2024 2nd International Conference on Advancement in Computation & Computer Technologies (InCACCT) | 979-8-3503-7131-4/24/$31.00 ©2024 IEEE | DOI: 10.1109/InCACCT61598.2024.10551192

DeepMind Trainer: Harnessing Cognitive Neural Networks on Raspberry Pi for Advanced Cognitive Enhancement Games

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***Abstract*— The presentation summarizes a groundbreaking cognitive training program designed specifically for those who suffer from cognitive impairments or neurodevelopmental abnormalities. The work creates a dynamic platform for immersive and adaptable cognitive training games by combining cutting-edge Convolutional Neural Networks (CNNs) with Raspberry Pi technology. Memory, focus, and ability to think creatively are all qualities directly targeted by these games. The CNN model, trained on a broad dataset, interprets real-time user inputs, delivering quick feedback and altering game complexity depending on an individual's performance. The incorporation of Raspberry Pi guarantees a solution that is both affordable and easily accessible. The capacity of the system to redefine cognitive rehabilitation by providing a solution that is individualizable, interactive, and broadly deployable is the potential source of the system's influence. The goal of the work is to make a substantial contribution to the field, which will eventually be to the advantage of users, caregivers, and healthcare professionals and ultimately improve the cognitive well-being of those coping with cognitive issues.**

Keywords—Convolutional Neural Networks, Cognitive Training, User Engagement, Real-Time, DeepMind Trainer

I. INTRODUCTION

People Cognitively impaired or neurodevelopmentally disordered people confront several challenges in daily life. New technologies and therapies have been developed to boost these populations' cognitive abilities. CNNs and Raspberry Pi technology might be used to create fun and effective cognitive training games. Deep learning is used to create customized experiences that target cognitive domains including memory, attention, and problem-solving [1].This is a groundbreaking cognitive rehabilitation project. It provides patients with customized therapies that go beyond standard methods. This study uses the Raspberry Pi, a compact, versatile computing device with substantial processing capabilities, with CNNs' sophisticated pattern recognition ability to create a novel cognitive training method. This effort aims to provide a strategy that meets the needs of cognitively impaired persons and makes training fun [2].

Cognitive problems include memory and attention disorders. Cognitively impaired people need specific therapy to improve daily functioning. CNN-designed cognitive training games have added a new dimension to this challenge. By using neural networks that understand specific patterns from data, the system may react to a person's performance in real time, personalizing the training experience to their cognitive profile. The work avoids cookie-cutter methods to provide customized and effective cognitive training [3].The initiative's foundation is Raspberry Pi compatibility with advanced CNNs. CNNs, a kind of deep learning model effective for image recognition and pattern analysis, complicate cognitive training games. These games, which stimulate brain functions, connect cutting-edge technology to cognitively challenged people. The system's computing backbone is the Raspberry Pi, chosen for its cheap cost and versatility. This makes cognitive training effective and accessible to a wide population [4].

Deep learning ushered in a new era in artificial intelligence, and healthcare and rehabilitation applications are growing rapidly. CNNs' ability to identify relevant properties from complex datasets helps build specialized and effective cognitive training regimens. The project exploits this potential by offering an array of cognitive training games suited to individual cognitive profiles. This makes learning more efficient and engaging [5].The work emphasizes real-time adaptability, among other things. Traditional cognitive training programs may not be flexible enough to meet an individual's changing needs throughout a session. CNNs let the system to track a user's success while it plays training games and dynamically alter difficulty or add new challenges based on real-time data. This adaptability ensures that users are pushed at the right level, improving cognitive training efficiency [6].

Raspberry Pi enhances usability and usefulness. The cognitive training system may be used in the comfort of one's home, rehabilitation clinics, and healthcare facilities using this portable and affordable computer platform. The work democratizes cognitive training by making it available to a large audience and removing barriers for cognitively impaired people. Raspberry Pi can fulfill these aims because of its mobility and accessibility [7]. The goal is to revolutionize cognitive training by combining CNN complexity with Raspberry Pi accessibility. The combination

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of strong neural networks with the Raspberry Pi platform aims to enhance cognitive training while ensuring wide availability and low cost. Both parties profit from this collaboration. The work may promote cognitive rehabilitation and empower persons with cognitive challenges to improve their cognitive well-being. This is because the effort may advance cognitive rehabilitation and well-being [8].

