



RESEARCH ARTICLE

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DESIGN OF A REAL-TIME AND DEPENDABLE HYBRID COMPUTER SYSTEM FOR THE RECOVERY FROM THE MEDICAL CUBITAL TUNNEL SYNDROME

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ABSTRACT

Computer systems are playing an increasingly vital role as core components in the design of dependable and medical cyber-physical systems (CPS) applications, which demand high levels of safety, reliability and performance. Cubital tunnel syndrome is a widespread upper limb peripheral nerve entrapment neuropathy that can cause significant discomfort and disability for the affected person. This critical medical condition frequently involves physical therapy activities aimed at reducing nerve compression. This paper presents a real-time and reliable hybrid computer system to optimize the efficacy of exercises for Cubital tunnel syndrome (CuTS) through automated video analysis, principles of computer vision, computer architecture and real-time dependable systems. The system compares exercises completed by the user with a reference image to verify proper joint angle alignment and improve therapeutic results. Specific joint angles are extracted and analyzed in real time by processing user videos and providing continuous feedback to users. The proposed computer system dynamically tracks angles and records them to facilitate consistent guidance and tracking of user progress through speech synthesis. OpenCV, MediaPipe, and Google Text-to-Speech (gTTS) were combined together for video processing, pose estimation, and text-to-speech conversion, respectively. Landmarks for specific joints are reliably detected and extracted using MediaPipe combined with precise custom angle calculation functions are consistently applied. The system compares calculated angles with predefined reference ranges and provides auditory feedback to users about the correctness of their joint angles, as well as guidance for adjustments. The proposed system is tested and validated to show promising result for this integration of hardware computer processing and speech synthesis for enhancing patient monitoring and rehabilitation.



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I. INTRODUCTION

Safety-critical digital computer systems are playing an increasingly vital role as core components in the design and assessment of fault-tolerant, dependable and medical healthcare, cyber-physical systems (CPS) and Internet of Things (IoT) applications, which demand enhanced levels of reliability, security, safety, and formal verification [1], [2], [3]. To develop dependable and real-time hardware and embedded software computer systems, designers rely heavily on hybrid fault tolerance strategies, real-time processing and biologically inspired computing modules [4], [5], [6]. Cubital tunnel syndrome is the second most common peripheral nerve entrapment neuropathy in the upper limb which represents a source of considerable discomfort and critical disability for the patient and in extreme cases may progress to loss of function of the hand. Cubital tunnel syndrome remains an often-misdiagnosed medical condition [7]. The ulnar nerve runs from the spine to the hand which is responsible for transferring feeling in the little finger and the ring finger also powers the small muscles in the hand.

Cubital tunnel syndrome happens when the ulnar nerve gets compressed or irritated within the tunnel found on the inside of your elbow. This prevents the nerve's ability from functioning correctly as shown in Fig. 1, and the early symptoms include pain on the inside of the elbow, pins and needles or numbness mainly in little and ring fingers that comes and goes. Most of the symptoms happen overnight or first thing in the morning and later, these symptoms start to happen more often. Cubital tunnel syndrome (see Fig. 1) typically affects many people in the world and physical therapy exercises designed to manage and alleviate the nerve compression. The requirement for professional supervision places difficulties on traditional ways of tracking exercise performance and makes it costly. Developments in the topical areas: computer vision microprocessor-based computer systems and artificial machine learning can automate the instrumentation procedure and give patients immediate feedback to guarantee that exercise is completed correctly. Researchers proposed many ways to automate the exercises such as computer vision and pose estimation techniques, machine learning for rehabilitation and physical therapy, yoga and pilates posture estimation, and ergonomic and activity recognition systems. However, most of the proposed methods are not comprehensive and give robust results in real-time. Consequently, achieving the automatic correction of the physical therapy remains an unresolved problem and requires more improvements and development. Recently, computer vision techniques have achieved astonishing results on different scale of applications such as biometric [8], smart surveillance [9], and very complicated pattern recognition [10].



Figure 1: Cubital tunnel syndrome.

Source: Authors, (2026).

Our project offers a comprehensive approach with a real time and reliable hardware embedded digital system to provide and ensure a proper physical therapy, which includes the primary contribution as follows:

- 1-The proposed computer system offers an integrated and reliable digital embedded system for Cubital Tunnel Syndrome (CuTS) rehabilitation by integrating different design principles such as computer vision, real-time audio feedback, and reliable microprocessor-based hardware implementation.
- 2-Our research project utilizes OpenCV and MediaPipe to track the joint angles during rehabilitation exercises to provide an accurate motion assessment with no need for an expert human observer.
- 3-The designed system includes Google Text-to-Speech to provide an auditory feedback to consider accessible for visually impaired cases.
- 4-The proposed digital embedded system leverages the processing platform Raspberry Pi implementation to provide cost-effective solution and portable edge computing device which can offer real time response without the need to use an external server to guarantee low latency, improved performance, and offline usability.

