Mechanical Geometry of a Self-Adaptive Prehensor with 2 or more Fingers

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Abstract—The paper presents the geometry and structure of a mechatronic system that defines the functions of a prehensor.By assembling the elements within the structure, it can be obtained prehensors configured with 2 to 5 elements, which by geometrical configuration can reproduce the dynamics of the human hand. The quality of the prehension is determined by the degree of mobility between the object and the prehensor during the functional activity specific to the programmed task.The mechanical characteristic of the proposed prehensor for the self-adaptive control represents the function generated by the linear and circular displacements of the elements that define the geometrical structure equivalent to the human hand.There are presented the kinematic diagrams, which each describe the rotational movement respectively, the translational movement.The combination of the geometrical elements of the two schemes defines the kinematic structure of a self-adaptive prehensor with complex movements.With this structure presented in the paper, objects with different geometric shapes, simple and complex or combined, can be prehensat. The mechanical particularities of the self-adaptive prehensor are realized by the mechanical independence of each arm or finger.The proposed self-adaptive control allows the definition of the geometric shapes of prehensat objects.

Key-words: - prehensor, self-adaptive, grippers, kinematic scheme, arms, jaw.

1 Introduction

The prehension system can be made from several fingers or arms depending on the geometric shape and dimensions that the prehensat object has. For an object with larger dimensions and irregular shape, its prehension is safer if the prehensor has more fingers or arms.

In general, prehension systems are also called grippers and are built for a limited range of objects or even for a single object.Self-adaptive prehension systems are designed to increase the range of objects and their shapes. With the ability to grab a wide range of objects, this prehension system can allow it to be changed into an industrial production line without the prehensor to support hardware or software changes. The self-adaptive prehension systems are operated with the help of direct current motors.With the help of the motors, we can control the mobile mechanical structure with a certain precision. Depending on the applications in which the self-adaptive prehensors are used, they require greater or lesser precision.At this self-adaptive prehensor, for the fulfillment of the adaptive condition, each prehensor arm or finger is operated independently.

The drive system is controlled by a complex sensory system that controls the number of steps or the number of rotations that the drive element (in this case the DC motor) performs[1].

2 Representation of Kinematic Schemes of Prehension Systems which can be used in Self-Adaptive Systems

Three types of movements are used for prehension:

2.1 Prehension Systems that Describe a Rotational Movement

The first attempts of prehension systems were made with lever-type rotational systems and their actuation was realized with pneumatic systems.In time, following the use of these prehensors, it was concluded that the pneumatic use cannot be controlled where appropriate, so electrically operated movements were implemented[2].

Prehension systems that use rotational movements are limited in applicability because they are not able to grab small objects and they change their gauge during movement by describing an R-radius, as in "Fig. 1".

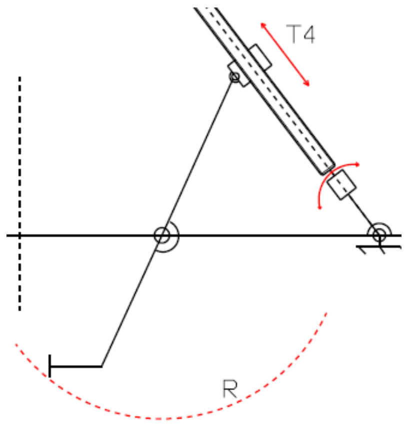

Fig.1: Kinematic scheme of a system that describes a rotational movement.

In order to use these systems in a self-adaptive prehensor, it is required to control the movement of the arm describing the radius R. The control of the prehension is achieved by controlled and verified movement of the components in motion.In the kinematic scheme shown in "Fig. 1", the controlled movement is realized using a threading system (screw and nut), realizing a T4 translation.

2.2 Prehension Systems that Describe only Translational Movements

To obtain better results for the purpose of prehension, it is necessary that the system has the capacity to grab smaller and more diverse objects.Taking these aspects into account, the prehension system must have a kinematic configuration so that it describes a translational motion "Fig. 2".

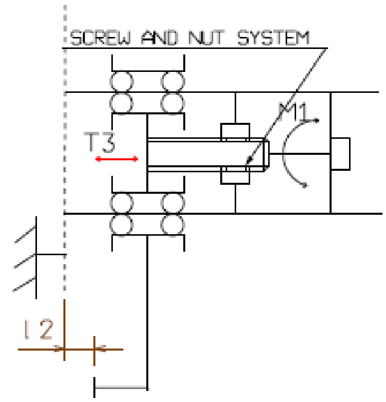

Fig.2: Kinematic scheme of an arm performing a translational movement.

