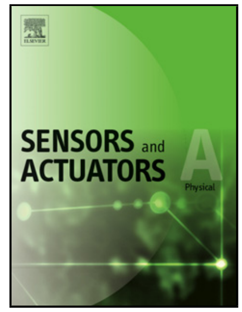

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Surface reconstruction by means of a flexible sensor array

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Highlights

- Algorithms for surface reconstruction based on signals from 6x6 sensors in a foil
- Sensor diagnosis intercepting failure of the system due to single dysfunctional sensors
- Self-sensing, ultra-thin and flexible sensor array foil with high sensor density
- Full and unambiguous determination of the bending vector

1 Introduction

In recent years, there has been growing interest in capturing the surface topography of deformable objects and exploiting this information to establish a variety of new smart systems. This trend has led to the development of topography capturing devices, which can be categorized as: *self-sensing* devices in which sensors are embedded into a deforming surface to directly measure local deformations and *external-sensing* devices, which require external sensing equipment like projectors and cameras to capture the surface deformations [1]. Microsoft Kinect [2] is probably the most famous vision-based *external-sensing* device for surface reconstruction. Such systems show very good surface reconstruction results but they require an undistorted field of view, which will suffer from any occlusions limiting their use in mobile applications. This paper focuses on *self-sensing* devices which can be distinguished on the basis of the employed shape sensing techniques. A simple device like Bookisheet [3] for example uses just two bending sensors to categorize discrete bend gestures which are used to flip through pages of an e-book. FlexRemote [4] uses 16 sensors and recognizes eight bend gestures to control a television. These systems are not aiming for accurate surface reconstruction. Other systems like ShapeTape [5], which is a long rubber tape with integrated fiber optic bend sensors and SensorTape [6], which is a long polyester tape with integrated accelerometer and gyroscope sensor chips are able to detect 3D bending and twisting of curved shapes. Such systems could be used as graphical input devices, for example by a CAD designer to easily enter arbitrary shapes into CAD software [5], or as a digital ruler to measure the shape of 3D objects [6]. A further promising application of such systems could be the measurement of deformations of a human backbone by attaching a flexible sensor tape directly to the skin [6,7] or integrating it into the clothing. Because many people suffer from backache due to incorrect posture, such kind of device could directly alert people when their posture worsens. It could subsequently analyze collected data to identify impairing physical activities, and hence increase the user's consciousness of healthy body movement. In the fast growing sector of virtual reality, applying such devices to the joints of the human body could become a very attractive technique for measuring body movements and controlling virtual reality applications in a similar fashion as with already existing data gloves [8]. For a more complex 2.5D surface reconstruction, FlexSense [1] uses 16 printed piezoelectric sensors on a thin, transparent A4-size plastic substrate. A pre-processing training phase on the basis of vision-based 3D ground truth measurements is used to infer the shape of the foil by either linear interpolation or a more sophisticated machine learning approach. Possible applications of such shape sensing systems could be, for example, using them as deformable input/output (IO) devices for digital interaction, in particular gaming [1].

In previous work, we have developed a thin sensor foil with strain gauge based bending sensors in a Wheatstone bridge configuration which provides voltage output proportional to the local bending without signal decay, as is typical for piezoelectric sensors and hence does not suffer from the related sensor drift [9]. A detailed description of the fabrication process and the characteristics of obtained signals has already been