally, for the treatment of patients with modern one-piece cast constructions, methods are used: two-layer one-stage, one-layer one-stage, injector, etc. [3] But they all involve the use of standard spoons. Individual ones are traditionally used in the treatment of complete absence of teeth. However, in the case of treating patients with combined structures, it becomes necessary to transfer the functional state of the tissues of the prosthetic bed, which is possible only when using an individual spoon [5]. Therefore, we have proposed a method for obtaining a refined impression using an individual spoon in the orthopedic treatment of partial absence of teeth.

RESEARCH METHOD

To create a uniform layer of impression material, we perform isolation with a base wax plate (thickness 2 mm). To create a differentiated pressure on the tissues of the prosthetic bed, we make perforations in an individual spoon. We make an individual spoon on a diagnostic plaster model with a drawing of the future design.

We outline the boundaries of the individual spoon: from the vestibular side in the region of the supporting teeth and the edentulous alveolar process along the transitional fold, bypassing the frenulum of the lips and the bands of the buccal mucosa, in the remaining teeth at the level of the necks; on the oral side - on the upper jaw it covers the entire sky, on the lower one - in the region of the edentulous part of the alveolar process and

supporting teeth, it passes along the transitional fold, and in the remaining teeth below the level of the necks by 10-15 mm. Then we outline the "contact zones", retreating from the border of the prosthesis by 2-3 mm, and "stop points". "Stop points" are specially created contacts in the area of the edentulous part of the alveolar process of the jaw. They are necessary for the orientation of the spoon on the tissues of the prosthetic field, which is carried out by contact of its inner surface with areas free from elements of the future prosthesis, or with "stop points". Next, we isolate the undercuts of the teeth and the alveolar process with wax / Compress the softened base wax plate (2 mm) over the entire surface of the model. The areas of "contact zones" and "stop points" are cut out. We add wax to the model.

Spoons are made from self-hardening plastic or by light curing from a glass-containing composite using traditional methods.

To obtain an impression, we fit an individual tray in the patient's mouth, specifying the boundaries and correct location on the prosthetic bed. The edge of an individual spoon in the area of the edentulous part of the alveolar process is formed using Herbst's samples. In the area of \u200b\u200b"contact zones" and "stop points" in the spoon, we make holes for the purpose of decompression in these areas. We carry out the expansion of the gingival sulcus to provide horizontal and vertical access to the impression material and to prevent bleeding and reduce the release of gingival fluid. Next, we apply an impression mass on the dried gingival sulcus and teeth from a special syringe. At the same time, the doctor's assistant prepares and places the same material in the individual impression tray. Then the spoon is inserted into the mouth and centered. With the help of passive and active movements with soft tissues, we shape the edges of the impression and then hold the impression on the prosthetic bed without pressure.

The manufacturing technology of a combined denture in one impression can be considered complete only if techniques are used for the manufacture of the model, when the interdental papillae are not destroyed during the processing of the model, the level and volume of the gums are preserved, for example, Modell-Tray [2]. The use of an individual tray in the treatment of partial absence of teeth, in combination with a correctly selected impression material, allows obtaining differentiated pressure on various parts of the prosthetic bed, functionally designing the edge of the artificial base of the removable part of the prosthesis, and reducing the adaptation time [4].

RESULTS AND DISCUSSION

As an example. Patient A., aged 50, applied to the clinic of the Department of Orthopedic Dentistry, a patient at the age of 50 complained of missing teeth, difficulty chewing food and an aesthetic defect. Based on the survey data, a treatment plan was drawn up: to make a combined prosthesis for the upper jaw, consisting of: a fixed part - bridge-like metal-ceramic prostheses and with a patric part of the locking system of fixation; the removable part is a clasp prosthesis with a locking fixation system. For the manufacture of a high-quality prosthesis, the patient needs to obtain an accurate imprint of the supporting teeth, gingival margin and ledge, the relief of the mucous membrane of the prosthetic bed and the functional state of the mobile oral tissues adjacent to the prosthesis, so we use an individual spoon. The technique for obtaining an impression is a one-stage single-phase with retraction of the gingival margin. The impression material can be a silicone material of group A-silicones of a liquid consistency.

The treatment was carried out according to the generally accepted method. Received a diagnostic model. Using a parallelometer, the structural features of the prosthesis were determined. Teeth were prepared for the manufacture of ceramic-metal bridges, and temporary dentures were made on the same visit. Further, on a diagnostic plaster model with a drawing of the future design, the boundaries of the individual spoon, the "contact zone" and the "stop points" were outlined, departing from the border of the prosthesis by 2–3 mm. We make an individual rigid spoon from self-hardening plastic according to the traditional method, with a thickness of at least 2-3 mm. On the next visit, an individual spoon was placed in the patient's mouth, specifying the boundaries and correct location on the prosthetic bed. The edge of an individual tray in the region of the edentulous part of the alveolar process was formed using Herbst's samples. And in the area of \u200b\u200b"contact zones" and "stop points" holes were made in the spoon. The impression was obtained by a one-stage single-phase technique. Retraction - by mechano-chemical method using a retraction thread impregnated with a buffer solution of aluminum chloride. The impression material was brought with a syringe to the gingival grooves and abutment teeth. A collapsible combined model was made. The model was obtained with the preservation of the level and volume of the gums. This model is working for the manufacture of both fixed and removable parts of the prosthesis. Next, a combined prosthesis was made according to the traditional method. During the manufacture of the removable part, the canopy was isolated on the vestibular slope in the frontal area using a light-cured composite.

When fitting and applying the prosthesis, there were no difficulties and the need for correction

The patient was scheduled for examination on the 10th day after fixation of the prosthesis. There were no complaints. On examination, the prosthesis is adjacent to the surface of the prosthetic bed, and is stable during function. There are no signs of trauma or inflammation on the mucous membrane. Analysis of the results of treatment of the patient within one year showed the effectiveness of the treatment. X-ray and clinical control confirmed the high-quality fitting of the structure and the absence of pathological changes in the area of the preserved teeth. The patient is quite satisfied with the restoration of functions and aesthetic requirements.

Conclusion

Thus, obtaining an impression in the treatment of partial absence of teeth with combined solid-cast prostheses, in combination with a correctly selected impression material, allows obtaining differentiated pressure on various parts of the prosthetic bed, functionally shaping the edge of the artificial base of the removable

part of the prosthesis, reducing the duration of adaptation and, in general, increasing quality of orthopedic treatment.

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POLITICAL SCIENCES

THE POLITICAL OPPOSITION: THEORETICAL PROBLEMS

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https://doi.org/10.5281/zenodo.7621389

Abstract
In the present article, the fundamental theoretical analyses of the political opposition are subject to interpretation at the level of its definitions and its place and role in the political process. The author systematizes the main classifications and models of the political opposition. An author's definition of the oppositions is offered and some fundamental conclusions and generalizations are made, connected with the need for future theoretical analyses and empirical research.

Keywords: *political opposition, opposition models, types of opposition, parliamentary opposition, secession*

1. INTRODUCTION

The analyses of the political opposition are a significant aspect of the problematic field of the political science. At the same time, the political opposition and its existence are part of the political practice. In this sense the research work on the theory and practical manifestations of the opposition are topical in a theoretical and practical aspect.

It is known that the political opposition is examined primarily in the English and American scientific literature (and more specifically in political sociology) in connection with the theory of elections and the theory of the political system. The reason for this fact is connected with a very important institutional characteristic of the political opposition: it is not a "tier" of power, nor is it a structure of power in an institutional sense. The political opposition is traditionally analyzed in three problematic situations: (1) during parliamentary elections; (2) during its activity in parliament (in the course of parliamentary sessions) and (3) in its activity in mass media.

The socio-political and economic changes in the East European countries after the end of the 90's of the 20th century have brought about an increase of interest in the topic of the political opposition and the need for topical analyses, generalizing the political practice in Eastern Europe. This is also the reason for the growth of interest in the political opposition during the last two or three decades, as well as its role in society and the Russian scientific literature, which leads to interesting analyses. In the Bulgarian scientific literature, the theoretical problems of the political opposition have not been examined independently.