II. LITERATURE REVIEW

For computer vision and pose estimation techniques, to promote self-correction and increase workout efficacy, Kotte et al. employed trained YOLOv7 to provide real-time posture feedback during fitness exercises [11]. Dedhia and Pratham Bhoir utilized Google's MediaPipe for posture estimation and feedback. They provided tracking of exercise repetitions and employing machine learning models to ensure precise and personalized feedback [12]. OpenCV and MediaPipe were used by Kwon and Kim to correct real-time workout posture and secure workout repetitions, thus enabling home exercisers to avoid wrong forms of postures without the help of trainers [13]. Modified Open Pose, as presented by Patel and Kalani have proved significant in fitness exercises where they detected poses that are being executed wrongly for safety reasons reducing the effect of their performance [14]. Jo and Kim contrasted four pose estimation models (OpenPose, PoseNet, MoveNet Lightning, and MoveNet Thunder) with PoseNet being accurate but slower while MoveNet Lightning was fast enough to provide performance insights on mobile devices [15]. Kim et al put forward a lightweight 3D pose estimation system combining 2D pose detection with humanoid models for real time recognition which addressed problems emanating from depth confusion through enhancing monitoring in real time [16]. Machine learning for rehabilitation and physical therapy were used by Schetz-Sobrinho et al. by taking advantage of computer vision together with the DTW algorithm. This helped them in classifying exercises for stroke recovery which was done remotely— thus enhancing flexibility and also fostering better communication during the rehabilitation process [17]. In another study, Pereira et al. introduced a smartphone-based shoulder rehabilitation approach using pose estimation that was later validated through clinical studies— guaranteeing effective autonomous recovery sessions [18]. Ameur Latreche et al., on their part, came up with an in-home lower body rehabilitation system based on lightweight pose estimation and a large dataset (presumably low-cost). Latreche et al., however, proposed a telerehabilitation website with AI capabilities for real-time monitoring of patients' range of motion since geographical constraints cannot allow easy access to such services [19]. Lastly, Hassan et al. adopted PoseNet plus dynamic time warping which played a major role in physiotherapy by helping patients to detect correct poses and provide feedback: this ensured high accuracy in posture detection [20].

Chen and Kalun created a video-based training system incorporating real-time tracking and feedback using machine learning for knee exercises, showing significant improvements in exercise performance and user experience [21]. For yoga and pilates posture estimation, Kim and his team have created a system to detect the posture during Pilates exercises in real time. The model they used, BlazePose, is combined with a deep neural network. This innovation has enabled home exercise management systems to achieve high accuracy rates in recognizing posture [22]. Another group, led by Thoutam, came up with deep learning techniques to identify incorrect yoga postures. Their system provided feedback that helped users improve their poses significantly and with high accuracy [23]. On a similar note, Borthakur's group implemented machine learning alongside angle-based feature extraction; this work detected accurate yoga poses in real-time feedback and made it possible for home yoga practice support to be effective [24]. Lastly, Kishore and his team came up with an approach that used deep learning methods coupled with the MediaPipe architecture to estimate yoga poses accurately. As such, practitioners were aided through successful detection of their pose details [25]. For ergonomic and activity recognition systems, İnce et al. implemented RGB-depth sensor-based human action recognition system to 3-D space combined Haar-wavelet transformation for efficient computation and superior performance of recognizing activities [26]. Ahmed et al. introduced a system to evaluate the quality of elderly exercises using Spatio-Temporal Polychromatic Trajectory (STPT) images and CNNs, effectively assessing the usability care of exercise [27]. In other work, Seo and Lee proposed a vision-based approach for construction workers' posture classification, which achieved high accuracy in ergonomic risk analysis to prevent work-related musculoskeletal disorders (WMSDs) [28].

