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Presents the Dynamics at a Basic Anthropomorphic Robot

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Abstract: Serial robots are the most used today and among them, the most common is the basic 3R module, the module that is developed in the vast majority of anthropomorphic serial industrial robots, which today occupies at least 80-90% of the total industrial robots existing worldwide. One studied the kinematics and the forces in this module in other works, with an emphasis on the inverse kinematics, so that in this paper the authors will deal with the dynamic functioning of this 3R structure, a basic structure as it could be observed, because the dynamics which represent in fact the actual operation of the entire robotic structure is, therefore, the most important in operation, both for the optimal analysis or design of the robotic structure, as well as for its implementation or maintenance throughout its life. The paper presents the real dynamic functioning of the 3R structure, the related calculation relationships and the diagrams with the simulation of the real dynamic functioning of the 3R platform.

Keywords: Robots, Mechatronic Systems, Dynamics, 3R System, 3R Basic System, 3R Module, 3R Structure

Introduction

The basic structure of the anthropomorphic robots used today massively in 80-90% cases from the industrial robots will be presented briefly, with the highlighting of an original method for determining the kinematics of the basic 3R module and with highlighting the forces at the basic structure set in the discussion. Some representative examples of calculation will be remembered as results. The paper is a basic one in the field and performs a recapitulation of how the basic anthropomorphic structures 3R are analyzed or designed correctly and quickly.

Such repeated manipulations of heavy and dangerous objects can be done only with the help of a manipulator, which can be a crane, a specially designed trolley, a complicated robot or a simple manipulator as is the case for the one presented in the paper.

Workers are prevented from using it to get various diseases because of the repeated lifting of heavy objects. In the past, an interior crane built on different systems walks through the respective hall to carry the heavy objects.

High-performance machine monitoring robots make a variety of operations efficient, such as sand casting, injection molding, cutting, machining and assembly of small parts.

Top providers should have solutions for every production scenario imaginable, from the smallest to the largest and in any cell configuration. It should also offer a full range of local and international support services available as soon as you need them.

Compact and equipped with up to six axes, certain types of robots are perfectly suited for the surveillance of small autonomous cells. In addition, their powerful controller can control the entire cell, as well as additional peripheral axes (Fig. 1).

Fig. 1: Compact and equipped with up to six axes, certain types of robots are perfectly suited for the surveillance

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Since space is already limited in most production units, many machine-monitoring robots have a small footprint. They also have standard equipment for protection against water and dust and the cables are drawn through the joint, so as not to be exposed to dangers. Some manufacturers also offer small models that are installed in the machine tool (Fig. 2).

One can use robots for a variety of additional cell-related operations, such as quality control, specification checking and surface inspection (Fig. 3).

Fig. 2: Compact solutions

Fig. 3: Use of robots in a variety of industrial operations

Due to the wide range of options for installing instrument replacement stations, including suspended mounting, some types of robots can be used for very efficient instrument replacement. Because they can work with a wide variety of tools, these models can handle any number of instruments, regardless of their weight (Fig. 4).

Robots are priceless when it comes to injection molding. From the disassembly of the parts to the cutting of the screws, unloading, labeling, laser treatment and adding inserts, they increase the efficiency in a variety of operations and prevent the risk of damage (Fig. 5).

Fig. 4: Faster tool changes

Fig. 5: Injection molding

With a range of rail, floor, wall and ceiling mount options to save space and expand your robot's workspace, some robot models are ideally suited for multi-tool monitoring - improving your performance and maximizing production time (Fig. 6).

To speed up processes involving containerized parts, container selection solutions based on visual detection allow robots to identify, select and load parts from a container. Sometimes improving 99.97 percent operating times, this technology dramatically accelerates even the most complicated of the selection operations (Fig. 7).

Fig. 6: Load more machinery

Fig. 7: Randomly load objects quickly

Machine surveillance is an operation that many people are not willing to do. In contrast, quality robots provide 720 h of perfect production, multiple operations between cells, loading and unloading parts and the ability to connect up to eight machines (Fig. 8).

