Chapter 8
Metrological Maps of Representative Species

ABSTRACT

Compositional ingredients of locomotion in living species interact to enhance survival. A major optimization indicator manifests within the detailed function of locomotor surfaces in many species. Surfaces highlight a design logic preserving the structural integrity of the surface and subsurface layers and energy conservation during motion. This chapter presents a comparative study of the topographical structure of three examples: human, canine, and feline-cat feet. It is shown that the metrological roughness of each of the examined feet is customized for the specific locomotion and energetic demands of the species. The textural parameters closely correlate to the pressure distribution experienced in movement. This enhances the durability and structural integrity of the bio-analogue.

INTRODUCTION

Locomotion of living species is a multifaceted vital and complex activity. It entails mechanical, chemical, and neurological contributions that interact to optimize motion output. Each of the aforementioned contributions is, in turn, the culmination of a multitude of sub-contributions which are complex in nature. This is especially true upon considering the energetic interaction of each sub contribution.

Mechanical contributions in the locomotion realm manifests complex interaction of muscular effort aiming at initiating, then maintaining motion. Additionally, the mechanical aspects entail mechanisms of gait optimization (as mentioned earlier), optimized contact mechanics, and calibrated material response. Contact mechanics and material response are interrelated in the manner that results in regulating locomotion effort and optimization of external reactions along with dissipation of resultant impact forces in order to avoid damage. The compositional ingredients of locomotion in living species interact in a sophisticated manner. Further, the collective evolution of this interaction is optimized in a manner that enhances the survival probability of the particular species. Optimization of interaction manifests through the dynamic performance of each the components making up the locomotion mechanisms within a particular species. A major optimization indicator manifests within the detailed function of locomotor surfaces in many species. Locomotor surfaces, in essence, showcase the fundamental building blocks of optimization of motion. In particular, the surfaces highlight a design logic aimed at preserving the

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structural integrity of surface and subsurface layers within the locomotor assembly. They further point at some of the intrinsic routes to energy conservation during motion.

The general conceptual design of locomotor surfaces depends on targeted customization that aims to meet the structural and kinematic demands of the particular locomotion style of a given species. In addition, customization facilitates meeting constraints, structural and kinematic, imposed by the living habitat of the particular species. Despite targeted customization, it is possible to identify a generalized "skeletal" outline of a locomotor assembly. Such an outline manifests in building blocks of similar general function. These represent the makeup of the outer "frictional" surfaces of the particular locomotor assembly and are supported by loadbearing and stress dissipation sublayers. In addition, the outer, i.e. frictional, contact surfaces, contained the roughness features. These features reflect customizable graphical elements. Customization in outer contact surfaces, it is important to point out, reflected both in the geometry and in the metrological attributes of the roughness features present within the particular contact surface.

The inner (i.e. supporting) sublayers meanwhile, are, in essence, integrated padding layers of which mechanical properties are customized to sustain the particular loading modes arising during motion. These loading modes include those that arise due to muscular effort and those that result from reactions of external surfaces contacted during motion. Both, the outer surface and the supporting sublayers, reflect a refined degree of customization that aims at preserving the structural integrity of the locomotor assembly. Further, the structure combined to mechanical properties facilitate balancing and dissipation of mechanical energy released by the muscles to initiate and maintain motion, and arising from external reaction forces.

Outer surfaces of locomotor pads represent the forefront of interaction between the biological species and the constraints of its habitat. They initiate contact with the locomotion terrain and channel reaction forces arising during motion. Thus, they manifest a gateway that maintains economy of effort (i.e. energy optimization) and preserves the structural integrity of the locomotor assembly. The gateway to maintain economy of effort and structural integrity is materialized by the roughness features present in the outer surfaces.

Customization of features, both on the macro and micro levels is, therefore, crucial to maintain optimized locomotion. Customization is typically reflected in the values of the metrological parameters of the surface and the overall geometry and shape of the roughness features within the contact locomotion surfaces. As such, detailed exploration of the metrology building blocks of active locomotor surfaces, stand to reveal the logic of customization to achieve optimization of the roughness features to optimize energy expenditure in locomotion function. It further helps reveal the mechanism of targeted functionalization of mechanical properties gradients in surface and subsurface layers of the locomotor assemblies.

This chapter studies in details the metrological structure of representative bio-locomotor assemblies of selected species. The exposition highlights the overall structure of the roughness features present within the foot pads of three selected species that reflect different locomotion modes. These are: human feet, canine feet, and feline feet pads. The presentation focuses on the exploration of the general traits of surface metrology describing the roughness features of the respective pads. Further, we detail the implications of the metrological parameters present within the pads on the structural and energetic aspects of locomotion performance.