Nishitha R identified the improper postures in computer-based professionals using CNN and RCNN for prevention of musculoskeletal disorders which would result into better workplace health [29]. Tlil et al. proposed a machine learning and inertial sensor-based posture monitoring system which is effective in detecting and monitoring the human postures with high accuracy [30]. Park et al. proposed a real-time push-up counting method using 2D video imagery and OpenPose, ensuring high accuracy and reliability in exercise counting and form correction [31]. Despite all tremendous improvement on physical therapy, all the previous work focused on a single aspect by only covering the classification of the correct exercise from the wrong one. Therefore, there is an obvious gap of research in the current works where the proposed methods should provide comprehensive solutions. For example, existing methods do not consider visually impaired individuals which can be compensated by an audio-based guidance correction. Additionally, plenty of works provided pose detection and basic feedback without accommodating real-time hardware implementation. The existing of an integrated framework that provides computer vision, speech synthesis, and hardware implementation for real-time physical exercise therapy is a need and can be a potential active area of research. Motivated by this gap, the paper's primary objectives are to develop a comprehensive instrumentation and control (I&C) digital embedded system that can accurately calculate joint angles from video frames. Next, compare these angles with predefined reference angles to ensure correct exercise performance providing real-time and convenient feedback to users in order to guide them by performing proper exercise execution. Also, dynamically update and store angle calculations and feedback for continuous improvement and tracking.

III. METHODOLOGY

III.1 MEDIAPIPE FRAMEWORK AND BLAZEPOSE MODEL FOR POSE ESTIMATION

MediaPipe is an open-source framework by Google used for pose estimation and hand tracking. It identifies key landmarks, including arm joints, to calculate angles and distances. This information is utilized in applications such as posture correction and exercise tracking. BlazePose, a component of MediaPipe, detects 33 key body landmarks in real time, including the arms. It extracts coordinates and angles of arm joints, aiding in movement evaluation and posture analysis, making it effective for real-time tracking applications. [12].

III.2 ANGLE CALCULATION FOR EXERCISE PERFORMANCE USING LANDMARKS

The joint points of the human body can all be assigned coordinate positions in an image. By using the coordinates of three landmarks, the arctangent method can accurately calculate the joint angles of the human body. A function is programmed to obtain these coordinates, and then the angles at each joint are calculated. So, angles between specific joints of the right hand are calculated as follows: Given three points A(a₁,a₂),B(b₁,b₂), and C(c₁,c₂), where B is the vertex point, the function calculates the angle formed by the vectors BA and BC. thus, by using arctan2 to avoid the division by zero issue:

$$\text{radians} = \arctan2(c_2 - b_2, c_1 - b_1) - \arctan2(a_2 - b_2, a_1 - b_1)$$

1. **Convert radians to degrees:**

$$\text{angle} = \text{abs}(\text{radians} \times 180 / \pi)$$

2. **Handle angles greater than 180 degrees:**

If the angle is greater than 180°, subtract it from 360°:

$$\text{if angle} > 180^\circ : \text{angle} = 360^\circ - \text{angle}$$

This process gives us the angle between the vectors BA and BC, which represents the angle between the three points A, B, and C.

III.3 MULTI-ANGLE ANALYSIS OF UPPER LIMB MOVEMENTS USING COMPUTER VISION

This research employed a combination of computer vision and machine learning techniques to analyze upper limb movements in the context of Cubital tunnel syndrome as shown in Fig. 2. it utilized the opencv-python and mediapipe libraries to facilitate real-time pose estimation from video streams. many libraries are used for image processing and data manipulation, including cv2, numpy, pandas, and os, ensuring a comprehensive computational environment.



Figure 2: Landmarks connected with joint angles and line segments on both the reference image and each frame of the video.
Source: Authors, (2026).

A fundamental aspect of the proposed methodology involved defining reference angles based on clinical standards. These angles served as benchmarks for assessing the correctness of limb postures and movements. It meticulously selected reference ranges for three key angles, reflecting critical joint configurations indicative of healthy upper limb functionality:

1. (Angle1): Formed by the right index, right elbow, and right shoulder.
2. (Angle2): Formed by the right wrist, right elbow, and right shoulder.
3. (Angle3): Formed by the right index, right wrist, and right shoulder.

As shown in Fig.3, the landmarks connected with line segments on both the reference image and each frame of the video with joint angles. Upon loading the reference image and specifying the video streaming path, pose estimation is initiated using the MediaPipe library. By leveraging MediaPipe's capabilities landmarks are extracted corresponding to specific arm joints and facilitating precise angle calculations. Custom function devised to compute angles between three points, crucial for quantifying joint flexion and extension during movements.

