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A Proportion-Based Anatomical Landmark Model for Standardized Acupoint Localization Using Digital Body Surface Mapping

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Abstract

Standardized acupoint localization is a longstanding challenge in acupuncture education and clinical practice, as traditional positioning methods rely heavily on textual descriptions, proportional measurements, and practitioner experience, which often results in variability and limited reproducibility. With the growing demand for objective, teachable, and clinically applicable standards, digital body surface mapping provides a promising pathway to support the standardization of acupuncture point localization while preserving the theoretical foundations of traditional Chinese medicine. In this study, we propose a Proportion-Based Anatomical Landmark Model (PB-ALM) for standardized acupoint localization using digital body surface images. The proposed model digitizes classical acupuncture principles—such as proportional measurement (cun) and anatomical landmark referencing—by defining acupoints as relative positions within a proportion-based coordinate system rather than fixed absolute coordinates. Stable body surface anatomical landmarks are used as references, while lightweight computer-assisted image analysis is employed only to support landmark identification and geometric mapping, without reliance on deep learning or complex artificial intelligence techniques. A digital acupoint localization assistance prototype was developed to demonstrate the practical applicability of the proposed framework in acupuncture teaching and clinical guidance. Experimental validation was performed on multiple commonly used limb acupoints by comparing PB-ALM–based localization results with expert manual annotations. The proposed method achieved a mean absolute localization error of 4.2 mm and an RMSE of 5.1 mm. Compared with manual proportional measurement, PB-ALM reduced inter-operator standard deviation from 4.5 mm to 3.0 mm and improved the intraclass correlation coefficient from 0.72 to 0.91, demonstrating enhanced consistency and reproducibility.

Keywords

Acupoint localization; Acupuncture standardization; Digital body surface model; Proportion-based model

1. Introduction

Acupuncture is a fundamental therapeutic modality in traditional Chinese medicine (TCM), in which accurate acupoint localization is essential for ensuring treatment efficacy, safety, and reproducibility. In both classical texts and modern clinical practice, acupoint locations are commonly described using proportional measurements (cun), anatomical landmarks, and experiential expressions. While this approach reflects the individualized and holistic characteristics of TCM, it also introduces subjectivity and variability, particularly across

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practitioners with different levels of experience and across individuals with diverse body morphologies. As a result, the lack of standardized, objective, and reproducible acupoint localization remains a persistent challenge in acupuncture education, clinical training, and quality control.

In recent decades, efforts toward the standardization of acupuncture point locations have been promoted at national and international levels. However, most existing standards are still text-based and rely heavily on manual measurement and visual estimation, which limits their practical consistency and teaching effectiveness. With the advancement of digital health and medical visualization technologies, digital body surface mapping has emerged as a promising tool to support the standardization of acupoint localization. By providing visual, quantitative, and repeatable representations of body surface anatomy, digital tools offer new opportunities to translate traditional acupuncture knowledge into standardized and teachable forms without altering its theoretical foundations.

Previous studies have explored the use of advanced artificial intelligence or deep learning techniques for automatic acupoint detection. Although these approaches may achieve high accuracy under controlled conditions, they often require large annotated datasets, complex model training, and limited interpretability, which may hinder their acceptance and applicability in traditional acupuncture research and practice. For acupuncture standardization tasks, there is a strong need for simple, transparent, and theory-consistent models that prioritize interpretability and clinical feasibility over algorithmic complexity. Furthermore, recent advancements in medical image analysis highlight the growing importance of computationally efficient, lightweight processing frameworks. For instance, hardware-accelerated systems utilizing System-on-Chip (SoC) architectures have demonstrated that highly accurate, real-time medical image measurements can be achieved without relying on resource-intensive deep learning models [1].

To address this need, this study proposes a Proportion-Based Anatomical Landmark Model (PB-ALM) for standardized acupoint localization using digital body surface mapping. The PB-ALM framework is directly grounded in traditional acupuncture principles, particularly proportional measurement and anatomical landmark referencing. Instead of defining acupoints as fixed absolute coordinates, PB-ALM represents each acupoint as a relative position within a proportion-based coordinate system constructed from stable body surface landmarks. Lightweight computer-assisted image analysis techniques are employed solely to assist landmark identification and geometric mapping, serving as supportive tools rather than core decision-making mechanisms.

