OBTAINING MEASUREMENTS OF THE ELBOW ARTICULATION USING MEDIAPIPE

OBTENÇÃO DE MEDIDAS DOS ÂNGULOS DA ARTICULAÇÃO DO COTOVELO UTILIZANDO O MEDIAPIPE

OBTENCIÓN DE MEDICIONES DE ÁNGULOS DE LA ARTICULACIÓN DEL CODO UTILIZANDO MEDIAPIPE

https://doi.org/10.56238/sevened2026.009-052

Carbón Victor Ferreira[1], Victor Gabriel Lopes Santana[2], Gilberto Cuarelli[3], Wagner de Aguiar[4]

ABSTRACT

Biomechanics is a science that applies physics principles for analyze human body's movements, in areas like sports, physiotherapy and ergonomics. Inside physiotherapy has the objective of prevent lesions, verify diseases, fractures analysis, protetics, deformations analysis, and evaluate the progress in patient's recuperation. For this the knowledge of specific angles between some articulations allows to understand how these body's parts behave. This article has as focus the initial and specific study of the angle formed between arm and forearm in the elbow articulation. This articulation is of interest when verifying lesions that can affect the movements, like Annular Ligaments lesions. Currently the measurements are done with the use of a goniometer, a manual tool that can be affected by values incertities. The proposition is to use a computational vision tool, with artificial intelligence supplied by MediaPipe the generate results in real time, to simplify the data collection for sector professionals, The angles results visualisation in a more stable manner, compared to manual methods, and independent of the professional conducting the measurements. Will be use only on a computer or tablet with a camera, connected to the Internet.

Keywords: Biomechanics. Computational Vision. Artificial Intelligence. Body's Angles. MediaPipe.

RESUMO

A biomecânica é uma ciência que aplica os princípios da física para analisar o movimento do corpo humano com a proposta de otimizar o desempenho em áreas como esportes, fisioterapia e ergonomia. Dentro da área de fisioterapia tem como objetivo prevenir lesões, verificar doenças, análise de fraturas, próteses e deformidades, e avaliar progresso da recuperação de pacientes. Para isso, o conhecimento de ângulos específicos entre algumas

[1] Control and Automation Engineer. Instituto Federal de São Paulo (IFSP). E-mail: carbonvictor@gmail.com
[2] Undergraduate Student in Control and Automation Engineering. Instituto Federal de São Paulo (IFSP). E-mail: Lopes.santana@@aluno.ifsp.edu.br
[3] Dr. Professor. Instituto Federal de São Paulo (IFSP). E-mail: gcuarelli@ifsp.edu.br
[4] Dr. Professor. Instituto Federal de São Paulo (IFSP). E-mail: w.aguiar@ifsp.edu.br

articulações permite entender como essas partes do corpo se comportam. Esse trabalho tem como foco o estudo inicial e específico do ângulo formado entre braço e antebraço, com a articulação do cotovelo. Essa articulação é de interesse ao verificar lesões que podem comprometer a movimentação, como lesões no Ligamento Anular. Atualmente as leituras são realizadas com a utilização de um goniômetro como ferramenta de medição e como trata-se de um método manual, sujeito a incertezas de valores A proposta é utilizar uma ferramenta de visão computacional, com inteligência artificial, fornecido pelo MediaPipe que gere em tempo real resultados para facilitar a coleta de dados para os profissionais da área, a visualização de resultados angulares de forma mais estável, em relação aos métodos manuais e independente do profissional que vai realizar a medida. Será utilizado apenas um computador, ou um tablet, com câmera, conectado a Internet.

Palavras-chave: Biomecânica. Visão Computacional. Inteligência Artificial. Ângulos do Corpo. MediaPipe.

RESUMEN

La biomecánica es una ciencia que aplica los principios de la física para analizar el movimiento del cuerpo humano con el fin de optimizar el rendimiento en áreas como el deporte, la fisioterapia y la ergonomía. Dentro del campo de la fisioterapia, su objetivo es prevenir lesiones, investigar enfermedades, analizar fracturas, prótesis y deformidades, y evaluar el progreso de la recuperación del paciente. Para ello, el conocimiento de los ángulos específicos entre ciertas articulaciones permite comprender el comportamiento de estas partes del cuerpo. Este trabajo se centra en el estudio inicial y específico del ángulo que forman el brazo y el antebrazo con la articulación del codo. Esta articulación es de interés en la investigación de lesiones que pueden comprometer el movimiento, como las lesiones del ligamento anular. Actualmente, las lecturas se toman utilizando un goniómetro como herramienta de medición y, al ser un método manual, está sujeto a incertidumbres en los valores. La propuesta consiste en utilizar una herramienta de visión artificial con inteligencia artificial, proporcionada por MediaPipe, que genera resultados en tiempo real para facilitar la recopilación de datos a los profesionales del sector, así como la visualización de resultados angulares de forma más estable que los métodos manuales, e independientemente del profesional que realice la medición. Solo se utilizará una computadora o tableta con cámara y conexión a internet.

