A Novel Haptic Sensor-Actuator System for Virtual Reality

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Abstract. The development of a novel system for the generation and representation of haptic information in virtual reality is described. With this system the stiffness distribution of mechanically inhomogeneous objects can be detected and made perceivable for users at distant locations. The sensor part is based on ultrasonic elastography and the actuator part utilizes the ability of electrorheological fluids to change their consistency in electric fields reversibly. Two-dimensional elastographic images or arbitrary projections of three-dimensional objects generated in the sensor part can principally be represented by the actuator part, which has a flat surface above a two-dimensional array of actuator elements with individually addressable stiffness.

1 Introduction

In haptics it may be distinguished between kinesthetic and tactile perception [1]. Kinesthetic perception is the registration of macroscopic forces such as the weight of an object, whereas tactile perception describes the feel of the surface properties of the object, e. g. roughness. By squeezing the object and feeling its stiffness, a complex perception mechanism corresponding to kinesthetic as well as to tactile information occurs. In the case of mechanically inhomogeneous objects, the problem of representing the stiffness information is a multidimensional one and requires sophisticated technical solutions. However, such a system would have a strong impact on medical applications and could lead to new diagnosis and treatment techniques. An example is the palpation of body organs and tissue by the physician. Palpation is the commonly used method to detect hard inclusions in soft tissue. Such regions of increased stiffness could be an indication of pathological changes in tissue. However, the possibility of directly feeling the hardness of tissue decreases corresponding to the increasing importance of techniques of minimally invasive surgery.