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Transforming Post-Operative Orthopedic Care with IoT Innovations

D.Dharshini[1], S. Ranjithkumar[2], B.R. Harivansh[3], R.Padma Priya[4], M.Manimegalai[5], P.Akshaya[6]

[1]M.E. Student, Department of Biomedical Engineering, GKM College of Engineering & Technology, (Affiliated to the Anna University), Chennai, Tamil Nadu
[2]M.Tech. Student, Department of Advanced Sports Technology, Tamil Nadu Physical Education and Sports University, (TNPESU), Chennai, Tamil Nadu
[3,4,5,6]B.E. Student, Department of Biomedical Engineering, King's Engineering College, (An autonomous institution and Affiliated to the Anna University), Chennai, Tamil Nadu

Abstract- This paper represents how the challenge of post operative orthopedic carried to palliative care with the IOT system. Orthopedic surgeons often employ external fixation to treat bone fractures, yet the surgery and recovery process can still face complications that hinder effectiveness and raise costs. By using this it replaces the nurse assistance. A key challenge is that doctors lack continuous access to critical data, such as the healing process, patientbehavior, and environmental factors. This paper aims to enhance fixation devices by integrating IoT technology, enabling real-time monitoring of bone fracture healing. The device can detect and report significant events in the patient's recovery to healthcare professionals. We demonstrate this design by monitoring patient compliance with prescribed behavior's during post-operative treatment of bone fractures. Through continuous monitoring and data insights, this approach aims to improve patient care, reduce complications, and enhance clinical outcomes.

Keywords: Post operative care, healing process, real time monitoring, Arduino.

I. INTRODUCTION

Orthopedic surgeons commonly use external fixation devices to treat bone fractures, but these devices often face challenges that can complicate the surgery and recovery process, leading to increased costs and inefficiencies. The proposed project seeks to enhance the capabilities of these devices by incorporating Internet of Things (IoT) technology, which allows for real-time monitoring of the healing process. This technology is designed for use by patients of all ages, including children and the elderly, without requiring nurse assistance. The system provides healthcare professionals with continuous access to critical data such as patient behavior, environmental factors, and the progress of bone healing. This real-time data enables healthcare providers to monitor patient compliance with prescribed behaviors during the post- operative period. By offering insights into recovery and ensuring that patients adhere to treatment plans, this IoT- enabled system aims to improve patient care, reduce complications, and enhance overall clinical outcomes.

The prevalence of chronic disease among aging populations profoundly impacts individuals' quality of life. Proper rehabilitation support can alleviate resulting limitations in motor activity and social participation. Current rehabilitation programs involve an initial inpatient phase followed by an outpatient phase where patients perform prescribed exercises independently. However, studies have shown low patient compliance and incorrect execution of exercises without therapists resulting in longer treatment times and increased healthcare costs. Since it is unlikely for therapists to observe all exercise trials of a patient the development of a quantitative model for automatically evaluating and guiding rehabilitation exercises is necessary. Such a model could improve patient compliance and exercise accuracy, and reduce healthcare costs, ultimately enhancing the effectiveness of rehabilitation programs.

In recent years, there has been a growing interest in the automated assessment of rehabilitation exercises driven by the increasing demand for social rehabilitation. This system aims to provide real-time monitoring of the healing process, patient behaviour, and environmental factors affecting recovery. The project focuses on enhancing patient care by enabling healthcare professionals to access continuous data and insights, thus improving decision-making and treatment adjustments. The target audience for this technology includes patients of all ages, from children to the elderly, ensuring accessibility and ease of use without requiring nurse assistance