Extremely lightweight and compact, dedicated monitoring robots available from some manufacturers have been created specifically for high-speed applications such as machine monitoring. Due to the compact arms, the protected harness and the 7 kg payload, these experts are ideal for production operations that require access to small spaces and where maneuver space is reduced (Fig. 9).

Fig. 8: Fully automated processing

Fig. 9: Experts in machinery supervision

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Fig. 10: Expand your visual ability

Fig. 11: Great security but invisible

Manufacturers with proven expertise in the field of visual detection systems can equip robots with intelligent visual detection options, which enable a wide range of machine surveillance operations. Options often include 2D visual detection for track location, 3D visual detection for track detection, positioning and orientation, line tracking for conveyors and area sensors for sorting boxes (Fig. 10).

On robots equipped with an optical scanner, the innovative security software provided by some manufacturers allows you to forgo the traditional constraints that take up a lot of space, such as fences and safety hardware. Instead, this feature prevents the robot from accessing specific areas and, by slowing it down, allows the operator to enter the workspace without interrupting production (Fig. 11).

In the case of operations involving multiple processes, the best robots quickly replace the claws to maximize production time (Fig. 12).

A full range of flexible standalone solutions makes machine monitoring robots a very viable option for small businesses (Fig. 13).

Fig. 12: Change the claws quickly

Fig. 13: A full range of flexible standalone solutions makes machine monitoring robots a very viable option for small businesses. Being cheaper and easier to use than you can imagine, they offer significant benefits even for small production cycles

Being cheaper and easier to use than you can imagine, they offer significant benefits even for small production cycles. This is especially the case where the tedious, dirty and dangerous nature of manual surveillance of machines makes it difficult to find and retain manual operators. In addition, after they are created, machine monitoring programs can be restored from memory whenever new commands are received. We can firmly state that today Fanuc robots are respected as the world's number one leading company as

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well as at the beginning of the global robotization of the years 1970-1980. How to analyze or design these robots today indispensable, how to be selected, then implemented and maintained, will be seen from the rapid study carried out in this paper (Antonescu and Petrescu, 1985; 1989; Antonescu *et al*., 1985a; 1985b; 1986; 1987; 1988; 1994; 1997; 2000a; 2000b; 2001; Aversa *et al*., 2017a; 2017b; 2017c; 2017d; 2016a; 2016b; 2016c; 2016d; Cao *et al*., 2013; Dong *et al*., 2013; El-Tous, 2008; He *et al*., 2013; Lee, 2013; Lin *et al*., 2013; Liu *et al*., 2013; Padula and Perdereau, 2013; Perumaal and Jawahar, 2013; Petrescu, 2011; 2012; 2019; Petrescu and Petrescu, 1995a; 1995b; 1997a; 1997b; 1997c; 2000a; 2000b; 2002a; 2002b; 2003; 2005a; 2005b; 2005c; 2005d; 2005e; 2011a; 2011b; 2012a; 2012b; 2013a; 2013b; 2016a; 2016b; 2016c; Petrescu *et al*., 2009; 2016; 2017a; 2017b; 2017c; 2017d; 2017e; 2017f; 2017g; 2017h; 2017i; 2017j; 2017k; 2017l; 2017m; 2017n; 2017o; 2017p; 2017q; 2017r; 2017s; 2017t; 2017u; 2017v; 2017w; 2017x; 2018a; 2018b; 2018c; 2018d; 2018e; 2018f; Langston, L.S., 2015-2016; Lee, B.J., 2013; Svensson et al., 2004).

Materials and Methods

The basic structure 3R of Fig. 14 can be studied more easily in the plane (Fig. 15), greatly facilitating the theoretical work and the computational relations especially to the dynamics of the module.

The forces in Fig. 16 have been presented in other works so that although they represent a part of the dynamics of the module they will not be resumed in the present work.

