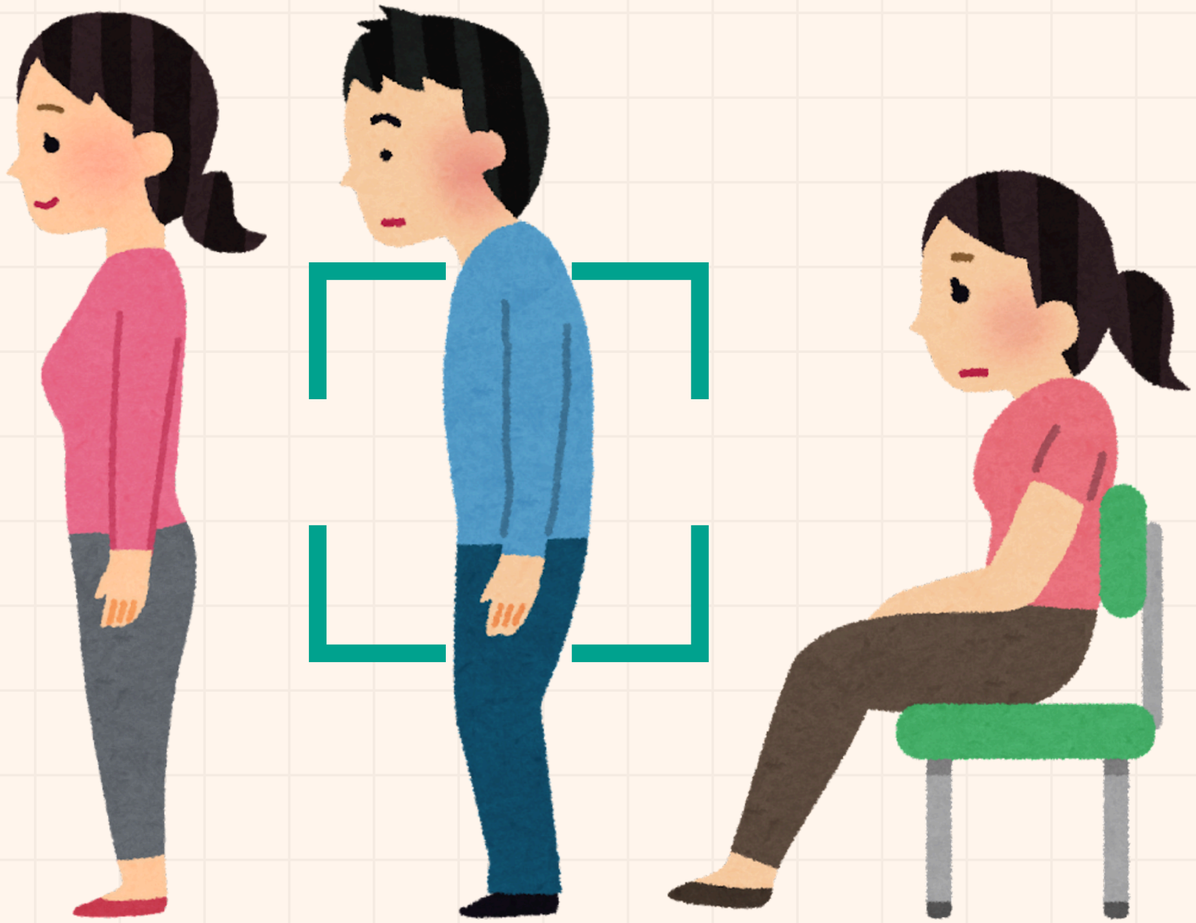
SLOUCH DETECTION

Digital Image Processing



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LIST OF CONTENT

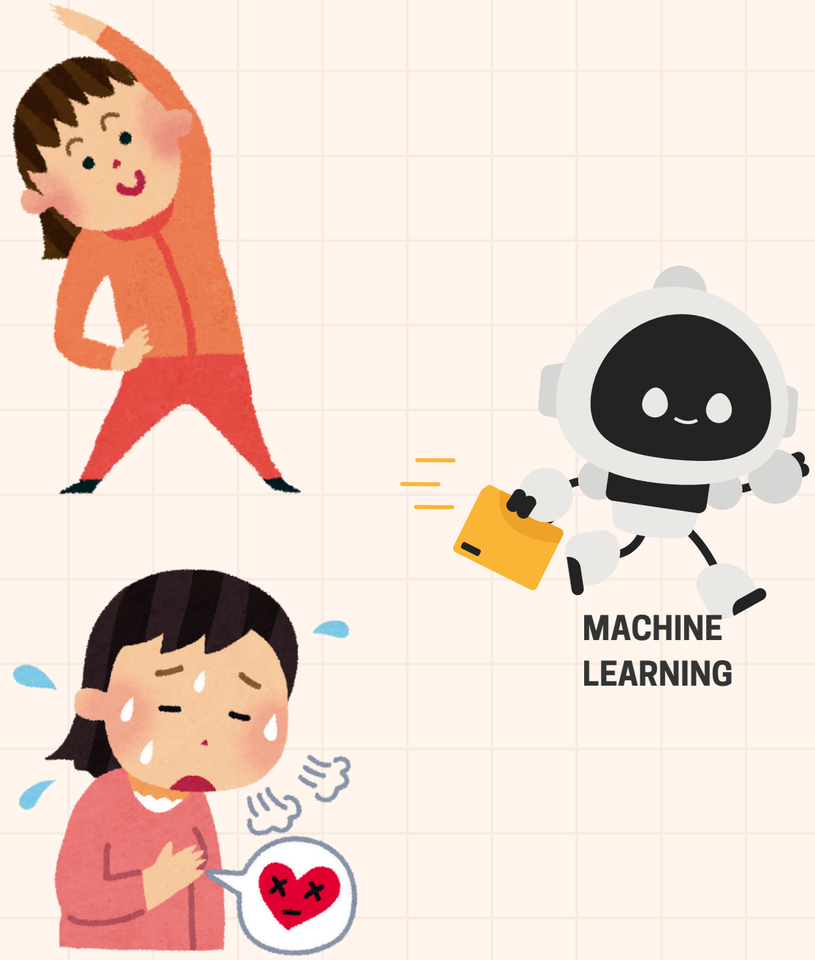
Posture Detection

PROBLEM STATEMENT

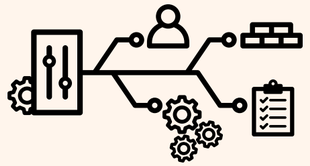
Manual posture monitoring is inefficient and error-prone. Poor posture, like slouching, causes health issues. An automated system is needed to detect sitting, standing, and slouching using digital image processing

OBJECTIVES

- To automate slouching posture detection
- To classify different slouching postures accurately
- To promote health and ergonomics



PROPOSED METHOD



INPUT ACQUISITION

```
cap = cv.VideoCapture(0)
ok, frame = cap.read()
if not ok:
    break
if MIRROR:
    frame = cv.flip(frame, 1)

h, w = frame.shape[:2]
rgb = cv.cvtColor(frame, cv.COLOR_BGR2RGB)
res = pose.process(rgb)
```

Camera Input process to send images to the image processing system.This code uses the computer's webcam to capture the user's movements in real time.

The resulting data is a series of frames, each representing an BGR image (in OpenCV).These frames are then passed to the MediaPipe pose estimation process.

POSE ESTIMATION

```
mp_pose = mp.solutions.pose
```

```
res = pose.process(rgb)
```

MediaPipe

Pose Estimation step uses the MediaPipe Pose module, a model that can identify 33 key points on the human body from real-time RGB images, and then select the most obvious side of the body (left or right) to use in calculating the torso and neck angles in the next step.

PROPOSED METHOD

GEOMETRY COMPUTATION

```
# ---------- Trunk angle ----------
trunk_vec = SH - HP   # จาก hip ไป shoulder
trunk_ang = angle_from_vertical(trunk_vec)

# ---------- Neck angle ----------
neck_vec = EA - SH
neck_ang = angle_between(neck_vec, SH - HP)

# ---------- FHD ratio ----------
torso_len = np.linalg.norm(trunk_vec)
fhd_ratio = abs(EA[0] - SH[0]) / torso_len if torso_len > 0 else 0
```

After obtaining the coordinates of various positions such as the ears, shoulders, and hips, the next step is geometric computation to convert these coordinates into “angular data” that can be used to indicate posture characteristics such as upright posture, leaning neck, or hunched back.

(Trunk Angle)

Measures the angle between the trunk and the vertical (Y-axis).
Used to indicate whether the user is leaning forward or backward.

