Secular Changes of Lumbar Spinal Canal Dimensions

Background Lumbar spinal stenosis (LSS) is one of the most common musculoskeletal disorder, which should affect ~64 million elderly adults by the year 2025 in the United States. Symptomatic lumbar spinal stenosis (LSS) with neurogenic claudication is the most frequent cause of surgery of the lumbar spine in elderly patients. LSS develops as a result of degenerative changes of the intervertebral discs and facet joints as well as ligamentum flavum buckling, resulting in structural narrowing occurring at the disc level. Patients with developmentally smaller bony spinal canals are probably more likely to develop symptoms leading to claudication and therefore surgery. This probably explains why not all patients with degenerative changes will develop symptoms, whereas others do so.
The adult size of the bony spinal canal is determined early in life; for example, the final size of the fifth lumbar vertebra is reached at the age of 5 years. This allows us to use CT scans available in institutional databases to determine the size of the bony spinal canal of patients born 100 years ago (and therefore the size of the spinal canal at that time) and compare it with more recent measurements. Of note, since degenerative changes occur at the disc level but do not alter the area/size of the bony spinal canal at the pedicle level, patients of varying ages with or without degenerative changes/osteoarthritis can be compared.
A previous study focusing on a small population showed a statistical decrease of the dimension of the spinal canal between populations born in the forties and in the seventies. However, these measurements were performed manually on a limited series of 200 patients. Due to the high potential health problems that would represent a general decrease of the bony spinal canal, new methods must be developed to perform these measurements rapidly/automatedly and reliably/accurately on larger multi-institutional and multi-ethnic cohorts of patients.

Aim In this project, the student will develop methods to automatically identify the vertebra L1-L5 from whole-body CT scans and measure the cross-sectional area of the corresponding bony spinal canal at the pedicle level.

Materials and Methods A series of 200 whole-body CT scans obtained from the institutional radiological database will be used for this study. The position of the pedicles of the L1-L5 vertebras will be identified for all the patients in this dataset, and will be used to train deep learning networks. The position of the pedicles will be performed using a localization neural network that will rely on large numbers of 3D localization patches. Once the position of the vertebras is determined, the L1, L2, L3, L4 and L5 axial-oblique images will be resampled and a 2D CNN will be used for the segmentation of the bony spinal canal at the different levels. Once validated, the system will be deployed as webservice to allow clinicians from different location to evaluate their datasets.

Nature of the Thesis:
Literature review & writing: 10%
Programming (machine learning): 50%
Evaluation: 40%

Requirements:
Familiarity with spinal anatomy
Programming knowledge (Python or equivalent)
Interest in machine learning, especially deep learning

Supervisors:
Guodong Zeng
Prof. Philippe Büchler

Institute:
ARTORG Center for Biomedical Engineering Research

Clinical partner:
Fabio Becce, Department of Radiology, Lausanne University Hospital

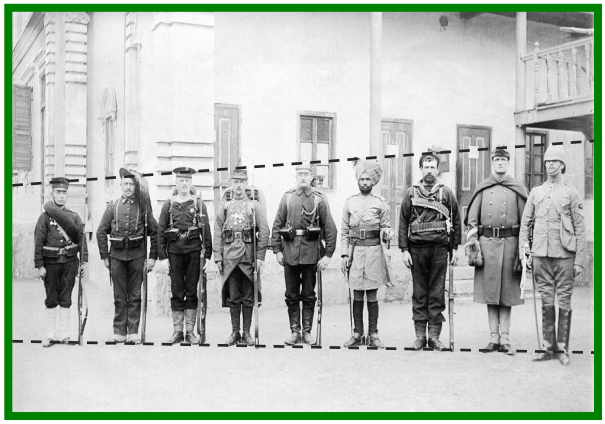

Fig. While the average height increases with younger generations, subjects born in 70' have a significantly smaller bony canal compared to those born in 40' (Schizas et al. 2014)

References:
Schizas C, Schmit A, Schizas A, Becce F, Kulik G, Pierzchała K. Secular changes of spinal canal dimensions in western Switzerland: A narrowing epidemic? Spine (Phila Pa 1976). 2014;39(17):1339-1344.
Monier A, Omoumi P, Schizas S, Becce F, Schizas C. Dimensional changes of cervical and lumbar bony spinal canals in one generation in Western Switzerland: a computed tomography study. Eur Spine J. 2017;26(2):345-352.

Contact: Philippe Büchler, philippe.buechler@artorg.unibe.ch, Stauffacherstrasse 78, 3014 Bern, T. 031 631 5947