Journal of Applied Data Sciences
Vol. 6, No. 3, September 2025, pp. 2144-2162

ISSN 2723-6471
2144

Human Shoulder Posture Anthropometry System for Detecting Scoliosis Using Mediapipe Library

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(Received: January 25, 2025; Revised: March 3, 2025; Accepted: June 3, 2025; Available online: July 19, 2025)

Abstract

The system proposed in this research is a posture detection system using real-time computer vision technology with system limitations aimed at detecting shoulder posture as part of anthropometric measurements, because if the shoulder posture is unbalanced and has a very significant height difference, it is called an indication of scoliosis. This research aims to facilitate the detection of scoliosis, especially in one of its symptoms, namely shoulder asymmetry with anthropometric measurements of the 'Elbow-to-Elbow breadth' position using the scoliomter method. In addition, common screening methods that can be used for scoliosis, especially in adolescents, include the Adams forward bend test, Cobb angle measurement, and Moire measurement. The anthropometric shoulder posture detection system includes the stages of preparation for detection using a webcam with T-position calibration, then MediaPipe Library processes 33 keypoints, OpenCV and Python to analyze body movements in real time, then this asymmetry is calculated using standard algorithms for pose prediction, vector projection and atan2 to obtain asymmetry angle information. The results of testing the shoulder detection system in the form of shoulder posture according to landmarks on one test subject and keypoint extraction on the user interface display in real time and provide information on the angle of asymmetry of the shoulder and hip in the front and rear facing positions. From testing 16 respondents, the shoulder tilt angle is obtained in the range of 7.42-19.84 degrees which will have a TRUE value if the angle is greater than 15 degrees. Information on the angle of more than 15 degrees can be used as a reference for scoliosis symptoms and further diagnosis by medical practitioners and through this detection system it will be easy to get information related to the results of shoulder posture detection accurately and in real time compared to using only a scoliometer.

Keywords: Scoliosis, Shoulder, MediaPipe, Webcam, Angle

1. Introduction

Equipment in health problems that have been made or created must be in accordance with current technological needs and advances and make it easier for humans as users in terms of examinations in order to obtain accurate examination results and avoid human error. However, now there are still some health equipment that is used manually to obtain measurement results, one of which is in detecting body posture such as shoulders. What is meant by measuring body posture such as shoulder posture, namely parallel shoulders or high and low manually is a measurement carried out using anthropometric tools [1].

Anthropometric tools can generally carry out manual measurements by measuring shoulder height, shoulder width, and scapular asymmetry. Shoulder height can be measured using a stadiometer or anthropometer to determine the vertical distance from the floor to the acromion on each side. Shoulder width can be measured with a measuring tape or anthropometer [2]. Anthropometry can be in the form of Digital photogrammetry provides measurements of body angles or distances that allow quantitative assessment of body posture with or without the use of external markers. Digital photogrammetry is becoming an increasingly popular tool for the assessment of the musculoskeletal system. The purpose of this paper is to present a structured method for the analysis of body posture and its changes using standardized digital photography techniques [3].

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DOI: https://doi.org/10.47738/jads.v6i3.870

Diagnosing and monitoring posture problems with posture examination can detect certain posture problems such as scoliosis, kyphosis, or lordosis. Posture problems can cause pain, mobility limitations, or other health problems. Examining body posture using anthropometric measurements and assessing shoulder asymmetry is a useful method for detecting potential posture problems, including scoliosis. Scoliosis is an abnormal lateral curvature of the spine [4]. One of the postures that can indicate scoliosis is shoulder posture, a condition in which the spinal structure experiences lateral curvature and rotation, which can cause the thorax, shoulder blades, shoulders, and pelvis to protrude asymmetrically [5], [6]. Early detection of scoliosis, especially during adolescence, is very important because it allows for timely intervention, which can often prevent the need for surgery or minimize the severity of the condition. If scoliosis is identified early, treatments such as braces or exercises can be more effective in stopping or reducing the progression of spinal curvature [7], [8].

According to research [9], physical examination of scoliosis sufferers can reveal asymmetry of shoulder height, protrusion of the shoulder blades (ribs), asymmetry of the ribs, a gap/cavity between the arm and the lateral side of the body in a comparison of the right side with the left side in an upright position, sagittal plane abnormalities such as kyphosis, and asymmetry of the waist folds that do not disappear when sitting. Manual measurements for scoliosis can use the scoliometer technique, which is to measure the safe angle of rotation of the trunk (ATR). Scoliosis patients are in a forward bending position during the examination. This examination is carried out quickly so that even though the patient's position is forward bending, patient comfort is maintained and supporting examinations such as radiographic imaging are needed if the results of the scoliometer examination have exceeded the maximum curvature limit [10], [11]. This study is about the measurement of diagnostic accuracy and reliability of Scoliometer and Adam Forward bend in detecting scoliosis [12]. The most commonly used screening methods for adolescent scoliosis include Adams forward-bend test, scoliometer measurement, Cobb angle measurement, and Moire measurement [13].

Scoliosis can be prevented by maintaining body posture. To find out whether the body posture position is correct, this study was carried out, where the wrong body posture can cause back and spinal injuries and to avoid it, an application is made that uses Computer vision and neural networks to analyze human body posture and immediately notifies users to recheck their body posture through android and desktop applications using real-time video feeds [14]. Anthropometry and stationery to detect scoliosis require more measurable and accurate measurements in real time. Along with the advancement of human body detection technology using devices that are already available on the computer, namely webcams and the development of the artificial intelligence and machine learning landscape, there are many tools and frameworks available, including Mediapipe as a comprehensive solution for various computer vision tasks, including human pose estimation to identify the location of reference points from body posture images that want capture and body detection to facilitate fast and accurate measurements and real time. MediaPipe is a tool for body detection and pose estimation because of its accuracy, ease of use, and cross-platform compatibility.