The **chief aim** of the present article is to systematize and analyze the main theoretical contributions to the topic of "political opposition" at the level of the definitions of it, its place and role in the political process and the fundamental classifications and models.

The etymology of the concept of "opposition" leads back to the Latin word "oppositio" – confrontation. It is claimed that its wide use in a political context can be attributed to highly placed civil servants from the middle of the 18th century and was put to scientific use by Edmund Burke and Henry Bolingbrook (See: Рыжикова, 2021; Татаркова, 2013). The use of the term "opposition" in the political parlance is associated with England and the well-known deferential expression "the opposition of His Royal Majesty, the King", despite the term having a strongly negative connotation for quite a while (Пономарева, 2002).

The problems of the political opposition can be found in the works of a number of well-established researchers, such as: Francois Guizot ("On the Means of Government and of Opposition in Modern France", 1821), Moisey Ostrogorsky ("Democracy and the Organization of Political Parties", 1902), Maurice Duverger ("The Political Parties", 1951), Charles Mills ("The Ruling elite", 1956), Jean-Paul Sartre ("Critique of Dialectical Reason", 1960), Robert Dahl ("Polyarchy: Participation and Opposition", 1971), Peter Bromhead ("Evolution of the British Constitution", 1978) and others. However, classical theoretical examinations of the opposition are considered "Political Opposition in Western Democracies" (collection under the editorship and with the participation of R. Dahl, 1966); "Opposition: Past and Present of the Political Institution", 1968 by Gita Ionesco and Isabel de Madariaga; "Political Opposition in One-Party States", 1972 by Leonard Shapiro; "The Opposition in Eastern Europe", 1979 by Rudolf Tökes (comp.).

2. EXPOSITION

In the present article, a theoretical interpretation is given to the following problems: the approaches to analysis of the political opposition; the boundaries of defining the opposition on the part of various researchers; the models and classifications of the political opposition ensuing from the definitions in question and the explicit generalization of the role of the opposition in the political process.

2.1. Approaches to analysis of the political opposition

The problem of the approaches to the analysis of the opposition is important because the ways in which the analysis is carried out determine the definition fields of each phenomenon, including the opposition. Various approaches can be identified in the analyses of the political opposition. The variety of approaches to the phenomenon of political opposition is actually a reflection of its complexity and multi-aspectual character.

According to E. Rijikova there are two approaches to the political opposition:

- The first approach treats political opposition as an element of the political structure of society and its political institution (this is the so-called institutional approach). The opposition is analyzed from the viewpoint of its institutionalization and the degree of its organizational structure. According to this approach, the focus is on the means and ways with which the opposition influences the political power and its degree of impact on the power structures. The approach, herein mentioned, defines the forms of opposition as systematic and non-systematic, while the opposition defines itself as parliamentary/non-parliamentary or as legal/illegal.
- The second approach analyzes the opposition as a behavioral predisposition of a person, group or organization towards manifestation of dissent concerning the existing political regime or the official state policy. This approach lays the accent on the social base of the opposition, the values, shared by the opposing groups, the behavioral activities and the conditions for transformation of the latent forms of opposition into active ones (Рыжикова, 2021). This approach is provisionally defined as behavioristic.

Another researcher – P. Vasilevski – extends the number of the approaches to analysis of the opposition and refers to them as:

- Institutional – it interprets the political opposition as an organized group, united on the basis of the common character of interests and values, which struggles for domination in the system of the state power with the ruling elite;
- Etymological – it lays the accent chiefly on the confrontation as a key characteristic of the opposition;
- Communicative – it regards the opposition as an alternative of the political power, in possession of specific meaningful, political and socio-cultural codes, determined by the minority, which are not shared and accepted by the majority;
- Structural and functional – it regards the opposition as a specific mechanism, ensuring feedback between society and the ruling elite (based on T. Parson's theory).

The author concludes that the rationalization of the opposition must be based on its role and status in the political system of society. Historically speaking, there are two types of approaches, connected with the evaluation of the role of the opposition: (1) the opposition as a pathology in the political world and a response to an imperfect state and political model, and (2) the opposition as a natural and legitimate structure in the system of the relations between "political power and society" (Василевский, 2018).

In our modern times, the political opposition is regarded as a crucial element, characteristic of both democratic and non-democratic political systems.

2.2. Analyses and Definitions of the Opposition

The analyses of the political opposition, which are best known in the scientific literature, are connected with the research work, done by Robert Dahl, Leonard Shapiro, Rudolf Tökes, Gita Ionesco and Isabelle de Madariaga, Otto Kirchheimer, G. Sartori, Natalie Brack and Sharon Weinblum.

2.2.1. Robert Dahl

Dahl analyzes the political opposition within the framework of his polyarchy theory by analyzing the political opposition only in bi-party and multiparty systems. An important characteristic of polyarchy is the attitude towards conflicts in the political system, which are regarded as unavoidable, but constructive elements of the system. The possible sources of conflict in the system of democracy are: (1) the development of technologies; (2) the development of the social and economic institutions of society and (3) the development of citizens' ideas and beliefs. For the researcher, the political conflict is not only unavoidable, but also desired, because it helps in the development of the system. Dahl, however, points out that the system does not need "drastic conflicts" which could threaten it. In this context, the conflict is defined as sharp and drastic, if "most people from each of the two sides regard the other one as an enemy and want to do way with it regardless of the means involved (Dahl, 1967). Proceeding from these assumptions in his book "Political Oppositions in Western Democracies", Dahl put forward the question: "How to handle and manage the political conflict?" and answers it by stating that this is a **task of the political opposition** (Dahl, 1966).

Dahl's definition of the political opposition is relational and hypothetical: "1) Let us assume that A determines in some aspect the behavior of the government of a given political system during some period of time; 2) Let us also assume that during this period **B** is unable to determine the behavior of the government and that **B** opposes the behavior of the government through **A;** then **B** is what is called an opposition" (Ibid., p. 71). By all means, in another time period **B** can determine the behavior of the government and then **A** will be in opposition, Dahl points out.

It is evident that Dahl does not regard the opposition as a structure in an institutional sense of understanding, but rather analyzes it judging by its role concerning the possibilities of exerting influence over the policy of the government.

Proceeding from the role of the political opposition, R. Dahl distinguishes between two types of opposition.

(1) *Active* – it functions in the cases when **B** undertakes a carefully planned course of action aiming to modify the activity of the government;

(2) *Passive* – it functions when **B** recognizes the conflict between itself and the government, but deliberately does not undertake any action aiming to change the government's behavior (Ibid., p. 73-74).

In "Political Oppositions in Western Democracies", the scientist subjects to analysis only the active opposition. Analyzing the active opposition, Dahl offers certain *criteria*, based on which, he distinguishes and defines *models* of political opposition. The following table presents systematically the criteria, suggested by the author, and their corresponding models of opposition. See Table 1.

Table 1.

Models of political opposition, according to R. Dahl

Criteria	Models
1. Coherence (concentration) of the opposition	4 models of opposition 1) In a bi-party system with a high degree of unity inside the party (Great Britain); 2) In a bi-party system with a relatively low degree of unity inside the party (North America); 3) In a multiparty system with a relatively high degree of unity inside the party (Sweden, Norway, The Netherlands); 4) In a multiparty system with a relatively low degree of unity inside the party (Italy, France)
2. Competitiveness of the opposition	3 types of strategies, determining the models of behavior: 1) Confrontation during elections and in parliament between the opposition and those in power; 2) Collaborationism during elections and in parliament; 3) Mixed – confrontation during elections and collaborationism in parliament
3. Possibility for conflict between the opposition and the groups who control the government	3 types of possibilities for conflict, determining the models of behavior (only in parliament) 1) The opposition persuades the government to take a certain decision; 2) Initiative on the part of the opposition to impose a decision on the government; 3) Coercion on the part of the opposition concerning the taking of a certain decision by the government
4) Self-knowledge of the opposition	4 problem zones, connected with the dichotomy of liberalism-conservatism, determining models of behavior and connected with the political culture; 1) Concrete v/s abstract (or empiricism and pragmatism v/s abstractness and rationality); 2) Economic problems v/s political and civic freedoms; 3) Internationalism v/s isolationism; 4) Innovation v/s tradition
5) Goals of the opposition	2 types of goals of the opposition, determining models of behavior; 1) Long-term (dominant) goals – referring to the gaining of the power; 2) Short–term (controlling) goals-referring to the composition of the government, the policy of the government, the structure of the political system, the socio-economic structure.
6) Strategies of the opposition (perceived as means which the opposition uses to accomplish its goals)	6 types of strategies of the opposition, determining models of behavior: 1) Focusing on the competition for gaining enough support in parliamentary elections, for majority in parliament and for forming a government; 2) Focusing on the neutral electorate and joining a ruling coalition; 3) Focusing on representation and participation in quasi formal negotiations and influencing lobby groups (USA); 4) Focusing on exerting influence at the level of relations between legislative and executive power, small parties, central and local institutions of power (USA) 5) Focusing on the preservation of the political system when it is threatened by internal crises or coup d'états; 6) Focusing on the destruction of the existing political and constitutional system (revolutionary opposition)

