

CLAIMS

1. Method for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a video frame rate higher than a video frame rate of super-resolution video, comprising the procedures of:
- 5 acquiring a plurality of microscanned images of at least one moving object, a first subset of said plurality of microscanned images forming a first data set and a second subset of said plurality of microscanned images forming a second data set;
- 10 for each respective data set, analyzing at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;
- determining a respective movement indication of said at least one moving object according to said spatial and temporal information;
- 15 in parallel to said procedure of analyzing, forming a respective super-resolution image from each said respective data set;
- for each respective super-resolution image, designating a respective bounded area surrounding said at least one moving object; and
- 20 repeatedly displaying each respective super-resolution image outside said respective bounded area a plurality of times at said video frame rate and displaying during said plurality of times within said respective bounded area, a plurality of consecutive microscanned images of said at least one moving object at said video frame rate,
- 25 wherein said plurality of consecutive microscanned images of said at least one moving object is displayed at a low image resolution within said respective bounded area.

2. The method according to claim 1, further comprising the procedures of:
- acquiring said plurality of microscanned images of said at least one moving object at a periodic plurality of fields-of-view (FOVs) using a step-and-stare method having a periodic refresh rate lower than a refresh rate at which said plurality of microscanned images are acquired at; and
- stretching said plurality of consecutive microscanned images of said at least one moving object within said respective bounded area over said periodic refresh rate.
3. The method according to claim 1, further comprising the procedures of:
- acquiring said plurality of microscanned images of said at least one moving object at a periodic plurality of fields-of-view (FOVs) using a step-and-stare method having a periodic refresh rate lower than a refresh rate at which said plurality of microscanned images are acquired at; and
- extrapolating a position of said at least one moving object within said respective bounded area according to said spatial and temporal information during said periodic refresh rate when said plurality of microscanned images of said at least one moving object is acquired at said periodic plurality of FOVs.
4. The method according to claim 1, wherein said procedure of displaying said plurality of consecutive microscanned images of said at least one moving object during said plurality of times within said respective bounded area comprises interpolating said plurality of consecutive microscanned images to fill said respective bounded area.

5. The method according to claim 4, wherein said procedure of interpolating is executed using a technique selected from the list consisting of:
- 5 image interpolation techniques; and
 digital zoom techniques.
6. Method for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a high image resolution, comprising the procedures of:
- 10 acquiring a plurality of microscanned images of at least one moving object, a first subset of said plurality of microscanned images forming a first data set and a second subset of said plurality of microscanned images forming a second data set;
- 15 for each respective data set, analyzing at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;
- determining a respective movement indication of said at least one moving object according to said spatial and temporal information;
- 20 in parallel to said procedure of analyzing, forming a respective super-resolution image from each said respective data set;
- for each respective one of said plurality of microscanned images, designating a respective bounded area surrounding said at least one moving object;
- 25 determining a corrected position of said at least one moving object in each said respective super-resolution image according to said spatial and temporal information; and
- displaying said at least one moving object in each said respective super-resolution image according to a combination of said
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at least one moving object in each said respective bounded area of each said respective one of said plurality of microscanned images at said corrected position.

5 7. The method according to claim 6, wherein said procedure of determining said corrected position comprises selecting one of said plurality of microscanned images in each said respective data set as an anchoring point in each said respective super-resolution image for displaying said at least one moving object.

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8. Method for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a high image resolution, comprising the procedures of:

15 acquiring a plurality of microscanned images of at least one moving object, a first subset of said plurality of microscanned images forming a first data set and a second subset of said plurality of microscanned images forming a second data set;

20 for each respective data set, analyzing at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;

determining a respective movement indication of said at least one moving object according to said spatial and temporal information;

25 in parallel to said procedure of analyzing, forming a respective super-resolution image from each said respective data set;

for each respective one of said plurality of microscanned images in each said respective data set, designating a respective bounded area surrounding said at least one moving object;

30 for each said respective data set, determining a respective position of said at least one moving object in each said respective

one of said plurality of microscanned images according to said spatial and temporal information;

resampling each said respective bounded area using each said determined respective position of said at least one moving object;
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displaying said at least one moving object in each said respective super-resolution image according to each said resampled respective bounded area at each said determined respective position.