This study uses mediapipe for ergonomic postures on the upper body posture of subjects sitting in front of a desk or operating a computer in real time using only webcam data and MediaPipe [15], [16]. Mediapipe with Yolov5 is used for shoulder posture range of motion assessment to prevent frozen shoulder [17], [18]. This paper proposes a program that uses OpenCV and MediaPipe to guide the content of exercise posture correction (squat, push-up) and the amount of exercise by estimating the real-time image posture and estimating the user's body reference point from the image obtained using a webcam in real time and calculating the body angle and numerical value needed to determine whether the posture is correct, helping people exercise at home while checking their posture and exercising with the right posture without the help of a sports coach [19].

In addition, we will use the Mediapipe framework to collect human pose landmarks and based on these landmarks also extract various features such as joint angles, 3d distances between various key points of the human body posture. Then the model will be able to detect human exercise postures such as jumping jacks, pull-ups, push-ups, squats, and sit-ups. Machine learning models are trained using decision trees, gradient boosting algorithms, and naíve bayes algorithms which will improve the precision of the predicted poses [20].

The research we conducted was to create a body posture detection system using real-time computer vision technology with system limitations aimed at detecting shoulder posture as part of anthropometric measurements, because if the shoulder posture is unbalanced and has a very significant difference in height, it can interfere with movement clearly and will cause pain. If the condition is like that, then the possible cause is scoliosis. This study aims to facilitate the detection of scoliosis, especially in one of its symptoms, namely shoulder asymmetry with anthropometric measurements of the 'Elbow-to Elbow breadth' position where in general the measurement of scoliosis symptoms uses the method, namely with a scoliometer. Measurements with a scoliometer are carried out as additional support for accuracy and can also be used as a comparison in anthropometric measurements of 'Elbow-to Elbow breadth' by detecting shoulder posture balance using a webcam camera and the MediaPipe library. Medipipe is a framework where developers can build Machine Learning channels with the OpenCV library and is supported by the use of the Python programming language. Landmarks formed from detecting shoulder posture with 'Elbow-to Elbow breadth' anthropometric measurements are measured in front and back positions. Measurements with threshold accuracy so that the pose of the skeleton shape at the shoulder and hip reference points can be precise so that it becomes a vector that will form a tilt angle as a reference for shoulder and hip asymmetry as an indication of scoliosis.

2. Literature Review

2.1. Anthropometry

Anthropometry comes from the word anthro meaning human and metri meaning size. Anthropometry is defined as a science specifically related to the measurement of the human body which is used to determine differences in individuals and groups by using a component of numerical data related to the physical characteristics of the human body in the form of size, shape and strength and the application of such data to handle design problems [21]. The types of anthropometric measurements are explained in figure 1.

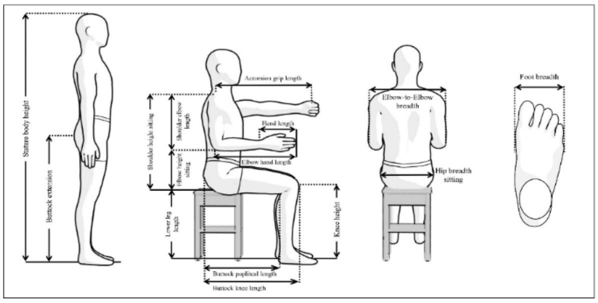

Figure 1. Types of Anthropometric Measurements: Standing Position and Sitting Position

Figure 1 [22] above provides an overview of several anthropometric measurements in sitting and standing positions. The anthropometric measurements in this study were measurements in the 'Elbow to Elbow Width' position. This measurement measures the position of shoulder alignment from end to end of the shoulder (between the right shoulder and the left shoulder), which can be associated with the detection of scoliosis.

2.2. Scoliometer Technique

As explained in the introduction, according to research [13], the most commonly used screening methods for adolescent scoliosis include the Adams forward bending test (A), scoliometer measurements (B), Cobb angle measurements (C), and Moire measurements (D) as can be seen in figure 2. For our research, the scoliometer method was used as an additional method to strengthen the detection diagnosis using mediapipe technology.

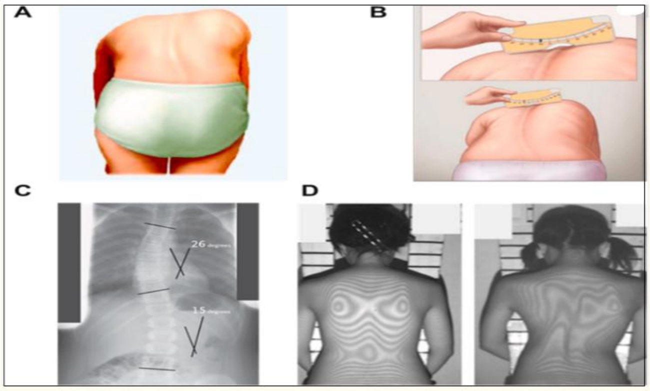

Figure 2. Types of Scoliosis Measurement Methods

The scoliometer technique is to measure the safe ATR. The patient is in a forward bending position when the examination is performed. This examination takes place quickly so that even though the patient's position is bent forward, patient comfort can be maintained and supporting examinations, such as radiographic imaging, are needed if the results of the scoliometer examination have exceeded the maximum curvature limit [10], [11].

The equipment needed for the examination is a scoliometer. There are two types of scoliometers that can be used, namely ruler-shaped and application-based scoliometers or inclinometers. Our study used both tools alternately. Ruler-shaped scoliometer: Measurement variability is determined by patient position, palpation of vertebral levels, patient discomfort and fatigue related to positioning and measurement several times, and repeated measurements that occur within several weeks [23]. Application-Based Scoliometer (Iphone, Android). A study conducted by [24] showed that application-based scoliometers can replicate the function of scoliometers at a lower cost and are more practical for medical personnel. In addition, a systematic review by Prowse et al also showed that this application-based scoliometer has high to very high reliability and moderate to very high validity [25].

