1) Names and surnames of authors of the solution

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2) Name of the technical solution

Program package **PPACM**, (**P**rogram **P**ackage **A**ctuator **C**hoice **M**ethodology)

3) Key Words

Cable robot, actuator choosing, workspace analysis and synthesis.

4) For whom the solution was done (legal entity or industries)

Scientific Research for the purpose of validation of theoretical assumptions

5) The year when the solution was completed

2017.

6) Year when it began to be implemented and by whom

The program package **PPACM** was implemented in published paper [1], in the journal FACTA UNIVERSITATIS, Series: Automatic Control and Robotics, 2018, in press, appropriate category **M51**.
We present the confirmation of theoretical contributions in the subtitle 5. "Program Package PPACM – Simulation Experiments" using software package **PPACM** in paper [1].

On this basis the software package **PPACM** acquires the right to be ranked in the category **M85**, **new technical solution, not commercialized.**

7) The area and the scientific field, which the technical solution refers to

The program package **PPACM** is developed and tested on a CPR-8 system (Cable-suspended parallel robot contains 8 actuators). With slight modifications, it is possible to use them with different complex configuration, e.g. industrial robotic configuration or other cable robot systems, or different other mechanisms.

8) Problem solved by technical solution

The main contribution of this work is the development of a novel methodology for choosing an actuator for the CPR-8 system, named CPR-ACM (CPR-**A**ctuator **C**hoice **M**ethodology). This methodology implies the formulation and application of a data base which contains catalogue parameters of the actuators available at the market. Both, users and designers define together the parameters and desired feasible workspace of the CPR-8 system being designed. The methodology is illustrated by a logic flow chart. It calculates the feasible workspaces for all available actuators from the data base and by a comparative analysis it identifies for the user and designer the possible usefulness of every available actuator. The novel procedure CPR-WWA (CPR-**W**hole **W**orkspace **A**nalysis) uses for analysis and synthesis of the feasible workspace of the CPR-8 system. This procedure is based on a complete kinematic and dynamic model of the CPR-8 system, as well as on the mathematical model of the actuator. Inclusion of actuator's mathematical model in the procedure CPR-WWA presents a novelty in comparison with available literature. Complexity of the procedure is high, because it involves mainly the parameters of the system which are mutually strongly coupled. The CPR-WWA procedure was defined and its validity was tested through a set of simulation experiments. Overlapping between the results achieved with application of the procedure and the results achieved from the simulation experiments is observed. In this way, a confirmation was achieved that the CPR-WWA procedure gives useful results. Through this research it is recognized that all actuator parameters affect the size of the feasible workspace of the CPR-8 system. Combination of these parameters is very important. It should be emphasized, that the actuator should not be chosen based only on one parameter, because all the other parameters, since they are strongly coupled, can equally strongly influence the response dynamics of the system.

A novel program package **PPACM** was defined. **PPACM** contains the methodology CPR-ACM and procedure CPR-WWA and makes a sub-program of this methodology. The program package is user friendly and offers the user all the benefits of the designed procedure CPR-WWA and methodology CPR-ACM.

9) State of the problem solution in the world

The developed methodology tests available actuators from its data base and extracts the useful ones for the predefined specific purpose of corresponding technical requirements, one of them being the relative size of the feasible work space of the CPR system. This methodology was not analysed in available world literature. This phenomenon was first analysed in detail in [1].

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10) Description of the technical solution

This program system **PPACM** was generated in MATLAB. A CPR system which carries system load (or a tool) via eight ropes is described. Each rope is controlled by an actuator, which means that this CPR system contains 8 actuators. Motion of the load is in 6DOF of the Cartesian space, which means that this CPR system is redundant. The system, named CPR-8 system, is presented in Fig. 1.

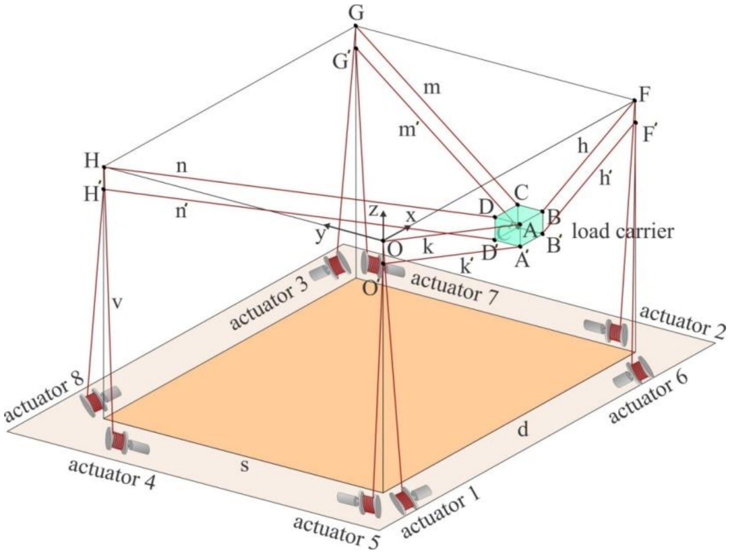

Figure 1 CPR-8 system in 3D space.