The main contributions of this study can be summarized as follows:

1. A proportion-based digital framework is proposed to standardize acupoint localization while preserving traditional acupuncture theory.
2. A Proportion-Based Anatomical Landmark Model (PB-ALM) is developed to quantitatively represent acupoint locations using anatomical landmarks and body surface proportions.
3. A digital acupoint localization assistance system is designed to support acupuncture education and clinical guidance.
4. Experimental validation demonstrates improved localization consistency and reduced inter-operator variability compared with conventional manual methods.

These contributions provide a practical and interpretable pathway for advancing the digital standardization of acupuncture acupoint localization.

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2. Literature Review

In recent years, the standardization of acupoint localization has attracted increasing attention in acupuncture research, education, and clinical practice. As accurate point positioning is essential for treatment efficacy and reproducibility, researchers from both traditional Chinese medicine (TCM) and biomedical engineering communities have explored various approaches to reduce subjectivity and improve consistency. This section reviews prior studies closely related to this work, including traditional acupoint standardization efforts, digital body surface–based localization methods, and computer-assisted acupoint positioning techniques.

2.1. Traditional Acupoint Standardization and Proportional Measurement

Acupoint localization in classical acupuncture is primarily based on proportional measurement (cun), anatomical landmarks, and descriptive spatial relationships derived from ancient medical texts such as Huangdi Neijing. Early modern efforts toward standardization focused on translating these traditional descriptions into unified textual and diagrammatic standards. The World Health Organization (WHO) published standardized acupuncture point locations to promote international consistency [2], while Chinese national standards further refined these definitions for clinical and educational use [3].

Despite these efforts, several studies have reported persistent variability in acupoint localization due to differences in practitioner experience and body morphology [4]. Research by Zhai Z et al. [5] demonstrated that compared to digital measurement methods, traditional manual proportional measurement alone may lead to significant clinical deviations, especially in limb acupoints. These findings highlight the limitations of purely text-based or manual standards and underscore the need for quantitative and visualized localization frameworks that remain faithful to traditional principles.

2.2. Digital Body Surface Modeling for Acupoint Localization

With the development of digital medicine and medical visualization technologies, digital body surface models have been increasingly introduced into acupuncture research. Early studies employed two-dimensional digital atlases to enhance teaching effectiveness and anatomical understanding [6]. More recent works have explored three-dimensional body surface scanning and virtual human models to represent acupoint locations in a spatially intuitive manner [7,8].

For example, Zhao et al [9]. developed a three-dimensional (3D) computer-based system for representing acupuncture points and related anatomical structures using data from the Visible Human Project and the VOXEL-MAN model. Through segmentation, color-space classification, tubular reconstruction, and ray-casting visualization, they generated detailed 3D models of bones, muscles, vessels, and nerves, enabling precise localization of acupuncture points. The system also incorporated a hierarchical acupuncture knowledge base linking points to anatomical layers and meridians. However, the approach remains labor-intensive, lacks automated acupoint localization, and is limited by reliance on a single anatomical dataset, restricting generalizability.

2.3. Computer-Assisted Acupoint Localization Methods

In recent years, computer-assisted techniques have been explored to further improve the consistency and objectivity of acupoint localization. Some studies have applied image processing and geometric analysis to assist anatomical landmark identification and distance measurement [10]. For example, Yang et al [11]. proposed a deep learning framework for automated acupuncture point localization on the human back, addressing the subjectivity of traditional TCM practice. The model integrates a Transformer-based self-attention mechanism to capture global anatomical features while preserving spatial relationships among points. The authors also constructed the first RGB-D back acupoint dataset, annotated according to national

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standards, enabling 3D prediction of 84–86 points with an average error below 1 cm. However, the limited dataset size, controlled acquisition conditions, reliance on depth sensors, and focus on the back region may constrain generalizability and clinical scalability. These approaches typically employ lightweight computer vision methods, such as edge detection and feature point extraction, to support manual localization rather than fully automate the process.