2.3. Computer Vision

Computer Vision is a discipline in computer science that studies how to extract data from the image, instead of image processing [26]. Computer Vision is about how machines see and extract information. Computer vision is a subset of machine learning that deals with getting computers or machines to understand actions, behaviors and language similar to humans. The idea is to make machines understand and interpret the visual world so that they make sense of it and gain some meaningful insights. Computer vision is about how machines see and retrieve information. Computer vision works by using algorithms and optical sensors to stimulate human visualization to automatically extract valuable information from an object. Computer vision has developed into a branch of artificial intelligence and human visualization simulation. Computer vision is also combined with lighting systems to facilitate image acquisition followed by image analysis. In more detail, the stages of image analysis are: image formation, in which the image of the object is captured and stored in the computer, image preprocessing, in which the image quality is improved to enhance the image details, image segmentation, in which the object image is identified and separated from the background; image measurement, in which some important features are quantized, and image interpretation, in which the extracted image is then interpreted.

2.4. Object Detection

Object detection is a computer technology related to digital images and image processing that functions to detect the shape of semantic objects from certain groups (such as humans, buildings, or cars) in digital images and videos [27]. The object detection process consists of finding the position and size of each object shape in the image. The goal of object detection is to find all object shapes from one or more classes of objects regardless of their size, position, pose, angle of capture, and lighting conditions. The way to find semantic objects such as humans, animals, trains in a video scene is called object detection.

ISSN 2723-6471

2.5. OpenCV

OpenCV (OpenSource Computer Vision Library), is an opensource library developed by Intel that focuses on simplifying programming related to digital images. OpenCV already has many features, including: face recognition, face tracking, face detection, Kalman filtering, and various types of AI (Artificial Intelligence) methods. And provides various simple algorithms related to Computer Vision for low-level APIs. OpenCV is an open-source computer vision library for the C/C++ programming language, and has been developed into python, java, matlab [28].

2.6. Mediapipe

Mediapipe is a framework for building pipelines and will conclude incoming data carelessly. Mediapipe is designed for those who want to implement artificial intelligence into the applications to be built. Mediapipe also enables the development of cross-platform applications that can run on a variety of different hardware [29]. The Mediapipe framework is specifically developed for artificial intelligence applications and incorporates Tensor Flow, which enables GPU (Graphics Processing Unit) and CPU (Central Processing Unit) acceleration of the device [30]. The BlazePose technique allows Mediapipe to detect and track 33 2D landmark points on the body in each frame of RGB video, providing a comprehensive and precise view of body movement the 33 landmark points on the body are explained in figure 3 below [31]. The BlazePose technique identifies key points on the identified body part, which produces x, y, and z coordinates as the output of the detection result [32].

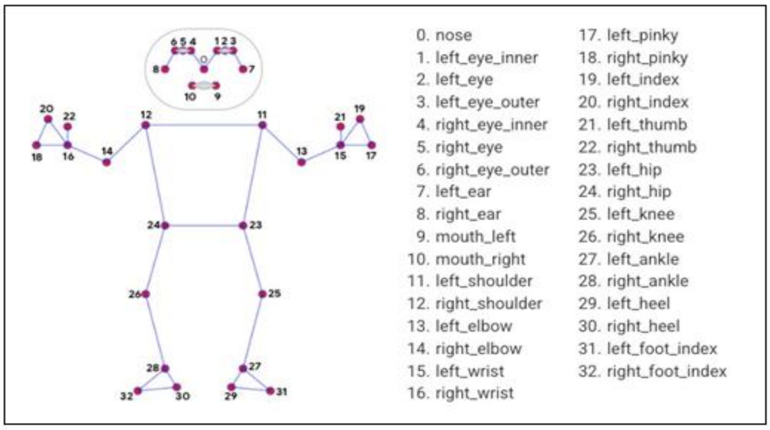

Figure 3. Mediapipe Pose Estimation Landmarks

2.7. Algorithm for Pose Prediction

The basic function that is important for the shoulder posture pose algorithm is the angle between the line and the horizontal. Assume a line between point 1 and point 2. Then, the angle between the line and the horizontal (x-axis) is calculated by the following algorithm, where the points on the landmarks are the left shoulder and right shoulder [33]. The algorithm shoulder pose:

Algorithm 1: shoulder pose

Input: self, point1, point2

Output: shoulder posture pose

Process:

```
Start
def angle_of_singleline(self, point1, point2):
x_diff = point2[0] - point1[0]
y_diff = point2[1] - point1[1]
return math.degrees(math. atan2(y_diff, x_diff))
end
```


To clarify the pose prediction algorithm, the Pythagorean theorem can be applied in calculating the distance between two vectors assumed from the distance between joints (in the MediaPipe pose implementation between 2 points on landmarks) as in figure 4.

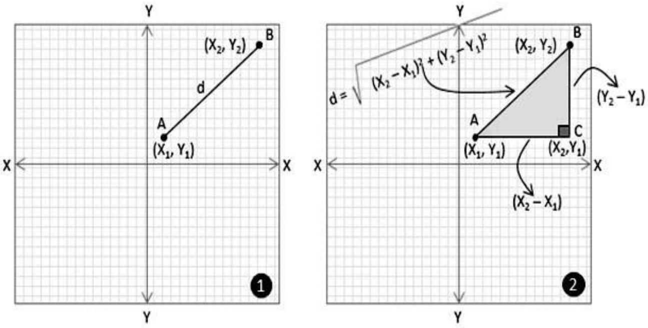

Figure 4. Pythagoras Theorem [34]

The Pythagorean theorem in figure 3 explains that if you have point A (X1, Y1) and point B (X2, Y2) in a two-dimensional coordinate plane. And want to calculate the distance (let's call it "d") between point A and point B see marked ❶To calculate the distance using the Pythagorean theorem, you must first draw a line parallel to the X-axis from point A and another line from point B, which is parallel to the Y-axis. In this case the line meeting is at point C (X2, Y1). The X-axis and Y-axis are perpendicular to each other, the triangle formed by points A, B, and C is a right triangle with the sign ❷. In figure 3, the value of "d", the distance between points A and B, will be the hypotenuse of the right triangle formed by points A, B, and C. The distance between A and B can be calculated using equation (1):

$$d = \sqrt{A - C)^2 + (B - C)^2} \quad (1)$$

A (X1, Y1) and point B (X2, Y2), and point C (X2, Y1), then we get equation (2):

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (2)$$

The Pythagorean Theorem is basically a theorem that applies to triangles [35]. Several researchers have developed their findings by utilizing this theorem. In this study, this theorem will also be utilized by making it a skeleton that is formed and to calculate its angle. If you want to measure the angle of the shoulder asymmetry, in the example below, it is by raising the upper right shoulder. So, the depiction of this theorem is like figure 5.

