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# INNOVATIVE IDEAS BY STUDENTS AT THE FACULTY OF TEXTILE TECHNOLOGY IN THE FIELD OF SMART CLOTHING

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## ABSTRACT

*The scientific team, led by Professor Dubravko Rogale, develops a completely new kind of clothing called intelligent clothing with adaptive thermal insulation properties for a long time. They have developed several functional prototypes to date. With the development of innovative solutions in the field of intelligent clothing, the team also develops measuring systems for textile technology.*

*Students of Faculty of textile Technology are involved in scientific research work and innovative development of new kind of clothing. Through the development of their student's projects, designed and created interesting prototypes. In this paper is presented the e-shirt, the e-bike jacket, the smart bag with built-in protection against theft of content, the smart cap for heart rate monitoring, the intelligent clothing item for supervising the work of forest workers and the triboelectric generator.*

## KEYWORDS

*Innovation, student projects, smart clothing, measurement systems*

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## INTRODUCTION

At the meeting of the Thematic Expert Group, TEG no 6 Smart Textiles & Clothing" within the European Technology Platform for the future of Textiles and Clothing organized by EURATEX in January 2006, 37 experts coming from all the European countries accepted the definition and characteristics of the term intelligent clothing. The experts agreed that three sets of instruments should be integrated into an article of clothing: sensors for measuring and information input which collect input information, processing unit for interpreting input information and making decisions (microcomputers, microprocessors or microcontrollers with accompanying programs) and output actuators for adapting an article of clothing and provide output information. This definition is in accordance with investigations performed in the sector of developing intelligent clothing and publications in the course of 15 previous years at the Department of Clothing Technology of the Faculty of Textile Technology of the University of Zagreb. The scientific team, led by Professor Dubravko Rogale, made several types of air-filled chambers with changeable thermal insulation properties, either by activating combinations of chambers or by changing chamber thickness. In addition, they developed own original and complete sensors, microcomputer system and actuators based on microcompressors, valves and other elements of micropneumatics. They also created own algorithms of intelligent behaviour and the software controlling the operation of the intelligent article of clothing and the function of the rational

consumption of electrical resources of battery supply. Within this development, we painstakingly made progress and developed an overall functioning architecture on the basis of which the first prototypes of the first generation were created and patented. Based on the shortcomings of the first generation a significant modification was developed, and a completely different approach was made to intelligent clothing with adaptive thermal protection which is considered to be second and third generations [1].

Intelligent clothing and measurement systems have been developed at the Department of Clothing Technology of the Faculty of Textile Technology of the University of Zagreb was presented at exhibitions of inventions, innovations and patents in order to valorise the results achieved at international level, and the following awards were won, Figure 1:

- 2017 - Gold Medal, Kaohsiung International Invention Exhibition 2017, Taiwan (for Multi-purpose differential thermal conductivitymeter for textile composites and clothing),
- 2017 - Silver medal, INVENTION EXPO 2017, Tokyo (for the development of intelligent clothing),
- 2017- Gold medal, 42. Inova / 13. Budi uzor (for Multifunctional differential thermal conductivitymeter for textile composites and clothing),
- 2017 - Grand Prix 2nd Prize, 42nd Inova / 13. Budi uzor (for Multifunctional differential thermal conductivity meter for textile composites and clothing),
- 2016 - Gold medal, Kaohsiung International Invention Exhibition 2016, Taiwan (for the development of intelligent clothing),
- 2016 - Award for Best Innovation in Applied Science, 41st Inova / 12. Budi uzor 2016 (for an Integrated Measuring Device for Human Body Physical Parameters in Exact Assessment of Heat Comfort Clothes),
- 2016. - Special Award for Best Scientific Commercialization of Smart Specialization awarded by Tera Tehnopolis and Croatian Association of Entrepreneurs Entrepreneurs, 41. Inova / 12 Budi uzor 2016 (for an Integrated Measuring Device for Human Body Physical Parameters in Exact Assessment of Heat Comfort Clothes),
- 2016. - Gold medal, 41. Inova / 12. Budi uzor 2016 (for an Integrated Measuring Device for Human Body Physical Parameters in Exact Assessment of Heat Comfort Clothes)2016 - Acknowledgment of the Croatian Community of Technical Culture,
- 2016 - Dean Award, University of Zagreb Faculty of Textile Technology2015 - E.S.PENKALA Award for Best Zagreb`s Innovation, Association of Inventors, Zagreb (for intelligent clothing),
- 2015 - Gold medal, 40. Inova/11. Budi uzor (for intelligent clothing),
- 2015 - Award INOVA - the best Croatian exhibitor, 40. Inova/11. Budi uzor (for intelligent

