Methodological Studies on Thoracic Spine Prediction

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Introduction

- Injury data shows that spine fractures occur frequently in vehicle crashes and they are highly correlated with occupant characteristics (gender, age, BMI, etc.).
- A parametric model that predicts 3D geometry of the thoracic spine (T-spine) is important to vehicle safety design.

Objectives

- To create parametric models of the T-Spine vertebrae to investigate if gender, size, and shape of the T-Spine can affect adult injury in motor vehicle accidents.
- Investigate different methods in T-Spine prediction and compare the model performance.
- Explore how the geometry features of T-spine varies with characteristics.

Methods

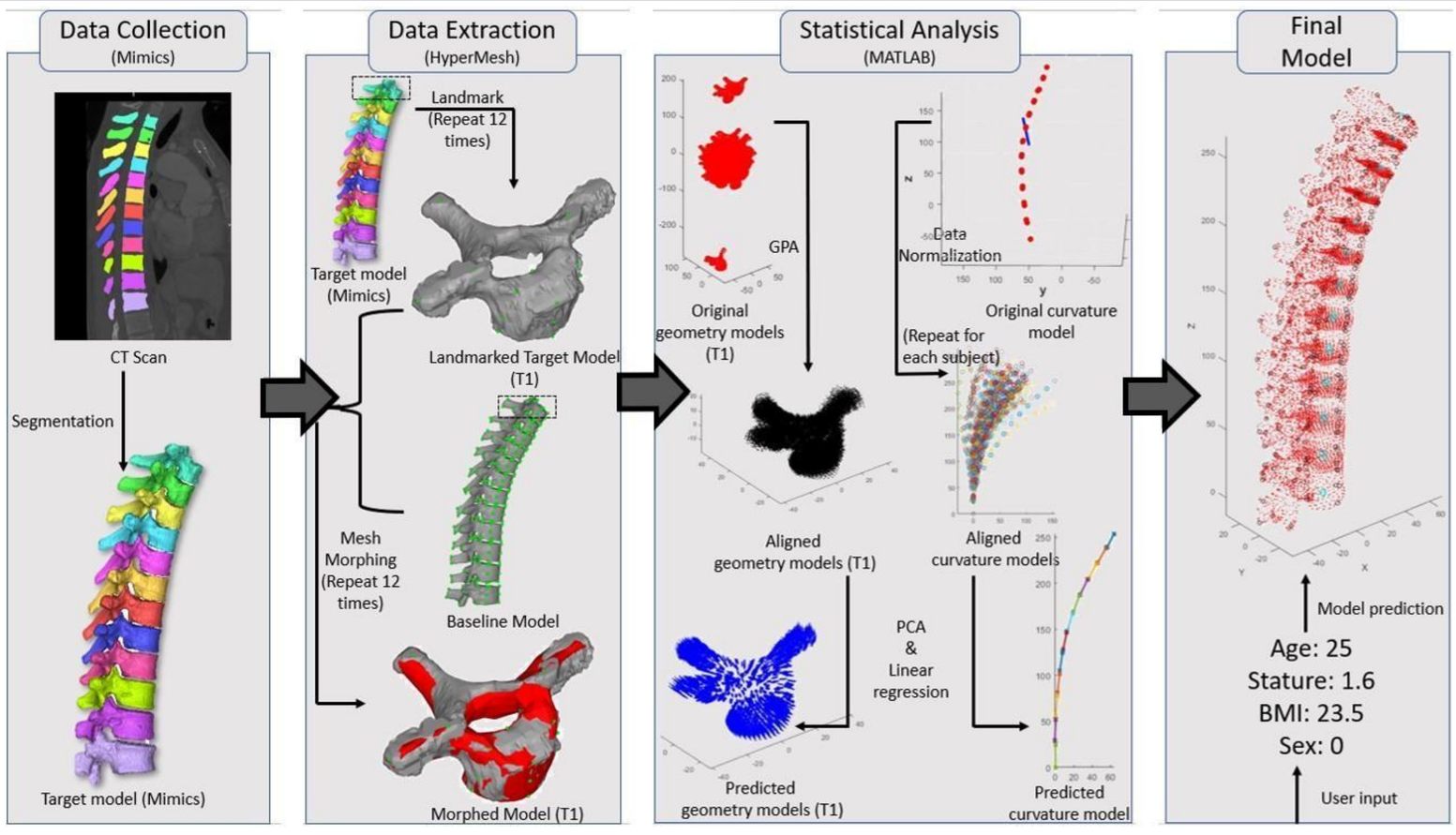


Figure 1. Graphical display of the methods.

