

## LSTM-based Cuff Continuous BP Monitoring

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**Abstract** - Continuous blood pressure monitoring is critical for early detection and management of cardiovascular diseases. This project presents an LSTM-based cuff continuous blood pressure monitoring system using machine learning techniques. The system employs BP and SpO<sub>2</sub> sensors to collect real-time physiological data, which is processed using an LSTM model to analyze temporal patterns and predict future blood pressure trends. An Arduino Mega is used as the main controller for sensor data acquisition and system coordination. The model compares present readings with predicted future values to identify abnormal conditions. In case of any critical variation, alerts are generated and transmitted to caregivers through a GSM module, along with location details obtained using a GPS module. The proposed system enables non-invasive, continuous, and intelligent health monitoring, providing timely alerts and improving patient safety, especially for remote and elderly care applications.

**Key Words:** Blood Pressure Monitoring, LSTM, Deep Learning, Arduino Mega, SpO<sub>2</sub> sensor, IoT Healthcare

### 1. INTRODUCTION

Cardiovascular diseases remain one of the leading causes of mortality worldwide, making continuous blood pressure monitoring essential for early diagnosis and effective management. To address these limitations, this project proposes an intelligent cuff blood pressure monitoring system based on Long Short-Term Memory (LSTM) neural networks, which are well-suited for analyzing time-series physiological data. The system acquires real-time blood pressure and SpO<sub>2</sub> signals through sensors interfaced with an Arduino Mega, enabling efficient data collection and coordination. The LSTM model processes temporal patterns to predict future blood pressure trends and detect potential abnormalities. When critical variations are identified, alert notifications along with patient location details are transmitted via GSM and GPS modules to caregivers. This approach ensures non-invasive, continuous, and intelligent health monitoring, enhancing patient safety, particularly for elderly and remote healthcare applications.

### 2. BODY OF PAPER

The proposed system presents an intelligent and continuous blood pressure monitoring framework by integrating embedded hardware with deep learning techniques. The system architecture is designed to perform real-time data acquisition, preprocessing, prediction, and alert generation in an efficient and reliable manner. Initially, physiological parameters such as systolic blood pressure, diastolic blood pressure, heart rate, and oxygen saturation (SpO<sub>2</sub>) are acquired using appropriate sensors. The blood pressure measurement is carried out using a cuff-based oscillometric method, which ensures clinical reliability and accuracy. The SpO<sub>2</sub> sensor provides additional information regarding oxygen saturation and pulse rate, which are essential indicators of cardiovascular health. All sensing components are interfaced with the Arduino Mega 2560 microcontroller, which serves as the central data acquisition and control unit. The Arduino processes both analog and digital inputs from the sensors and converts them into meaningful numerical values using its internal Analog-to-Digital Converter (ADC). The collected data is transmitted to a computing system via serial communication for further analysis. On the software side, Python is employed for data processing and implementation of the prediction model. The incoming data is subjected to preprocessing techniques such as normalization and noise filtering to enhance data quality and ensure consistency. This preprocessed data is then used as input to the Long Short-Term Memory (LSTM) network. The LSTM model is specifically designed to handle time-series data and is capable of capturing temporal dependencies in physiological signals. It learns patterns from historical data and predicts future blood pressure values with improved accuracy. The predicted values are continuously compared with real-time measurements to identify any abnormal variations.

### 3. RELATED WORK

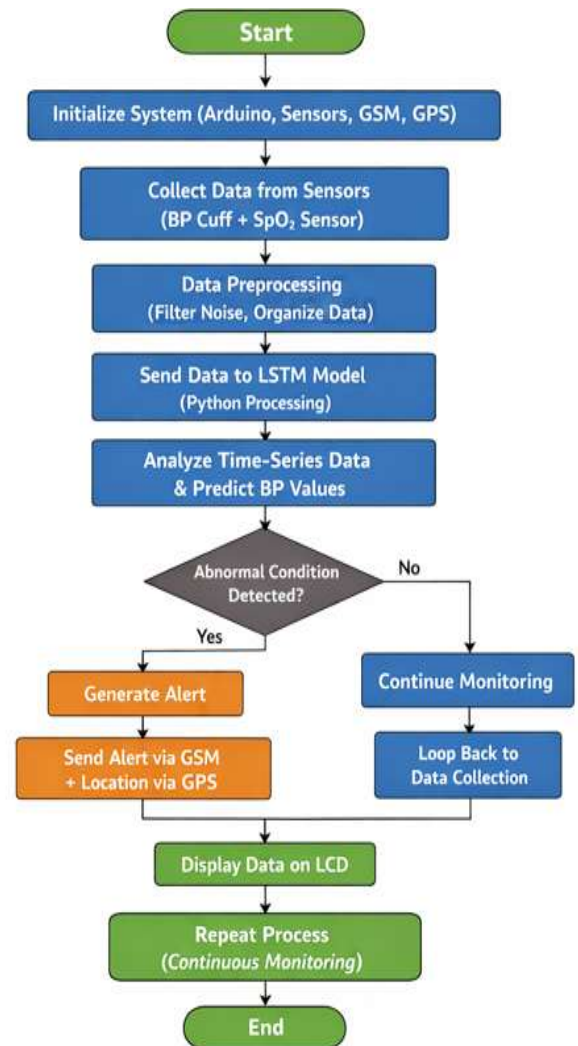
Continuous blood pressure monitoring has been an important research area in healthcare due to its role in early detection and management of cardiovascular diseases. Traditionally, blood pressure is measured using cuff-based devices, which are widely accepted for their accuracy and reliability. Most commercial systems use the oscillometric method to determine systolic and diastolic pressure values. However, these devices provide only discrete measurements and are not suitable for continuous monitoring. To overcome these limitations, several researchers have developed microcontroller-based health monitoring systems using platforms such as Arduino. These

