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AI ENABLED IOT BASED AUTISIM CARE SYSTEM FOR IMPROVING COGNITIVE ABILITY OF CHILDREN WITH AUTIM DISORDER

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ABSTRACT

Smart monitoring and assisted living systems for cognitive health assessment play a central role in assessment of individuals' health conditions. Autistic children suffer from some difficulties including social skills, repetitive behaviors, speech and nonverbal communication, and accommodating to the environment around them. %us, dealing with autistic children is a serious public health problem as it is hard to determine what they feel with a lack of emotional cognitive ability. Currently, no medical treatments have been shown to cure autistic children, with most of the social assistive research to date focusing on Autism Spectrum Disorder (ASD) without suggesting a real treatment. In this paper, we focus on improving cognitive ability and daily living skills and maximizing the ability of the autistic child to function and participate positively in the community. %rough utilizing intelligent systems based Artificial Intelligence (AI) and Internet of %ings (IoT) technologies, we facilitate the process of adaptation to the world around the autistic children. To this end, we propose an AI-enabled IoT system embodied in a sensor for measuring the heart rate to predict the state of the child and then sending the state to the guardian with feeling and expected behavior of the child via a mobile application. Further, the system can provide a new virtual environment to help the child to be capable of improving eye contact with other people. %is way is represented in pictures of these persons in 3D models that break this child's fear barrier. %e system follows strategies that have focused on social communication skill development particularly at young ages to be more interactive with others.

INTRODUCTION

Cognitive impairment is a brain condition resulting from trauma such as old age, falls, road accidents or sports-related injuries, or other causes, including vascular, infective, or inflammatory insults [1]. Some signs of cognitive impairment are memory concerns, or other cognitive complaints. Cognitive assessment assists individuals who cannot efficiently carry out their routine activities to promote sustainability

and

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support independent living. Nowadays, intelligent systems based AI technologies are widely used in smart cognitive health and medical applications for health monitoring of individuals with diseases to avoid possible risks [2]. %ese AI based systems do not complain fatigue; thus, they can process large quantities of data at very high speed outperforming humans accuracy in the same job [3, 4]. Machine learning and AI techniques are used in medical technologies to improve the diagnostic capability of clinicians, especially in multidisease diagnosis [5–9]. With progress in employing intelligent AI systems with help of IoT in healthcare, patients can be diagnosed professionally and faster; thus, they may start treatment sooner. On the other hand, IoT has been the key part of the Internet [10, 11]. It has been used in many domains such as identifying objects, determining the location and sensing changes in physical data. %e descriptive models for IoT are introduced based on two attributes ("being an Internet", "relating to thing's information") and different features based on the thing's information [12, 13]. Autism is a neurological disorder that affects the ability to communicate and interact socially. It can be defined as a neurobehavioral condition that involves weaknesses in communication skills and social interaction and developmental language combined with repetitive behaviors. Because of the range of symptoms, this is called Autism Spectrum Disorder (ASD) [14, 15]. %e cause of the increasing number of autistic children is not yet known. However, early intervention is critical to enabling a positive long-term outcome, and even with early intervention, many individuals will need high levels of support and care throughout their lives [16, 17]. Children with difficulties in relating and communicating may fall within a wide series of disorders such as autistic spectrum disorder, language processing disorders, attention disorders, and sensory or regulatory disorders. %e child gets a diagnosis established by the observation of the behaviors outlined above. Although the child may share a common diagnosis with others, each child is unique in his processing of sensory as a unique pattern of development and functioning [18, 19]. One of the difficulties we face when dealing with the children is to determine what they feel, especially autistic children, as those with this disease suffer from a difficulty in accommodating to the environment around them. One way to overcome this problem is by using assistive technologies and finding ways how to benefit from the use of technology of intelligent systems to help these children. An assistive smart environment has the effort to improve the quality of life for large populations of users: elderly, individuals with physical impairments, and individuals with cognitive disabilities and developmental and social disorders [20, 21]. %e primary goal of this research is to establish a supportive environment using IoT and AI technology to help autistic children in communicating with others in an easy and flexible way. %e main problem of autistic children is considered in expressing their feelings and in communicating with others. Also, they suffer from an inability to connect visually. %us, we suggest a new technical solution to help them interact with people visually and use the technology to make this easy for interaction. It can be done by using computer graphics to make a three-dimensional model that simulates the real person, whom we want the autistic child to interact with visually and acoustically. In this paper, we proposed and implemented an intelligent system prototype based on machine learning algorithms and an assistive smart environment for promoting learning and developing interaction with autistic children life. %e main objective is to convert the child's state to emotion and send it to the guardian. Looking for the best way to know the state of the person, we found that the heart rate reading is the most accurate. So, we choose sensor "Heartbeat" for reading the heart rate because it is easy, accurate, and practical in use. %is sensor is embodied in the form of a hand watch to be suitable for children, and it will read the heart rate, which is converted to numeric values representing the heart rate. %ese values are classified by the retrained classification models. %en, based on the classification result, a message is sent with the state of child feeling via mobile application to the guardian or a charge person. Also, the system will help in affording different activities of the child with scheduling and alerting the mother when it is time. Further, the system can provide a new virtual environment to help the child to be capable of improving eye contact with other people. %is way is represented in pictures of these persons in 3D models that break the child's fear barrier. %e system follows strategies that have focused on social communication skill development particularly at young ages from 4 to 12 years to be more interactive with others.

