A Statistical Method for the Evaluation of Rupture Risk in Abdominal Aortic Aneurysms based on Medical Images

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ABSTRACT

An Abdominal Aortic Aneurysm (AAA) is a dilation of the abdominal aorta, threatened by rupture which often ends fatally. As AAAs develop more likely in the elderly population, surgical or endovascular intervention is accompanied by potential risks as well. Consequently, surgeons have to balance rupture risk with the risk of suitable repair. In the attempt to assist this decision-making process, groupwise statistics are performed on a database of geometrical surfaces of asymptomatic and ruptured AAA cases. Based on the surface information, the obtained statistical model can be employed to assess the rupture risk of a given individual AAA. This approach is relevant for clinical applications as a surface can be extracted easily from medical images and discretized using a triangular mesh.

The main challenge facing such a statistical model lies primarily in finding a statistically significant feature-space of surfaces. As in [1], with respect to a specific population, a particular surface is characterized by an optimal diffeomorphic mapping of the respective population representative, called *atlas*, to it, and by the resulting residual. Such a deformation can be parameterized by an associated vector field which transports the atlas' points in the ambient space and which can be taken therefore as a feature of the AAA surface. In order to reduce its dimensionality, while capturing the largest possible variability or *variance*, the *first principal components* of the vector field are identified using principal component analysis.
Algorithmically, the atlas creation [1] as well as the identification of the optimal mappings is realized by using the space of currents [2] as metric space to compare surfaces [3].
In order to train the statistical model to differentiate between the two groups (asymptomatic and ruptured), the atlas is mapped to the AAA surfaces in the database and the first principal components of the corresponding vector field are extracted. Afterwards the mean and covariance matrix of each group is estimated. The rupture risk of a given AAA can then be assessed by the evaluation of the likelihood of its vector field to the two groups.

REFERENCES

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