clothing),

- 2015 - Gold medal, 13. international exhibition of inventions ARCA Zagreb (for intelligent clothing),
- 2015 - Gold medal, 13. international exhibition of inventions ARCA Zagreb (for thermal manikin),
- 2015- Silver medal, Malaysia Technology EXPO (for intelligent clothing),
- 2015 - Gold medal 7th European exhibition of creativity and innovation EUROINVENT (for intelligent clothing),
- 2014 - Grand Prix for the best Industrial Design, 17. Moscow International Salon of Inventions and Innovation Technologies Archimedes (for intelligent clothing),
- 2014 - Gold medal, 17. Moscow International Salon of Inventions and Innovation Technologies Archimedes (for intelligent clothing),
- 2014 - Silver medal, 17. Moscow International Salon of Inventions and Innovation Technologies Archimedes (for thermal manikin),
- 2014 - Golden medal, 6th European exhibition of creativity and innovation EUROINVENT (for intelligent clothing),
- 2014 - Special Prize, University of Sibij Lucian Blaga, as a sign of honor, recognition and appreciation of the scientific creativity and originality to inventors, 6th European exhibition of creativity and innovation, EUROINVENT (for intelligent clothing),
- 2014 - Silver medal, 6th European exhibition of creativity and innovation EUROINVENT (for thermal manikin),
- 2014 - Silver medal, Taipei International Invention Show (for thermal manikin),
- 2014 - Gold Medal – Award of Merit, 29th INPEX - Invention & New Product Exposition, Pittsburgh (for intelligent clothing),
- 2014 - Humanitarian Award, 29th INPEX - Invention & New Product Exposition, Pittsburgh (for intelligent clothing),
- 2014 - Spanish Delegation Award, 29th INPEX - Invention & New Product Exposition, Pittsburgh (for intelligent clothing),
- 2014 - Gold medal, 14th British Invention Show, London (for intelligent clothing),
- 2014 - Gold medal, 39. Inova/10. Budi uzor (for intelligent clothing),
- 2014 - INOVA - The best innovation of the science, 39. Inova/10. Budi uzor (for intelligent clothing),
- 2014 - Special Award, Romanian Inventors Forum EUROINVENT, 39. Inova/10. Budi uzor (for intelligent clothing),

- 2014 -Silver medal, Kaohsiung International Invention Exhibition, Taiwan (for thermal manikin).



Figure 1. Several awards for intelligent clothing and thermal manikin

As part of the bilateral project Development of smart clothing for people with dementia (funded by the Ministry of Science and Education) of the aforementioned scientific team and team at the Faculty of Mechanical Engineering of University in Maribor, smart clothes for demented persons has been developed. The goal of developing smart clothing for people with dementia is to provide comfortable clothing with active character, that is, smart clothing that will be equipped with modern sensors for the installation of clothing and the benefits of information technology. Such a clothes could help and guide the user in everyday activities, therapies, maintenance of everyday personal hygiene, appearance editing, and / or automatic tracking of body functions, as well as user location information to the dental care caregiver.

### INNOVATIVE IDEAS BY STUDENTS

The aforementioned scientific team involved students, scientific research and innovative work through was developed of their masters thesis. Students produced very interesting prototypes: the e-shirt, the e-bike jacket, the smart bag with built-in protection against theft of content, the smart cap for heart rate monitoring, the intelligent clothing item for supervising the work of forest workers and the triboelectric generator. The smart pyjamas for those suffering from apneas is just in the final stage

of development. The awards for student innovative projects are presented in Table 1 and Figure 2.

Table 1. The awards for student innovative projects

Student / Mentor	Innovation	Award	Invention show
Ljubica Radišić / Snježana Firšt Rogale	The e - shirt	Silver medal award	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
Martina Peck Tijeglič / Snježana Firšt Rogale	The e - bike cycling jacket	Gold medal award & the best innovation in sports and recreation	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
Marina Mesić, Matej Mesić / Snježana Firšt Rogale	The smart bag with built – in protection against theft of content	Gold medal award	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
Marija Veldić / Snježana Firšt Rogale	The smart cap for heart rate monitoring	Gold medal award	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
Damir Begić / Dubravko Rogale	The intelligent clothing item for supervising the work of forest workers	Gold medal award	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
		Bronze medal award	10 <sup>th</sup> International Innovation Fair and 3 <sup>rd</sup> World Innovation Forum (IEI & WIIF 2018), China
Juro Živičnjak / Dubravko Rogale	The triboelectric generator	Gold medal award & the best innovation in science	44 <sup>th</sup> International Invention show INOVA 2018, Zagreb
		Silver medal award & special award	KIDE 2018, Taiwan

Including a designer in the development of e-shirts, Figure 3, apart from technical functionality, the significance of aesthetic components has increased. This is achieved in a way that the shirt has a so called *Cyber looku*. In this way, the world of fashion tries to bridge the gap between new technologies and modes. The LEDs, integrated into the T-shirt, are powered by batteries and are based on the algorithm in the microcontroller, located inside the T-shirt [2].

The e-Bike Cycling jacket includes the diodes at the front and back. The front are placed on the chest area and they are lighted all the time while driving, after switching on the power supply located in the front pocket while the rear side illuminates when the button is pressed on the left or right side of the sleeve depending on whether the bicycle is turned to the left or right. In this way, the bicycle driver is visible from both the front and the rear, offering greater safety in traffic, which was the

purpose of making this prototype [3].

