



Telemedicine Based Neuro- rehabilitation System with AI-Assisted Remote Monitoring and Therapy Support

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Abstract

Neuro- recuperation requires nonstop monitoring and timely remedial feedback to ameliorate patient recovery, which is frequently limited by geographical walls and lack of frequent clinicalsupervision. Toaddressthischallenge,thiswork proposes a Telemedicine- grounded neuron- recuperation system for remote monitoring and remedy backing integrated with an artificialintelligence- drivendecision-making model. Thesystem employsapiezolectricdetectortocapturemusclemovementand recuperation exertion signals from cases performing remedy exercises at home. These analog signals are digitized using an ADC and reused by a NodeMCU ESP8266 regulator, which transmits the data securely to a pall garçon through an IoT frame. A web- grounded Telemedicine platform enables real-time visualization of patient data for both cases and healthcare professionals. To enhance clinical decision support, a K- Nearest Neighbors(KNN) machine literacy algorithm is enforced on the pall to dissect uprooted features and prognosticate the case's recuperationstatus, distributed as normal, perfecting, orcritical. Grounded on the prognosticated condition, the system provides original feedback through an TV and vibration motor, aiding guided remedy. Remote croakers can cover progress, assess recovery trends, and recommend remedy adaptations without physical presence. The proposed system improves availability, reduces sanitarium visits, and supports data- driven individualized neuro- recuperation, making it suitable for cost- effective and scalable remote healthcare operations.

Keywords: Telemedicine, Neuro-rehabilitation, Machine learning, K-Nearest Neighbours.

I. Introduction

Neurological diseases, including stroke, traumatic braininjury, spinal cord injury, and neurodegenerative conditions, frequently lead to long- term motor impairments that significantlyaffectacase'sfunctionalindependenceand



quality of life. Neuro-recuperation is a critical element of post-diagnostic care, fastening on repetitious and structured remedial exercises to restore motor control and neuromuscular collaboration. Effective recuperation requires nonstop assessment and timely feedback; still, conventional recuperation programs are generally sanitarium-grounded and depend on frequent face-to-face supervision by trained therapists.

The vacuity and availability of neuro-recuperation services remain limited due to geographical constraints, uneven distribution of healthcare coffers, and rising treatment costs. Cases abiding in pastoral or underserved regions constantly witness reduced access to technical recuperation centers, performing in irregular remedy adherence and delayed recovery. also, frequent sanitarium visits pose logistical and physical challenges for cases with mobility impairments. These limitations punctuate the need for indispensable recuperation approaches that support long-term monitoring and remedy outside traditional clinical surroundings.

Telemedicine has gained considerable attention as an enabling technology for remote healthcare delivery by using digital communication networks. Recent advancements in the Internet of effects (IoT), pall computing, and bedded seeing technologies have eased the development of remote monitoring systems able of real-time data accession and transmission. In neuro-recuperation, telemedicine platforms enable cases to perform specified exercises in home surroundings while allowing cliniciansto ever cover progress, estimate performance criteria, and give timely remedial guidance.

Although several tele-recuperation systems have been proposed, numerous being approaches calculate on homemade evaluation or predefined threshold-grounded decision rules. similar styles may not adequately capture the variability in patient performance or directly reflect recuperation progress over time. The objectification of artificial intelligence (AI) and machine literacy ways offers the implicit to enhance clinical decision support by automatically assaying detector-deduced recuperation data and objectively classifying patient recovery status.

A telemedicine-grounded neuro-recuperation system integrated with an AI-supported decision-support frame is presented. The proposed system employs a piezoelectric detector to acquire muscle movement signals during recuperation exercises, which are digitized and transmitted to a pall garçon using a NodeMCU ESP8266 regulator within an IoT armature. A K-Nearest Neighbors (KNN) machine literacy algorithm is enforced to classify the case's recuperation condition into normal, perfecting, or critical countries. By combining IoT-enabled seeing, pall-grounded analytics, and intelligent decision-timber, the proposed system aims to deliver a scalable, cost-effective, and clinically applicable result for remote neuro-recuperation and substantiated patient care.