Palabras clave: Biomecánica. Visión Artificial. Inteligencia Artificial. Angulos Del Cuerpo. MediaPipe.

1 INTRODUCTION

In the health area, it is necessary to know a lot of parameters of the human body, one of these, used in the area of physiotherapy, are the linear and angular measurements of the human body, which determine the posture of the subject, in this branch biomechanics is gaining a lot of notoriety. To evaluate these angles there is a set of tools, each with its own particularities. In this work, the focus is to develop a tool for measuring these measurements that works with the instantaneous capture of images of the subject under analysis, so that health professionals can have the measurements quickly, efficiently, and with high reliability.

2 THEORETICAL FRAMEWORK

The biomechanical assessment studies in detail human movement, posture and how external forces cause stress on a person's body. This is necessary because poor body posture can cause injuries and pain to the subject (Jia Qiu, 2026), and is also used to monitor the evolution of patients in physiotherapy treatments; One of the simplest ways to check angular measurements is by goniometry, which is a manual method, where an evaluator uses a goniometer, formed by two rods connected to a graduated joint, to check the angle formed in the patient's joints. To do this, the rods of the goniometer must be positioned on the segments and the axis of the device on the joint. Then, the evaluator reads the indication of the angle on the device (Ace, 2006). Although it is a simple method, this method is affected by the evaluator's experience, which can occur during the positioning of the tool and the reading, (Sacco, 2017) thus causing uncertainties.

Some digital measurement tools have been developed for the use of health professionals. Most of them make it possible to load an image, and after a calibration, obtain measurements and angles. Some of these applications found in the literature review are mentioned below.

The Postural Assessment Application (SAPO) (BMCLab, 2006) is a free, open-source computational tool used for postural analysis based on static images. The evaluation is based on photographs acquired, according to a standardized protocol, in the anterior, posterior and lateral views. The individual must be in a position of balance and with visible anatomical points. To ensure image calibration, a plumb line must be used, with known distance marks, the camera must remain fixed, positioned perpendicular to the ground. After importing the images, the evaluator must manually mark all anatomical points of interest for analysis. There is also the possibility of creating a personalized protocol, in order to observe only points of interest. Based on the data provided, SAPO calculates angles, distances, asymmetry indices and body alignments, and generates a report at the end of the process.

Current photogrammetry applications, such as Surgimap Spine (Helmya 2015) and PostureCO, both of which require a subscription and allow you to upload an image, calibrate the system with a known measurement, and then place markers at points of interest. With this, the application informs the angle, or distance between the desired markers. In this way, the evaluator can use multiple sources, such as photographs, radiographs, where each image must be treated individually. These tools are widely used for the detection and verification of postural diseases, such as scoliosis (Helano, 2019). With photogrammetry tools, professionals can perform a first analysis, and monitor the patient's evolution.

Another photogrammetry tool, the Posture Screen Mobile (PSM) aimed at detecting scoliosis, which operates in a similar way to the previous methods, allows the analysis of images of the patient, and then the health professional marks the points of interest manually, to calculate the deviation of the spine (Lugari, 2019).

In early 2020, Google made available MediaPipe, which is a module with artificial intelligence tools and models, which can be applied in computer vision (Lugari, 2019), compatible with several programming languages such as Web/Javascript; Python, Android and IOS, which attracted the attention of the public that uses image recognition models; the MediaPipe framework provides high-performance models, which can perform reads of up to 30 frames per second on systems with high-performance graphics (Google, 2020).

