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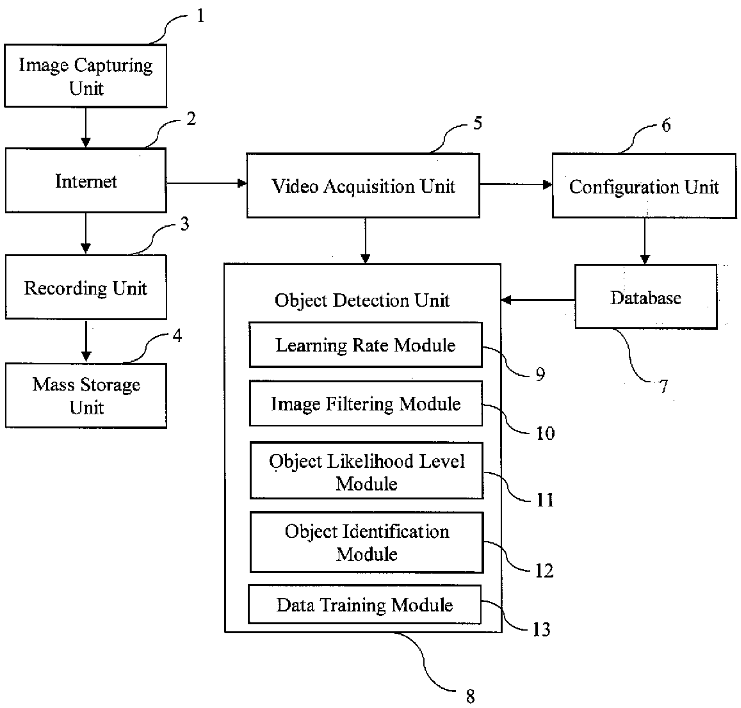

FIG. 1

(57) Abstract: The present invention discloses a system to detect a moving object in a dynamic environment from a sequence of captured images, comprising a learning rate module (9), an image filtering module (10), an object likelihood level module (11), and an object identification module (12). The system executes the following steps: determining a learning rate seed (301) based on the speed rate (306) of the moving object, applying the determined learning rate seed (301) to a data training module (13) for filtering of background images (403) from captured images, calculating an object likelihood level (505) by computing statistical properties of the filtered images (406), and identifying the moving object based on the object likelihood level (505), wherein the learning rate seed (301) and the object likelihood level (505) are updated based on a processing of one or more new images.

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A SYSTEM AND METHOD FOR DETECTING A MOVING OBJECT IN A DYNAMIC ENVIRONMENT FROM A SEQUENCE OF CAPTURED IMAGES

FIELD OF INVENTION

The present invention relates to a system and method for detecting a moving object in a dynamic environment, and more particularly to a system and method for detecting the moving object from a sequence of captured images.

BACKGROUND OF THE INVENTION

In recent years, advancements in technology has brought forth the integration of artificial intelligence in digital industry. Image processing technologies combined with machine learning algorithms have drastically improved the information extraction capabilities of a surveillance system. In the surveillance system, cameras, video cameras or other sensing devices are commonly used to capture images or videos of the environments. Conventionally, the captured images or videos are then analysed by an operator to understand and monitor activities surrounding the environment. As such, automated surveillance systems are developed to reduce the human error that occurs during analysis by the operator, by combining the image processing technology and machine learning algorithms in artificial intelligence, thus further improving quality of detection and processing.

Many technologies related to detecting a moving object in a dynamic environment have been proposed to further improve the system. For example, United States with patent publication no. US8159536B2 discloses a method for detecting desired objects in a highly dynamic environment by a monitoring system, comprising: taking at least one image of the environment; generating at least one background image from the image taken, wherein the background image comprises a plurality of pixels; dividing the background image into a plurality of pixel blocks; forming at least one data cluster of each pixel block based on at least one feature of the background pixels in the pixel block; comparing each pixel in the pixel block to a subsequently generated background image to generate a first and second discrepancy value; determining whether the pixel of the subsequent image is a background pixel or foreground pixel based on the first and second discrepancy value; generating a binary map of the subsequent image based on the subsequent image based on the determined foreground pixels and background pixels; and marking connected pixels in the binary map corresponding to the foreground pixels to form at least one foreground object, wherein the foreground object is at least one object detected in the environment.

A United States patent with publication no. US20190005361A1, recites a method of real-time identification moving objects in video images, the method comprises the following steps: capturing a video input from a scene comprising one or more moving objects, wherein the video input comprises at least two temporally spaced image frames captured from the scene; transforming the video input into one or more image pattern layers, wherein each of the image pattern layers comprises a pattern representing one of the desired moving objects; determining a probability match between each of the image pattern layers and a stored image in a big data library; adding one or more image pattern layers having the probability of match that exceeds a predetermined level to the big data library automatically; and outputting the probability of match. The method of obtaining a result through probability matching is unreliable as the outcome may not be accurate to the object of interest.