Starting from Fig. 17 which shows the positions of the centers of mass of the module, one can write the dynamic equations of the module 3R (system 1):

$$
\begin{cases}
J^* \equiv J_B^* = J_{G_2} + m_2 \cdot \dfrac{\dot{x}_{G_2}^2 + \dot{y}_{G_2}^2}{\omega_2^2} + J_{G_3} \cdot \dfrac{\omega_3^2}{\omega_2^2} + m_3 \cdot \dfrac{\dot{x}_{G_3}^2 + \dot{y}_{G_3}^2}{\omega_2^2} \\
J^{*'} \equiv J_B^{*'} = \dfrac{2m_2}{\omega_2^3} \cdot \left(\dot{x}_{G_2} \cdot \ddot{x}_{G_2} + \dot{y}_{G_2} \cdot \ddot{y}_{G_2} \right) \\
+ \dfrac{2m_3}{\omega_2^3} \cdot \left(\dot{x}_{G_3} \cdot \ddot{x}_{G_3} + \dot{y}_{G_3} \cdot \ddot{y}_{G_3} \right) + \dfrac{2J_{G_3}}{\omega_2^3} \cdot \omega_3 \cdot \varepsilon_3 \\
\omega_2^* = \sqrt{J_{med}^*} \cdot \dfrac{\omega_2}{\sqrt{J^*}} \\
\varepsilon_2^* = \dfrac{2 \cdot J_{med}^* \cdot J^* \cdot \varepsilon_2 - J_{med}^* \cdot J^{*'} \cdot \omega_2^2}{2 \cdot J^{*2}} \\
J_C^* = J_{G_3} + m_3 \cdot \dfrac{\dot{x}_{G_3}^2 + \dot{y}_{G_3}^2}{\omega_3^2} \\
J_C^{*'} = \dfrac{2m_3}{\omega_3^3} \cdot \left(\dot{x}_{G_3} \cdot \ddot{x}_{G_3} + \dot{y}_{G_3} \cdot \ddot{y}_{G_3} \right) \\
\omega_3^* = \sqrt{J_{Cmed}^*} \cdot \dfrac{\omega_3}{\sqrt{J_C^*}} \\
\varepsilon_3^* = \dfrac{2 \cdot J_{Cmed}^* \cdot J_C^* \cdot \varepsilon_3 - J_{Cmed}^* \cdot J_C^{*'} \cdot \omega_3^2}{2 \cdot J_C^{*2}}
\end{cases}
\tag{1}
$$

