SUMMARY

[0003] An embodiment of the present disclosure provides a method of generating synthetic data for composite manufacturing inspection. A three-dimensional model of a composite layup is created. An inconsistency is generated in the three-dimensional model of the composite layup. A camera position and a camera orientation is set in the three-dimensional model space. A captured image of the three-dimensional model and the inconsistency is generated from the camera position and the camera orientation. A secondary image is created from the captured image, the secondary image having colorations of a preselected inspection type. Creating the secondary image comprises of applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image.

[0004] Another embodiment of the present disclosure provides a method of training a composite inspection system. A captured image of a three-dimensional model of a composite layup with an inconsistency is generated at a predetermined camera position and at a predetermined camera orientation within the three-dimensional model space. The captured image is modified to form a secondary image having coloration of a preselected inspection type. Modifying the captured image comprises applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image. The inconsistency identifier program is trained using the secondary image.

[0005] Yet another embodiment of the present disclosure provides a method of using synthetically generated training data. An inconsistency is generated in a three-dimensional model comprising a plurality of layers of a composite layup. A captured image of the inconsistency and the three-dimensional model is generated at a predetermined camera position and at a predetermined camera orientation based on a head orientation of an inspection system connected to a composite laying head. A secondary image is generated

from the captured image, the secondary image having a coloration of an inspection type of the inspection system. Generating the secondary image from the captured image comprises applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image. The secondary image is provided as training data for an inconsistency identifier program.

[0006] The features and functions can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

CLAIMS:

What is claimed is:

1. A method of generating synthetic data for composite manufacturing inspection comprising:

creating a three-dimensional model of a composite layup in a three-dimensional model space;

generating an inconsistency in the three-dimensional model of the composite layup;

setting a camera position and a camera orientation in the three-dimensional model space;

generating a captured image of the three-dimensional model and the inconsistency from the camera position and the camera orientation; and

creating a secondary image from the captured image, the secondary image having colorations of a preselected inspection type, wherein creating the secondary image comprises applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image.

2. The method of claim 1, wherein the inconsistency is one of overlapping tows, gaps between tows, or foreign object debris.

3. The method of claim 1 or 2 further comprising:

determining a layup of a portion of a part; and

generating the three-dimensional model of the composite layup using the layup of the portion of the part.

4. The method of claim 3, wherein the layup comprises a plurality of layers of composite material and the three-dimensional model comprises a plurality of layers arranged the same as the plurality of layers of composite material.

5. The method of claim 1, wherein applying the number of filters to the captured image creates colorations of an IR image.

6. The method of claim 1, wherein the inconsistency has an inconsistency type, and wherein applying the number of filters to the captured image creates colorations characteristic of the inconsistency type for the preselected inspection type within pixels of the secondary image with the inconsistency.

7. The method of any of claims 1 to 4, wherein creating the secondary image comprises sampling colors from pixels of the inconsistency in the captured image and adjusting color values for the pixels to values within a range for an inconsistency type of the inconsistency in stock images of the preselected inspection type.

8. The method of any one of claims 1 to 7 further comprising:

determining a head orientation of an inspection system attached to a composite laying head in a manufacturing environment, wherein setting the camera position and the camera orientation in the three-dimensional model space comprises setting the camera orientation based on the head orientation.

9. The method of any one of claims 1 to 8 further comprising:

supplying the secondary image as training data to an inconsistency identifier program.

10. The method of claim 9 further comprising:

generating inspection images of composite tows after the composite tows are laid; and

evaluating the inspection images using the inconsistency identifier program trained using the secondary images.

11. A method of training a composite inspection system comprising:

generating a captured image of a three-dimensional model of a composite layup with an inconsistency at a predetermined camera position and at a predetermined camera orientation within a three-dimensional model space containing the three-dimensional model;

modifying the captured image to form a secondary image having coloration of a preselected inspection type, wherein modifying the captured image comprises applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image; and

training an inconsistency identifier program using the secondary image.

12. The method of claim 11 further comprising:

inspecting composite tows as the composite tows are laid down to form inspection images; and

evaluating the inspection images using the inconsistency identifier program trained using the secondary images.

13. The method of claim 12, wherein the composite tows are inspected using an inspection system, and wherein the predetermined camera orientation within the three-dimensional model space is based on a head orientation of the inspection system.

14. The method of claim 12 or 13, wherein inspecting the composite tows comprises generating IR images of the composite tows after deposition.

15. The method of any one of claims 11 to 14, wherein modifying the captured image comprises sampling colors from pixels of the inconsistency in the captured image and adjusting color values for the pixels to values within a range for an inconsistency type of the inconsistency in images of the preselected inspection type.

16. The method of any one of claims 11 to 15 further comprising:

determining a head orientation of an inspection system attached to a composite laying head in a manufacturing environment; and

setting the predetermined camera position and the predetermined camera orientation in the three-dimensional model space based on the head orientation.

17. A method of using synthetically generated training data comprising:

generating an inconsistency in a three-dimensional model comprising a plurality of layers of a composite layup;

generating a captured image of the inconsistency and the three-dimensional model at a predetermined camera position and at a predetermined camera orientation based on a head orientation of an inspection system connected to a composite laying head;

generating a secondary image from the captured image, the secondary image having a coloration of an inspection type of the inspection system, wherein generating the secondary image from the captured image comprises applying a number of filters to the captured image to create the secondary image, wherein applying the number of filters creates the colorations of the preselected inspection type in the pixels of the secondary image; and

providing the secondary image as training data for an inconsistency identifier program.

18. The method of claim 17, wherein generating the secondary image comprises applying a number of filters to the captured image to create colorations of an IR image.

19. The method of claim 17 or 18 further comprising:

creating the three-dimensional model based on a layup of a portion of a part to be manufactured.

20. The method of any one of claims 17 to 19, wherein generating the inconsistency comprises moving at least one tow representation in the three-dimensional model.

21. The method of claim 17, wherein generating a secondary image from the captured image comprises

sampling colors from pixels of the inconsistency in the captured image and adjusting color values for the pixels to values within a range for an inconsistency type of the inconsistency in images of the preselected inspection type.

22. The method of claim 17 further comprising:

generating inspection images of composite tows after the composite tows are laid; and

evaluating the inspection images using the inconsistency identifier program trained using the secondary images.