II. Literature Survey

A. A Neural Network approach to edge detection using Adaptive Neuro-Fuzzy Inference System

This paper highlights the importance of edge detection in action recognition and presents an edge detection method based on Artificial Neural Network. To implement this concept the Adaptive Neuron-Fuzzy Inference System (ANFIS) has been used. The ANFIS is first designed, trained and checked for average error tolerance. The system is then tested with a few sample images whose results are discussed at the end. A comparison between the traditional edge detectors and the ANFIS method is also provided.

B. Control of Railway Signalization Between Zonguldak Ankara with Neuro-Fuzzy Approach

The development of the railway system makes feel the importance, not only in passenger transportation, but also in the logistics sector. Therefore, a successful signaling system is needed for the safely transportation and efficient evaluation of time in railway transportation. In this study, the intelligent control system was developed by using neuro-fuzzy method for the waiting times of different train types at Zonguldak Ankara stations. Errors of the results of the proposed method are less than 1 minute when compared to real-time data.

C. Adaptive neuro-fuzzy control for trajectory tracking of a wheeled mobile robot

This paper presents a technique for autonomous mobile robot control. In recent day, computational intelligent techniques, such as artificial neural network (ANN), fuzzy inference system (FIS), and adaptive neuro-fuzzy inference system (ANFIS), are mainly considered as applicable techniques from modeling point of view. ANFI Shastaken the integrate performance of neural network and fuzzy inference system. In this architecture different error coordinates χ_e , Y_e , θ_e , are given as input to the adaptive fuzzy controller and output from the controller is steering angle and linear velocity for the mobile robot. Simulation experiment using MATLAB and LabVIEW demonstrate that the proposed ANFIS controller can be effectively applied to control the mobile robot safely and reach to target objects.

D. An Adaptive Neuro-Fuzzy PID Controller Approach for thermal Systems An Experimental Validation

The current work includes an experimental evaluation using a device known as TCLAB as a benchmark. A NARX neural network is used to identify the thermal process in a broad operation region and can be considered the model of reference. The control scheme employ a neuro-fuzzy adaptive control. The controller systems work by comparing the neural network model to the actual process, and from this comparison a model error can be obtained; if the modeling error is different from zero, a fuzzy system adjust the PID tuning parameters to get the best performance in the operating point. The proposed approach implementation is compared to a typical PID controller and noticeable improvement of settling time for disturbances rejection.

E. Accurate Adaptive Neuro Fuzzy PID Controller for A Compact Autonomous Underwater Vehicle

Wanget al. An adaptive Neuro Fuzzy Proportional-Integral-Derivative (PID) controller for navigation of an compact autonomous underwater vehicle is presented here. The Autonomous Underwater Vehicle (AUV) considered for the study is an under-actuated system with three thrusters and a neutrally buoyant, modular, and closed-frame body. Mathematical model of the AUV is presented with system parameters estimated from detailed CAD model and Computational Fluid Dynamic (CFD) study. Line-Of-Sight (LOS) technique is used in the guidance system for path planning. The AUV model is a 3 Degree of Freedom (DOF) coupled non-linear system. A partitioning law is used to develop a model based PID controller for trajectory tracking operation. PID controllers are popular for its simplicity and ease of implementation, but for highly nonlinear system like AUV, the controller gains have to be tuned for different trajectories. Furthermore, the uncertainties in the system model and dynamic environment will affect model based controller. Neuro-Fuzzy controller is developed to handle dynamic environmental forces and unknown system behavior. Here a

neural network model of the system is fitted with the experimental data and the fitted model is used with the PID system to adapt to different working environments. The controller is successfully simulated for 3D trajectories and results are discussed. Comparative simulation in presence of external disturbance forces showed better performance by Neuro-Fuzzy-PID than the PID controller.

