

The structure of a sliding sensory system for a self-adaptive prehensor

I C Frincu¹ and I Stroe²

¹Product Design, Mechatronics and environment Department, Transilvania University of, Braşov, Romania

cezarfrincu@yahoo.com

Abstract. The quality of the prehension is determined by the mobility state of the prehension object. The emphasis on sliding within the self-adaptive prehensor, proposed in the paper, is achieved by correlating the parameters generated by the rotation sensor (encoder), the contact sensor and the angular position of the stepper motor. The rotation of the encoder is influenced by the active and passive mechanical components in the prehensor jaws. In this way, it is obtained a 2D sliding sensory system. The sensory system is a complex mechatronic system that can adapt to most industrial robots of different sizes and types, including the cartesian type. The prehension of the objects is accomplished through a sensory technique which integrates all software and hardware operations to achieve the image of the two directions grip. The sensory system has a resistive position sensor in its structure which determines the angular position of the axis of rotation of the execution element. The inductive position sensor is the second sensor of the system. It highlights the mechanical tensionless contact on the prehensile object. The sliding of the object is emphasized by a resistive position sensor. An important role in programming the prehensor is the correlation between the software information from the three sensing elements with the stepper motor that achieves the force required for the prehension.

1. Introduction

In a prehensible system, the most important is the products safety system as they are moved from point A to point B. The safety of products is when the prehensible system handles a product and it does not leave prints on it, it does not plastically deform it and it is manipulated without the possibility of being dropped. The sliding sensory system does not allow the product to slip into the prehensor jaws, so it cannot escape during movement and knows at the same time how hard to squeeze it.

All parameters generated by the sensors are variable and can be changed during the movement, and in real time a correction is applied when the product is squeezed into the jaws. This sensory system can be adapted and mounted on classical prehensible systems, but the maximum yield is achieved on the self-adaptive prehensible system[1].

2. Presentation of the sensory system

The sensor system consists of a resistive encoder (1) having a spindle that exerts a rotational motion, generating values that are amplified by an electronic system for being readable.

The encoder is actuated by means of an elastic strap (6) which provides an amplified transmission between two drive wheels. The drive wheel (2) that transmits motion to the encoder also has the role of straining the drive belt. Each value generated by the encoder correlates with the position of the stepper motor spindle in real time to make a decision if it is necessary to exert a greater or lesser force on the product. The whole system is trained by a flat band that forms a lever with the first rotation system, while at the same time realizing a translational motion relative to the horizontal of the system.

The flat band makes a sensible translation movement, does not make any effort on the prehensible product, and once it is at the end of the stroke, the firm contact of the product is detected by an inductive sensor (3). The entire sensory system is activated with the contact confirmation of the inductive sensor'Figure 1'[2].

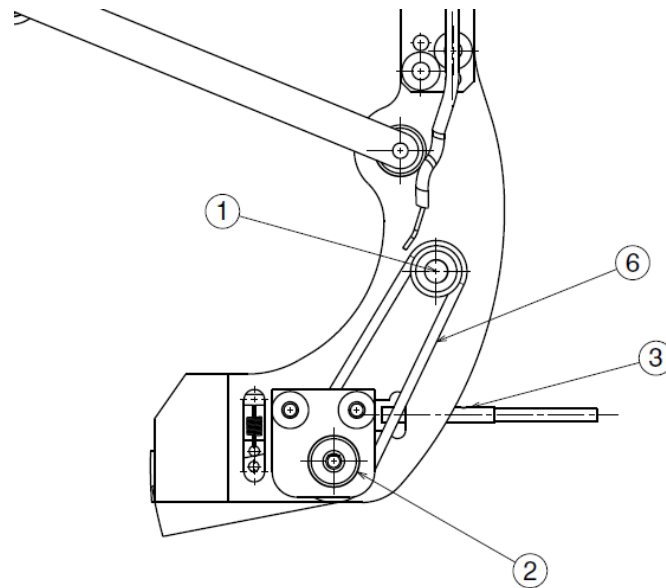


Figure 1. The self-adaptive prehensor jaw with the implemented sensory system.

2.1. Description of the movement made by the flat band

The flat band is an active part of a sensory system that plays an important role in detecting the movement of the prehensile object. The flat band is a stainless steel sheet of 1.5 mm that has adherent material on the contact surface with the object and at one end is fastened to a shaft through which it transmits the rotation movement. It has an atypical geometric shape with a length of approximately 40mm. After it performs the rotation motion, it returns to the initial position with a slightly tensioned extension spring.

