"Classification of Textile-Based Sensors for Smart Garment Application"

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I. Introduction

Highly durable, flexible, and even washable multilayer electronic circuitry can be constructed on textile substrates, using conductive yarns and suitably packaged components [1].

Since clothes are the objects that stay closest to the human body 24 hours a day, they are the best platform to consistently measure biomedical signals without bothering wearers [2].

Sensors are essential for all monitoring applications. Designing wearable systems for physiological and biomechanical parameters monitoring, it's important to integrate sensors that are easy to use, comfortable to wear and minimally obtrusive [3].

Sensors can be categorized by several criteria, for example:

- sensor type by input and output data;
- sensor type by transduction method;
- measured parameters;
- location of sensor;
- material of sensor;
- possibility to be directly integrated in textiles;
- application.

In paper textile-based sensors are summarized, analysed and categorized considering the above mentioned parameters. Classification of textile-based sensors could make it easier to design smart garments and to select required constructions and type of sensor for specified application. Especially it would be helpful for textile / clothing designers and technologists who are related to smart garment designing.

II. Classification of Textile-Based Sensors by Measured Values and Type of Integration

According to signal measurement sensors can be divided into two large categories: biomedical signals and environmental signals [2].

Biomechanical sensors can be used to record kinematic parameters of body segments [3]. EMG, ECG, EEG and GSR are frequently used biomedical signals that are measured with electrodes. Such biomedical signals like respiration, pulse, gesture, body temperature and moisture etc. are often measured as well [2].

Environmental sensors integrated in clothing can detect, for example: environmental temperature and moisture, humidity, pressure, light intensity, sound, solar rays etc.

Some part of sensors can be designed as multisystem fabric using only conductive and non-conductive textile materials. Another part of sensors cannot be fully replaced with textile materials, therefore it is important to consider their integration, so that they would be stably fixed to fabric, providing good signal transmission and keeping well comfort properties in garment.

III. Classification of Textile-Based Sensors by Type and Application

By application sensors can be categorized both by field of usage (medicine, entertainment, safety etc.) and by type of sensor (pressure sensor, moisture sensor etc.).

For example, pressure sensors depending on their type often are used both in biomedical measurements and to measure environmental signals. Pressure sensors can be categorized in the following way:

Piezoresistive pressure sensors are based on resistive principle. They consist of materials that change their electrical resistance according to pressure. Examples of application:

- detection of sitting posture in a wheelchairs
- intelligent carpets for analysing dance movements
- pressure distribution on the human body

Capacitive pressure sensor is based on capacitive coupling which takes human body capacitance as input. Application is similar as for piezoresistive pressure sensor. Touch sensor is another field of application [2; 4].

Mechanical pressure sensor is based on principle of creating a circuit with a breaking point. At braking point it is possible to reconnect the circuit and to determine whether connection is active or not. Applications for such type of sensors are soft pushbuttons and keyboards that are made of 3 layers – two conductive parts and perforated insulator between them [5].

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