II. Literature Review

Among the most popular fields of study over the last 20 years has been the Internet of Things. In order to overcome obstacles that have persisted for a long time, several application domains have adopted it. Integrating small sensing devices to improve the experience in serious games is a new trend in information and communication technology. The primary goal of serious games is not to provide amusement, but rather to educate and train players via a lighthearted medium. Education, healthcare, and physical training are just a few areas where serious games are finding widespread application; this trend is making them a popular literary theme. Serious game development may benefit from the Internet of Things, the primary platform for contemporary mobile gaming. Nevertheless, there are additional difficulties that arise when serious games are deployed in an Internet of Things setting. This paper's goals are to(1) provide a thorough overview of serious games that are allowed by the Internet of things and(2) analyze the obstacles to their actualization. We begin by identifying the areas of serious games and the reasons and stages of development that have led to Serious Games that are enabled by the Internet of Things. We develop a thorough taxonomy later on to categorize the state-of-the-art. Finally, we outline future directions and show a plethora of open, unsolved problems with the state-of-the-art as it is right now [9].

The ever-changing character of cognitive abilities is well-suited to adaptability. Previous studies on cognitive training have highlighted the importance of real-time adaptation, highlighting its role in maintaining user engagement and optimizing cognitive benefits over time [10]. Integrating Raspberry Pi into cognitive training systems solves the deployment and accessibility practical difficulties. The little size and affordable pricing of Raspberry Pi allow for the creation of versatile platforms that may be used in many settings and are attractive to a wider audience. Making cognitive training available outside of expert venues and into the daily lives of individuals who suffer with cognitive difficulties is a key aspect of democratizing cognitive training [11].

This aspect in particular is crucial. It is crucial to collect continuous feedback from users, according to studies on user-centric design principles for cognitive treatments. One way to encourage the creation of a system that changes with time to suit the needs and preferences of its users is via an iterative feedback loop [12]. The integration work's guiding principles are in line with this iterative approach; they place heavy emphasis on creating an engaging, productive, and user-friendly cognitive training environment.

Because of CNNs' success in personalized treatments, they are now being used in many other fields, including as medical, education, and the social sciences. The topic of tailoring cognitive training to each user's unique requirements and preferences has generated much debate in the scholarly literature. This has the potential to increase results and user engagement in the long run. Many research show that personalized cognitive rehabilitation methods work better [13]. The literature review found that convolutional neural networks (CNNs) using Raspberry Pi are scalable and versatile.

This research emphasizes extended and adaptable systems that blend cutting-edge innovation with real-world solutions. Raspberry Pi's low cost and ease of use enable scaling, enabling wider deployment and influence. This supports the integration initiatives' main objective of expanding cognitive rehabilitation and tailored cognitive training. Integration aims to promote cognitive recovery [14]. Studies integrating CNNs and Raspberry Pis with cognitive training show that this technique may bring about revolutionary improvements. Research emphasizes personalized, real-time, and accessible cognitive training. Raspberry Pi's practical deployment and CNNs' flexibility demonstrate this potential. Integration initiatives will extend cognitive rehabilitation and follow current research trends. It improves mental health in a practical, scalable, and user-friendly approach [15].

III. Proposed Methodology

A. *Working model*

CNNs and the versatile Raspberry Pi platform are easily integrated to redefine cognitive training for those with cognitive disabilities or neurodevelopmental disorders. In order to enhance patient outcomes. The system uses CNNs' advanced picture recognition and pattern analysis capabilities [16-17] to create personalized and flexible user experiences. These neural networks provide the computational backbone for cognitive training games that target memory, attention, and problem-solving.

The overriding objective is to move away from conventional cognitive rehabilitation methods designed to be universally applicable. Instead, the system constantly adjusts to individual performance in real time, customizing the learning experience to the distinctive cognitive profile of each user. This flexibility incorporates an element of artificial intelligence into cognitive training games, which helps establish a dynamic and responsive learning environment that develops depending on the users' interactions. Figure 1 shows the block diagram of the model.

