1. **Application**

The potential for harmful side-effects resulting from using x-ray imaging to quantify scoliosis (pathological curvature of the spine) has motivated research [1,2] into using spatially tracked ultrasound imaging as an alternative means of quantification. Accurate quantification of the disease is important if patients are to receive an appropriate treatment [2], but such ultrasound images are difficult to interpret [3]. For accurate quantification using ultrasound, anatomic landmarks must be accurately located by the clinician. Because of their visibility in ultrasound, the vertebral transverse processes can be used to this end [1,2,4]. However, because of the difficulty in interpreting ultrasound images, these landmarks are often located inconsistently or inaccurately [2].

I propose to use a neural network to predict the curvature of scoliotic patients’ spines from incomplete landmarks point sets, also containing noise and inaccuracy. There are numerous studies on missing data imputation [5-7] and outlier detection [8,9], as well as scoliosis quantification from surface imaging using neural networks [10]. However, to my knowledge, there is no literature on using ultrasound-accessible anatomic landmark data as input to a neural network to quantify scoliosis.

1. **Data**

I will train the neural network using spatial landmark points which I have placed on the transverse processes of over 100 scoliotic patients located using prior CT scans. I will reserve a portion of these landmark point sets to test the neural network on. I will manually or programmatically degrade these reserved landmarks point sets to simulate the difficulties inherent in ultrasound imaging by deleting and shifting some of their points.

1. **Neural network overview**

The architecture of the network will need to be such that the input node layer can accommodate sets (of varying size) of 3D spatial point data, and possibly other geometric features I extract from them. During training, the output estimation of the angle of spinal curvature will be compared to that which I measure manually from the patient’s CT scan, and used as an error value for backpropagation.

**References**

[1] T. Ungi, F. King, M. Kempston, Z. Keri, A. Lasso, P. Mousavi, J. Rudan, D.P. Borschneck, and G. Fichtinger, “Spinal Curvature Measurement by Tracked Ultrasound Snapshots”. Ultrasound in Med. & Biol. 2014 Feb; 40(2): 447-54.

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

[3] F. Berton, F. Cheriet, M.-C. Miron, and C. Laporte, “Segmentation of the spinous process and its acoustic shadow in vertebral ultrasound images”. Computers in Biology and Medicine 2016 Mar; 72: 201-11.

[4] K. E. Purnama, M. H. F. Wilkinson, A. G. Veldhuizen, P. M. A. van Ooijen, J. Lubbers, J. G. M. Burgerhof, T. A. Sardjono, and G. J. Verkerke, “A framework for human spine imaging using a freehand 3D ultrasound system”. Technology and Health Care. 2010; 18: 1-17.

[5] I. A. Gheyas, and L. S. Smith, “A neural network-based framework for the reconstruction of incomplete data sets”. Neurocomputing. 2010; 73: 3039-65.

[6] A. K. Mohamed, F. V. Nelwamondo, and T. Marwala, “Estimating Missing Data Using Neural Network Techniques, Principal Component Analysis and Genetic Algorithms”. PRASA Proceedings. 2007.

[7] P. Lingras, M. Zhong, and S. Sharma, “Evolutionary Regression and Neural Imputations of Missing Values”. Soft Computing Applications in Industry, STUDFUZZ. 2008; 226: 151-63.

[8] Q. Cai, H. He, and H. Man, “Spatial outlier detection based on iterative self-organizing learning model”. Neurocomputing. 2013; 117: 161-72.

[9] N. Upasani, and H. Om, “Evolving fuzzy min-max neural network for outlier detection”. Procedia Computer Science. 2015; 45: 754-61.

[10] J. L. Jaremko, P. Poncet, J. Ronsky, J. Harder, J. Dansereau, H. Labelle, and R. F. Zernicke, “Genetic Algorithm – Neural Network Estimation of Cobb Angle from Torso Asymmetry in Scoliosis”. Transactions of the ASME. 2002; 124: 496-503.