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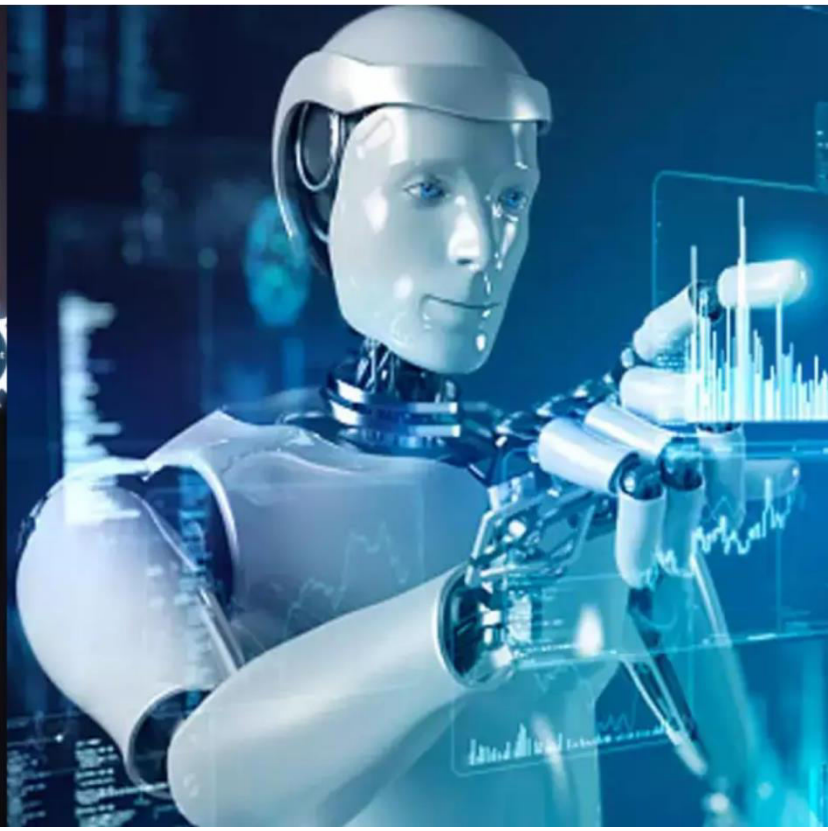

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Digital Twin Based Analysis Health Condition by using an AV System and Predicting Health Deterioration in Remote Patient

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ABSTRACT: This project proposes a real-time ICU patient health monitoring system using a Digital Twin (DT) framework integrated with Augmented Vision (AV), IoT, glucose monitoring, and SOS emergency alert mechanisms. The system is designed to assist doctors in rapid screening, prioritization, and emergency treatment of high-risk patients admitted to Intensive Care Units (ICUs). Each patient is assigned a unique Digital Twin–based Augmented Vision (AV) scannable code at the time of admission. Wearable biomedical sensors—including heart rate, oxygen saturation (SpO_2), body temperature, and continuous glucose monitoring sensors—are deployed on the patient. These sensor values are continuously uploaded to a centralized IoT server, mapped securely to the patient's unique DT-based AV code. In emergency situations such as cardiac arrest, respiratory distress, abnormal glucose levels, or sudden patient collapse, an SOS alert mechanism is automatically triggered when critical thresholds are crossed. The SOS alert immediately notifies duty doctors and medical staff through the DT vision software and mobile application, enabling faster response and intervention. Using an Android-based AV code scanner, the duty doctor can scan multiple patients' AV codes in real time. The Digital Twin Vision Software System retrieves corresponding biomedical data from the server and visualizes the patient's health condition using intuitive color-coded DT representations:

- Green DT – Normal and stable condition
- Orange DT – Moderate risk requiring observation
- Red DT – Severe or life-threatening condition requiring immediate attention

Additionally, abnormal glucose levels are highlighted within the DT visualization, assisting in early detection of diabetic emergencies such as hypoglycemia or hyperglycemia. By ranking patients based on DT severity levels and SOS alerts, senior doctors can prioritize emergency treatment efficiently, ensuring faster clinical decisions and improved patient survival rates.

KEYWORDS: Digital Twin, Artificial Intelligence (AI), Mental Health Monitoring , Academic Environments, Smart Campus.