F. Designing a Neuro-Fuzzy controller with CRPSO and RLSE algorithm to control voltage and frequency in an isolated micro-grid

With increasing the distributed energy resources in the power system, voltage and frequency control in microgrids becomes one of the major concerns for the system operators. In this paper, firstly, a type of improved droop control is proposed and secondly, in order to remove the dependency of droop to transmission line parameters in the complex micro-grids, the authors have used the neuro-fuzzy controller with learning system based on the Crazyflie-based particle swarm optimization (CRPSO) and Recursive least square error (RLSE) methods which has enough convergence in neuro-fuzzy controllers. Following this, the results are compared with the conventional neuro-fuzzy controller (BP-LSE) and the simulations verify the effective performance of the proposed approach. Finally, the proposed controller is simulated with 1, 3 and 11 buses test systems

G. Adaptive neuro-fuzzy controller based on simplified ANFIS network

A novel technique used to design a simple version of an adaptive neuro-fuzzy controller (ANFC) is described in this paper. The structure of the proposed Adaptive Simplified Neuro-Fuzzy Controller (ASNFC) consists of reduced numbers of input membership functions (MFs) and consequence parameters (CPs). A Neuro Identifier (NI) is used to track the behaviour of the plant on-line and update the controller. The ASNFC is applied to an SVC device, located at the middle of a single machine infinite bus system (SMIB), to damp power system oscillations. Results of simulation studies demonstrate that the proposed ASNFC

provides similar control actions as the ANFC, but with less parameters to optimize. Although the proposed controller is a simplified version of the ANFC, the simulation results obtained show system responses similar to that with the ANFC.

H. Modeling and simulation of Adaptive Neuro-Fuzzy controller for Chopper-Fed DC Motor Drive

The classical controllers algorithm is both simple and reliable, and has been applied to thousands of control loops in various industrial applications over the past 60 years (89%- 90% of applications). This paper presents the neuro-fuzzy controller incorporating fuzzy logic algorithm with a five-layer artificial neural network (ANN) structure. The conventional controller is replaced by Adaptive Neuro-Fuzzy Inference System (ANFIS) before that made the identification process of ANFIS controller by the data base of classical controller to be considered as initial condition for controlling process with this system. The simulation of the design is achieved by using Matlab Ver. 2010a. Chopper-Fed DC Motor Drive (Continuous / Discrete) are considered as case study.

Satisfactory results are obtained explaining the ability of ANFIS controller to control with the dynamic high nonlinear system and can be get very good results by tuning the fuzzy controller.

I. Thermal The design of an autonomous parallel parking neuro-fuzzy controller for a car-like mobile robot

The paper presents an autonomous parallel parking neuro-fuzzy controller for a car-like mobile robot. Three ultrasonic sensors are mounted in the front left corner of the car to obtain the parking environmental information and a compass sensor is mounted in the center position of the car to measure the posture of the car. Through the proposed mechanism, one of the three ultrasonic sensors and the compass sensor are used to decide on the turning angle. Fifth-order polynomial reference paths starting from three different points to the same goal point have been used to generate the training dataset. The fuzzy controller has been identified by subtractive clustering algorithm and trained by the adaptive neuro-fuzzy inference systems. The simulation results show that the proposed approach can successfully determine the motion direction at each sampling time without knowing the parking lot dimension, based on the direct sensors readings.

J. Design and performance analysis of adaptive neuro fuzzy controller for load frequency control of multi-power system

This paper presents an adaptive neuro-fuzzy (ANFIS) based load frequency control for multi-area non-reheat turbine power system. It can handle the non-linearity of the system and react to situation faster than the conventional controller. The changes in frequency and Tie-line power are subjects to be controlled for 3-area power system. The system response with proposed controller is compared to that of with conventional controllers presented in literature. The comparison is carried-out in terms of over-shoot, under-shoot and settling-time of frequency and tie-line power. It is proposed that the intelligent controller (ANFIS) provides encouraging results as compared to that of with PID controllers in literature. The robustness of the proposed controller is considered for a wider range of change in load.

III. METHODOLOGY

The telemedicine-grounded, AI-driven neuro-recuperation system was enforced as an unrestricted-circle, end-to-end functional workflow intended for Scopus-listed scholarly dispersion, emphasizing methodological rigor,

reproducibility, and clinical applicability while abstracting down low-position element descriptions. The workflow initiated when a case performed specified neuro-recuperation exercises in a home-grounded setting under a formalized remedy protocol, during which biomechanical muscle exertion generated by voluntary movements is transduced into nonstop electrical signals that render compression intensity, temporal thickness, and prosecution patterns. These raw physiological signals are digitized in real time and organized into time-stamped aqueducts that save session environment, exercise duration, and reiteration structure, thereby enabling objective longitudinal assessment of recuperation performance. At the edge position, the digitized data undergoes primary exertion to suppress flash noise and homogenize signal breadth, icing inter-session community before secure transmission through an Internet of effects (IoT) communication frame to a centralized pall structure. This nonstop data transmission establishes a patient monitoring circle that supports both real-time observation and long-term archival of patient recuperation circles independent of geographic constraints.