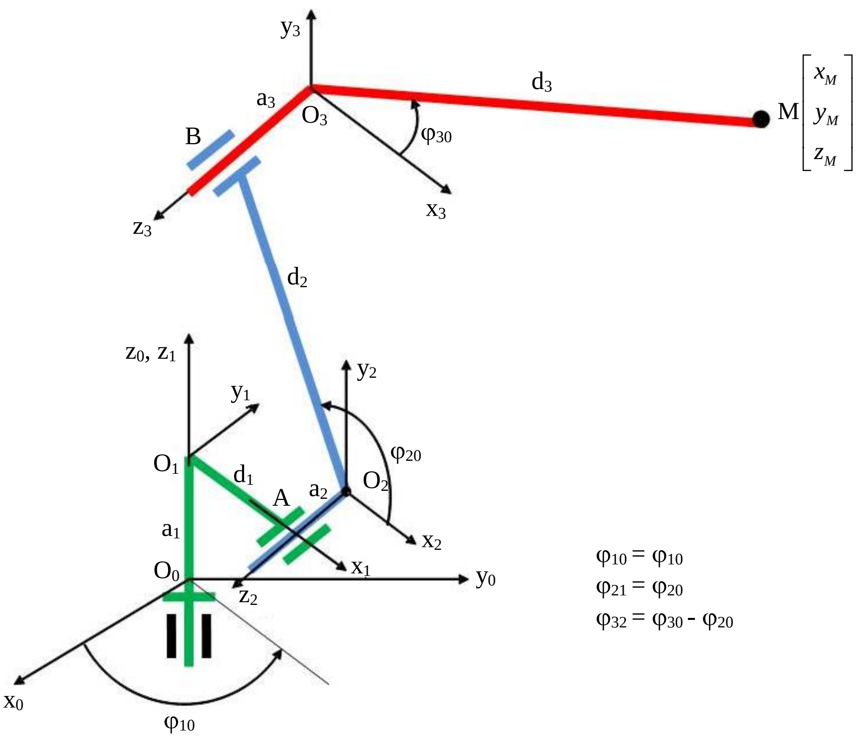

Fig. 14: The spatial basic structure

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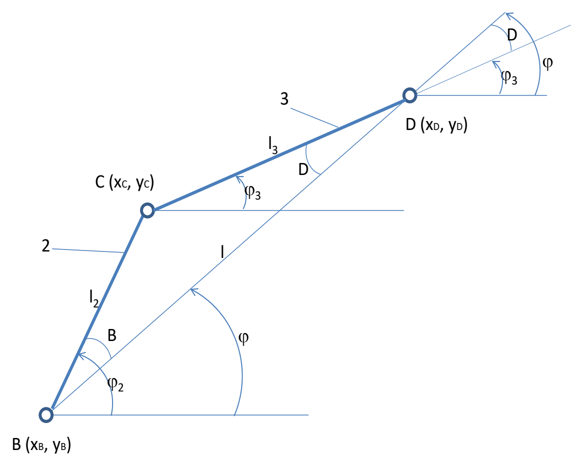

Fig. 15: The planar basic structure

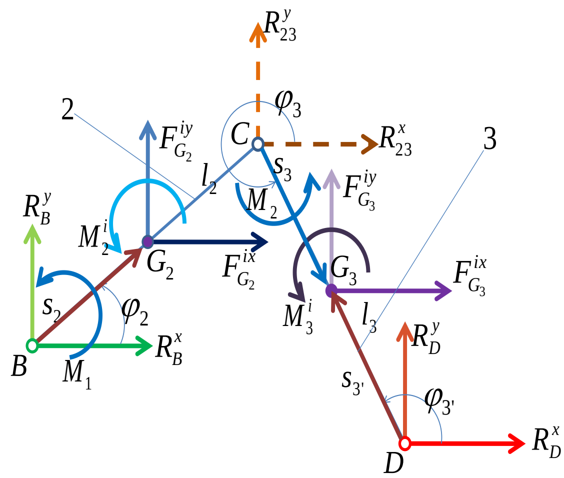

Fig. 16: Forces of the base planar system

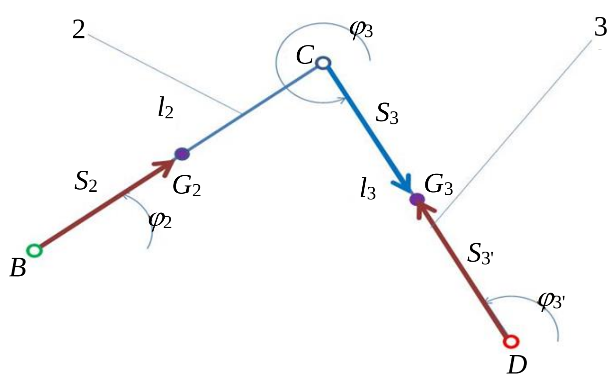

Fig. 17: The centers of mass on the two constituent elements of module 3R

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All the dynamic relationships presented in the relational system (1) are original and are based on the classical dynamic knowledge but also on the original dynamic equations of the authors already presented in other previous works.

Obviously the dynamic values sought are those noted above with a star and it is clear that the element 2 that supports the whole platform 2-3 has a more complex dynamic, whereas the element 3 that acts only on itself has a simpler dynamics closer of known kinematics.

Results and Discussion

The following will be represented J* and J*', within a calculation example, for element 2 (Fig. 18), which also supports element 3 and the variation of w* and eps* dynamic (Fig. 19) for the same element 2. Angular velocities are considered constant and known of the two electric motors that operate the planar system discussed so that the kinematic angular accelerations are null, but due to the real dynamic operation for the element 2 there is a variation of the effective angular velocity and therefore a non-zero angular acceleration is born.

