Medical Device to Tackle Neurogenic Bladder

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Abstract— **Almost one in twenty adults experience urinary incontinence problems according to major test surveys across all the populations irrespective of geography, cultures or backgrounds (Source: rightdiagnosis.com on 9th March 2015). While most of us take the blessing of voluntary voiding of our urinary bladder as a given, there are patients around the world who are not sensitive to the filling up of their bladder or its involuntary leakage. Thus, incontinence has a major impact on the quality of all patients leading to stress and embarrassment apart from other biological problems such as Urinary Tract Infections. Thus, to tackle this problem we have devised an innovative device that not only helps the patient concerned to track how much his/her bladder has filled up, but also helps in voluntary emptying of the same. The device, hence, has three major components, namely: 1) The sensor, 2) The Display and 3) The Micturition Control.**

The sensor circuit will help to convert the volume expansion of the urinary bladder into a resistance value. This value will keep on changing as the sensor bends and will be used as an input to the microcontroller that will control the display panel. The display panel works such that the changes seen are directly proportional to the volume expansion of the bladder. The sensor and the display are connected wirelessly.

As such, the patient can get a clear indication of the filling up of the bladder. The micturition control part of the device consists of a micro-pump around the sphincter that gets activated when the patient presses a switch. The pump deflates to let the patient urinate and inflates again once the bladder is empty.

This device thus hopes to make the urinary incontinence patients more independent and ready to face the world without any feelings of shame.

Keywords— **Neurogenic Bladder, Incontinence, Innovation, Biomedical, Paraplegics.**

I. Introduction

Paraplegia refers to the complete (-plegia) loss of voluntary motor function in the pelvic limbs. Paraplegia generally results from any spinal cord lesions which may have been caused to the second thoracic spinal cord segment. The limbs may be affected equally; however, the asymmetric lesions cause even greater clinical involvement on the ipsi-lateral side.[1]

Urinary incontinence often occurs concomitant with paralysis. [1] Because of the complex nature of the neural control of the lower urinary tract, paraplegic patients generally complain about bladder problems. The main neural circuits controlling the two functions of the bladder—that is, voiding and storage—are trans-spinal so that intact cord connections between the pons and the sacral segments are necessary to sustain physiological control. Furthermore, input from the higher centers is critical in the assessment of appropriate timing of voiding. There are many types of cortical diseases that can affect the centers involved with this. In addition to the spinal pathways and input from higher centres, the peripheral innervation to the bladder is through the pelvic plexus, sacral, and pudendal nerves. [2]

Hence, it is pertinent to note that a need of a medical device is highly necessary which can not only help paraplegic patients with the voiding of the urinary bladder, but also notify them about the filling up of the same.

The currently available medical devices in the market that tackle incontinence such as pessaries, catheters, artificial sphincters and urinary inserts solve one part of the problem – the urinary micturition control. However, besides the problems of Urinary Tract Infections (UTIs) and involuntary micturition, one of the most adverse side-effects of a neurogenic bladder, and hence incontinence is the inability of the patients to know when they need to void their bladder. This leads to continuous embarrassment and make the patients more vulnerable to depression than they already are.

The main aim of this medical device is to innovation in terms of not only micturition control, but also measuring the filling up of the urinary bladder and communicating the same to the patient. In this paper, the proof of concept of this medical device and its complete working has been described.

II. Method

A. Design Approach for the device

The proposed medical device to tackle neurogenic bladder must be able to perform three necessary functions: a) Sense the filling up of the Urinary Bladder, b) Convey the filling up of the bladder to the patient and c) Help the patient control the micturition as and when needed.

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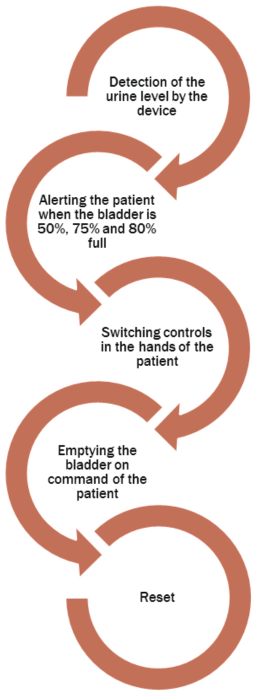

Fig. 1Work Flow of the proposed device

Thus it suffices to say that the medical device has been divided into three broad areas in order to achieve the targeted functionalities. The device can thus be studied under three main titles, namely the a) The Sensor, b) The Display and c) The Micturition control.

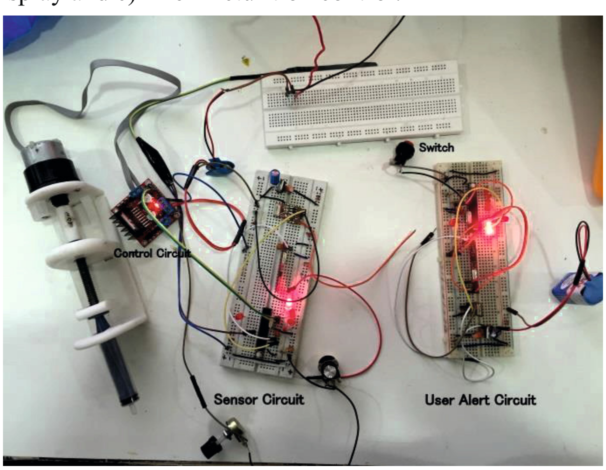

Fig. 2 Working Circuit

B. The Sensor Circuit

The sensor used in our concept is a simple flex sensor which is 2.2” in length. The working of a flex sensor depends on its curvature; as the sensor is flexed, the resistance across the sensor increases.

