CLAIMS

What is claimed is:

~~1. A method of assessing an effect of a treatment on an organ comprising:~~

~~acquiring a first measurement for each of a plurality of regions of the organ;~~

~~acquiring, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;~~

~~obtaining a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and~~

~~determining a treatment effect based the plurality of regional change measurements and regional treatment information of the treatment delivered to the organ.~~

~~2. The method of claim 1, wherein acquiring either of a first measurement for each of a plurality of regions of the organ or a second measurement for each of a plurality of regions of the organ comprises:~~

~~obtaining a time series of two-dimensional (2D) images of the organ; and~~

~~processing the time series of 2D images to obtain a motion measurement for each of the plurality of regions.~~

~~3. The method of claim 2, wherein obtaining a time series of 2D images of the organ comprises receiving the time series of 2D images from an imaging apparatus or an image source.~~

~~4. The method of claim 2, wherein obtaining a time series of 2D images of the organ comprises capturing a plurality of time series of 2D images of the organ, each from a different angle relative to the organ.~~

~~5. The method of claim 4, wherein the plurality of time series of 2D images of the organ are captured from no more than ten different angles.~~

~~6. The method of claim 4, wherein the plurality of time series of 2D images are captured simultaneously.~~

~~7. The method of claim 2, wherein processing the time series of 2D images comprises cross-correlating the 2D images of the organ.~~

~~8. The method of claim 7, wherein processing the time series of 2D images comprises reconstructing motion measurements for each of the plurality of regions of the organ from the time series of 2D images of the organ.~~

~~9. The method of claim 8, wherein the plurality of regions of the organ comprise tissue of the organ and the motion measurements represent motion of the tissue.~~

~~10. The method of claim 9, wherein reconstructing motion measurements comprises reconstructing 3D motion measurements without first reconstructing a 3D image.~~

~~11. The method of claim 9, wherein processing the time series of 2D images further comprises, for each of the plurality of regions of the organ, deriving a volume measurement from one or more motion measurements associated with that region.~~

1. A system for assessing an effect of a treatment on an organ comprising:

a measurement acquisition module configured to:

acquire a first measurement for each of a plurality of regions of the organ, and

acquire, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;

a measurement change module configured to obtain a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and

a treatment effect module configured to determine a treatment effect based on the regional change measurements of the plurality of regions compared against regional treatment information of the treatment delivered to the plurality of regions of the organ.

2. The system of claim 1, wherein the measurement acquisition module acquires either of a first measurement for each of a plurality of regions of the organ or a second measurement for each of a plurality of regions of the organ by being configured to:

obtain a time series of two-dimensional (2D) images of the organ; and

process the time series of 2D images to obtain a motion measurement for each of the plurality of regions.

3. The system of claim 2, wherein the measurement acquisition module obtains a time series of 2D images of the organ by being configured to capture a plurality of time series of 2D images of the organ, each from a different angle relative to the organ; and

optionally

wherein the plurality of time series of 2D images of the organ are captured from no more than ten different angles; and/or

optionally

wherein the plurality of time series of 2D images are captured simultaneously.

4. The system of claim 2, wherein the measurement acquisition module processes the time series of 2D images by being further configured to cross-correlate the 2D images of the organ; and

optionally

wherein the measurement acquisition module processes the time series of 2D images by being configured to reconstruct motion measurements for each of the plurality of regions of the organ from the time series of 2D images of the organ; and

optionally

wherein the measurement acquisition module reconstructs motion measurements by being configured to reconstruct 3D motion measurements without first reconstructing a 3D image; and

further optionally

wherein the measurement acquisition module processes the time series of 2D images by being configured to, for each of the plurality of regions of the organ, derive a volume measurement from one or more motion measurements associated with that region.

5. The system of any one of claims 1 to 4, wherein the measurement acquisition module is configured to:

acquire each of the plurality of first measurements before the treatment, and each of the plurality of second measurements is acquired either during the treatment or after the treatment, or

acquire each of the plurality of first measurements during the treatment, and each of the plurality of second measurements is acquired after the treatment.

6. The system of any one of claims 1 to 5, wherein the first measurement and the second measurement are one of: displacement measurements, velocity measurements, ventilation measurements, perfusion measurements, ventilation/perfusion (V/Q) ratio measurements, or any measurements that may be derived from any of the foregoing measurements.

7. The system of any one of claims 1 to 6, wherein the treatment effect module determines a treatment effect by being configured to:

map each of the plurality of regional change measurements with a corresponding regional treatment information of the treatment delivered to the organ to generate a mapping; and

derive the treatment effect from the mapping.

8. The system of claim 7, wherein the treatment effect module derives the treatment effect from the mapping by being configured to fit a line through a plot of regional change measurements as a function of regional treatment information.

