Chapter 3
Biological Basics of Haptic Perception

3.1 The Sense of Touch and its Biology

Examples of haptic systems and the importance of the haptic sense have been discussed in the preceding chapters without actually giving an exact idea of the function of haptic perception. For the design of haptic systems it is vital to have a basic understanding of characteristic biological parameters, as only these will help to identify relevant technical requirements. This chapter introduces the most important terminology and basics for understanding the neurobiology of haptic perception. Please note that research on haptic perception is far from being complete. As a consequence this short presentation of complex biological coherences is a well-founded working hypothesis which will be extended or confuted by further research. In order to perceive information from our surroundings, man is equipped with five senses: Hearing, Smelling, Tasting, Sight and Touch. The physiology of senses distinguishes five sensors and sensory-systems [219] differing from this very popular definition. They allow a classification in a vocabulary lent from a technical approach to describe things:

- **Thermal** sensor for registering the change of temperature especially within the skin,
- **Chemical** sensors reacting on odorous or gustatory substances,
- **Optical** sensors reacting on the impact of photons, especially within the cones and rods in the retina,
- **Pain** sensors, also named nociceptors, to identify chemical and physical tissue damage,
- **Mechanical** sensors for detecting mechanical tensions and strains e.g. within the skin or muscles.
The sensory capacity and its importance for haptic perception are valued differently. The visual sensors register $\approx 10$ Mio. bit/s, the sense of touch $\approx 1$ Mio. bit/s and the acoustic sense $\approx 100$ kbit/s [18]. The processing of these sensory data happens within the cerebral cortex. It is structured in functional brain areas. The primary motor cortex is the physiological location for processing data from the sense of touch. A visualization of the distribution of body parts on the primary motor cortex (fig. 3.1) shows a significant portion being used for fingers and hand.

**Fig. 3.1** Visualization of the functional brain areas in the motor cortex (somatotrope ordering) [52].

Within the sensorimotor functions the haptic sense has the highest importance. It consists of a group of mechanical sensors detecting force induced deformations within tissues in the skin, muscles and joints. As a consequence haptic perception is the sum of signals from a large number of measurement points distributed among the human body, consisting of at least 6 types of sensors which can be divided into two basic groups: Tactile and kinaesthetic sensors (fig. 3.2).

Tactile sensors are located in the outer areas of the skin in exposed positions (e.g. the fingertips). They react on strains of the skin and are activated either proportionally to the elongation, to the velocity or to the acceleration. The neuro-pysiology distinguishes between four different types of tactile sensors [236, 219]:

- Rapid-adaption or Fast-Adaption (RA or FA-I) *Meissner corpuscles* - with velocity dependent activation.