TELEINTIMATION GARMENT: A WEARABLE ELECTRONIC GARMENT FOR SOLDIER'S STATUS MONITORING APPLICATIONS

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Abstract: This paper develops and demonstrates technologies useful for implementing a manageable cost effective systems approach to monitoring the medical condition of personnel by way of an instrumented uniform hereafter referred to as Teleintimation Garment (TG). The TG consists of a form fitting garment which contains and interconnects sensing elements and device to an electronics pack containing a processor and transmitter. The TG prototype requires fiber, textile, garment and sensor development. The TG consists of a mesh of electrically and optically conductive fibers integrated into the normal structure of fibers and yarns selected for comfort and durability. A suite of Teleintimation garment compatible embedded biological and physical sensors are then integrated into the TG. The initial TG sensor suite is selected to improve triage for combat causalities.

Keywords: *Bullet impact detection, POF Fabric, Teleintimation Garment, Wearable Electronics*

1. Introduction

This project funded by Defence Research Development Organization (DRDO) develops a novel combat uniform consisting of medically instrumented wearable circuit garment (Figure1) useful for identifying, developing and demonstrating technologies useful for implementing a manageable cost effective systems approach to monitor the medical conditions of combat soldiers by way of an instrumented uniform hereafter referred to as a Teleintimation Garment (TG). The TG consists of a form fitting single/two piece suit which contains and interconnects sensing elements and devices to an electronics pack containing a processor and transmitter. The proof of concept TG includes both biological (vital sign) and physical (bullet impact) in order to depict the causalities status as completely as possible.

The goal of this project is to develop innovative technological approaches that will provide military forces with enhanced combat casualty care capabilities. The TG is focused on the following areas (1) technology development consisting of textile fabrication incorporating the optical fiber in the warp and weft direction for bullet penetration (2) biological sensor selected from blood pressure, pulse rate(heart rate) and respiratory rate. (3) Physical sensors including barrier penetration (optical sensor for projectile penetration sensing) (4) Development of Soldier’s Status Monitor (SSM) software to acquire the signals and to alert the combat casualty unit.

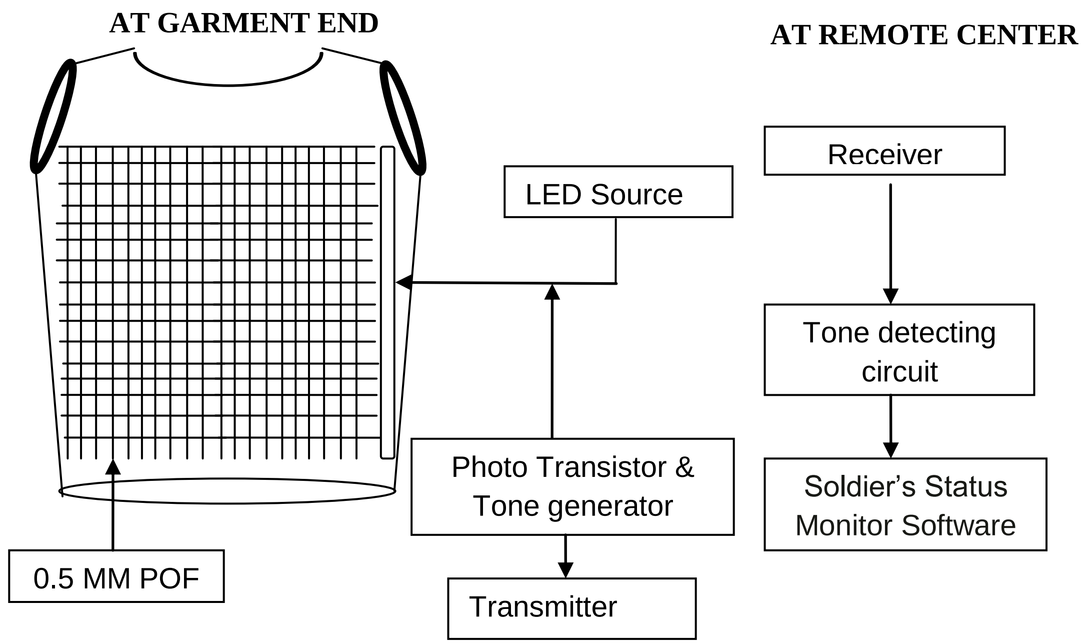

Figure1: *Wearable Circuit Garment and Working Methodology*

2. Teleintimation Garment Circuit Requirements

The Teleintimation Garment is being designed to meet the performance requirements associated with combat usage and typical textile characteristics of durability, wearability, usability, maintainability and manufacturability and the integration of the objectives realized through interconnected sensors. The information processing garment should be an integral garment, flexible and comfortable to the wearer.