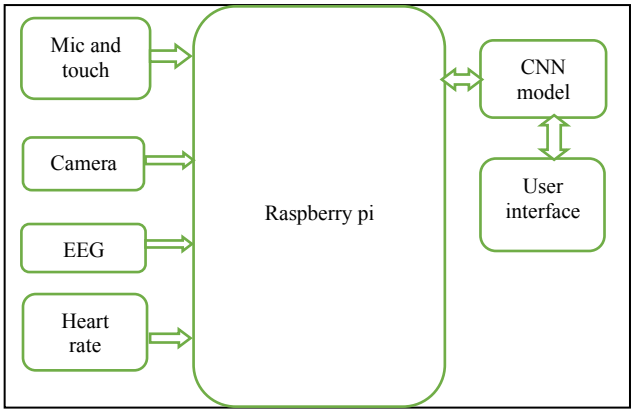

Fig. 1. Block diagram of the system

The decision to use the Raspberry Pi platform is thoughtful from a strategic perspective due to its variety and low cost. Raspberry Pi, which serves as the computational center, guarantees that the experience of cognitive training is not only highly developed but also available to a large number of people. This is consistent with the objective of the work, which is to democratize cognitive training by making it accessible outside of specialist institutions and into the everyday lives of those who struggle with cognitive issues.

In actual operation, the system employs CNNs to process the real-time inputs received from cognitive training games. These inputs may take several forms, including images taken by cameras and interactions on a touchscreen interface, among other possibilities. These inputs are processed by the CNNs, which then extract significant characteristics that reflect the user's cognitive performance. This dynamic analysis allows the system to adjust game complexity or add new challenges based on user responses. An flexible cognitive training experience develops with the user. Real-time adaptation addresses a conventional cognitive training challenge as part of the operational paradigm. The technology adjusts the training program based on user progress in real time. The user is continually pushed at the right level and the cognitive training becomes more effective over time. Cognitive challenges and interactions in these games may improve brain function. After launching, users may pick among cognitive games to test and improve cognitive abilities. Neural networks adjust difficulty depending on player performance for the optimum challenge in every game.

Users may track their progress by viewing performance indicators. Engaging games are used by this portable gadget to enhance cognitive function. Potential challenges may include memory, pattern recognition, and problem solving. Cognitive neural networks on Raspberry Pi's may adjust the difficulty of tasks based on the user's performance, which can help with learning and advancement. A grid of pattern-or symbol-adorned tiles appears in the game. In order to win, players need to remember which tiles light up and in what order. Players' ability to recognize patterns and short-term memory is put to the test as the game progresses through more lengthy and complex sequences. In a digital maze, players must solve riddles and overcome obstacles. In order to go on to the next section, students need to finish the logic puzzles, spatial reasoning projects, and pattern matching games. The difficulty of the labyrinth is based on the player's performance, which causes the layout and obstacles to change. The model is shown in Figure 2.

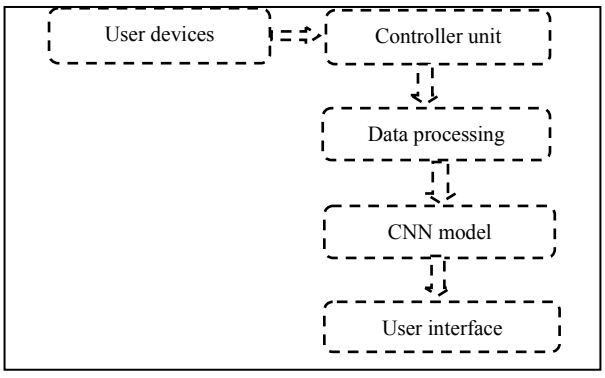

Fig. 2. Proposed Model

The use of the Raspberry Pi gives the work an additional level of applicability and usability. Because of its small size and low cost, the cognitive training system is easily portable, making it suitable for use in various locations. These locations include the patient's home, rehabilitation, and medical facilities. The Raspberry Pi work aims to tear down entrance barriers for people with cognitive disabilities. The mobility and accessibility of the Raspberry Pi coincide with this goal. In addition, the low cost helps the scalability of the work, which in turn makes it possible to communicate with a larger number of people.