This kinematic configuration uses as a movement system a screw and nut, with which it performs the parallel movement described by the T3 translation. Through the M1 rotation, the mobile structure moves constantly with variable speed, modifying the distance l2, relative to the clamping axis of the system.

2.3 Prehension Systems that Describe Combined Movements (Rotational Movements, Translational Movements)

Compared to the prehension systems that only perform a translational or rotational movement, this configuration allows the grabbing of objects more efficiently and much faster [3].

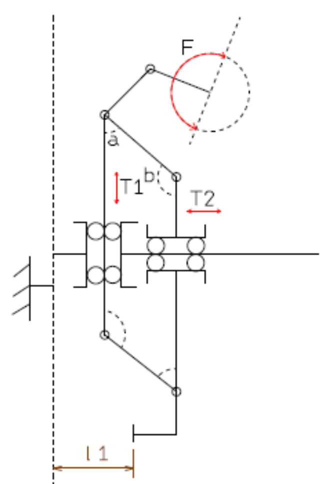

Fig.3: Kinematic scheme.

From the kinematic scheme, we can see the influence of the rotational torques on the translational movements. The force applied to the whole system is from point F and describes a circle arc influencing further the other joints a, b, as shown in "Fig. 3".

These chains of rotational movements from one joint to another are in turn guided by two translation, one vertical T1 and the other horizontal T2, which allows modifyingin parallel plane the distance l1 without the system changing its size. Such a mechanical structure allows the grabbing of larger objects in the same gauge, as the levers support the resistance structure during the prehension.

3 Kinematic Scheme of a Self-Adaptive Prehensor with Multiple Amrs

The kinematic structure of the self-adaptive prehensor “Fig. 4”, is made up of several prehension fingers that are fixed on the same axis.

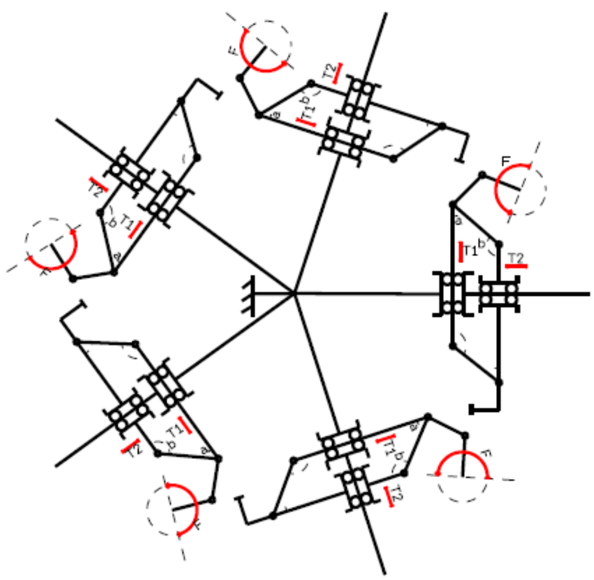

Fig.4: Kinematic scheme of the self-adaptive prehensor with combined movements.

The kinematic structure of the self-adaptive prehensor demonstrates the mechanical independence of each module. By a circular arrangement of the prehension elements, it covers all the contact areas of the object and does not allow it to move. The kinematic scheme shown demonstrates the mechanical features of a prehension system.This prehensor is built with contact elements that fulfill the function of jaws “Fig. 5”, which benefits its practicality.

Most prehension or gripping systems that perform a translational movement to the horizontal of the system are not adaptive and can be used in a very limited range of applications[4].

The existing self-adaptive systems are built based on rotations that do not allow the fastening of objects with a reduced thickness therefore there is the possibility of sliding the prehensat objects.The self-adaptive prehensor which has the resultant description a parallel movement of the jawss has the ability to grab different irregular geometric shapes and can catch objects with very small thicknesses, g1“Fig. 2”.

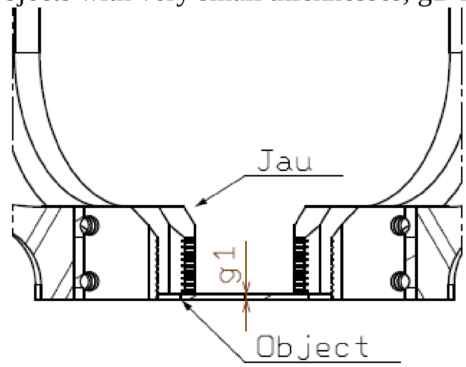

Fig.5: A detailed example of the particularity of the prehensor.