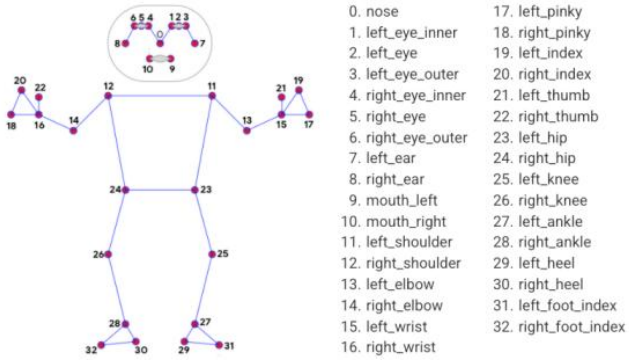
After literature analysis, there was a lack of consensus on the tools that each professional uses, which can vary between the simple goniometer and even several computer applications, where points are defined manually. With technological advancement, new AI-based tools can be developed, with the same objective, without the need for manual markings, which makes it easier for the professional in the area to identify the markers and determine the desired angles, with more comfort to the subject under analysis.

3 METHODOLOGY

MediaPipe is a set of artificial intelligence models, to analyze images and identify information of interest, among the models available is the pose model.

Figure 1

Body Coordinates provided in the Pose Model



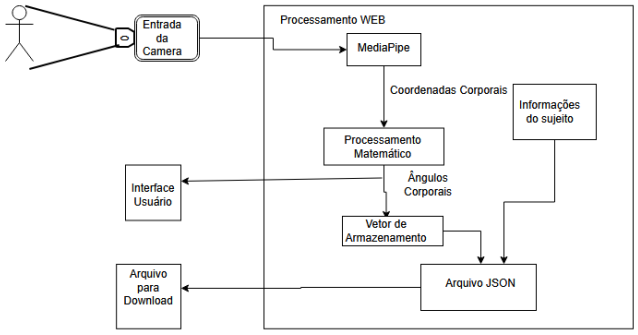
Source: MediaPipe Official Documentation.

The model provides position information from 32 points of the human body, the data is provided as a percentage of the screen, and can be worked on mathematically.

With this set of tools in hand, the developed project topology is

Figure 2

Tool Operation Diagram



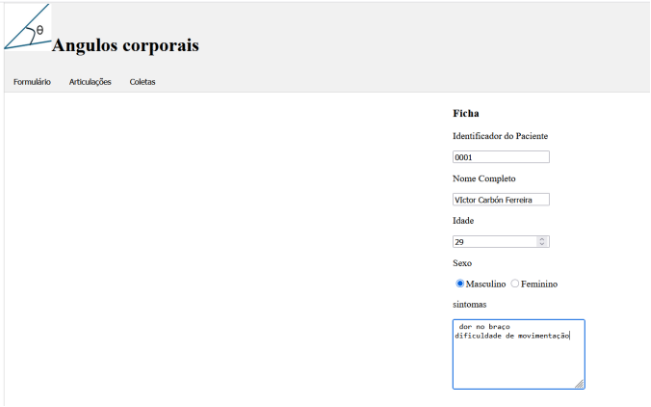
Source: Authorial Image.

Initially the image of the subject is captured by the camera, then the images are sent to the MediaPipe model, the model returns a data structure with the 32 points, which then undergoes a mathematical treatment, this treatment calculates the angle of the joint under analysis, which is stored in a vector of results, and does the statistical treatment of all readings performed, Calculating their mean and standard deviation, the lower the standard deviation, the more stable the readings were.

The application starts in a first tab, so that the professional enters the subject's data, the data entered are the name, age, an identification, which must be a unique number for each person, sejo, and the symptoms or queijas presented by the subject.

Figure 3

Subject Registration Page



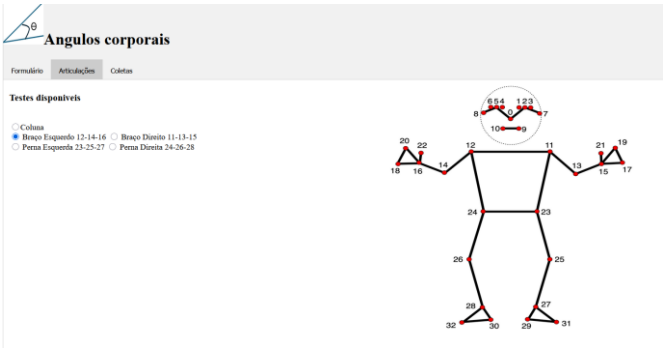
Source: Authorial Image.

The tool created depends on the Internet connection, in the first tab, seen in figure 3, this data will later be recorded in a database.

The sequential page allows you to choose the joint to be analyzed from a list of options. The application with the MediaPipe allows the collection of multiple points of the human body. The points used to determine the angle formed between arm 14-16 and left forearm 12-14, with articulation at elbow 14.