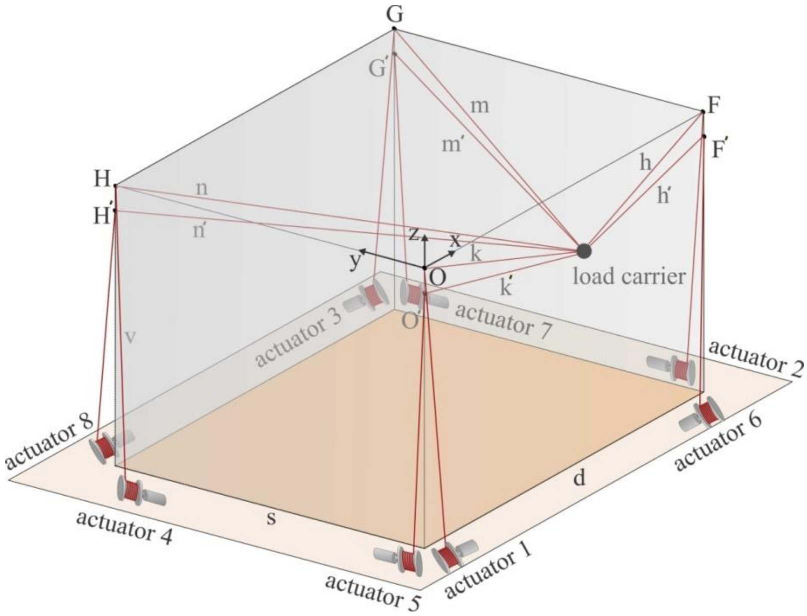

Figure 2 Theoretical workspace of the CPR-8 system.

The kinematic and dynamic models of the CPR-8 system are defined by eqs. (1) - (21), but synthesis of CPR-8 system's workspace CPR-WWA is defined and presented by eqs. (22) - (34) in [1].

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Components of the CPR system dictate the corresponding set of constraints. Some of them are set by the user's requirements: dimensions of the workspace, load carrier's velocity, etc.; while some of them are set by the CPR system's design: load weight, winches radii; and the rest of them are set by the components which are available at the market: motors, gearboxes, etc. It is clear that all of these components need to be mutually compatible and adequately designed to make the system function as it is required by the corresponding technical requirements.

For CPR-8 system's functioning, the choice of a good actuator is very important. To check if the actuator satisfies all specified technical requirements, its catalogue parameters are used. The important catalogue parameters of five actuators are given in Table. 1.

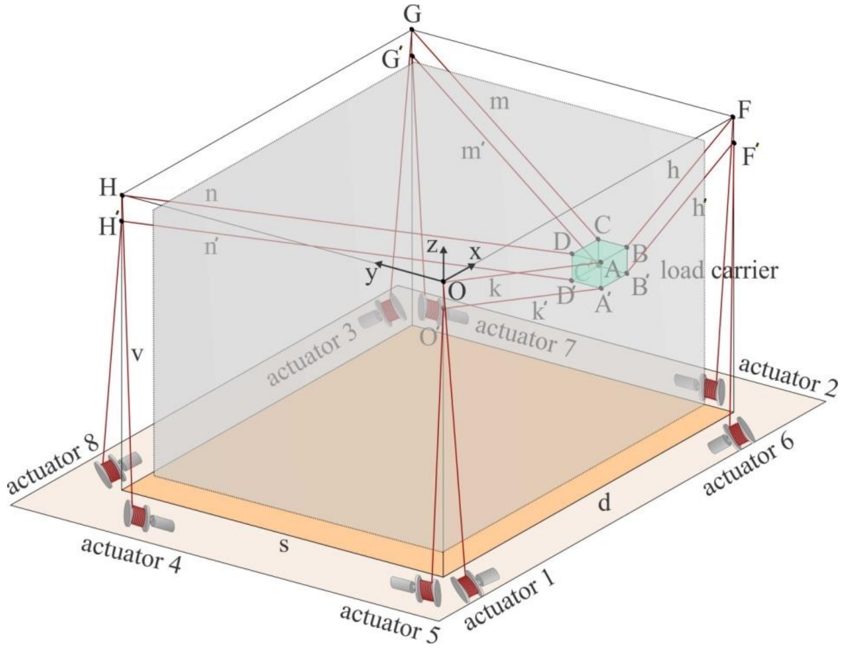

Figure 3 Geometric workspace of the CPR-8 system.

In this fashion, all the variables are constrained according to the catalogue parameters of the chosen actuator: motor + gearbox + winch. By using eqs. (22)-(34), a novel procedure CPR-WWA for the analysis and synthesis of the CPR-8 system's workspace is defined.

The analysis and synthesis of a feasible workspace were made for a CPR-8 system of dimensions $d \cdot s \cdot v$ = *3,2[m]* $\cdot$ *2,2[m]* $\cdot$ *2,2[m]*. Load weight is *m=2[kg]*, while dimensions of the load carrier are $l \cdot w \cdot h_o$ = *0,224[m]* $\cdot$ *0,154[m]* $\cdot$ *0,140[m]*. Maximal value of the reference velocity is V_{cmax}*=1,3[m/s]*, while the acceleration and deceleration times are t_{acc}= t_{dec}*=1,82[s]*. It was assumed that the actuator of the same type was used for all eight ropes. This case study was implemented by using Actuator 1 from Table 1. A specific example of the feasible workspace analyses will be given along with the simulation experiments used for comparison and validation of the CPR-WWA procedure.

Now a comparative analysis of the feasible workspace acquired by the CPR-WWA procedure and the corresponding simulation experiments will be given.