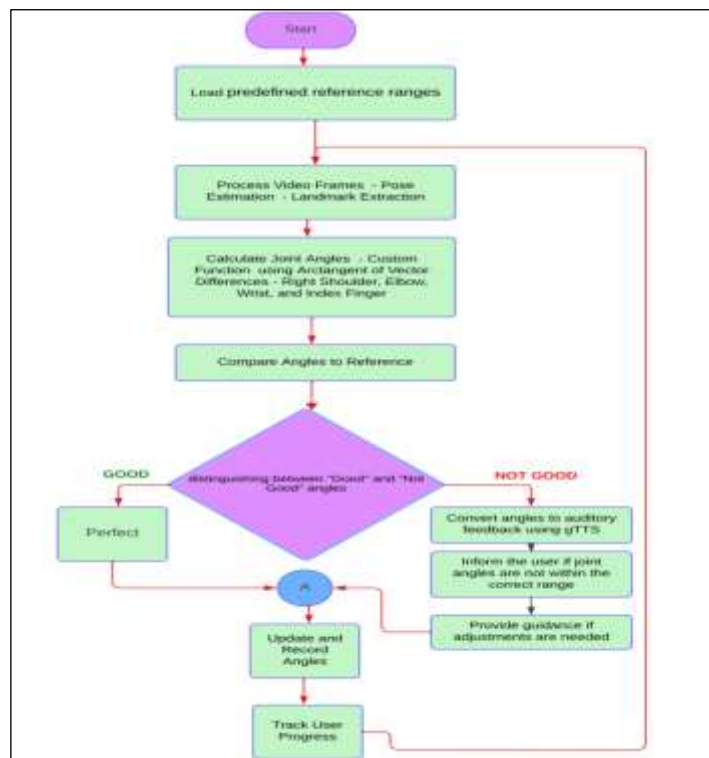


Figure 3: Flow chart of the proposed digital embedded system.
Source: Authors, (2026).

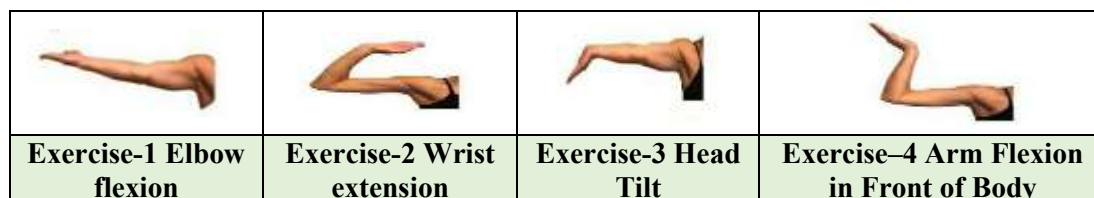


Figure 4: Images of the four exercises.
Source: Authors, (2026).

This function accounts for the geometric relationship between landmarks, yielding accurate angle measurements crucial for clinical evaluation. Each frame analyzed to extracting relevant landmarks and computing angles in real-time. Landmarks and angles visualized on the video frames to provide clinicians with intuitive insights into limb posture and movement dynamics. The quality of movements, angles were calculated against predefined reference ranges, distinguishing between "Good" and "Not Good" angles. This comparative analysis enabled us to identify deviations from optimal joint configurations.

III.4 REAL-TIME POSE CORRECTION WITH AUDIO FEEDBACK USING OPENCV, MEDIAPIPE, AND GTTS

Utilizing advanced computer vision techniques combined with speech synthesis to analyze joint angles in real time. It is specifically focusing on poses indicative of cubital tunnel syndrome as shown in Fig. 2. For position estimation and video processing, the Python libraries OpenCV and Media Pipe were utilized, and for text-to-speech conversion, gTTS was used. The landmarks for particular joints were found and extracted using Media Pipe. Every scene frame's angle between these joints was computed. The accuracy of these angles was assessed by comparing them to predetermined reference ranges. The user was then informed whether their joint angles were within the proper range or not. Additionally, the user is instructed if adjustments were required by means of auditory feedback messages generated from the calculated angles using gTTS. Our system's front end has an intuitive user interface that helps the user feel at ease while using it. From the four exercises that are offered, the user selects the one he wants to perform, as shown in Fig. 4 to train on the right side. The primary purpose of incorporating auditory alerts is to assist blind and visually impaired people in carrying out their exercise routines efficiently. Given the difficulties that this group faces, the proposed system converted written instructions into audible indications using the Google Text-to-Speech (gTTS) library. This creative method encourages independence and safe exercise when engaging in physical activities in addition to improving accessibility. Our approach guarantees accurate and easy understandable exercise guidance by utilizing cutting-edge text-to-speech technology. This research develops an exercise monitoring and control digital system based on the processing module embedding the Raspberry Pi processor enhanced with a camera module to support home-based rehab activities as shown in Fig. 5a. The system leverages OpenCV for video processing, MediaPipe for pose estimation, and Google Text-to-Speech (gTTS) for interactive feedback.