The flat band together with the axis on which it is fastened and with the whole rotation movement system perform a 2 mm translation motion so that the prehensile object to reach the holding jaw and at the same time we can detect its presence.

The translation motion is made horizontally and returns to the initial position by means of a compression spring that is positioned around the inductive sensor and the flat band axle support bracket.

The axle on which the flat band is secured has a chamfer shape to provide its moment of rotation without allowing it to rotate about the axis 'Figure 3'[3].

The flat band has two holes by which is set the lever which makes the rotation and then we can generate the ideal position for the location of the extension spring. The position of the spindle is given by the

dimensions $a + c$ and b , with these dimensions we can vary the transmission of the moment and the sensitivity of the transmission; therefore as the position of the spindle of rotation is further, the sensitivity decreases. During rotation, the flat band describes an R_x radius that is permanently in contact with the object, rolling on the prehensile object 'Figure 2'[4].

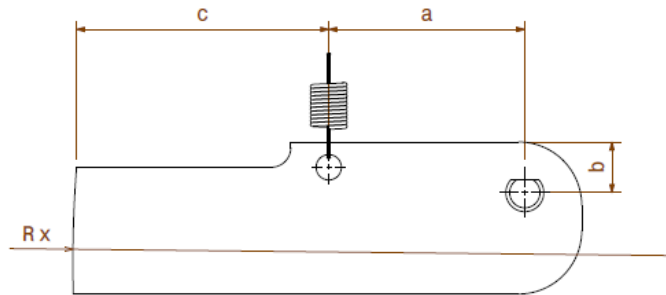


Figure 2. The geometric from of the flat band

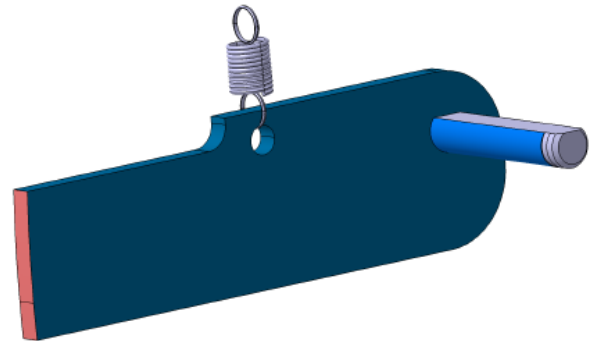


Figure 3. 3D view of the flat band with the spindle and the retraction spring

2.2. Flat band characteristics

The flat band is a piece of stainless steel sheet with a density of 7860 kg/m^3 and a weight of 5g which is cut into an irregular shape with a volume of $6.41835 \times 10^{-7} \text{ m}^3$.

In order to establish the position of the extension spring, we must find the center of gravity toward the flat band origin, and the coordinates are: $G_x=0 \text{ mm}$, $G_y=20.136 \text{ mm}$, $G_z=5.543 \text{ mm}$.

For the flat band to return to its original position, the spring must overcome its weight, but it must also be sensitive. It should not exceed the force of 0.8N because it can prevent proper functioning of the sensory system. The entire weight of the flat band does not just lie in the spring, it also has a support point in the axis of rotation[5].

2.3. Gripping process description

The jaw of the self-adaptive prehensor with 5 arms in which the sliding sensory system is implemented is interchangeable. In the section represented it can be noted the rotation movement that it does after the contact with the object.

The stages of prehension with sensory sliding systems are:

- The stepper motor operates the prehensor arm until the flat band from the jaw reaches the product and confirms the inductive sensor;
- After the presence sensor confirms, then the motor tightens up to 5%;
- If the product moves in jaws due to inertia or weight greater than the force exerted upon it after it is gripped, then the flat band makes a downward rotation, and at the same time every 0.1° the stepper motor puts more pressure on the product until it does not move. The flat band performs the rotation movement from position (5) to position (4), thus achieving a maximum rotation of 11° , and then it returns to the initial position (5) by means of a traction spring 'Figure 4'.