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9. Video display system for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a video frame rate higher than a video frame rate of super-resolution video, comprising:

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an image detector, for acquiring a plurality of microscanned images of at least one moving object;

a processor, coupled with said image detector, for designating a first subset of said plurality of microscanned images as a first data set and a second subset of said plurality of microscanned images as
20 a second data set; and

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a display generator, coupled with said processor,

wherein for each respective data set, said processor analyzes at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;

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wherein said processor determines a respective movement indication of said at least one moving object according to said spatial and temporal information;

wherein in parallel said processor forms said first subset into a respective first super-resolution image and said second subset into a respective second super-resolution image;

5 wherein for each respective super-resolution image, said processor designates a respective bounded area surrounding said at least one moving object;

10 wherein said display generator repeatedly generates each said respective super-resolution image outside said respective bounded area a plurality of times at said video frame rate and generates during said plurality of times within said respective bounded area, a plurality of consecutive microscanned images of said at least one moving object at said video frame rate; and

15 wherein said plurality of consecutive microscanned images of said at least one moving object is displayed at a low image resolution within said respective bounded area.

10. The video display system according to claim 9, further comprising a pan-and-tilt mechanism, coupled with said image detector, for acquiring said plurality of microscanned images of said at least one moving object at a periodic plurality of fields-of-view (FOVs), said pan-and-tilt mechanism being operated using a step-and-stare method having a periodic refresh rate lower than a refresh rate at which said plurality of microscanned images are acquired by said image detector.

25 11. The video display system according to claim 10, wherein said processor executes an operation selected from the list consisting of:

30 stretching said plurality of consecutive microscanned images of said at least one moving object within said respective bounded area over said periodic refresh rate; and

extrapolating a position of said at least one moving object within said respective bounded area according to said spatial and temporal information during said periodic refresh rate when said plurality of microscanned images of said at least one moving object is acquired at said periodic plurality of FOVs.

12. The video display system according to claim 9, wherein said display generator interpolates said plurality of consecutive microscanned images to fill said respective bounded area.

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13. The video display system according to claim 12, wherein said display generator interpolates using a technique selected from the list consisting of:

image interpolation techniques; and
digital zoom techniques.

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14. Video display system for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a high image resolution, comprising:

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an image detector, for acquiring a plurality of microscanned images of at least one moving object;

a processor, coupled with said image detector, for designating a first subset of said plurality of microscanned images as a first data set and a second subset of said plurality of microscanned images as a second data set; and

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a display generator, coupled with said processor,

wherein for each respective data set, said processor analyzes at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;

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wherein said processor determines a respective movement indication of said at least one moving object according to said spatial and temporal information;

5 wherein said processor combines said first subset into a respective first super-resolution image and said second subset into a respective second super-resolution image;

wherein for each respective one of said plurality of microscanned images said processor designates a respective bounded area surrounding said at least one moving object;

10 wherein said processor determines a corrected position of said at least one moving object in each said respective super-resolution image according to said spatial and temporal information;

wherein said display generator generates said at least one moving object in each said respective super-resolution image according to said processor combining said at least one moving object in each said respective bounded area of each said respective one of said plurality of microscanned images at said corrected position; and

20 wherein said display generator generates consecutive respective super-resolution images.

15. The video display system according to claim 14, wherein said processor determines said corrected position by selecting one of said plurality of microscanned images in each said respective data set as an anchoring point in each said respective super-resolution image for displaying said at least one moving object.

16. The video display system according to claim 14, wherein said processor executes said combining using at least one image processing algorithm involving pixel interpolation.