Another technology as disclosed in United States patent with publication no. US7929730B2 recites a method and system for object detection and tracking, for detecting and tracking a plurality of continuous videos generated by the object motion in a scene, wherein the method comprising of: updating information of a foreground and background appearance models based on a new input video and past accumulated information; performing an object detection process based on the information of the updated foreground and background appearance models, past propagated time axis information and current observed video; using the detection result from the object detection process to update the information of the foreground and background appearance models until a convergent condition is met; using the convergent detection result as a new tracking measurement to update the tracking prediction model; using the updated tracking prediction model to obtain a final tracking result; and predicting the location of the tracked object at the next scene, storing the predicted labelling and appearance information of the foreground and background objects to update further.

The aforementioned patent documents disclose the various systems and methods of detecting and tracking an object based on performing probability matches and predictions from a plurality of continuous images. However, these systems and method fail to provide an effective detection on the moving object of interest in a highly dynamic environment.

Accordingly, it would be desirable to provide a system and method for detecting a moving object in a dynamic environment, more particularly a system and method employing machine learning algorithms based on a predetermined feature of the moving object to effectively identify the moving object in the foreground.

SUMMARY OF INVENTION

The present invention discloses a system to detect a moving object in a dynamic environment from a sequence of captured images, comprising of: a learning rate module, configured to determine a learning rate seed based on the speed rate of the moving object; an image filtering module, configured to apply the determined learning rate seed to a data training module for filtering of background images from captured images; an object likelihood module, configured to calculate a likelihood level by computing statistical properties of the filtered images; an object identification module, configured to identify the moving object based on the likelihood level; and wherein the learning rate seed and the object likelihood level are updated based on a processing of one or more new images.

Preferably, the image filtering module applies an absolute subtraction technique to remove the background from the captured images.

Preferably, the object likelihood level module is further configured to compute statistical properties of the filtered images based on an average calculation of a series of indicator values for each filtered image.

Preferably, the data training module is configured to optimise the updated learning seed as a new learning rate seed to be input into the learning rate module.

In another aspect of this invention, there is provided a method for detecting a moving object in a dynamic environment from a sequence of captured images, the method comprising: determining a learning rate seed based on a speed rate of the moving object, by a learning rate module; applying the determined learning rate seed to a data training module for filtering of background images from the captured images, by an image filtering module; computing a likelihood level by computing statistical properties of the filtered images, by an object likelihood level module; and identifying the moving object based on the likelihood level, by an object identification module; and wherein the learning rate seed and the object likelihood level are updated based on processing of one or more new images.

Preferably, the method further comprising applying, by the image filtering module, an absolute subtraction technique to filter the background images from the captured images.

Preferably, the absolute subtraction technique comprises the steps of applying two or more updated background images onto the captured images; and removing the updated background images from the overall captured images.

Preferably, the method further comprising the step of computing, by the object likelihood level module, statistical properties of the filtered images based on an average calculation of a series of indicator values for each filtered image.

Preferably, the series of indicator values for each filtered image is calculated by the steps of determining a standard deviation value of the filtered images; computing an occupancy value for pixels of interest based on an overlay of a dynamic grid base on the filtered images; and calculating a scatteredness value for the pixels of interest based on the distance of the pixels of interest on the dynamic grid base to adjacent points on the dynamic grid base.

One skilled in the art will readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiment described herein is not intended as limitations on the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of facilitating an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

FIG. 1 is a block diagram of a system to detect a moving object in a dynamic environment from a sequence of captured images, according to the present invention.

FIG. 2 is a flow chart illustrating an exemplary embodiment for a method to detect a moving object in a dynamic environment from a sequence of captured images based on the above-mentioned system.

FIG. 3 is a flow chart illustrating a preferred embodiment to determine the learning rate seeds based on the speed rates of the moving object.

FIG. 4 is a flow chart illustrating a preferred embodiment to filter the background images based on the determined learning rate seeds.

FIG. 5 is a flow chart illustrating an exemplary embodiment to calculate the object likelihood level and the varying filtered images corresponding to the object likelihood levels.

FIG. 6 is a flow chart illustrating a preferred embodiment to identify the moving object based on the object likelihood levels.

FIG. 7 is an exemplary embodiment for determining the optimum learning rate from each learning rate seed based on the object likelihood level.

FIG. 8 is a flow chart illustrating an exemplary embodiment for determining the optimum learning rate for each learning rate seed by conducting forward and backward learning rate updates.

DETAILED DESCRIPTION OF THE INVENTION

It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, that execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means that implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

The invention will now be described in greater detail, by way of example, with reference to the drawings.