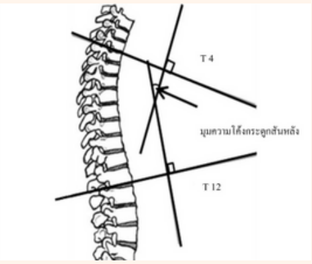
(Neck Angle)

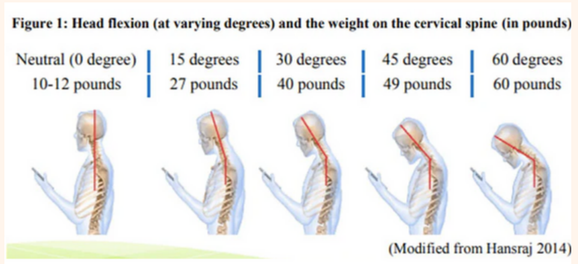
Measures the angle between the neck and the body.
Used to determine whether the head is tilted forward or upward.

FHD Ratio (Forward Head Displacement Ratio)

Measures the distance the head is tilted from the shoulder line relative to the body length.Used to confirm "Forward Head Posture" behavior.

SEVERITY CLASSIFICATION





Convert angle and ratio values to levels (1–4) based on conditions.

From code conditions :

Severe: neck ≥ 40° or trunk ≥ 14° or fhd_ratio ≥ 0.3.

Moderate: neck ≥ 30° or trunk ≥ 12° or fhd_ratio ≥ 0.2

Mild: neck ≥ 15° or trunk ≥ 9.7° or fhd_ratio ≥ 0.1

Normal: else

Antonelli-Incalzi's research : A person whose thoracic spine curves backward more than 40 degrees is considered to have scoliosis.

Kenneth K. Hansraj: chief of spine surgery at New York Spine Surgery & Rehabilitation Medicine, says the bad posture can put up to 60 pounds of pressure on the upper spine

FHD Ratio : FHD Ratio = 0.1 is the forward reach (X axis) is 0.1 time the neck height.

PROPOSED METHOD

VISUALIZATION

```
# ---------- Draw skeleton ----------
SHi, HPi, EAi = tuple(SH.astype(int)), tuple(HP.astype(int)), tuple(EA.astype(int))
cv.line(frame, HPi, SHi, (0,255,0), 2)
cv.line(frame, SHi, EAi, (255,255,0), 2)
```

```
# ---------- HUD ----------
y0 = 30
cv.putText(frame, f"Side: {side_used_disp}", (10,y0), cv.FONT_HERSHEY_SIMPLEX,0.7,(255,255,255),2)
cv.putText(frame, f"Trunk angle: {trunk_ang:.1f}°", (10,y0+30), cv.FONT_HERSHEY_SIMPLEX,0.6,(0,255,0),2)
cv.putText(frame, f"Neck angle: {neck_ang:.1f}°", (10,y0+60), cv.FONT_HERSHEY_SIMPLEX,0.6,(0,0,255),2)
cv.putText(frame, f"Back bend: {back_bend:.1f}°", (10,y0+90), cv.FONT_HERSHEY_SIMPLEX,0.6,(255,200,0),2)
cv.putText(frame, f"FHD ratio: {fhd_ratio:.2f}", (10,y0+120), cv.FONT_HERSHEY_SIMPLEX,0.6,(0,255,255),2)
cv.putText(frame, f"Posture Level: {label_txt}", (10,h-30), cv.FONT_HERSHEY_SIMPLEX,0.8,label_col,2)
```

Displays user-friendly and provides immediate feedback

Head-Up Display:Displays text and angle values measured by the camera at the same time as the video image.

Skeleton Overlay: Draw lines connecting the hips and shoulders, shoulders and ears, and circle landmarks.

Colors by Level: (Green, Yellow, Orange, Red) Use bold colors.

