

## Force Measurement Possibilities for Gripping Biomechanisms

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### Abstract

The living creatures provide a lot of gripping biomechanisms [1]. The study of these biomechanisms makes possible the discovery of interesting equivalent mechanisms, which can be used for industrial robots in many fields of activity. It is possible to obtain some technical gripping mechanisms starting from the ones of the living creatures in their biological evolution: insects (stag beetle) [2], birds (parrot), marine (crawfish) or terrestrial (elephant) animals, human beings. It is a good idea to try the synthesizing of a universal gripping mechanism.

### 1. Introduction

Since 1600 European history has seen a succession of figures renowned for their breakthroughs in the ever-widening area of bioscience. In 1680, Giovanni Borelli published his *de Motu Animalium* (on the Movement of Animals) which showed through illustrations (Figure 1) and explained mathematically the mechanics of the body's movements.

The age of "science" as we think of it today had begun, and the modern age of biomechanisms (Fig. 1,A) was well and truly established.

### 2. Brief Description of Experimental Work

Interesting analogies could be made between the human fingers and the robot ones (Fig. 1,B). For example, the human phalanx has been divided into 16 sections parts with the tomograph computer for the determination of the phalanx bone's spatial geometry [3].

The modeling was made with hexahedral finite elements. The bone was subjected to a bending force of 2 kN distributed on the lateral head surface and to a torque at its head. Finally, the stress and displacement distributions were defined. Undoubtedly, the robot fingers have increased the admissible stresses owing to their metallic structure.

A lot of gripping positions are presented in Figure 2 (a. k). This universal human function is achieved by two to five fingers. The

prehension capacity variation with the fingers number for the above-mentioned four cases is presented in Table 1.

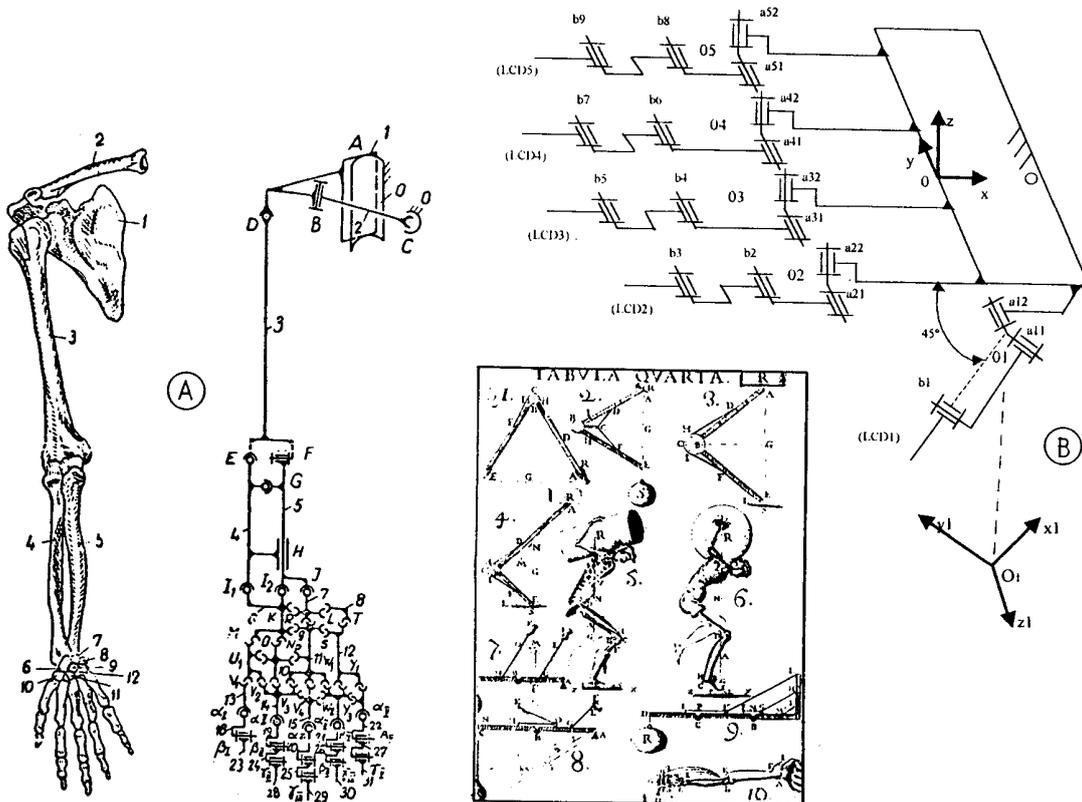


Figure 1. Evolution in studying forces in various biomechanisms.

Table 1. Gripper capacity reported to the number of fingers.

