The focus of this research is a hierarchical image matching strategy and a multiple surface registration technique for 3D reconstruction of a scoliotic torso. Scoliosis is a deformity of the human spine most commonly occurring in children. After being detected, periodic examinations via x-rays are traditionally used to measure its progression. However, due to the increased risk of cancer, non-invasive and radiation-free scoliosis detection and progression monitoring methodologies are being researched. For example, quantifying the scoliotic deformity through the torso surface is a valid alternative because of its high correlation with the internal spine curvature. This work proposes a low-cost, multi-camera photogrammetric system for semi-automated 3D reconstruction of a torso surface with a sub-millimetre level accuracy. The paper first describes the system design and calibration for optimal accuracy. It then covers the reconstruction and registration procedures giving insights into the hierarchical image matching strategy and the multiple surface registration technique. Final accuracy is evaluated through the goodness of fit between the reconstructed surface and a more accurate set of points measured by a coordinate measuring machine.

Introduction

Scoliosis is a lateral curvature of the spine. A normal spine viewed from behind appears straight, while a scoliotic spine appears “S” or “C” shaped. A person is diagnosed with scoliosis once the spinal curvature exceeds 10° [Kane 1977]. The disease generally begins at the onset of puberty and progresses during the period of rapid growth. If left untreated, it can negatively impact the patient’s quality of life (e.g. causing respiratory problems and/or heart malfunction), so it is imperative to detect abnormal spinal curvature as early as possible. Scoliosis is usually first detected, or at least suspected, during a school screening session. The method most widely practiced during such a session is the Adam’s bend forward test, where a scoliometer is used to initially estimate any visible trunk asymmetry. If scoliosis is detected, a full-length standing x-ray is taken in order to better quantify the spinal curvature. This is done by measuring what is known as the Cobb angle [Cobb 1948].

The magnitude of the Cobb angle and the speed of the curvature progression are essential for assigning optimal scoliosis treatment. A curvature of 45° or less can be treated conservatively with exercises or bracing, however, rapidly changing curvature or curvature exceeding 45° requires surgery [Roach 1999]. This is why the disease progression must be monitored by periodic examinations;