III. BLOCK DIAGRAM

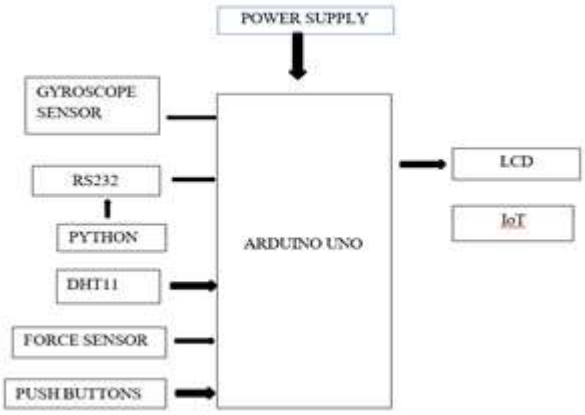

Fig 1: Block Diagram for IoT Integration

B. Challenges and Existing Approaches

In Traditional External Fixation,they rely on periodic in- person check-ups by doctors, leading to delayed detection of complications and increased reliance on subjective patient reports and it Requires constant nurse supervision for exercise compliance and proper device usage, resulting in higher healthcare costs and potential inconsistencies in monitoring and its drawback is Delayed Complication Detection by using Traditional methods rely on periodic check-ups, leading to delayed identification of issues and potentially worsening patient outcomes and also it increasing healthcare costs and leading to inconsistencies in patient exercise compliance and device usage monitoring.

C. Sensor Integration in orthopaedic care:

The integration of sensors gives us a solution for taking care of the patient of post orthopaedic surgery or rehabilitation and it is done by Continuous Monitoring by Implementing IoT-enabled devices to provide real-time data on patient activity and healing progress, ensuring timely intervention and reducing the risk of complications during recovery. By utilizing AI models to analyse sensor data, detecting improper exercise or sudden movements, and instantly notifying healthcare professionals to enhance patient care and improve clinical outcomes.

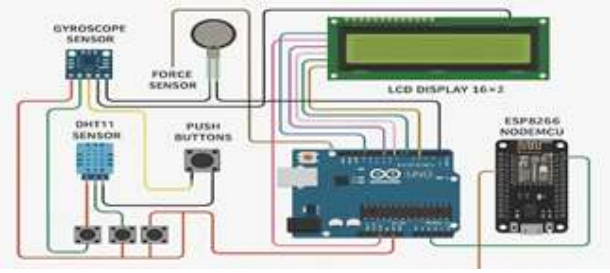

Fig 2: Circuit Diagram for Post-Operative Orthopedic Care

IV. METHODS

We divided this model as three modules to work together

1. Exercise monitoring:

We are using a gyroscope sensor and IoT technology tracks real-time movements and posture during workouts. The gyroscope detects motion changes, while IoT integration allows data to be shared with doctors to know patient condition. This system enhances exercise efficiency, ensures proper technique, and supports personalized fitness programs.

2. Bone crack chack using AI

An AI model detects bone cracks using medical imaging data, and the results are shared with a hardware interface. This information is then updated to doctors through an IoT platform, enabling real-time monitoring, timely diagnosis, and improved patient care and treatment outcomes.

3. updated to IOT

All sensor and exercise data, along with AI model insights, are seamlessly transmitted to doctors through an IoT platform. This real-time data sharing allows healthcare professionals to monitor patients' progress, assess treatment effectiveness, and make informed decisions, enhancing patient care and personalized health management

V. WORKING PRINCIPLE

The Arduino serves as the brain of the system. Gyroscopes are used to monitor whether the patient is performing exercises correctly. If the patient suddenly moves their leg, the sensor detects this movement. An AI model processes the data to determine if there is a risk of a leg bone break due to the sudden movement. All detected events are updated to the doctor via IoT. Additionally, force sensors ensure the kit is worn properly.

It detects the movements of the ankle to detect if the fracture is healing by exercising and doing rehabilitation actions. The continuous real time data is sent to the doctor to know the condition of the patient. The temperature sensor also used to know the body temperature of the patient whether the patient has fever or inflammation or swelling on the affected area.

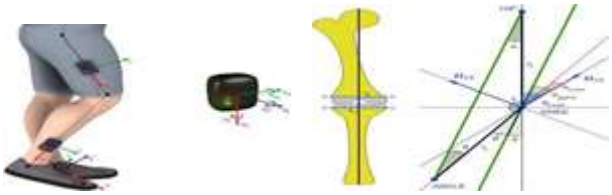

Fig 3: Gyroscope implementation Fig 4: Angle detected by Gyroscope

Here we use arduino code to detect the actions from the sensor and the data is sent to the wifi module (esp8266) to store the data.