Source: Author's table

Another interesting idea of R. Dahl, concerning the opposition, is the idea of typifying it, based on the type of political system and its accompanying political culture. Thus, the researcher, defining two hypothetical types of political systems – Anglo-American (he includes also the Scandinavian countries in it) and Mediterranean (mainly represented by Italy and France), typifies the political opposition and defines its main characteristics. The following table presents the general characteristics of the opposition in the two types of political system, according to Dahl. See Table 2.

Table 2. Characteristics of the political opposition in the Anglo- American and the Mediterranean types of political system

Type of political system	Characteristics of the opposition
Anglo-American	1. Support for a stable government; 2. Staunch support of the political institutions and the constitutional rules; 3. Advocates of evolutionary social changes 4. Advocates of a factual analysis, i.e. there is no ideological system analysis
Mediterranean	1. The oppositions achieves its goals even if this leads to instability of the government; 2. "the rules of the game" (constitutional rules) may be changed, if this is what the goals of the opposition require; 3. Achievement of the structural power and social changes even if this requires revolutionary means and ways 4. Advocates of ideological analysis (strong ideological colouring)

Source: Author's table

R. Dahl's analysis of the political opposition is the first system analysis and contributes to the theory of the political opposition with the following: (1) it defines the political opposition; (2) it analyses the opposition on the basis of its role and functions in the political system; it defines different models of opposition, based on a system of developed criteria, and (4) it typifies the opposition on the basis of the type of political system and political culture.

2.2.2. *Leonard Schapiro and Rudolph Tokes*

What the two authors have in common is that they analyze the political opposition in the Eastern European country during the period of the totalitarian communist regime.

L. Schapiro analyzes the political opposition in the one-party systems, proceeding from M. Duverger's classification of political systems into one-party, biparty and multiparty ones. According to Schapiro, it is necessary to analyze the process of government "not only in the light of what people in power try to do and actually achieve, but also concerning those who oppose these goals or whose interests and resistance must be reconciled, before those in power can act" (Schapiro, 1966, p. 2), i.e. the role of the opposition must also be analyzed.

In his book "Political Opposition in One-Party States", Schapiro defines three main reasons for the emergence of a political opposition in the states with one-party political systems. They are (1) the economic insecurity in the countries; (2) the existing obstructions on the way to social mobility and (3) delay of the fulfillment of the promises for improving the quality of life on the part of the ruling party.

The author provides the following definition of political opposition: "an organized political group (groups), whose goal is to oust the existing government from power and substitute it for a new one, elected by it" (Schapiro, 1972, p. 345). Thus, Schapiro regards the political opposition from the perspective of a specific field of action – the parliament, a concrete participant – the party of the minority, a concrete opponent – the government, and a concrete goal – taking the political power. The above-mentioned approach is not much different from Dahl's approach. However, Schapiro distinguishes the political opposition from another critic of the official political power – the dissidents. The author refers to the dissidents as "… unorganized political group for political action, who does not aim to substitute the existing political regime, nor does it aim to gain the right of exercising the political power. Its aim boils down to criticizing, giving advice, convincing and desiring to be heard by those in power" (Ibid., p. 346). Therefore, the main differences between the opposition and dissidents are determined by the degree of organizations and the attitude towards the exercising the political power (or not exercising it).

R. Tokes and the authors of the collection "The Opposition in Eastern Europe" analyze the historical emergence, goals and strategies of the political opposition after the imposition of the communist regimes in Hungary, Poland, Czechoslovakia, the USSR, and East Germany (DDR). In the collective work are identified *four main forms of opposition in Eastern Europe*, which are made concrete for the separately analyzed states. They are:

(1) *Integral opposition* (from the mid 40's to the mid 50's of the 20th century)- it is represented by the bourgeois political parties, subjected to ostracism and persecution, which are forced to retreat from political participation;

(2) *Factionary opposition* (from the mid 50's to the mid 60's of the 20th century) - it is connected with the faction stratification in the ruling communist parties and the fight for political influence among them;

(3) *Fundamental opposition* (from the mid 60's to the mid 70's of the 20th century) – it presents a particular unification of the oppositional attitudes of the working class with the dissidents of the intelligentsia.

(4) *Specific opposition* (from the 70's of the 20th century) – it is connected with a development of the above-mentioned forms of opposition and their attempts for organizational unification (an example of

such an opposition is the "Solidarity" trade union in Poland) - (Tokes, 1979).

The concept and understanding of political opposition, presented in the cited book is maximally wide and includes all forms of dissent with the official political power.

2.2.3. Other analyses

As we have already mentioned, there are also other analyses of the political opposition, although small in number. Without any claims for comprehensiveness, we present some more popular studies.

- Gita Ionescu and Isabel de Madiaraga, in their book "Opposition: Past and Present of the Political Institution", succinctly define the opposition as "logically and morphologically … a dialectical double of the political power" (Ionescu and de Madariaga, 1968, p. 2). The authors analyze the parliamentary opposition, because, in their opinion, it is "the most advanced and institutionalized form of political conflict" (Ibid., p. 9). Consequently, the analysis is in the common paradigm of the institutional understanding of the political opposition. According to Ionescu and Madariaga, "the term … must be used in situations, in which the opposition is not only allowed to function, but (certain) functions are entrusted to it. Thus, it turns into an institution… higher institution of a completely institutionalized political society and (becomes) a criterion for these societies, which are referred to with different names: democratic, liberal, parliamentary, constitutional, pluralistic, and even open and free" (Ibid., p. 12). It can be inferred that in the authors 'opinion, the political opposition is a part (characteristic) of democracy.
- Otto Kirchheimer and Giovanni Sartori analyze the types of opposition. Thus, for example, Kirchheimer distinguishes among three different types (kinds) of opposition: (1) "*classical "or "loyal" opposition* – it offers an alternative to the exercised policies while at the same time it recognizes the right of the government to rule and support the existing constitutional system; (2) *opposition of principles* – this is an opposition, opposing both the government's policy, and the constitutional requirements of the political system; and (3) "*political competition"* – here, the oppositional group competes with the current team holding the political power, but it does not offer alternative goals and objectives, different from those of the government (Brack and Weinblum, 2009). G. Sartori also distinguishes between the "normal" opposition from its deviant form. According to him, the "real" opposition involves agreement on a fundamental level, which is an agreement on the level of community and political regime. It opposes the "government but not the political system as such and acts quietly and constructively by opposing but not obstructing. Along with this "constitutional opposition", he identifies another type of opposition: the anti-system opposition which contests the legitimacy of the regime, such as it is. The latter opposition acts "irresponsibly", since it does not have the chance of gaining the political power and taking responsibility for the policy (Sartori, 1966, p. 151).
- Nathalie Brack and Sharon Weinblum, proceeding from the classical analyses of the opposition and taking into account the modern tendencies towards a wider view of this political phenomenon, offer an expanded definition of the political opposition. The authors understand the political opposition to mean:

✓ "Any organized and active subject – parliament, political party, unrepresented politica; formations, trade unions, social movements;

✓ Expressing a position, different from the official one in the public sphere – government, parliament, media, and others;

✓ Anyone who constantly or timely checks out, informs, and criticizes the current state of things by using various non-forcible modalities – legislative processes, parliamentary questions, press releases, mobilization of media, social protests, demonstrations etc.;

✓ Any activity, whose critical targets are the government and/or its policy, and/or the political elite, and/or the political regime as a whole" (Brack and Weinblum, 2009).

