INTELLIGENT CERVICAL COLLAR

Flavia PALADE[1], Corneliu DRUGA[2] Ileana ROSCA[3]
[1]Transilvania University of Brasov, palade.flavia@gmail.com
[2]Transilvania University of Brasov, druga@unitbv.ro
[3]Transilvania University of Brasov, ilcrosca@unitbv.ro

***Abstract*—**This paper presents a low-cost solution for an intelligent cervical collar by improving an existing cervical collar. It will achieve total immobilization of the cervical spine, using an immobilizer extended system for head and superior thoracic vertebrae.

Because this intelligent cervical collar is provided with a system for monitoring vital functions, doctors work will be simplified so, after fitting neck brace, they can turn their attention to other priority needs or injuries of the patient. The intervention time will be reduced and the efficiency increased.
This collar is provided with sensors which will retrieve information from the body to be displayed on the thin-film transistor screen (TFT) attached to this medical device. The TFT will display the pulse, blood pressure, blood oxygen level, Electrocardiography graph(EKG), level of tightness, patient temperature and degree of humidity.
Also,this collar is provided with sound and light warning system designed to warn physicians about the patient's condition.

***Keywords*—**Arduino, cervical collar, sensors, CAD model.

I. INTRODUCTION

THE inception of the Cervical Collars dates back to the Vietnam war in the early 1960’s. Then, to transport patients with fractures of the cervical spine, were used as an immobilizer, sandbags placed on the side of the head, but these bags doesn’t protect the column.

Initially, makeshift collars, using rolled up towels, were implemented. The soft foam collar appeared in the late 60’s, but although very comfortable, provided little more than 10% immobilization.

In 1974, Glen Hare designed the first true cervical collar using a medium density foam, that still provides reasonable comfort, gave greater immobilization to the cervical spine. In the late 1970’s, semi-rigid collars began to be developed using polyethylene plastic. Being extremely strong and durable, this product still remains the primary material used in collars today. [1]

Cervical collars are mainly used in traumatic lesions of the neck or head and the most important concern is the spinal cord damage. This device is normally used during an emergency situation for immobilization and prevention subsequent injury. Also cervical collars are used to treat neck pain.

Today the most commonly used are collars made of soft foam sponge, polyethylene, Plast azote or rigid materials.

There are many models that combine the utility of the core being a combination of their and are provided with adjustable chin support, equipped with tracheostomy window, fitted with Velcro fastening and immobilization system, adjustable height and available sizes.

But nowadays doesn’t exist cervical collars equipped with systems for monitoring vital signs and warning system about patient's condition.

Intelligent cervical collar offers a high degree of innovativeness, because, besides the function of restraining overall the cervical spine, it is provided with a comprehensive patient monitoring and display of digital information taken from the body of a thin-film transistor screen(TFT), attached to the collar. Also, it is provided with a sound and light warning system that alerts the medical staff in relation to negative changes in patient outcomes.

This collar is equipped with a screen that will display pulse, patient temperature, blood oxygen level and degree of humidity. Light-emitting diodes (LED) attached are designed to warn physicians about the patient's condition.

Because this collar is equipped with sensors for pressure, doctors will no longer need cervical collars of different sizes, they may use a single collar on a variety of patients, even though the circumference of the necks is different, which is an economic advantage.

Using these sensors it will apply a suitable pressure on the sides of the neck and as a result, the degree of restraint is increased.

This type of brace It is suitable for patients with cervical spine injuries, postoperative immobilization and support , and for victims who suffered various injuries.

Also this cervical collar addresses to doctors because it will simplify their work so, after fitting neck brace, and start the monitoring system they can turn their attention to other priority needs or injuries of the patient . The intervention time will be reduced and efficiency increased.

II. CONSTRUCTION OF THE INTELLIGENT CERVICAL COLLAR

Starting from an existing rigid cervical collar, it was modified in order to increase immobility level.

Computer-aided design model (CAD model) will be realized using 3D printer or manufacturing from plastic materials. Also, the padding will be made using soft antiallergic materials.

After this stage, the monitoring system (sensors, EKG module) and warning system (sound and light) it was install.

A. CAD Model and Prototyping

The initial cervical collar was a rigid brace, (Fig. 1) universal size, suitable for neck circumference between 310 and 480 (mm). [2]

Fig. 1. Cervical collar Philadelphia Ortel C4 Vario Model [2]

The back of the neck brace is not rigid enough to provide full support. So, it took the design of an extension model using SolidWorks software (Fig. 2). By using this extension, the degree of immobilization of the cervical spine will increase to 100%.

Fig. 2. CAD Model of the extension

I projected this CAD model, using SolidWorks software, part of the most advanced CAD-CAM systems currently used in the design and contains compared to other similar systems, a series of facilities in 3D work.

