Knee Fracture Surgery Monitoring for Advanced Post-Operative System using IOT

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***Abstract*—An accurate assessment of joint kinematic patients, who walk with neuromuscular and musculoskeletal disorders may provide essential data regarding modifications of disease status and the efficacy of pharmacological treatments and rehabilitation regimens. This research study introduces a cost effective wearable device for monitoring the long term conditions of joint kinematics patients. The respective data are taken from 17 people, who are made to walk at three different speeds while wearing a retractable string sensor integrated with two points on different regions of the knee joint. The proposed Random Forest (RF) algorithm is used to measure the calibrated sensor inputs. Hence, a wearable device can accurately measure the flexibility of knee angles at different walking speeds during locomotion. This type of wearable technology has a potential to monitor the patients conditions, rehabilitation programmes, and improve therapeutic outcomes.**

Keywords—Internet of Things (IoT), sensors, implant, knee, prosthesis

I. INTRODUCTION

Accurate joint angle monitoring in the ambulatory situation may be beneficial for patients with neuromuscular and musculoskeletal diseases such stroke, Parkinson's disease, osteoarthritis (OA), ruptured anterior cruciate ligaments, and rotator cuff injuries. [1]. Optoelectronic motion capture devices have historically been utilized in kinematic analysis in laboratories and are the industry standard for human kinematic analysis. In order to build a three-dimensional (3D) skeleton model, these systems use a number of infrared cameras to collect the locations of reflecting markers set on predetermined anatomical landmarks. Despite the fact that these technologies are helpful in clinical and research settings, wherein clinical settings usually lack access to well-equipped gait laboratories[4] due to expense and a lack of technical expertise. Monitoring kinematic parameters continuously offers an objective evaluation of physical function and illness progression. As a result, it is possible to develop individualized therapy and rehabilitation programmes that take performance levels constantly changing into account. There have been several attempts to create wearable sensors that can continuously monitor the joint health and mobility condition of patients using electrical bio impedance, near infrared spectroscopy, bio-acoustics, and kinematic modelling. Kinematic modelling has been made possible through the investigation of a number of sensing devices, including radio frequency and inertial measurement units (IMUs).

The implementation of long-term field investigations requires these qualities. The wearable sensor described in this study is reliable, economical, and suitable for long term joint kinematic monitoring in an ambulatory situation. This sensor was primarily developed to monitor the knee osteoarthritis patients' joint angles. The suggested sensing platform uses a retractable, flexible, and extensible string sensor. This soft sensor uses data-driven modelling to measure joint angle and detects changes in string length between two anchor points on opposing standard sections during movement, which is equivalent to detecting skin stretch across the joint. We compute the angle of knee flexion/extension while travelling at various speeds on flat ground as a proof of concept [8].

II. LITERATURE REVIEW

A. Collo and Co. demonstrated the use of a small system to actuate a novel instrumented component of a fixed bearing for full knee prosthesis. Since the tibial baseplate has built-in actuation technology, the surgeon may monitor postoperative balance issues and restore them appropriately without doing a revision procedure. The recommended method was distinctive because it might be able to fix main Total Knee Arthroplasty (TKA) surgery flaws post-operatively without requiring additional surgery. Solutions for intelligent design ensure the longevity and robustness of the entire system. The results of theoretical calculations and 3D simulations, as well as the fundamental design of the mechanism, were supported by a first full-scale prototype. Others include D. Marioli [3] power devices implanted within the human body, this research offers a more advanced power harvesting technique based on an electromagnetic converter. During total knee replacements, the recommended method would provide electricity to an implanted measurement circuit. The generator is composed of two rows of magnets, one coil, and an energy control circuit. A novel power management circuit was created, assembled, and put to test. By altering the switching thresholds, this circuit makes it feasible to utilize the recaptured energy more efficiently. An improvised setup was employed to perform exploratory testing on the whole system. The experiments demonstrated the feasibility of using a 1 Hz step frequency walk to deliver electricity to an implanted measurement circuit every 1.5 seconds. The experimental results were obtained using an under construction optimized power consumption and operational time monitoring circuit. Optimizing the course regarding reduced power and operation time may result in improved performance.