9. The system of claim 7, wherein the treatment effect is indicative of one of:

a) no change in organ function;

b) change in organ function linked to treatment; or

c) change in organ function not linked to treatment.

10. The system of any one of claims 1 to 9, wherein the treatment is a non-uniform treatment characterized by varying levels of treatment delivery throughout the organ; and

optionally

wherein the treatment is a radiation therapy treatment, and the regional treatment information is a dose map comprising a radiation level for each of the plurality of regions of the organ.

11. The system of any one of claims 1 to 10, wherein the measurement acquisition module is further configured to either of:

associate the plurality of first measurements and the plurality of second measurements to a fluid flow structure of the organ, prior to obtaining a regional change measurement for each of the plurality of regions of the organ; or

associate the plurality of regional change measurements to a fluid flow structure of the organ, prior to determining a treatment effect.

12. A method of assessing an effect of a treatment on an organ comprising:

acquiring a first measurement for each of a plurality of regions of the organ;

acquiring, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;

obtaining a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and

determining a treatment effect based on the regional change measurements of the plurality of regions compared against regional treatment information of the treatment delivered to the plurality of regions of the organ.

~~12~~13. The method of claim ~~1~~12, wherein:

each of the plurality of first measurements is acquired before the treatment, and each of the plurality of second measurements is acquired either during the treatment or after the treatment, or

each of the plurality of first measurements is acquired during the treatment, and each of the plurality of second measurements is acquired after the treatment.

~~13~~14. The method of claims ~~1~~12 or 13, wherein the first measurement and the second measurement are one of: displacement measurements, velocity measurements, ventilation measurements, perfusion measurements, ventilation/perfusion (V/Q) ratio

measurements, or any measurements that may be derived from any of the foregoing measurements.

~~14. The method of claim 1, wherein obtaining a regional change measurement for a region comprises comparing the first measurement of the region to the second measurement of the region.~~

15. The method of claim ~~1~~12, wherein determining a treatment effect comprises:

mapping each of the plurality of regional change measurements with a corresponding regional treatment information of the treatment delivered to the organ; and

deriving the treatment effect from the mapping~~.~~; and

optionally

wherein deriving the treatment effect from the mapping comprises fitting a line through a plot of regional change measurements as a function of regional treatment information; and

further optionally

wherein the treatment effect is indicative of one of:

a) no change in organ function;

b) change in organ function linked to treatment; or

c) change in organ function not linked to treatment.

~~16. The method of claim 15, wherein deriving the treatment effect from the mapping comprises fitting a line through a plot of regional change measurements as a function of regional treatment information.~~

~~17. The method of claim 15, further comprising:~~

~~determining whether the treatment has altered regional organ function based on the treatment effect.~~

~~18. The method of claim 15, further comprising:~~

~~assessing organ function based on the treatment effect.~~

~~19. The method of claim 15, wherein the treatment effect is indicative of one of:~~

~~a) no change in organ function;~~

~~b) change in organ function linked to treatment; or~~

~~c) change in organ function not linked to treatment.~~

20. The method of claim 1, wherein the treatment is a non-uniform treatment characterized by varying levels of treatment delivery throughout the organ.

21. The method of claim 20, wherein the treatment comprises at least one of radiation therapy, proton therapy, antibody therapy, surgery, valve placement, heat/ablation, or glue.

22. The method of claim 20, wherein the treatment is a radiation therapy treatment, and the regional treatment information is a dose map comprising a radiation level for each of the plurality of regions of the organ.

23. The method of claim 1, further comprising either of:

prior to obtaining a regional change measurement for each of the plurality of regions of the organ, associating the plurality of first measurements and the plurality of second measurements with a fluid flow structure of the organ; or

prior to determining a treatment effect, associating the plurality of regional change measurements with a fluid flow structure of the organ.

24. The method of claim 23, wherein:

the organ corresponds to a lung and the fluid flow structure corresponds to one of an airway tree of the lung or a vascular tree of the lung, or

the organ corresponds to a heart and the fluid flow structure corresponds to a vascular structure of the heart.

25. A system for assessing an effect of a treatment on an organ comprising:

a measurement acquisition module configured to:

acquire a first measurement for each of a plurality of regions of the organ, and

acquire, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;

a measurement change module configured to obtain a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and

a treatment effect module configured to determine a treatment effect based the plurality of regional change measurements and regional treatment information of the treatment delivered to the organ.

26. The system of claim 25, wherein the measurement acquisition module acquires either of a first measurement for each of a plurality of regions of the organ or a second measurement for each of a plurality of regions of the organ by being configured to:

obtain a time series of two-dimensional (2D) images of the organ; and

process the time series of 2D images to obtain a motion measurement for each of the plurality of regions.