Referring to **FIG. 1**, there is provided a system for detecting a moving object in a dynamic environment from a sequence of captured images from an image capturing unit **1**, wherein the image capturing unit **1** may be a digital or analog camera, digital video recorder, a network video camera or any other mediums suitable for capturing images in a sequence. In one preferred embodiment, the captured images are transferred over the internet **2**, wherein the captured images may be transferred wirelessly over a communication network to a recording unit **3.** The communication network can be a wireless network connection established via a wireless protocol cloud such as Long-Term Evolution (LTE) cloud, Code Division Multiple Access (CDMA) and its derivatives, Enhanced Data Rates for GSM Evolution (EDGE), 3G protocol, High Speed Packet Access (HSPA), 4G protocol, 5G protocol and the like, in accordance to the advancement of wireless technology with time. The communication network can also be a wired network via a local network port**.** Further, the recording unit **3** may be a video converter which operates by converting the data from the image capturing unit **1** to be stored in a mass storage unit **4**, wherein the mass storage unit **4** may be an internal memory storage device which can be installed within the image capturing unit or externally linked to the image capturing unit **1.** The mass storage unit can be any type of hardware device that is capable of storing and retrieving data, wherein the hardware device may come in the form of hard drives or optical discs. Primary storage devices, such as Raw Access Memory (RAM), is used by computer systems to temporarily store and retrieve data whereas secondary storage devices, such as Hard Disk Drives (HDD) or Solid State Drives (SSD) store data permanently. Further, the mass storage unit may also be a third party cloud service provider, wherein the third party cloud service provider is able to transmit and store data to remote storage system, where it is maintained, managed, backed up and made available to users over a network, typically the internet **2**.. Further, the captured images transferred over to the internet **2** are subsequently transferred into a video acquisition unit **5**, wherein the video acquisition unit further processes the captured images into a sequence of images to be configured in a configuration unit **6** and object detection unit **8**. Preferably, the configuration unit **6** configures at least one data analytics of either the image capturing unit **1** or the video acquisition unit **5.** For example, the data analytics to be configured on the image capturing unit **1** may comprise of camera credentials, location name of the camera, or stream URLs, whereas the data analytics to be configured on the captured images from the image capturing unit **1** may be a monitoring area which includes a region of interest, or a data analytics parameter such as image resolution or pixel density. Preferably, the configured data from the configuration unit **6** is transferred to a database **7,** which then transfers said information to the object detection unit **8**, wherein the database **7** may be an internal or external computer system in wired or wireless communication with the video acquisition unit **5**, configuration unit **6** and object detection unit **8**. Preferably, the plurality of modules in the object detection unit **8** communicate with one another to form an interconnected communication network.

In one particular embodiment, the object detection unit **8** comprises a learning rate module **9**, configured to determine a learning rate seed **301** based on the speed rate **306** of the moving object. Preferably, the speed rate **306** of the moving object may be classified into three groups, which is low **306a,** medium **306b**, and high **306c**, whereby a corresponding learning rate to be initiated for the respective groups. Further, the learning rate seed **301** may be adjusted based on the optimum learning rate seed **303** from the previous frame. As such, the learning rate module **9** will determine the initial learning rate seeds **301** for each speed rate **306** defined and input the various learning rate seeds **301** into the next module.

In another particular embodiment, the object detection unit **8** comprises an image filtering module **10**, configured to filter the background from the background images **403** that are updated based on the predefined learning rate seeds **301**. With reference to **A** in **FIG. 4,** each learning rate seed **301** determined by the various speed rates **306** of the moving objects subsequently updates the background images **403** which are then compared to the current image frame of the captured images. Preferably, the image filtering module **10** applies an absolute subtraction **404** technique to filter and remove the background images **403** from the current image frame, which is subsequently compared to a predefined threshold **405** implemented into the image filtering module **10** to obtain a final filtered image **406** for the corresponding learning rate seed **301**.

In another particular embodiment, the object detection unit **8** comprises an object likelihood module **11**, configured to compare differences between the filtered images **406** based on an average calculation of a series of indicator values for each filtered image **406**. Referring to **FIG. 5**, the object likelihood module **11** determines the standard deviation **501** of the filtered image **406** formed as the first indicator value. The second indicator value is computed by the occupancy **502** of pixels of interest **507** within a dynamic grid base **509** when overlaid onto the filtered image **406**. The third indicator value is obtained by calculating the scatteredness **503** of the pixels of interest **507** within the dynamic grid base **509** based on the distance of each pixel of interest **507** to adjacent points on the dynamic grid base **509**. All three indicator values are then weighted and averaged to produce a likelihood level of varying degrees depending on the filtered image **406** formed, which will be discussed further herein. By way of example, variants of the filtered images **406** corresponding to the respective object likelihood levels **505** are shown in **FIG. 5**.

In another particular embodiment, the object detection unit **8** comprises an object identification module **12** for identifying the object of interest based on the calculated object likelihood levels **505**. The varying filtered images **406** are compared based on their likelihood levels in order to determine the final output image of the moving object. By way of example, a filtered image **406** with a high **510c** likelihood level corresponding to one learning rate seed **301** is compared to other filtered images **406** of high **510c** likelihood levels corresponding to other learning rate seeds **301**. Upon comparison, the filtered images **406** with high **510c** likelihood levels are combined to determine the final image outcome which successfully depicts the moving object in a foreground image.