I. INTRODUCTION

Mental health issues among students have become a growing global concern with stress, anxiety, and depression increasingly recognized as major barriers to academic performance and overall well-being. Recent studies have found that up to 30-40% of university students globally feel substantial psychological discomfort as a result of constant academic pressure, uncertain about their future career, and strong competitiveness[1]. This transition to online and hybrid learning models has further worsen emotional strain, introducing challenges such as social isolation, digital fatigue, and cognitive overload. These factors have collectively contributed to an alarming rise in mental health problems, affecting students concentration, motivation, and engagement[2], [3]. The situation gets worse by the stigma surrounding mental health talks, which discourages many people from getting treatment. Consequently, academic institutions face an urgent need for mechanisms that enable early detection of mental health deterioration and provide personalized, proactive interventions rather than reactive responses[4]. Traditional student mental health support systems such as counselling centers, peer-support programs, and self-report surveys remain limited in scope and temporal coverage. These interventions focus heavily on voluntary participation and self-disclosure, making them

ineffective in detecting hidden or evolving stress and anxiety symptoms[5]. Furthermore, such methods are episodic and subjective, with no ability to continuously track and evaluate the complex mixture of psychological, behavioural, and physiological factors influencing mental health[6]. The counselor-to-student ratio in most of the institutions remains far below recommended levels, further constraining the ability to provide individualized monitoring and timely care[7]. As a result, there is a desire to increase objective, continuous, and technologyassisted frameworks that can supplement traditional techniques while also providing actionable insights into student well-being through real-time data analytics[8]. The emergence of Digital Twin (DT) technology presents a transformative opportunity to address these limitations. A Digital Twin is a dynamic, virtual depiction of a physical entity that communicates with its real-world counterpart using real-time data streams. The idea began in the fields of industrial, aerospace for the monitoring of the performance systems of and predicting of maintenance requirements. However, the Digital Twin has been transformed to become an important tool in personalized medicine and human morphological models[9], [10], [11], [12]. In medicine, DTs use physiological and environmental data to recreate patient situations, which lets them analyse data in real time and make predictions about the future. By reflecting the individual's changing state, DTs bridge the gap between real and virtual spaces, resulting in adaptive digital models capable of assisting decision-making[13], [14], [15]. When applied to mental health, a Digital Twin can function as a virtual representation of an individual's emotional and cognitive condition, continuously updating through multimodal data sourced from wearables, smart devices, and behavioural inputs[16]. The integration of Artificial Intelligence (AI) into Digital Twin architectures further amplifies their analytical potential.AI models including deep learning architectures such as convolutional, recurrent, and transformerbased networks can process multimodal inputs such as voice tone, facial expressions, and physiological signals to infer affective states with high precision[17], [18]. These models have shown that they can successfully recognize emotions, find stress, and analyse behavioural patterns in a wide range of situations. When coupled with the self-updating capability of a Digital Twin, AI-driven analytics can produce an intelligent, adaptive system capable of mirroring and predicting psychological variations[19].

II. LITERATURE SERVEY

Title: STEMI Recognition in Electrocardiogram (ECG) by Online AI Bot for Emergency Service and Mobile Medicine
Year:2021
Author: Shi-Jim Yen; Serkan Kavak; Jen-Yeu Chen
Description: Emergency medical treatment in remote areas often requires immediate medical decision and on-board medical treatments in ambulances before patients could arrive hospitals. For example, a heart attack (Myocardial Infarction) particularly needs prompt treatments to save life. Amid all acute heart diseases, the ST-Elevation Myocardial Infarction (STEMI) is de facto one of the main causes of death. Adequate and immediate treatments for STEMI patients in ambulances before arriving the hospital could largely improve the chance of survival. This paper proposes an online mobile application for real time STEMI ECG pattern recognition. In the cloud AI computing server, a Deep Learning based mechanism is developed to accurately recognize STEMI ECG pattern. On the side of mobile clients, the developed system exploits the salient properties of seamless connections and prompt responses of a wireless mobile network. The main component of our system is an online AI Bot which can help paramedics to recognize STEMI and then to give patients appropriate treatment, such as giving therapeutic drugs and carrying them to the emergency medical center. Collaborating with a teaching hospital, the proposed system is under a testing run and the results show that our system has a very high STEMI recognition accuracy and could be a great help for saving lives of those patients encountering STEMI in remote areas far away from the hospital.