systems enable real-time data acquisition from sensors like heart rate and SpO<sub>2</sub>, improving portability and enabling remote monitoring. However, these systems mainly focus on data collection and lack intelligent analysis capabilities.

In recent years, machine learning techniques have been introduced to enhance blood pressure monitoring systems. Regression models and neural networks have been used to estimate blood pressure from physiological signals. Among these, deep learning models have shown better performance in handling complex and time-dependent data. Long Short-Term Memory (LSTM), a type of Recurrent Neural Network, has gained significant attention for analyzing time-series data in healthcare applications. Several studies have used LSTM models to predict blood pressure using signals such as heart rate and oxygen saturation. These models are capable of capturing temporal dependencies and improving prediction accuracy. Despite these advancements, many existing systems either rely entirely on cuff-based measurements without predictive intelligence or use cuffless approaches that may compromise accuracy. There is still a need for a hybrid system that combines the reliability of cuff-based measurement with the predictive capabilities of deep learning models. In this work, a hybrid approach is proposed by integrating cuff-based blood pressure measurement with an LSTM-based prediction model. The system uses real-time physiological data and applies deep learning techniques to enable continuous monitoring and early detection of abnormalities, thereby improving patient safety and healthcare efficiency.

#### 4. SYSTEM DESIGN

The proposed system is designed to perform continuous blood pressure monitoring by integrating hardware components with machine learning techniques. It consists of sensing units, a processing unit, communication modules, and a prediction model. The system begins with multiple sensors, including a blood pressure (BP) sensor with a cuff, a heart rate sensor, and an SpO<sub>2</sub> sensor. These sensors are responsible for collecting real-time physiological parameters such as systolic pressure, diastolic pressure, pulse rate, and oxygen saturation levels from the patient. All sensor modules are interfaced with the Arduino Mega 2560, which acts as the central controller of the system. The Arduino collects analog and digital signals from the sensors, converts them into meaningful numerical values, and manages the overall data flow. It ensures proper synchronization between different hardware components. The collected data is then transmitted to a computer system through serial communication. On the software side, Python is used to receive and process the incoming data. Preprocessing techniques are applied to remove noise and organize the data for further analysis.



The core component of the system is the Long Short-Term Memory (LSTM) model, which is implemented using deep learning techniques. The LSTM model analyzes the time-series physiological data and predicts future blood pressure values based on learned patterns. This enables early detection of abnormal conditions. In addition to prediction, the system includes communication modules such as GSM and GPS. The GSM module is used to send alert messages to caregivers or medical personnel when abnormal blood pressure levels are detected. The GPS module provides real-time location information of the patient, which is useful in emergency situations. Overall, the system integrates sensing, processing, prediction, and communication into a single platform. This design ensures continuous monitoring, intelligent analysis, and timely alert generation, making it suitable for remote healthcare and elderly patient monitoring.

#### 5. LONG SHORT-TERM MEMORY(LSTM)

Long Short-Term Memory (LSTM) is a type of Recurrent Neural Network (RNN) used in deep learning for processing sequential and time-series data. It is specifically designed to overcome the limitations of traditional RNNs, such as the

vanishing gradient problem, which makes it difficult to learn long-term dependencies. An LSTM network consists of a memory cell that maintains information over time and three main gates: the input gate, forget gate, and output gate. These gates regulate the flow of information into and out of the memory cell. The input gate controls how much of the new information is stored in the memory cell. The forget gate determines which information from the previous state should be discarded. The output gate decides what information is passed to the next time step or used as output. This gating mechanism allows LSTM networks to selectively retain important information and ignore irrelevant data. By using LSTM, the system not only measures current blood pressure using a cuff-based method but also predicts future trends. This helps in early detection of abnormal conditions and enables proactive healthcare monitoring.

## 6. CONCLUSION AND FUTURE WORK

In this paper, an intelligent health monitoring system for continuous blood pressure measurement has been proposed using a cuff-based approach combined with a Long Short-Term Memory (LSTM) model. The system integrates sensors, an Arduino Mega 2560, and communication modules such as GSM and GPS to enable real-time data acquisition, processing, and alert generation. The use of LSTM allows the system to analyze time-series physiological data and predict future blood pressure values, enabling early detection of abnormal conditions. By combining accurate cuff-based measurement with predictive analytics, the system overcomes the limitations of traditional monitoring methods. The proposed system ensures continuous monitoring, timely alerts, and improved patient safety, making it highly suitable for remote healthcare and elderly patient monitoring applications. Overall, this work demonstrates the effectiveness of integrating embedded systems with deep learning techniques for advanced healthcare solutions.

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