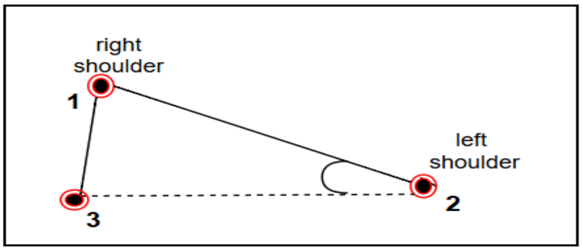

Figure 5. Application of the Pythagorean Theorem to shoulder detection

Points 1, 2 and 3 in the calculation become coordinates p1, p2, and p3. The vector formed is from point 2- 1 as v1 and from point 2-3 as v2. The angle between the shoulders to be calculated is the angle between v1 and v2. Point 1 becomes p1 relatively, because the angle can be from the left shoulder or the right shoulder. Then the subtraction (difference) between the two coordinates is carried out. The same applies to finding the hip angle. To calculate the difference (distance) between two points in two-dimensional space (x, y) the Euclidean distance is used. This function calculates the direct distance between points p1 and p2, each of which has coordinates (x, y).

3. Methodology

3.1. System Block Diagram

In classifying an activity, it is necessary to pay attention to finding body parts in each Frame and then analyzing the movement of body parts over time. The first step, the movement is detected using the Camera then MediaPipe processes the Keypoints used to display human body posture (33 Keypoints), after observing one Frame in a video. The second step analyzes body movement over time and makes a classification of the Detection System. So, the Keypoints from the system are sent to the Detection System for Real-Time posture detection classification, as shown in figure 6.

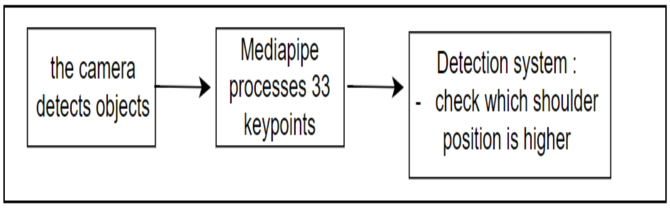

Figure 6. Block Diagram of the Detection System

3.2. Body Position Calibration

There are some general steps for calibrating the T-position process: first, prepare the body in a T-position, which consists of a vertical line running down the center of the body from the top of the head to the navel, and a horizontal line running across the shoulders. Ensure that these lines are properly aligned and form a balanced T and take pictures from the front and back. Then secondly, place the camera in a position that is parallel to the vertical line of the T position by ensuring that the camera is parallel to the line to ensure that the camera is not tilted. After that, third, determine the distance between the object and the camera by adjusting the distance between the object or subject to be captured and the camera. Ensure that the distance suits your needs and the desired image composition.

Once the calibration process is complete, take some pictures or video footage to verify that the results are as expected. Check whether the subject is in a proper and balanced position in the camera shot, and whether the T-position remains aligned and proportional. The application of T-position calibration in MediaPipe can improve the accuracy and reliability of human body landmark recognition and tracking. By referring to a predefined reference posture and using the detected landmark-keypoints, MediaPipe can better interpret the user's body movements and positions, thereby assisting in applications such as gesture recognition, posture analysis, and human-computer interaction. By going through the body position calibration process using the T-position as a reference, it can ensure that the camera is not tilted and the shooting is in optimal conditions. This helps produce balanced, accurate, and aesthetic images. In summary, the stages of this detection system that can be implemented in a detection system application: [User]: open the detection system application → [System]: detect webcam → [System]: display webcam → [User]: adjust body position → [System]: detect landmark -keypoint → [System]: perform shoulder posture detection logic calculations → [System]: display the results of landmark-keypoint detection obtained. The stages of the shoulder detection application can be described in the flowchart in figure 7 below.

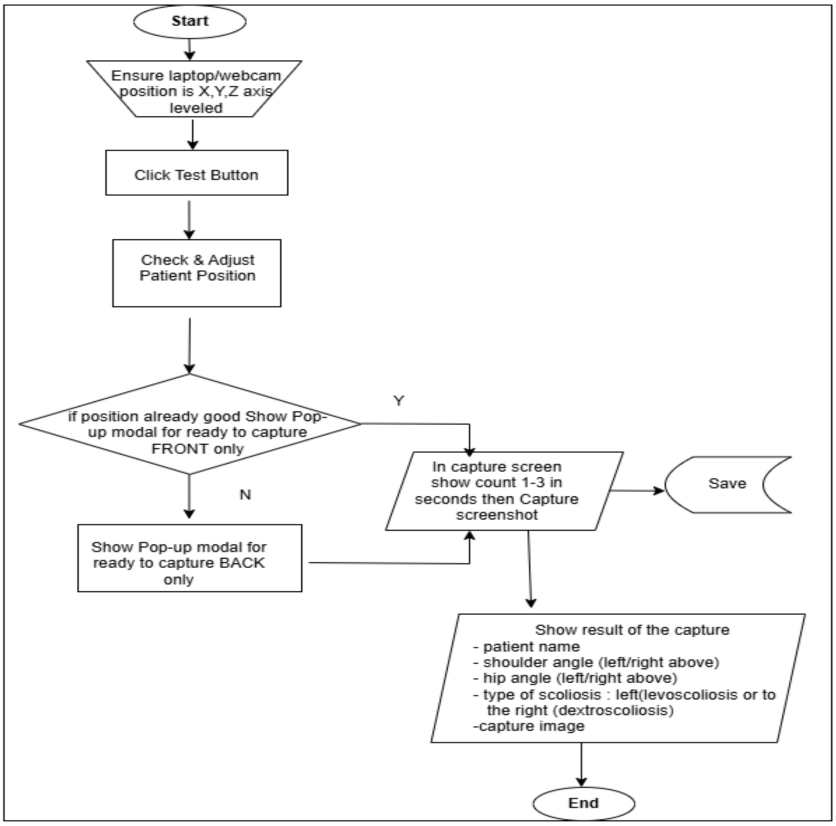

Figure 7. Flowchart of the Shoulder Detection System

3.3. Method Stages

In this study, how MediaPipe is applied to the shoulder posture detection system using computer vision can be seen from the following method stages:

Algorithm 2: shoulder posture detection.

