

CLAIMS

What is claimed is:

1. A method for collecting and processing physical space data for use while performing an image-guided surgical (IGS) procedure, the method comprising:

performing a rigid alignment of a computer model of a non-rigid structure of interest in a patient and surface data in a patient space associated with at least a portion of said non-rigid structure; and

computing a deformation of the computer model that provides a non-rigid alignment of said computer model and surface data, said deformation computed using a set of boundary conditions defined for each node of said computer model, said boundary conditions based on said rigid alignment and a kernel function.

2. The method of claim 1, wherein said computing further comprises:

calculating a set of spatial difference values between the surface data and corresponding portions of the computer model based on said correspondence function;

computing the boundary conditions based on the set of spatial difference values and said kernel function;

generating volumetric deformation displacement vector values for said computer model based on the boundary conditions;

generating an updated computer model based on the volumetric step values;

updating the correspondence function based on the updated computer model;

recalculating the spatial difference values based on the updated correspondence function;

repeating the computing, generating, adjusting, and updating steps if the set of spatial

difference values fail to meet a convergence criteria; and

outputting the updated computer model.

3. The method of claim 1, further comprising selecting said convergence criteria to be at least one of a minimum threshold value for the set of spatial difference values, a minimum difference value between the set of spatial difference values before said updating and the set of spatial difference values after said updating, and a pre-defined number of iterations.

4. The method of claim 1, further comprising displaying data for facilitating said IGS procedure based on said deformation, and wherein said displaying further comprises generating a display of preoperative image data associated with said computer model, wherein the preoperative image data is modified to correspond to said deformation.

5. The method of claim 4, wherein said displaying further comprises:
receiving image data associated with said computer model and a location of an object in said patient space;
transforming said computer model into said patient space based on said rigid alignment and said deformation;
computing reverse deformation displacement vector field values for each node of said computer model;
calculating an envelope of additional reverse deformation vector field values for a portion of said patient space surrounding said deformed computed model;
transforming said location into a computer model space of said computer model based on

said rigid alignment and said reverse deformation displacement vector field values; and
calculating coordinates in an image space of said image data for said transformed
location of said instrument.

6. The method of claim 5, further comprising:
displaying said image data without deformation; and
displaying indicia of said object location in said image space based on said calculated
coordinates in said image space.

7. The method of claim 4, wherein said displaying further comprises:
receiving image data associated with said computer model and at least one location of
interest in an image space of said image data;
transforming said location into a computer model space of said computer model;
calculating coordinates in said patient space for said transformed location of interest.

8. A system for collecting and processing physical space data for use while performing an
image-guided surgical (IGS) procedure, the system comprising:
a storage medium for storing a computer model of a non-rigid structure of interest in a
patient and surface data in a patient space associated with at least a portion of said non-rigid
structure; and
a processing element communicatively coupled to said storage medium, wherein said
processing element is configured for:
obtaining a rigid alignment of the computer model and the surface data, and

computing a deformation of the computer model that provides a non-rigid alignment of said computer model and surface data, said deformation computed using a set of boundary conditions defined for each node of said computer model, said boundary conditions based on said rigid alignment and a kernel function;

9. The system of claim 8, wherein said processing element is further configured during said computing for:

calculating a set of spatial difference values between the surface data and corresponding portions of the computer model based on said correspondence function,

computing the boundary conditions based on the set of spatial difference values and said kernel function,

generating volumetric deformation displacement vector values for said computer model based on the boundary conditions,

generating an updated computer model based on the volumetric step values,

updating the correspondence function based on the update computer model,

recalculating the spatial difference values based on the updated correspondence function,

repeating the computing, generating, adjusting, and updating steps if the set of spatial difference values fail to meet a convergence criteria, and

outputting the updated computer model.

10. The system of claim 8, further comprising a display device communicatively coupled to said processing element and configured for displaying data for facilitating said IGS procedure based on said deformation, and

wherein said processing element is further configured for generating signals for said display device to generate a display of preoperative image data associated with said computer model, wherein the preoperative image data is modified correspond said deformation..

11. The system of claim 10, wherein said processing element is further for selecting said convergence criteria to be at least one of a minimum threshold value for the set of spatial difference values, a minimum difference value between the set of spatial difference values before said updating and the set of spatial difference values after said updating, and a pre-defined number of iterations.

12. The system of claim 10, wherein said processing element is further configured for:

- receiving image data associated with said computer model and locations of an object in said patient space;
- transforming said computer model into said patient space based on said rigid alignment and said deformation;
- computing reverse deformation displacement vector field values for each node of said computer model;
- calculating an envelope of additional reverse deformation vector field values for a portion of said patient space surrounding said deformed computed model;
- transforming said location into a computer model space of said computer model based on said rigid alignment and said reverse deformation displacement vector field values; and
- calculating coordinates in an image space of said image data for said transformed

location of said object.

13. The system of claim 12, further comprising:

transforming additional locations in said patient space neighboring said location of said object into the computer model space based on said rigid alignment and said reverse deformation displacement vector field values; and

calculating coordinates in an image space of said image data for said transformed additional locations.

14. The system of claim 13, wherein said processing device is further configured for generating signals for said display device to display said image data without deformation and indicia of at least one of said object and said additional locations in said image space based on respective ones of said calculated coordinates in said image space.