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Table 1. Actuator parameters

Actuator	1	2	3	4	5
Output power $P_{mot}[w]$	300	100	50	20	10
Voltage $U_{mot}[v]$	48	48	24	24	18
Speed $\omega_{mot}[RPM]$	4700	3970	4500	5060	4777
Torque $M_{mot}[Nm]$	0.6	0.319	0.131	0.212	0.03
Back-EMF constant $C_{ei}[V/(rad/s)]$	0.0945	0.1145	0.0356	0.0352	0.029
Torque constant $C_{mi}[Nm/A]$	0.095	0.114	0.0357	0.0352	0.0299
Viscous friction $B_{ci}[Nm/(rad/s)]$	0	0	0	0	0
Rotor circuit resistance $R_{ri}[\Omega]$	0.369	1.1	0.567	3.99	3.01
Actuator inertia $J_{Mi}[gcm^2]$	3579	1210	181	45.3	9.26
Gear ratio N_{Vi}	30	25	26	30	26
Actuator efficiency coefficient ξ_i	0.6	0.7	0.7	0.7	0.7
Winch radius $R_i[m]$	0.08	0.08	0.08	0.08	0.08

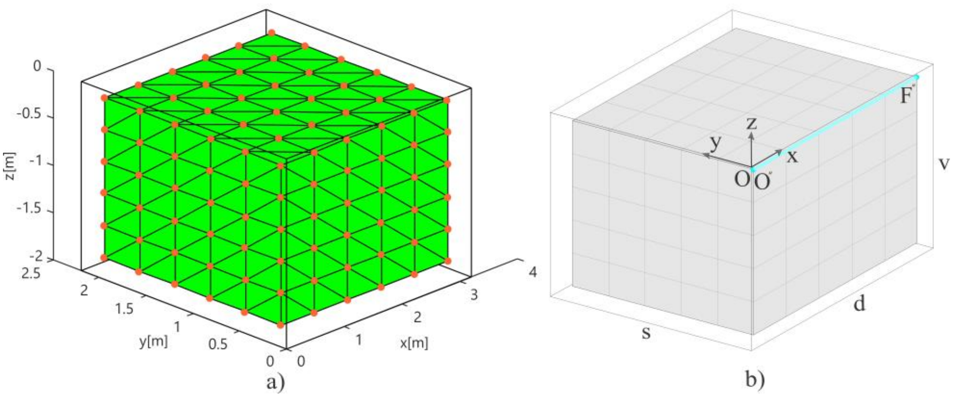

Figure 4 Feasible workspace of the CPR-8 system generated by a) the defined procedure CPR-WWA and b) simulation experiments, for: $\psi=0[rad]$, $\theta=0[rad]$ and $\varphi=0[rad]$.

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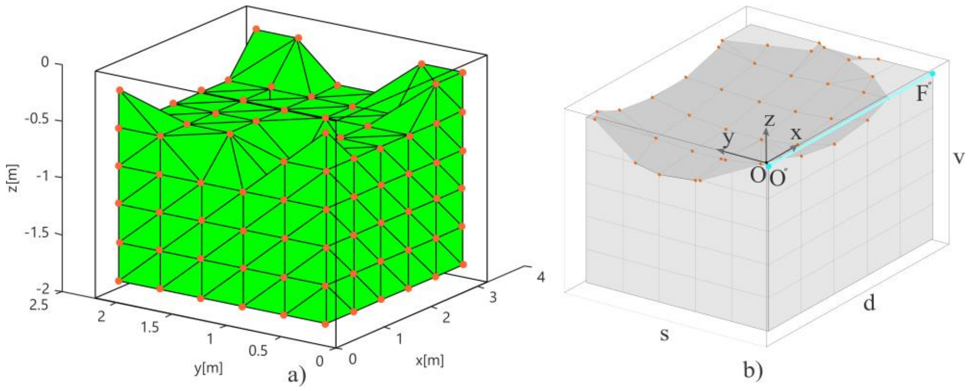

Figure 5 Feasible workspace of the CPR-8 system generated by a) the defined procedure CPR-WWA and b) simulation experiments, for: $\psi=0,5[rad]$, $\theta=0,5[rad]$ and $\varphi=0,5[rad]$.

The simulation experiments were defined as straight lines which confirm the feasible workspace achieved by the defined procedure. For Fig. 4 and 5 was assumed that $\psi=0[rad]$, $\theta=0[rad]$, $\varphi=0[rad]$

and $\psi=0,5[rad]$, $\theta=0,5[rad]$, $\varphi=0,5[rad]$, respectively.

The simulation experiments confirmed the results achieved with the CPR-WWA procedure.

The purpose of this division is twofold:

I) to show how the results form Figs. 4b) and 5b) were obtained, and

II) to compare these results.