Input: MediaPipe.

Output: shoulder posture.

Process:

Start.

Importing the mediapipe library and the opencv library.

Initializing the mediapipe pose.

Detecting landmarks and displaying keypoints generated from landmark detection.

Creating a posture detection function using keypoints and landmarks that have been.

Detected or found and implementing the calculation of the shoulder posture.

Detection logic.

End.

Import the MediaPipe library and OpenCV library, then initialize the MediaPipe pose.

The first step is to import the library consisting of DataService, cv2, os, math, time, mediapipe and enum. Import math which will later be used to calculate the angle between the line and the X axis. Import PoseLandmark which is used to define different landmarks in human poses and import DrawingSpec to draw landmarks on images or videos. Here is algorithm:

Algorithm 3: Draw landmarks on images or videos

Input: DataService, cv2, os, math, time, mediapipe and enum

Output: landmarks on images or videos

Process:

Start

Import dataservice

Import cv2

Import os

Import math

Import time

Import mediapipe

From enum import Enum

From mediapipe.python.solutions.pose import poselandmark

From mediapipe.python.solutions.drawing_utils import drawingspec

End

At this initialization stage, it contains the settings for the posture detection function using an image with the name pose_image and the posture detection function using a video with the name mp_pose. Then initialize the MediaPipe image class with the name mp_drawing. the algorithm:

Algorithm 4: settings for the posture detection

Input: mediapipe

Output: inisialisasi kelas gambar mediapipe

Process:

Start

Mp_pose = mediapipe.solutions.pose

Mp_drawing = mediapipe.solutions.drawing_utils

Mp_drawing_styles = mediapipe.solutions.drawing_styles

My_pose = mp_pose.Pose()

End

Perform landmark detection and display keypoints generated from landmark detection. At this stage, keypoints and landmarks that are available in MediaPipe will be taken. Landmark connections are custom_connections = list(mp_pose.POSE_CONNECTIONS) takes and stores a list of connections between pose landmarks that have been defined in the MediaPipe module. These connections will help in drawing lines connecting certain landmarks. Take keypoints to display landmarks only on the shoulders and hips, later the landmarks found will be used to calculate the angle on the shoulder.

Algorithm 5: stores a list of connections between pose landmarks

Input: keypoints

Output: landmarks only on the shoulders and hips

Process:

Start

excluded_landmarks = [

HEAD

    PoseLandmark.LEFT_EYE,
    PoseLandmark.RIGHT_EYE,
    PoseLandmark.LEFT_EYE_INNER,
    PoseLandmark.RIGHT_EYE_INNER,

PoseLandmark.LEFT_EAR,
PoseLandmark.RIGHT_EAR,
PoseLandmark.LEFT_EYE_OUTER,
PoseLandmark.RIGHT_EYE_OUTER,
PoseLandmark.NOSE,
PoseLandmark.MOUTH_LEFT,
PoseLandmark.MOUTH_RIGHT,
HAND
PoseLandmark.LEFT_ELBOW,
PoseLandmark.RIGHT_ELBOW,
PoseLandmark.LEFT_WRIST,
PoseLandmark.RIGHT_WRIST,
PoseLandmark.LEFT_PINKY,
PoseLandmark.RIGHT_PINKY,
PoseLandmark.LEFT_INDEX,
PoseLandmark.RIGHT_INDEX,
PoseLandmark.LEFT_THUMB,
PoseLandmark.RIGHT_THUMB,
FOOT
PoseLandmark.LEFT_KNEE,
PoseLandmark.RIGHT_KNEE,
PoseLandmark.LEFT_ANKLE,
PoseLandmark.RIGHT_ANKLE,
PoseLandmark.LEFT_HEEL,
PoseLandmark.RIGHT_HEEL,
PoseLandmark.LEFT_FOOT_INDEX,
PoseLandmark.RIGHT_FOOT_INDEX
end

The above algorithm functions to adjust the pose recognition by eliminating the above landmarks in the analysis or visualization process. This is done to focus on other body parts and only focus on relevant landmarks and other than those mentioned above (head, hands, feet) when analyzing poses without interference from the poses mentioned above. Also created is a algorithm that changes the drawing style where for each excluded landmark, the drawing style is changed to DrawingSpec, where the color is set to white (COLOR_WHITE) and means no lines are drawn (transparent). This will make the landmark not appear when the image or video is processed.