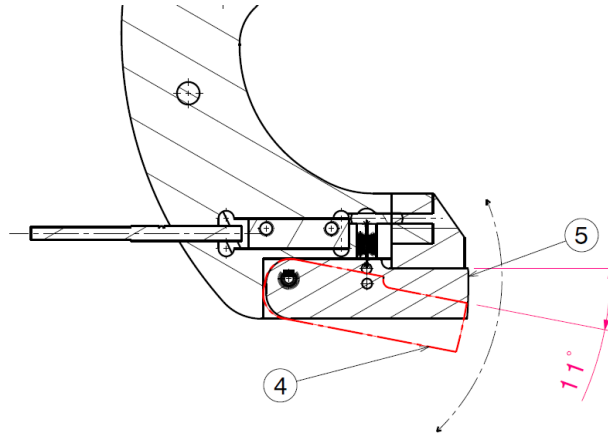


Figure 4.The section of the jaw where the sensory system is implemented.

3. Software design of the sensory system

The sensory system is a system where multiple electrical values generated by the sensors are cumulated to finally make a momentary decision.

3.1. Encoder structure and generated signals

The encoder is a sensory system that generates electrical signals or parameter variations according to the type chosen. In the self-adaptive prehensor sensory system is used a resistive encoder allowing a 360° rotation. It generates resistive variations to the programmer on its inputs.

Tabel 1.The values generated by the encoder and read by the controller.

Angular position of the flat band	The value generated by the encoder displacement	Stepper motor
0°	0 + (-0.03 to +0.03)V	0° = 0 steps
0.5°	0.05 + (-0.03 to +0.03)V	0.9° = 1 step
1°	0.07 + (-0.03 to +0.03)V	1.8° = 2 steps
1.5°	0.09 + (-0.03 to +0.03)V	2.7° = 3 steps
2°	0.11 + (-0.03 to +0.03)V	3.6° = 4 steps
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6.5°	0.29 + (-0.03 to +0.03)V	11.7° = 13 steps
7 °	0.31 + (-0.03 to +0.03)V	12.6° = 14 steps
7.5°	0.32 + (-0.03 to +0.03)V	13.5° = 15 steps
8°	0.35 + (-0.03 to +0.03)V	14.4° = 16 steps
8.5°	0.37 + (-0.03 to +0.03)V	15.3° = 17 steps
9°	0.39 + (-0.03 to +0.03)V	16.2° = 18 steps
9.5°	0.41 + (-0.03 to +0.03)V	17.1° = 19 steps
10°	0.43 + (-0.03 to +0.03)V	18° = 20 steps
10.5°	0.45 + (-0.03 to +0.03)V	18.9° = 21 steps
The 11°	0.47 + (-0.03 to +0.03)V	19.8° = 21 steps

signal
read by the programmer is made through an analogue input with a read function, (val = analogRead(Ax)).
There is resistive variations of the encoder make the output current to be variable with a linear feature but also

with a reading error. The reading error is declared with the function $\text{if } ((\text{val } \text{„read value”} > \text{previous} + 3) \parallel (\text{val } \text{„read value”} < \text{previous} - 3))$, where the declared error 3 is the sensitivity threshold of the encoder. This declared threshold is important because there are times when at a certain mechanical position the encoder can generate lower or higher values even if it is at rest. These error values are variable and do not have to further influence the mechanical system, and depending on the noise generated by the encoder at rest, the interval at which it can generate variable currents is established. The encoder performs the rotation motion until it is mechanically stopped by the flat band at the angle of 11° (Table 1).

3.2. Correlation parameters with stepper motor movement

In this case, the sensor system consists of a presence sensor and an encoder sensor. Values are read from the encoder as long as the proximity sensor confirms the presence of the object generating the signal (1 or true). In software, the proximity sensor of this type is declared as a simple contactor (`int digitalRead x`) where x is the pin number chosen.

After declaring the connection between the sensor and the programmer, is declared the connection type (input). A very important parameter for stabilizing the system is the declared resolution in stepper motor programming. For a stepper motor with a 150 resolution declared as (`stepResolution 150`), it takes a step when the encoder error value is exceeded. To reposition the motor, the constant value generated by the encoder with the function $(\text{previous} = \text{val } (\text{current value}))$ is read in real time.

4. Conclusions

If the angular position of the flat band reaches 11° , then it means that the object is too heavy to achieve the prehension and it is not safe to move the object.

In order to achieve an even clearer prehension, it is possible to replace the stepper motors with servomotors.

5. Bibliography

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