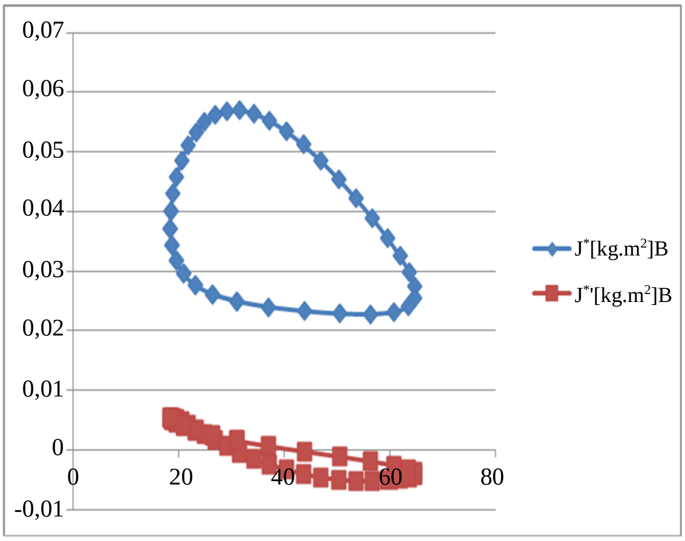

Fig. 18: The moment of inertia of the module 2-3 reduced to the element 2, depending on the positioning angle FI2 and its derivation according to the same angle FI2

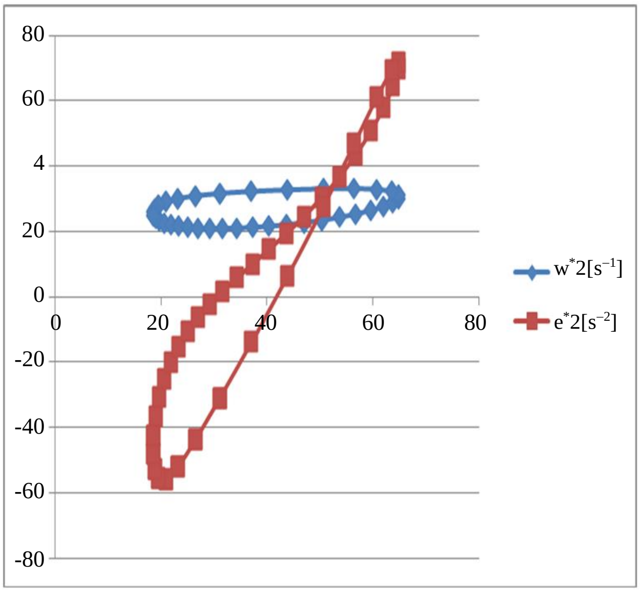

Fig. 19: Variation of the dynamic (real) angular velocity w2* of the element 2 depending on the positioning angle FI2 and of the dynamic angular acceleration eps2* also according to the angle FI2

