DEVELOPMENT OF NEUROMORPHIC ARTIFICIAL INTELLIGENCE FOR PHYSIOTHERAPEUTIC POSTURAL ASSESSMENT INTEGRATED WITH OPENCV

DESENVOLVIMENTO DE INTELIGÊNCIA ARTIFICIAL NEUROMÓRFICA PARA AVALIAÇÃO POSTURAL FISIOTERAPÊUTICA INTEGRADO AO OPENCV

DESARROLLO DE INTELIGENCIA ARTIFICIAL NEUROMORFICA PARA EVALUACIÓN POSTURAL DE FISIOTERAPIA INTEGRADA CON OPENCV

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ABSTRACT
This paper presents the development of a computational system aimed at automating physiotherapy postural assessments, using neuromorphic artificial intelligence and computer vision techniques with the OpenCV library in Python. The system captures images of patients during assessments and performs advanced analyses using neuromorphic networks to identify and predict postural deviations, contributing to more accurate diagnoses of musculoskeletal pathologies. The proposal will be implemented in a clinic located in Mocajuba, Pará, aiming to increase the efficiency of postural monitoring, reduce manual errors, and optimize the time of physiotherapy professionals.

Keywords: Neuromorphic Artificial Intelligence. OpenCV. Physiotherapeutic Postural Assessment. Automated Musculoskeletal Diagnostics.

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RESUMO

Este trabalho apresenta o desenvolvimento de um sistema computacional voltado à automatização de avaliações posturais fisioterapêuticas, utilizando técnicas de inteligência artificial neuromórfica e visão computacional com a biblioteca OpenCV em Python, o sistema captura imagens dos pacientes durante as avaliações, e realiza análises avançadas, por meio de redes neuromórficas, para identificar e prever desvios posturais, contribuindo para diagnósticos mais precisos de patologias musculoesqueléticas. A proposta será aplicada em uma clínica localizada em Mocajuba-PA, visando aumentar a eficiência no monitoramento postural, reduzir erros manuais e otimizar o tempo dos profissionais de fisioterapia.

Palavras-chave: Inteligência Artificial Neuromórfica. OpenCV. Avaliação Postural Fisioterapêutica. Diagnósticos Musculoesqueléticos Automatizado.

RESUMEN

Este trabajo presenta el desarrollo de un sistema computacional orientado a la automatización de evaluaciones posturales fisioterapéuticas, utilizando técnicas de inteligencia artificial neuromórfica y visión por computador con la librería OpenCV en Python. El sistema captura imágenes de los pacientes durante las evaluaciones y realiza análisis avanzados, a través de redes neuromórficas, para identificar y predecir desviaciones posturales, contribuyendo a diagnósticos más precisos de patologías musculoesqueléticas. La propuesta se implementará en una clínica ubicada en Mocajuba-PA, con el objetivo de aumentar la eficiencia en el monitoreo postural, reducir errores manuales y optimizar el tiempo de los profesionales de fisioterapia.

Palabras clave: Inteligencia Artificial Neuromórfica. OpenCV. Evaluación Postural Fisioterapéutica. Diagnóstico Musculoesquelético Automatizado.

1 INTRODUCTION

Artificial Intelligence (AI), as a field of research, had its formal origin in the summer of 1956, being driven by pioneers such as John McCarthy, Marvin Minsky, Alan Newell, and Herbert Simon (SICHMAN, 2021). Since then, the trajectory of AI has been marked by cycles of advances and stagnations, configuring a non-linear path of development, often compared to a sinusoidal curve.

In recent decades, there has been a new cycle of accelerated expansion of AI, driven mainly by large-scale language models (LLMs). According to Carraro (2023), these technologies reached more than 100 million users in just two months, making it the fastest adoption technology in history. Ramkumar et al. (2022), highlight that: Artificial Intelligence can be seen as the fourth industrial revolution and the emerging frontier of medicine. At the same time, new approaches have emerged with a promising practical approach, such as neuromorphic artificial intelligence – a paradigm that aims to replicate the neural architecture of the human brain, promoting solving complex problems more efficiently and with lower energy consumption (INDIVERI; CHICCA; DOUGLAS, 2011). The potential applications of neuromorphic computing are vast and varied, for example, these systems can be used to develop neural prostheses that communicate directly with the human nervous system, allowing for more natural and effective control of artificial limbs (Melo, 2024).

