Non-invasive optical technique for urodynamic testing using a wireless near infrared spectroscopy device

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Abstract. A real time wearable medical device for monitoring of urological parameters like bladder pressure, urine flow rate is measured by using cyst metric test and uroflow metric test. It is an invasive method, Patients needs local anesthesia, and patient may feel discomfort for few days. Such problems will be overcome by using a Near Infrared Spectroscopy Device. Near Infrared Spectroscopy is an optical technique, utilizes light in the NIR Spectrum ranges between 700nm – 1000nm has a high penetration depth in the living tissue. In urology, NIRS has been utilized to screen bladder muscle work and to analyze bladder brokenness. Since, it is a Noninvasive method; it is compatible for patients like Multiple Sclerosis, Stroke, Spinal Card injury, elderly patients with incontinence and neurological disorders. With such a gadget utilized as a sensor with a caution, it is thus achievable to caution the subject when the volume of pee in his/her bladder arrives at a pre-decided edge of bladder limit. This technique would possibly empower patients in danger for urinary maintenance to shield themselves from renal harm.

1. Introduction

The expression "urologic ailments" portrays a wide assortment of conditions, all identified with the preparing and completing of pee of the body [1]. They can influence men, ladies, and offspring everything being equal. These maladies influence quite certain pieces of the body. In females, they include the urinary lot. In guys, they influence the urinary lot. In guys, they influence the urinary plot or potentially the regenerative organs. Urologic infection can include innate or procured brokenness of the urinary system. The reason for illnesses of the body is normal to the urinary parcel. Colonization by microscopic organisms, protozoa or parasites can cause disease.

Uncontrolled cell development can cause neoplasia. There are numerous urologic issues and illnesses. Coming unnext are a determination of a portion of the maladies recognized by the American Urological Association Foundation (AUAF) as normal. The proposed method is simulated and hardware is implemented [2].

1.1 Benign Prostatic Hyperplasia (BPH)

Kind prostatic hyperplasia (BPH) is a developed prostate. It is an expansion in the size of the prostate organ. BPH is normal in more seasoned men. It isn't brought about by prostate disease. Men with BPH may encounter a regular inclination to pee. They may likewise have a frail stream of pee when they do go and an inclination that the bladder isn't unfilled after pee. In this paper, your primary care physician may
decide to simply screen this condition or endorse prescriptions like alpha-blockers for treatment [3]. It might likewise be tended to through medical procedure on the off chance that it is serious.

1.1.1 Incontinence
Incontinence is lost bladder control. It brings about the undesirable arrival of pee. This condition can be awkward and humiliating for victims. In any case, it is a long way from extraordinary. As indicated by the AUAF, in excess of 15 million individuals in the U.S. have incontinence (AUAF, 2011). There are various things that can cause incontinence. A few of the most common causes include:

- Diabetes
- Labor
- Hyperactive Bladder
- Prostate enlargement
- Spinal Cord trauma
- Hemorrhoids

1.1.2 Urinary Tract Infections (UTIs)
UTIs are the aftereffect of bothersome yeast, microorganisms, or infections that attack the urinary plot and cause disease. They are significantly more typical in ladies, in spite of the fact that men can get them as well. As per the AUAF, approximately 40 percent of females and 12 percent of guys will have an UTI that causes recognizable indications sooner or later in their lives (AUAF, 2011). A consuming sensation during pee is one of the manifestations of an UTI. Others incorporate an incessant inclination to pee and the inclination that the bladder isn't totally vacant subsequent to peeing. Performance and reduces complexity problem can normally clear up most UTIs inside a couple of days [4].

1.1.3 Kidney and Urethral Stones
Stones create in the kidneys when there are precious stones in the pee and little particles encompass and gather on these gems. Urethral stones are ones that move from the kidney into the ureter (the cylinders that convey pee from the kidneys to the bladder. These stones can square pee stream and cause a lot of agony. Numerous individuals wind up ousting these stones from the body without clinical assistance however this isn't generally the situation [5-6].