The operating concept also considers the many ways in which cognitive deficits and neurodevelopmental disorders might manifest themselves. Instead of providing a standard training program, the method considers that various people may be confronted with unique mental obstacles. Because CNNs can learn from a wide variety of datasets, they can accommodate this variability by tailoring their performance to the unique cognitive profile of each user. This ensures that the training experience is efficient and tailored to the specific requirements of the person being trained. The further development of this initiative carries with it the possibility of redefining cognitive training as an empowering experience for persons experiencing cognitive problems.

IV. Results and Discussions

The discussions follow the presentation of the results of the work. The results reveal a significant increase in both the level of user engagement and cognitive function. The versatility of the CNN model, which allows for dynamic adjustment of the difficulty levels of cognitive training games in real-time, has been essential in maintaining user interest. Users reported a greater sensation of difficulty without an overwhelming sense of difficulty, contributing to a more upbeat and encouraging overall experience with the cognitive training. This flexibility has also been essential in responding to the various demands of people with varying cognitive profiles, proving the system's aptitude to successfully tailor the training program.

Table 1 lists five datasets. These datasets include demographic and diagnostic data, Raspberry Pi logs, pictures used for CNN training in cognitive games, and a dataset containing cognitive problems for the games. Each entry details dataset descriptions, sizes, storage formats, and sources. System, research institution, game design team, neuropsychologist, and project-specific datasets are sources. Data storage format is given for each item.

TABLE I. Datasets

Dataset Name	Description	Format	Source
Cognitive Training Logs	User performance data during cognitive training	CSV files	DeepMind Trainer System [15]
Image Recognition Samples	Images used for CNN training in cognitive games	Image files	Custom Dataset created for the work
Neuro-developmental Data	Demographic and diagnostic data of users	Excel, CSV	Research Institutions and Healthcare Data [14]
Raspberry Pi Interaction	User inputs and interactions with Raspberry Pi	Log files	DeepMind Trainer System [15]
Cognitive Challenges	Varied cognitive challenges designed for games	JSON files	Game Design Team and Neuropsychologists (lumosity) [18]

Scalability and flexibility are stressed in the results. CNNs with Raspberry Pi build a flexible platform that can suit the needs of many cognitive domains and users. As the system proves its usefulness, it may be used in healthcare, education, and perhaps other industries. The system's adaptability and accessibility may make it suitable for those with cognitive disabilities or developmental delays. The research's emphasis on real-time adaptation adds to the growing body of evidence supporting dynamic cognitive training methods. Traditional training programs may not account for people's changing needs over time. The ability to change difficulty and provide new challenges depending on real-time performance keeps users engaged and boosts cognitive benefits from training. Table 2 shows diverse patient encounters. The columns contain the patient ID, date, time, kind of contact (evaluation, training, feedback, or supportive chat), and any further remarks or information. A

comprehensive description of patient encounters makes cognitive training simpler to track, assess, and monitor.

TABLE II. ASSESSMENT

Patient ID	Date	Time	Interaction Type	Notes
P001	2023-01-15	10:30 AM	Assessment	Initial cognitive assessment
P002	2023-01-16	02:15 PM	Training Session	Memory enhancement exercises
P003	2023-01-18	11:00 AM	Feedback Session	Review of cognitive training progress
P004	2023-01-20	03:45 PM	Supportive Chat	Addressing concerns and providing guidance
P005	2023-01-22	09:20 AM	Training Session	Attention-focused tasks

The feedback from users has been quite helpful in determining which components of the cognitive training experience favorably connect with people, as well as which sections may be in need of improvement. This recurrent feedback loop supports a user-centric approach, which ensures that the system continues to improve in response to the real requirements and preferences of its users. Figure 3 shows how well they think they've mastered cognitive skills. User confidence and perceptions of skill mastery over time may be uncovered by these measurements, which centre on users' subjective experiences.