Figure 4

Choice of Annuli



Source: Authorial Image.

The collections were carried out with the following protocol:

3.1 EQUIPMENT DESCRIPTION

- i7 notebook with Ram, 2Gb video card and Windows 11 Operating System
- Camera with 1Mp and 720p resolution

3.2 ENVIRONMENT

- Subject in front view with the camera.

- Distance between subject to camera 1.5m
- Hips visible in the image,
- Wall with white background
- Blue Shirt
- Analyzed angles of 45 degrees, 60 degrees and 90 degrees, with respective molds

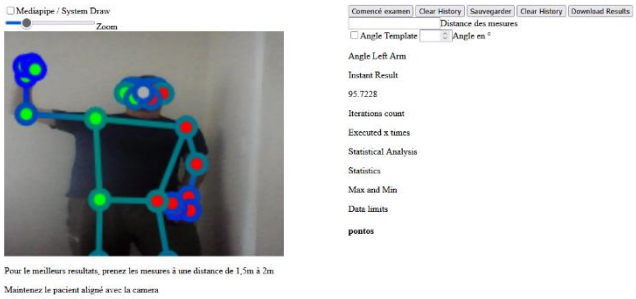
3.3 SUBJECT

- Height 1.76 m ;
- Weight 75 Kg
- Gender: Male
- Age:29 years

3.4 APPLICATION DESCRIPTION

Figure 5

Angle capture at work

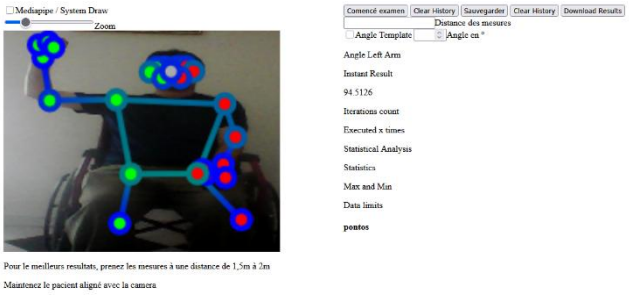


Source: Authorial Image.

Once the patient is displayed on the screen, it is necessary to click on start exam, to insert the results in the collection vector, this vector indicates the number of captures made, and with it the standard deviation of the measurements is calculated, thus meeting the patient's movement during the exam. Collections can also be made in patients with motor disabilities, such as wheelchair users

Figure 6

Collection demonstration with a person in a wheelchair



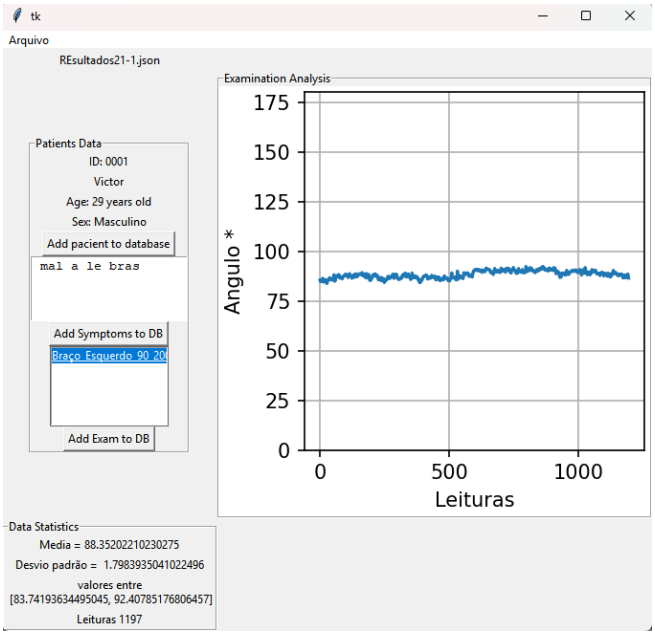
Source: Authorial Image.

In Figure 5, it can be seen that even for situations in which it is necessary to analyze a person with a disability in a wheelchair, collections can be made, as long as the presence of the hips in the image is respected.

The operator can still enter the distance between the patient and the camera, and the angle that is being analyzed, so when clicking on Save Exam, this data will be stored in a structure, which when selecting Download, will download the data in JSON format. This allows for further analysis, even without internet access

Figure 7

Analysis of the application's saved data



Source: Authorial image.