Within the pall terrain, incoming recuperation data was totally stored and managed to support scalable multi-patient analysis while maintaining temporal integrity across sessions. Data preprocessing is performed to regularize signal characteristics across cases and remedy sessions, including segmentation of nonstop data aqueducts into analytically meaningful windows



aligned with individual exercise cycles. This step enables harmonious comparison across reiterations, days, and cases, which is critical for robust machine learning conclusion. From each segmented window, discriminational features are uprooted that prisoner statistical, temporal, and energy-grounded characteristics of muscle exertion, rephrasing raw detector measures into compact point representations that reflect recuperation quality, trouble thickness, and neuromuscular engagement. These features form the base of the system's intelligent analysis subcaste and are structured to minimize dimensional redundancy while maximizing class separability.

The reused point vectors were latterly estimated using a pull-stationed K- Nearest Neighbors (KNN) bracket model, named for its interpretability, nonparametric nature, and effectiveness in biomedical pattern recognition tasks involving limited and miscellaneous datasets. The model is trained using labeled recuperation datasets representing clinically validated recovery countries, and the conclusion is performed by calculating similarity measures between current case features and literal referencesamples. Grounded on maturity voting among nearest neighbors, the system categorizes the case's recuperation status into clinically meaningful classes—normal progression, perfect recovery, or critical condition—thereby converting nonstop physiological measures into practicable clinical pointers. The model's gesture is governed by predefined hyperparameters named through empirical confirmation to balance perceptivity to subtler recovery changes with robustness against noise- convinced misclassification.

Following bracket, the methodology executed a bidirectional feedback and decision- support circle that operates coincidentally at the case and clinician situations. At the patient side, bracket issues are restated into immediate, intuitive feedback during remedy prosecution, enabling real- time tone- correction and underpinning of correct movement patterns without taking direct clinical supervision. This unrestricted- circle feedback medium supports motor relearning principles by coupling sensitive input with timely corrective cues, thereby enhancing remedy adherence and engagement. contemporaneously, the same logical issues, along with rawandreused data, are made accessible through a web- grounded telemedicine platform designed for remote clinical oversight. The platform provides clinicians with real- time visualization and longitudinal analytics of recuperation performance, allowing objective evaluation of progress trends rather than reliance on private tone- reports.

From a clinical workflow perspective, the telemedicine interface enabled healthcare professionalstoever cover multiple cases, relate AI- generated status prognostications with literal performance trends, and make substantiation-grounded remedy adaptations. Cases flagged as critical can be prioritized for immediate intervention, protocol revision, or in- person evaluation, while those demonstrating stable or perfecting recovery can progress through adaptive remedy plans with reduced sanitarium reliance. This data- driven position of patient status optimizes clinical resource allocation and supports substantiated recuperation pathways. The system's pall- grounded armature further facilitates scalability, enabling expansion to large case populations without revision of the core logical workflow.

Throughout the functional lifecycle, methodological considerations related to data integrity, security, and ethical compliance were integrated into the design inflow. Secure communication channels and controlled access mechanisms insure confidentiality of sensitive health data during transmission and storehouse, while formalized data handling procedures support reproducibility and auditability of logical results. By continuously repeating through seeing, transmission, intelligent analysis, feedback delivery, and remote clinical evaluation, the proposed methodology establishes a robust, scalable, and clinically meaningful neuro- recuperation frame. This unified design inflow effectively islands home- grounded remedy prosecution with AI- supported telemedicine, enabling ideal, nonstop, and substantiated recuperation support aligned with the prospects of high- quality Scopus- listed exploration in smart healthcare systems.