Number of fingers	5	4	3	2
Gripper capacity	100	99	90	40

Comparing technical variants utilized in Robotics, one may say that four fingers (Model B) ensure a good gripping force while two fingers (Model A) satisfy only simplified gripping models, schematically representing different human functions. The corresponding

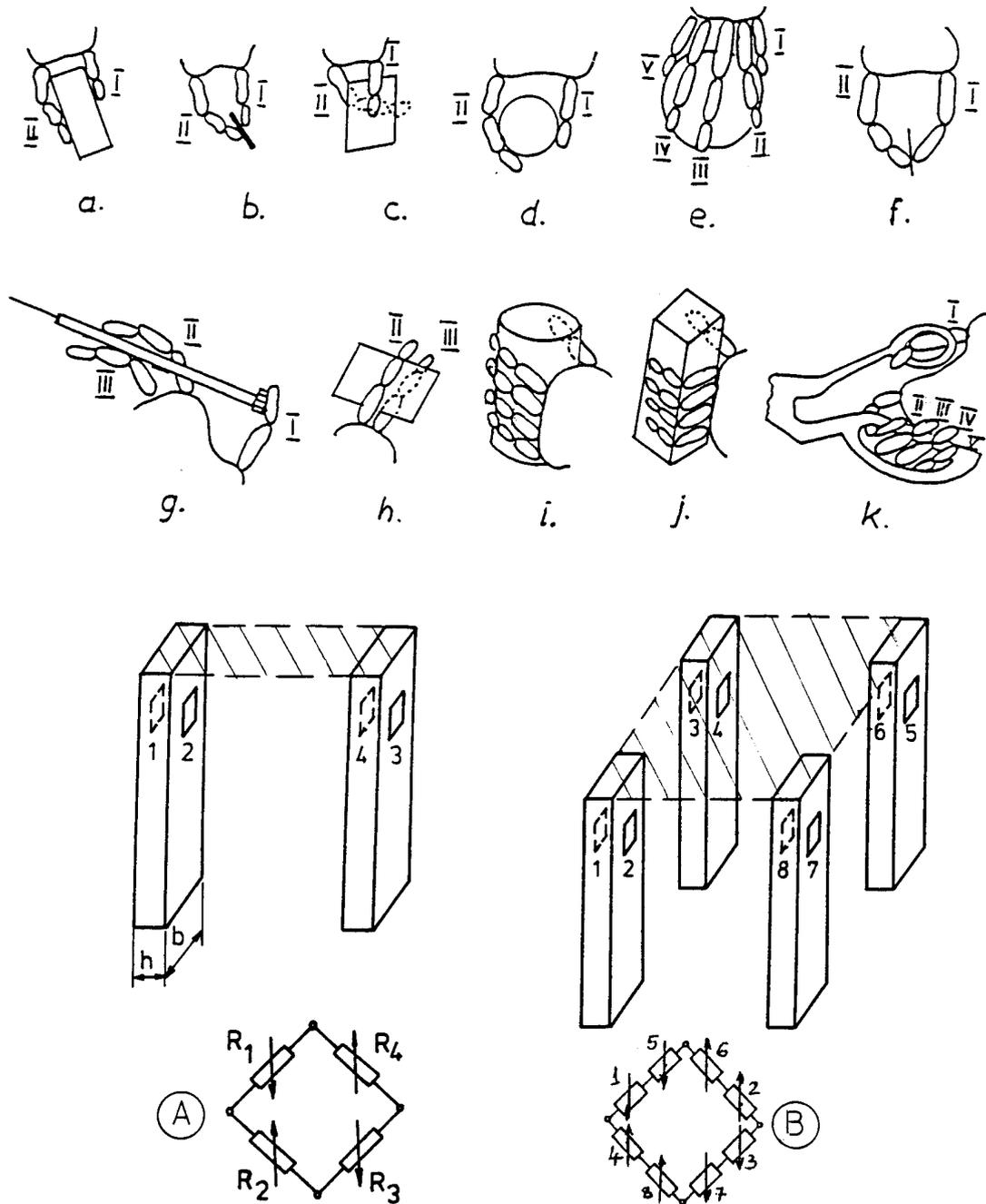
structural variants, equipped with strain gauges, are shown in Figure 2.

### 3. Application

An example is the gripping mechanism of a MERO handling robot (Fig. 2,B) for the

casting moulds manipulation [4]. It is structured of four elastic fingers made of iron

band having appropriate chosen dimensions in bending.



**Figure 2.** Various bio- and robotic mechanisms for gripping. Their strain gauges connection in Wheatstone bridge.

The gripping force is indirectly measured by means of the strains in the manipulator fingers. For the very sensitive sensors, as

strain gauge like, the Wheatstone bridge configuration is the ideal conditioning device [5].

The strain gauges can be located either on two or on all the four fingers. In the first case the classical configuration (two strain gauges extended and the other two shortened) is recognized. In the latter case the strain gauge connection consists in a complete Wheatstone bridge with eight strain gauges.

Because the elastic fingers mode of mounting is not definitely known and the maximum load depends on the material, and quality of the piece surface, on the fingers shape, on the operating pressure and motion speed, the gripping appliance calibration in operating conditions similar to the real ones is more important than the dimensioning.

#### 4. Conclusions

Robotics is an *"intelligent connection between perception and action"* - said Mike Bradley.

By realizing the complex analogies with robotics field the authors tried to systemize the knowledge in the field of force/torque strain gauged sensors, illustrated by several achievements. It also takes into account the point of view of advanced human-robot systems.

Considering the great progress in the field of thin coating (10  $\mu\text{m}$ ) or thick coating (100  $\mu\text{m}$ ) and in the silicon technology one, the strain gauges promise wide applicability in the field of gripping biomechanisms. These semiconductor strain gauges can detect relative

variations of length and, implicitly, of force under 1/million (1 ppm).

The complete Wheatstone bridge (with four equal resistive arms and tensometrically active), in combination with the differential nature of the electronic amplification configuration, ensures a good rejection of the noise, the thermal compensation and a linear transfer characteristic. It respects according to both diagonals (of excitation and response) the symmetry law, omnipresent in nature.

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