2.1 Realizing the Teleintimation Garment: Concept to Reality

Research is being carried out to realize the proposed design of Teleintimation Garment. Based on an extensive analysis of materials properties, appropriate materials have been chosen for the various components of the Teleintimation Garment. The appropriate fabrication technology has been identified for the production of the structure. A prototype, an integrated one piece garment, has been created and it is tested for its information processing characteristics. Based on an evaluation of the experimentally observed electro-optical performance of the circuit garment, the design and process parameter will be suitably refined to create the truly wearable Teleintimation Garment.

3. Teleintimation Garment Surface Penetration Localization

This section details the design philosophy, materials used and the challenges of this TG. To facilitate integration of embedded systems to a flexible garment, it is proposed to use 0.5 mm of POF systems as the mechanism to detect and locate penetrations in the garment, and to interface other potential sensors. The POF threads integrated into a grid of rows and columns within an upper torso garment. Each row and column is scanned (via microcontroller) for end-to-end connectivity. When a penetration occurs, the POF path of the thread is broken and detected by the microcontroller, which in turn, provides grid location in (X-Y coordinates) indicating where the penetration physically occurred relative to garment and anthropomorphic features.

3.1 Materials

Material selection is vital to the development of the TG, including the selection of a highly sensitive POF thread system and the garment materials which are conformal, comfortable and durable [2]. Ideally the POF system is insulated to protect against shorting and is easily (with major modifications in the existing loom systems) and uniformly integrated to the garment using high volume fabrication techniques. Evaluation of the suitable POF is based on the separate test rig applied with different voltage levels. Both the POF and the POF integrated fabric was tested with this test set-up. Circuit interfaces to the controllers are accommodated using a robust flexible film bus which is buried within the garment, hidden completely from the wearer.

3.2 Experimental Results

Bench tests have successfully demonstrated the penetration sensitivity and the controller capabilities of the soft circuit concept on representative test panels. A full scale garment fabrication has been demonstrated which will incorporate an 80 row x 80 column upper torso POF fabric. Figure 2 shows the Flexible PCB for Bullet impact detection and 80 x 80 POF Integrated Garment. Microcontroller code is complete for detecting the multiple bullet penetration and location which will provide the interface of the POF to the processor and the details can be sent to the remote unit's Soldier's Status Monitoring (SSM) software. Figure 3 depicts the front end and the soldier's details.

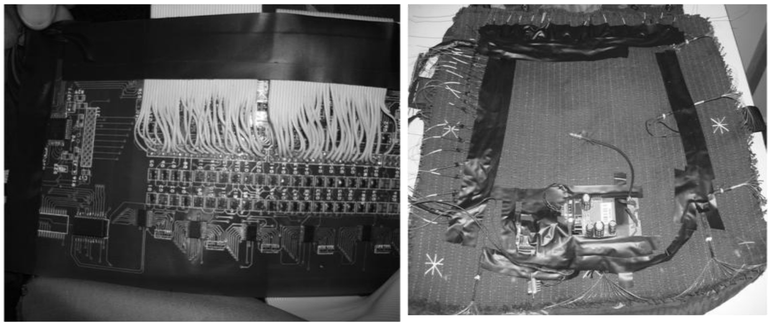

Figure 2: *Flexible PCB for Bullet impact detection and 80 x 80 POF Integrated Garment*

