

What is claimed is:

1. A method for replicating performance of an automated visual inspection (AVI) station, the method comprising:
constructing a mimic AVI station that performs one or more AVI functions of the AVI station, wherein the mimic AVI station includes a mimic illumination system, a mimic imaging system, and mimic sample positioning hardware configured to hold and/or support containers containing samples;
capturing, by an imaging system of the AVI station while a container is illuminated by an illumination system of the AVI station, one or more container images;
capturing, by the mimic imaging system while a container is illuminated by the mimic illumination system, one or more additional container images;
identifying, by one or more processors, one or more differences between the one or more additional container images and the one or more container images;
generating, by the one or more processors, a visual indication of (i) the one or more differences, and/or (ii) one or more suggestions for modifying the mimic AVI station; and
modifying the mimic AVI station based on the visual indication, at least by modifying the mimic illumination system, the mimic imaging system, and/or the mimic sample positioning hardware.
2. The method of claim 1, wherein either (i) the AVI station is included in commercial line equipment and the mimic AVI station is a lab-based setup, or (ii) the mimic AVI station is included in the commercial line equipment and the AVI station is the lab-based setup.
3. The method of claim 1, wherein modifying the mimic station includes:
modifying a spatial arrangement of at least one lighting device of the mimic illumination system, at least one imaging device of the mimic imaging system, and/or the mimic sample positioning hardware; and/or
modifying hardware components of at least one lighting device of the mimic illumination system, at least one imaging device of the mimic imaging system, and/or the mimic sample positioning hardware.
4. The method of claim 1, further comprising:
installing, on a computer system of the mimic AVI station, AVI software that implements an inspection algorithm that is also implemented by the AVI equipment; and
after modifying the mimic AVI station,
capturing, by the mimic imaging system, one or more new container images while a test container is illuminated by the mimic illumination system, and
determining one or more characteristics of the test container, and/or a sample within the test container, by processing the one or more new container images according to the inspection algorithm.
5. The method of claim 4, further comprising:
troubleshooting or optimizing the mimic AVI station based at least in part on the determined one or more characteristics, wherein troubleshooting or optimizing the mimic AVI station includes modifying or further modifying the mimic illumination system, the mimic imaging system, the mimic sample positioning hardware, and/or the AVI software.
6. The method of claim 5, further comprising:

modifying the AVI station in accordance with the modifications or further modifications to the mimic illumination system, the mimic imaging system, the mimic sample positioning hardware, and/or the AVI software.

7. The method of claim 1, wherein:

the one or more container images includes a first plurality of container images;

the one or more additional container images includes a second plurality of container images; and

identifying the one or more differences between the one or more additional container images and the one or more container images includes identifying one or more differences between a first composite image derived from the first plurality of container images and a second composite image derived from the second plurality of container images.

8. The method of claim 1, wherein identifying the one or more differences between the one or more additional container images and the one or more container images includes identifying differences with respect to:

container alignment;

defocus;

intensity;

variation in intensity;

motion blurring; and/or

imaging sensor noise.

9. The method of claim 1, wherein identifying the one or more differences between the one or more additional container images and the one or more container images includes computing (i) a fast Fourier transforms (FFT) of the one or more container images or a composite image derived therefrom, and (ii) an FFT of the one or more additional container images or a composite image derived therefrom.

10. The method of claim 1, wherein identifying the one or more differences between the one or more additional container images and the one or more container images includes generating (i) a histogram of pixel intensity levels for the one or more container images or a composite image derived therefrom, and (ii) a histogram of pixel intensity levels for the one or more additional container images or a composite image derived therefrom.

11. The method of claim 1, wherein identifying the one or more differences between the one or more additional container images and the one or more container images includes computing (i) a Laplacian of the one or more container images or a composite image derived therefrom, and (ii) a Laplacian of the one or more additional container images or a composite image derived therefrom.

12. The method of claim 1, wherein (i) identifying the one or more differences, and (ii) generating the visual indication, are performed in real time as the one or more additional container images are captured.

13. The method of claim 1, further comprising:

generating, by the one or more processors, the one or more suggestions for modifying the mimic AVI station based on the one or more differences,

wherein generating the visual indication includes generating the visual indication of the one or more suggestions.

14. The method of claim 13, wherein generating the one or more suggestions includes generating:
a suggestion to modify one or more configurable settings of at least one imaging device of the mimic imaging system;
a suggestion to modify one or more configurable settings of at least one lighting device of the mimic illumination system;

a suggestion to modify a position of at least one imaging device of the mimic imaging system; and/or
a suggestion to modify a position of at least one lighting device of the mimic illumination system.

15. The method of claim 13, wherein:
the mimic sample positioning hardware is configured to move containers according to a movement profile; and
generating the one or more suggestions includes generating a suggestion to modify one or more characteristics of the movement profile.

16. The method of claim 1, further comprising:
receiving, by the one or more processors, one or more operational parameters of the imaging system and one or more operational parameters of the mimic imaging system;
comparing, by the one or more processors, the one or more operational parameters of the imaging system to the one or more operational parameters of the mimic imaging system; and
generating, by the one or more processors, an additional visual indication of at least one operational parameter that differs between the imaging system and the mimic imaging system.