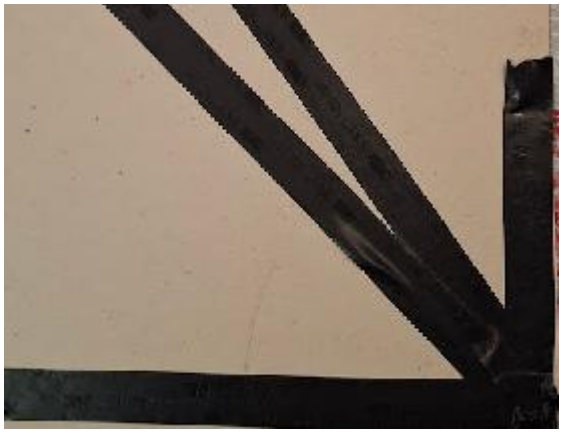
The tool demonstrated in figure 5 displays the patient form that was filled out, and allows you to see the movement of the joint during the collection period, and allows this information to be sent to a local database, which the user will indicate

4 RESULTS AND DISCUSSIONS

Collections were carried out with the developed application, and guides made with Paraná paper and tape were used to serve as a reference for the desired angles, of 90, 60 and 45 degrees.

Figure 8

Angle Reference



Source: Authorial image.

With the guide shown in Figure 8, collections were carried out with the WEB application, which obtained the following results.

Table 1

Results obtained in the collections

ANGLE	AVERAGE READINGS [ANGLES]	STANDARD DEVIATION	NUMBER OF ANGLES CAPTURED
90	89.643	1.001	379
60	61.016	2.038	519
45	45.219	0.68	485

Source: Authorial image.

The results obtained as a statistical character demonstrate the reliability and repeatability of the measurements, as they keep the standard deviation of the collections below 2.5 degrees The comparison between the manual and developed methods should be made together with the medical team in the future.

5 CONCLUSION

For the sequence of the project, the aim is to increase the available angles, to meet the needs of the largest number of doctors. For this, the study group is

seeking support from other institutions focused on the health area, in order to prove the accuracy of the data collected in comparison to manual methods, And for continuity, the participation of the team of health professionals is essential to inform what the main needs are, during development, and to compare manual methods, and the tool developed, for this to become possible, it is necessary, first, the approval of the Ethics Council for the sequence of development.

REFERENCES

Qiu, J., et al. (2026). Biomechanical evaluation of anterolateral ligament anatomical variants in anterior cruciate ligament-injured and reconstructed knee joints. Clinical Biomechanics, 13. https://doi.org/10.1016/j.clinbiomech.2025.106709

ACE Gestão em Saúde. (2016). Manual de goniometria: Medição de ângulos articulares. Recuperado de https://acegs.com.br/wp-content/uploads/2016/06/MANUAL-DE-GONIOMETRIA-FINAL.pdf

Sacco, I. C. N., et al. (2007). Confiabilidade da fotogrametria em relação à goniometria para avaliação postural de membros inferiores. Brazilian Journal of Physical Therapy, 11(5), 411–417.

BMCLab. (2006). Software de avaliação postural. Recuperado de https://bmclab.pesquisa.ufabc.edu.br/sapo/

Helmy, N. A., El-Sayyad, M. M., & Kattabei, O. M. (2015). Intra-rater and inter-rater reliability of Surgimap Spine software for measuring spinal postural angles from digital photographs. Bulletin of Faculty of Physical Therapy, 20, 193–199. https://doi.org/10.4103/1110-6611.174719

Ferreira, M. E. C. (2025). Programa de intervenção conservadora em adolescentes com escoliose idiopática moderada e grave (Tese de doutorado). Universidade de São Paulo. Recuperado de https://www.teses.usp.br/teses/disponiveis/17/17142/tde-14072025-111028/en.php

Helano, M. B. F. P., et al. (2019). Aplicação móvel para avaliação postural usando visão computacional. Anais do SBAI 2019. Recuperado de https://proceedings.science/sbai-2019/papers/aplicacao-movel-para-avaliacao-postural-usando-visao-computacional

Lugaresi, C. (2019). MediaPipe: A framework for perceiving and processing reality. Recuperado de https://static1.squarespace.com/static/5c3f69e1cc8fedbc039ea739/t/5e130ff310a69061a71cbd7c/1578307584840/NewTitle_May1_MediaPipe_CVPR_CV4ARVR_Workshop_2019.pdf

Google. (2020). MediaPipe: Framework concepts (GPU). Recuperado de https://mediapipe.readthedocs.io/en/latest/framework_concepts/gpu.html