In the field of health, and in particular in postural physical therapy, AI has proven to be a powerful tool to improve accuracy in the diagnosis of musculoskeletal problems, anticipate rehabilitation results, and help personalize treatments, improving diagnoses and enhancing the work of physical therapists (Santos et al., 2024). According to Physiopedia contributors (2024), discussing the use of AI in health and rehabilitation, it highlights the application of AI algorithms to: learn, think, analyze, and even assist in clinical practices. Furthermore, it evidences the ability to seek relevant information, helping in the assertiveness of clinical decisions, impacting the reduction of medical errors in health practices. However, despite great potential, this type of digital health solutions still faces challenges such as a shortage of technological infrastructure (MV, 2023), as well as a deficiency in electrical infrastructure, especially clinics in isolated rural regions that are powered by electric generators (GestãoDS, 2024). Classical deep learning models rely on high-performance GPUs and have high power consumption, which makes their continued use in environments with limited infrastructure (Gelles, 2024). On the other hand, neuromorphic AI — based on networks of spiking neurons that process information by asynchronous spikes — drastically reduces power consumption and response latency, thanks to parallel processing and the absence of the memory bottleneck typical of Von Neumann architectures (Davies et al., 2018). These characteristics make SNNs especially suitable for postural assessment systems, capable of operating in real time and with low energy cost, filling the gap left by traditional models.

In view of this scenario, the present work proposes the development of an Intelligent system for physiotherapeutic postural assessment, based on neuromorphic AI and computer vision, using the OpenCV library in Python. The solution aims to automate the capture and analysis of postural images of patients, identifying postural patterns and contributing to more accurate and consistent diagnoses, with low energy cost and greater processing speed in the results.

The system will be applied at the FisioPilates Clinic, Dr. Raisa Dias, in Mocajuba-PA, aiming at the practical validation of the proposal in a real clinical context. Throughout this article, the theoretical framework, the methodological procedures adopted, the expected results, and the contributions of the system to regional physical therapy practice are presented.

2 PROBLEM

Postural assessment is a fundamental step in the physical therapy process, being decisive for the diagnosis of musculoskeletal pathologies such as scoliosis, hyperkyphosis and other postural changes. Musculoskeletal diseases (MSDs) represent a significant challenge to global and national public health, due to their high prevalence, impact on quality of life, and associated socioeconomic costs. According to the World Health Organization (2023), it is estimated that more than 1.7 billion people worldwide live with musculoskeletal conditions, making them the leading cause of years lived with disability, representing a challenge of great magnitude for public health systems. In Brazil, the situation is equally worrying. Data indicate that approximately 45% of the population suffers from chronic musculoskeletal pain, with a higher prevalence in adult and elderly women, especially in the lumbar region. (WSCIEKLICA et al., 2023)

Despite the clinical importance of postural assessment in physical therapy, daily practice still relies heavily on traditional methods based on visual observation and manual recordings. These techniques, in addition to requiring a high degree of experience from the professional, are characterized by low standardization, a high degree of subjectivity, and inter- and intra-rater variations, compromising the reproducibility and accuracy of the diagnosis. Studies have shown that manual assessments can show agreement of less than 70% between different physiotherapists, making it difficult to make safer and more consistent clinical decisions (Pfeiffer & Pfeil, 2018).

In addition, the time required to carry out these evaluations, combined with the overload of work in public clinics or those with few resources, contributes to delays in diagnosis, prolonged queues for care and reduction in the personalization of treatments, directly affecting the quality of physiotherapeutic care provided.

Although there are technological solutions on the market, such as PostureScreen Mobile® and PhysioCode, which are based on computer vision for postural analysis, these tools have critical limitations for the Brazilian context. First, the cost of acquisition and maintenance is high, requiring a monthly subscription and high-performance mobile devices, which makes it unfeasible for clinics in regions with limited infrastructure to adopt them. In addition, these platforms do not perform fully automated analysis in real time — they still require manual intervention to mark anatomical points, which compromises the efficiency of the process and perpetuates the risk of human error.