27. The system of claim 26, wherein the measurement acquisition module obtains a time series of 2D images of the organ by being further configured to receive the time series of 2D images from an imaging apparatus or an image source.

28. The system of claim 26, wherein the measurement acquisition module obtains a time series of 2D images of the organ by being configured to capture a plurality of time series of 2D images of the organ, each from a different angle relative to the organ.

29. The system of claim 28, wherein the plurality of time series of 2D images of the organ are captured from no more than ten different angles.

30. The system of claim 28, wherein the plurality of time series of 2D images are captured simultaneously.

31. The system of claim 26, wherein the measurement acquisition module processes the time series of 2D images by being further configured to cross-correlate the 2D images of the organ.

32. The system of claim 31, wherein the measurement acquisition module processes the time series of 2D images by being configured to reconstruct motion measurements for each of the plurality of regions of the organ from the time series of 2D images of the organ.

33. The system of claim 32, wherein the measurement acquisition module reconstructs motion measurements by being configured to reconstruct 3D motion measurements without first reconstructing a 3D image.

34. The system of claim 32, wherein the measurement acquisition module processes the time series of 2D images by being configured to, for each of the plurality of regions of the organ, derive a volume measurement from one or more motion measurements associated with that region.

35. The system of claim 25, wherein the measurement acquisition module is configured to:

acquire each of the plurality of first measurements before the treatment, and each of the plurality of second measurements is acquired either during the treatment or after the treatment, or

acquire each of the plurality of first measurements during the treatment, and each of the plurality of second measurements is acquired after the treatment.

~~36. The system of claim 25, wherein the first measurement and the second measurement are one of: displacement measurements, velocity measurements, ventilation measurements, perfusion measurements, ventilation/perfusion (V/Q) ratio measurements, or any measurements that may be derived from any of the foregoing measurements.~~

~~37. The system of claim 25, wherein the measurement change module obtains a regional change measurement for a region by being configured to compare the first measurement of the region to the second measurement of the region.~~

~~38. The system of claim 25, wherein the treatment effect module determines a treatment effect by being configured to:~~
~~map each of the plurality of regional change measurements with a corresponding regional treatment information of the treatment delivered to the organ to generate a mapping; and~~
~~derive the treatment effect from the mapping.~~

~~39. The system of claim 38, wherein the treatment effect module derives the treatment effect from the mapping by being configured to fit a line through a plot of regional change measurements as a function of regional treatment information.~~

~~40. The system of claim 38, wherein the treatment effect module is further configured to:~~
~~determine whether the treatment has altered regional organ function based on the treatment effect.~~

~~41. The system of claim 38, wherein the treatment effect module is further configured to:~~
~~assess organ function based on the treatment effect.~~

~~42. The system of claim 38, wherein the treatment effect is indicative of one of:~~
~~a) no change in organ function;~~
~~b) change in organ function linked to treatment; or~~
~~c) change in organ function not linked to treatment.~~

~~43. The system of claim 25, wherein the treatment is a non-uniform treatment characterized by varying levels of treatment delivery throughout the organ.~~

~~44. The system of claim 43, wherein the treatment comprises at least one of radiation therapy, proton therapy, antibody therapy, surgery, valve placement, heat/ablation, or glue.~~

~~45. The system of claim 43, wherein the treatment is a radiation therapy treatment, and the regional treatment information is a dose map comprising a radiation level for each of the plurality of regions of the organ.~~

~~46. The system of claim 25, wherein the measurement acquisition module is further configured to either of:~~

~~associate the plurality of first measurements and the plurality of second measurements to a fluid flow structure of the organ, prior to obtaining a regional change measurement for each of the plurality of regions of the organ; or~~

~~associate the plurality of regional change measurements to a fluid flow structure of the organ, prior to determining a treatment effect.~~

~~47. The system of claim 46, wherein:~~

~~the organ corresponds to a lung and the fluid flow structure corresponds to one of an airway tree of the lung or a vascular tree of the lung, or~~

~~the organ corresponds to a heart and the fluid flow structure corresponds to a vascular structure of the heart.~~

~~48~~16. An apparatus for assessing an effect of a treatment on an organ comprising:

an interface;

a memory; and

a processor coupled to the interface and the memory and configured to execute instructions in the memory to cause the apparatus to:

acquire a first measurement for each of a plurality of regions of the organ;

acquire, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;

obtain a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and

determine a treatment effect based on the ~~plurality of~~ regional change measurements of the plurality of regions compared against ~~and~~ regional treatment information of the treatment delivered to the plurality of regions of the organ.