The class for the point is Class Point defined to represent a point in 2D coordinates. This class has two attributes x and y, which store the position of the point, the algorithm is as below:

Algorithm 6: point

Input: self, x, y
Output: 2D coordinates
Process:
Start
Excluded_landmarks = [
Class Point:
Def _init_(self, x, y):

 ISSN 2723-6471

```
Self.x = x
Self.y = y
End
```

Then Enumeration for Recording Status is by defining several statuses in the recording or data capture process. By using Enum, these statuses can be used in a more structured way, providing better understanding in application development (e.g., preparing the user, taking pictures from the front or back, saving data, and completing the process). This code creation is to adjust the pose recognition process by ignoring certain landmarks from the visualization and connections, and to organize the stages in the data capture process using enumeration. This can help clarify the implementation and provide better control over the application system being built. At this stage, the posture detection function will be created using keypoints and landmarks that have been detected or found and implementing the shoulder posture detection logic calculation. Next, the following algorithm will be created:

Algorithm 7: created using keypoints and landmarks

Input: frame, p1, p2

Output: geometric position information

Process:

```
Start
Def mappingposition(frame, p1, p2):
Frame_height, frame_width, _ = frame.shape
Proj = (p2.x, p1.y)
Lower = p1
Upper = p2
P1_lower = True
If p1.y < p2.y:
Proj = (p1.x, p2.y)
Lower = p2
Upper = p1
P1_lower = False
Horizon = ((int(proj[0] * frame_width), int(proj[1] * frame_height) )
(int (lower.x * frame_width), int (lower.y * frame_height)))
Return proj, lower, upper, horizon, p1_lower
Def getmedianpoint(frame, p1, p2):
Frame_height, frame_width, _ = frame.shape
Return Point (
Int (((p1.x + p2.x) / 2) * frame_width),
Int (((p1.y + p2.y) / 2) * frame_height) )
Def euclideandistance(p1, p2):
Return math.sqrt(
((p1.x - p2.x) * 2) + ((p1.y - p2.y) * 2))
End
```

In the algorithm above, the mappingPosition function is to calculate the projection of the point position on the frame based on two points (for example, points on the shoulder and hip). This function is responsible for determining some geometric position information used for body analysis, such as the horizontal projection between two points (for example, the shoulder and hip). Then the Projection code (proj) first calculates the projection of the second point (p2) on the horizontal line passing through the first point (p1). This is done by maintaining the x coordinate of p2 and the y coordinate of p1.

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The Lower and Upper variables are the lower and upper points determined based on the vertical position of points p1 and p2. The point with the smaller y coordinate is considered "lower", and the larger one is considered "upper". This is used to determine direction and orientation. The Horizon variable is to calculate two horizon points in pixel coordinates based on the frame coordinates (width and height). The projection point and the lower point are calculated based on the image size to get the pixel position on the frame. While p1_lower is to identify whether point p1 is below point p2 in the y axis, which will be used to determine the measurement direction.

The getMedianPoint function is this function calculates the median point (midpoint) between two points (p1 and p2) on the frame. Usually, this is used to find the center point between two points on the human body (for example, between two shoulder or hip points). This means that the median point is calculated by averaging the x and y coordinates of points p1 and p2. The output is to return a Point object containing the coordinates (x, y) of the median point between p1 and p2 on the frame. The euclideanDistance function is used to calculate the Euclidean distance between two points in two-dimensional space (x, y). This function calculates the direct distance between points p1 and p2, each of which has coordinates (x, y). Euclidean distance is a way of measuring the direct distance (straight line) between two points.The three functions mappingPosition, getMedianPoint and euclideanDistance are useful in the context of applications related to image processing or human posture analysis, where the calculation of the position and distance between important points (such as shoulders and hips) is used to assess posture or body movement. Then the following algorithm is created:

Algorithm 8: calculates the direct distance between points

Input: shoulder_right, shoulder_left
Output: distance between points
Process:
Start
Def checkpatientposition(shoulder_right, shoulder_left):
Shoulder_distance = euclideandistance(shoulder_right, shoulder_left)
Check if the distance is within the threshold
If shoulder_distance <= NEAR_THRESHOLD and shoulder_distance >= FAR_THRESHOLD:
Text = 'Good'
Color = COLOR_GREEN # Green
Return text, color
If shoulder_distance > NEAR_THRESHOLD:
Text = 'Too close'
Color = COLOR_RED # Red
Return text, color
If shoulder_distance < FAR_THRESHOLD:
Text = 'Too far'
Color = COLOR_RED # Red
Return text, color
Return 'Unknown', COLOR_RED
End

The checkPatientPosition function aims to assess the position of the patient based on the distance between two important points on the human body, namely the right shoulder (shoulder_right) and the left shoulder (shoulder_left) using the previously defined euclideanDistance function. This function will return a status and color indicating whether the patient's position is good, too close, or too far, based on a predetermined distance threshold. This distance is then used to determine whether the patient's position is in a "good", "too close", or "too far" position. Determining position based on threshold:

Position NEAR_THRESHOLD and FAR_THRESHOLD are distance thresholds used to determine whether the patient is too close or too far. This function will evaluate the calculated distance (shoulder_distance) against the threshold value. Position Status “Good” is if the distance between the left and right shoulders is within the range specified by NEAR_THRESHOLD and FAR_THRESHOLD, then the patient's position is considered good. In this case, the function returns the status “Good“ and position status “Too close” is if the distance between the left and right shoulders is greater than NEAR_THRESHOLD, then the patient is considered too close to the position it should be, and the function returns the status “Too close“ and “Too far” is if the distance between the left and right shoulders is smaller than FAR_THRESHOLD, then the patient is considered too far, and the function returns the status “Too far“.

Undefined Status is f the distance does not match the three conditions above, then the status “Unknown"”, although this condition rarely occurs if the threshold is correct. The existing parameters are shoulder_right is coordinate point for the right shoulder and shoulder_left is coordinate point for the left shoulder. This means that in the algorithm above, the checkPatientPosition function is used to evaluate the position of the patient based on the distance between two points of the body (for example, the left and right shoulders). This function is important in applications that monitor the posture or position of the patient, and can provide visual feedback on whether the patient is in the correct position, too close, or too far, based on a specified threshold value. The core stages of calculating the angle are in the following algorithm:

Calculates the angle between two vectors starting at the same point using atan2.