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Wearable devices are rapidly spreading thanks to multiple advantages. Their use is expanding in several fields, from medicine to personal assessment and sport applications. At present, more and more wearable devices acquire an electrocardiographic (ECG) signal (in correspondence to the wrist), providing potentially useful information from a diagnostic point of view, particularly in sport medicine and in rehabilitation fields. They are remarkably relevant, being perceived as a common watch and, hence, considered neither intrusive nor a cause of the so-called “white coat effect”. Their validation and metrological characterization are fundamental; hence, this work aims at defining a validation protocol tested on a commercial smartwatch (Samsung Galaxy Watch3, Samsung Electronics Italia S.p.A., Milan, Italy) with respect to a gold standard device (Zephyr BioHarness 3.0, Zephyr Technology Corporation, Annapolis, MD, USA, accuracy of ±1 bpm), reporting results on 30 subjects. The metrological performance is provided, supporting final users to properly interpret the results. Moreover, machine learning and deep learning models are used to discriminate between resting and activity-related ECG signals. The results confirm the possibility of using heart rate data from wearable sensors for activity identification (best results obtained by Random Forest, with accuracy of 0.81, recall of 0.80, and precision of 0.81, even using ECG signals of limited duration, i.e., 30 s). Moreover, the effectiveness of the proposed validation protocol to evaluate measurement accuracy and precision in a wide measurement range is verified. A bias of −1 bpm and an experimental standard deviation of 11 bpm (corresponding to an experimental standard deviation of the mean of ≈0 bpm) were found for the Samsung Galaxy Watch3, indicating a good performance from a metrological point of view. Wearable devices are continuously spreading, thanks to their multiple advantages. Indeed, they are user-friendly, minimally intrusive/invasive, and they can be easily adapted to different tasks and users’ needs [1], creating a plethora of relevant applications. Their use is very often combined with artificial intelligence (AI) algorithms and machine learning (ML) classifiers, for both prediction and regression purposes [2]. The application fields are the most various, from sleep stage classification [3] to automated diagnoses [4], as well as thermal comfort assessment [5], sport applications (e.g., rugby [6], football [7], swimming [8], and tennis [9]), rehabilitation, and management of patients with neurological disorders [10,11,12]. In fact, wearable sensors allow the assessment of a plethora of relevant physiological signals, like heart rate (HR) and its variability (HRV) [13,14] obtained via an ECG at wrist [15], the saturation of blood oxygen (SpO_2) [16], and energy expenditure [17]. Also, diverse quantities can be indirectly estimated through dedicated procedures, like blood pressure [18,19] or breathing rate [20,21]. Such devices are extremely powerful in the context of remote monitoring and in recent years, there has been a continuously growing request for wireless wearables for diagnostic purposes, thanks to the development of AI technologies. Certainly, data quality is fundamental to obtain robust models: Dong [22] evaluated data leakage in ML algorithms ingesting data from sports wearable sensors, considering variables coupling through a Bayesian approach. The importance of data quality was stressed also by Kunze et al. [23], who evaluated the potential benefits of AI techniques in the orthopedic field, in the perspective of a real transformation of clinical practice towards more automated procedures (but the measurement results must be adequately accurate). Similarly, Xu et al. [24] highlighted the importance of identifying "free-of-noise" data to be ingested by ML algorithms for mobile health (mHealth) applications, in particular in the context of electrocardiographic (ECG) and respiratory signals.