FIG. 2 illustrates an exemplary embodiment for a method for detecting a moving object in a dynamic environment from a sequence of captured images based on the above-mentioned system. At Step **201**, the image capturing unit **1** first captures a sequence of images to be used for detecting the moving object. At Step **202,** the learning rate module **9** determines the learning rate seed **301** based on the speed rate **306** of the moving object, wherein the speed rate **306** of the moving object is predefined based on prior knowledge of the environment. However, if prior knowledge of the environment does not exist, then three common speed rates **306** are used: low **306a**, medium **306b**, high **306c**. At Step **203,** the image filtering module **10** applies the learning rate seed **301** to the data training module **13** in order to determine a suitable learning rate at incremental **402** interval and decremental **401** interval, and subsequently begin the process of filtering the background images **403** from the sequence of captured images. At Step **204**, the filtered images **406** are then obtained from the image filtering module **10** based on a comparison with a predefined threshold **405.** At Step **205,** the object likelihood level module **11** calculates the object likelihood level by computing the statistical properties for each filtered image **406**. At Step **206,** the object likelihood levels **505** obtained from the filtered images **406** are compared to a threshold at Step **206** to determine if another set of filtered images **406** is required. Steps **207** and **208** are taken if the object likelihood levels from the filtered images **406** are categorised as low **701** likelihood level. At Step **211**, the object identification module **12** then identifies the moving object based on the calculated likelihood level **505**. The calculated object likelihood level **505** of the moving object is then subsequently applied to the data training module **13** to update the learning rate seed **301**, wherein the updated learning rate seed **301** for the identified moving object is optimised **303** as a new learning rate seed **301**, and wherein the steps taken to obtain a filtered image **406** is repeated. Step **209** is taken if there are no optimum learning rate seeds **303** that could be obtained from the initial learning rate seeds **301**, whereby a forwards **802** and backwards **801** update on the learning rate seeds **301** will take place until an optimum learning rate seed **303** is achieved. At Step **212,** all filtered images **406** from each optimum learning rate seed

303 will be obtained and subsequently combined at Step **213** into a master filtered image **214,** wherein the master filtered image **214** establishes the successfully identified moving object. The steps shown in **FIG. 2** are further elaborated in **FIG. 3** to **FIG. 8**.

FIG. 3 illustrates an exemplary embodiment to determine the learning rate seeds **301** for detecting the moving object. At step **300**, a minimum learning rate value **304** and maximum learning rate value **305** are generated by the learning rate module **9.** The learning rate seed **301** is initially determined by three common speed rate **306** groups of the moving object at different predefined locations in the first frame, whereby the speed rates **306** are classified as low **306a**, medium **306b** and high **306c** speed rates **306**. Learning rate seeds **301a, 301b, 301c** are then determined based on the respective speed rates **306** for the initial frame. For a following frame in Step **302**, if a previous optimum learning rate seed **303** is within the tolerance range of the predefined learning rate seed **301** at the specific object speed rate **306**, then no new learning rate seed **301** is generated and the following frame will utilize the optimum learning rate seed **303** to become a reference learning rate seed **301** for the next module. However, the initial predefined learning rate seeds **301d, 301e** will be generated and initialized if the optimum learning rate seed **303** is not within the tolerance range of the predefined learning rate seeds **301** from the previous frame.

FIG. 4 illustrates an exemplary embodiment to filter the background images **403** by removing the background from the captured images. At step **400**, each learning rate seed **301** further generates two learning rates at incremental **402a, 402b, 402c** intervals and decremental **401a, 401b,402c** intervals from the learning rate seed **301**. In one preferred embodiment, the incremental **402a, 402b, 402c** learning rates and decremental **401a, 401b, 401c** learning rates have a predefined range from the initial learning rate seeds **301**. At step **403,** the background image is updated based on each learning rate intervals **401, 402**. With the updated background images **403** formed, the image filtering module **10** filters the background images **403** from the current image by applying an absolute subtraction **404** to obtain a filtered image **406** which only shows the foreground object. The output images of the absolute subtraction **404** technique are then compared to a threshold at step **405** in order to obtain the final filtered image **406** corresponding to the learning rate seed **301**.

FIG. 5 illustrates an exemplary embodiment to calculate the likelihood level **501** of the moving object. The object likelihood level module **11** computes three indicator values to be averaged in order to obtain a likelihood level **505** of the object of interest. At step **501**, the standard deviation of the obtained filtered image **406** is determined, giving a first indicator value. At step **502**, the second indicator value is computed by overlaying a dynamic grid base **509** onto the filtered image **406** in order to calculate the occupancy of pixels of interest **507** on the dynamic grid base **509**, wherein each pixel of interest **507** indicates a segment of the moving object which is located on the dynamic grid base **509.** Step **508** shows by way of example, the occupancy value of the pixels of interest **507** of the moving object in an 8x8 dynamic grid base **509**, wherein the pixels of interest **507** corresponding to the moving object in the filtered image **406** occupies 7/64 pixels. At Step **503**, the third indicator value is calculated based on the scatteredness **506** of the pixels of interest **507** of the filtered image **406** in the dynamic grid base **509.** By way of example but not limitation, the scatteredness **506** value is obtained by calculating the distance of the pixels of interest **507** to adjacent points in the dynamic grid base **509**, whereby an average is calculated from the average distance of the pixels of interest **507** with the total number of calculated distances from the adjacent points. The first two steps of calculating the distance of the pixels of interest **507** to the adjacent points in the dynamic grid base **509** and calculating the average of the average distances are repeated with all points of interest. As such, the final scatteredness **506** value is obtained by averaging all the average values from the first three steps. At step **504**, the final object likelihood level **505** is obtained by calculating the weightage and average of all the indicator values. Each object likelihood level **505** obtained is further classified in order of lower likelihood level to higher likelihood level, as depicted in **510** which shows the variants of filtered images **406** corresponding to the object likelihood levels **505**. The variant filtered images **406** classified in respective categories of low **510a** likelihood level, medium **510b** likelihood level, and high **510c** likelihood level are exemplified further in **FIG. 6** and **FIG.** 7.