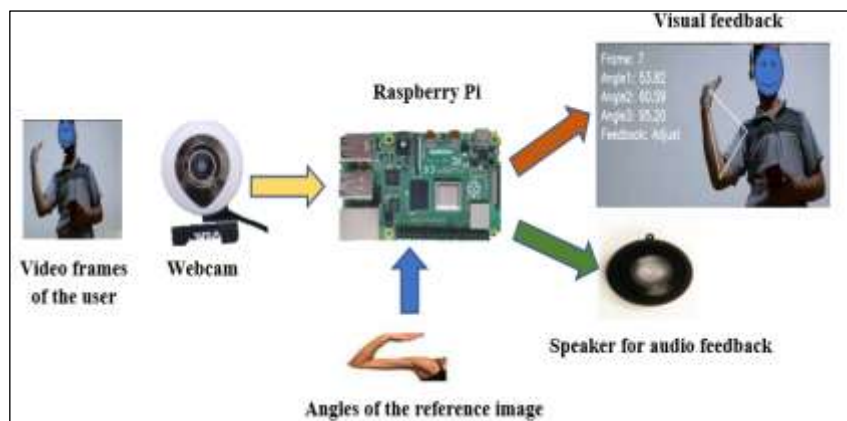


Figure 5: A A real-time, dependable and hybrid computer system.
Source: Authors, (2026).

Figure 5b, shows a block diagram for the proposed digital system, which is comprised of three basic modules: sensing module, processing module and feedback and alarm module. The Raspberry Pi camera embedded in the sensing module operates with 640x480-resolution video at 30 frames per second while maintaining optimal clarity and system performance. The quad-core ARM Cortex A72 processor was used in the realization of the decision and processing module, which is continuously monitoring the status of the video frames data, and issues control signals to the alarm module. In addition, the graphical processing processor (GPU) was used as accelerator for the decoding and encoding logic operations between the stored data frames in the dynamic ram of size 8 giga bit which is shared between CPU and GPU.

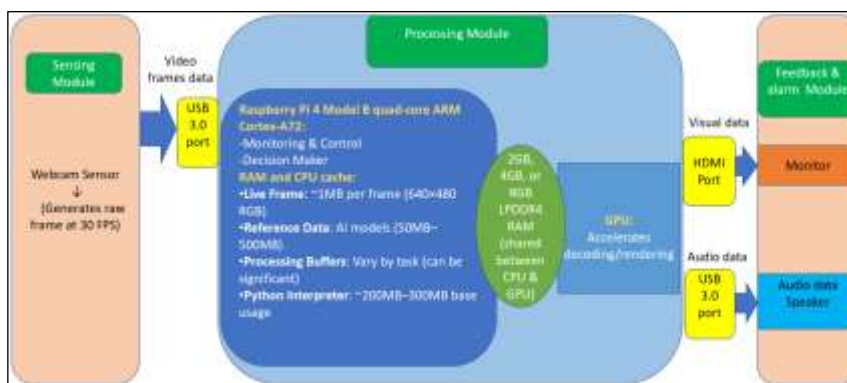


Figure 5: B Block diagram of the real-time, reliable and hybrid computer system.
Source: Authors, (2026).

The feedback and alarm module includes the monitor that is connected to the processing module through the HDMI port. In addition, it uses the audio data speaker for alarming the used by connecting the USB 3.0 port of the processing module for audio data processing. The system runs real-time frame intake through OpenCV while implementing resizing and normalization steps to optimize the analysis process.

The MediaPipe framework detects key body landmarks, with special consideration for Cubital Tunnel Syndrome (CuTS) exercise-relevant joints. Using trigonometric functions, the system computes dynamic values for joint angles particularly at the elbow and wrist. A comparison between identified angles and set reference values measures movement accuracy. Data feedback happens instantly by providing visual indications with audio signals throughout the process. Verbal prompts from gTTS activate while the system runs which lets users stay attentive without repeated screen monitoring. The system boosts its operational performance by directing frame processing while distributing tasks between multiple threads to enhance simultaneous video catching and pose evaluation. Exercise sessions get saved automatically for medical professionals who need data for patient progress tracking. An embedded system achieves efficient rehabilitation along with cost-effectiveness through its combination of real-time analysis capabilities and interactive feedback and joint-tracking functions. Through its convenient usage and portability capability the system works effectively for home-based therapy by providing exercise accuracy while eliminating professional support dependence.

