Automated Measurement of Pelvic Parameters Using CNN in Spinal Conditions: Overcoming Challenges in Coronal Deformity Cases

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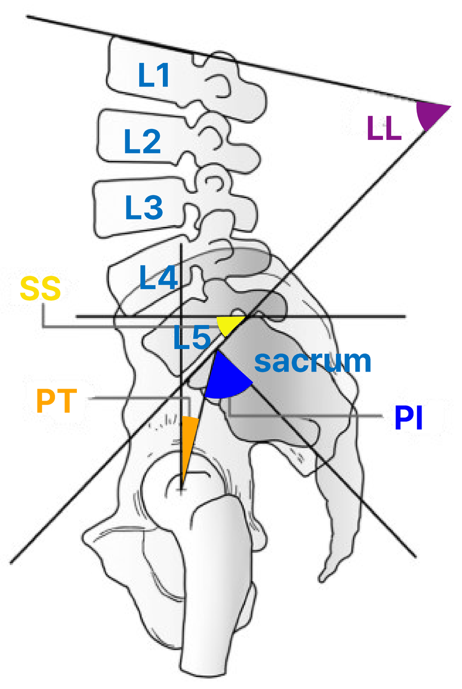
Introduction

- Accurate measurement of sagittal alignment is difficult in severe coronal deformities such as degenerative lumbar scoliosis (DLS).
- The goal is to achieve measurement consistency similar to experienced orthopedic surgeons, enhancing clinical decision-making for various spinal deformities, including complex cases like DLS.



Data and Method

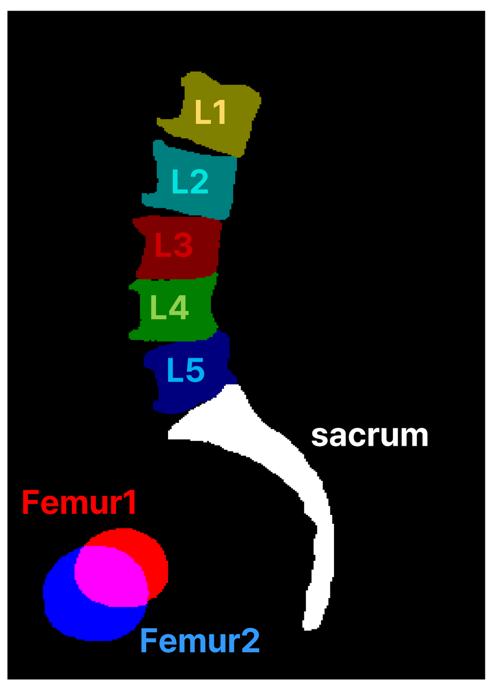
[Data]

- 1124 paired data, each consisting of both segmentation and keypoint annotations

[Method]