FIG. 6 illustrates an exemplary embodiment for obtaining an absolute subtracted **404** image if two filtered images are of non-high likelihood levels. Step **601** depicts a mixture of low **510a** likelihood level and medium **510b** likelihood level examples of movement mixtures of the different objects in the actual scenario undergoing the interval learning rate process to generate a new filtered image **406** which will be input into the object likelihood module **9** to determine the respective likelihood level **505**. The absolute subtraction **404** technique will not be conducted if there is a pairing of varying levels**,** whereby a filtered image **406** pairing which does not contain any high **510c** likelihood level in any one of them will not undergo the absolute subtraction **404** technique. However, should a pairing of filtered images **406** exhibit the same object likelihood levels **505**, either low **510a** likelihood level or medium **510b** likelihood level without any high **510c** likelihood level, the object likelihood module **11** will apply the absolute subtraction **404** technique to obtain a possible filtered image **406** of high **510c** likelihood level, which will be used to determine the moving object.

FIG. 7 illustrates an exemplary embodiment of determining the optimum learning rate seed **303** from a sequence of difference images **406** of varying object likelihood levels **505**, based on each learning rate seed **301**. The three categories of the object likelihood levels **505** as shown are low **510a** likelihood level, medium **510b** likelihood level, and high **510c** likelihood level. The filtered images **406** are categorised as such that the filtered images **406** are of low **510a** likelihood level if only noise is detected, medium **510b** likelihood level if both noise and the moving object are detected in the filtered images **406**, and high **510c** likelihood level if the filtered images **406** contain only the moving object. At Step **701**, one of the exemplary results of all the filtered images **406**

of each learning rate seed **301** is all the likelihood level is medium **510b** and another exemplary result is there is a mixture of low **510a** and medium **510b** likelihood levels. These two examples indicate that the optimum learning rate has yet to be achieved. However, at Step **702**, the optimum learning rate seed **303** is achieved if at least one of the filtered images **406** are of a high **510c** likelihood level or if all the filtered images **406** have a low **510c** likelihood level.

FIG. 8 illustrates an exemplary embodiment of determining the optimum learning rate seed **303** by implementing backward **803** and forward **804** updates on the learning rate seeds **301**, as configured in the data training module **13**. At Step **801**, in the event that no optimum learning rate seed **303** is achieved as all filtered images **406** from the respective learning rate seeds **301** corresponds to low **510a** likelihood level, the data training module **13** will update the learning rate seeds **301** in a manner of forward **804a, 804b, 804c** updates or backward **803a, 803b, 803c** updates in order to obtain a new set of learning rate seeds **301**, wherein at least one new pair of learning rates are similarly created from the learning rate seeds **301** in order to obtain a new sequence of filtered images **406**. At Step **802**, the process of backward **803** updates and forward **804** updates on the learning rate seed **301** will take place until at least one filtered image **406** with a high **510c** likelihood level is obtained, indicating the achievement of the optimum learning rate seed **303**. Once the optimum learning rate seed **303** is achieved, it will be input into the learning rate module **1** to be utilized for the following sequence of captured images.

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularly, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

CLAIMS

1. A system for detecting a moving object in a dynamic environment from a sequence of captured images, the system is characterized by having:
   a learning rate module (9), configured to determine a learning rate seed (301) based on a speed rate (306) of the moving object;
   an image filtering module (10), configured to apply the determined learning rate seed (301) to a data training module (13) for filtering of background images (403) from the captured images;
   an object likelihood level module (11), configured to calculate a likelihood level (505) by computing statistical properties of each filtered image (406); and
   an object identification module (12), configured to identify the moving object based on the object likelihood level (505), wherein the learning rate seed (301) and the object likelihood level (505) are updated based on a processing of one or more new images.

2. The system according to Claim 1, wherein the image filtering module (10) is further configured to remove the background from the captured images by applying an absolute subtraction (404) technique.

3. The system according to Claim 1, wherein the object likelihood level module (11) is further configured to compute statistical properties for each filtered image (406) based on an average calculation of a series of indicator values for each filtered image (406).

4. The system according to Claim 1, wherein the data training module (13) is configured to optimise the updated learning seed (301) as a new learning rate seed (301) to be input into the learning rate module (9).