CAD Model dimensions are higher than the originals ones [only 175 (mm) length], plus that will provide stability. Because his up limit is on top of the head and lower limit to thoracic vertebrae T3-T4, this improvement it will block the entire head and neck complex.

CAD model realized in Solid Works, was imported in CATIA V5. Using CATIA options, I realized Finite Element Analysis (FEA). So, using FEA, it can be tested resistance to various forces or check if an assembly is or not removable (Fig.3).

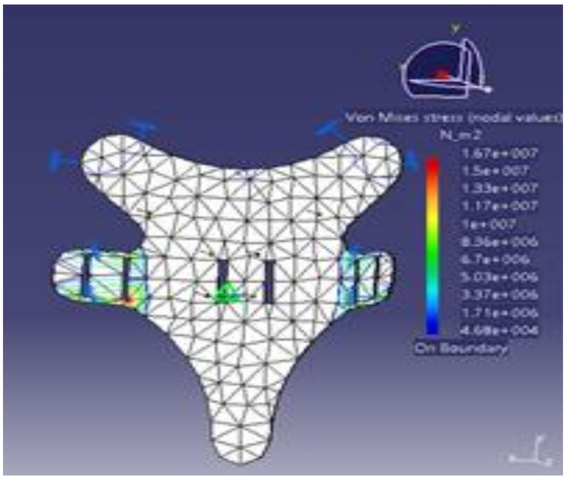

Fig. 3. FEA analysis of the extension

After achieving FEA analysis for different plastic materials, I realized various prototypes, to be subjected to real requests like torsion, tensile, shear or bending.

Prototypes were made of plastic materials like polyethylene (PE), polyvinyl chloride (PVC), polystyrene and polylactic acid (Fig.4).

Fig. 4. Prototype extensions of various materials

Plastic materials are organic, inorganic or mixed products, that can be easily processed into various forms, hot or cold, with or without pressure.

The polyethylene (PE) are thermoplastic polymers resulting from ethylene monomer polymerization . It has a high resistance to impact, modest structural strength and good resistance to chemical attack.

The Polyvinyl Chloride (PVC) is obtained from vinyl chloride monomer polymerization . Is thermoplastic and it has an amorphous structure[3]. Guttagliss is a PVC, used in different domains, with good resistance to weather, good thermal properties and smooth, non-porous surfaces.

The polystyrene is obtained by mass polymerization, emulsion or solution of styrene. Acrylonitrile butadiene styrene (ABS) is the most used polystyrene. It has high resistance to impact or contact with different abrasive bodies and also high resistance to alkaline or acid solutions.

The Polylactic Acid (PLA) is a biodegradable thermoplastic aliphatic polyester used especially in 3D printing [3].

For testing multiple plastic materials in order to establish the coefficient of elasticity and tensile strength, I conducted a series of samples that were subjected to various forces of torsion, bending, shearing. After plastic samples have been submitted to several stresses, I have chosen the right material to achieve an optimal constructive solution. In order to achieve fully cervical support practical construction , is required the use of plastic materials for the rigid support, but also shape memory foam,sponge and cotton for lining. Liners will be made of recycled materials like knee shields, systemVelcro, fixation elastic band and 100% cotton material.

B. Automatization of the neck brace

The automatization of the neck brace was made using Arduino open source platform. Arduino is an integrated environment for writing programs that can be uploaded to the Arduino physical platforms.

The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and onboard I/O support. The software consists of a standard programming language and the boot loader that runs on the board.

Hardware platform Arduino Mega 2560 operates at a voltage of 5V, has 54 pins digital input / output and 16-pin analog (Fig. 5). Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions.

The Mega 2560 has 16 analog inputs, each of which provides 10 bits of resolution (Fig. 5). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range. The maximum current that it can provide has a value of 40 mA. For the storage of the programs, Arduino Mega has 128 KB of Flash memory.[4]

For my project, I used Arduino Mega 2560 board, which is an update of Mega board. Using Mega 256 board, I programmed different sensors and shields.

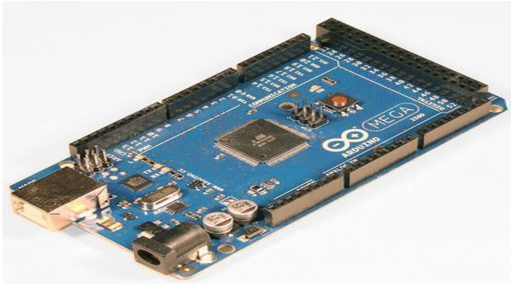

Fig. 5. Arduino Mega 2560 Platform [4]

Force sensor is able to notify pressure, having a sensitive area of 44,70(mm) (Fig. 6. a). The functioning is very simple, making the Arduino interface to be very fast.Connection with Arduino board is made through pins: Signal pin(OUT) connects to an Arduino board analog pin; Mass pin(GND) is connected to GND pin from Arduino board; Supply pin(VCC) is connected to a 5V pin from Arduino board.