IV. RESULT AND DISCUSSION

To test and evaluate the correct operation of the proposed real-time and dependable pose correction digital system many experiments and comparisons were performed. In addition, to quantify the quality of movements, angles were calculated against predefined reference ranges, distinguishing between "Good" and "Not Good" angles. This comparative analysis identify deviations from optimal joint configurations, indicative of potential abnormalities or impairments as shown below in Fig. 6 as example Reference image ,User 1 frames User 2, frames with three angles comparison for quantifying the processing time for each frame, to ensure the efficiency and scalability of our approach. By profiling the computational overhead, to gain insights into the feasibility of real-time deployment in clinical settings. The result for the frame processing that represents the time elapsed during the frame processing was approximately from 0.044559 to 0.054686 seconds. The system provides real-time feedback by comparing the calculated angles with the reference angles. If the deviation exceeds a certain threshold, the system alerts the user to correct their posture Table 1 with separate counters for each angle, incrementing the correct and incorrect exercises based on whether the angles fall within the reference specified ranges. To provide a holistic understanding of limb movements, wave form used to visualize angle variations over time using matplotlib. Through comprehensive visualizations, the user can elucidated temporal trends in joint angles, enhancing clinical interpretation and decision-making. Fig. 7 showing example how the angles change over time and how they compare to the reference ranges.

Table 1: Example of separate counters for correct and incorrect exercises for each of the three angles.

Correct Exercises Angle1	Incorrect Exercises Angle1
66	24
Correct Exercises Angle2	Incorrect Exercises Angle2
64	26
Correct Exercises Angle3	Incorrect Exercises Angle3
5	85

Source: Authors, (2026).



Figure 6: Reference image.

Source: Authors, (2026).

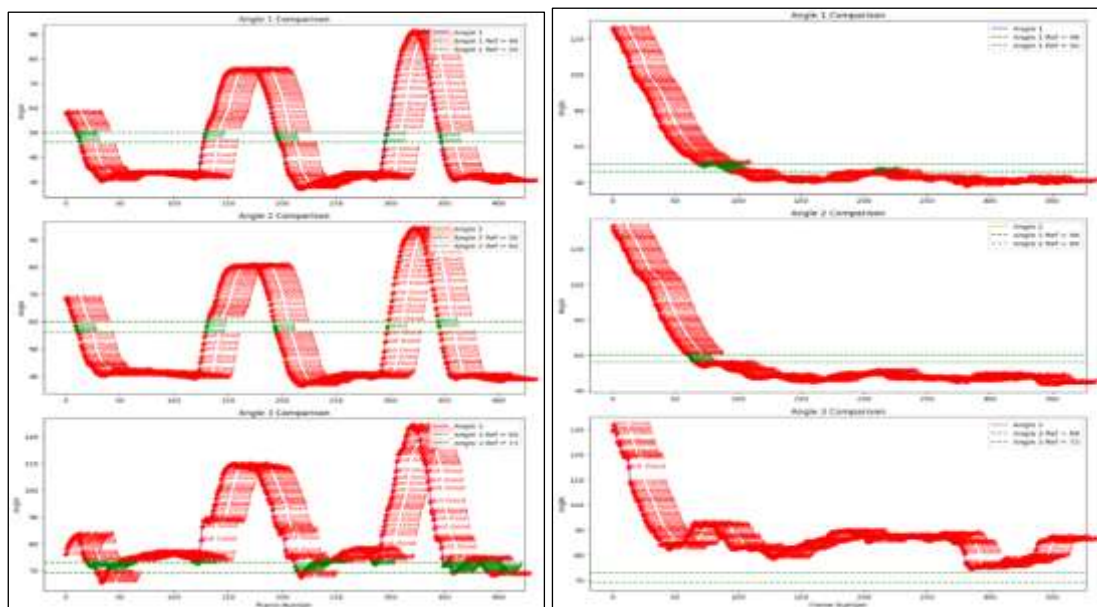


Figure 7: Reference image, User 1 frames User 2 frames with three angles.

Source: Authors, (2026).