4 Adaptability of the Prehensor

Like any mechanical system, the structure of the self-adaptive prehensor also has the maximum prehension limits of the objects as shown in “Fig. 6”, where there are highlighted with a red circle.

The self-adaptive prehensor system has the ability to grab objects of different sizes depending on the mechanical permittivity. This prehension system can be built in several versions with a different prehension gauge[5].

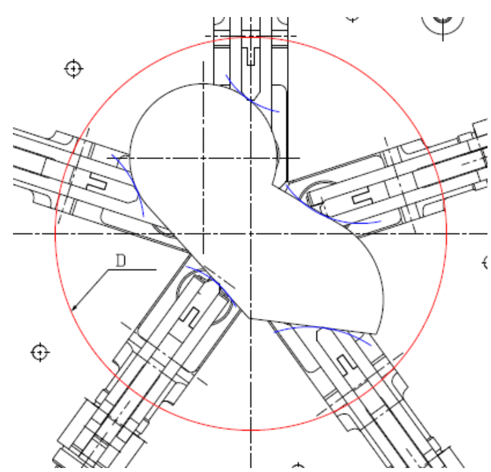

Fig.6: Adaptability of the prehensor

As the prehensor system is larger it can have a larger prehension active area, but there is also the possibility that it can be dimensioned according to the weight of the objects so that the large dimension of the prehensor can be a result of this.

The self-adaptive prehensor can achieve more efficient prehension with more arms or fingers.By increasing the contact points or areas with the object the chances of it not slipping or escaping from the jaws is lower. The contact areas and the angles below which they fall to the surface of the object are exemplified by a blue circle arc in "Fig. 6", where one can distinguish the angles of incidence between the prehensor jaws and the object.

Following the contacts between the jaws and the object, different geometric figures can be obtained by which we can deduce the shape of the prehensat object in "Fig. 2".

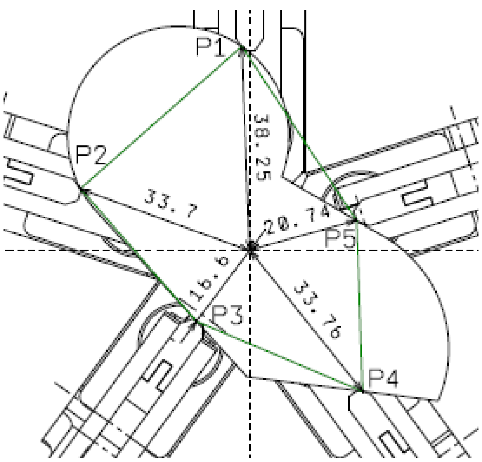

Fig.7: Geometric deduction of objects.

Since all the arms of the prehensor start from the same point, they move at different distances depending on the shape of the grabbed object. From the angular contact of the jaws with the grabbed object, it can generate moments of movement of the object in different directions; at first glance, this may seem like a disadvantage, but the system can move in any direction and can compensate for the angular difference generated during the prehension.

5 Conclusions

Following the analysis of the mechanical structures, it is demonstrated that the pre-tensioning systems are more efficient during the pre-tensioning if they have more contact points. Depending on the range of objects and the complexity of the geometric shapes they have, the number of fingers that the prehensor must-have can be determined.

Prehension systems that combine rotations and translations during movement are faster in operation and can be used in processes that require speed.

References:

[1] Stroe I. "Sensors and transducers for industrial robots" Romania, Brasov, Reprografia Universitatii Transilvania, .

[2] Frincu C, Stroe I, "The state of stress and deformation by the finite element method of the mechanical structure for a self-adaptive prehensor", Romania, Oradea, Proceedings of the annual session of scientific papers, 2019.

[3] Frincu C, Stroe I, "The state of the modular element structure of a prehensor through virtual prototyping", Romania, Brasov, PRASIC, 2018,

[4] Dudita F, Staretu I "Structural synthesis and systematisation of flat elementary mechanisms with articulated bars usable as prehension robots" Cluj-napoca: Buletinulcelui de-al VIII-lea Simpozion National de IR, 1988.

[5] Staretu I "Systems of Prehension (Sisteme de Prehensiune", Romanian, Brasov, Lux Libris, 1996.