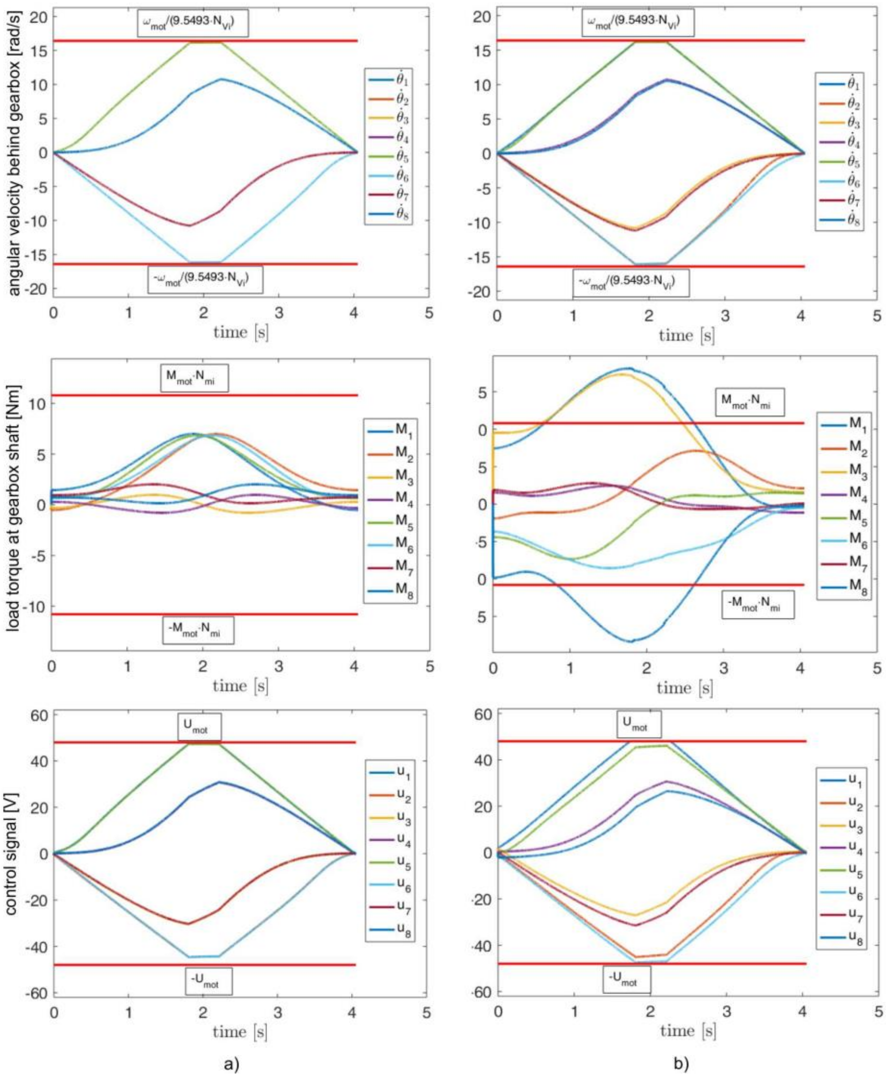

Figure 6 The simulation results of trajectory *O”- F”* for the following Euler angles: a) $\psi=0[rad]$, $\theta=0\ [rad]$ and $\varphi=0[rad]$ and b) $\psi=0,5[rad]$, $\theta=0,5[rad]$ and $\varphi=0,5[rad]$

The results of the simulation experiments of only one straight line from the geometric workspace will be shown. The chosen line connects the points *O”* and *F”*. This motion is coloured in light blue in Figs. 4b) and 5b).

Comparative results of the mentioned trajectories are shown in Fig. 6. It should be emphasized that the simulation experiments were made under the same conditions and for the same parameters of the CPR-8 system with the only difference in carrier’s orientation. Example a) from Fig. 6 relates to the motion when Euler angles are $\psi=0[rad]$, $\theta=0\ [rad]$ and $\varphi=0[rad]$, see Fig. 4b), while example b) from Fig. 6 shows the results for trajectory when $\psi=0,5[rad]$, $\theta=0,5[rad]$ and $\varphi=0,5[rad]$, see Fig. 5b).

Each example shows the changes of: angular velocity behind the gearbox, load torque behind the gearbox, and control signal of the motor for all eight actuators.

The feasible workspaces given in Figs. 4b) and 5b) were achieved in exactly the same fashion – by execution of the number of straight lines (trajectories) at different levels in the *x, y, z* coordinate system. In this way, it was obtained that the feasible workspace presented in Fig. 4b) when $\psi=0[rad]$, $\theta=0\ [rad]$ and $\varphi=0[rad]$ is identical to the geometric workspace shown in Fig. 3. E.g. from Fig. 5b) where $\psi=0,5[rad]$, $\theta=0,5[rad]$ and $\varphi=0,5[rad]$, it can be seen that the feasible workspace is much smaller in comparison with the one from Fig. 3.

Also, it can be generally concluded (for Figs. 4 and 5) that the simulation experiments confirm the validity of the novel procedure CPR-WWA used for performing the analysis and synthesis of the feasible workspace of the CPR-8 system.

The Novel procedure CPR-WWA for the analysis and synthesis of the feasible workspace of the CPR-8 system which includes the kinematics and dynamics of the system and mathematical model of the actuator. This procedure opened a space for new research to define a novel methodology for choosing the CPR-8 system's actuators.

The main contribution of program package PPACM is development of a novel methodology, named CPR-ACM (CPR-**A**ctuator **C**hoice **M**ethodology), which is intended to interconnect the engineering knowledge from this area and the theoretical analysis presented here. CPR-ACM for a systematic analysis of usability of several actuators can be generated. Catalogue parameters of the actuators are kept in a data base. During the development of CPR-WWA methodology, it was evident that the complexity of the CPR-8 system, its actuators, and other parameters was considerable. All these parameters are mutually strongly coupled. Development of the CPR-ACM methodology is important because it is applicable not only to the CPR-8 but to any other robotic system.

Flow chart of the methodology CPR-ACM is presented in Fig. 7.

At the beginning, parameters of the CPR-8 system are defined. These parameters are defined together with the end-user in accordance with the design requirements. All the parameters are kept the same during the analysis of each of the actuators. Based on the parameters of the system and the requirements of the user, the desired percentage of the feasible workspace $x[\%]$ relative to the geometric workspace of the CPR-8 system is defined.

In general, the data base contains *M* different feasible workspace of the CPR-8 system will be actuators. By using each of these actuators, the calculated. Upon completion of this sub-program,

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the obtained feasible workspaces will be compared. Counter i_a is initialized at the beginning, as shown in Fig. 7. During each passing through the loop, the parameters of the i_a – th actuator are loaded and the CPR-WWA procedure is used for performing the analysis and synthesis of the current feasible workspace of the CPR-8 system. The Variable $x(i_a)[\%]$ represents the percentage of the feasible workspace in comparison with the geometrical workspace of the CPR-8 system. For each passing through the loop, the feasible workspace percentage is memorized and connected with the type of the current actuator. This process is repeated for all M actuators. When $i_a=M$, this process is ended and the program logic generates the list of all actuators which satisfy the condition: $x(i_a)[\%] > x[\%]$. In this fashion, only the actuators which satisfy user's and designer's requirements are listed.