It is worthy to note that ECG signals are mostly exploited to identify cardiovascular issues. Convolutional neural network (CNN) results tend to be the most utilized method (exploited in 52% of the analysed papers); gated recurrent unit (GRU) and long short-term memory (LSTM) are also very common for the identification of cardiac arrhythmias and abnormal heartbeats [25,26]. On the other hand, activities classification is commonly based on accelerometer and gyroscope data [27,28,29]. However, ECG-related features are also correlated to activity level, since the HR is expected to be higher during (and immediately after) a physical exertion [30]. The discrimination between rest and activity conditions can be particularly useful in the context of rehabilitation, where personalized therapeutic indications can be provided according to the activity level achieved by the patient at a precise moment. Furthermore, such distinction can be significant to evaluate the patient's state in pathologies such as depression and other mood disorders, where activity represents an important discriminant [31]. This distinction made by a wrist-worn sensor is also more significant, since a smartwatch is not perceived as intrusive (not even by ageing people or subjects with mental disorders), thus it can provide results while avoiding the so-called "white coat effect". On the other hand, literature studies focus more on the classifiers' performance than on the metrological performance of the used sensors, leaving these aspects scarcely investigated, even if their relevance is very high, especially in health-related applications. It is worthy to remind the reader that the metrological performance can be intended as the ensemble of metrological characteristics describing the performance of a sensor from a metrological point of view, e.g., accuracy, precision, and confidence interval. In fact, the expanding medical applications of wearable sensors result in the need for validating the measurement signals. Only in this way can the gathered data be properly interpreted; moreover, it is possible to evaluate if the measurement accuracy is suitable for a specific application. Indeed, a proper metrological performance is required in such fields and the validity of wearable sensors must be demonstrated considering the needs of the target application. However, despite the rapidly growing use of wearable sensors, manufacturers/researchers rarely perform a rigorous metrological characterization. As a consequence, the measurement accuracy and precision data related to this type of measurement device are generally incomplete (or even missing). Moreover, to the best of the authors' knowledge, at present, no test protocols have been defined and widely adopted to validate wearable devices from a metrological point of view. Each study is performed according to its own experimental procedure and the results are expressed with diverse metrics, resulting in data that are scarcely comparable to what is available in literature. Even when manufacturers provide information on measurement accuracy, the evaluation procedure remains unknown, rendering the evaluation non-replicable.

The authors would like to propose a meticulous method to characterize wearable sensors from a metrological point of view, providing rigorous evaluation metrics for the correct interpretation of the measurement results. Hence, the main aim of this study is to present a rigorous test protocol for the metrological characterization of wireless wearable devices for ECG monitoring and the assessment of HR. The metrological performance is evaluated on a commercial smartwatch in comparison to a reference device in terms of measurement accuracy and precision, linear correlation with a reference device, and statistical confidence of the measurement. Moreover, the authors used the ECG data collected from the wrist-worn wearable sensor as input for a few ML classifiers, which have been tested to distinguish among resting and activity-related signals (without using standard activity-related data, as those from accelerometers and gyroscope). Finally, the authors also tested an LSTM model for the same classification purposes, using raw ECG time-series segments.

L. J. Baptist Andrews, L. Raja, and S. sundaram Suresh, "Mhealth applications providing a way through community development and its necessity," Journal of Computational and 8eoretical Nanoscience, vol. 18, no. 3, pp. 850–856, 2021.