17. Video display system for displaying super-resolution video of at least one moving object without image artifacts using a plurality of microscanned images, said video being displayed having a high image resolution, comprising:
- 5 an image detector, for acquiring a plurality of microscanned images of at least one moving object;
- a processor, coupled with said image detector, for designating a first subset of said plurality of microscanned images as a first data set and a second subset of said plurality of microscanned images as
- 10 a second data set; and
- a display generator, coupled with said processor,
- wherein for each respective data set, said processor analyzes at least a portion of said respective subset of said plurality of microscanned images for spatial and temporal information;
- 15 wherein said processor determines a respective movement indication of said at least one moving object according to said spatial and temporal information;
- wherein said processor combines said first subset into a respective first super-resolution image and said second subset into a
- 20 respective second super-resolution image;
- wherein for each respective one of said plurality of microscanned images said processor designates a respective bounded area surrounding said at least one moving object;
- 25 wherein for each said respective data set, said processor determines a position of said at least one moving object in each said respective one of said plurality of microscanned images according to said spatial and temporal information;

wherein said processor resamples each said respective bounded area using each said determined respective position of said at least one moving object; and

5 wherein said display generator generates said at least one moving object in each said respective super-resolution image according to said processor resampling each said respective bounded area of each said respective one of said plurality of microscanned images at each said determined respective position.

10 18. The video display system according to either one of claims 9, 14 or 17, further comprising a microscanner, coupled with said image detector, for shifting a line-of-sight (LOS) of said image detector in a controlled manner for acquiring said plurality of microscanned images.

15 19. The video display system according to either one of claims 9, 14 or 17, further comprising a platform, said image detector being mounted on said platform, said platform experiencing vibrations thereby causing random changes in a line-of-sight (LOS) of said image
20 detector in an uncontrolled manner for acquiring said plurality of microscanned images.

20. The video display system according to either one of claims 9, 14 or 17, further comprising a pan-and-tilt mechanism, coupled with said
25 image detector, for shifting an orientation of said image detector from a first field-of-view (FOV) to a second FOV.

21. The video display system according to claim 20, wherein said
30 pan-and-tilt mechanism can shift said orientation in at least one axis of said image detector.

22. The video display system according to claim 20, wherein said pan-and-tilt mechanism shifts said orientation of said image detector using a setup selected from the list consisting of:
- 5 a mechanical setup; and
 an optical setup.
23. Method for motion detection of at least one moving object using a plurality of microscanned images, comprising the procedures of:
- 10 acquiring a plurality of microscanned images of said at least one moving object, for generating a super-resolution image;
 forming at least one data set from a subset of said plurality of microscanned images;
 respectively analyzing at least one portion of said plurality of microscanned images forming said at least one data set for
15 extracting spatial and temporal information of said at least one moving object; and
 determining at least one movement indication of said at least one moving object according to said spatial and temporal information.
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24. Method for enhanced motion detection of at least one moving object using a plurality of microscanned images, comprising the procedures of:
- 25 acquiring a plurality of microscanned images of said at least one moving object for forming at least two data sets from at least two subsets of said plurality of microscanned images, a first subset of said plurality of microscanned images forming a first data set and a second subset of said plurality of microscanned images forming a second data set of said at least one moving object;

forming a respective super-resolution image from each one of said first subset and said second subset of said plurality of microscanned images;

analyzing each respective super-resolution image for extracting spatial and temporal information of said at least one moving object;

determining a respective first movement indication of said at least one moving object according to said spatial and temporal information derived from said procedure of analyzing each respective super-resolution image;

in parallel to said procedure of forming each said respective super-resolution image, for each one of said first data set and said second data set, respectively analyzing at least one portion of said plurality of microscanned images forming each data set for extracting spatial and temporal information of said at least one moving object;

determining a respective second movement indication of said at least one moving object according to said spatial and temporal information derived from said procedure of respectively analyzing said at least one portion of said plurality of microscanned images; and

combining said respective first movement indication and said respective second movement indication for enhancing motion detection of said at least one moving object.

25. The method according to either one of claims 23 or 24, wherein said spatial and temporal information of said at least one moving object comprises at least one of:

a determination of said at least one moving object as a potential moving object between at least two consecutive microscanned images;

a determination of said at least one moving object as a potential moving object between at least two consecutive super-resolution images;

5 a determination of a movement path of said potential moving object between at least two consecutive microscanned images; and

a determination of a movement path of said potential moving object between at least two consecutive super-resolution images.

10 26. The method according to either one of claims 23 or 24, wherein said procedure of respectively analyzing at least one portion of said plurality of microscanned images comprises the sub-procedures of:

determining a respective position of said at least one moving object in at least one portion of said plurality of microscanned images forming said data set; and

15 determining at least one angular velocity estimate of said at least one moving object according to at least two determined respective positions of said at least one moving object.