Title: Smart Car Seat Belt: Accident Detection and Emergency Services in Smart City Environment
Year: 2021
Author: Majd Khaled Almohsen; Renad khlief alonzi; Taif Hammad Alanazi; Shahad Nasser BinSaif; Maha Mohammed almujally
Description: Delay in the arrival of emergency team after a road accident is one of the main reasons for the increase in the number of deaths in many counties across the globe. Saudi Arabia is not exception. This was the key motivation to undertake this project with an aim to contribute an IoT product that can reduce the number of deaths resulting from the problem of delaying the arrival of emergency team or ambulance. In this project we have designed a seat belt with sensor that senses the heart beat rate of the driver and send a notification to the ambulance about the driver's location if he had an accident. To determine whether accident has occurred, the raw data from heart beat sensor is collected along with the data from vibration sensor of the car. Based on the value of these two collected data, UNO microcontroller is used to process and determine whether it is an accident. If accident the controller utilizes the GPS in the car to get the

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current location and sends notification to the pre-stored emergency contact numbers. The system will use GSM technology to send an alert containing the location of the accident. Also, we have added a fingerprint to confirm the identity of the passenger so that the sensor does not make mistakes when monitoring the heart rate if the driver changes. Here, we use Arduino platform to implement the hardware connections and for programming Arduino IDE is used. Thus, the end-product of our project is expected to reduce the percentage of deaths that may occur due to delaying ambulance.

Title : Application of Artificial Intelligence in Emergency Nursing of Patients with Chronic Obstructive Pulmonary Disease
Year:2021
Author: Lingzhi Hong, Xufang Cheng, and Deming Zheng
Descripion: The research achievements of artificial intelligence technology in the development of chronic obstructive pulmonary disease were explored, and the advantages and problems encountered in the development of intelligent nursing were analyzed. This paper presents the application of artificial intelligence in the emergency care of patients with chronic obstructive pulmonary disease. The method included 447 COPD patients in a randomized controlled trial to observe the improvement of quality of life at 4 and 12 months after artificial intelligence medical intervention. A prospective randomized controlled trial included 101 patients with COPD who underwent a 9-month web-based knowledge exercise on the prevention of acute exacerbation of COPD through artificial intelligence medicine and were randomly divided into two groups: the experimental group and the control group.

III. RELATED WORK

TEMPERATURE SENSOR LM35

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling.

The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy.

Temperature Sensor

HEARTBEAT SENSOR PCB TYPE

The operation of the board is very simple. After powering the board from a 3-5.5V supply, the Enable(EN) pin must be pulled high to activate the IR sensor. Next, place the tip of your forefinger gently over the sensor on its face. Your finger should be still and should not press too hard on the sensor. With in a couple seconds the circuit stabilizes and you will see the LED flashing synchronously with your heartbeat. You can feed the output signal(Vout) to either a digital I/O or an ADC input pin of the microcontroller for measurement of the heartbeat rate in BPM. The output voltage waveform canal so be viewed on an oscilloscope. I connected Digilent's Analog Discovery tool to check the input PPG and the output waveforms from the two LPF stages.

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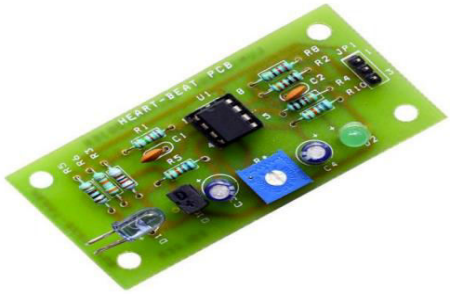

Heart beat PCB type

RESPIRATORY SENSOR

The Respiration Sensor is used to monitor abdominal or thoracical breathing, in biofeedback applications such as stress management and relaxation training. Besides measuring breathing frequency, this sensor also gives you an indication of the relative depth of breathing. The Respiration Sensor for Nexus can be worn over clothing, although for best results we advise that there only be 1 or 2 layers of clothing between the sensor and the skin. The Respiration Sensor is usually placed in the abdominal area, with the central part of the sensor just above the navel. The sensor should be placed tight enough to prevent loss of tension.