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The electrocardiogram (ECG) is a non-invasive tool used to diagnose various heart conditions. Arrhythmia is one of the primary causes of cardiac arrest. Early ECG beat classification plays a significant role in diagnosing life-threatening cardiac arrhythmias. However, the ECG signal is very small, the anti-interference potential is low, and the noise is easily influenced. Thus, clinicians face challenges in diagnosing arrhythmias. Thus, a method to automatically identify and distinguish arrhythmias from the ECG signal is invaluable. In this paper, a hybrid approach based on marine predators algorithm (MPA) and convolutional neural network (CNN) called MPA-CNN is proposed to classify the non-ectopic, ventricular ectopic, supraventricular ectopic, and fusion ECG types of arrhythmia. The proposed approach is a combination of heavy feature extraction and classification techniques; hence, outperforms other existing classification approaches. Optimal characteristics were derived directly from the raw signal to decrease the time required for and complexity of the computation. Precision levels of 99.31%, 99.76%, and 99.47% were achieved by the proposed approach on the MIT-BIH,EDB, and INCART databases, respectively. Cardiac arrhythmia, a disease characterized by irregular heart activity [1]–[3] and a cardiac condition associated with the rhythm of the heartbeat or heart rate, is the main source of cardiac mortality. It is reported that about 2200000 people in the US and 4500000 people in EU annually die from arrhythmia [4], which exceeds the mortality of all cancers combined. An arrhythmia is a concern with the rate or rhythm of the heartbeat. The heart may beat excessively quickly, too slowly or in an unaccountable rhythm during arrythmia. The disorder is called tachycardia when the heart beats too quickly. The condition is called bradycardia when a heart beats too slowly [5]. Various studies have been conducted using computer-aided detection (CADe) to precisely forecast arrhythmia in order to enhance diagnostic efficiency [6]–[8]. Thus, This work aims to early alerts for unusual disorders may be given by creating a computational framework focused on machine learning that rapidly, correctly, and consistently diagnose cardiac arrhythmia such that qualified doctors can provide appropriate care. However, because of the variance of ECG signals and the changes in the recording environment, this is still a challenge for a computer to execute automatically. For a healthy person, even in a short time, morphology and rhythm may vary considerably. Many methods for generic heartbeat categorization with ECG-based signal were proposed. A fully-automatic approach to detect arrhythmia from signals collected by the electric cardiogram (ECG) system can be used in four phases: (1) ECG preprocessing signal (2) signal segmentation, (3) Features extraction and (4) classification. In each of the four steps, an action is taken, and the goal is to discriminate/classify the type of heartbeat [9], [10]. Different techniques have been extensively investigated for preprocessing phase and features extraction phases [11]–[13]. The methods employed in the preprocessing step greatly influence and are selected as such for the final output. The results of the cardiac segmentation process in the instance of QRS detection are nearly optimal. While the subject of ECG delineation is essential, the methodologies studied here are only of little significance. Researchers have been led to optimize the accuracy level in numerous ways for ECG classification strategies, thus neural fuzzy networks [14], [15], genetic algorithms [9], Bayesian approaches [16], key component analysis based on support vector machine (SVM) [17], and key component analysis based on neural networks [18] have been suggested. The main contributions of this paper are summarized as follows: • An efficient architecture of deep CNN is designed. It folds four convolutional layers with two fully connected layer to improve the capacity of the CNN for ECG classification. The structure of the input data and convolution is revamped to satisfy the ECG classification process, where the input data is always in one dimension rather than multi-dimensions like traditional used input. Sub-sampling convolutional filters are adopted to extract more Plentiful features. We extended information about original heartbeat using different handcraft features (using different descriptors). The effectiveness and efficiency of deep CNN for ECG classification are evaluated. • A new training mechanism based on MPA-CNN learning generic features and fine-tuning classification parameters to learn the characteristic of heartbeats is proposed for ECG classification (CNN for classification task and MPA algorithm for optimizing learning parameters). The MPA-CNN is trained based on a large common dataset containing Plentiful ECG heartbeats, which accelerates the convergence of the MPA-CNN. Moreover, MPA-CNN accelerates learning time and provide high accuracy percentage. • We explore feature fusion and propose a novel scheme for combining CNN with handcrafted features. The scheme has two main advantages: First, handcraft features in CNN, which takes advantage of