~~49. The apparatus of claim 48, wherein the processor causes the apparatus to acquire either of a first measurement for each of a plurality of regions of the organ or a second measurement for each of a plurality of regions of the organ by being configured to execute instructions in the memory to cause the apparatus to:~~

~~obtain a time series of two-dimensional (2D) images of the organ from an imaging apparatus or image source; and~~

~~process the time series of 2D images to obtain a motion measurement for each of the plurality of regions.~~

~~50. The apparatus of claim 49, wherein the processor causes the apparatus to process the time series of 2D images by being further configured to execute instructions in the memory to cause the apparatus to cross-correlate the 2D images of the organ.~~

~~51. The apparatus of claim 50, wherein the processor causes the apparatus to process the time series of 2D images by being configured to execute instructions in the memory to cause the apparatus to reconstruct motion measurements for each of the plurality of regions of the organ from the time series of 2D images of the organ.~~

~~52. The apparatus of claim 51, wherein the processor causes the apparatus to reconstruct motion measurements by being configured to execute instructions in the memory to cause the apparatus to reconstruct 3D motion measurements without first reconstructing a 3D image.~~

~~53. The apparatus of claim 51, wherein the processor causes the apparatus to process the time series of 2D images by being configured to execute instructions in the memory to cause the apparatus to, for each of the plurality of regions of the organ,~~

~~derive a volume measurement from one or more motion measurements associated with that region.~~

~~54. The apparatus of claim 48, wherein the first measurement and the second measurement are one of: displacement measurements, velocity measurements, ventilation measurements, perfusion measurements, ventilation/perfusion (V/Q) ratio measurements, or any measurements that may be derived from any of the foregoing measurements.~~

~~55. The apparatus of claim 48, wherein the processor causes the apparatus to obtain a regional change measurement for a region by being configured to execute instructions in the memory to cause the apparatus to compare the first measurement of the region to the second measurement of the region.~~

~~56~~17. The apparatus of claim ~~48~~16, wherein the processor causes the apparatus to determine a treatment effect by being configured to execute instructions in the memory to cause the apparatus to:

receive regional treatment information from a treatment apparatus or treatment information source;

map each of the plurality of regional change measurements with a corresponding regional treatment information of the treatment delivered to the organ to generate a mapping; and

derive the treatment effect from the mapping.

~~57~~18. The apparatus of claim ~~56~~17, wherein the processor causes the apparatus to derive the treatment effect from the mapping by being configured to execute instructions in the memory to cause the apparatus fit a line through a plot of regional change measurements as a function of regional treatment information.

~~58. The apparatus of claim 56, wherein the processor is further configured to execute instructions in the memory to cause the apparatus:~~

~~determine whether the treatment has altered regional organ function based on the treatment effect.~~

59. The apparatus of claim 56, wherein the processor is further configured to execute instructions in the memory to cause the apparatus:

assess organ function based on the treatment effect.

60. The apparatus of claim 56, wherein the treatment effect is indicative of one of:

a) no change in organ function;

b) change in organ function linked to treatment; or

c) change in organ function not linked to treatment.

61. The apparatus of claim 48, wherein the treatment is a non uniform treatment characterized by varying levels of treatment delivery throughout the organ.

62. The apparatus of claim 61, wherein the treatment comprises at least one of radiation therapy, proton therapy, antibody therapy, surgery, valve placement, heat/ablation, or glue.

63. The apparatus of claim 61, wherein the treatment is a radiation therapy treatment, and the regional treatment information is a dose map comprising a radiation level for each of the plurality of regions of the organ.

64. The apparatus of claim 48, wherein the processor is further configured to execute instructions in the memory to cause the apparatus to either of:

associate the plurality of first measurements and the plurality of second measurements to a fluid flow structure of the organ, prior to obtaining a regional change measurement for each of the plurality of regions of the organ; or

associate the plurality of regional change measurements to a fluid flow structure of the organ, prior to determining a treatment effect.

65. The apparatus of claim 64, wherein:

the organ corresponds to a lung and the fluid flow structure corresponds to one of an airway tree of the lung or a vascular tree of the lung, or

the organ corresponds to a heart and the fluid flow structure corresponds to a vascular structure of the heart.

66. A non-transitory computer readable storage medium having a computer program stored therein, that when executed by a processor of a computer, causes the computer to execute steps directed to assessing an effect of a treatment on an organ, the steps comprising:

acquiring a first measurement for each of a plurality of regions of an organ;

acquiring, after acquisition of the first measurements, a second measurement for each of the plurality of regions of the organ;

obtaining a regional change measurement for each of the plurality of regions of the organ based on the first measurement and the second measurement of the region; and

determining a treatment effect based the plurality of regional change measurements and regional treatment information of the treatment delivered to the organ.