The smart bag with built-in protection against theft of content embedded microcontroller that is via Bluetooth module connected to the bracelet. The microcontroller is a flexible electrically conductive coupling element connected to the upper and lower part of the magnet clasp on the backpack, which opens the circuit. Circuit breaks information is sent via a Bluetooth module to the microcontroller embedded in the bracelet. The bracelet with light and sensory stimuli signals that the backpack is open. Based on the control algorithm, the LED and vibration motor are activated. The smart cap for monitoring heart rate is embedded with a sensor and microprocessor, which efficiently monitor the wearers heart rate using the sensors light intensity. The information received is then transmitted through Bluetooth to a mobile application on the wearers smart phone. It can be used for monitoring the health status of different groups of people: from children to the elderly, from patients to professional athletes and soldiers [4].

The design of the smart cap for monitoring heart rate, Figure 4, was designed to demonstrate the advancement of technology in the textile industry as well as the multidisciplinary intelligence of smart clothing. The cap is embedded with a sensor and microprocessor which efficiently monitor the wearers heart rate using the sensors light intensity. The information received is then transmitted through Bluetooth to a mobile application on the wearers smart phone. It can be used for monitoring the health status of different groups of people: from children to the elderly, from patients to professional athletes and soldiers [5].

The intelligent clothing for monitoring of forest workers work was designed for labourers who use a chainsaw and it can be classified as a type of intelligent clothing because it has a built-in sensor, a microcomputer with an algorithm of intelligent behavioural and actuators. This intelligent article of clothing has two primary functions: oversight over the labourer and the labourer's protection in the case of a workplace injury. The oversight element is based on the observation of the environmental sounds the worker produces through the use of a chainsaw, but also a vibration sensor that logs the vibrations caused by the chainsaw's engine in order to reduce mistakes induces by random surrounding noise. This makes it possible to track the effectiveness of the labourer over the course of his working day. A built in GPS system tracks the movement of the worker, which is then displayed on a map of the terrain (forest) the labourer is operating on. The protection of the worker is based on the built in vibration sensor and gyroscopic body position trackers. The built in microcomputer tracks the movements of the labourer as well as the position of his body [6].



Figure 2. The awards for student innovative projects



Should an injury occur, the labourer will change the way he moves and stands and the microcomputer will, based on this data, conclude that an injury has occurred and then activate the executive device (a cell phone or radio transmitter) which will then forward a request for help to rescuers, along with GPS data regarding the position of the worker. The microphone and miniature sound device can then further facilitate communication if needed.



Figure 3. e-shirt

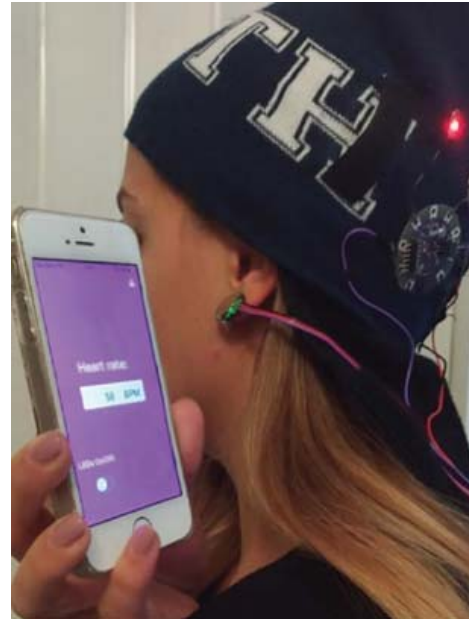


Figure 4. Smart cap for heart rate monitoring

The triboelectric generator is a device that has the ability to store a static charge that can occur in many different ways, and one of them is by rubbing two materials, figure 5 [7].



Figure 5. The triboelectric generator

The materials used to loosen the static charge are textile materials, used for making garments. The mode of operation will be demonstrated on the device that consists of two parts and one of them is mechanical part, which simulates rubbing layers of material in garments. The mechanical part of the device is made of the lower, static sample carrier, which also has a copper contact surface for draining the resulting electrical charge. Then, the upper, movable sample carrier, which also has a copper contact surface, bearing of the sample loads and the lever to which the linear movement of the carrier is realized. Both carriers have contacts for connection to the triboelectric generator.

The triboelectric generator is the second part of the device, that displays the amount of generated charge and has the ability to change the generator capacity to 1, 20 or 200 nC and discharge it. The device has confirmed the ability and cost effectiveness of installing triboelectric generators in clothing items as a renewable source of electricity.

## CONCLUSIONS

A project *Development and thermal properties of intelligent clothing* funded by the Croatian Science Foundation is underway. The miniaturization of electronic and pneumatic components for the development of new prototypes of intelligent clothing will be used on this project. Alternative ways of supplementing battery resources (flexible photovoltaic panels, power conversion adapters from other sources, etc.) will also be used. Five doctoral theses within the project will be produced. Therefore, it is expected that doctoral students will continue to demonstrate their innovation.

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