20 27. The method according to claim 26, wherein said procedure of respectively analyzing at least one portion of said plurality of microscanned images further comprises the sub-procedure of determining an angular acceleration estimate of said at least one moving object according to at least two angular velocity estimates.

25 28. The method according to claim 24, wherein said procedure of analyzing each said respective super-resolution image comprises the sub-procedures of:

determining a respective position of said at least one moving object in each said super-resolution image; and

determining at least one angular velocity estimate of said at least one moving object according to consecutive ones of said respective super-resolution images.

- 5 29. The method according to claim 28, wherein said procedure of analyzing each super-resolution image further comprises the sub-procedure of determining an angular acceleration estimate of said at least one moving object according to at least two angular velocity estimates.

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30. The method according to claim 23, further comprising the procedure of tracking said at least one moving object according to said spatial and temporal information derived from said at least one portion of said plurality of microscanned images.

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31. The method according to claim 24, further comprising the procedure of tracking said at least one moving object according to said spatial and temporal information derived from at least one of:

each said respective super-resolution image; and

- 20 said at least one portion of said plurality of microscanned images.

32. The method according to either one of claims 23 or 24, wherein said procedure of extracting spatial and temporal information is executed using an algorithm selected from the list consisting of:

- 25 image differencing;
background subtraction;
background modeling and foreground detection;
mixture of Gaussians (MOG);
30 MOG2;

- kernel density estimation (KDE);
global minimum with a guarantee (GMG);
running average;
temporal median;
5 principal component analysis (PCA);
Bayesian background modeling;
optical flow;
Lucas-Kanade method;
Horn-Schunk method;
10 a combination of optical flow and image differencing;
motion detection based on objection detection and recognition;
machine learning approaches;
support vector machines (SVMs);
deep learning algorithms;
15 convolutional neural networks (CNNs);
image registration for background modeling and image
subtraction;
correlation based registration;
feature based registration;
20 scale-invariant feature transform (SIFT);
speeded up robust features (SURF);
binary robust independent elementary features (BRIEF); and
pyramidal image registration.
- 25 33. The method according to either one of claims 23 or 24, wherein said
procedure of acquiring said plurality of microscanned images
comprises the sub-procedure of shifting a line-of-sight (LOS)
between said at least one moving object and an image detector for
acquiring said plurality of microscanned images,

wherein said sub-procedure of shifting said LOS is selected from the list consisting of:

a controlled shifting of said LOS; and
an uncontrolled shifting of said LOS.

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34. The method according to claim 24, further comprising the procedures of:

acquiring said plurality of microscanned images at a periodic plurality of different fields-of-view (FOVs) using a step-and-stare method; and forming a respective super-resolution image at each one of said plurality of different FOVs.

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35. System for motion detection of at least one moving object using a plurality of microscanned images, comprising:

an image detector for acquiring a plurality of microscanned images of said at least one moving object, for generating a super-resolution image; and

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a processor, coupled with said image detector,

wherein a subset of said plurality of microscanned images forms

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at least one data set;

wherein said processor respectively analyzes at least one portion of said at least one data set for extracting microscan spatial and temporal information of said at least one moving object; and

wherein said processor determines at least one movement indication of said at least one moving object according to said spatial and temporal information.

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36. System for enhanced motion detection of at least one moving object using a plurality of microscanned images, comprising:

an image detector, for acquiring a plurality of microscanned images of said at least one moving object, for forming at least two data sets from at least two subsets of said plurality of microscanned images, a first subset of said plurality of microscanned images forming a first data set and a second subset of said plurality of microscanned images forming a second data set of said at least one moving object; and

a processor, coupled with said image detector, for forming a respective super-resolution image from each one of said first subset and said second subset and for analyzing each respective super-resolution image for extracting super-resolution spatial and temporal information of said at least one moving object; said processor also for respectively analyzing, in parallel, at least one portion of said plurality of microscanned images forming each said data set for extracting microscan spatial and temporal information of said at least one moving object;

wherein said processor determines a respective first movement indication of said at least one moving object according to said super-resolution spatial and temporal information;

wherein said processor also determines a respective second movement indication of said at least one moving object according to said microscan spatial and temporal information; and

wherein said processor combines said respective first movement indication and said respective second movement indication for enhancing motion detection of said at least one moving object.