1.1.4 Urological disorders
Some other common urological conditions include:

- Prostatic Cancer
- Urinary Bladder Cancer
- Urinary Bladder Prolapsed

2. Structure of urinary tract
The urinary tract is the body's seepage framework for expelling squanders and additional water. The urinary tract incorporates two kidneys, two ureters, a bladder, and a urethra. Blood courses through the kidneys and the kidneys silt through squanders and additional water, making pee. The pee goes down two thin cylinders called the ureters.[4] The pee is then put away in a solid, expand like organ called the bladder. The bladder swells into a round shape when it is full and gets littler as it purges. At the point when the bladder discharges, pee streams out of the body through the urethra. Kidsneys are a couple of bean-formed organs found along the back mass of the stomach cavity. The left kidney is found somewhat higher than the correct kidney in light of the fact that the correct side of the liver is a lot bigger than the left side. The kidneys, in contrast to different organs of the stomach cavity, are found back to the peritoneum and contact the muscles of the back. [11]
The kidneys are encircled by a layer of fat that holds them set up and shields them from physical harm. The kidneys channel metabolic squanders, overabundance particles, and synthetic compounds from the blood to shape pee. The ureters are a couple of cylinders that convey pee from the kidneys to the urinary bladder. The ureters are around 10 to 12 inches in length and run on the left and right sides of the body corresponding to the vertebral section [7-8]. Gravity and peristalsis of smooth muscle tissue in the dividers of the ureters push pee toward the urinary bladder. The closures of the ureters expand marginally into the urinary bladder and are fixed at the purpose of passage to the bladder by the ureterovesical valves. These valves keep pee from streaming back towards the kidneys [9].

The urinary bladder is a sac-like empty organ utilized for the capacity of pee. The urinary bladder is situated along the body's midline at the mediocre finish of the pelvis. Pee entering the urinary bladder from the ureters gradually occupies the empty space of the bladder and stretches its flexible dividers. The dividers of the bladder permit it to stretch to hold somewhere in the range of 600 to 800 milliliters of pee [10-11]. The urethra is the cylinder through which pee goes from the bladder to the outside of the body. The female urethra is around 2 inches in length and closures second rate compared to the clitoris and better than the vaginal opening. In guys, the urethra is around 8 to 10 inches in length and finishes at the tip of the penis. The urethra is additionally an organ of the male regenerative framework as it helps sperm out of the body through the penis. The progression of pee is through the urethra. Urinary framework cross-area is constrained by the inner and outer urethral sphincter muscles. The inside urethral sphincter is made of smooth muscle and opens automatically when the bladder arrives at a specific set degree of enlargement. The opening of the inner sphincter brings about the impression of expecting to pee [12]. The outer urethral sphincter is made of skeletal muscle and might be opened to permit pee to go through the urethra or might be held shut to postpone pee [13]. Pee is the way toward discharging pee from the urinary bladder through the urethra and out of the body. The procedure of pee starts when the muscles of the urethral sphincters unwind, permitting pee to go through the urethra. While the sphincters unwind, the smooth muscle in the dividers of the urinary bladder agreement to outst pee from the bladder.

2.1. Block diagram

The pressure information from the abdominal skin is collected using the optical sensor. The emitter (LED) delivers IR signals which are reflected by the tissue surface and is collected by the detector (phototransistor) in the sensor. [17-19] The sensor output is given to the PIC 16F887. Microcontroller performs the analog to digital conversion of the obtained bio signals serially. The output from the PIC is given to the level converter which transfers the digital signal from TTL to RS232 series. This signal can be used for communication with the
Personal Computer. This data is connected to the computer using a serial port connector (DB9) and the obtained pressure signals are then analyzed using LABVIEW. It is necessary to determine the urinary flow rate, the signals are processed. Thus the intra bladder pressure and urinary flow rate is determined [14].

2.2. components

- Sensor
- PIC16F887 Microcontroller
- Level Converter (MAX 232)
- DB-9 Connector
- LABVIEW

NIR Sensors use condition of craftsmanship optical parts including elite thin band pass NIR Channels over a wide scope of the infrared range to make precise, steady, hearty estimation. Chemo metric methods are utilized to recognize the territory of the NIR range required for a given estimation; these particular close to infrared frequencies are amplified in the NIR sensor to make an estimation which is heartless toward process changes, for example, encompassing lighting, relative moistness, item stature vacillations and inside item varieties, for example, crop-source changes, occasional contrasts or shading variety subsequently, steady item quality can be accomplished. A NIR investigation conveys quick precise estimations of tests taken from the procedure then [15].

![Block diagram](image)

Figure2. Block diagram

3. Software description

The software simulation of this project is done using LABVIEW software.

