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Explicit shape descriptors: novel morphologic features for histopathology classification

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Abstract

Object morphology, defined as shape and size characteristics, observed on medical imagery is often an important marker for disease presence and/or aggressiveness. In the context of prostate cancer histopathology, gland morphology is an integral component of the Gleason grading system which enables discrimination between low and high grade disease. However, clinicians are often unable to distinguish between subtle differences in object morphology, as evidenced by high inter-observer variability in Gleason grading. Boundary-based morphologic descriptors, such as the variance in the distance from points on the boundary of an object to its center, may not have the requisite discriminability to separate objects with subtle shape differences. In this paper, we present a set of novel explicit shape descriptors (ESDs) which are capable of distinguishing subtle shape differences between prostate glands of intermediate Gleason grades (grades 3 and 4) on prostate cancer histopathology. Calculation of ESDs involves: (1) representing object morphology using an explicit shape model (e.g. medial axis); (2) aligning the shape models via a non-rigid registration scheme with a diffeomorphic constraint and quantifying shape model dissimilarity; and (3) applying a nonlinear dimensionality reduction scheme (e.g. Graph Embedding) to learn a low dimensional projection encoding the shape differences between objects. ESDs are hence the principal eigenvectors in the reduced embedding space. In this work we demonstrate that ESDs in conjunction with a Support Vector Machine classifier are able to correctly distinguish between 888 prostate glands corresponding to different Gleason grades (benign, grade 3, or grade 4) of prostate cancer from 58 needle biopsy specimens with a maximum accuracy of 0.89 and corresponding area under the receiver operating characteristic curve of 0.78.

Keywords: Shape Descriptors, Prostate Histopathology, Gleason Grading, Manifold Learning, Diffeomorphic Registration, Classification

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