Artificial Intelligence Data-driven Model for Adolescent Idiopathic Scoliosis: Analysis, Prediction and Treatment

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What is Scoliosis?
Scoliosis, 3D deformation of the human spinal column, is characterized by a lateral deviation of the spine, accompanied by axial rotation of the vertebrae. In this research, the primary focus is on Adolescent Idiopathic Scoliosis (AIS) which is the most common type of scoliosis affecting children mostly between ages 8 to 18 when bone growth is at its maximum rate. The treatment of scoliosis is highly dependent on the scoliosis curve. Currently, the selection of the most appropriate treatment option is based on the surgeon’s experience. Therefore, developing a clinically validated, patient-specific, real-time predictive model of the spine will aid the surgeons in monitoring curve progression and proposing efficient methods of treatment for individual patients.

**Project Plan**

1. First visit of a patient (x-ray image)
2. Image segmentation
3. Predict spine shape over years
4. Treatment plan

**Task 1:** Automatic framework for the reconstruction of patient-specific spine geometry from medical images including X-ray and MRI

- **Atlas model geometry of vertebra (from CT)**
- **Landmark based shape registration**
- **Patient-specific vertebra model**
- **2D to 3D reconstruction of landmarks**
- **Landmark Detection**
- **AP and LAT 2D X-ray images from patient**

- Landmark detection from 2D anteroposterior (AP) and lateral (LAT) X-rays using novel B-spline based image segmentation.
- The landmarks are reconstructed in 3D space and integrated into the landmark-based deformable registration framework. Higher order B-splines are used to evaluate the deformation field and will be robust towards large variations in the patient-specific shapes.

**Task 2:** Developing a clinically validated patient-specific Reduced-Order Finite Element Model (ROFEM) of the spine

Generating the detailed geometry of the vertebrae, including growth area, trabecular bone and cortical bone.

**Task 3:** Predicting the spine curvature using data mining methods

The third task is a physical guided finite-element neural network for predicting the spine curvature. Physical guided neural network (PGNN) is a neural network trying to solve problem with physical equations.

- **Model features**
  - \(X = \text{Vector of input coordinates of a landmark } [x_1 x_2 x_3]\)
  - \(\alpha = \text{Stress vector} [01 c2 c3 c312 c23 c31]\)
  - \(\beta = \text{Global angle vector} [01 2 c3 04 05]\)
  - \(t = \text{Age of the patient}\)
  - \(\Delta t = \text{Age variance between target age and current age (month)}\)

- **Dimension of the data**
  - \(X^* = \text{Vector of output co-ordinates of a landmark } [x_1^* x_2^* x_3^*]\)
  - \(N_s = \text{Total number of landmarks}\)

**References**