3.1. Lab view

Lab VIEW (Laboratory Virtual Instrument Engineering Workbench) is a framework plan stage and improvement condition for a visual programming language from National Instruments. It is graphical programming language based on structured data flow which consists of graphical objects or G-programming elements. [16]

It has 2 windows namely,

1) Block diagram- which is meant for programming (shows the graphical source code).
2) Front panel- which gives the graphical view of the output to be displayed (shows the graphical user interface items connected to the source code).

The front panel consists of various controls and indicators for both input and output whereas the block diagram has the terminals corresponding to the front panel controls and indicators as well as constants, functions, sub VI s, structures( program control elements like for loop, while loop etc), wires etc.
Figure 3 Lab view Front Panel

.lvproj - extension for projects in labview.
.vi - extension for files in labview.

Hardware’s integrated with labview workbench makes it a powerful tool. It provides a complete development environment with project explorer, debugging tools, source code control and more.

3.2. Graphical Programming

Lab VIEW ties the making of UIs (called front sheets) into the movement cycle. Lab VIEW programs/subroutines are called virtual instruments (VIs). Each VI has three sections: a square diagram, a front board and a connector board. The last is used to address the VI in the square charts of other, calling VIs. The front board is created using controls and markers. Controls are inputs – they license a customer to smoothly information to the VI. Pointers are yields – they show, or show, the results subject to the data sources given to the VI. The back board, which is a square outline, contains the graphical source code. The aggregate of the things set on the front block will show on the back board as terminals. The back board in like manner contains structures and limits which perform technique on controls and deftly data to markers. The structures and limits are found on the Capacities palette and can be determined to the back board. In general controls, markers, structures and limits will be insinuated as center points. Center points are related with one another using wires – for instance two controls and a marker can be wired to the extension work with the objective that the pointer shows the all out of the two controls. Suitably a virtual instrument can either be run as a program, with the front board filling in as a UI, or, when dropped as a middle onto the square diagram, the front board depicts the wellsprings of information and yields for the given place through the connector board. This proposes every VI can be handily endeavored before being brought as a subroutine into a more prominent program. The graphical way of thinking in addition permits non-programming modelers to accumulate programs by moving virtual portrayals of lab hardware with which they are beginning at now ordinary. The Lab VIEW programming condition, with the included models and documentation, makes it easy to make little applications. This is a good situation on one side, yet there is moreover a specific peril of scarcely thinking about the capacity required for top notch G programming. For complex figuring’s or enormous degree code, it is immense that the originator has a far reaching information on the exceptional Lab VIEW sentence structure and the geology of its memory the board. The most powerful Lab VIEW improvement structures offer the chance of building
self-ruling applications [17-18]. Moreover, it is conceivable to make spread applications, which award by a customer/server plot, and are in this way less hard to execute considering the normally equal nature.

The image above is a layout of an essential Lab VIEW program demonstrating the dataflow source code as the square outline in the lower left packaging and the data and yield factors as graphical things in the upper right packaging. The two are the fundamental sections of a Lab VIEW program implied as a Virtual Instrument. The programming reproduction of the bladder filling recognition unit is finished utilizing LABVIEW. The intra bladder pressure signal is reenacted utilizing a nonstop sine wave signal and is intensified, separated and afterward this simple sign is carefully changed over and shown. The urinary stream rate which is determined utilizing the intra bladder pressure and the bladder volume is shown and when the bladder pressure surpasses the ordinary level (13-15mmHg), the LED alert sparkles advising that the patient is prepared for maturation [19].

4. Results and discussion

In this work, NIR (Near infrared) sensor is used to detect the bladder pressure and urinary flow rate by noninvasive method. Patients with disorders such as, spinal cord injury, neurological disorders and elderly patients with incontinence. This method will be highly useful. The device indicates alarm when it reaches the abnormal level. The below figure shows, the simulation output with normal and abnormal condition.

Figure 4. Block Diagram in Lab view
5. Conclusion
This Project presents a simple but effective technique for monitoring bladder pressure and urine flow rate by noninvasive method. It is a wearable medical device for monitoring the mentioned parameter. These parameters are used to screen the obstruction in the flow of urine and can screen some diseases like BPH, BOO and Prostate cancer. The test is noninvasive and may be used to assess bladder and sphincter function. The contraption is prepared for isolating between when the bladder is unfilled or contains a little volume of pee and when it ends up being full by using the osmosis properties of water at a recurrence of 950nm. Urological checking with this NIRS instrument is plausible and creates information of likely indicative worth. The simulation output is successfully executed using Lab view software and the hardware is ready to be implemented.
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