Another important limitation is that these tools operate with classic AI models, which require large computational power (GPUs or cloud), resulting in high energy consumption and higher response latency — aspects incompatible with the reality of public, rural, or mobile clinics, which often operate with an unstable network or dependence on electrical generators (MV, 2023; GestãoDS, 2024).

In view of this scenario, the need for a technological solution that overcomes the aforementioned limitations is evident, providing automated, efficient and low energy cost postural assessment. Neuromorphic artificial intelligence, based on spiking networks (SNNs), emerges as an innovative alternative: it processes data asynchronously and in parallel, with energy consumption up to 1,000 times lower than conventional models (Davies et al., 2018). Integrated with the OpenCV library in Python, this approach allows the capture and analysis of postural images autonomously and embedded, even on low-power devices, enabling real-time, scalable clinical applications accessible to contexts with limited infrastructure.

This proposal represents a significant advance over existing solutions, by combining technological accessibility, diagnostic automation and energy efficiency — three fundamental elements to democratize access to quality physiotherapy in Brazil.

2.1 NEUROMORPHIC ARTIFICIAL INTELLIGENCE

Given the limitations of traditional postural assessment methods and existing commercial solutions, it becomes imperative to explore innovative approaches that meet the specific needs of physical therapy, especially in resource-limited settings. In this scenario, Neuromorphic Artificial Intelligence emerges as a promising solution, offering energy efficiency and real-time processing, essential characteristics for clinical applications.

Neuromorphic artificial intelligence is an innovative approach to computing, which according to Caballar and Stryker (2024), is also known as: neuromorphic engineering, where it is directly inspired by the functioning of the human brain, to process information and solve complex problems. In the view of Ivanov et al. (2022), it is highlighted that unlike traditional neural networks, based on the Von Neumann model, which operate with continuous and synchronous operations, neuromorphic networks process data asynchronously, with parallel processing, based on events, mimicking the energy efficiency and synaptic plasticity observed in biological systems, through discrete electrical impulses, known as "spikes", mimicking the behavior of biological neurons. This concept is approached as a way to mitigate the limitations of modern computing systems, especially neural networks based on the Von Neumann architecture.

Neuromorphic networks use spiking neurons (SNNs), which faithfully replicate the behavior of biological neurons through discrete electrical impulses (*spikes*). As highlighted by Maass (1997), these networks represent the "third generation" of neural models, where information is temporally encoded through discrete events, in contrast to the continuous values used in conventional neural networks (DNNs). This time coding allows for greater energy efficiency, since processing occurs only when neurons reach pre-defined thresholds, reducing redundant operations (DAVIES et al., 2018).

For Schuller and Stevens (2015), neuromorphic architecture seeks to overcome the limitations of traditional computing, such as the memory bottleneck and high energy consumption inherent to the Von Neumann model. In addition, platforms such as the Loihi chip, developed by Intel Labs, demonstrate that SNNs can achieve energy efficiencies up to 1,000 times higher than conventional systems in unsupervised learning tasks (DAVIES et al., 2018). Roy et al. (2019), comment that scalability in neuromorphic systems and their compatibility with *in-memory computing* paradigms position them as promising candidates for the next generation of artificial intelligence, especially in contexts where latency and energy consumption are critical.

In the context of healthcare, especially in physiotherapy, the application of postural assessment systems with neuromorphic AI offers significant advantages. These systems can operate in real time, with low energy consumption, enabling immediate feedback during Posture Assessment sessions, even in environments with limited infrastructure. Similar approaches are already under development, such as the *PosePilot* system, which uses artificial intelligence for automatic recognition of human posture and provides personalized feedback on postural correction in real time, overcoming the limitations of traditional fitness solutions (Gadhvi, Desai, and Siddharth, 2025).

The adoption of this technology is driven by the need for sustainable solutions in the energy field for emerging computational challenges, because according to Gelles (2024), data centers used by AI have a great appetite for electricity, due to the use of graphics processing, known as GPUs, for model training and queries. The author of this study shows that AI could represent 0.5% of global electricity consumption by 2027, which is roughly equivalent to Argentina's annual consumption.

