MODELING, SIMULATION AND REALIZATION OF A COLLABORATIVE ROBOT

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ABSTRACT: In this work we consider the creation of a collaborative arm capable of repeating series of movements continuously. The field of the robot is an industrial one,being designed to increase productivity and reduce the risk of operator injury. In the first stage, the optimal component elements of a Slave robot arm were designed, modeled and identified. In the second stage, the components were 3D printed and assembled, and then the robot was programmed to repeat the movements. In the last stage, economic studies were carried out to identify the optimal constructive variant to be sold, and endurance and functionality tests were carried out.

KEYWORDS: robot arm, learning, modeling, command.

1. Product description

The proposed objective is to create a collaborative robot commanded by a controller, capable of reproducing movements in continuous flow. To achieve the objective, in the first stage the kinematic elements were designed, 3D modeled and the resistance of the entire robot was checked. After the first attempt, the decision was made to take over a similar, but more resistant, model from the online environment. Successively, 3D printing and assembly of all components was carried out, and then we moved on to the electronics and programming part. After certain endurance tests, the optimal necessary components for the realization of the robot and the controller for an efficient commercialization were analyzed from an economic point of view.

In the first stage, the decision was made to make a controller and a robot arm. The controller will have the role of commanding the robot arm.

The stages of design and installation of the controller were the following:

1.The dimensions of the potentiometers were analyzed to identify the optimal shape and dimensions for the realization of the controller and a 3D model was made to establish the position of the components.

Fig. 1 3D modeled potentiometer

2. In the end, a simple, light, and maximally intuitive to command form was chosen. It was decided to incorporate the potentiometers that control the movement of the Slave arm into the

controller housing. An LCD display and a button have been installed inside the case, helping in counting and in identifying the robot's current operating mode. The button was installed to be able to reset the current counter.

Fig. 2 Controller

The stages of designing and modeling the robot arm were as follows:

a) a) Different engine models were analyzed to identify the optimal variant. After a detailed analysis, MG995 servomotors were chosen due to the following advantages:
- The angle of rotation of the motor is proportional to the number of pulses;
- Maximum torque is available when the engine is off;
- Excellent response when starting and stopping, and vice versa;
- The absence of a brush, the duration of operation depending on the duration of use of the bearings;
- The speed is proportional to the pulse frequency.

Fig. 3 MG995 Servomotor

b) The various components of the Slave arm were modeled, and after a functional analysis it was decided to take over a model from an online library due to its stability.

Fig. 4 3D rendered assembly of the Slave arm

c) The next stage was the 3D printing and assembly of the Slave arm components.

Fig. 5 Printed elements

Fig. 6-7 Assembly of the main elements

Fig. 8 Final assembly of the 3D components

c) The last stage is represented by connecting the cables, mounting the servomotors and connecting to the controller.

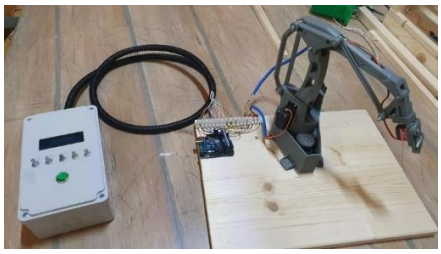


Fig. 9 Complete assembly

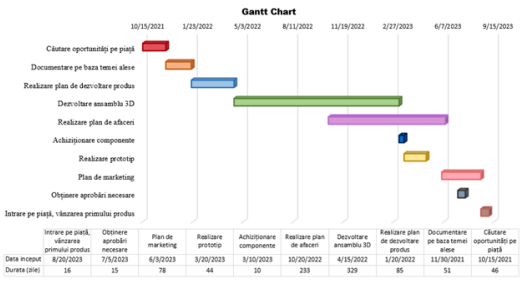
2. Market analysis, S.W.O.T

In order to achieve effective management and to develop a successful project, we prepared the SWOT analysis for the proposed product: collaborative robotic arm. This analysis will allow obtaining an overview of the positioning and the factors that influence the company's activities.