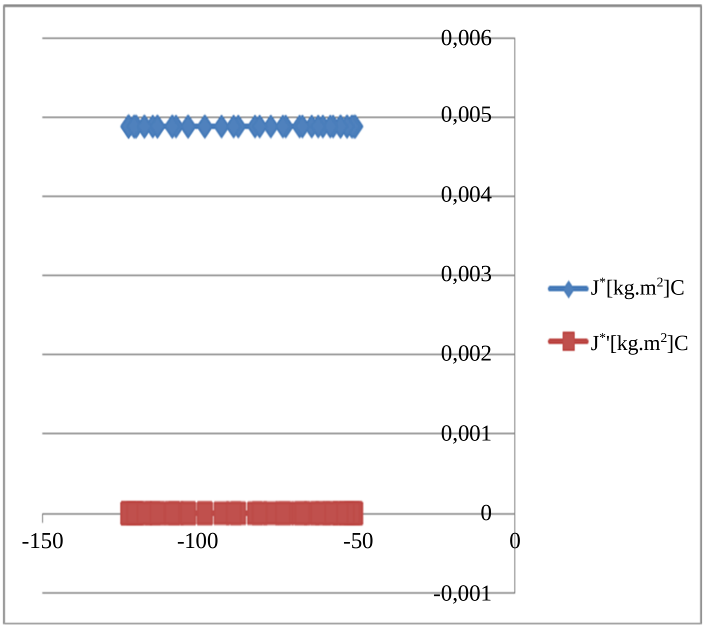

Fig. 20: The moment of inertia of the element 3 reduced to the element 3, depending on the positioning angle FI3 and its derivation according to the same angle FI3

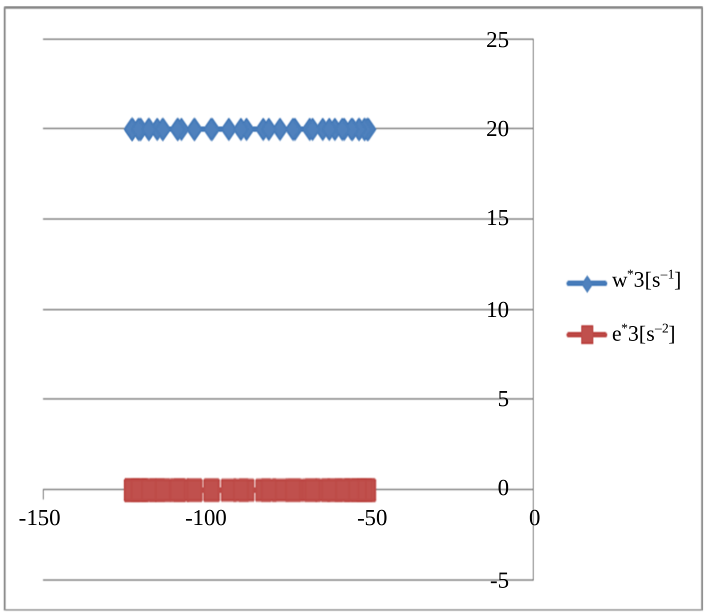

Fig. 21: Variation of the dynamic (real) angular velocity w3* of the element 3 depending on the positioning angle FI3 and of the dynamic angular acceleration eps3* also according to the angle FI3

To element 2 the variation is depending on the positioning angle of the element FI2 and on element 3 the input variable is the positioning angle of the element FI3.

At element 3, which in the case of the considered model does not support another additional element, so no more additional loading, dynamics is equivalent to kinematics (Fig. 20-21).

Conclusion

The real, dynamic functioning of a system is often the most important and from this point of view, the study of the dynamics of the systems becomes extremely important, both in their analysis and in the case of the design and synthesis of the respective system, which is valid. and in the serial mobile mechanical systems, the basic module 3R, where for the simplification of the calculations the authors adopted the solution of using the main plan of the system, which will then be rotated around the vertical axis to generate the real spatial motion of the initial module.

All the dynamic relationships presented in the relational system (1) are original and are based on the classical dynamic knowledge but also on the original dynamic equations of the authors already presented in other previous works.

Obviously the dynamic values sought are those noted above with a star and it is clear that the element 2 that supports the whole platform 2-3 has a more complex dynamic, whereas the element 3 that acts only on itself has a simpler dynamics closer of known kinematics.

The following will be represented J* and J*', within a calculation example, for element 2 (Fig. 18), which also supports element 3 and the variation of w* and eps* dynamic (Fig. 19) for the same element 2. Angular velocities are considered constant and known of the two electric motors that operate the planar system discussed so that the kinematic angular accelerations are null, but due to the real dynamic operation for the element 2 there is a variation of the effective angular velocity and therefore a non-zero angular acceleration is born.

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Author’s Contributions

All the authors contributed equally to prepare, develop and carry out this manuscript.

Ethics

This article is original and contains unpublished material. Authors declare that are not ethical issues and no conflict of interest that may arise after the publication of this manuscript.

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