The sensor has two connectors, and resistance measured between these two connectors varies with the pressing force. When no strain is placed on the sensor, its resistance is greater than 1 (MΩ) and pressure is applied as the resistance decreases[5]. Using this sensor in my project it provides an economic advantage, because physicians can use the same collar on a variety of patients with different neck sizes. They will know, when the sensor detects a certain pressure, that the collar was fitted on patient's neck, and assures its immobility.

Humidity and temperature sensor offers the possibility to measure the ambient temperature and humidity with high precision(Fig. 6. b). The device uses the integrated circuit that provides two sensors already calibrated in the same capsule physics. Connection with Arduino board requires two pins and two digital power pins.A unique capacitive sensor element is used for measuring relative humidity while the temperature is measured by a band-gap sensor. Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit. This results in superior signal quality, a fast response time and insensitivity to external disturbances. Using this sensor, the doctors will know if the patient has a higher body temperature or if he is sweating for different reasons.

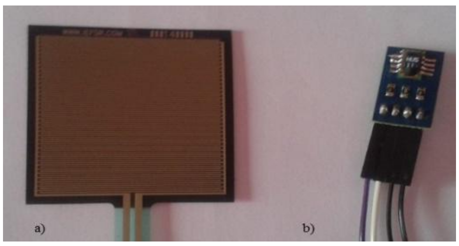

Fig. 6 a). Force sensor ; b). Humidity and temperature sensor

Also, I will use a pulse sensor and an Electrocardiography/Electromyography(EKG/EMG) shield (Fig.7). Pulse Sensor is a well-designed plug-and-play heart-rate sensor for Arduino. The sensor clips onto a fingertip or earlobe and plugs right into Arduino with some jumper cables. It also includes an open-source monitoring application that graphs the pulse in real time[6]. EKG/EMG shield allows Arduino boards to capture electrocardiography / electromyography signals (Fig.7).

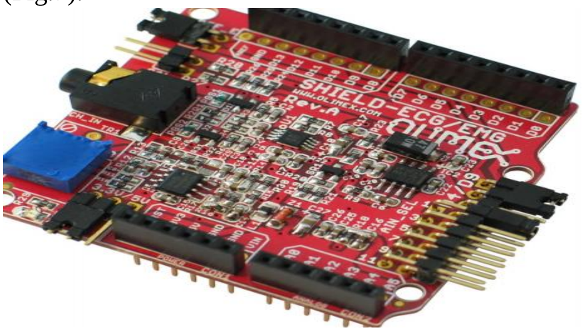

Fig. 7. EKG/EMG Shield [6]

The information taken from the body will be displayed using Processing or Electric Guru programs. Information taken from EKG/EMG module and pulse sensor are very important because warns medical staff about patient condition.

The pulse sensor will be accompanied by a green led that will flash simultaneously with the heart rate. The led will be attached to one side of the collar. Also, a red led will be attached on the other side of the cervical collar. This one will light when the pulse sensor does not detect any signal. The EKG module will be linked to a mini speaker who will start when the patient's heart stops or register changes of the heart rhythm. Another plus of this cervical collar is connecting the Arduino board to a digital blood pressure monitor. This plus will offer precious information about blood pressure, or blood oxygen level.

All the information taken from the body, will be displayed on a TFT screen attached in front of the cervical collar, below the window for tracheostomy. TFT touch shield for Arduino Capacitive screen is big (2.8" diagonal) bright (4 white-LED backlights) and colorful (240x320 pixels with individual RGB pixel control)[7]. This TFT screen will fit perfectly over Arduino 2560 board, so it will be placed in front of the cervical collar (Fig.8). On this touch screen will be displayed all the time the pulse value, temperature, humidity and blood pressure.

Accessing the menu from this TFT screen, doctors will be able to view pulse graph, EKG or EMG graph, thermal comfort or blood pressure and blood oxygen level.

Fig. 8. TFT screen over Arduino board

When the intelligent collar is on, monitoring and warning systems starts automatically.

The intelligent collar will work using a lipo battery so is portable, offering the possibility for medical stuff to use it on the hospital units. Also, it will work connected to a laptop or any other source of power.

III. CONCLUSION

The subject, "INTELLIGENT CERVICAL COLLAR" belongs to medical engineering area and it will have a big influence in this domain because it will simplify the medical stuff work and it will help patients with injuries and trauma of cervical spine and head. By using this collar, when the takeover of accident victims, emergency physicians are able to deal with injuries or priority needs. As a result, the intervention time will be reduced and efficiency increased. This collar can be used postoperatively because it takes pressure on the spinal cervical and also . monitors the patient's condition.

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