Such characteristics make the neuromorphic approach especially suitable for physiotherapeutic postural analysis systems, meeting the demands for affordable, efficient and adaptable solutions to clinical needs. Integration with libraries such as OpenCV in Python allows the capture and analysis of patients' postural images, identifying postural patterns and contributing to more accurate and consistent diagnoses, even in resource-limited environments.

2.1.1 Simulation

To simulate the Neuromorphic Artificial Intelligence (IAN) models, in order to analyze the images captured by cameras and processed by the OpenCV library in Python, in order to develop the Intelligent system for physiotherapeutic postural assessment, based on neuromorphic AI, it is necessary to use different strategies in software and hardware, aiming to balance biological precision, scalability and energy efficiency.

In software simulation, tools such as *NEST-SIMULATOR,* which allows biophysically realistic modeling of complex *spiking* networks , supporting large-scale parallelism for studies of synaptic plasticity and dynamics of neuronal populations (GEWALTIG; DIESMANN, 2007). Alternatively, *BRIAN2*, offers flexibility in the mathematical description of neurons and synapses through differential equations, facilitating the prototyping of algorithms inspired by neurophysiological processes (STIMBERG et al., 2019). In addition, *NENGO* stands out for its integration with robotic control systems, using principles of the Theory of Dynamical Systems to map cognitive functions in neuromorphic architectures (BEKOLAY et al., 2014).

In the field of specialized hardware, the Loihi chip, developed by Intel Labs, stands out, which implements *SNNs* directly on silicon, combining programmable cores with online learning blocks. This architecture eliminates the communication bottleneck between memory and processor typical of the Von Neumann model, reducing energy consumption (DAVIES et al., 2018).

The choice between *software* and *hardware* simulation depends on the context: while software approaches are ideal for theoretical validation and parameter tuning, implementations in neuromorphic hardware are critical for embedded applications, such as sensory processing in autonomous robotics, where power and latency constraints are a priority (ROY et al., 2019).

Considering that this proposal is a prototype system, the choice to continue with the research was for a software simulation model, with the intention of improving and calibrating the system to the ideal requirements for clinical use, allowing to adjust and increase the accuracy and assertiveness of the system. In the context of this study, the neuromorphic model adopted will be based on Spiking neuron networks, and will be simulated through the *NEST-SIMULATOR* tool, to test the ability of the neuromorphic model to identify postural patterns, with the objective of detecting possible musculoskeletal pathologies, simulated from the images captured by the cameras and processed with the OpenCV library, with the objective of identifying anatomical reference points, such as joint alignments, angles between body segments and postural displacements. This data is converted into numerical vectors through the structure of multidimensional arrays, to serve as inputs in the Spiking neural networks. Once validated and calibrated, the model can be applied in clinical contexts through the use of Postural Assessment Systems.

2.1.2 Applications, Advantages And Challenges

Neuromorphic artificial intelligence has been applied in several domains, standing out for its energy efficiency and temporal processing. In physiotherapeutic contexts, it has demonstrated concrete benefits. For example, Wang et al. (2022) developed a smart chair that uses a Liquid State Machine-type SNN to recognize 15 sitting postures with an accuracy of 88.5% in a study with 19 participants. The system also provides immediate feedback to the user, promoting self-correction of posture. It is important to highlight the *PosePilot* system, which uses artificial intelligence in order to automatically recognize human posture, pointing out postural correction in a personalized way, overcoming the limitations of traditional fitness solutions (Gadhvi, Desai, and Siddharth, 2025). In robotics, systems such as those proposed by Schuman et al. (2022) use SNNs for adaptive motor control and sensorimotor integration in dynamic environments, reducing latency by up to 40% compared to classical approaches. In computer vision, neuromorphic sensors based on asynchronous events for each pixel. Neuromorphic devices do not write redundant data due to their asynchronous nature. The neuromorphic retinas (as they are known) send data packets informing only the address of the pixel that captured a significant variation in luminosity (POSCH, 2008), (LIU, 2015) apud GOUVEIA (2019). In healthcare, neuromorphic chips are used in the processing of biomedical signals, such as detecting anomalies in EEG and ECG in real time, with an accuracy of over 95% in low-power environments (CHAOMING et al., 2022).