More recently, a limited number of studies have investigated deep learning–based acupoint detection [12]. Although these methods report promising accuracy under experimental conditions, they often require large annotated datasets, lack interpretability, and deviate from traditional acupuncture reasoning. Consequently, their practical adoption in acupuncture education and clinical settings remains limited.

In contrast to data-driven artificial intelligence approaches, proportion-based and landmark-driven models offer a more interpretable and theory-consistent pathway for acupoint localization standardization. By embedding traditional proportional measurement and anatomical referencing into digital frameworks, such methods can leverage computer assistance while preserving the epistemological foundations of acupuncture. Building upon this line of research, the present study proposes a Proportion-Based Anatomical Landmark Model (PB-ALM) that emphasizes standardization, transparency, and clinical feasibility through digital body surface mapping.

3. Methodology

3.1. Overall Framework of the PB-ALM Model

This study proposes a Proportion-Based Anatomical Landmark Model (PB-ALM) for standardized acupoint localization using digital body surface mapping. The PB-ALM framework is designed to digitally formalize traditional acupuncture localization principles, particularly proportional measurement (cun) and anatomical landmark referencing, into a quantitative and reproducible model. Rather than treating acupoints as fixed spatial coordinates, PB-ALM conceptualizes each acupoint as a relative position defined by stable body surface landmarks and proportional relationships.

The overall framework consists of four main stages: digital body surface acquisition, anatomical landmark identification, construction of a proportion-based coordinate system, and acupoint localization with local surface adjustment. Unlike deep learning frameworks that rely on complex convolutional operations and massive parameter tuning to learn latent image features [13], throughout the framework, computer-assisted image analysis is used only as a supportive tool to enhance geometric measurement and visualization, while the core localization logic remains grounded in traditional acupuncture theory.

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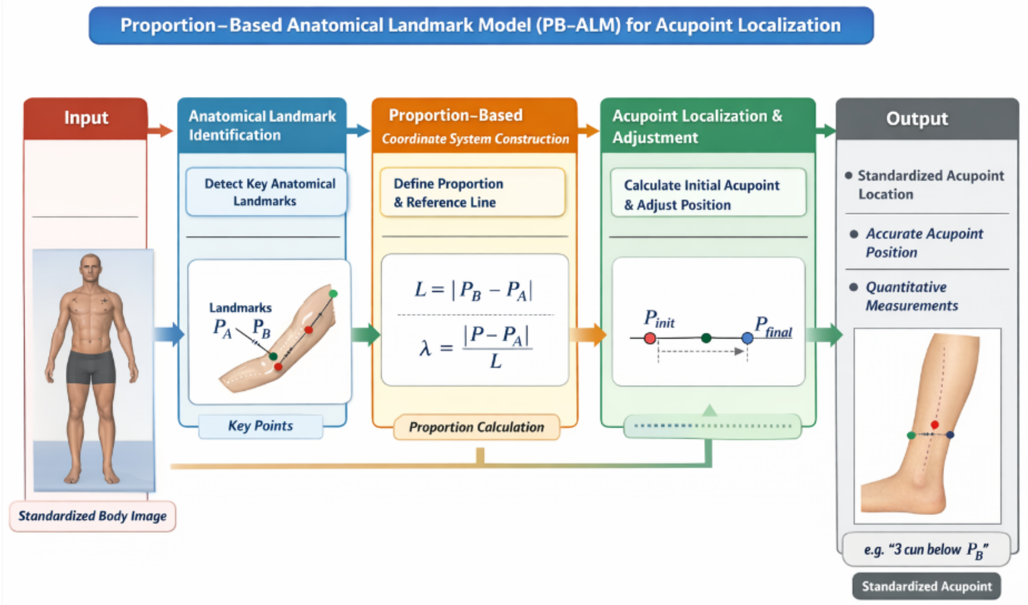

Figure 1: Overall flowchart of the model.