Model Analysis

Traditional method
- linear regression after GPA & PCA (Tang et.al, 2022).

Sub-region method
- Split the vertebrae into 4 geometrical subspaces with distinctive features in their shapes.
- Assemble local predicted model for the global model.

DNN method (future work)
- Use the data set under GPA.
- Design fully linearly connected layer and find best-performed model.

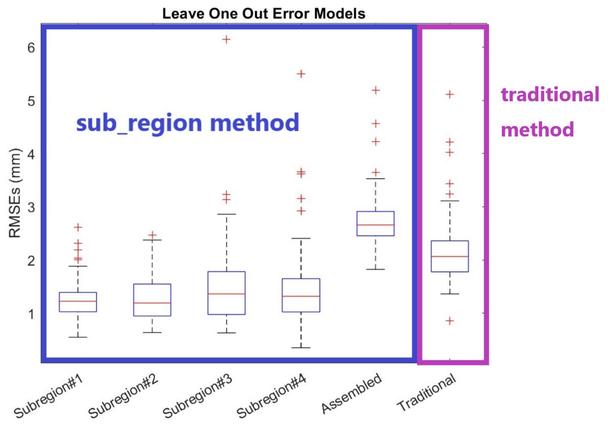


Figure 2. Error distribution plots for T-1.

Feature Results

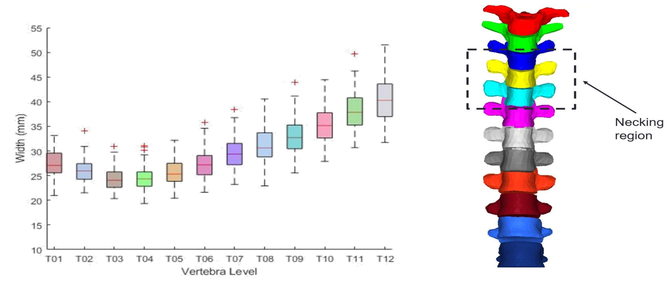
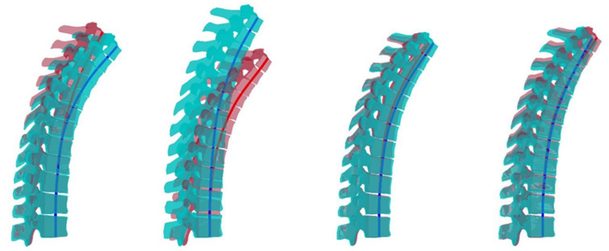


Figure 3. Necking effect.



Age: 20 (Red) 80 (Blue) Stature:1.75m BMI:25 Sex: Male	Age:45 Stature: 1.55 (Red) 1.95 (Blue)m BMI:25 Sex: Male	Age:45 Stature:1.7m BMI:25 Sex: Female (Red) Male (Blue)	Age:45 Stature:1.75m BMI: 20(Red) 40(Blue) Sex: Male

Figure 4. Effects of age, statue, gender and BMI on thoracic vertebral geometry.

Conclusions

This study developed a statistical T-spine model that can account for variation by age, sex, stature, and BMI. The data set used in this study comes from 84 subjects' CT scan, and then proceed by 4 steps of listed in the methods section. The results showed that PC1 mainly account for the overall size effect, PC2 and PC3 mainly account for the curvature. Age and stature have bigger impact on T-spine geometry and curvature compared with sex and BMI. Necking effect is revealed, and this model can be served as basis for both T-spine injury assessment and pathologic analysis.

Acknowledgement

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References

[1] Tang L, Hu Z, Lin Y, Hu J (2022) "A Statistical Lumbar Spine Geometry Model Accounting for Variations by Age, Sex, Stature, and Body Mass Index" *Journal of Biomechanics*, 130, DOI: 10.1016/j.jbiomech.2021.110821.