JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ADVANCED HUMAN STRESS LEVEL-BASED VEHICLE TOP SPEED CONTROLLING SYSTEM *For Accident Prevention*

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Abstract: This paper presents a multi-modal human stress detection system integrating computer vision and machine learning. The proposed method uses OpenCV's Haar cascade for face detection and a Convolutional Neural Network (CNN) for facial stress assessment. Simultaneously, a k-Nearest Neighbors (KNN) algorithm analyzes emotional cues and physiological data from the MAX30100 sensor. The integrated model provides real-time stress level predictions, offering a robust, non-intrusive, and adaptable solution for mental health monitoring.

IndexTerms - Stress detection, CNN, KNN, MAX30100, facial recognition, OpenCV, emotion analysis.

I. Introduction

Stress detection is critical in today's fast-paced society where mental health issues are on the rise. Conventional methods relying on subjective reports or physiological data lack real-time capabilities. This paper proposes a dual-modality system utilizing facial expression analysis and physiological monitoring for accurate stress assessment.

II. Abbreviations and Acronyms

- **CNN** – Convolutional Neural Network
- **KNN** – k-Nearest Neighbors
- **OpenCV** – Open-Source Computer Vision Library
- **ESP32-CAM** – Embedded Serial Peripheral 32-bit Camera Module
- **DHT11** – Digital Humidity and Temperature Sensor
- **MAX30100** – Integrated Pulse Oximetry and Heart Rate Sensor
- **NODEMCU** – Network Open Development Environment Microcontroller Unit
- **ADC** – Analog-to-Digital Converter
- **EEPROM** – Electrically Erasable Programmable Read-Only Memory

- **GPIO** – General-Purpose Input/Output
- **PWM** – Pulse Width Modulation
- **USART** – Universal Synchronous/Asynchronous Receiver/Transmitter
- **RTC** – Real-Time Clock
- **SPI** – Serial Peripheral Interface
- **I2C** – Inter-Integrated Circuit
- **SVM** – Support Vector Machine
- **HOG** – Histogram of Oriented Gradients
- **DWT** – Discrete Wavelet Transform

- **FER** – Facial Expression Recognition
- **JAFFE** – Japanese Female Facial Expression Database
- **DELCON** – IEEE Delhi Section Flagship Conference
- **ISCON** – International Conference on Information Systems and Computer Networks
- **ICACITE** – International Conference on Advance Computing and Innovative Technologies in Engineering
- **ICRAIE** – International Conference and Workshops on Recent Advances and Innovations in Engineering

III. Data and Sources of Data

The stress detection system relies on two key data sources: facial expressions and physiological signals. Facial data is collected using a web camera and analyzed by a Convolutional Neural Network (CNN) trained on a diverse dataset of stress-related expressions. Physiological data, including heart rate and oxygen saturation, is obtained from the MAX30100 sensor. The K-Nearest Neighbors (KNN) algorithm processes this sensor data to enhance stress level estimation. By integrating facial and physiological metrics, the system provides a real-time, non-intrusive, and accurate assessment of stress, making it valuable for mental health monitoring and intervention.

IV. Theoretical framework

The theoretical framework of this stress detection system is rooted in computer vision, deep learning, and physiological signal processing. It leverages OpenCV's Haar cascade algorithm for efficient face detection and Convolutional Neural Networks (CNNs) for emotion recognition. The CNN model is trained on a diverse dataset to accurately estimate stress levels from facial expressions. Complementing this, a K-Nearest Neighbors (KNN) algorithm processes physiological data collected from the MAX30100 sensor, which monitors heart rate and oxygen saturation. Together, these techniques provide a multi-modal approach to stress detection by integrating facial and physiological cues.

This framework is supported by **machine learning principles**, enabling real-time, adaptive stress assessment. By fusing facial recognition and biometric data, the system minimizes **subjectivity and reliance on self-reported stress levels**, ensuring **objective and quantifiable results**. The combination of CNNs for deep feature extraction and KNN for physiological pattern analysis enhances the **accuracy and reliability** of stress detection, making it suitable for **mental health applications, workplace monitoring, and personal well-being initiatives**.

V. RESEARCH METHODOLOGY

5.1. Facial Expression Analysis:

Facial images are captured using a web camera. OpenCV's **Haar cascade algorithm** is used for robust face detection. A **pre-trained Convolutional Neural Network (CNN)** model processes facial expressions to estimate stress levels.

5.2. Physiological Data Processing:

Physiological signals (heart rate, oxygen levels) are measured using the **MAX30100 sensor**.A **K-Nearest Neighbors (KNN)** algorithm processes the sensor data to enhance stress level classification.

5.3. Integration of Facial and Physiological Data:

Machine learning techniques synthesize facial and physiological metrics for a **comprehensive stress assessment**.
The system generates **real-time insights** to improve mental health monitoring and interventions.

VI. SYSTEM DESIGN

The integrated system involves: (1) Capturing facial data using OpenCV, (2) Stress estimation via CNN, (3) Physiological signal acquisition from MAX30100, (4) Emotion analysis using KNN, and (5) Merging outputs for final stress evaluation.

VII. HARDWARE COMPONENTS

The hardware consists of the Node MCU ESP8266 microcontroller, MAX30100 pulse oximeter and heart rate sensor, and DHT11 temperature/humidity sensor. These sensors collect real-time physiological signals such as heart rate and SpO2, which contribute to stress assessment.

VIII. SOFTWARE DESCRIPTION

The system is implemented using Arduino IDE for embedded coding and Python (OpenCV, TensorFlow, and Scikit-learn) for AI processing. CNN models are trained using TensorFlow and the KNN classifier processes live data from the MAX30100 sensor.

IX. RESULTS AND DISCUSSION

The system achieves real-time and accurate stress detection by integrating CNN and KNN techniques. Validation tests confirm its robustness and potential use in workplaces, schools, and personal wellness applications. It effectively identifies stress based on both emotional expressions and physiological signals, providing a comprehensive solution for mental health monitoring.

X. ACKNOWLEDGEMENT

We express our sincere gratitude to everyone who contributed to the successful completion of this research. We extend our deepest appreciation to Mahendra Institute of Technology, Department of Biomedical Engineering, for providing invaluable resources and guidance throughout this study. Special thanks to our mentors and colleagues for their insightful discussions, constructive feedback, and unwavering support, which played a crucial role in shaping this work. We also acknowledge the assistance received from the project coordinators and laboratory staff for their technical and administrative support.

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