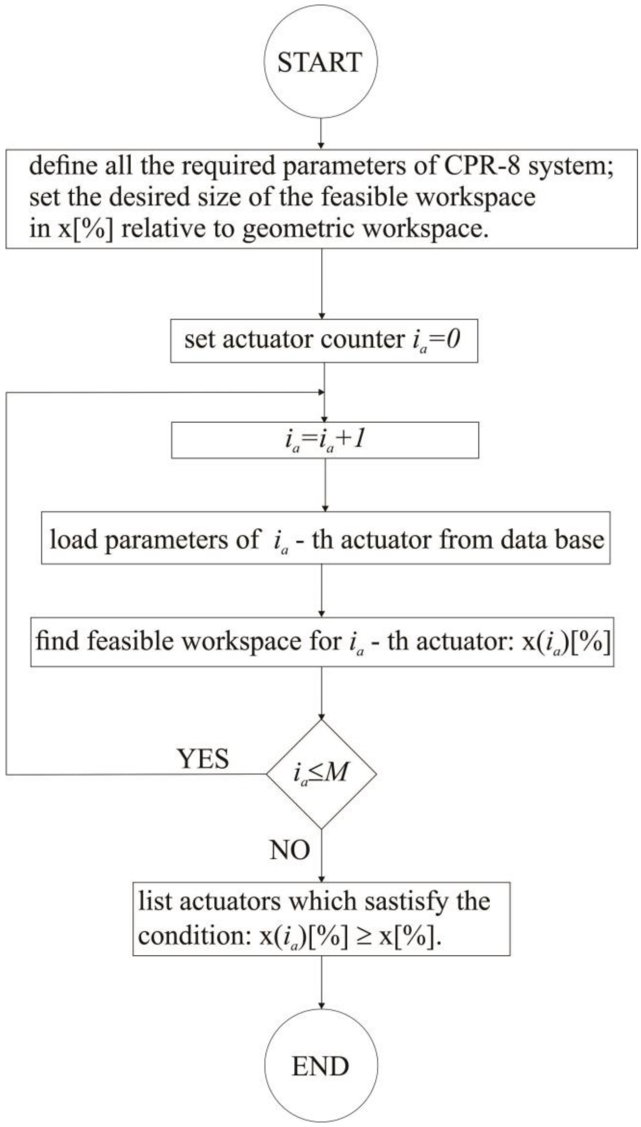

Figure 7 Flow chart of the CPR-ACM method.

PPACM was used for generation of the results and validation of the novel methodology CPR-ACM. The results are given through the case study presented in the continuation of this text.

In order to facilitate understanding of the procedure CPR-WWA, methodology CPR-ACM, and generally program package PPACM, one example of choosing the actuator of a CPR-8 system will be presented.

Catalogue parameters of the potential actuators are given in Table 1. It can be seen that the number of actuators is M=5. It is assumed that the user requires a feasible workspace of at least $x[\%]=90[\%]$ in comparison with the geometric workspace shown in Fig. 3. The following results were generated by the program package PPACM. The feasible workspace achieved with Actuator 1 was presented in Fig. 4a) and it can be seen that it is $x(1)[\%]=100[\%]$. The feasible workspaces of the CPR-8 system achieved with Actuators 2, 3, 4 and 5 are shown in Figs. 8a), 8b), 8c) and 8d), respectively.

These figures show the reductions of the feasible workspace, the percentage is shown in Table 2. In order to facilitate understanding, these results are also shown in Fig. 9. From the given results, it can be seen that only Actuators 1 and 2 satisfy the condition set by the user, $x(i_a)[\%] \geq 90[\%]$, marked by the grey color in Table 2 and shown in Fig. 9.