The above-cited definition is maximally comprehensive and includes a wide range of subjects, their roles and various forms of activity in politics. In it the oppositional activity is targeted not only at certain political subjects, but also at the political system and its corresponding regime.

3. GENERALIZATIONS AND CONCLUSIONS

Based on the above-mentioned analyses of the political oppositions, some generalizations and conclusions on the topic can be made.

First. The political opposition is an element of the political system and a subject of the political process. It exists – either overtly, or in latent forms – in every political system – both democratic and undemocratic. Its main role is to criticize or correct the political power and the official policy, regulate the conflicts in society and/or offer alternative policies and solutions. The forms of activity, sphere of action and means, used by the opposition, are different and depend on both its organizational state, and the type of political culture and existing traditions.

Second. The functions of the political opposition are numerous and are mainly connected with the following:

✓ Offering various political alternatives in parliament and in public;

✓ Expressing the interests of its adherents;

✓ Offering alternatives to officially passed bills in parliament and governmental decisions;

✓ Participating in parliamentary and social debates by searching for constructive approaches;

✓ Evaluating and critically commenting on the suggested legislative initiatives from the standpoint of its goals;

✓ Commenting critically the governmental policy and the activities of the state administration;

✓ Contributing to guaranteeing transparency and control over all stages of the political process;

✓ Contributing to analyzing and guaranteeing the legitimacy of conflicts.

Third. The classification of the political opposition is carried out on various criteria and is connected with the type of political system and goals of the oppo-

sition. The following table presents a possible classification of the opposition according to certain criteria. See Table 3.

Table 3.

Classification of the political opposition

Criteria	Types of opposition
1. Spheres of activity	Parliamentary Non-parliamentary
2. Degree of participation	Active Passive
3. Attitude to the political system	System Anti-system
4. Positions, connected with its constitutional regulation	Legitimate Illegitimate

Source: Author's table

Fourth. The additively political opposition can be defined in the following way: an organized group of subjects (actors on the political stage), united by common interests, values and goals, opposing the official subjects of the political power and expressing by various means criticism and dissent with the government and its policy, the political system, or political regime. The political opposition is a carrier of various alternatives for social development and public policies. Its long-term goal is to take over the power resources in the political system (See: Татаркова, 2013, p. 115).

The problems of the political opposition will play important part in future political analyses, both at the level of theory, and the level of the empirical analysis of the activity of the various manifestations of the opposition. Particularly productive would be the analyses of the political opposition in concrete and specific national frameworks – the classical and new democracies and the non-democratic political systems.

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TECHNICAL SCIENCES

A SMALL-SCALE MANIPULATION ROBOT A LABORATORY LAYOUT DEVELOPMENT

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Abstract

This article is devoted to the control system development for a mobile manipulation robot with a computer vision system. A feature of this study is the development of a decentralized control system based on microcontroller modules with the possibility of remote control using wireless networks. During the design, the authors developed a generalized block diagram of the manipulation robot and analyzed and selected hardware modules for implementing the control system. For the implementation of the laboratory layout of a mobile manipulation robot, the restrictions that are imposed on the control system were selected and justified. Based on these restrictions, it was proposed to use the following hardware modules: ESP32-Cam - for computer vision system implementation and ESP32 Devkitc v4 for motion control system implementation 2WD robotic platform and control system for the manipulator itself. Based on the selected hardware modules, a block diagram of the information interaction of the main modules of a mobile manipulation robot and an electrical circuit diagram are proposed, an experimental model of a small-sized manipulation robot is assembled to test the control system. A generalized control algorithm for a mobile manipulation robot has been developed based on the "client-server" architecture approach using "thin client" technologies, which makes it possible to use any mobile device that supports hardware connection to Wi-FI and any Web browser.

Keywords*: mobile robots, mobile manipulation robots, control systems, computer vision system, decentralized control system, laboratory layout*

Introduction

The modern development of robotics, which has led to the introduction of new technologies within Industry 5.0, poses new challenges for the development of mobile small-sized manipulation robots that allow not only to analyze the environment, but also to influence it with the help of a manipulator [1,2]. These small-sized mobile robots can be used in areas of man-made disasters, in the study of narrow enclosed spaces that occur during the collapse of reinforced concrete structures [3,4]. Small size and mobility allows the manipulation robot to penetrate narrow passages between structural elements and analyze the environment and transmit data to the operator. As a result of this, the task of developing this robot using small hardware modules based on microcontroller technologies arises. This will allow not only to implement a platform and manipulator control system, but also to implement a computer vision system with the ability to further use it as a system for identifying and recognizing objects on the basis of artificial intelligence (AI), which will simplify the work of the operator [5,6].

Literature Analysis

Zhengxue Zhou's work gives an example of a mobile robotic arm with a computer vision system development. The mobile robotic arm is equipped with cameras, an in-house developed adaptive grip, and a computer vision training system based on the PV-RCNN network model [7]. The developed robot is attracted to automatic production processes in small and medium-sized enterprises (SMEs), as a result of which it has significant dimensions and high requirements for hardware modules, for example, for the operation of a neural network, this robot uses a GEFORCE RTX 3090 GPU, and therefore this robot cannot be considered small-sized. An article by Dmitry Topolsky gives an example of the experience of developing a mobile robot for Mine Exploration, the mobile robot control system is built on the basis of a Raspberry Pi 3 single-board computer using the Multi Camera Board V.2.1 module, which makes it possible to connect two Rpi Camera cameras for visualization of the surrounding space [8]. The developed prototype has a number of limitations of the working environment, such as the minimum height and width should not be less than 300mm, which is due to its overall dimensions, while the mobile robot does not have a manipulator, which limits its functionality. In [9], the authors presented an approach to designing equipment and a control system for a mobile manipulation platform that was used in the MBZIRC 2020 competition. The mobile robot is controlled based on OS ROS, and the video stream is processed based on the Open CV library. The mobile platform is equipped with

a manipulator, which makes it possible to move small objects. For visualization of the surrounding space, the authors use RS-LiDAR16 and the Intel Realsense D435 camera, which leads to an increase in the overall dimensions of the mobile manipulation platform and does not allow its use in confined spaces. As you can see, research in the development of mobile manipulation platforms is an urgent task, especially creating prototypes for working in confined spaces in areas of man-made disasters.

Setting the Research Goal

The main goal of this study is to develop a decentralized control system for a small-sized mobile manipulation robot with the function of visualizing the environment through a computer vision system.

Разработка макета малогоборитного манипуляционного робота

A Small-Sized Manipulation Robot Layout Development

At the first stage of a small-sized manipulation robot laboratory layout development, it is necessary to design a block diagram, determine the main elements and the type of relationships between them. As a result, it is necessary to define a number of restrictions that will be imposed both on the entire structure and on individual hardware modules, as well as on the proposed design solutions. Based on the purpose of the development, it is proposed to present a block diagram in the form of a set of block elements and the relationship between them. We define the following main blocks for the implementation of a small-sized mobile manipulation robot:

- Computer Vision System (CVS) module for processing and broadcasting a video stream, via wireless networks, for visualizing the environment to the operator;
- Sensor (S) sensors for sensing the mobile robot (ultrasonic, infrared);
- Manipulator Control System (MCS) manipulator control system (servomotors);
- Engine Management System (EMS) motor control system (DC Motor), to ensure the movement of the mobile platform.
- Robot Control System (RCS) a system for controlling the movement of a mobile platform and processing data from sensors on which the manipulator is installed;
- Power Management System (PMS) power management of the mobile robot and manipulator;
- Motor (M) propellers (motors).

The developed generalized block diagram of the developed manipulation robot is shown in Figure 1.