When the sensor is placed on the urinary bladder, the volume expansion of the bladder (due to increasing amount of the urine stored in it) leads to a change in the curvature of the sensor. As a result of the same, the resistance of the sensor changes.

This change in resistance is converted into voltage signals by using an external voltage divider circuit which provides output in voltage as a linear function of the resistance. These voltage signals are thus processed by the micro-controller and converted into various pressure levels.

C. The Control and Display Circuit

This circuit provides the feedback of the sensor to the user by displaying the 10 levels of the volume expansion of the urinary bladder on 10 3mm red LEDS. This means that as the volume expansion of the bladder increases, the number of LEDs glowing on the LED panel also increases, with 10 being the maximum number of LEDs that can light up.

When the patient demands, he/she can press a simple switch that will activate a motor to help in micturition.

D. The Actuator Circuit

The actuator circuit consists of an H-bridge Motor driver L-298N circuit to control speed and direction of motor.

L298N is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as solenoids, relays, DC and stepping motors. Two enable inputs are provided to disable or enable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

The actuator circuit can activate either by automatic mechanism or by using manual input from user.

In this proposed device, the actuator circuit turns on when the patient presses a switch and turns off automatically after a delay of 10 seconds, i.e., after the voiding of the urinary bladder has completed.

E. The Microcontroller and The Tranceiver Circuit

In this circuit, the Atmega8 microcontroller has been used to accumulate sensor data using the analog reading functionality of the controller. The controller has an analog to digital converter which reads analog data and converts the analog data to 10 bit digital data and saves it into the RAM for processing. This saved digital data is then processed and the range of sensor is then limited to 0 to 1024 voltage levels. These levels are now converted into levels by taking a range of multiple voltage levels for each level for the purpose of studying the volume expansion of the urinary bladder.

The range is taken linearly as the sensor used here is linear.

Now this final value is transmitted by using 433 MHz RF transmitter to the receiver circuit. The Atmega8 used on the receiver side is used for receiving data and this received data is then displayed by actuating the LED attached to 10 pins of the controller

At the same a time controller is also monitoring the status of buttons. When a button is pressed, it sends a command to the receiver circuit to actuate the motor using a 433 MHz transmitter.

III. Results

In order to analyze the working of the circuit, it is important to know the sensitivity of the sensor. This is mainly because the working of the entire system, whether it is the filling up of the urinary bladder or the indication of the same to the patients, depends of how the sensor detects the filling up of the bladder. The sensitivity lies at 0.157 Kilo-Ohms per Degree bend of the flex sensor, as determined by the manufacturing of the used sensor.

Table 1 Sensitivity of the Flex Sensor

Number of LEDs	0	15	30	45	60	75	90
Resistance (Kilo-Ohms)	31.27	33.89	35.14	36.54	37.61	42.18	45.40

Thus we can easily see the sensor is extremely sensitive and can be used effectively to sense the filling up of the urinary bladder and consequently notify the patient.

Moreover, as the volume expansion of the urinary bladder increases, the number of LEDs that glow on the panel will also increase.

As the volume expansion of the urinary bladder increases, the number of LEDs glowing on the panel also increases. When the sensor reaches it maximum bend, i.e. 90 degrees, all the LEDs on the panel start glowing as can be seen in Fig.3.

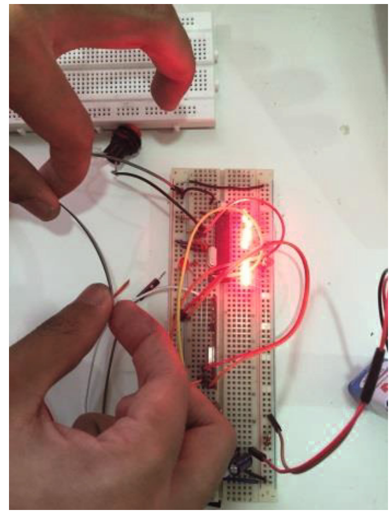

Fig. 3 Full Bend of the Sensor

As already stated the saved digital data is processed and the range of sensor is then limited to 0 to 1024 voltage levels. These levels are now converted into steps by taking a range of multiple voltage levels for each step for the purpose of studying the volume expansion of the urinary bladder.

Table 2 Voltage Levels and Glowing of LEDs

Number of LEDs glowing	Voltage Levels	Actual Voltage Delivered (in Volts)
1	0-102.4	0-0.5
2	102.5-204.8	0.5-1
3	204.9-307.2	1-1.5
4	307.3-409.6	1.5-2
5	409.7-512	2-2.5
6	512.1-614.4	2.5-3
7	614.5-716.8	3-3.5
8	716.9-819.2	3.5-4
9	819.3-921.6	4-4.5
10	921.7-1024	4.5-5

IV. Conclusion

The described device will detect the fullness of the urinary bladder of a paraplegic patient. Not only the sensing, it will also notify the patient about the same using a series of LEDs in an LED panel.

The device will allow patients to restore their independence and also allow them to complete their normal everyday tasks without the worry of their incontinence issues.

Overall the device will provide an affordable, practical, and user friendly solution to urinary incontinence to patients of all ages and abilities, as well as both sexes, and individuals with every type of incontinence.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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