

Chapter 12

Tactile Resonance Sensors for Detection and Diagnosis of Age-Related Diseases

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ABSTRACT

The chapter involves the description and the application of a new sensor technology called tactile resonance sensors for diagnoses of the age-related diseases glaucoma and prostate cancer. Tactile resonance sensors in general are used for measuring the parameters of a contact between sensor and object of unknown physical properties. Tactile sensing can be defined as a system that can measure tactile properties of an object or contact event, through physical contact between the system and the object. This differs from other kinds of force/torque sensors in which there are requirements for measurement of total magnitudes of forces acting upon an object. Tactile resonance sensors described in this chapter consist of piezoelectric transducers and have a mechanical resonance frequency or relative phase of oscillation dependent on the measured parameter. Such sensors are used in industrial as well as medical applications. It can be concluded that the potential of tactile resonance sensors for detecting different symptoms of age related diseases, like glaucoma and prostate cancer, is very promising. The presented sensor systems have already been patented, and no doubt, we will in the near future experience several new biomedical instruments on the health care market based on tactile resonance sensors.

INTRODUCTION

Glaucoma is an age-related disease that causes damage on the optic nerve. The disease affects 6% of people over 70 years (Rudnicka, Mt-Isa, Owen, Cook, & Ashby, 2006). All treatment, so far, is aimed at reducing the Intraocular Pressure (IOP). The reduction of IOP is done by reducing the production or by increasing the outflow of aqueous humour. Both pharmaceutical and surgical methods are available. Therefore, for diagnostic purposes and for follow-up after treatment, it is important to have simple and reliable methods for measuring the IOP. Today, tonometry is a standard procedure in all examinations of the eye. However, current standard methods are affected by known sources of error and can sometimes be difficult to use for non-specialists. This justifies the development of new reliable and user-friendly tonometry methods. Applanation Resonance Tonometers (ART®) is a new tonometry method based on resonance technology which presents a user friendly concept with documented precision and accuracy.

Prostate cancer is an age related disease among men. It is very unusual that younger men get prostate cancer. For example in Sweden 1997, no case was diagnosed in men before the age of 40 years. There were the same year 0.3% diagnosed cases in the year interval 40-49 and 5.7% in the interval 50-59 years. The majority of the cases, 70.2% were men 70 years or older. During the period 1983-1987, the risk of getting prostate cancer before 65 and 75 years of age was 1.2 and 5.8 percent respectively (Socialstyrelsen, 1991). Existing methods for prostate cancer detection are under constant debate. Summarizing there is not a single one of them that are sufficiently accurate to reliably detect cancer of the prostate and there is a need for complementary methods (Candefjord, 2010). A complementary tool that is very promising is the use of tactile resonance sensors to complement existing methods and make the diagnosis more reliable.

The objectives of this chapter are to describe the resonance sensor technology and its evolving applications towards the age related diseases prostate cancer and glaucoma.

BACKGROUND

The Tactile Resonance Sensor Technology

The new type of biomedical sensor whose applications are described in this chapter is based on resonance sensors comprising of a piezoelectric rod used both for driving of an oscillation and for pick-up of the vibration (Figure 1). In 1988 Omata first suggested this sensor technique (Omata, 1988), and in 1992 (Omata & Terunuma, 1992) presented the basic description of this resonance sensor system. The ceramic piezoelectric element is shaped like a rod or cylinder, made out of Lead Zirconate Titanate (PZT) and has a piezoelectric pick-up. By applying an alternating voltage across its electrodes the element will vibrate freely in the direction of its length. The pick-up detects the vibration and transfers the signal of the oscillation to a feedback circuit consisting of an amplitude limiter to create a square wave signal, a filter that can be tuned to select the desired resonance mode and a driving amplifier that drives the PZT-element. The system will thus oscillate at its resonance frequency.

The resonance frequency of the sensor system will be set by the zero-phase condition, meaning that the sum of phase shifts around the closed circuit must be zero. Thus, the phase-frequency characteristics of the sensor element and the phase-frequency characteristics of the feedback circuit are matched and for a specific frequency, they will cancel out giving the resonance frequency. In addition to this, the amplitude of the mechanical vibration at that frequency must be sufficient to sustain the oscillation. In practice, the selection of resonance frequency can be tuned

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