5. A method for detecting a moving object in a dynamic environment from a

sequence of captured images, the method is characterized by having the steps of:

determining, by a learning rate module (9), a learning rate seed (301) based on a speed rate (306) of the moving object;

applying, by an image filtering module (10), the determined learning rate seed (301) to a data training module (13) for filtering of background images (403) from the captured images;

computing, by an object likelihood level module (11), a likelihood level (505) by computing statistical properties of the filtered images (406); and

identifying, by an object identification module (12), the moving object based on the object likelihood level (505),

wherein the learning rate seed (301) and the object likelihood level (505) are updated based on a processing of one or more new images.

6. The method according to Claim 5, further comprising the step of applying, by the image filtering module (10), an absolute subtraction technique (404) to filter the background images (403) from the captured images.

7. The method according to Claim 6, wherein the absolute subtraction technique (404) comprises the steps of:

applying two or more updated background images (403) onto the captured images; and

removing the updated background images (403) from the captured images.

8. The method according to Claim 5, further comprising the step of computing, by the object likelihood level module (11), statistical properties of the filtered images (406) based on an average calculation a series of indicator values for each filtered image (406).

9. The method according to Claim 8, wherein the series of indicator values for each

filtered image (406) is calculated by the steps of:

determining a standard deviation (501) value of the filtered images (406);

computing an occupancy (502) value for pixels of interest (507) based on an overlay of a dynamic grid base (509) on the filtered images (406); and

calculating a scatteredness (506) value for the pixels of interest (507) based on the distance of the pixels of interest (507) on the dynamic grid base (509) to adjacent points on the dynamic grid base (509).

10. The method according to Claim 5, further comprising the step of updating the learning rate seed (301) in predefined increment values (804) and decrement values (802) until an optimum learning rate seed (303) is achieved to be input into the learning rate module (9) as a new learning rate seed (301).

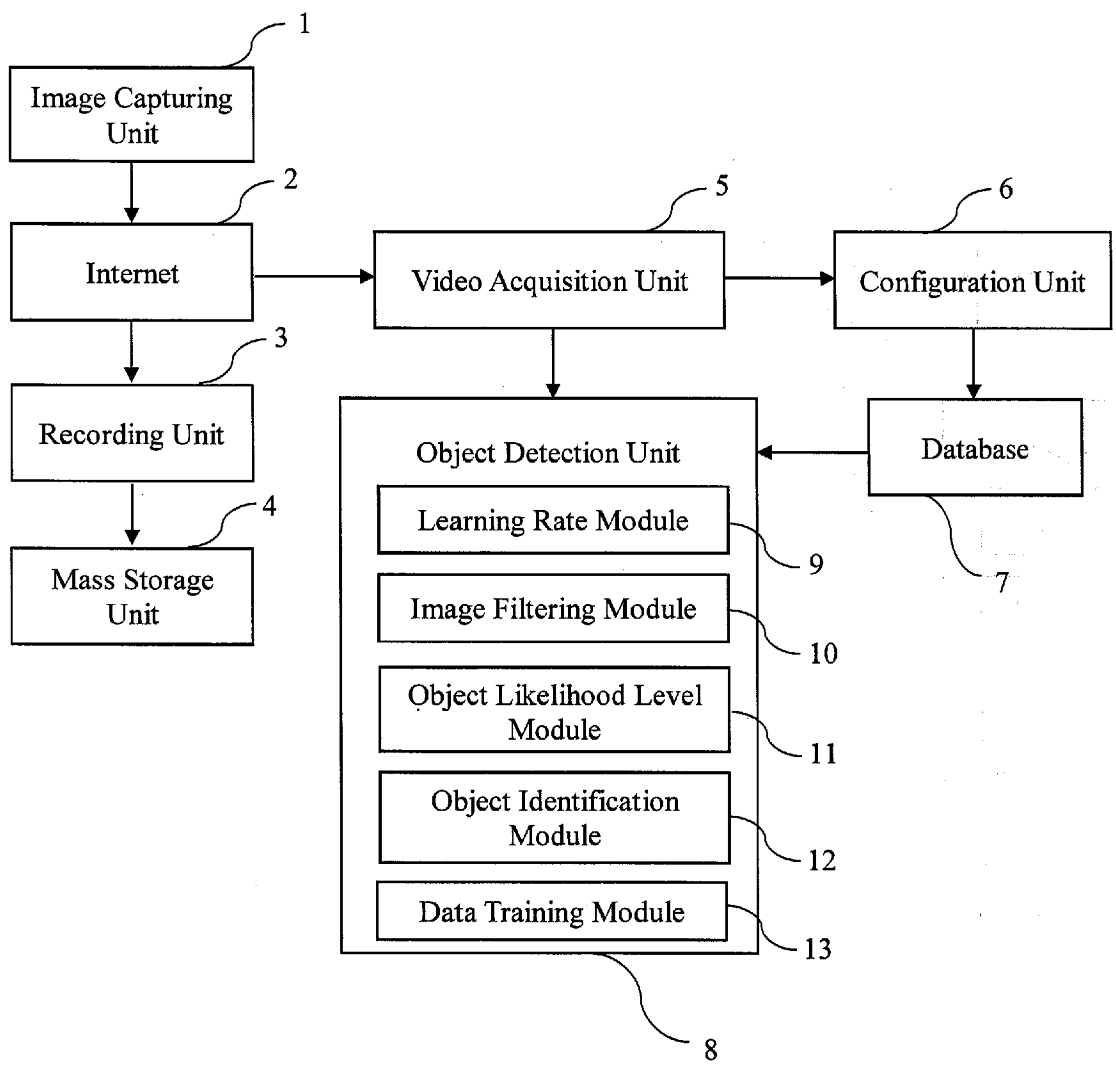
1
Image Capturing Unit
2
Internet
3
Recording Unit
4
Mass Storage Unit
5
Video Acquisition Unit
6
Configuration Unit
Object Detection Unit
Learning Rate Module
9
Image Filtering Module
10
Object Likelihood Level Module
11
Object Identification Module
12
Data Training Module
13
8
Database
7