First Sensor develops and manufactures highly reliable sensors and customized sensor systems as a strategic partner to medical product manufacturers in the area of breathing and respiration. The first step in this process is breathing in air, or inhaling. The taking in of air rich in oxygen into the body is called inhalation and giving out of air rich in carbon dioxide from the body is called exhalation. The second step is gas exchange in the lungs where oxygen is diffused into the blood and the carbon dioxide diffuses out of the blood.

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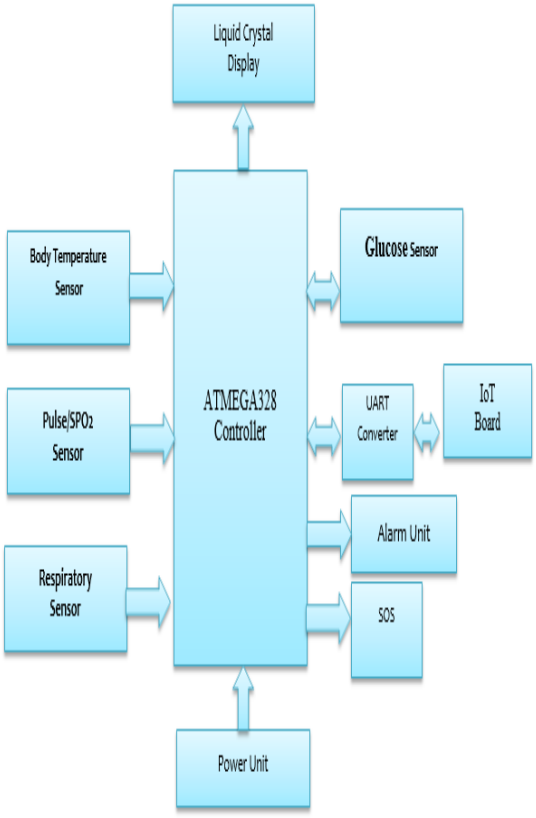
IV. BLOCK DIAGRAM



V. RESULT AND DISCUSSION

Digital twins (DTs) represent a transformative paradigm in personalized medicine, enabling real-time, patient-specific simulations that support precision diagnosis, continuous monitoring, and adaptive treatment planning. This paper presents a novel hybrid framework that integrates mechanistic physiological modeling with deep learning to construct patient-specific digital twins. The proposed architecture couples a dynamic simulation engine—capable of modeling organ-system interactions—with neural encoder-decoder networks that extract latent representations from heterogeneous clinical data sources, including biosignals (e.g., ECG), medical imaging, and wearable sensor streams. A probabilistic learning module further enables predictive adaptation under uncertainty, leveraging Bayesian inference and reinforcement learning. The framework supports continuous synchronization between a patient's real-world physiological state and its digital counterpart, enabling individualized risk assessment, disease trajectory forecasting, and therapy simulation. Extensive experiments on large-scale benchmark datasets (MIMIC-IV and PhysioNet) demonstrate that our hybrid approach significantly outperforms conventional machine learning and standalone AI models across multiple clinical prediction tasks. By fusing physiological realism with datadriven intelligence, the proposed digital twin framework offers a scalable, interpretable, and clinically actionable foundation for next-generation precision healthcare systems.

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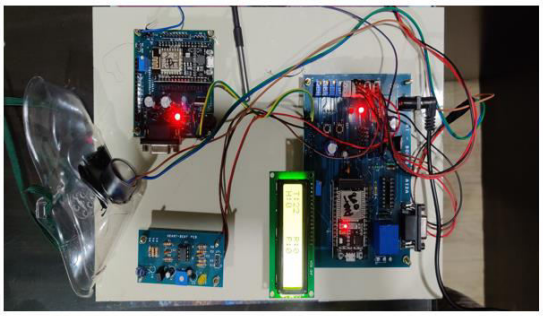

VI. CONCLUSION

In this project we have presented a Digital Twin based healthcare management system with augmented vision. In this project we take advantage of monitoring patient health care values like temperature and heartbeat values during emergency care through augmented vision. The Augmented vision can significantly improve the fastening of treatment they receive from their healthcare data through IOT with digital TWIN vision display with digital representation format. The doctors, they are in term of the risk of invasive surgery screening to be done faster which can be avoided by keeping the all the patients in bed considering normal situation.

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