While neuromorphic AI offers substantial gains in energy efficiency, real-time processing, and robustness inspired by biological patterns, which has the ability to handle noisy and complex data, it faces significant challenges that limit its expansion. As it is an emerging technology, it would be no different from any other in the primary phase. According to Caballar and Striker (2024), we can highlight the steep learning curve, as it requires mastery in several complex areas such as Biology, Computer Science, Mathematics, Neuroscience, and technology; Lack of defined benchmarks, making it difficult to evaluate performance and prove effectiveness; Lack of standards when it comes to Architectures, Hardware and Software. For Luna (2025), the lack of standardization is a challenge, because although there is a growing number of Neuromorphic projects, there is still no widely consolidated standard in Software and Hardware, directly impacting commercial scalability.

In this work, the neuromorphic approach is applied to postural analysis in physical therapy, integrating SNNs with event-based computer vision. As demonstrated by Chaoming et al. (2023) in biomedical signal processing, the ability to detect complex temporal patterns with low energy consumption allows for the automation of postural diagnoses, reducing the subjectivity of clinical assessments and optimizing the therapeutic workflow.

2.2 COMPUTER VISION

Computer vision, especially when integrated with libraries such as OpenCV, has proven to be a powerful tool in physical therapy posture assessment. This technology allows for the automated capture and analysis of images, facilitating the identification of postural patterns and aiding in the diagnosis of musculoskeletal dysfunctions.

Joint point detection algorithms are employed to map key structures of the body, such as shoulders and spine. From this detection, it is possible to analyze body alignment by comparing the data obtained with pre-established patterns. For example, the study by Portela et al. (2019) developed a mobile application that uses computer vision for postural assessment, demonstrating the feasibility of this approach in clinical practice. Among the most used methods are algorithms based on supervised machine learning, which encompasses a large volume of feature samples labeled with some useful information about those features, and more recently, Convolutional Neural Networks, also known as deep learning, which have revolutionized image classification by allowing the extraction of visual features in different layers, a process that is biologically inspired and known as cascade learning (WENG, 1992) apud (GOUVEIA, 2019). However, even with the significant advancement of computer vision in recent decades, computer vision is far from achieving the efficiency in interpreting the information of a scene, which a three-year-old child would easily do, not to mention that in the practical approach, such technology requires a lot of processing power to perform the task of assigning meaning to the values of pixels that represent an image, burdening the financial cost of the above technology (GOUVEIA, 2019).

2.2.1 Integration with intelligent agents

The combination of computer vision with artificial intelligence models, such as neuromorphic networks, enhances the analysis of visual data in real time. This integration allows systems to learn and adapt to individual variations, increasing the accuracy of postural assessments. According to Santos et al. (2023), the synergy between physiotherapy and AI has the potential to revolutionize rehabilitation practices, offering more accurate diagnoses and personalized treatments.

Despite the advances, the application of computer vision in postural assessment faces challenges, such as sensitivity to lighting variations and patient positioning during image capture. In addition, careful calibration of equipment is essential to ensure the accuracy of measurements. Portela et al. (2019) highlight the importance of a controlled environment to minimize these variables and ensure reliable results.

Postural assessment is a fundamental practice in physical therapy, aiming to analyze the alignment of body segments in relation to the line of gravity, with the aim of identifying musculoskeletal imbalances that may predispose to injuries or dysfunctions. Traditionally, this evaluation is carried out qualitatively, based on clinical observation and the professional's experience. However, studies indicate that the subjectivity inherent to this method can compromise the reliability of the results, Iunes et al. (2009).

With the advancement of technology, quantitative methods have been incorporated to improve the accuracy of postural assessments. Photogrammetry, for example, uses the analysis of digital photographs to measure body angles and alignments, offering objective data that complements visual evaluation. Research has shown that computerized photogrammetry can reduce interobserver variability, increasing the consistency of postural diagnoses. Iunes et al. (2009).

For Brito et al. (2016), In addition to photogrammetry, other instruments have been developed for postural assessment. The use of specific software allows for a detailed analysis of body alignment, facilitating the identification of postural deviations and assisting in the development of more effective intervention plans. These technological resources contribute to a more objective and standardized approach to postural assessment, minimizing subjectivity and enhancing the effectiveness of physical therapy interventions.