OUTPUT

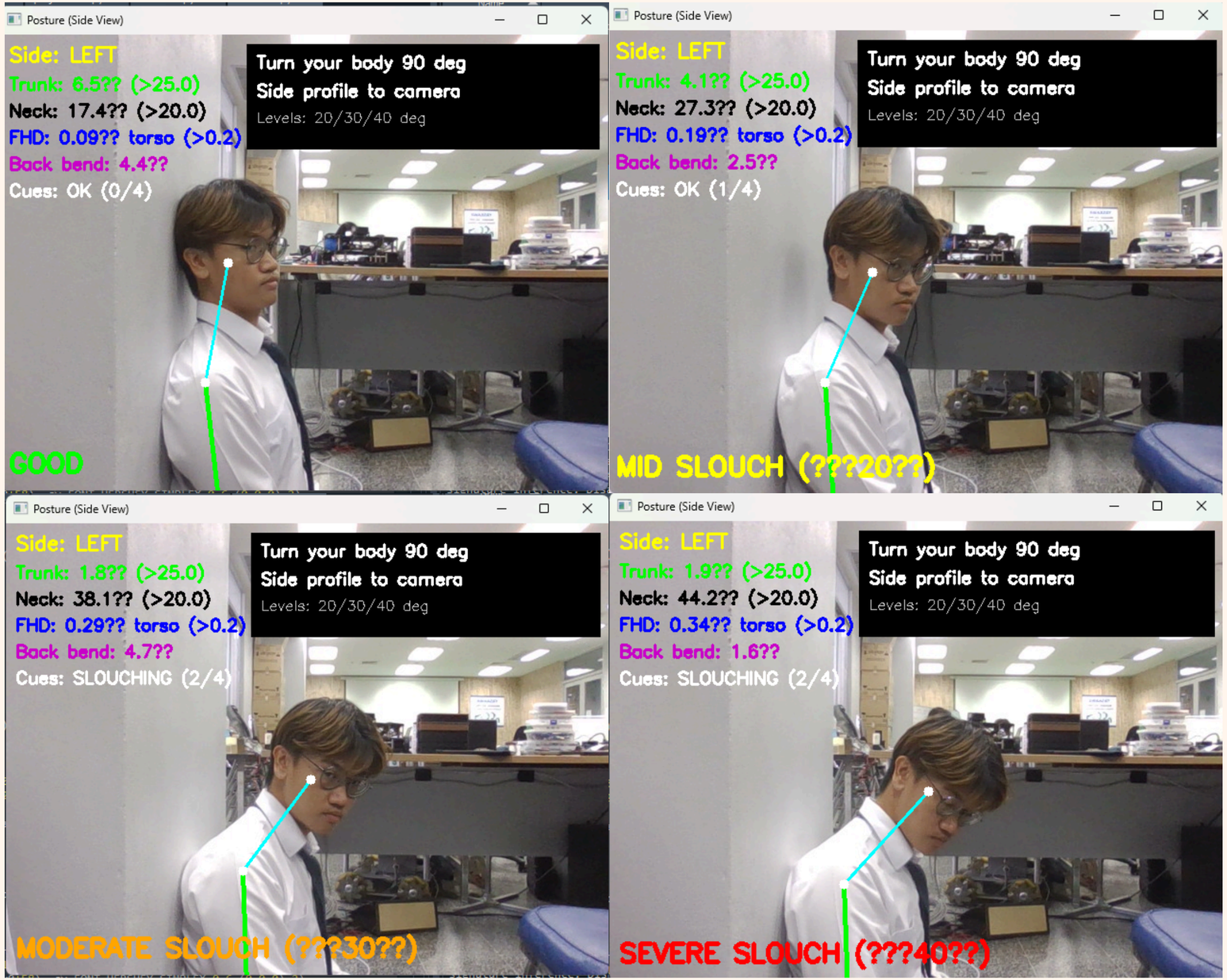
Displays real-time camera images

Head-up Display (HUD):