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Vol 12 Issue1 Feb 2024

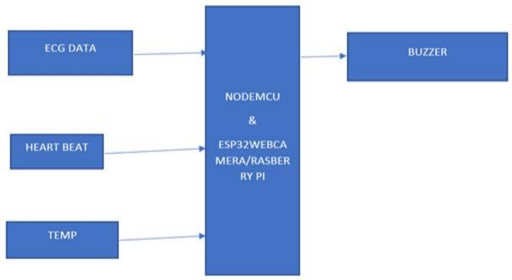
some robust and local features; second, discriminative handcrafted features help to improve the performance of original CNN and accelerate training time. • The available ECG datasets highly category imbalanced as regular heartbeats take place much more often than irregular heartbeats (over sampling for regular and under sampling for irregular), resulting in the majority of methods providing low sensitivity and positive predictive values for heartbeats classification. To solve the problem of imbalanced category classification, synthetic minority over sampling technique (SMOTE) is used for over sampling and Random under sampling for under sampling both are applied over the extracted handcraft features. • Several experiments are conducted on common benchmarking datasets, where the obtained results demonstrate the effectiveness of the proposed approach. The state-of-the-art performance is achieved using the MPA-CNN, and the events of VEB and SVEB can be identified accurately.

EXISTING SYSTEM

The existing AI-enabled IoT-based autism care system represents a cutting-edge approach to addressing the unique needs of children with autism spectrum disorder (ASD). This innovative system utilizes the power of artificial intelligence (AI) and the connectivity of the Internet of Things (IoT) to create a comprehensive solution for improving the cognitive abilities of children with autism. The system incorporates AI algorithms that analyze and adapt to the individualized learning patterns of each child, providing personalized interventions tailored to their specific cognitive challenges. IoT connectivity enhances the system's capabilities by enabling real-time monitoring of the child's activities, behaviors, and responses. The integration of smart sensors and devices allows for continuous data collection, contributing to a more accurate and dynamic understanding of the child's progress. This interconnected system facilitates remote monitoring by caregivers and healthcare professionals, fostering collaborative and data-driven approaches to autism care. By combining AI and IoT technologies, the existing system not only enhances the cognitive abilities of children with autism but also provides valuable insights for caregivers and professionals, ultimately contributing to a more effective and personalized approach to autism care.

IMPLEMENTATION

BLOCK DIAGRAM



The proposed system introduces an AI-enabled IoT-based Autism Care System designed to enhance the cognitive abilities of children with Autism Spectrum Disorder (ASD). This innovative solution leverages the power of Artificial Intelligence (AI) and Internet of Things (IoT) technologies to create a personalized and adaptive care environment. The system incorporates various sensors and devices strategically placed in the child's surroundings, collecting real-time data on their behavior, preferences, and responses to stimuli.

The AI component of the system utilizes machine learning algorithms to analyze the collected data and identify patterns specific to each child's needs and strengths. This information is then used to tailor therapeutic interventions and activities aimed at improving cognitive abilities such as communication, social interaction, and sensory processing. The system continuously learns and adapts its strategies based on the child's progress, creating a dynamic and individualized care plan.

IoT devices play a crucial role in creating a connected environment. Wearable sensors and smart devices are employed to monitor the child's physiological indicators, track their daily activities, and assess their emotional state. The data generated by these devices are seamlessly integrated into the AI model, providing a holistic view of the child's well-being. Additionally, caregivers and therapists can remotely access the system through a user-friendly interface, allowing them to monitor progress, adjust settings, and provide timely support.

This AI-enabled IoT-based Autism Care System not only serves as a powerful tool for therapeutic intervention but also fosters a more inclusive and supportive environment for children with ASD. By harnessing the capabilities of AI and IoT, the proposed system aims to revolutionize autism care, offering a personalized and data-driven approach that empowers both children and their caregivers in the journey towards improved cognitive abilities and enhanced quality of life.

CONCLUSION

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In this paper, we proposed an intelligent system with AIenabled Internet of %ings to help the autistic child adapt to the surrounding environment by determining the emotional state of the child through a sensor that reads the child's heartbeat that is classified by the machine learning models. Four classification models are tested, where SVM and RF were the best for this task. %en, a notification is sent with the child's state to the guardian with recommendations suitable for the child's emotion. Further, the application interface of the proposed system allows the guardian to remember a child's activities. In addition, this application helps autistic children who suffer from an eye contact problem, through interacting with the 3D graphical model. %e proposed system attempts to obtain emotional feelings in a group of autistic children by analyzing heart rate before, during, and after challenging behaviors. To achieve more security for the data, cloud computing services can be used to improve the results to be more accurate. Moreover, optimization algorithms can be performed to help parents in improving the behavior of their Autistic children in an easy way using this technology.

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