Algorithm 9: calculating the angle

Input: x1, x2, y1, y2, x3, y3
Output: angle
Process:

```
Start
Calculates the angle between two vectors starting at the same point using atan2.
Args:
p1: Coordinates of the first vector endpoint (x1, y1).
p2: Coordinates of the starting point (x2, y2).
p3: Coordinates of the second vector endpoint (x3, y3).
Returns:
The angle between the two vectors in radians.
""""
global ANGLE_CACHE
Calculate vectors
v1_x = p1[0] - p2[0]
v1_y = p1[1] - p2[1]
v2_x = p3[0] - p2[0]
v2_y = p3[1] - p2[1]
Calculate angles using atan2
angle1 = math. atan2(v1_y, v1_x)
angle2 = math. atan2(v2_y, v2_x)
Calculate difference in angles (adjust for negative differences)
angle_diff = angle2 - angle1
if angle_diff < -math.pi:
angle_diff += 2 * math.pi
elif angle_diff > math.pi:
angle_diff -= 2 * math.pi
```

```
result      = abs(angle_diff) * 180 / math.pi
difference = abs (result - ANGLE_CACHE [cacheKey])
if (difference > ANGLE_CALC_THRESHOLD or ANGLE_CACHE [cacheKey] == 0):
update cache
ANGLE_CACHE [cacheKey] = result
return result
return ANGLE_CACHE [cacheKey]
end]
```

The calcAngle function is designed to compute the angle between two vectors originating from the same point. It utilizes the atan2 (arc tangent) function to determine the direction of each vector and subsequently calculate the difference between the two angles. To enhance efficiency, the function incorporates a caching mechanism that stores previous results and avoids recalculations when the angle values remain largely unchanged.

The function takes three points as input: p1, p2, and p3. Point p2 serves as the origin or common base of the two vectors, while p1 and p3 represent the ends of the vectors. It first computes the coordinates of each vector: the first vector is formed from p2 to p1, and the second from p2 to p3. The vector components are derived by subtracting the base point's coordinates from the endpoint's coordinates. Using atan2, the function calculates the angle of each vector relative to the x-axis. This method is preferred over the basic atan because it correctly handles quadrant-specific cases and negative values.

Once the two angles are determined, the function computes the angular difference using the formula angle_diff = angle2 - angle1. Since angle differences can exceed the range of $-\pi$ to π, adjustments are made by adding or subtracting 2π to bring the result within that range. This ensures consistency and correctness in angle representation. Finally, the angle in radians is converted to degrees using the formula result = abs(angle_diff) * 180 / math.pi, giving the final result in degrees. To further improve performance, the function implements a caching strategy using ANGLE_CACHE. This mechanism checks whether a previously computed angle is still valid, and if so, avoids reprocessing. This not only enhances speed but also ensures accurate and consistent angle computations, especially in repeated or real-time applications.

4. Results and Discussion

4.1. Shoulder Posture Detection Testing

At this stage, testing is carried out on the detection of shoulder posture according to the flowchart in figure 4. In this test, the subject will make movements to detect shoulder posture, namely the right shoulder posture is higher, the left shoulder posture is higher with a position facing the camera (front) or facing away from the camera (back).

Manually ensure the position of the laptop/webcam is parallel to the X, Y, Z axes. In the application system, click the Test, Check & Adjust Patient Position button, if the position is correct, then display the Pop-up modal to be ready to capture the FRONT section only. If it is active, then on the capture screen display a count of 1-3 in seconds then take a layer capture. Then display the Pop-up modal to be ready to capture the BACK section only. If it is active, then on the capture screen display a count of 1-3 in seconds then take a layer capture. If all is certain and the results are good, then it can be saved. The results can also display the capture results regarding: patient name, shoulder angle (left/right above), hip angle (left/right above) and capture image.

4.2. Results of Capturing Shoulder Detection from the Front and Back

Logical calculations are performed to detect whether the subject's shoulder posture detected by the webcam meets the specified conditions. In the trial, to obtain the desired capture, the threshold value is 15. The threshold value is used to determine the meaning limit of the "almost" criterion (for example, the criterion: "The position of the key point and the reference point with the capture is almost the same", at the desired position). The results of the front and back detection are as shown in the following figure 8.

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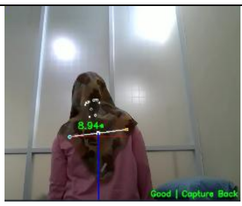
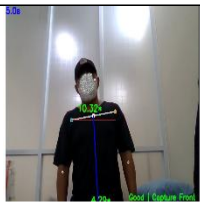
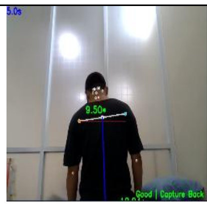
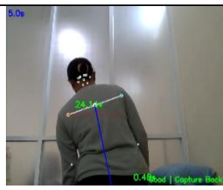
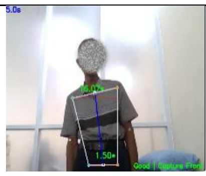
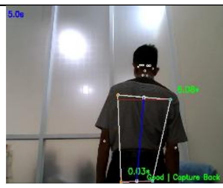
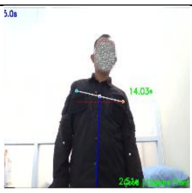
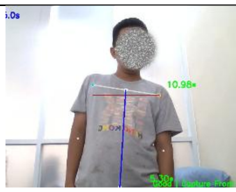
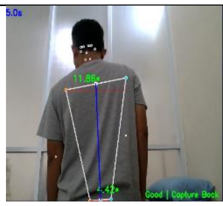
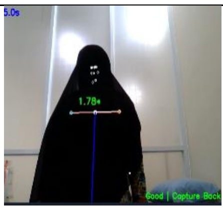
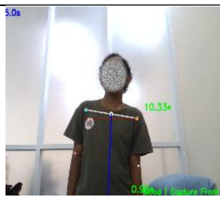
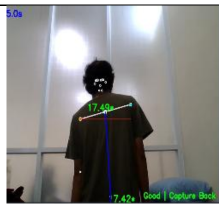
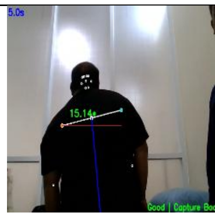
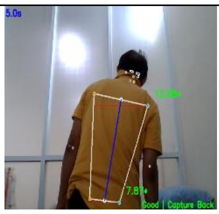
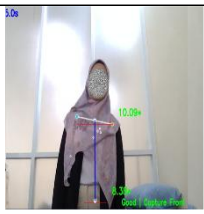
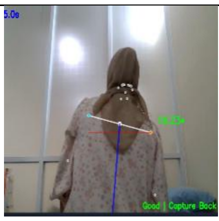
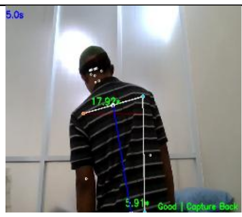
Figure 8. Front and Back shoulder detection results

The following table 1 is a table of the results of a trial of data collection of 16 respondents to detect the position of the shoulders from the front and back.