- Side Detection
- Trunk Angle
- Neck Angle
- FHD Ratio
- Posture Level

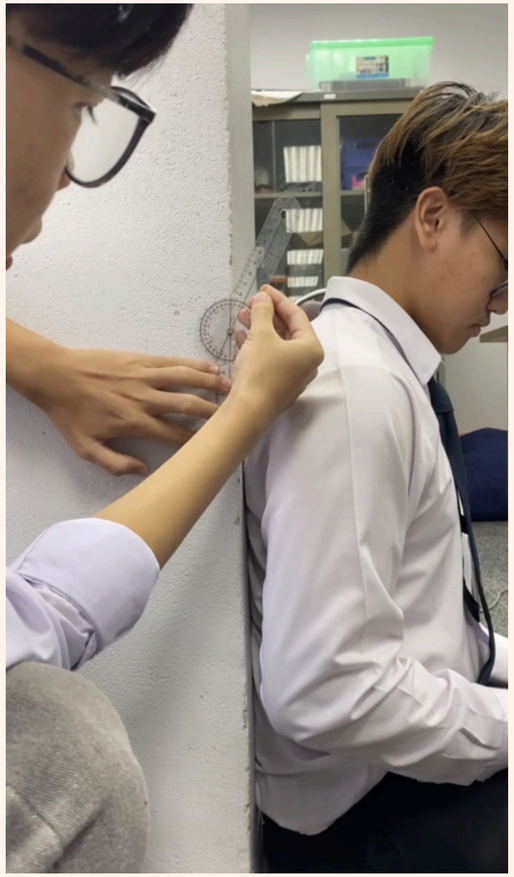
Resize the image to display at 1500×940 px.

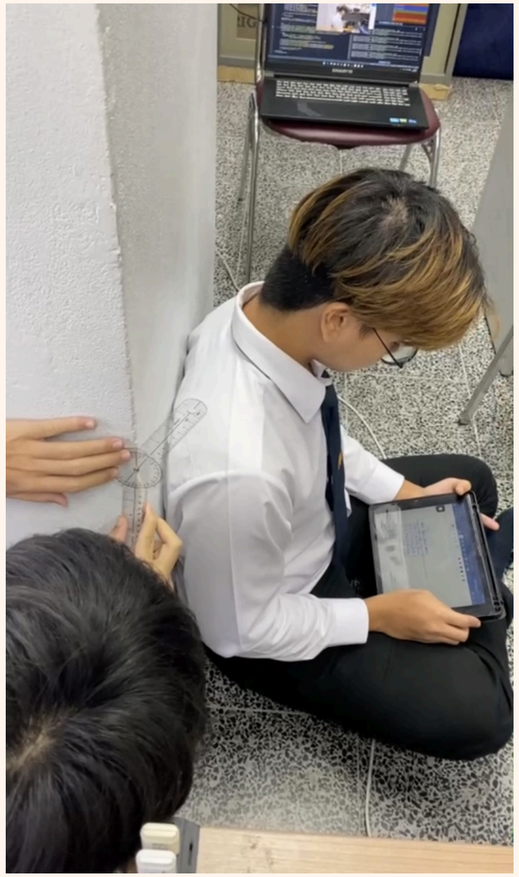
EXPERIMENT

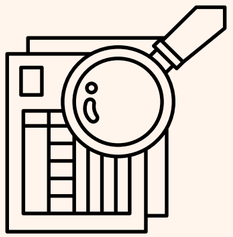


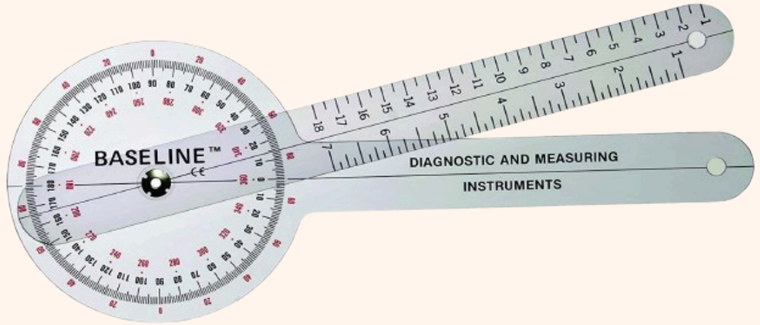
- Real-time detection using MediaPipe Pose (Python)
- Measured Neck and Trunk angles to assess slouch severity
- Thresholds defined for Good, Mild, Moderate, Severe
- Visual feedback overlays (lines + labels) update per frame

EXPERIMENT









Goniometer

Measuring neck and trunk angles using a goniometer as ground truth for slouching detection

RESULT

Good (0-19 degrees)	Mild (20-29 degrees)	Moderate (30-39 degrees)	Severe (40> degress)
Goniometer/image processing	Goniometer/image processing	Goniometer/image processing	Goniometer/image processing
12/15	21/25	32/32	40/38
9/10	25/25	36/34	40/41
15/16	26/26	33/38	45/50
10/12	30/27	38/35	54/54