In the context of physical therapy, Noll et al. (2013), postural assessment is essential not only for the identification of static changes, but also for understanding the dynamic compensations that the body performs during movement. The integration of qualitative and quantitative methods provides a more comprehensive understanding of postural dysfunctions, allowing for more targeted and effective interventions.

In summary, the incorporation of technological tools in postural assessment represents a significant advance in physical therapy practice, offering greater diagnostic accuracy and helping to monitor the effectiveness of therapeutic interventions.

3 RELATED WORKS

Previous studies have investigated the integration of technologies for postural assessment, with promising results, but still have significant limitations regarding automation, ~~and~~ energetic efficiency and accuracy in uncontrolled environments.

A widely cited example is the *PostureScreen Mobile®* (PSM), aimed at static postural analysis from photographs. In a study conducted by Boland et al. (2016), PSM demonstrated near-perfect agreement (ICC ≥ 0.81) on measures such as lateral head displacement and hip tilt, even among users with different levels of experience. However, accuracy decreased under full-garment conditions, especially for obscure anatomical landmarks (e.g., anterior superior iliac spine). The application has the advantage of being low cost and easy to use, requiring minimal training. The limitation was due to its reduced precision in measurements dependent on anatomical landmarks hidden by clothing (e.g., hip tilt, ICC = 0.26). Recommendation of use in minimum clothing conditions to maximize reliability (BOLAND et al., 2016, p. 3401).

Another relevant initiative is *PhysioCode,* an open-source system developed in a doctoral thesis at the Faculty of Medical Sciences of Minas Gerais. According to Sabino (2023), the application uses artificial intelligence to identify key body posts (such as shoulders and spine) and compares the data with population patterns, generating detailed reports. The premium version (R$ 17.99–R$ 35.99) includes features such as postural evolution monitoring and integration with health professionals. It has a differential because it democratizes access to postural analysis, but depends on human interpretation for final diagnoses, limiting automation (SABINO, 2023). It has limitations because it does not use neuromorphic spike networks, resulting in high energy consumption for real-time processing.

While solutions such as *PostureScreen Mobile®* and *PhysioCode* offer accessibility, our system combines neuromorphic AI (for technological accessibility, energy efficiency, and diagnostic automation) and OpenCV (for adaptation to real-world environments), overcoming limitations in automation and accuracy. The integration of a database for mining pathological patterns allows for automated and personalized diagnoses, optimizing the time of professionals and patients.

4 MATERIAL AND METHODS

This research has an exploratory character, with the objective of investigating the integration of two emerging technologies: neuromorphic artificial intelligence, based on Neural Peak Networks (SNNs) and computer vision, using the Python OpenCV library, for image capture and processing. The focus is on its application in physical therapy postural assessment, aiming at the identification of pathological patterns.

According to Gil (2019), exploratory studies are common in areas where knowledge is incipient or when seeking to test new approaches to known problems, he also stresses that this research model is familiar with problems and research aimed at becomes more explicit or to build hypotheses. In the case of this work, the application of neuromorphic networks for automated postural analysis is an innovation, requiring the exploration of integration methods, parameter calibration and adaptation of algorithms to biomedical data.

In addition, it is also a quantitative research, as it uses objective metrics to validate the results. Such as:

- Accuracy assessment, with statistical comparison (e.g., correlation coefficient, mean square error) between diagnoses generated by the system and physiotherapist evaluations;
- Energy efficiency, with measurement of the energy consumption of the neuromorphic system compared to traditional approaches (e.g., GPUs);
- Processing time, evaluating the latency ~~for~~ real-time ~~image~~ analysis.

These measures allow statistical analyses and generalizations to be carried out about the system's performance (GIL, 2019).

Although not the main focus, there are qualitative components in the validation phase, such as:

- feedback from professionals, with a subjective evaluation by physiotherapists about the usability and reliability of the system;
- Clinical feasibility analysis, considering the adaptation of the tool to different therapeutic contexts.

As a method, a systematic review of the literature will be carried out, with the reading and analysis of scientific articles on the application of neuromorphic artificial intelligence and computer vision in postural assessment. Related works will be used for theoretical basis and comparisons of expected results.