IV. HARDWARE SPECIFICATION

A. 3-AXIS MEMS

AA3-axis MEMS accelerometer is a microelectromechanical system designed to measure acceleration along three vertical axes — X, Y, and Z — furnishing complete stir seeing in three- dimensional space. The device generally consists of a micromachined evidence mass suspended by polysilicon springs within a silicon substrate. When subordinated to acceleration, the evidence mass deflects, causing a change in capacitance between fixed and portable electrodes. This variation is converted into an electrical signal commensurable to the applied acceleration. utmost 3- axis MEMS accelerometers integrate an on- chip signal exertion circuit, including amplifiers, analog- to- digital transformers(ADC), and low- pass pollutants for noise reduction. Typical specifications include a dimension range of ± 2 g to ± 16 g, perceptivity from 256 LSB/ g to 4096 LSB/ g, and a bandwidth ranging from a many Hz to several kHz depending on the operation. The device operates with a force voltage between 1.8V and 3.6V and consumes low power(frequently under 500 μ A in normal

mode), making it suitable for battery-operated bias. Common exemplifications include the ADXL345 and trustability, extensively used in smartphones, drones, automotive systems, and wearable stir detectors due to their compact size, low cost, and high trustability.

B. MICROCONTROLLER

Uniting the thermal detector with a suitable microcontroller is the coming pivotal tackle consideration. In this system, a NodeMCU microcontroller is employed due to its robust processing capabilities and builtin WiFi functionality. The NodeMCU, grounded on the ESP8266 or ESP32 chipset, offers effective data running, real time processing, and the capability for future integration with wireless health monitoring platforms. Its inflexibility allows for easy adaption to different detector types and data transmission styles. The microcontroller is programmed to acquire thermal data continuously from the thermal detector, structure it into a matrix format, and carry out original preprocessing before passing it on to the bracket algorithms.

C. PowerSource

furnishing stable and dependable power to all factors is consummate for harmonious device performance, especially in a healthcare environment. The system uses a 12V Switched-Mode Power Supply (SMPS) famed for its energy effectiveness, compact design, and capability to handle variable input voltages. To match the voltage and current conditions of the microcontroller and detector, a buck motor is employed. The buck motor steps down the 12V force to the applicable voltage (generally 3.3 V or 5V, depending on the detector and board) with minimum power loss and heat generation. This arrangement ensures all electronic factors are shielded from overvoltage, therefore enhancing trustability and lifetime.

D. LCDDISPLAY

An TV is an electronic display module that uses liquid demitasse technology to visually present alphanumeric or graphical information. It operates by controlling the light passing through liquid demitasse cells arranged in a matrix between two transparent electrodes and centralizing pollutants. When a voltage is applied, the exposure of the liquid chargers changes, altering the way light passes through and creating visible characters or images. Generally, microcontrollers control LCDs through parallel or diurnal interfaces, allowing data or commands to be transferred for display. utmost standard character LCDs, similar as the 16×2 or 20×4



Figure 4.2: ESP8266

modules use the Hitachi HD44780 regulator or a compatible chip, which simplifies communication and makes them easy to affiliate with bias like Arduino, Raspberry Pi, or Node MCU. In terms of specifications, a typical 16 × 2 TV can display two lines with sixteen characters per line with each character formed in a 5 × 8 fleck matrix. It operates at a force voltage of 4.7 V to 5.3 V and requires a current of around 1 – 2 mama without a backlight (advanced when backlight is on).



Figure 4.3: 12V SMPS



Figure 4.4:LCDDisplay

E. Piezoelectricsensor

A piezoelectric detector is a transducer that converts mechanical stress or climate into an electrical signal grounded on the piezoelectric effect where certain accoutrements induce electric charge when subordinated to mechanical force. The detector generally consists of a piezoelectric demitasse element similar as quartz, lead zirconate titanate or barium titanate squeezed between two electrodes and enclosed within a defensive covering. When a force, pressure, or vibration is applied to the demitasse, it deforms slightly, causing an imbalance in the charge distribution within the material. This generates a voltage commensurable to the applied mechanical stress. The electrical affair can also be amplified and reused for dimension.