15. A computer-readable storage medium, having stored thereon a computer program for causing a computing device to perform any of the methods of claims 1-7

CLAIMS

1. A method for collecting and processing physical space data for use while performing an image-guided surgical (IGS) procedure, the method comprising:

performing a rigid alignment of a computer model of a non-rigid structure of interest in a patient and surface data in a patient space associated with at least a portion of said non-rigid structure;

computing a deformation of the computer model that provides a non-rigid alignment of said computer model and surface data, said deformation computed using a set of boundary conditions defined for each node of said computer model, said boundary conditions based on said rigid alignment and a kernel function; and

displaying data for facilitating said IGS procedure, based on said deformation, and wherein said displaying further comprises generating a display of preoperative image data associated with said computer model, wherein the preoperative image data is modified to correspond to said deformation.

2. The method of claim 1, wherein said computing further comprises:

calculating a set of spatial difference values between the surface data and corresponding portions of the computer model based on said correspondence function;

computing the boundary conditions based on the set of spatial difference values and said kernel function;

generating volumetric deformation displacement vector values for said computer model based on the boundary conditions;

generating an updated computer model based on the volumetric step values;

updating the correspondence function based on the update computer model;

recalculating the spatial difference values based on the updated correspondence function;

repeating the computing, generating, adjusting, and updating steps if the set of spatial difference values fail to meet a convergence criteria; and

outputting the updated computer model.

3. The method of claim 1, further comprising selecting said convergence criteria to be at least one of a minimum threshold value for the set of spatial difference values, a minimum difference value between the set of spatial difference values before said updating and the set of spatial difference values after said updating, and a pre-defined number of iterations.

4. The method of claim 2, wherein said generating said volumetric deformation displacement vector values further comprises accumulating said volumetric deformation displacement vector values, and wherein said outputting further comprises outputting an accumulated displacement vector field comprising said accumulated displacement vector field values.

5. The method of claim 3, wherein said displaying further comprises:

receiving image data associated with said computer model and a location of an object in said patient space;

transforming said computer model into said patient space based on said rigid alignment and said deformation;

computing reverse deformation displacement vector field values for each node of said computer model;

calculating an envelope of additional reverse deformation vector field values for a portion of said patient space surrounding said deformed computed model;

transforming said location into a computer model space of said computer model based on

said rigid alignment and said reverse deformation displacement vector field values; and

calculating coordinates in an image space of said image data for said transformed location of said instrument.

6. The method of claim 5, further comprising:

displaying said image data without deformation; and

displaying indicia of said object location in said image space based on said calculated coordinates in said image space.

7. The method of claim 3, wherein said displaying further comprises:

receiving image data associated with said computer model and at least one location of interest in an image space of said image data;

transforming said location into a computer model space of said computer model;

calculating coordinates in said patient space for said transformed location of interest.

8. A system for collecting and processing physical space data for use while performing an image-guided surgical (IGS) procedure, the system comprising:

a storage medium for storing a computer model of a non-rigid structure of interest in a patient and surface data in a patient space associated with at least a portion of said non-rigid structure; and

a processing element communicatively coupled to said storage medium, wherein said processing element is configured for:

obtaining a rigid alignment of the computer model and the surface data, and

computing a deformation of the computer model that provides a non-rigid

alignment of said computer model and surface data, said deformation computed using a set of boundary conditions defined for each node of said computer model, said boundary conditions based on said rigid alignment and a kernel function, and

generating instructions for displaying data for facilitating said IGS procedure, based on said deformation, and wherein said displaying further comprises generating a display of preoperative image data associated with said computer model, wherein the preoperative image data is modified to correspond to said deformation.

9. The system of claim 8, wherein said processing element is further configured during said computing for:

calculating a set of spatial difference values between the surface data and corresponding portions of the computer model based on said correspondence function,

computing the boundary conditions based on the set of spatial difference values and said kernel function,

generating volumetric deformation displacement vector values for said computer model based on the boundary conditions,

generating an updated computer model based on the volumetric step values,

updating the correspondence function based on the update computer model,

recalculating the spatial difference values based on the updated correspondence function,

repeating the computing, generating, adjusting, and updating steps if the set of spatial difference values fail to meet a convergence criteria, and

outputting the updated computer model.

10. The system of claim 9, wherein said processing element is further configured during-said generating of said volumetric deformation displacement vector values for accumulating said volumetric deformation displacement vector values, and wherein said processing-element is further configured during said outputting for outputting an accumulated displacement vector field comprising said accumulated displacement vector field values.

11. The system of claim 9, wherein said processing element is further for selecting said convergence criteria to be at least one of a minimum threshold value for the set of spatial difference values, a minimum difference value between the set of spatial difference values before said updating and the set of spatial difference values after said updating, and a pre-defined number of iterations.

12. The system of claim 9, wherein said processing element is further configured for:

receiving image data associated with said computer model and locations of an object in said patient space;

transforming said computer model into said patient space based on said rigid alignment and said deformation;

computing reverse deformation displacement vector field values for each node of said computer model;

calculating an envelope of additional reverse deformation vector field values for a portion of said patient space surrounding said deformed computed model;

transforming said location into a computer model space of said computer model based on said rigid alignment and said reverse deformation displacement vector field values; and

calculating coordinates in an image space of said image data for said transformed location of

said object.

13. The system of claim 12, further comprising:

transforming additional locations in said patient space neighboring said location of said object into the computer model space based on said rigid alignment and said reverse deformation displacement vector field values; and

calculating coordinates in an image space of said image data for said transformed additional locations.

14. The system of claim 13, wherein said processing device is further configured for generating signals for said display device to display said image data without deformation and indicia of at least one of said object and said additional locations in said image space based on respective ones of said calculated coordinates in said image space.

15. A computer-readable storage medium, having stored thereon a computer program for causing a computing device to perform any of the methods of claims 1-7.