Registration and shape modelling of porcine bone structures via CT

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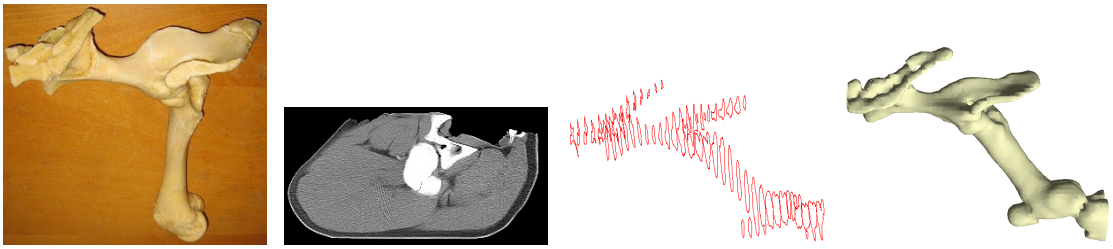
Based on 2D computed tomography (CT) scans of porcine carcasses, a 3D point based statistical shape model of bone structures connected to the pelvic bone, fig. 1(a), is built. The shape model is used by the Danish Meat Research Institute (DMRI) to optimize and validate the functionality of a specific tool in a slaughterhouse robot currently being developed.

The data consists of 2D CT scans, fig. 1(b), of 40 porcine carcasses separated along the medial plane. Each scan has a slice thickness of 10mm with a spacing of 10mm between each scan. Voxel dimensions are $[x, y, z] = [0.88, 0.88, 10]$mm. The full length of the carcasses is scanned resulting in approximately 130 scans per carcass, but only 30 scans per carcass are used in this application, covering the parts around the region of the pelvic bone.

Extracting corresponding points on a 3D shape from 2D scans is a tedious and difficult task, calling for (semi-)automated methods. Standard tresholding techniques combined with morphology ensures a robust segmentation of bone contours in the 2D scans. Points on the contours, fig. 1(c), are used as 3D constraints in the reconstruction of the bone surfaces using variational interpolation and radial basis functions (RBF) [3]. Due to the massive amount of data, each contour is approximated using fourier basis functions and then resampled. Only points along the contours having high curvature are selected to be constraints on the 3D surface. The implicit surface, fig. 1(d), is then resampled much more dense than the original scanning and the shapes are aligned using the iterative closest point (ICP) algorithm [1] and point correspondence is achieved. Using principal component analysis (PCA) a compact statistical shape model [2] is built describing the shape variation of the data set.

A generative statistical shape allows simulation of bone structures and thereby the different conditions under which the robotic tool is to be applied. Furthermore, the generative model can be used as a prior for segmentation of new unseen pig carcass scans.

The shape model is used by the DMRI to optimize the design of a tool in a new slaughterhouse robot. Applying the knowledge of how the bone structures vary, makes the process of developing new tools to do specific cuts, much less cumbersome compared to the normal trial-and-error approach.



(a) Photo. (b) CT scan. (c) Contours. (d) Implicit Surface.

Figure 1: Pelvic Bone

References

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