The system provides real-time feedback by comparing the calculated angles with the reference angles. If the deviation exceeds a certain threshold, the system alerts the user to correct their posture as shown in Table 2. The system dynamically updates the vector of angles and stores the data for continuous improvement and tracking. This data can be analyzed to identify patterns and trends in the user's exercise performance. To evaluate the accuracy of the angle calculation, a series of experiments were conducted using videos with known joint angles. The results demonstrated high accuracy, with the calculated angles deviating from the actual angles as shown in Fig. 8 as example for evaluating the accuracy of the angle calculation. This system successfully processed video frames, calculated joint angles, and provided real-time auditory feedback, demonstrating its potential to enhance patient monitoring and rehabilitation by offering immediate, actionable feedback. This study emphasizes how important adaptive technologies are to enhancing the quality of life for people who are visually impaired. A Comparison was arranged to compare the ability of the proposed system with other researchers. Table 3 below illustrates the extracted information in a systematic manner to compare the features across studies. Although recent research has been heavily split into examining and comparing existing pose estimation systems to physical rehabilitation settings, including tracking knee kinematics during athletic stress tests with smartphones versus Kinetic V2 [32], assessing the motions of patients with low back pain with OpenPose and BlazePose and systematic reviews or novel datasets of AI-based skeletal tracking [33-35], these systems Conversely, the paper stands out through the introduction of a real-time, trustworthy hybrid computer system that is specifically tailored to optimize therapeutic exercises in the Cubital tunnel syndrome (CuTS). This is not just evaluation but a strong solution to the problem of absence of continuous monitoring and correct joint angle positioning in nerve compression therapy. Compared to earlier approaches that mainly concentrate on offline processing or the use of costly sensor configurations, our proposed framework proves to be more efficient through the dynamic combination of OpenCV and MediaPipe to provide accurate pose estimation with the usage of Google Text-to-Speech (gTTS). This is because it gives the user real-time continuous auditory feedback and adjustment instructions, which makes it highly viable in terms of consistent patient monitoring and progress tracking in both clinical and home-based rehabilitation environments.

Table 2: Feedback Based on Angle Deviation example for 10 frames.

Frame Number	Angle1 frame	Angle2 frame	Angle3 frame	Feedback
0	167.264429	169.061511	167.219272	Adjust
1	168.320370	170.225010	167.395590	Adjust
2	168.370571	170.319294	167.285159	Adjust
3	168.690632	170.849896	166.633947	Adjust
4	169.246929	171.583402	166.303073	Adjust
8	169.488412	172.196659	164.875549	Correct
217	169.456174	172.054278	164.866725	Correct
513	169.713464	172.645042	164.717967	Correct
514	169.681742	172.655977	164.564631	Correct
515	169.628909	172.609341	164.517575	Correct

Source: Authors, (2026).

Table 3: Comparison the proposed system ability with another researchers.

Study Reference	Objective	Methodology	Technologies/Tools	Feedback Mechanisms	System Capabilities	Potential Benefits	Clinical Relevance
Ours	Optimize rehab exercises for CuTS	Automated video analysis	OpenCV, MediaPipe, gTTS	Evaluation and Auditory feedback generation based on AI analysis of skeleton data	Real-time joint angle analysis	Enhanced patient monitoring	Clinical feedback tool
Ref 32	Compare Kinect V2 and MediaPipe accuracy.	Captured 254 athletes using Kinect and MediaPipe.	Microsoft Kinect V2, Google's MediaPipe framework, and custom software.	N/A	Real-time knee angle extraction and comparison of knee kinematics between two frameworks.	Potential for low-cost, portable ACL injury risk assessment using smartphones.	Portable, cost-effective ACL injury assessment tool.
Ref 33	Evaluate rehab exercises using a robot and cameras.	Uses RGB-D cameras and GMM for rehabilitation.	RGB-D cameras (Microsoft Kinect), RGB videos, OpenPose, BlazePose algorithms, GMM.	Performance evaluation based on log-likelihood values from GMM.	Accurate motion capture and exercise assessment.	Comprehensive evaluation enhances rehab outcomes.	Enhances rehab evaluation with robot assistance.
Ref 34	Compare OpenPose and Detectron 2 performance	Assessed rehab exercises using Kinect cameras.	OpenPose, Detectron 2, Kinect 2 RGBD cameras.	Numerical comparison of angle measurements (RMSE and MAE).	Precise joint angles, compare pose estimators.	Accurate, low-cost pose estimation improves outcomes.	Enhances rehab safety with affordable tools.