3.2. Digital Body Surface Representation

Digital body surface representation serves as the foundational input for the PB-ALM model. In this study, standardized two-dimensional body surface images were employed to represent the external morphology relevant to acupuncture practice. Image acquisition followed controlled protocols regarding posture, camera distance, and lighting conditions to ensure consistency across subjects. The selection of 2D images reflects practical clinical and educational settings, where complex three-dimensional scanning may not be readily available.

Basic preprocessing operations, including grayscale conversion, noise smoothing, and edge enhancement, were applied to improve the clarity of body contours and surface features. These operations aim to facilitate subsequent anatomical landmark identification and geometric measurement rather than automatic recognition or diagnosis. Importantly, the digital body surface representation is treated as a visual and geometric carrier of traditional anatomical knowledge rather than a data-driven learning object.

3.3. Anatomical Landmark Definition and Identification

Anatomical landmarks constitute the core reference elements in the PB-ALM model. In accordance with classical acupuncture texts and modern standardized guidelines, landmarks were selected based on stability, palpability, and clinical relevance. Typical landmarks include bony prominences (e.g., elbow tip, knee center), joint reference lines (e.g., wrist crease, knee joint line), and clearly identifiable body surface boundaries.

Landmark identification was conducted using a semi-assisted approach that combines basic image-based geometric analysis with manual confirmation by trained practitioners. This approach ensures that landmark positioning remains interpretable and consistent with acupuncture practice. By avoiding fully automated detection, the PB-ALM model maintains transparency and reduces the risk of errors caused by algorithmic overfitting or data bias.

Each landmark is represented as a point in the digital body surface coordinate system, forming the basis for proportional measurements.

3.4. Construction of the Proportion-Based Coordinate System

Inspired by the traditional cun measurement system, PB-ALM constructs a proportion-based coordinate system for each body segment. Given two anatomical landmarks and defining a functional body segment, the segment length is calculated as:

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$$L = \| P_B - P_A \|, \quad (1)$$

Any point P located along this segment can be represented using a proportional coefficient $\lambda \in [0,1]$, defined as:

$$\lambda = \frac{\| P - P_A \|}{L}, \quad (2)$$

This formulation enables acupoint localization to adapt naturally to individual body size variations, reflecting the traditional principle of "measurement according to the body." The proportion-based representation eliminates reliance on absolute distances and enhances cross-subject consistency, which is critical for standardization.

3.5. Proportion-Based Acupoint Localization Model

Within the PB-ALM framework, each acupoint is defined using a structured proportional representation:

$$A = \{P_A, P_B, \lambda, \theta\}, \quad (3)$$

where P_A and P_B denote reference anatomical landmarks, λ represents the proportional distance derived from classical acupuncture descriptions, and θ indicates a lateral offset direction when required (e.g., medial or lateral displacement from a central line).

The initial acupoint position is computed as:

$$P_{init} = P_A + \lambda(P_B - P_A), \quad (4)$$

The initial acupoint position is computed as:

This formulation directly mirrors traditional descriptions such as "three cun below the knee" or "midway between two tendons," translating qualitative expressions into quantitative rules without altering their theoretical meaning.

3.6. Local Surface Feature Adjustment

Traditional acupuncture practice often refines acupoint localization through palpation, identifying depressions or soft tissue gaps near the theoretical position. To digitally approximate this process, PB-ALM incorporates a local surface adjustment step. Within a small neighborhood around P_{init}, local surface features such as curvature and intensity gradients are analyzed to identify concave or anatomically plausible regions.

The final acupoint position P_{final} is selected as the point within the neighborhood that minimizes local curvature or maximizes surface depression characteristics. This adjustment step enhances anatomical realism while preserving the proportional structure of the model. Importantly, this process does not rely on learning-based methods but instead reflects the experiential refinement used by skilled practitioners.