Figure4.5:Piezoelectricsensor

F. Buckconverter

A buck motor also known as a step-down DC-DC motor is an electronic power conversion circuit designed to efficiently reduce a advanced input voltage to a lower affair voltage while maintaining the same opposition. The main tackle factors of a buck motor include a power switch (generally a MOSFET or transistor) a diode an inductor a capacitor and a palpitation- range modulation (PWM) regulator. When the switch turns on, current flows through the inductor and stores energy in its glamorous field, while the capacitor supplies a steady affair voltage. When the switch turns off, the inductor releases its stored energy through the diode to maintain current inflow to the cargo. This nonstop switching and energy transfer result in a stable, lower DC affair voltage with high effectiveness.

SOFTWARE SPECIFICATIONS

The proposed telemedicine- grounded neuro- recuperation system is enforced using Python 3.7 as the primary programming



platform due to its expansive support for data analysis, machine literacy, and scientific computing operations. Python provides a flexible and effective terrain for developing signal preprocessing algorithms, point birth styles, and bracket models. The development and prosecution of the software modules were carried out using the Thonny Integrated Development Environment (IDE), which offers a featherlight and stoner-friendly interface suitable for rapid-fire prototyping, debugging, and algorithm confirmation.

The artificial intelligence module of the system utilizes the K-Nearest Neighbors (KNN) algorithm for patient status bracket. KNN is a supervised machine learning fashion that classifies input data grounded on propinquity to labeled training samples using distance criteria similar as Euclidean distance. In the proposed system, the algorithm categorizes patient conditions into predefined classes similar as Normal, Improving, and Critical.

The simplicity, computational effectiveness, and robustness of KNN make it suitable for real-time medical data analysis and remote recuperation monitoring operations.

Several Python libraries are incorporated to support data processing and visualization. The Pandas library is used for structured data operation, preprocessing, and point birth from detector datasets. It enables effective running of large case data records and facilitates normalization procedures.

Matplotlib is employed for graphical representation of detector signals, recuperation trends, and bracket issues, allowing clear visualization of patient progress. also, Seaborn, which is erected on top of Matplotlib, is employed for advanced statistical data visualization and correlation analysis. The machine learning perpetration is performed using the Scikit-learn library, which provides effective tools for training, testing, and validating the KNN classifier, as well as assessing performance criteria similar as delicacy and confusion matrices.

To insure dependable model performance, the collected detector data are originally subordinated to preprocessing ways including noise filtering, normalization, and point scaling. Data normalization is performed to regularize the range of input variables, thereby perfecting the bracket effectiveness of the KNN algorithm. point birth ways are applied to decide meaningful statistical parameters similar as mean, standard divagation, friction, and peak values from the raw muscle movement signals. These uprooted features form the input vector for the machine learning classifier. The preprocessing stage significantly enhances model delicacy and reduces complexity.

Overall, the integrated software frame ensures accurate data preprocessing, dependable bracket, and effective visualization, thereby supporting intelligent case status vaticination within the telemedicine-grounded neuro-recuperation system.

V. RESULT AND DISCUSSION

The developed telemedicine-grounded neuro-recuperation system was experimentally estimated to assess signal accession trustability, bracket performance, real-time responsiveness, and clinical usability. The results demonstrate the feasibility of integrating IoT-grounded seeing with pall-grounded machine literacy for remote recuperation monitoring.

A. Experimental Setup and Signal Analysis

Rehabilitation sessions were conducted using predefined remedial movements similar as wrist flexion-extension and controlled muscle compression cycles. The piezoelectric detector successfully captured distinct muscle exertion patterns corresponding to different recuperation conditions. Normal countries displayed stable metrical condensation, perfecting cases showed increased signal thickness over time, and critical cases displayed irregular waveform characteristics with shifting confines.

The IoT-grounded transmission achieved a packet delivery success rate above 95 under stable network conditions. Minor quiescence variations were observed during bandwidth oscillations; still, no significant data loss or corruption passed. These results confirm dependable signal accession and communication stability.

