DEVELOPING OF THE SMART TEXTILE FOR ENERGY EXPENDITURE MONITORING

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EXTENDED ABSTRACT

Key Words: textile wearable, heat loss monitoring, energy expenditure, direct calorimetry, personalized nutrition.

1. INTRODUCTION

Nowadays, diets and nutrition are very popular topics for the major part of the population to ensure the healthy habits and prevent the overweight. Besides, they are an occupational topic for many heath care professionals as well the interest of the societies trying to manage with the overweight epidemic. [1]

Smart Textiles are one type of the wearable technology products. They include products based on different functionalities *sensitivity and user monitoring* being one big application area offering powerful tools for exercising by listening your body as well for personalized medicine and also for personalized nutrition. In 2018, Gartner forecasted that the global wearable devices market will have value greater than $84 billion in 2022 [2].

Energy expenditure is a key parameter to be able to personalize someone's diet. It means the amount of energy that a person needs to maintain body functions (e.g. breathing) and to perform physical activities (e.g. running). For both body weight and body composition management, energy expenditure should be monitored in order to match it with energy intake (when the goal is to maintain body weight), or to obtain a negative energy balance (when the goal is to decrease body weight) or a positive energy balance (when the goal is to increase body weight or muscle mass).

The current solutions for monitoring the energy expenditure by non-invasive and autonomous way are theoretical, meaning using equations such as the Harris-Benedict equation [3], which is commonly used among dietitians. More complex and expensive alternatives commonly used in research are *direct calorimetry*, which involves the use of isolated hermetic chambers designed to measure the amount of heat generated by the body, and *indirect calorimetry*, which estimates energy expenditure from O_2 consumption and CO_2 expiration [4].

Moreover, there are several commercial wearable products, which try to predict the energy expenditure from activity information obtained from sensors included on the gadgets, such us smart bands and smart watches [5][6]. Other wearables incorporate heat measurement as extra data to be combined with accelerometers and build algorithms [7] or uses exclusively heat sensors [8], [9].

2. THE PROPOSAL

In this project, we will develop an alternative wearable approach to measure energy expenditure, the core is to monitor heat loss from the body and corroborate it by few other parameters. In our approach, heat flux will be monitored on chest/upper torso of the user, then the algorithm will extrapolate it to whole body energy expenditure.

Textiles have been revealed as a natural and convenient substrate choice for the development of wearable electronics applications. On the one hand, it is due to the fact that humans have been covering their bodies with fabrics for thousands of years. On the other hand, many monitoring applications require long monitoring periods, e.g. energy expenditure around the clock or from morning to evening, when softness and comfort of the textiles is a big advantage for the products in skin contact.

Keeping the skin conditions as close to normal as possible is important for the best possible monitoring accuracy of the heat flux. Therefore, we will study the use of different textile architectures as a support for the heat flux sensor in order to develop a comfortable wearable device, which doesn't occlude the skin or change the skin conditions in the monitoring area.

Direct calorimetry approach is challenging as it requires monitoring of all the four heat loss forms: evaporation, radiation, conduction, and convection. On the other hand, rapid miniaturization of the electronic components as well development of the new materials is allowing new possibilities for both developing new sensing systems and integrating them onto textiles. In this project, instead of developing a gadget to be attached on the body to measure the energy expenditure, we will develop a specific textile wearable with sensing capabilities to measure the energy expenditure.

The Figure 1 depicts the principle drawing of the energy expenditure textile wearable under development. The current list in progress of the parameters includes heat flux, heart rate, impedance pneumography, core body temperature, activity (9-DOF inertial measurement unit, IMU), and galvanic skin response. All the sensors will be connected to the control unit(s) located on the torso (or alternatively to the possible second unit on the arm). Currently, a study is being made to be able to decide which parameters will be included to the design drawing of the product.

3. CONSORTIUM

Deelowear project started in February 2019 and it is co-lead by two Eurecat units: Nutrition & Health and Functional Textiles. Two other Eurecat units have a big role: Functional Printing & Embedded Devices to develop the electronics device and e-Health to develop the algorithm for data processing. Besides, there is a significant co-operation with Department of Electronics Engineering at Catalan Polytechnic University related to research and development of sensors and sensing system.

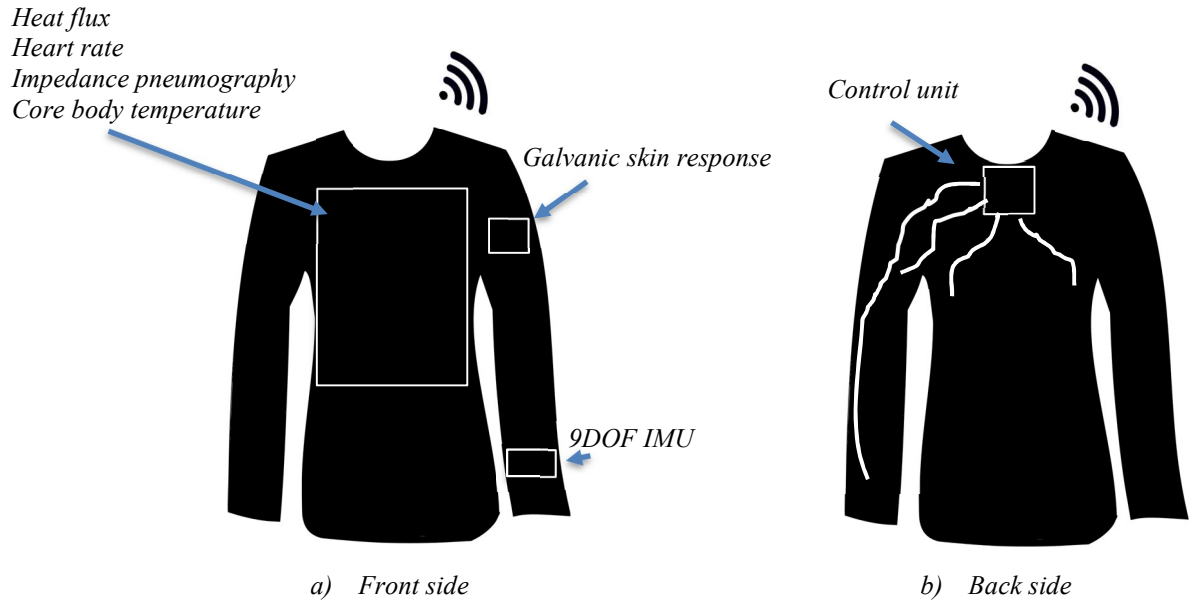

Figure 1. The principle drawing of the energy expenditure textile under development.

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