Table no. 1: SWOT Analysis for Collaborative Robotic Arm

"S"trengths: 1) The robot fulfills its role of easing the work of the staff 2) Made of durable materials at affordable prices 3) Easy to use device	**"O"pportunities** 1) Increased demand for collaborative robots in industry 2) Special robotics classes organized at schools/high schools/universities 3) Collaborations with educational institutions 4) Small companies at the beginning of the journey or in the development stage
"W"eaknesses 1) Existence of similar products on the market 2) Lack of experience in the industrial robot market	"T"hreats 1) Increase in the prices of the materials used in the construction of the product 2) Loss of jobs by personnel whose work has been replaced by robots

3. Presentation of the general strategy



	Intrare pe piață, vânzarea primului produs	Obținere aprobări necesare	Plan de marketing	Realizare prototip	Achiziționare componente	Realizare plan de afaceri	Dezvoltare ansamblu 3D	Realizare plan de dezvoltare produs	Documentare pe baza temei alese	Căutare oportunități pe piață
Data inceput	8/20/2023	7/5/2023	6/3/2023	3/20/2023	3/10/2023	10/20/2022	4/15/2022	1/20/2022	11/30/2021	10/15/2021
Durata (zile)	16	15	78	44	10	233	329	85	51	46

With the help of the Gantt chart, the main activities carried out in order to realize the project over 3 years until the sale of the first product on the market were drawn. The Gantt chart is often used in project management because it clearly illustrates their status, graphically highlighting the order and time allocated to tasks.

Fig. 10 Gantt chart for organizing activities

The company will start with a legal form of limited liability company (romanian: societate cu răspundere limitată – SRL), carrying out our activity in accordance with Romanian laws and its statute.

Table no. 5 shows the estimated costs for the milestones used to create an early version of the proposed product that can be dedicated to manufacturers and traders in the industrial area of small products such as: buttons, plugs/caps, make-up shades, nail polish , etc.

Table no. 5: Financial analysis of early product

No. crt.	Components	No. pieces	Price/piece/kg/m (cu Tax)	Total price (cu Tax)
1	Arduino UNO	1	59 ron	59 ron
2	Jumper wires Slave-Master Master-Master	set	2.5 ron	2.5 ron
3	LCD Display	1	14 ron	14 ron
4	I2C serial module	1	8.5ron	8.5 ron
5	SG90 Servomotors	1	13.6 ron	13.6 ron
6	MG955 Servomotors	3	31.5 ron	94.5 ron
7	Connection box with pre-setup	1	29 ron	29 ron
8	Potentiometers	5	1.4 ron	7 ron
9	IR obstacle sensor	1	2.2 ron	2.2 ron
10	Connection strip 14x2	1	30 ron	30 ron
11	Connection strip 3x2	1	15 ron	15 ron
12	Recall button	1	5 ron	5 ron
13	Hardware elements for robot assembly	set	15 ron	15 ron
14	Spiral cable protections	0.5 m	1.5 ron	1.5 ron
15	PLA	0.63 kg	53 ron	53 ron
Pret per produs final				350 ron

Production will start in an industrial hall, manufacturing around 40 collaborative robots monthly (about 2 collaborative robots per day) for the first 6 months. Production times will be slower due to the global shortage of electronics stocks, the reduced number of staff and the amount of money the company is starting with. In the 2nd part of the year, however, a doubling of production is foreseen.

Starting from this point, following the accumulated experience, the entry into the market and the profit obtained by marketing this product, it will be possible to develop a further improved version of it. In 2 years we can approximate the launch of a new product from the same market segment with the same uses, but of different sizes and shapes, superior quality that allows the handling of objects of larger size and dimensions or that have special requirements to be handled.

4. Conclusions

Following what was described in the first chapter, it emerges that the robot we propose for sale allows further improvements in terms of hardware and software with the experience accumulated over time and the continuous technological evolution.

Considering that the industrial robots' market in Romania is still developing, and the main suppliers of such products are foreign companies that collaborate directly with factories in the country, or other company that play the role of distributors on the Romanian market, we believe that the idea of founding a companies producing collaborative robots in the country is a business idea that will be successful in the long term.

There are many chances to enter the industrial robot market in the country through partnerships with educational institutions that can present the product to classes in robotics, technology, computer science, etc., small companies at the beginning of the journey that cannot afford to spend a substantial amount for most existing products on the market that perform the same tasks but at a noticeably higher price, part-time student internships which can represent experience for them and a possible employee for our company, and so on.

Taking into account all the above, we are confident that our product will be viewed with interest in the country's market, and that in about 3 years we will be able to expand our company offering a wider range of products and services.

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