

Claims

1. A computer-implemented method of obtaining data characterizing a biological structure having a periodic structure, the method employing a plurality of three-dimensional input meshes which represent an instantaneous shape of the biological structure at successive respective times within a cycle of periodic motion, the method comprising:

using the input meshes to form a set of three-dimensional morphed meshes, the morphed meshes having respective shapes which are the shapes of corresponding ones of the input meshes, wherein the operation of forming the morphed meshes comprises:

designating one of the input meshes, or a template mesh which is a geometric primitive, as a generic mesh, and

for each of undesignated input meshes, forming a corresponding one of the morphed meshes by deforming the generic mesh to the shape of the respective one of the undesignated input meshes,

wherein the morphed meshes have the same number of vertices as the generic mesh such that each vertex of each of the morphed meshes has a corresponding vertex in each of the other morphed meshes;
performing three-dimensional shape analysis comprising,

for each of the morphed meshes, obtaining a curvedness value at each of a plurality of corresponding locations comprising corresponding vertices in the morphed meshes, and

producing a value indicative of a change of curvedness per time unit using the curvedness values of the morphed meshes corresponding to the successive respective times; and

restoring the shapes of the plurality input meshes to correct motion artifacts prior to forming the morphed meshes.

2. A method according to claim 1 in which, for each of the undesignated input meshes:

a plurality of feature points located on the generic mesh and a respective plurality of feature points located on the undesignated input mesh, are used to generate an affine transformation from the generic mesh to the undesignated input mesh.

- 5 3. A method according to claim 2 in which the feature points of the generic mesh and the feature points of the undesignated input meshes are found using landmarks having known positions on the generic mesh and undesignated input meshes.
4. A method according to claim 2 in which the affine transformation is using radial
10 basis functions (RBF).
5. A method according to claim 1 in which the shape analysis comprises fitting quadric surfaces over the vertices of the generic mesh and each morphed mesh, and computing geometrical parameters of the quadric surfaces.
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6. A method according to claim 5 in which the fitting of the quadric surface is performed using a set of vertices spanning a portion of the corresponding mesh representing at least about 5% of the total area of the endocardial surface.
- 20 7. A method according to claim 1 in which, for each of a plurality of predefined segments of the biological structure, corresponding segments of the input meshes are found, each of said corresponding segments of the input meshes comprising multiple vertices of the input meshes, and said curvedness values comprise average curvedness values for each of said segments.
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8. A method according to claim 7 in which the segments of the input meshes are found using landmarks having known positions in the input meshes.
9. A method according to claim 7 comprising obtaining for each region a regional
30 curvedness rate which is a first time derivative of the curvedness for the region.

10. A method according to claim 1 in which the biological structure is the left ventricle (LV).

5 11. A computer system for obtaining data characterizing a biological structure having a periodic motion, the computer system having at least one processor and a data storage device storing program instructions, the program instructions being operative, upon being run by the processor, to cause the processor to:

10 form, from a plurality of input meshes which represent an instantaneous shape of the biological structure at successive respective times within a cycle of the periodic motion, a set of three-dimensional morphed meshes, the morphed meshes having respective shapes which are the shapes of corresponding ones of the input meshes, wherein the operation of forming the morphed meshes comprises:

15 designating one of the input meshes, or a template mesh which is a geometric primitive, as a generic mesh, and

for each of undesignated input meshes, forming a corresponding one of the morphed meshes by deforming the generic mesh to the shape of the respective one of the undesignated input meshes,

20 wherein the morphed meshes have the same number of vertices as the generic mesh such that each vertex of each of the morphed meshes has a corresponding vertex in each of the other morphed meshes;

perform three-dimensional shape analysis comprising,

25 for each of the morphed meshes, obtaining a curvedness value at each of a plurality of corresponding locations comprising the corresponding vertices in the morphed meshes, and

producing a value indicative of a change of curvedness per time unit using the curvedness values of the morphed meshes corresponding to the successive respective times; and

30 restore the shapes of the plurality input meshes to correct motion artifacts prior to forming the morphed meshes.

12. A method of obtaining data characterizing a heart ventricle of a subject, the method comprising:

for each of a plurality of times of a cardiac cycle, scanning the heart ventricle to generate corresponding MRI data which image the ventricle at that time;

using the MRI data to obtain a border delineated ventricular contour for each corresponding time;

using each ventricular contour to generate a corresponding three-dimensional input mesh representing a shape of a ventricle at the respective time;

using the input meshes to form a set of three-dimensional morphed meshes, the morphed meshes having respective shapes which are the shapes of corresponding ones of the input meshes, wherein the operation of forming the morphed meshes comprises:

designating one of the input meshes, or a template mesh which is a geometric primitive, as a generic mesh, and

for each of undesigned input meshes, forming a corresponding one of the morphed meshes by deforming the generic mesh to the shape of the respective one of the undesigned input meshes,

wherein the morphed meshes have the same number of vertices as the generic mesh such that each vertex of each of the morphed meshes has a corresponding vertex in each of the other morphed meshes;

performing three-dimensional shape analysis comprising,

for each of the morphed meshes, obtaining a curvedness value at each of a plurality of corresponding locations comprising the corresponding vertices in the morphed meshes, and

producing a value indicative of a change of curvedness per time unit using the curvedness values of the morphed meshes corresponding to the successive respective times; and

restoring the shapes of the plurality input meshes to correct motion artifacts prior to forming the morphed meshes.

13. A method according to claim 1 further comprising generating a temporal profile of the curvedness values for the plurality of morphed meshes corresponding to the successive respective times, and producing the value using the temporal profile.
- 5 14. A computer system according to claim 11 further comprising generating a temporal profile of the curvedness values for the plurality of morphed meshes corresponding to the successive respective times, and producing the value using the temporal profile.
- 10 15. A method according to claim 12 further comprising generating a temporal profile of the curvedness values for the plurality of morphed meshes corresponding to the successive respective times, and producing the value using the temporal profile.