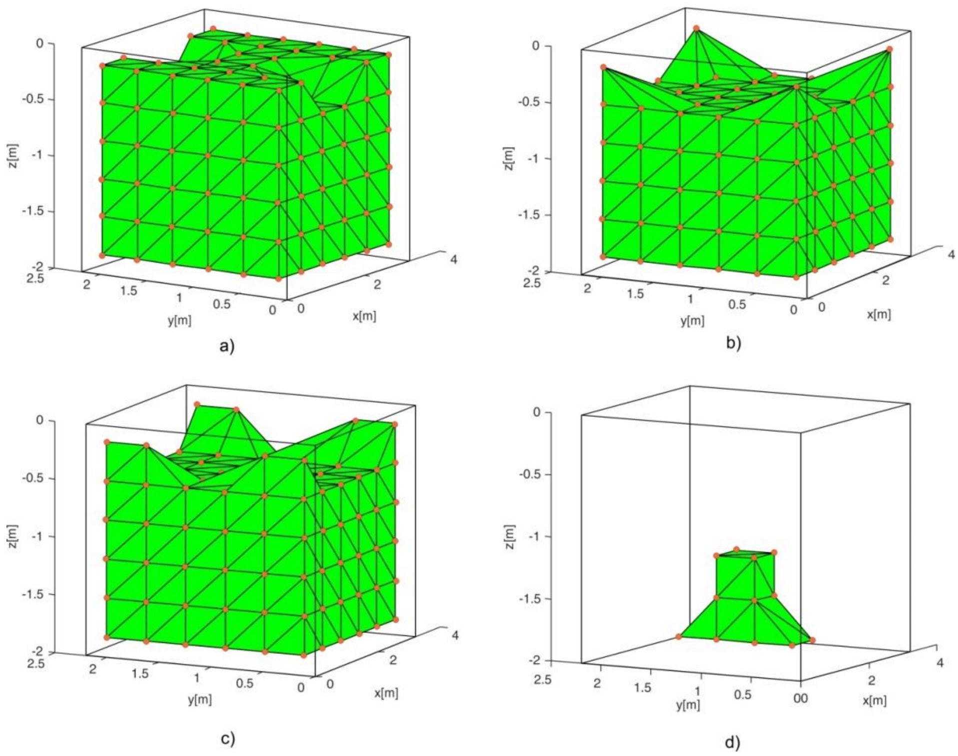

Figure 8 The feasible workspaces achieved with Actuator: a) 2, b) 3, c) 4, and d) 5.

It can be seen that Actuators 3 and 4 do not satisfy the requirements set by the user and designer. But these two actuators are interesting from another perspective. It can be noticed that Actuator 3 has output power $P_{mot}(3)=50[W]$, while Actuator 4 has output power $P_{mot}(4)=20[W]$. Regardless of this fact, Actuator 3 has percentage of the feasible workspace $x(3)[\%]=85.19[\%]$, while Actuator 4 has this percentage as $x(4)[\%]=87.04[\%]$ in comparison with the geometric workspace of the CPR-8 system. Compare Figs. 8b) and 8c) and see Fig. 9 as well. This may seem illogical to be presented in this paper. However, this result is presented since it is very interesting, because it was not achieved by accident. Through the research related to the development of methodology CPR-ACM, a much larger number of actuators were analyzed.

This phenomenon is analyzed in more detail, because it appeared in a number of different cases. It can be concluded that output power of the actuator, which is given in the catalogue, is not a relevant indicator for making actuator choice during the CPR system's construction. Here, it is evident that other parameters of the actuators given in Table 1, and their mutual influence on dynamics of the actuators and CPR system, have a significant role in generation of the system's feasible workspace. This opens a space for new research, not only in the field of Robotics, but much wider. Motor manufacturers would probably be especially motivated for supporting the research in this field.

Table 2. The results achieved by using the CPR-ACM methodology

Actuator	1(i_a=1)	2(i_a=2)	3(i_a=3)	4(i_a=4)	5(i_a=5)
Acquired feasible workspace $x(i_a)[\%]$ for $\psi=0[rad]$, $\theta=0\,[rad]$, $\varphi=0[rad]$	100	96.3	85.19	87.04	7.41
Presented in	Fig. 4a)	Fig. 8a)	Fig.8b)	Fig. 8c)	Fig. 8d)

The CPR-ACM methodology for choosing an actuator is based on the mathematical model of the CPR-8 system. By relying on this methodology, a designer of the CPR-8 system has a valuable help during the process of construction of the system.

The developed CPR-ACM methodology was tested on the CPR-8 system. With slight modifications it can be tested on any robotic configuration.

This opens a space for new research, not only in the field of Robotics, but much wider. Motor manufacturers would probably be especially motivated for supporting the research in this field.

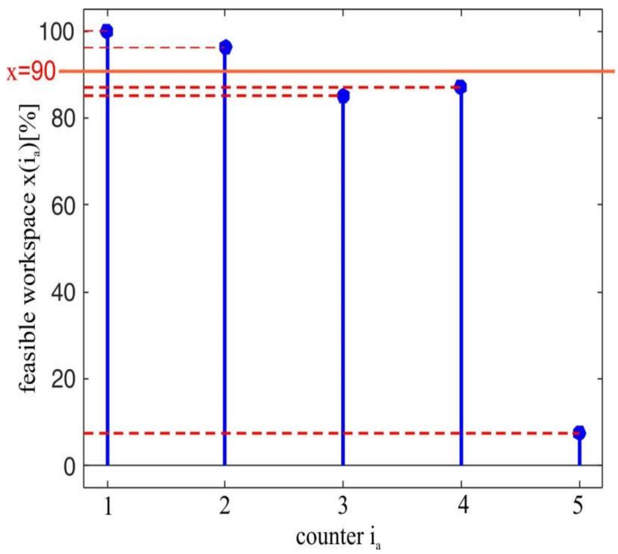

Figure 9 A comparative presentations of the feasible workspaces achieved by different actuators

This research was supported by the Ministry of Education, Science and Technological Development, Government of the Republic of Serbia through the following two projects: Grant TR-35003, "Ambientally intelligent service robots of anthropomorphic characteristics", by Mihajlo Pupin Institute, University of Belgrade, Serbia, and Grant OI-174001, "The dynamics of hybrid systems of complex structure", by SANU Institute Belgrade and Faculty of Mechanical Engineering University of Nis, Serbia.

References

[1] Mirjana Filipović, Ljubinko Kevac, "A novel methodology for choosing actuators of Cable-suspended parallel robots", FACTA UNIVERSITATIS, Series: Automatic Control and Robotics , in press, 2018.