The tools chosen combine agility of development, flexibility of use and robustness to meet the requirements of visualization and neuromorphic simulation, namely:

- **Python**: High-level language with clear syntax and extensive library ecosystem. It supports direct integration with OpenCV for computer vision and PyNEST for SNN simulation. According to Bekolay et al. (2014), this combination allows rapid prototyping of bioinspired algorithms and facilitates the transition from theoretical models to clinical applications.

- **OpenCV:** OpenSource library optimized for real-time image processing. It offers specialized functions (e.g., contour detection, geometric transformations, noise filtering) essential for locating anatomical markers such as shoulders and spine.
- **NEST Simulator**: Large-scale SNN simulation environment. Implements biophysical models and supports parallelism via MPI/threads, allowing testing networks with millions of neurons and billions of synapses before deployment on neuromorphic hardware.
- **Video capture system**: 4K cameras at 60 fps with high-sensitivity CMOS sensors, as recommended by Boland et al. (2016), ensure sufficient resolution to measure postural microdeviations and maintain low noise levels in environments with limited lighting.

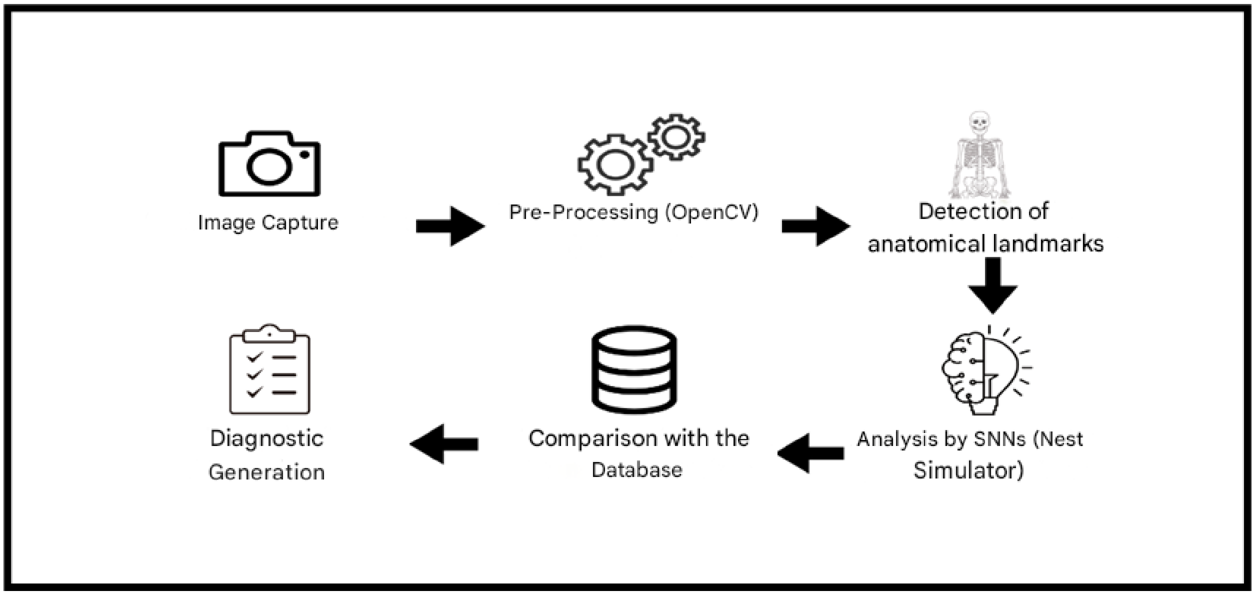
Data collection will be carried out with volunteers who consent to participate in the study. According to Iunes (2009), the sample should follow resolution 196/96 of the National Health Council, which was approved on October 10, 1996, which establishes norms and guidelines for research with human beings, in any area of knowledge. Images of the participants will be captured in a controlled environment, ensuring uniform lighting and a neutral background to minimize interference in image processing.

The captured images will be processed using the OpenCV library to detect relevant anatomical points, which according to Gaffar (2021), allows the estimation of human pose in real time. The data obtained will be analyzed by a neuromorphic network implemented in the NEST Simulator, a validated tool for modeling large-scale spiking networks with biological precision (GEWALTIG; DIESMANN, 2007).