VI. DISCUSSION AND RESULTS

It has potential to enhance for future development of this IoT-enabled orthopedic fixation system include expanding its capabilities to monitor a wider range of physiological parameters, such as muscle activity, blood circulation, and inflammation levels, to provide a more comprehensive understanding of the healing process. Additionally, integrating machine learning algorithms could enable predictive analytics, allowing healthcare providers to anticipate potential complications and intervene proactively. Enhancements could also involve the development of a user-friendly mobile application that provides patients with personalized recovery plans and real-time feedback, fostering greater engagement and compliance. Expanding the system's application to other orthopedic conditions beyond bone fractures, such as joint replacements and ligament repairs, would broaden its impact. Collaborations with medical professionals, engineers, and researchers could drive continuous improvement and innovation, ultimately leading to more effective and efficient orthopedic care solutions that enhance patient outcomes and quality of life.

Fig 5 and 6: Notification for Angle detection and Graph IoT Network Orientations

VII. CONCLUSION

Thus, the conclusion of this paper is that integrating IoT technology into external fixation devices represents a significant advancement in the field of orthopedic care. By providing real-time monitoring and continuous data access, this system addresses the challenges associated with traditional fracture treatments, such as limited visibility into the healing process and patient compliance. The IoT-enabled device empowers healthcare professionals with critical insights, allowing for more informed decision-making and personalized treatment adjustments. This approach not only improves patient care and reduces complications but also enhances overall clinical outcomes. With its potential to transform the treatment of bone fractures and other orthopedic conditions, this innovative solution paves the way for a more efficient and effective healthcare system. By fostering collaboration between medical and technological fields, the project sets a precedent for future advancements in orthopedic care, ultimately contributing to improved patient experiences and outcomes.

REFERENCES

1. M. S. Ghiasi et al., "Bone fracture healing in mechanobiological modeling: A review of principles and methods," Bone Rep., vol. 6, pp. 87–100, Jun. 2017, doi: 10.1016/j.bonr.2017.03.002.
2. L. Claes et al., "Fracture healing under healthy and inflammatory conditions," Nature Rev.. Rheumatol., vol. 8, no. 3, pp. 133–143, Jan. 2012, doi: 10.1038/nrrheum.2012.1.
3. A. C. Rajamanthrilage et al., "Measuring orthopedic plate strain to track bone healing using a fluidic sensor read via plain radiography," IEEETrans. Biomed. Eng., vol. 69, no. 1, pp. 278–285, Jan. 2022, doi: 10.1109/TBME.2021.3092291.
4. S. M. Perren, "Physical and biological aspects of fracture healing with special reference to internal fixation," Clin. Orthopaedics Related Res., vol. 138, pp. 175–196, Jan./Feb. 1979.
5. B. McKibbin, "The biology of fracture healing in long bones," J. Bone Joint Surg., vol. 60, no. 2, pp. 150–162, May 1978, doi: 10.1302/0301- 620x.60b2.350882. 2118 IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 71, NO. 7, JULY 2024
6. V. C. Protopappas et al., "An ultrasound wearable system for the monitoring and acceleration of fracture healing in long bones," IEEE Trans. Biomed. Eng., vol. 52, no. 9, pp. 1597–1608, Sep. 2005, doi: 10.1109/TBME.2005.851507.
7. E. F. Morgan et al., "Correlations between local strains and tissue phenotypes in an experimental model of skeletal healing," J. Biomech., vol. 43, no. 12, pp. 2418–2424, Aug. 2010, doi: 10.1016/j.jbiomech.2010.04.019.
8. P. Pivonka et al., "Role of mathematical modeling in bone fracture healing," Bonekey Rep., vol. 1, Nov. 2012, Art. no. 221, doi: 10.1038/bonekey.2012.221.
9. C. Ament et al., "A fuzzy logic model of fracture healing," J. Biomech., vol. 33, no. 8, pp. 961–968, Aug. 2000, doi: 10.1016/S0021-9290(00)00049- X.
10. A. Carlier et al., "Bringing computational models of bone regeneration to the clinic," Wiley Interdiscipl. Rev. Syst. Biol. Med., vol. 7, no. 4, pp. 183– 194, Apr. 2015, doi: 10.1002/wsbm.1299.