Ref 35	Compare pose methods for mobility assessment.	New dataset evaluates pose estimation methods.	Multiple pose estimation methods, RGB cameras, OptiTrack infrared tracking system.	Statistical analysis of pose estimation accuracy	Evaluate pose methods in diverse scenarios.	Optimizes rehab with effective pose methods.	Enhances remote monitoring and resource allocation.
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Source: Authors, (2026).

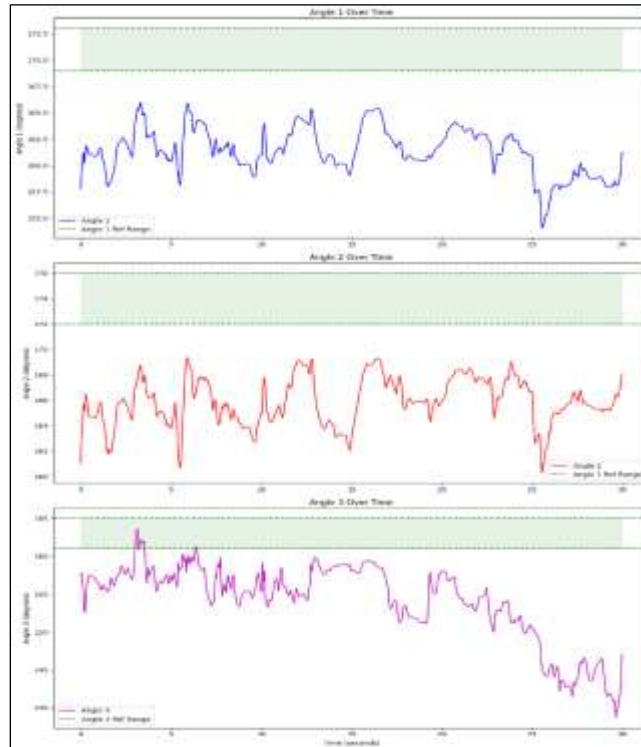


Figure 7: How the angles change over time and how they compare to the reference ranges.

Source: Authors, (2026).

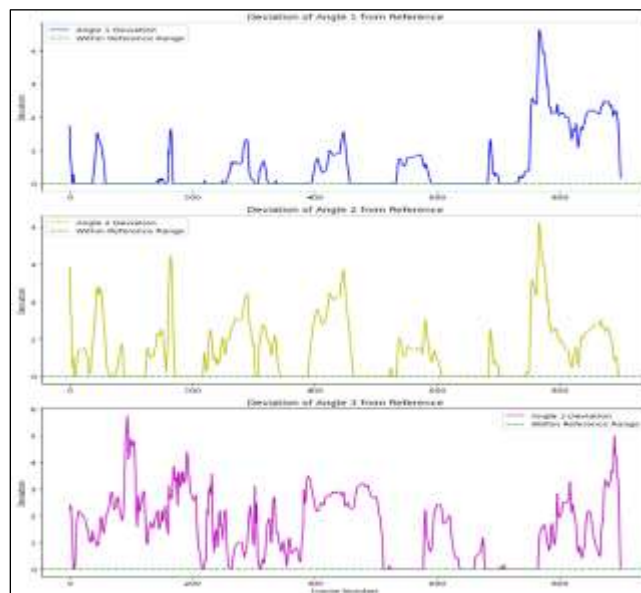


Figure 8: Evaluating the accuracy of the angle calculation.

Source: Authors, (2026).

V. CONCLUSION

We have demonstrated and analyzed a real-time and dependable hybrid computer system for the recovery from the medical cubital tunnel syndrome. The main properties of the proposed computer system are that it is reliable and using the computer vision, real-time processing and computer architecture-based design principles for the effective monitoring and guidance of medical cubital tunnel syndrome exercises. The proposed digital computer embedded system calculates the joint angles and real-time feedback capability, and dynamically updates and stores data for continuous improvement.

In addition, this research offers a robust and dependable framework for quantitative analysis of upper limb movements by combining advanced monitoring algorithms with clinical insights. The system results and experiments show the effective capability for cubital tunnel syndrome exercises tracking. Looking ahead, our research will focus on refining the proposed dependable digital system to handle a wider variety of safety-critical medical health exercises and incorporating fault-tolerant and machine-learning decision techniques.

VI. AUTHOR'S CONTRIBUTION

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Resources: Hamed A. Mahmood, Shawkat S. Khairullah, Mohammed T. Mohammed, And Amar I. Daood.

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Approval of the final text: Hamed A. Mahmood, Shawkat S. Khairullah, Mohammed T. Mohammed, And Amar I. Daood.

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