The results obtained by the developed system will be validated through comparison with evaluations carried out by experienced physiotherapists, following traditional methods of postural analysis such as ADAMS (1985), ASCHER (1976), CAILLET (1988) and MORO (1973). The agreement between the analyses will be quantified to verify the effectiveness of the system, as was the case of Iunes (2009), who demonstrates the effectiveness of this comparative analysis, as shown in Figure 1.

Figure 1

Flowchart of the Postural Assessment System Process with Neuromorphic AI and Open CV



Source: Prepared by the Authors, 2025

In the final phase (Expert Validation), the diagnoses generated by the system are compared with manual evaluations by experienced physiotherapists. Agreement is quantified using metrics such as Cohen's Kappa Index (for Interobserver agreement) and Global Accuracy. If the accuracy is less than 85%, the system returns to the [SNN Analysis] step for parameter adjustment (e.g., spiking neuron activation thresholds). This iterative cycle ensures the robustness of the system prior to clinical deployment.

5 RESULTS AND DISCUSSION

Postural assessment is an essential practice in physiotherapy, aiming to identify misalignments and muscle imbalances that can lead to dysfunctions and pain. Traditionally, this evaluation is carried out qualitatively, based on clinical observation and the professional's experience. However, technological advances have allowed the development of quantitative methods that complement this analysis, providing greater precision and objectivity.

Qualitative methods involve direct visual inspection, where the physiotherapist observes the patient in different postures and planes, identifying possible asymmetries or deviations. Although widely used, these methods can be subjective and depend on the experience of the evaluator. On the other hand, quantitative methods use tools such as photogrammetry, which consists of analyzing photographs of the patient to measure angles and body alignments. Studies indicate that photogrammetry increases the reliability of postural assessments, reducing inter-observer variability Iunes et al. (2009).

The integration of computer vision in postural assessment has shown promise. Mobile applications, for example, use pattern recognition algorithms to analyze posture from captured images, facilitating the diagnosis and follow-up of patients Portela et al. (2019).

In addition, artificial intelligence systems have been developed to monitor posture in work environments, identifying and classifying risk postures, contributing to the prevention of occupational injuries. These technological resources offer objective data that complement clinical evaluation, enabling a more accurate diagnosis and more effective therapeutic planning. In short, postural assessment has evolved significantly with the advent of technologies that allow for more detailed and objective analyses. The combination of qualitative and quantitative methods enriches physical therapy practice, contributing to more assertive and effective interventions. Da Silva e Silva (2023).

6 FINAL CONSIDERATIONS

The present pre-project proposes the development of an integrated computational system that uses neuromorphic artificial intelligence and computer vision to automate physiotherapeutic postural assessment. The innovation lies in the ability to capture images, analyze postural patterns, and provide automated diagnoses through neuromorphic networks, increasing the accuracy and efficiency of assessments.

It is expected that the application of this solution will contribute to optimizing the work of physiotherapy professionals, making postural analyses more objective and less dependent on the subjectivity inherent to traditional methods. In addition, the possibility of automating the detection of postural deviations can result in earlier diagnoses and more effective treatments. From a scientific point of view, the project offers a valuable opportunity to explore the combination of neuromorphic networks with computer vision, an approach that is still little explored in health studies. The chosen technologies, such as the OpenCV library and the NEST simulator, are robust tools that will allow the efficient implementation and validation of the system.

However, there are challenges to be faced, such as the need for proper calibration of the cameras, the quality of the data captured, and the clinical validation of the results. Compliance with these requirements will be key to ensuring the practical applicability of the system. The integration of neuromorphic artificial intelligence and computer vision has the potential to revolutionize physiotherapy postural assessment. By automating the postural analysis process, the proposed system seeks to provide more accurate diagnoses, reduce manual errors, and optimize the time of health professionals.

Although in the pre-project phase, the research presents significant contributions to the field of digital physiotherapy and to technological advancement in the health area. Future studies should focus on practical validation of the system, with tests in a clinical environment and comparison with traditional methods. If successful, the solution could represent an important advance in personalized, evidence-based care.

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