37. The system according to either one of claims 35 or 36, further comprising a pan-and-tilt mechanism, coupled with said image

detector, for shifting an orientation of said image detector from a first field-of-view (FOV) to a second FOV.

38. The system according to claim 37, wherein said pan-and-tilt
5 mechanism can shift said orientation in at least one axis of said image detector.

39. The system according to claim 37, wherein said pan-and-tilt
mechanism shifts said orientation of said image detector using a
10 setup selected from the list consisting of:

a mechanical setup; and

an optical setup.

40. The system according to claim 36, further comprising a pan-and-tilt
15 mechanism, coupled with said image detector, for shifting an orientation of said image detector from a first field-of-view (FOV) to a second FOV,

wherein said processor combines at least one of said first data set and said second data set at said first FOV into a first
20 super-resolution image of said at least one moving object and combines at least one of said first data set and said second data set at said second FOV into a second super-resolution image of said at least one moving object.

25 41. The system according to either one of claims 35 or 36, further comprising a microscanner, coupled with said image detector, for shifting a line-of-sight (LOS) of said image detector in a controlled manner for acquiring said plurality of microscanned images.

42. The system according to either one of claims 35 or 36, further comprising a platform, said image detector being mounted on said platform, said platform experiencing vibrations thereby causing random changes in a line-of-sight (LOS) of said image detector in an uncontrolled manner for acquiring said plurality of microscanned images.
43. The system according to either one of claims 35 or 36, wherein at least one of said microscan spatial and temporal information and said super-resolution spatial and temporal information of said at least one moving object comprises at least one of:
- said processor determining said at least one moving object as a potential moving object between at least two consecutive microscanned images;
 - said processor determining said at least one moving object as a potential moving object between at least two consecutive super-resolution images;
 - said processor determining a movement path of said potential moving object between at least two consecutive microscanned images; and
 - said processor determining a movement path of said potential moving object between at least two consecutive super-resolution images.
44. The system according to either one of claims 35 or 36, wherein said processor determines a respective position of said at least one moving object in at least one portion of said plurality of microscanned images forming said data set and also determines at least one angular velocity estimate of said at least one moving object according

to at least two determined respective positions of said at least one moving object.

5 45. The system according to claim 44, wherein said processor further determines an angular acceleration estimate of said at least one moving object according to at least two angular velocity estimates.

10 46. The system according to claim 36, wherein said processor determines a respective position of said at least one moving object in each said respective super-resolution image; and
wherein said processor determines at least one angular velocity estimate of said at least one moving object according to consecutive ones of said respective super-resolution images.

15 47. The system according to claim 46, wherein said processor determines an angular acceleration estimate of said at least one moving object according to at least two angular velocity estimates.

20 48. The system according to claim 35, wherein said processor tracks said at least one moving object according to said microscan spatial and temporal information.

25 49. The system according to claim 36, wherein said processor tracks said at least one moving object according to at least one of:
said microscan spatial and temporal information; and
said super-resolution spatial and temporal information.

30 50. The system according to either one of claims 35 or 36, wherein said processor tracks said at least one moving object using an algorithm selected from the list consisting of:

image differencing;
background subtraction;
background modeling and foreground detection;
mixture of Gaussians (MOG);
5 MOG2;
kernel density estimation (KDE);
global minimum with a guarantee (GMG);
running average;
temporal median;
10 principal component analysis (PCA);
Bayesian background modeling;
optical flow;
Lucas-Kanade method;
Horn-Schunk method;
15 a combination of optical flow and image differencing;
motion detection based on objection detection and recognition;
machine learning approaches;
support vector machines (SVMs);
deep learning algorithms;
20 convolutional neural networks (CNNs);
image registration for background modeling and image
subtraction;
correlation based registration;
feature based registration;
25 scale-invariant feature transform (SIFT);
speeded up robust features (SURF);
binary robust independent elementary features (BRIEF); and
pyramidal image registration.