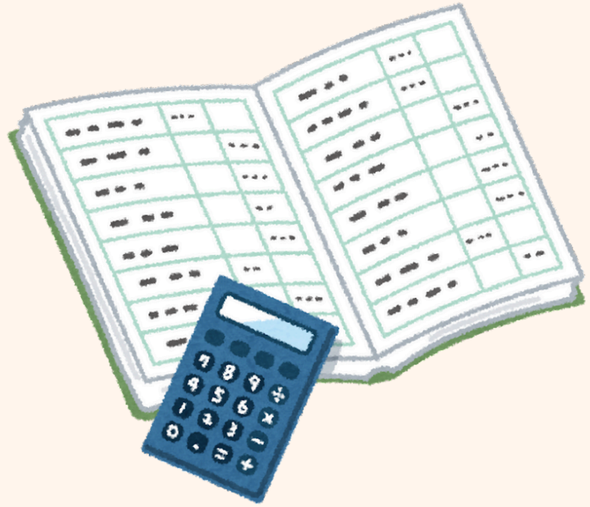
RESULT

Good (0-19 degrees)	Mild (20-29 degrees)	Moderate (30-39 degrees)	Severe (40> degress)
+3	+4	+0	-2
+1	+0	+2	+1
+1	+0	+5	+5
+2	+3	-3	+0