In addition to M. Jain's [5] real-time load monitoring was a technique that showed promise for improving knee implant durability. This paper describes a revolutionary self-powered electronic load monitoring system for a knee implant that uses turboelectric technology.

According to research by M. K. Dion et al. [7], a passive, wireless, intelligent implant can now for the first time detect dynamic forces throughout a simulated femoral joint patella. The results of this study demonstrate that these

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author sensors were reliable at identifying knee forces under real-world conditions. These measurements might aid in the understanding of intraoperative patellar component size, anterior knee discomfort, and knee biomechanics.

S. Xiang et al. [12] described an explicit wireless image capture system for use during TKA operations is proposed. The quality of surgical treatments may be enhanced with its help, according to physicians. The image sensor device, data recorder, and picture display workstation have all been integrated into the prototype system. The quality of photographs taken in a particular low light situation is improved by the image processing pipeline that is suggested here.

III. SYSTEM METHODOLOGY

IOT technology is used in this project, and sensor values are displayed in real-time on a mobile device. The knee implant has failed due to a lack of post implant care. We can avoid this failure with our suggested method by continually monitoring the patient's implant with several sensors. MEMS sensor is used for monitoring the bending position of the leg. If the detector finds the bending position wrong, the buzzer will be ON and information Sent to a person through IOT. Figure 1 shows the workflow of the proposed methodology.

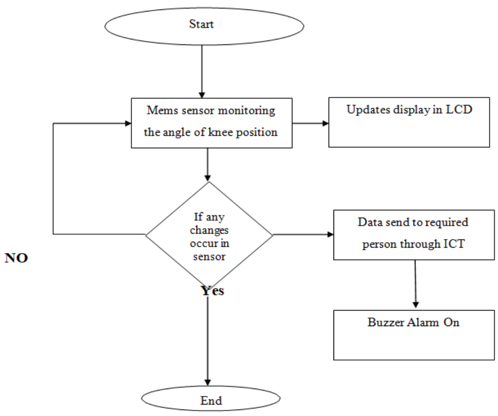

Fig.1 Workflow of Proposed Methodology

- The force sensor is used to monitor the pressure on knee joints. Because after knee surgery patient must don't give high pressure on the knees
- Knee implant patients need to exercise regularly to monitor their leg movement; during exercise, a flex sensor is used to monitor the 0-90 bending position. If the leg reaches 0 and 90, the buzzer will alarm to stop the leg movement at their particular angle.

4. Node MCU Pinout

A total of 30 pins connect the ESP8266 Node MCU to the external environment. These connections are made

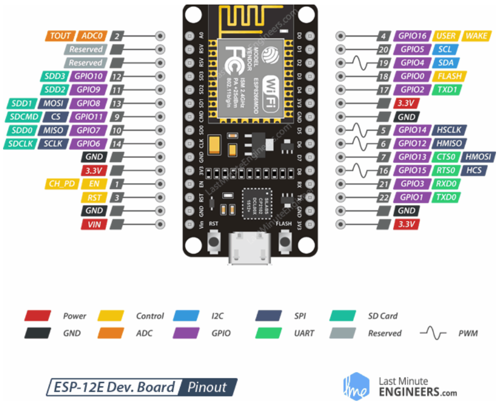

Fig.2. Node MCU

One VIN pin and three 3.3V pins make up the four power pins. If you have a regulated 5V voltage source, the ESP8266 and its peripherals can be powered straight from the VIN pin. The output of an inbuilt voltage regulator is the 3.3V pins. Power can be provided to external components using these pins. Figure 2 depicts the general representation of Node MCU board.

5 RESULTS AND DISCUSSION

A sketchbook is referred to as a standard location to store programming (or drawings) in the Arduino Software (IDE). You may access your sketchbook's drawings by choosing File Sketch book from the menu or by clicking the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. Enables you to handle sketches that contain many files, each of which has its own tab. These can be header files (.h), C files (.c extension), C++ files (.cpp), or typical Arduino code files (no visible extension).

5.1 Language Support

Arduino Software (IDE) has been translated into 30+ different languages. By default, the IDE loads in the language selected by the used operating system. Figure 3 shows the writing sketch.