FIG. 1

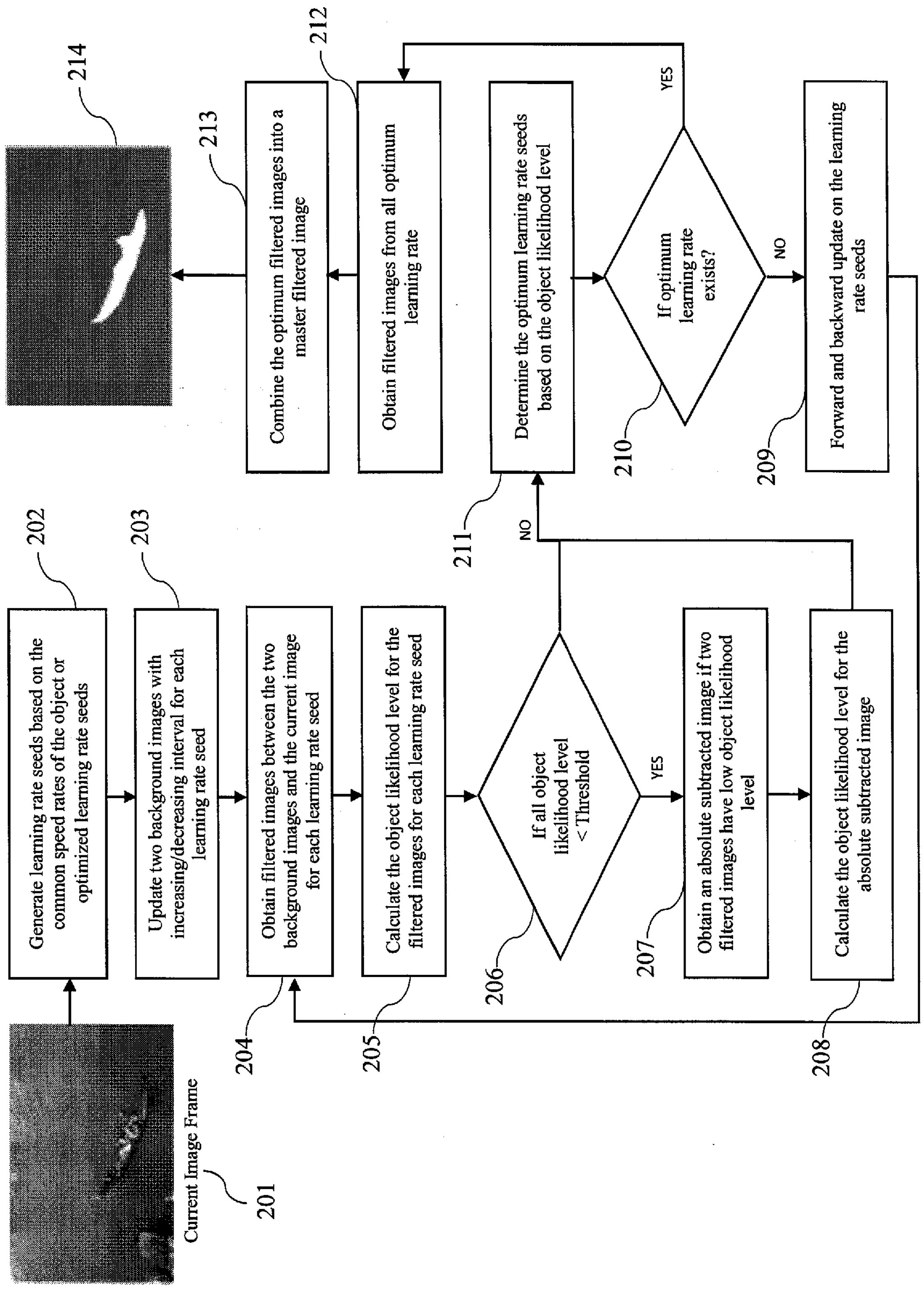
Current Image Frame
201
202
Generate learning rate seeds based on the common speed rates of the object or optimized learning rate seeds
203
Update two background images with increasing/decreasing interval for each learning rate seed
204
Obtain filtered images between the two background images and the current image for each learning rate seed
205
Calculate the object likelihood level for the filtered images for each learning rate seed
206
If all object likelihood level < Threshold
YES
NO
207
Obtain an absolute subtracted image if two filtered images have low object likelihood level
208
Calculate the object likelihood level for the absolute subtracted image
209
Forward and backward update on the learning rate seeds
210
If optimum learning rate exists?
YES
NO
211
Determine the optimum learning rate seeds based on the object likelihood level
212
Obtain filtered images from all optimum learning rate
213
Combine the optimum filtered images into a master filtered image
214