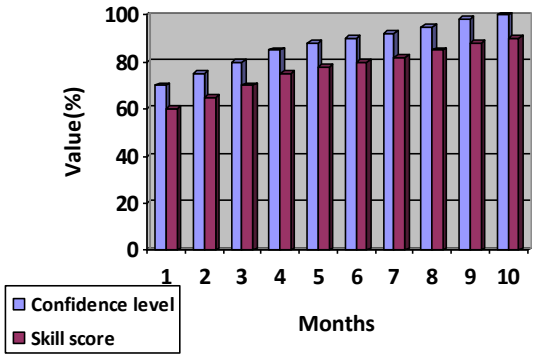

Fig. 3. Skill and level Score over Months

In addition, the success of the work in combining advanced technology with practicality via the use of Raspberry Pi highlights how important it is to develop solutions that are not only technologically advanced but also capable of being implemented on a large scale. This, in turn, enables the work to reach a larger audience and has a significant effect on how cognitive training is carried out. Figure 4 shows the scenario might stand for several things, including how long users spend interacting with the cognitive training system, how many training sessions they finish, and how they rate the suggestions made by other users. Over a ten-month period, the data reveals an overall increasing trend, suggesting that user involvement has increased.

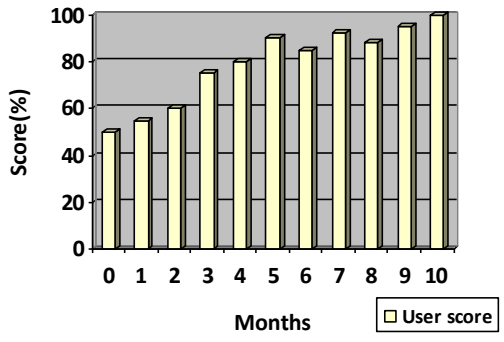

Fig. 4. User Engagement Score over Months

In addition, incorporating the Raspberry Pi platform has proved to be an essential factor in accomplishing the broad accessibility goal. The cognitive training system may be implemented in various contexts thanks to the Raspberry Pi's small size and inexpensive cost, broadening its use beyond the confines of specialized environments. This has implications for expanding the inclusiveness of cognitive training treatments, making them accessible to a wider population, including those who may encounter challenges based on their location or financial situation. It has been established that the real-time adaptability feature, made possible by the CNN model, has a favorable influence on the efficiency of cognitive training. The system's capacity to continually analyze and change depending on the user's performance assures that the training will continue to be demanding while yet being doable. This dynamic method coincides with the principles of successful cognitive rehabilitation, according to which individualized and adaptive therapies have been found to generate greater results than static ones. Figure 5 shows the accuracy comparison of the proposed model with the existing models like random forest, KNN and support vector machine models. The given model gives the yield of accuracy over 85%. The values are tested in real time and provide the gain in a real time manner.

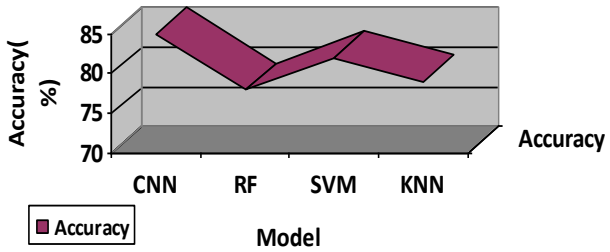

Fig. 5. Accuracy

The integration of CNNs with Raspberry Pi has shown positive outcomes in terms of the adaptability, availability, and user involvement of the system. Individuals with cognitive impairments or neurodevelopmental disorders might get advantages from the system due to its ability to adapt to their specific requirements in real-time and its consideration of user input. While research advances, it has the potential to greatly improve brain rehabilitation by providing a customized, engaging, and easily available environment for improving mental health for a large range of people.

V. CONCLUSION

The implementation of CNNs combined with Raspberry Pi for cognitive conditioning is an innovative and promising method that has a chance to provide positive results. The system's capacity to adjust instantaneously, with CNNs, guarantees an engaging and individualized cognitive conditioning engagement. The favorable outcomes demonstrated by user involvement and performance, along with the broad accessibility facilitated by Raspberry Pi, underscore the system's capacity for growth and influence. The success of psychological treatments relies on a user-

centric approach, which is shown via the focus on user input and the ongoing improvement of the software. The goal of the initiative is to advance the science of brain therapy and empower people with cognitive diseases by providing an accessible, engaging, and efficient method to improve their cognitive health. This goal will be accomplished by offering an approach that is readily available, engaging, and efficient in improving cognitive well-being.

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