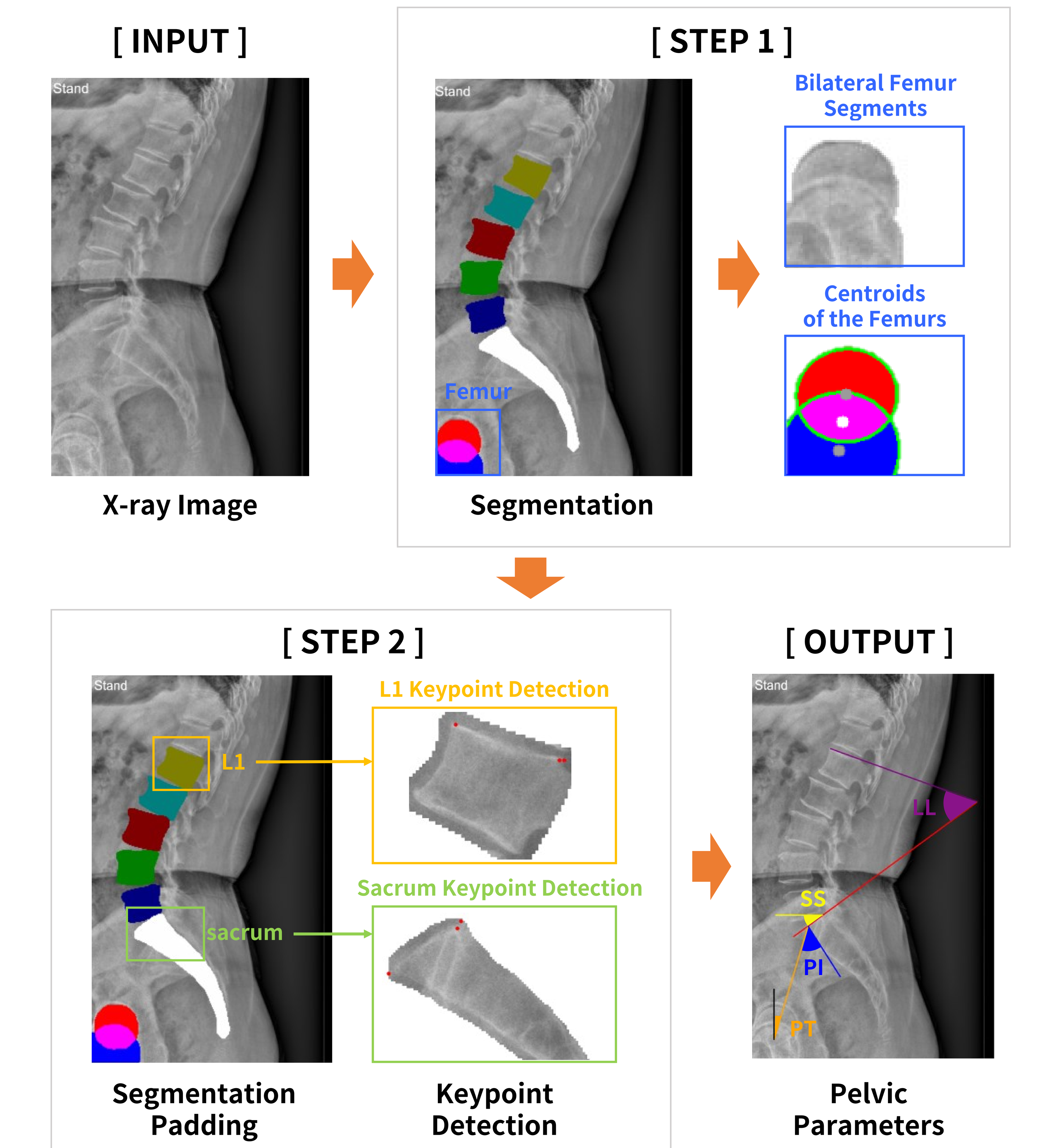
- U-Net
- Keypoint R-CNN

Segmentation Data



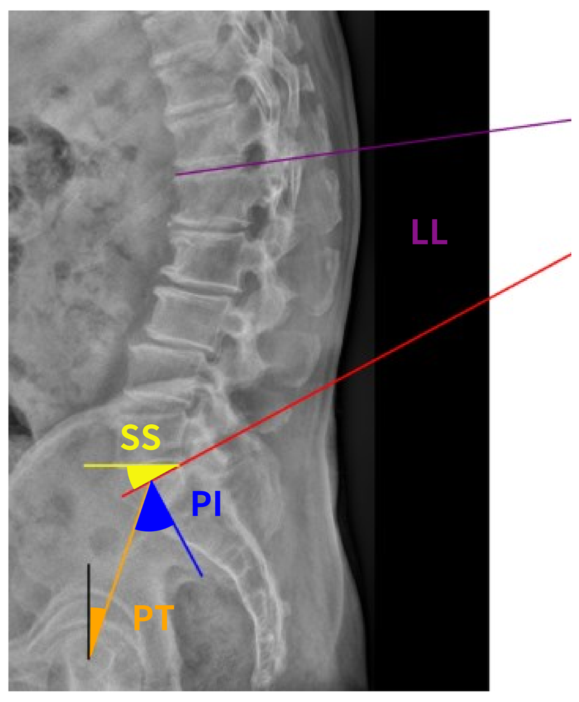
Keypoint Data

Overview of the AI Model



Result

- The AI system outperformed experienced orthopedic surgeons, with interclass ICCs ranging from 0.96 to 0.99 and no significant systemic bias observed in Bland-Altman analysis.
- Compared to previous studies, this model demonstrated superior performance with lower mean errors (0.1° to 0.2°) and standard deviations (1.2° to 4.0°).



Prediction Results for Pelvic Parameters

Study	Interclass ICC	Absolute value of mean error	Standard deviation
Grover et al.(2022) [1]	0.83 - 0.88	0.4° - 3.9°	3.3° - 6.2°
Song et al. (2023) [2]	0.62 - 0.85	3.6° - 8.8°	3.6° - 5.7°
Löchel et al. (2024) [3]	0.71 - 0.85	1.5° - 3.9°	4.1° - 8.9°
Current Study	**0.96 - 1.00**	**0.1° - 0.2°**	**1.2° - 4.0°**

Comparison of interclass ICC ranges, absolute value of mean error, and standard deviation between ground truth and AI-predicted PI, LL, SS, and PT in preoperative radiographs across multiple studies.

Conclusion

- The study developed and validated an AI-based system for accurately measuring sagittal parameters in spinal deformities, demonstrating good agreement with experienced orthopedic surgeons.
- Conducted using radiographs from a single institution, the study highlights the need for more diverse datasets to ensure broader applicability in clinical settings.
- Future work should focus on extending the models capabilities to include whole spine lateral and postoperative radiographs.

Reference

[1] Orosz LD, Bhatt FR, Jazini E, Dreischarf M, Grover P, Grigorian J, et al. Novel artificial intelligence algorithm: an accurate and independent measure of spinopelvic parameters. J Neurosurg Spine 2022;37:893-901.

[2] Song SY, Seo MS, Kim CW, Kim YH, Yoo BC, Choi HJ, et al. AI-Driven Segmentation and Automated Analysis of the Whole Sagittal Spine from X-ray Images for Spinopelvic Parameter Evaluation. Bioengineering-Basel 2023;10:17.

[3] Löchel J, Putzier M, Dreischarf M, Grover P, Urinbayev K, Abbas F, et al. Deep learning algorithm for fully automated measurement of sagittal balance in adult spinal deformity. European Spine Journal 2024:6.

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