

# Preface

Biological sensors found in nature have been optimized through evolution but have features that are not well understood yet. Knowledge obtained from natural systems could significantly benefit the engineering of artificial devices. Bio-inspired studies try to look outside the traditional domains, into natural processes, to find inspiration to devise novel designs for engineering systems. Biological species are equipped with impressive sensing systems that work on diverse sensing principles and demonstrate a staggering range of multifaceted functionalities that exceed the range of sensing capabilities of many human-engineered sensors. Some species use micromechanical biological sensors to evaluate various physical parameters that are needed for their locomotion and survival. Hence, nature has already solved some of the problems that humans are still struggling with. Translating nature-based engineering solutions to artificial man-made technologies could lead to innovative solutions for crucial problems. In nature, we can find some of the finest engineering designs of sensors that work efficiently (efficiency) and accurately (accuracy and sensitivity), are critical (necessity), and are long-lasting (reliability). Efficiency, accuracy, sensitivity, and reliability in artificial sensors and sensing systems are exactly what most modern researchers are grappling with.

The main goal of Chap. 1 is to translate the knowledge gained from the biological mechanosensory lateral-line system found in blind cave fish to a functional product in the form of an artificial lateral line of sensors that finds applications mainly in UUV navigation and various other areas of flow sensing. We demonstrate here the development of arrays of polymer MEMS pressure sensors, which are flexible and can be readily mounted on curved surfaces of AUV body.

Olfaction, the sense of smell, is one of the most unique skills of vertebrates, especially for aquatic animals, developed through evolution for survival. Olfactory sensors in some marine animals feature sophisticated micro/nano-structural morphology with thousands of receptors specifically binding to varieties of smells, which render these animals to develop ultrasensitive odorant detection both in the airborne medium and in the aqueous environment. In recent years, research attempting to design artificial counterpart to mimic the sensing capacity of biological olfaction system has attracted more and more attention in light of globally

increased concerns about chemical and biological threats. Chapter 2 portrays several examples of artificial sensors/systems inspired by the structure/function of biological olfactory sensing system.

Chapter 3 provides a glimpse of the field of underwater sensors inspired by various active and passive sensing strategies employed by dolphins, fishes, and crocodiles. The active sensing strategies are discussed briefly while a detailed account is provided for mechanoreception by crocodiles. The crocodile is a successful species which has evolved through about 85 million years and has dominated the water–land interface. Through the evolutionary process, they have equipped themselves with sensory organs like dome pressure receptors (DPRs) which are scattered on their skin and are responsible for the detection of origin of disturbances in water, thereby enabling crocodiles to hunt preys even in dark environment or turbid waters. DPRs in crocodiles can be an interesting addition to the list of sensors which could inspire a novel design of hydrodynamic passive sensory system for UUVs.

Chapter 4 discusses a harbor seal-inspired whisker sensor, an octopus-inspired robot, a stingray-inspired robot and bio-inspired sensing on robots. Cephalopods such as octopus, when threatened, escape fast by inflating its mantle cavity and rapidly expelling the fluid in the form of a propelling jet, assuming a streamlined shape. The octopus-like flexible hull robot uses jet propulsion to move tens of body lengths in few seconds, a performance matching its biological counterparts. Batoids, such as stingrays, adopt rajiform swimming, where they move forward by creating vertical undulations along their large disk-shaped pectoral fins. An under-actuated soft stingray robot was developed to have maneuverability unlike traditional underwater vehicles. The simple robot allows for long-term monitoring of harsh ocean environments without biofouling. Pinnipeds such as harbor seals use their well-developed vibrissae (whiskers) to detect structures and animals in their environment. Harbor seals track a prey even after 35 seconds from their passing of a particular location, and can discriminate between shape and size of nearby objects and animals. A near-field flow sensor inspired by harbor seal whiskers was developed to be deployed on marine vehicles to improve their navigation capabilities. The last section in this chapter is about autonomous robots with biomimetic sensors that outperform traditional robots in sensing and navigation capabilities.

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Biomimetic Microsensors Inspired by Marine Life

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2017, IX, 112 p. 86 illus., 75 illus. in color., Softcover

ISBN: 978-3-319-47499-1