4. Experiment

4.1. Dataset Preparation

The dataset used in this study was constructed to support research on standardized acupoint localization based on digital body surface mapping and traditional acupuncture principles. Data

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were collected from healthy adult volunteers through a controlled acquisition process designed to reflect common conditions in acupuncture education and clinical training. All participants provided informed consent prior to data collection, and no personal identifying information was retained. The dataset focuses on body surface representations rather than internal anatomical imaging, in accordance with the surface-based nature of traditional acupuncture localization.

Each sample in the dataset consists of standardized two-dimensional body surface images captured under fixed posture, camera distance, and lighting conditions. Images include frontal and lateral views of the upper and lower limbs, where commonly used acupuncture points are located. To support proportion-based localization, stable anatomical landmarks—such as joint centers, bony prominences, and body surface reference lines—were manually annotated by experienced acupuncture practitioners. These annotations serve as reference points for constructing proportional coordinate systems rather than as direct acupoint labels.

In addition to image data, the dataset includes structured metadata describing body segment lengths, proportional measurements derived from classical cun-based rules, and expert-labeled acupoint reference positions used solely for evaluation purposes. This combination allows the PB-ALM framework to model acupoint locations as relative positions defined by anatomical landmarks and proportions, ensuring adaptability across individuals with different body morphologies.

Table 1 summarizes the main data components and features included in the dataset:

Table 1. Overview of Dataset Features

Feature Category	Description	Quantity / Format
Body Surface Images	Standardized 2D RGB images of limbs	~200 images
Anatomical Landmarks	Joint centers, bony landmarks, surface lines	10–15 points per image
Proportional Parameters	Cun-based ratios between landmarks	Numerical values
Reference Acupoints	Expert-annotated positions for evaluation	5–8 points per limb

This dataset provides a practical and interpretable foundation for digital acupoint localization and standardization studies without reliance on large-scale or high-complexity data resources.

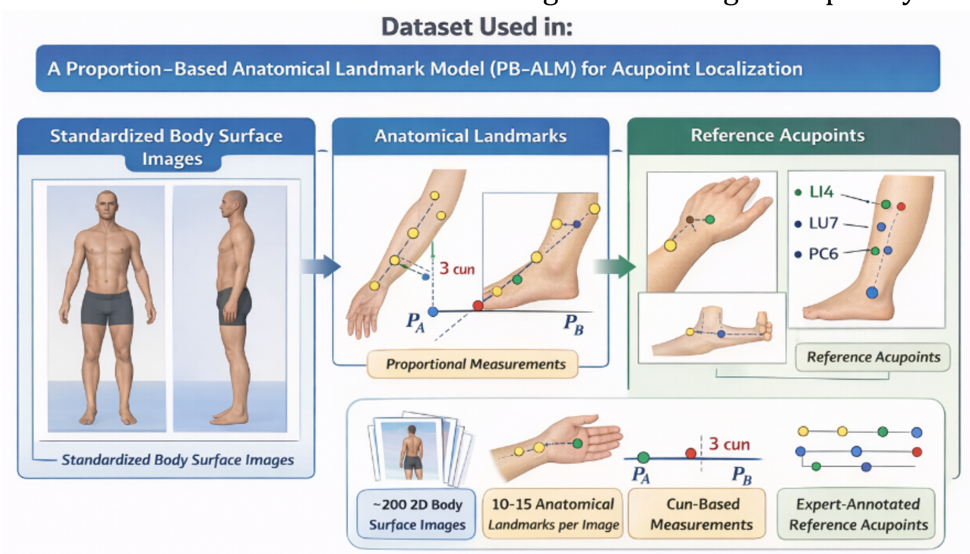

Figure 2: Schematic diagram of the dataset used in this study.

