

## Task 1 – Review #2

Paper: C.-W. J. Cheung, G.-Q. Zhou, S.-Y. La, T.-M. Mak, K.-L. Lai, and Y.-P. Zheng, “Ultrasound Volume Projection Imaging for Assessment of Scoliosis”, IEEE Transactions on Medical Imaging 2015; 34(8): 1760-1768.

### 1. Claims

- That their imaging system can be used with the presented method, ultrasound volume projection imaging, can be used to quantify scoliosis. This quantification is an estimate of the angle of maximum curvature, the Cobb angle. Specifically, that their method produces curvature estimates which are well correlated with ground-truth Cobb angle measurements.

### 2. Factors, scope, and limitations

- One point of this study is that it is carried out on living participants, rather than phantom models
- They state that they evaluated their method on subjects with different spinal curvature angles.
  - While true, the spirit of this statement is not reflected in the data: all of their patients had Cobb angles less than 30°. Their population consisted on individuals with mild, some verging on moderate, scoliosis. In cases of severe scoliosis, the Cobb angle can more than double and triple 30°.
- The paper does not discuss limitations early on. In the conclusion they mention demonstrating clinical value with a larger sample of patients and improving the system for obese patients.

### 3. Methodology

- Perform ultrasound scans and extract curvature angles from landmark data.
- Compare curvature estimates to ground-truth Cobb angles obtained from X-rays.
- Compare intra and inter-observer results.

### 4. Evaluation

- The value of their method is assessed on the basis of accuracy of quantification, inter, and intra-observer variability.

### 5. Performance metrics

- The accuracy of their method is conveyed in the  $R^2$  value of the correlation between the angles produced by their method plotted against the ground-truth angles.
- Intra-class correlation coefficients were used to quantify the inter and intra-observer variability.

### 6. Data collection

- 36 patients with scoliosis were scanned using their ultrasound system, 29 of which had X-rays for ground-truth comparison.
- Observers located the necessary anatomic landmarks on the coronal spine images generated by their system.
- The angle of curvature is extracted from the set of landmark locations.

**7. Result comparison**

- For the 29 patients who had prior X-rays, their angles of curvature as estimated by Cheung et al.'s method were compared to actual Cobb angle measurements taken from their X-rays.
- The results were also compared to each other. Multiple scans of the same patient by a single observer were compared to assess intra-observer variability. While multiple observer's results for a single patient were compared to assess inter-observer variability.

**8. Result validation**

- The accuracy of their method itself was validated by comparing the curvature estimates it produced to Cobb angles taken from X-ray.
  - The Cobb angle, being the clinical standard for scoliosis quantification, is a sensible choice for results validation.
- Repeated trials by each observer served not only to investigate intra-observer variability, but also to provide significance to their estimation accuracy.
- Interestingly, the authors report their method's intra and inter -observer variation to be lower than those of X-ray Cobb angle measurement, which is the current gold-standard. Their intra and inter-observer variations being  $1.4^{\circ} \pm 1.0^{\circ}$ , and  $2.2^{\circ} \pm 1.6^{\circ}$ , respectively. Those of X-ray are reportedly  $3^{\circ}$ - $5^{\circ}$ , and  $6^{\circ}$ - $9^{\circ}$ , respectively.

**9. Findings**

- Their spine imaging modality is suitable for the assessment of scoliosis.
  - i. I feel that the authors stating this without reference to limitations or scope to be premature. As I mentioned, their study is performed on patients having relatively small angles of curvature. And as they mention in their conclusion, the work can still be improved for obese patients.

**10. Hedges**

- I cannot say that the authors hedge their findings in any manner we have discussed. As mentioned in Findings, the authors state the effectiveness of their approach without reference to scope or limitations.
- Although presented in the conclusion along with the claimed suitability of their method, and as such, as more so of a possible extension than existing limitation of scope or hedge, the size of their study and obese patients who can be difficult to image are mentioned.