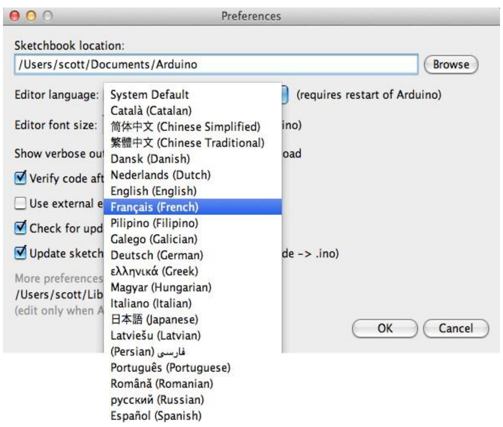

Fig. 3 Writing Sketch

Simone Zanella developed the procedural programming language Proteus (Processor For Text Easy To Use) in 1998. Corporate Proteus routines commonly use Clipper/dBase, C, BASIC, and Assembly since it includes hundreds of functions particularly for handling with strings. As a result, it has some of the most robust text-manipulation features. Figure 4 depicts the simple representation of the external fixation device.

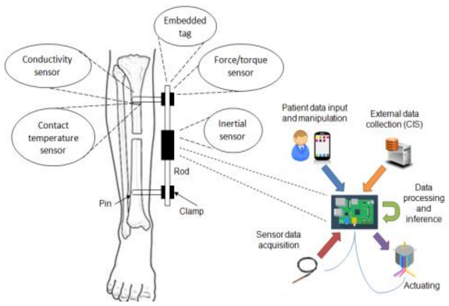

Fig. 4 Simplified Illustration of the External Fixation Device

6. HARDWARE AND PROGRAMMING

Figure 5 depicts the hardware interpretations of knee detection system. Table I and II illustrates the results and finally the software results are shown in Figure 6.

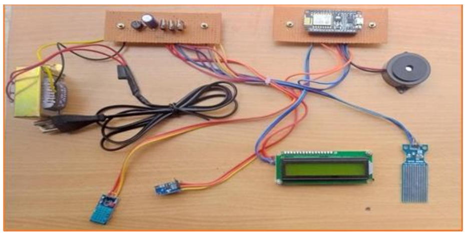

Fig. 5 Hardware Results

TABLE 1. RESULTS TAKEN FROM DIFFERENT PATIENTS

NAME	*FLEXIBILITY*	*LUQUID LEKAGE*	*TEMPARATURE*
VIDHYA	19	02	96
SARAN	32	16	92
TILAK	51	15	95
THARIK	48	21	96

TABLE 2: CLASSIFICATORY ACCURACY FOR VARIOUS NUMBERS OF FEATURES

Number of features / Algorithm	Random Forest	KNN	Naive Bayes
43	92.29%	85.19%	90.7%
11	94.577%	96.46%	91.99%
7	91.216%	94.19%	90.83%
6	79.33%	83.8%	86.3%

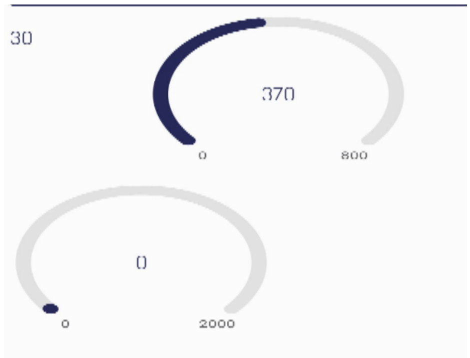

Fig. 6 Software Results

This study successfully developed a real-time motion monitoring system for knee fractured individuals. By capturing variations in skin stretch and resistance using the system's sensors over 25 repetitions of knee extensor muscle training, the six involved muscles were categorized into three tiers. Remarkably, after 40 repetitions, the flexible sensors exhibited exceptional consistency, meeting the demands of knee extensor muscle training by the 24th repetition. The investigation uncovered correlations between skin stretch, knee flexion angle, and resistance change, enabling real-time measurement during exercise sessions.

7. CONCLUSION

This innovative system enables simultaneous analysis of knee motion angle, angular velocity, and static or dynamic isometric exercises, enhancing exercise monitoring capabilities. Furthermore, the adaptable sensors allow for personalized tracking, catering to individual needs and optimizing exercise effectiveness. This breakthrough offers a valuable tool for monitoring and improving knee extensor muscle training, contributing to enhanced fitness outcomes and injury prevention strategies.

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