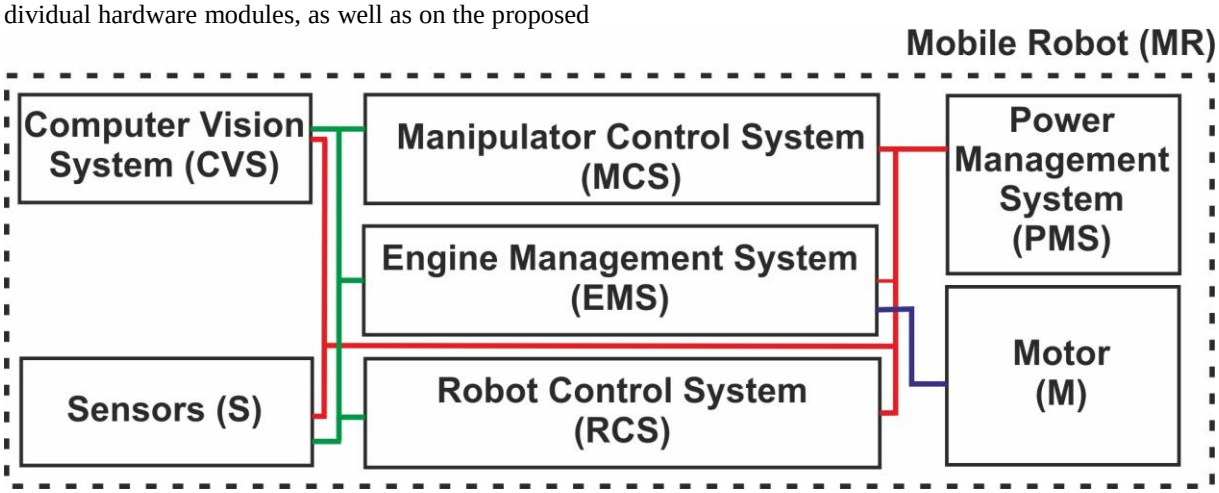


Figure 1. – Generalized Block Diagram of the Developed Manipulation Robot

The next step in the development of a small-sized manipulative robot is to analyze, determine the restrictions and select hardware modules on the basis of which the developed block diagram can be implemented (Fig. 1.).

To implement the functions of the Computer Vision System (CVS), it is necessary to select a microprocessor module with the ability to connect and work with a video camera. Let's define the range of some restrictions that must be taken into account during development:

- overall dimensions no more (~40.5*27*5mm);
- supply voltage (no more than 5V);
- matrix resolution SVGA 800x600 (30 fps)
- the ability to transmit streaming video via wireless networks;

In the course of the analysis of existing hardware modules that satisfy the identified restrictions, are presented in Figure 2, and a comparison of their parameters is presented in Table 1

a) *b)* *c)*

a) ESP32-Cam Wi-Fi Bluetooth, камера OV2640 [10]
b) Miniature TTL Serial JPEG Camera with NTSC Video [11]
c) OpenMV Cam M7 Open Source Computer Vision Board [12]
Figure 2 – Microprocessor Modules for Computer Vision System Implementation

As you can see from Table 1, the Miniature TTL Serial JPEG Camera module is not suitable as a CVS, since you need to buy an additional microcontroller-based module, the remaining two ESP32-Cam and OpenMV Cam M7 modules have similar parameters, but have a difference in the development environment. To develop the ESP32-Cam firmware, the Arduimo IDE based on the C++ language is used, OpenMV Cam M7 recommends the MicroPython language, as a result of which it is proposed to use ESP32-Cam to develop the CVS of the experimental layout, since it has smaller overall dimensions and is also acceptable in terms of price.

The next step is to select the Manipulator Control System (MCS) as well as the Robot Control System (RCS). Let's define the basic requirements for these modules:

- not large overall dimensions;
- the ability to connect additional modules;
- support for wireless networks.

Table 1 – - Computer Vision System Hardware Modules Main Characteristics Comparison

Parameters	Hardware Modules		
	ESP32-Cam Wi-Fi Bluetooth, camera OV2640 [10]	Miniature TTL Serial JPEG Camera [11]	OpenMV Cam M7 [12]
MCU	32-bit dual-core microprocessor Xtensa	-	STMicro STM32F765VI ARM Cortex M7
Operating frequency (MHz)	до 240	-	216
Memory	512KB RAM, 4 MB flash + micro SD slot	-	512KB RAM, 2 MB flash + micro SD slot
Camera	OV2640, OV7670	OV2640	Omnivision OV7725
Image size	UXGA 1600x1200 (15 fps) / SVGA 800x600 (30 fps)	VGA（640*480), QVGA（320*240), QQVGA（160*120）	640×480 8-bit grayscale images or 320×240 16-bit RGB565 images at 30 FPS
Viewing angle	70-120	90	70
Wireless Module	WiFi 802.11 b/g/n + Bluetooth 4.2 LE	-	WiFi 802.11 b/g/n + Bluetooth 4.2 LE
Power Supply (V)	5	5	5
Power Consumption (V)	3.3	3.3	3.3
Dimensions (mm)	27*45*40	20*28	45*36*30
Weight (g)	8	3	16
Цена	~10$	~35$	~64$

Let's analyze the hardware modules that can be used for Manipulator Control System (MCS) and Robot Control System (RCS) implementations. The selected modules are shown in Figure 3, and their technical characteristics are in Table 2.

a) *b)* *c)*

a) ESP32 Devkitc v4 [13]
b) WI-FI модуль WeMos D1 mini [14]
c) Wi-Fi модуль ESP8266 Witty Cloud [15]
Figure 3 – Microprocessor Modules for MCS and RCS Implementation

Table 2

Comparison of the Hardware Modules Main Characteristics for Implementation Manipulator Control System (MCS) and Robot Control System (RCS)

Parameters	Hardware Modules		
	ESP32 Devkitc v4 [13]	WI-FI module WeMos D1 mini [14]	Wi-Fi module ESP8266 Witty Cloud [15]
MCU	2-core 32-bit processor Tensilica Xtensa LX6	32-bit processor	32-bit processor
Operating frequency (MHz)	до 240	80	160
Memory	512KB RAM, 4 MB flash + micro SD slot	512KB RAM, 4 MB flash	512KB RAM, 4 MB flash
Wireless Module	Wi Fi 802.11 b/g/n + Blue-tooth 4.2 LE	Wi Fi 802.11 b/g/n	Wi Fi 802.11 b/g/n
Hardware Interfaces	3×UART;3×SPI; 2×I²C; 3× I²S	SPI, I2C, I2S, 1-wire, UART, UART1, IR Remote Control	UART, HSPI, I2C, I2S
Power Supply (V)	5	5	5
Power Consumption (V)	3.3	3.3	3.3
Dimensions (mm)	48*27*5	33*26*6	30*30*20
Weight (g)	15	10	18
Price	~5-7$	~5-6$	~4-6$

Based on the results of the comparison, we can single out the ESP32 Devkitc v4 module, since it has a large number of supported interfaces, with which you can implement the connection of additional hardware modules and sensors to feel the mobile manipulation platform, this module will also allow you to develop a decentralized approach to management manipulation robot by dividing tasks: ESP32-Cam will implement the functions of the Computer Vision System, and ESP32 Devkitc v4 will be responsible for working with the manipulator and the mobile robot platform movement system.

For the Engine Management System (EMS) implementation - motion control of a mobile manipulation platform, a 2WD platform based on DC Motor with the following parameters was chosen: voltage 3-6V; current 180-500mA; moment 0.7 kg/cm. Based on the above parameters, it is proposed to use the following hardware modules for DC Motor control, which are shown in Figure 4, and their technical characteristics in Table 3.

a) *b)* *c)*

a) motor driver L298N [16]
b) motor driver L9110S[17]
c) motor driver MX1508 [18]
Figure 4 – Motor Driver Hardware Modules

Table 3

Motor Driver Hardware Modules Main Features Comparison

Parameters	Motor Driver		
	L298N [16]	L9110S [17]	MX1508 [18]
Module Supply Voltage	3-35B	2.5-12 B	2-10 B
Input Voltage	5-7 B	1.8-7 B	1.8-7 B
Operating Current	operating 2 A, peak 3 A	operating 1.5 A, peak 2.5 A	operating 1.5 A, peak 2.5 A
Cooling System	+	-	-
Dimensions (mm)	44*44*27	30*23*15	25*21*0.75
Weight (g)	26	6	4
Price	~2$	~1,5$	~1$

Analyzing the comparison of the main characteristics of motor drivers, we can distinguish two groups: the first is modules based on L9110S and MX1508, and the L298N module. The L298N module is designed to control more powerful motors, and therefore has passive cooling and is more reliable than analogues. Based on the characteristics of the selected hardware modules, the following block diagram of the information interaction of the main modules of the mobile manipulation robot is proposed, which is shown in Figure 5.