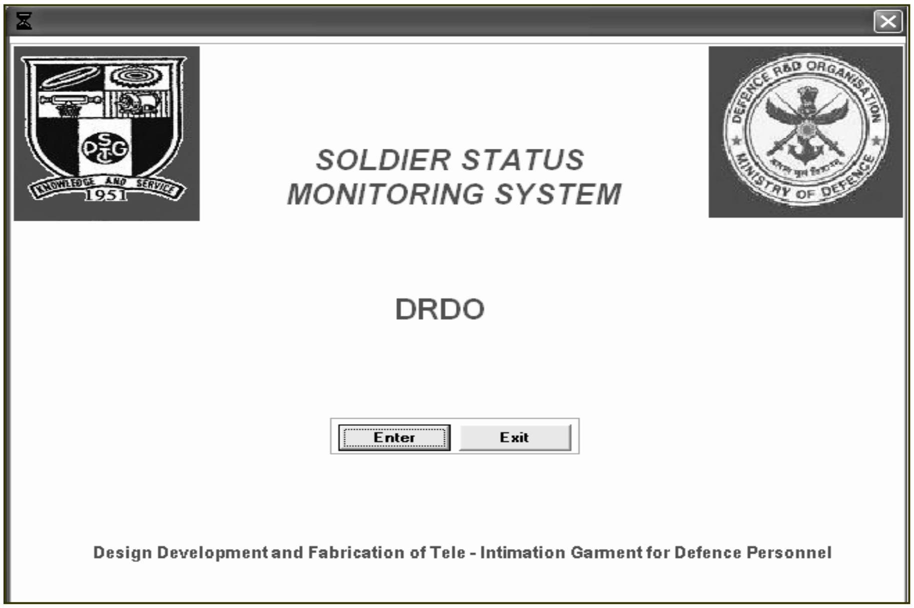

Figure3: *View of Front End of SSM*

4. Automated wound analysis

The TG is intended to be worn as an undergarment, without significantly encumbering the wearer. Signal from these sensors will be monitored, acquired, processed and interpreted in a remote computer, consisting of SSM. This software consists of garment simulated in a grid format, once the penetration occurs it will intimate the number and place of the bullet wound and also the corresponding colour of the grid will be changed from black to red (Figure 4).

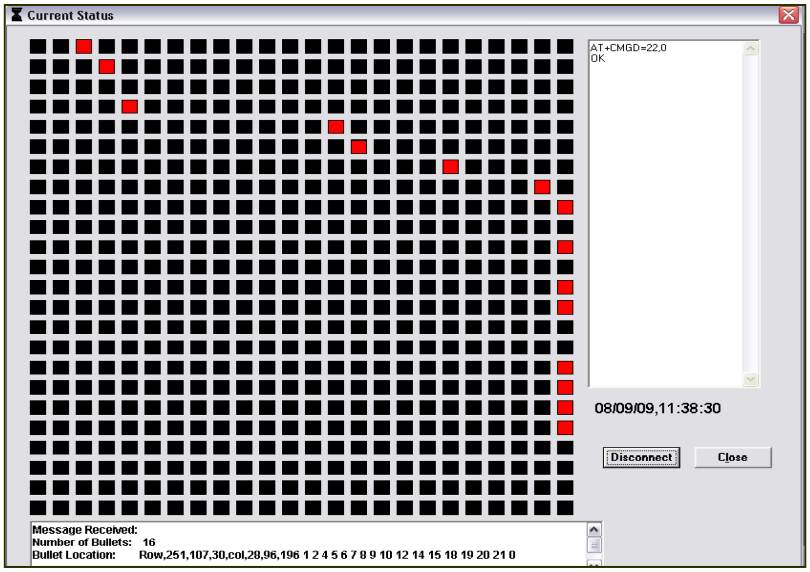

Figure 4: *Bullet impact detection in the SSM*

4.1 Experimental Analysis

The signal received from the remote end is connected to the server with the receiver circuitry, which employs RS232 connection method. It is one of the simplest serial communication methods. The cut in the optical signal from the POF is transmitted by means of one of the technique such as RF, Mobile communication or GSM module. The received signal is send to the server PC through RS232 cable. The row and column information is received in the hyperteminal window of the server. The data receiving methods are programmed using VB 6.0 such away that the row and column information are received in a sequential manner**.**

5. Conclusion

The teleintimation garment has been designed to incorporate a variety of other sensors to the fabric substrate. Two unique applications have been demonstrated under this research work

a) The ability to produce a garment using POF fabric woven in the warp and weft direction with some modifications in the rigid rapier loom and also the fabric is made using hand loom. This technology has a wide variety of potential applications where penetration detection and location are critical in a fabric component
b) The ability to interface microcontroller technology to the conductive fabrics, and interface of this system to the remote unit to monitor the status of the soldier, that may prove critical for battlefield casualty care operations.

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