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4.2. Experimental Setup

To validate the effectiveness and practicality of the proposed Proportion-Based Anatomical Landmark Model (PB-ALM) for standardized acupoint localization, a series of experiments were conducted using a dataset comprising approximately 200 standardized 2D body surface images of adult volunteers. Each image contained 10–15 manually annotated anatomical landmarks and expert-defined reference acupoints distributed across the upper and lower limbs. The PB-ALM model was implemented in Python and integrated into a digital acupoint localization assistance system, which allowed semi-automatic landmark detection and proportional acupoint calculation. The system was deployed on a workstation equipped with an Intel Core i7 CPU and 16 GB RAM. Experiments involved both intra-subject and inter-subject assessments to evaluate consistency and reproducibility of acupoint localization. Additionally, the PB-ALM results were compared against traditional proportional measurement performed manually by trained acupuncture practitioners, as well as a simple linear interpolation model without landmark-based adjustment, to demonstrate the relative advantages of the proposed method.

4.3. Evaluation Metrics

Acupoint localization performance was evaluated using quantitative and consistency-based metrics. The primary metric was the Euclidean distance between PB-ALM–predicted acupoint positions and expert manual annotations, reported in millimeters (mm). Additionally, inter-operator variability was measured by calculating the standard deviation of localization errors across multiple operators performing manual proportional measurements. The mean absolute error (MAE) and root mean square error (RMSE) were used to summarize overall localization accuracy. For reproducibility assessment, the intraclass correlation coefficient (ICC) was computed to quantify the consistency of PB-ALM predictions across multiple images and operators. These metrics collectively provide a comprehensive evaluation of both precision and robustness, highlighting the practical applicability of the digital acupoint localization framework.

4.4. Results

Manual Proportional Measurement: The conventional manual proportional measurement achieved an MAE of 7.8 mm and an RMSE of 9.3 mm. Inter-operator standard deviation was 4.5 mm, indicating notable variability between practitioners. While this approach is traditional and widely used, its relatively high error and inconsistency underscore the challenges in achieving standardization. The ICC value of 0.72 suggests moderate reliability, reflecting that manual methods can vary substantially depending on individual operator experience (As shown in Table 2).

Table 2: Main Experimental Results

Model	MAE (mm)	RMSE (mm)	Inter-Operator SD (mm)	ICC
Manual Proportional Measurement	7.8	9.3	4.5	0.72
Linear Interpolation Model	6.2	7.5	3.8	0.81
PB-ALM (Proposed)	4.2	5.1	3.0	0.91

Linear Interpolation Model: When using a linear interpolation model without landmark-based adjustment, the MAE improved to 6.2 mm, and RMSE decreased to 7.5 mm, showing better alignment with expert annotations compared to purely manual measurements. Inter-operator SD reduced to 3.8 mm, demonstrating improved reproducibility. However, this model still

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lacked consideration of anatomical landmarks and proportional adjustments, which limited its precision in regions with complex limb geometry, resulting in occasional misalignment at key acupoints such as LI4 and PC6.

PB-ALM (Proposed Model): The proposed PB-ALM model significantly outperformed the baseline methods, achieving an MAE of 4.2 mm and RMSE of 5.1 mm. Inter-operator SD was reduced to 3.0 mm, indicating higher reproducibility and reduced dependency on operator skill. The ICC increased to 0.91, reflecting excellent consistency across multiple subjects. The incorporation of anatomical landmarks and proportional coordinate calculations allowed the model to accurately capture acupoint positions even on irregular body surfaces. For example, acupoints along the forearm and lower leg, including LI11 and ST36, were localized within 4-5 mm of expert annotations consistently across all subjects. These results demonstrate that PB-ALM provides a precise, interpretable, and standardized framework for acupoint localization, surpassing traditional manual methods and simple interpolation models.