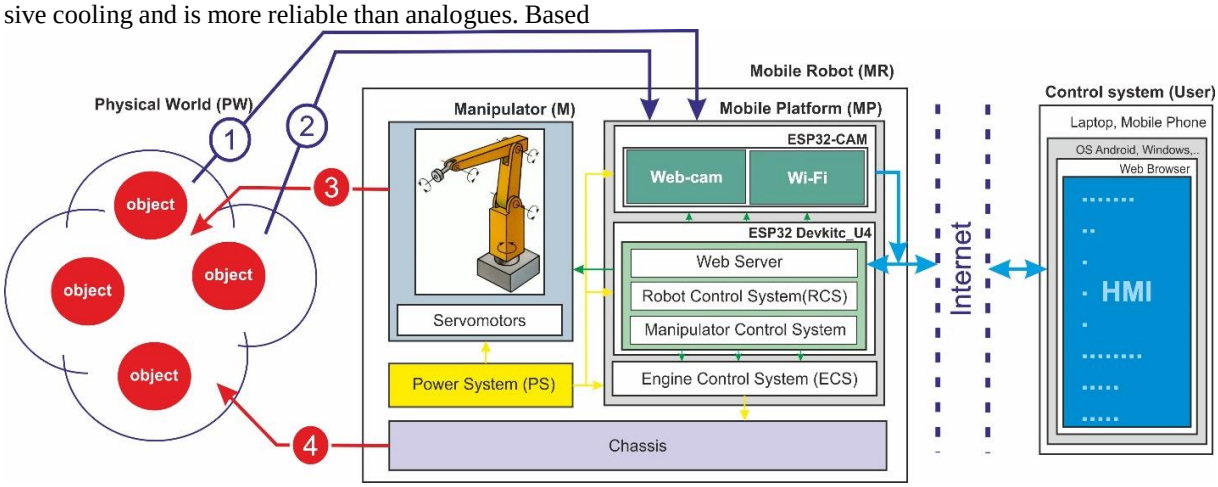


Figure 5 – Structural Diagram of the Information Interaction between the Main Modules of a Mobile Manipulation Robot

The mobile platform (MP) hosts two hardware modules ESP32_Devkite_U4 and ESP32-CAM. ESP32-CAM implements a computer vision system via wireless data transmission technology to the operator by creating a local Web service with the ability to broadcast streaming video. An access point is created on the ESP32_Devkite_U4 board, to which an asynchronous Web server is connected, which is designed to control the movement of the robotic platform, as well as to control the manipulator itself. The rationale for this decision was an attempt to distribute the level of loads on the hardware modules, since they do not have high speed, which accordingly increases the reaction time of the mobile manipulation robot to the operator's commands. The proposed solution will significantly increase the speed of processing commands and reduce

their execution time. The interaction of a mobile manipulation robot with the surrounding physical world ("object") occurs due to the influence on it through the manipulator (Fig. 2. designation 3) and the Chassis module, which ensures its movement in space (Fig. 2. designation 4). Obtaining data on the environment is carried out through a Web camera (Fig. 2. designation 1) and an ultrasonic sensor (Fig. 2. designation 2). The control of a mobile manipulation robot is carried out by the operator through a portable device (Laptop, Mobile Phone). The main requirement for a mobile robot control system is the presence of a Wi-Fi hardware module and a Web browser.

The next step in the development of a laboratory layout of a manipulation robot is the design of an electrical circuit diagram in the Altium Designer 20.2 PCB environment using the specifications of the selected hardware modules [19]. The developed electrical circuit diagram is shown in Figure 6. 3 batteries of the 18650 serie (3.7V, 3500mA) will act as batteries, to control the power supply of the ESP32-Cam, ESP32_Devkite_U4 modules will be carried out through the DC Converter LM2596S, which will reduce the input voltage from 12V to 5V [20].

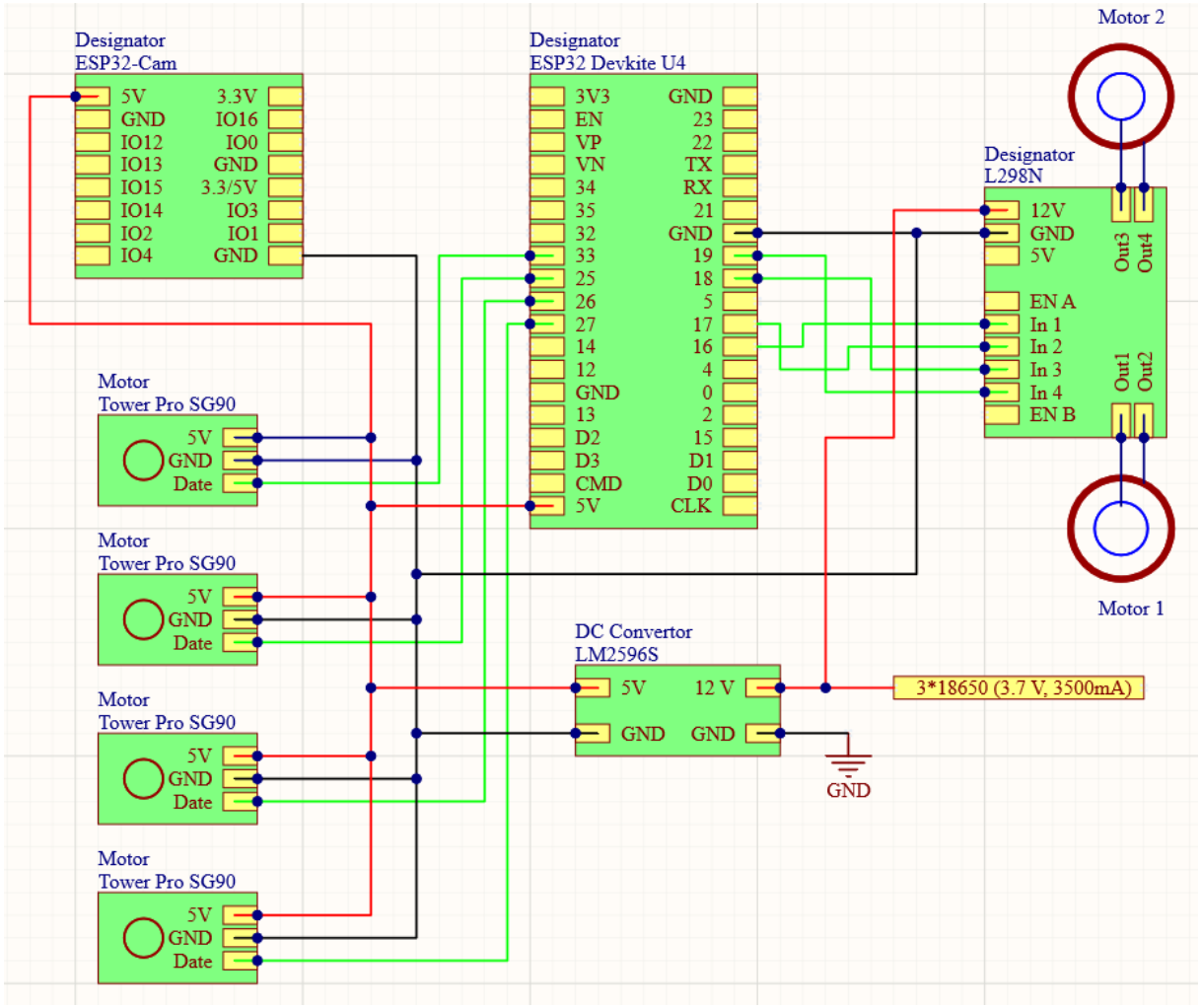
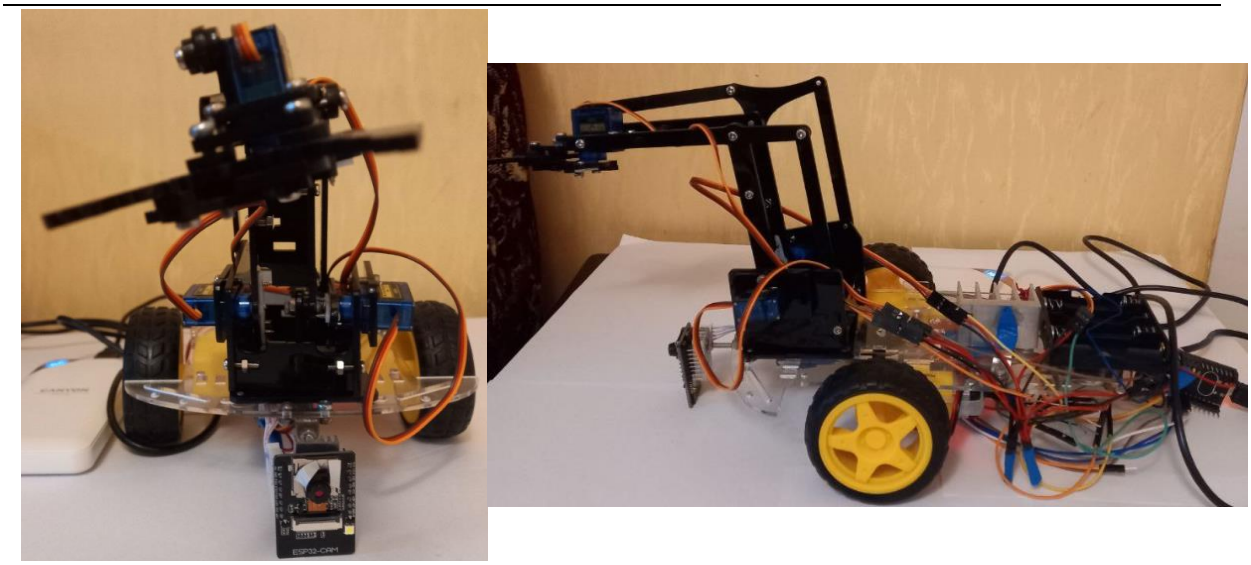