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Subject: Opinion on meeting the criteria for recognition of the technical solution

According to the submitted material and in accordance with the provisions of The Rules of procedures and methods of evaluation and quantitative presentation of scientific research results of researchers, brought by the National Council for Scientific and Technological Development of Serbia ("Official Gazette of the Republic of Serbia", No. 38/2008) **reviewer: Prof. dr Ana Djuric, Wayne State University , 4855 Fourth St. Detroit, MI 48202, U.S.A,** *has evaluated that conditions for the recognition of the properties of the technical solution are fulfilled for the following result:*

Title: program system **PPACM,** (**P**rogram **P**ackage **A**ctuator **C**hoice **M**ethodology), (*Projects:* Ambientally intelligent service robots of anthropomorphic characteristics, TR-35003 and "Dynamics of hybrid systems of complex structures" OI-174001*)*

Author: **Mirjana Filipovic, Ljubinko Kevac**

Category of technical solution: **M85** *„**New technical solution, not commercialized**", Program system– **Software.***

Explanation

Objective and significance: *The goal is to define a novel methodology for choosing actuators of a CPR system. This methodology base on a novel procedure for analysis and synthesis of the workspace of Cable-suspended parallel robot, CPR system. Besides the kinematic and dynamic models of the CPR system, this procedure includes the complete mathematical model of the actuator as well. The user and designer together define the corresponding technical requirements, one of them being the relative size of the feasible work space of the CPR system. Based on these requirements, the developed methodology tests available actuators from its data base and extracts the useful ones for the predefined specific purpose.*

Proposed solution is done in: *2017.*

Area to which the technical solution refers is: *The program package **PPACM** is developed and tested on a CPR-8 system (Cable-suspended parallel robot contains 8 actuators). With slight modifications, it is possible to use them with different complex configuration, e.g. industrial robotic configuration or other cable robot systems, or different other mechanisms.*

Problem that is being solved with this technical solution: *The program package **PPACM** implies the formulation and application of a data base which contains catalogue parameters of the actuators available at the market. Both, users and designers define together the parameters and desired feasible workspace of the CPR-8 system being designed. The methodology is illustrated by a logic flow chart. It calculates the feasible workspaces for all available actuators from the data base and by a comparative analysis it identifies for the user and designer the possible usefulness of every available actuator.*

State of the problem solution in the world: *The developed methodology tests available actuators from its data base and extracts the useful ones for the predefined specific purpose of corresponding technical requirements, one of them being the relative size of the feasible work* *space of the CPR system. This methodology was not analysed in available world literature. This phenomenon was first analysed in detail in [1].*

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Essence of technical solution. *The program package* ***PPACM*** *contains the methodology CPR-ACM (CPR-**A**ctuator **C**hoice **M**ethodology) and procedure CPR-WWA (CPR-**W**hole **W**orkspace **A**nalysis) and makes a sub-program of this methodology. The program package is user friendly and offers the user all the benefits of the designed procedure CPR-WWA and methodology CPR-ACM. The novel procedure CPR-WWA uses for analysis and synthesis of the feasible workspace of the CPR-8 system. This procedure is based on a complete kinematic and dynamic model of the CPR-8 system, as well as on the mathematical model of the actuator. Inclusion of actuator's mathematical model in the procedure CPR-WWA presents a novelty in comparison with available literature.*

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Possibility of implementation of proposed technical solution: *The developed program package* ***PPACM*** *was tested on the CPR-8 system. With slight modifications, it is possible to use them with different complex configuration, e.g. industrial robotic configuration or other cable robot systems, or different other mechanisms.This opens a space for new research, not only in the field of Robotics, but much wider. Motor manufacturers would probably be especially motivated for supporting the research in this field.*

On the basis of all above mentioned, the reviewer has concluded that the program system PPACM includes the expert knowledge, the original scientific research contribution, and it is meeting the criteria for the recognition of the technical solutions.

Belgrade,
09.01.2019.

Reviewer:

Prof. dr Ana Djuric,
Wayne State University , 4855 Fourth St.
Detroit, MI 48202, U.S.A.

Subject: Opinion on meeting the criteria for recognition of the technical solution

According to the submitted material and in accordance with the provisions of The Rules of procedures and methods of evaluation and quantitative presentation of scientific research results of researchers, brought by the National Council for Scientific and Technological Development of Serbia ("Official Gazette of the Republic of Serbia", No. 38/2008) **reviewer: Dr Milovan Živanović, dipl.inž**, *Digital Control Systems Oziris, Kosmajska 32, 11450 Sopot, Belgrade, Serbia***,** *has evaluated that conditions for the recognition of the properties of the technical solution are fulfilled for the following result:*

Title: program system **PPACM,** (**P**rogram **P**ackage **A**ctuator **C**hoice **M**ethodology), (*Projects:* Ambientally intelligent service robots of anthropomorphic characteristics, TR-35003 and "Dynamics of hybrid systems of complex structures" OI-174001*)*

Author: **Mirjana Filipovic, Ljubinko Kevac**

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State of the problem solution in the world: *The developed methodology tests available actuators from its data base and extracts the useful ones for the predefined specific purpose of*

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[1] Mirjana Filipović, Ljubinko Kevac, “A novel methodology for choosing actuators of Cable-suspended parallel robots”, FACTA UNIVERSITATIS, Series: Automatic Control and Robotics , in press, 2018.