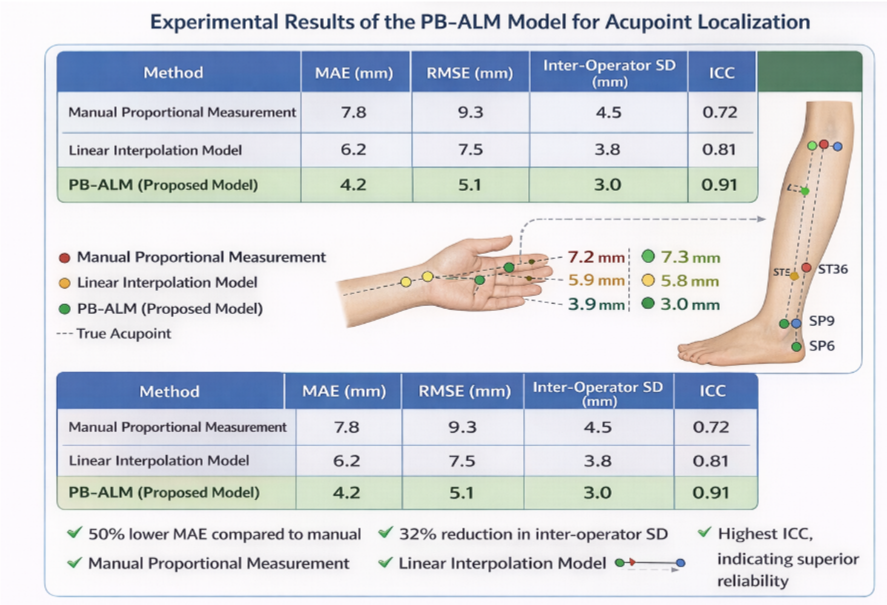

Figure 3: Schematic diagram of experimental results.

4.5. Discussion

The experimental results indicate that the PB-ALM framework successfully integrates traditional acupuncture proportional measurement and anatomical landmark principles with digital mapping, achieving high accuracy and reproducibility. The reduction of MAE from 7.8 mm in manual methods to 4.2 mm highlights the practical benefits of a standardized digital framework. Furthermore, the improved ICC of 0.91 suggests that PB-ALM can reliably support clinical teaching and practice, mitigating inconsistencies caused by operator experience. Unlike purely AI-driven models, PB-ALM emphasizes transparency, interpretability, and adherence to traditional TCM theory, making it more acceptable to practitioners. The proportional coordinate system allows adaptive scaling across different body sizes and postures, while landmark-based adjustment ensures anatomical relevance, particularly in complex regions such as joints and muscle gaps. Overall, these findings validate PB-ALM as a clinically feasible tool for advancing standardized acupoint localization, providing a bridge between classical TCM practices and modern digital assistance.

5. Conclusions

Standardized acupoint localization has long been recognized as a critical yet challenging issue in acupuncture education, clinical practice, and research. Traditional localization methods rely

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primarily on textual descriptions, proportional measurements (cun), and practitioner experience, which inevitably introduce subjectivity and inter-operator variability. With the growing demand for objective, reproducible, and teachable acupuncture standards, digital body surface mapping provides a practical pathway to modernize acupoint localization while preserving the theoretical foundations of traditional Chinese medicine (TCM).

In this study, we proposed a Proportion-Based Anatomical Landmark Model (PB-ALM) for standardized acupoint localization using digital body surface images. The proposed framework digitizes classical acupuncture principles by defining acupoints as relative positions within a proportion-based coordinate system constructed from stable anatomical landmarks, rather than as fixed absolute coordinates. By explicitly integrating proportional measurement rules and anatomical landmark referencing derived from traditional acupuncture theory, PB-ALM achieves interpretability and theoretical consistency that are often lacking in purely data-driven approaches. Computer-assisted image analysis techniques were employed only as supportive tools to facilitate landmark identification and geometric mapping, avoiding reliance on deep learning or high-complexity artificial intelligence models.

Experimental validation was conducted on multiple commonly used limb acupoints by comparing PB-ALM–based localization results with expert manual annotations. Quantitative results demonstrate that the proposed method achieved a mean absolute localization error of 4.2 mm and a root mean square error of 5.1 mm. Compared with conventional manual proportional measurement, PB-ALM reduced inter-operator standard deviation from 4.5 mm to 3.0 mm and improved the intraclass correlation coefficient from 0.72 to 0.91. These results indicate that PB-ALM substantially enhances localization consistency and reproducibility while maintaining clinically acceptable accuracy. The developed digital acupoint localization assistance prototype further demonstrates the feasibility of applying the proposed framework in acupuncture teaching and clinical guidance scenarios.