Figure 6. – Electrical Circuit Diagram

Based on the developed electrical circuit diagram, a laboratory layout of a mobile robot with a manipulator was assembled on the basis of the Arduino 2WD platform chassis [21]. The assembled layout is shown in Figure 7.

In the future, the platform can be replaced, depending on the tasks that are set for the mobile manipulation robot, both for wheeled (4WD) and caterpillar ones with more powerful engines, while the developed control system and computer vision system do not change.



a) *b)*

a) front view
b) side view

Figure 7. – Laboratory Layout of a Mobile Robot with a Manipulator

Development of an algorithm and program for the control system of a mobile robot with a manipulator

To work out the control mechanisms and operation of the computer vision system of the developed laboratory layout, it is necessary to develop a software package that will enable the operator to solve the set manipulation tasks with objects. At the initial stage, we will develop a generalized algorithm for control systems for a mobile manipulation robot, which is shown in Figure 8.

As can be seen from Fig. 8, the general control algorithm of a mobile robot, the control system of a manipulating robot is presented in the form of two independent algorithms, both a mobile manipulative robot and an operator of a mobile robot [22-30]. Let's describe the main elements of the Mobile Manipulation Robot algorithm:

1. Library initialization – initialization of libraries for working with ESP32-Cam and ESP32_Devkite_U4 (esp_camera.h, WiFi.h, Arduino.h, sp_http_server.h, etc.) which will make it possible to implement all the basic functions;

2. LAN Connections – connecting hardware modules to a local wireless network (Wi-Fi);

3. Starting the Web Server – initialization and launch of the Web Server based on ESP32-Cam and ESP32_Devkite_U4;

4. Camera Initialization – initialize and start streaming video from the camera ESP32-Cam;

5. Robot Control HMI Initialization – mobile platform motion control interface initialization;

6. Initialization the HMI Control of the Manipulator – initialization of the manipulator control interface;

7. Timer Counter – time counter, to update waiting for operator commands in time;

8. Waiting for Commands from the Operator – the procedure for waiting for commands from the operator by a mobile manipulation robot.

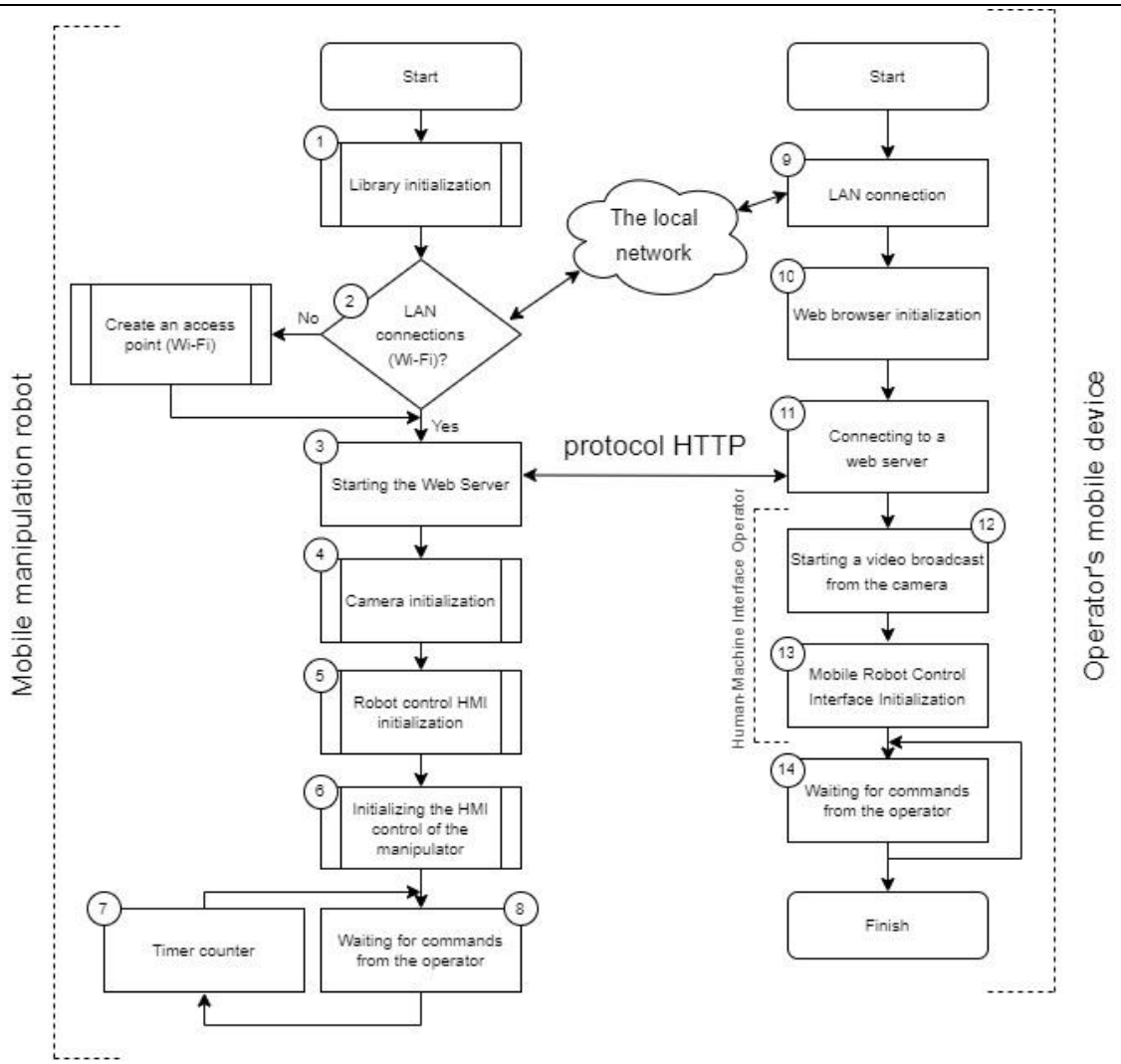


Figure 8. – Generalized Control Algorithm for a Mobile Manipulative Robot

Key elements of the Operator`s Mobile Device algorithm:

9. LAN Connections – wireless LAN connection functions;

10. Web Browser Initialization – initialization of the Web Browser installed on the mobile device of the operator;

11. Connecting to a Web Server – setting up a connection to the Web Server on the ESP32-Cam and ESP32_Devkite_U4 modules within a single HMI;

12. Starting a Video Broadcast – launching the functions of displaying the video stream in the operator's HMI;

13. Mobile Robot Control Interface Initialization – initialization and display of control commands for a mobile robot and a manipulator;

14. Waiting for Commands from the Operator – procedure for waiting for commands from the operator.

Data transfer between the mobile manipulation robot and the operator control device is based on the concepts of a "thin client" client-server architecture, based on the HTTP protocol. That will allow you not to install additional software on the operator's mobile device.