Essence of technical solution. *The program package **PPACM** contains the methodology CPR-ACM (CPR-**A**ctuator **C**hoice **M**ethodology) and procedure CPR-WWA (CPR-**W**hole **W**orkspace **A**nalysis) and makes a sub-program of this methodology. The program package is user friendly and offers the user all the benefits of the designed procedure CPR-WWA and methodology CPR-ACM. The novel procedure CPR-WWA uses for analysis and synthesis of the feasible workspace of the CPR-8 system. This procedure is based on a complete kinematic and dynamic model of the CPR-8 system, as well as on the mathematical model of the actuator. Inclusion of actuator's mathematical model in the procedure CPR-WWA presents a novelty in comparison with available literature.*

Characteristics of the proposed technical solution are following: *Complexity of the program package **PPACM** is high, because it involves mainly the parameters of the system which are mutually strongly coupled. The CPR-WWA procedure was defined and its validity was tested through a set of simulation experiments. Overlapping between the results achieved with application of the procedure and the results achieved from the simulation experiments is observed. In this way, a confirmation was achieved that the CPR-WWA procedure gives useful results. Through this research it is recognized that all actuator parameters affect the size of the feasible workspace of the CPR-8 system. Combination of these parameters is very important. It should be emphasized, that the actuator should not be chosen based only on one parameter, because all the other parameters, since they are strongly coupled, can equally strongly influence the response dynamics of the system.*

Possibility of implementation of proposed technical solution: *The developed program package **PPACM** was tested on the CPR-8 system. With slight modifications, it is possible to use them with different complex configuration, e.g. industrial robotic configuration or other cable robot systems, or different other mechanisms.This opens a space for new research, not only in the field of Robotics, but much wider. Motor manufacturers would probably be especially motivated for supporting the research in this field.*

On the basis of all above mentioned, the reviewer has concluded that the program system PPACM includes the expert knowledge, the original scientific research contribution, and it is meeting the criteria for the recognition of the technical solutions.

Belgrade,
09.01.2019.

Reviewer:

Dr Milovan Živanović, dipl.inž,
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DECLARATION

OF USING THE PROGRAM SYSTEM **PPACM**

The program system: **PPACM (Program Package Actuator Choice Methodology)**, *Projects:* "Ambientally intelligent service robots of anthropomorphic characteristics" TR-35003 and "Dynamics of hybrid systems of complex structures" OI-174001, whose authors are Mirjana Filipovic, Ph.D,El.Eng., and Ljubinko Kevac, Ph.D,El.Eng. presents a scientific and technical achievement in robotics which we, the below-signed, use in education and research purposes as well as during the realization of our theoretical and practical solutions. We, the below-signed, confirm that we have used the program system **PPACM** since 2017.

15, January 2019.

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DATE 15.1.2019.

DIVISION OF ENGINEERING TECHNOLOGY
COLLEGE OF ENGINEERING
WSU
APPROVED AND ENDORSED

ИНСТИТУТ МИХАЈЛО ПУПИН ДОО БЕОГРАД
Број: 3249/20-18
23. јануар 2019. године
Б е о г р а д

На основу чл. 24. Статута Института „Михајло Пупин“ ДОО Београд – Пречишћен текст („Билтен“ бр.4/2016.), а у вези чл. 25. Закона о научноистраживачкој делатности („Сл. гласник РС“ бр. 110/2005, 50/2006-испр., 18/2010 и 112/2015) и Прилога 2 Правилника о поступку и начину вредновања и квантитативног исказивања научноистраживачких резултата истраживача („Сл. гласник РС“ бр. 24/2016, 21/2017 и 38/2017), Научно веће ИНСТИТУТА МИХАЈЛО ПУПИН ДОО БЕОГРАД доноси следећу:

О Д Л У К У

ПРИХВАТА СЕ **техничко решење под називом:** Program package **PPACM**, (**P**rogram **P**ackage **A**ctuator **C**hoice **M**ethodology).

Реализатор: Authors.

Аутори: Mirjana Filipovic, Ljubinko Kevac.

Број аутора: **2**, Година када је комплетирано: **2017,** Пријављена категорија: **M85**, new technical solution, not commercialized.

Техничко решење је рађено за: for scientific purposes, for the purpose of confirming scientific contributions.

Техничко решење користи: Wayne State University, 4855 Fourth St. Detroit, MI 48202, U.S.A. од: 2017.

Техничко решење је резултат рада на пројекту (ев.број):

- “Ambientally intelligent service robots of anthropomorphic characteristics” TR-35003,
- “Dynamics of hybrid systems of complex structures“ OI-174001.

Кратак опис решења:

This program system **PPACM** was generated in MATLAB. A novel methodology for choosing actuators of a CPR system has been defined. This methodology is based on a novel procedure for analysis and synthesis of the workspace of Cable-suspended parallel robot, CPR system. Besides the kinematic and dynamic models of the CPR system, this procedure includes the complete mathematical model of the actuator as well. On this basis, this procedure presents a novel solution for the analysis and synthesis of a CPR system's workspace. When using the proposed methodology for choosing actuators of a CPR system, the user and designer together define the corresponding technical requirements, one of them being the relative size of the feasible work space of the CPR system. Based on these requirements, the developed methodology tests available actuators from its data base and extracts the useful ones for the predefined specific purpose. The purpose of this research is to interconnect theoretical contributions from the CPR system's modelling and needs of the user and designer during their practical implementation. For this purpose, a user friendly program package called **PPACM** has been generated. The program package PPACM and obtained results have been validated through the presentation of several case studies.

Рецензенти:

1. Prof. dr Ana Djuric, Wayne State University , 4855 Fourth St. Detroit, MI 48202, U.S.A.,
2. Dr Milovan Živanović, dipl.inž, Digital Control Systems Oziris, Kosmajska 32, 11450 Sopot, Belgrade, Serbia.

На основу позитивног мишљења два рецензента – експерта из области техничког решења, Научно веће је донело предметну одлуку и исту упућује надлежном Матичном научном одбору на Мишљење.

ИНСТИТУТ МИХАЈЛО ПУПИН ДОО БЕОГРАД
НАУЧНО ВЕЋЕ
за **Председник**

Горан Димитић

***Проф. др Ђуро Кутлача**, дипл. инж.,*
Научни саветник

Достављено:
- ауторима
- Секретаријату Института