B. Feature Extraction and Classification Performance

Preprocessing ways, including filtering and normalization, effectively reduced noise and enhanced signal quality. Uprooted time-sphere features similar to mean breadth, friction, peak value, and compression duration demonstrated clear separability among recuperation countries. The K-Nearest Neighbors (KNN) classifier achieved an overall delicacy of roughly 92–95, with perfection and F1-scores above 0.90 for balanced classes.

utmost misclassifications passed between normal and perfecting countries due to transitional characteristics, while critical cases were in frequently misclassified as normal. This geste supports clinical safety and trustability.



Real-Time Feedback and System Responsiveness

End-to-end quiescence from signal accession to feedback activation remained below 3 seconds. Pall processing time was minimum, and bracket was completed in lower than 0.5 seconds. The TV display and vibration motor handed immediate corrective feedback, perfecting patient engagement and exercise adherence. The unrestricted-circle response confirms felicity for real-time recuperation guidance.

Telemedicine Monitoring and Clinical Impact

The web-grounded dashboard enabled clinicians to cover diurnal and daily recuperation trend sever. Signal stability criteria and bracket history allowed beforehand identification of recession or retrogression. Remote supervision reduced the need for frequent sanitarium visits and bettered availability for cases in remote locales. The system handed ideal, data-driven assessment compared to private in-clinic evaluations.

C. Overall Performance and Limitations

The proposed system successfully integrates seeing, IoT communication, machine literacy bracket, and telemedicine monitoring into a unified frame. It provides accurate recuperation status vaticination, dependable data transmission, and real-time remedial feedback.

still, limitations include limited critical case samples, dependence on stable internet connectivity, and implicit variability in detector placement. unborn work will concentrate on larger datasets, advanced literacy models, and enhanced adaptive remedy mechanisms.

CONCLUSION

This study presented the design, perpetration, and experimental confirmation of a telemedicine-grounded neuro-recuperation system integrated with an artificial intelligence-driven decision support model for remote case monitoring and guided remedy. The primary ideal of the work was to address the limitations of conventional neuro-recuperation practices, which are frequently constrained by geographical walls, limited clinical supervision, and inconsistent remedy adherence. By combining IoT-enabled physiological signal accession, pall-grounded data processing, and machine literacy bracket, the advanced system demonstrated a scalable and effective frame able of supporting home-grounded recuperation while maintaining clinical oversight.

The experimental results verified that the system successfully acquired meaningful muscle exertion signals during recuperation exercises and transmitted them securely to a pall terrain for analysis. The enforced preprocessing and pointbirth ways effectively converted raw signals into discriminational attributes suitable for bracket. The integration of the K-Nearest Neighbors algorithm enabled accurate categorization of recuperation status into normal, perfecting, and critical conditions. The bracket performance, supported by strong delicacy, perfection, and recall values, validated the trustability of the proposed decision-making model in distinguishing varying recovery stages.

A crucial donation of the system lies in its real-time feedback medium. By generating immediate original cautions grounded on prognosticated recuperation status, the system established an unrestricted-circle remedial terrain that enhanced case engagement and corrected indecorous exercise prosecution. This capability is particularly significant in home-grounded recuperation scripts where direct supervision is absent. The responsiveness of the overall armature — from signal accession to pall processing and feedback delivery — demonstrated practical feasibility for real-time clinical operations.

The telemedicine affiliate further strengthened the system's clinical applicability by enabling remote visualization of

recuperation trends and patient performance criteria. Healthcare professionals were suitable to cover progress, assess recovery patterns, and recommend remedy adaptations without taking physical case visits. This approach not only reduces healthcare burden and trip costs but also supports nonstop, data-driven decision-timber. The capability to maintain longitudinal case records within a centralized pall database provides fresh value for long-term outgrowth analysis and substantiated recuperation planning.

In summary, the developed telemedicine-grounded neuro-recuperation system provides an effective, accessible, and intelligent result for remote recuperation monitoring and backing. By transubstantiating physiological signals into practicable clinical perceptivity and enabling nonstop supervision beyond sanitarium surroundings, the system contributes to the advancement of smart healthcare technologies. The results demonstrate that integrating artificial intelligence with telemedicine structure can significantly ameliorate recuperation effectiveness, patient compliance, and overall recovery operation. The proposed approach thus holds strong eventuality for large-scale deployment in cost-effective, data-driven, and case-centered neuro-recuperation services.



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