Here is a description of the implementation of some functions for the computer vision system in the Arduino IDE.

The initialization of the CameraServer for streaming video via the HTTP protocol via port 80, using the GET method, is presented below.

```
void startCameraServer(){
httpd_config_t config = HTTPD_DEFAULT_CONFIG();
config.server_port = 80;
httpd_uri_t index_uri = {
.uri = "/",
.method = HTTP_GET,
.handler = stream_handler,
.user_ctx = NULL
```

To test the launch of the OV2640 camera module on the ESP 32-Cam, it is proposed to use the following function, with the ability to output an error code to the Arduino IDE port monitor.

```
esp_err_t err = esp_camera_init(&config);
if (err != ESP_OK) {
Serial.printf("Camera init failed with error 0x%x", err);
return;
```

Connecting the ESP32-Cam module to a local wireless network is implemented in the following way-

```
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
```

```
}
Serial.println("");
Serial.println("WiFi connected");
Serial.print("Camera Stream Ready! Go to: http://");
Serial.print(WiFi.localIP());
```

The movement control of the mobile platform and the control of the onboard manipulator are implemented on the basis of the module, an example of the implementation of the commands for moving the mobile platform when executing the “Forward” command is presented below.

```
if(key == "Forward") {
 Serial.println("Forward");
 digitalWrite(MOTOR_1_PIN_1, 0);
 digitalWrite(MOTOR_1_PIN_2, 1);
 digitalWrite(MOTOR_2_PIN_1, 0);
 digitalWrite(MOTOR_2_PIN_2, 1);
```

Similar to the "Forward" command, the following commands are executed: "Left", "Stop", "Right", "Backward".

The initial position of the servomotors of the mobile manipulator for each link will be set as a ServoPins vector with specified rotation angles, as the initial points of the report:

```
std::vector<ServoPins> servoPins =
{
 { Servo(), 27 , "Base", 90},
 { Servo(), 26 , "Shoulder", 90},
 { Servo(), 25 , "Elbow", 90},
 { Servo(), 33 , "Gripper", 90},
};
```

To visualize the control menu of the “Gripper” command by the robot manipulator for the operator, in HTML, we will describe the following block element inside which the range visual element is located, with the parameters of the minimum and maximum angle.

```
<div class="slidecontainer">
 <input type="range" min="0" max="180" value="90" class="slider" id="Gripper" oninput='sendButtonInput("Gripper",value)'>
 </div>
```

The developed control interface for a mobile manipulation robot with a computer vision system is shown in Figure 9.

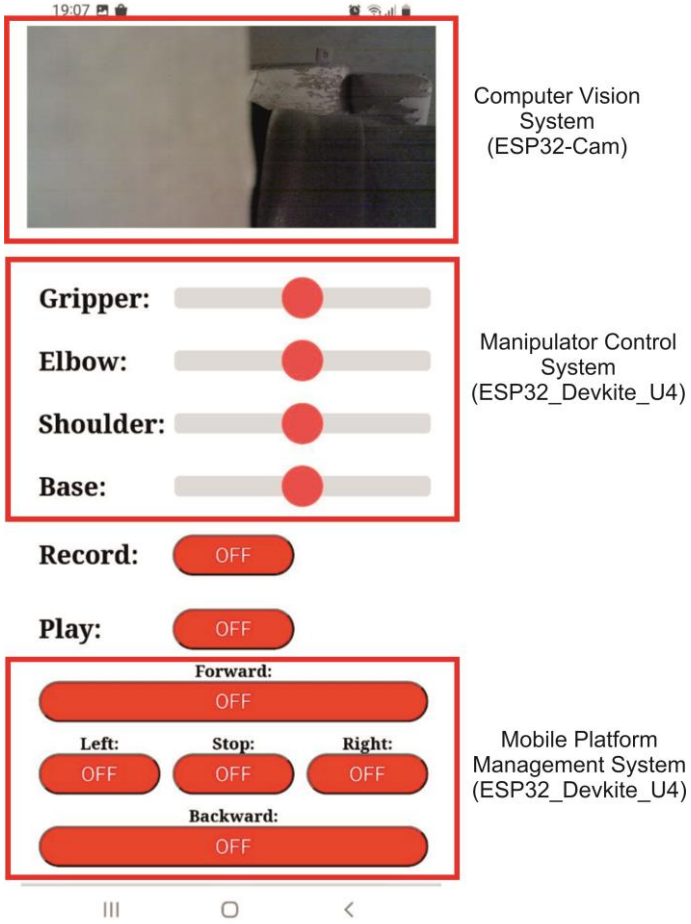


Figure 9. – Control Interface for a Mobile Manipulation Robot with a Computer Vision System

As can be seen from Figure 9, the mobile manipulation robot control interface is divided into three main control blocks, the Computer Vision System block transmits streaming video from the ESP32-Cam hardware module with SVGA 800x600 resolution (30 fps). The Manipulator Control System block allows you to implement the control of the position of the links and the capture of the manipulator in manual mode. The Mobile Platform Management System block makes it possible to control the movement of a 2WD mobile platform. Additional buttons "Record" allows you to record a video stream on the control device for further analysis by the operator for a more detailed assessment of operating situations.

Conclusions

In the course of the research on the development of a mobile small-sized manipulation robot, the authors developed a generalized block diagram. Taking into account the peculiarities of the application and restrictions on the requirements for overall dimensions, it was proposed to use a decentralized control system, in the form of separate hardware modules based on microcontrollers. This solution makes it possible to separate the computer vision system and the control system of the mobile platform and the manipulator, which improves performance. The analysis of modules for the implementation of control systems and computer vision systems was carried out, showed that within the framework of these studies, the ESP32-Cam and ESP32_Devkite_U4 modules are suitable, which fully meet the requirements for small-sized mobile manipulation robots. Based on this, an electrical circuit diagram of a mobile robot was designed and a laboratory model was assembled to verify the correctness of the development of a decentralized control system. The software implementation of the control system is built on the basis of the "client-server" architecture on the "thin client" method using the Web Server approach. The Web Server view will use the ESP32-Cam and ESP32_Devkite_U4 hardware modules to solve certain problems. We will develop a generalized algorithm for control systems for a mobile manipulation robot and provide fragments of functions for implementing streaming video transmission from the ESP32-Cam module and functions for processing commands for moving the mobile robot platform and controlling the manipulator itself based on the ESP32_Devkite_U4 module. A feature of the developed decentralized control system is that no additional software needs to be installed on the operator's mobile device and the control system is a cross-platform solution. In the future, the authors plan to redesign the design of a small-sized mobile manipulation robot, optimize the placement of components, develop a new design in the CAD system and use a 3D printer. And to integrate the Yolo v.4 library into the computer vision system, which in the future will allow for the identification of objects in the working area of the mobile robot.

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№47 2023
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Redaktor naczelny – Jacob Skovronsky (Uniwersytet Jagielloński, Poland)

1000 copies
International independent scientific journal
Kazimierza Wielkiego 34, Kraków, Rzeczpospolita Polska, 30-074
email: info@iis-journal.com
site: http://www.iis-journal.com