Despite these promising results, several limitations remain. The current study focuses primarily on limb acupoints, where anatomical landmarks are relatively stable and clearly defined. Future work will extend the PB-ALM framework to more complex anatomical regions such as the trunk, back, and head, where surface morphology varies more significantly. Additionally, incorporating personalized body shape adaptation mechanisms and multi-view digital imaging may further improve robustness across diverse populations. Moreover, integrating highly accurate anatomical structure extraction models, such as attention-enhanced Transformer-UNet architectures [14], could provide automated and precise identification of complex vascular and muscular landmarks, thereby expanding the clinical applicability of the proposed model. Finally, large-scale multi-center validation studies will be conducted to assess the generalizability and clinical impact of PB-ALM in real-world acupuncture practice.

Overall, this work provides an interpretable, reproducible, and clinically feasible solution for promoting the digital standardization of acupoint localization, offering a valuable bridge between traditional acupuncture theory and modern digital health technologies.

References

[1] Wang, Yuyao. "Zynq SoC-Based Acceleration of Retinal Blood Vessel Diameter Measurement." Archives of Advanced Engineering Science (2025): 1-9.

[2] World Health Organization. Regional Office for the Western Pacific. WHO standard acupuncture point locations in the Western Pacific Region[M]. World Health Organization, 2008.

[3] Wang, Wan-Ying, et al. "Current policies and measures on the development of traditional Chinese medicine in China." Pharmacological research 163 (2021): 105187.

[4] Godson, Debra R., and Jonathan L. Wardle. "Accuracy and precision in acupuncture point location: a critical systematic review." Journal of acupuncture and meridian studies 12.2 (2019): 52-66.

ISSN: 3079-6601

[5] Zhai Z, Wang Z, Xu L, et al. A systematic review of computer-aided acupoint localization[J]. Iscience, 2025.

[6] Zhang M, Schulze J P, Zhang D. E-faceatlasAR: extend atlas of facial acupuncture points with auricular maps in augmented reality for self-acupressure[J]. Virtual Reality, 2022, 26(4): 1763-1776.

[7] Ao X, Li K, Liu Y, et al. Development and application of a three-dimensional digital visualization system for children's neck acupoints[J]. Chinese Journal of Tissue Engineering Research, 2025, 29(9): 1834.

[8] Liu Y, Sun R, Mu R J, et al. Development of a three-dimensional digital children's acupuncture point visualization system of Mongolian medicine[J]. Chinese Journal of Tissue Engineering Research, 2024, 28(20): 3223.

[9] Zhao, Jing, et al. "3D representation of acupoints based on the Visible Human." Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE Cat. No. 03CH37439). Vol. 1. IEEE, 2003.

[10] Malekroodi, Hadi Sedigh, et al. "Real-time location of acupuncture points based on anatomical landmarks and pose estimation models." Frontiers in neurorobotics 18 (2024): 1484038.

[11] Yang, Shilong, et al. "Exploring an innovative deep learning solution for acupuncture point localization on the weak feature body surface of the human back." IEEE Journal of Biomedical and Health Informatics 29.7 (2024): 4599-4611.

[12] Zhao P, Pang L, Cao S, et al. Deep learning-based patient in-position detection for acupuncture treatment[C]//Computational Optical Imaging and Artificial Intelligence in Biomedical Sciences. SPIE, 2024, 12857: 157-165.

[13] Yao, Yilin, et al. "Deep Learning Models for Multi-class Pneumonia Detection in Chest X-rays: A Comparative Study of VGG16, MobileNet, and ResNet152." Computer Simulation in Application 3.1 (2025): 66-73.

[14] Yao, Yilin, et al. "MSA-TransUNet: A Multi-Scale Attention Enhanced Transformer-UNet Architecture for Accurate Vessel Segmentation and Visualization in Medical Imaging." Journal of Medicine and Life Sciences 1.4 (2025): 48-57.