Table 1. Data capture on shoulder position detection from Front and Back

No	id	Front	Back	No	id	Front	Back
1.	78			9.	87		
2.	79			10.	88		
3.	80			11.	89		
4.	81			12.	90		
5.	83			13.	91		
6.	84			14.	92		

ISSN 2723-6471

7.	**85**			**15.**	**93**		
8.	**86**			**16.**	**94**		

Perform logical calculations to detect whether the subject's shoulder posture detected by the webcam meets the specified conditions. Complete patient data containing identity in the form of name, place and date of birth are not listed in table 2 for confidentiality, only the name is listed and not the full name.

Table 2. Results of data testing in the clinic

	Patient_ id	patient_ name	clinic_ name	is_ scoliosis	front_ shoulder_ angle	front_ hip_ angle	Back shoulder_ angle	Back hip_ angle	Scolio-meter
1.	78	Rita H	G-Clinic	FALSE	7.42	13.42	9.78	1.50	7
2.	79	Sri H.	G-Clinic	TRUE	9.02	1.75	15.70	2.65	7
3.	80	Yani	G-Clinic	FALSE	9.12	3.86	4.52	3.92	5
4.	81	Riski A	G-Clinic	FALSE	14.03	2.51	2.18	3.72	9
5.	83	Restiyani	G-Clinic	FALSE	4.21	2.51	1.78	3.76	5
6.	84	Frans	G-Clinic	TRUE	15.97	5.84	15.04	1.95	10
7.	85	Ujang S	G-Clinic	FALSE	19.43	5.68	12.68	7.87	10
8.	86	Nadia	G-Clinic	TRUE	14.26	7.06	16.23	8.16	17
9.	87	Rio	G-Clinic	FALSE	10.32	4.29	9.50	2.53	10
10.	88	Aulia	G-Clinic	TRUE	15.97	2.27	24.14	0.48	12
11.	89	Nasir	G-Clinic	FALSE	16.07	1.50	6.08	1.80	15
12.	90	Chery A	G-Clinic	FALSE	10.98	5.30	12.38	4.42	10
13.	91	Akhdan	G-Clinic	TRUE	10.33	0.90	17.49	13.77	10
14.	92	Yowan	G-Clinic	TRUE	15.45	4.08	15.14	13.77	11
15.	93	Sani	G-Clinic	FALSE	10.09	8.38	8.04	5.94	10
16.	94	Sadah	G-Clinic	TRUE	19.84	7.38	17.92	5.91	12

In table 2, manual measurements were also carried out using a scoliometer. Measurements with a scoliometer can be used as a comparison or as support to strengthen the diagnosis. According to [9], the group of young adolescents and young adults (age> 10 years), scoliometer measurements of 5-7° or> 10° Cobb angle (X Ray) is recommended to be referred to an orthopedic specialist. While in the research results table, the respondent's age is already an adult and with shoulder posture measurements if there is asymmetry it is considered part of the measurement of scoliosis and is filled with TRUE with a tendency to tilt to the left (LEFT) or right (RIGHT). We take the reference angle of inclination at the shoulder above 15° as the measurement limit for the amount of shoulder asymmetry that will be indicated as scoliosis and the measurement limit with a scoliometer is 5° even though it was tested for adults [23].

5. Conclusion

Based on the results of the study on the real-time shoulder posture detection system, it can be concluded that the research conducted was successful. The testing of the shoulder posture detection application system was also designed to detect the pelvic part, which is as supporting data if you want to analyze it further to detect scoliosis. Manual measurement with a scoliometer is also to support the diagnosis. Usually, manual physical examination of scoliosis uses a scoliometer with the Adam Bending Test method. Our research was conducted with shoulder detection and the Adam Bending Test and a complete application starting from patient data collection, then angle information from the front and back positions, the results of which display the results of the system detection in the form of keypoint extraction from the pose estimation on the user interface and video display in real time, where the testing of the shoulder posture detection system was carried out on the shoulder position from the front and back and the landmark - keypoint testing on one test subject has also been successful, namely with a threshold value of the estimated pose taken is 15. If you try to take a value of more than 15, then the position of the keypoint and landmark is captured in the right position, and so on if less. This value can change relatively in each trial and which type of pose will be estimated. Actually, if there is already an asymmetry between the right and left shoulders, it can indicate a spinal disorder (scoliosis). Manual measurements can use a scoliometer by reading the ATR. The examination is considered positive if the reading on the scoliometer is 7 degrees or more ($\geq 20^{\circ}$ Cobb angle with X-Ray) at one or more levels of the thoracic or lumbar spine. A lower degree of rotation may indicate a milder degree of scoliosis. Furthermore, this shoulder posture detection system can be further developed by conducting trials on many respondents or patients with scoliosis, kyphosis spinal structures by adding features and displays to this system until it becomes better and can be useful in the medical practitioner environment and the health world in general.

6. Declarations

6.1. Author Contributions

Conceptualization: H., T.R., M.H.; Methodology: H., M.H.; Software: H.; Validation: T.R., M.H.; Formal Analysis: H.; Investigation: H.; Resources: T.R., M.H.; Data Curation: H.; Writing – Original Draft Preparation: H.,T.R.; Writing – Review and Editing: T.R., M.H.; Visualization: H.; All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.3. Funding

The authors would like to thank The Directorate of Research and Community Service - Ministry of Research, Technology and Higher Education (DRPM - Kemenristek / BRIN) for financial support of this experiment, 26 July 2024.

6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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