17. A non-transitory, computer-readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to:
receive one or more container images captured by an imaging system of an automated visual inspection (AVI) station;
receive one or more additional container images captured by a mimic imaging system of a mimic AVI station;
identify one or more differences between the one or more additional container images and the one or more container images; and
generate a visual indication of (i) the one or more differences, and/or (ii) one or more suggestions for modifying the mimic AVI station.

18. The non-transitory, computer-readable medium of claim 17, wherein the instructions cause the one or more processors to identify one or more differences between the one or more additional container images and the one or more container images with respect to:
container alignment;
defocus;
intensity;
variation in intensity;
motion blurring; and/or
imaging sensor noise.

19. The non-transitory, computer-readable medium of claim 17, wherein the instructions cause the one or more processors to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

computing a fast Fourier transforms (FFT) of the one or more container images or a composite image derived therefrom; and

computing an FFT of the one or more additional container images or a composite image derived therefrom.

20. The non-transitory, computer-readable medium of claim 17, wherein the instructions cause the one or more processors to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

generating a histogram of pixel intensity levels for the one or more container images or a composite image derived therefrom; and

generating a histogram of pixel intensity levels for the one or more additional container images or a composite image derived therefrom.

21. The non-transitory, computer-readable medium of claim 17, wherein the instructions cause the one or more processors to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

computing a Laplacian of the one or more container images or a composite image derived therefrom; and

computing a Laplacian of the one or more additional container images or a composite image derived therefrom.

22. The non-transitory, computer-readable medium of claim 17, wherein the instructions cause the one or more processors to (i) identify the one or more differences, and (ii) generate the visual indication, in real time as the one or more additional container images are received.

23. The non-transitory, computer-readable medium of claim 17, wherein:

the instructions cause the one or more processors to generate the one or more suggestions for modifying the mimic AVI station based on the one or more differences; and

the visual indication indicates the one or more suggestions.

24. The non-transitory, computer-readable medium of claim 23, wherein the one or more suggestions include: a suggestion to modify one or more configurable settings of at least one imaging device of the mimic imaging system; a suggestion to modify one or more configurable settings of at least one lighting device of a mimic illumination system of the mimic AVI station;

a suggestion to modify a position of at least one imaging device of the mimic imaging system; and/or

a suggestion to modify a position of at least one lighting device of the mimic illumination system.

25. A system comprising:

an automated visual inspection (AVI) station comprising

an imaging system,

an illumination system, and

sample positioning hardware configured to hold and/or support containers containing samples;

a mimic AVI station that performs one or more AVI functions of the AVI station, the mimic AVI station comprising

a mimic illumination system,

a mimic imaging system, and

mimic sample positioning hardware configured to hold and/or support containers containing samples; and
a computing system configured to
 receive one or more container images captured by the imaging system of the AVI station;
 receive one or more additional container images captured by the mimic imaging system of the mimic AVI station;
 identify one or more differences between the one or more additional container images and the one or more container images; and
 generate a visual indication of (i) the one or more differences, and/or (ii) one or more suggestions for modifying the mimic AVI station.

26. The system of claim 25, wherein the computing system is configured to identify one or more differences between the one or more additional container images and the one or more container images with respect to:

 container alignment;
 defocus;
 intensity;
 variation in intensity;
 motion blurring; and/or
 imaging sensor noise.

27. The system of claim 25, wherein the computing system is configured to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

 computing a fast Fourier transforms (FFT) of the one or more container images or a composite image derived therefrom; and
 computing an FFT of the one or more additional container images or a composite image derived therefrom.

28. The system of claim 25, wherein the computing system is configured to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

 generating a histogram of pixel intensity levels for the one or more container images or a composite image derived therefrom; and
 generating a histogram of pixel intensity levels for the one or more additional container images or a composite image derived therefrom.

29. The system of claim 25, wherein the computing system is configured to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

 high pass filtering the one or more container images or a composite image derived therefrom; and
 high pass filtering the one or more additional container images or a composite image derived therefrom.

30. The system of claim 29, wherein the computing system is configured to identify the one or more differences between the one or more additional container images and the one or more container images at least by:

 computing a Laplacian of the one or more container images or a composite image derived therefrom; and
 computing a Laplacian of the one or more additional container images or a composite image derived therefrom.

31. The system of claim 25, wherein the computing system is configured to (i) identify the one or more differences, and (ii) generate the visual indication, in real time as the one or more additional container images are received.

32. The system of claim 25, wherein:
the computing system is configured to generate the one or more suggestions for modifying the mimic AVI station based on the one or more differences; and
the visual indication indicates the one or more suggestions.

33. The system of claim 25, wherein the one or more suggestions include:
a suggestion to modify one or more configurable settings of at least one imaging device of the mimic imaging system;
a suggestion to modify one or more configurable settings of at least one lighting device of a mimic illumination system of the mimic AVI station;
a suggestion to modify a position of at least one imaging device of the mimic imaging system; and/or
a suggestion to modify a position of at least one lighting device of the mimic illumination system..