Mean Difference or Bias

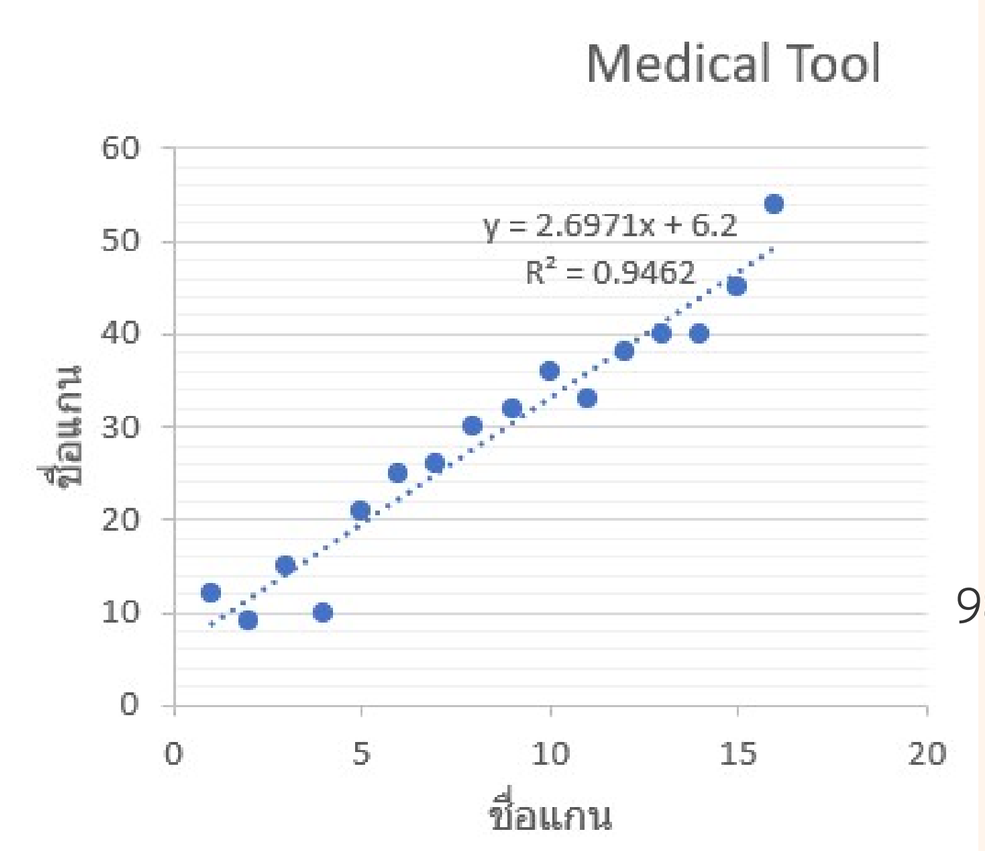
Σdata/Σnumbers of total data

22/16 = +1.4 degrees



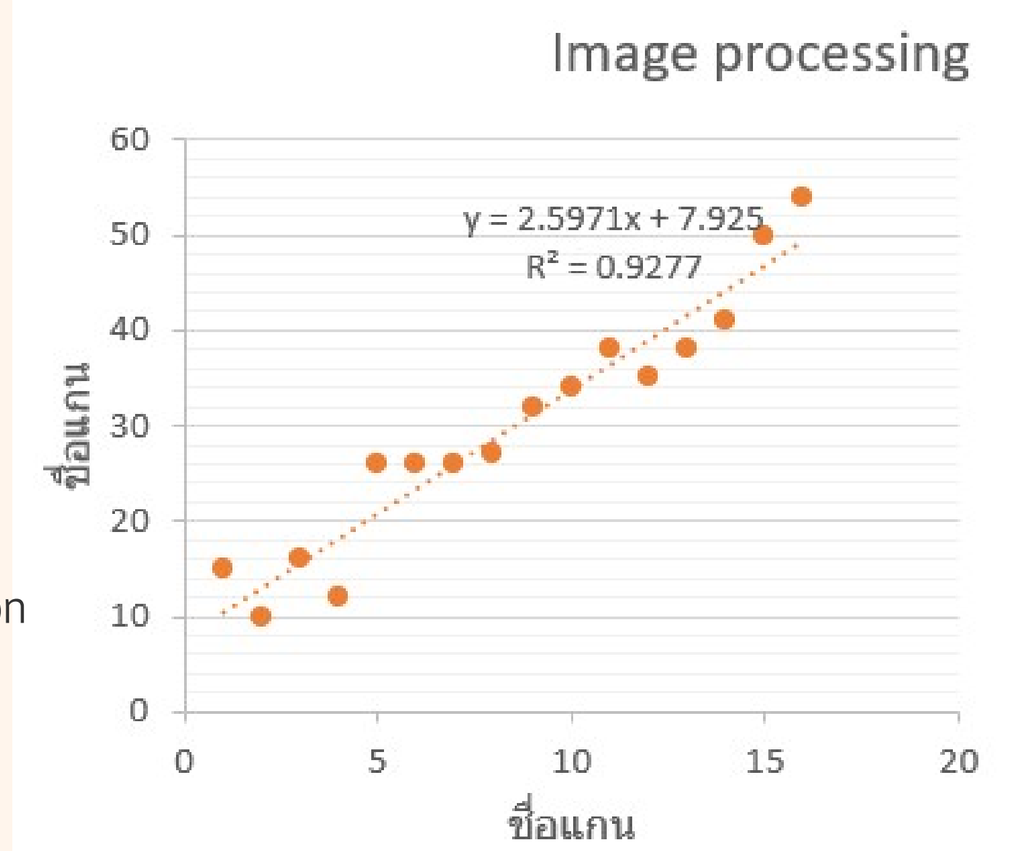
RESULT

Correlation and Root Mean Square



XLS

98% correlation



Both methods show a strong positive correlation and similar root mean square, confirming the accuracy of the image-processing approach compared to the medical goniometer

CONCLUSION

This project develops an intelligent system to monitor and classify sitting posture using a fixed camera. By applying pose estimation techniques such as MediaPipe , the system analyzes body angles to distinguish between correct sitting and slouching.Its objectives are to automate posture detection, improve classification accuracy, and promote ergonomic awareness for healthier sitting habits.

FUTURE WORK

- 3D Posture Estimation: use depth cameras (like OAK-D) or stereo vision to estimate posture in 3D rather than relying on 2D angles.

- Multi-Angle Support: add detection for both side view and front view using symmetry (shoulder and ear height differences).

- Real-Time Feedback System: sound/vibration alerts, or an LED that turns red when slouching.

REFERENCES

Academic Research & Paper

Pose Estimation

https://ieeexplore.ieee.org/document/10603040

https://ieeexplore.ieee.org/document/11115324

https://ai.google.dev/edge/mediapipe/solutions/vision/pose_landmarker?hl=th

https://arxiv.org/abs/1812.08008

Medical research

https://www.npr.org/sections/thetwo-way/2014/11/20/365473750/keep-your-head-up-text-neck-can-take-a-toll-on-the-spine

https://www.physio-pedia.com/Cobb_Angle

YouTube (AI Pose Estimation with Python and MediaPipe)

https://youtu.be/06TE_U21FK4?si=CVWSy7WHmqUkS-e0

THANK YOU