FIG. 2

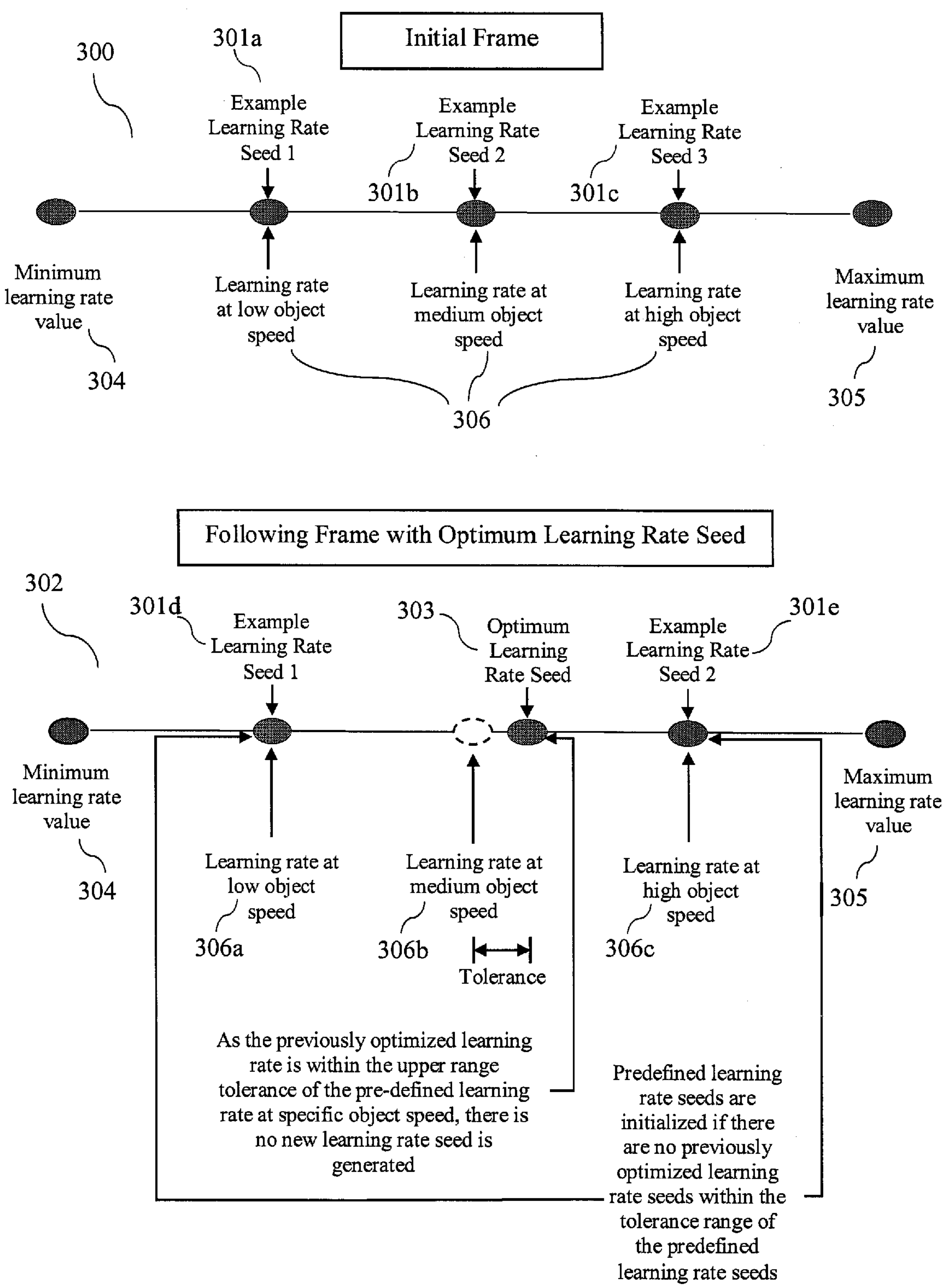
Initial Frame
300
301a
Example Learning Rate Seed 1
Example Learning Rate Seed 2
Example Learning Rate Seed 3
301b
301c
Minimum learning rate value
304
Learning rate at low object speed
Learning rate at medium object speed
Learning rate at high object speed
Maximum learning rate value
305
306
Following Frame with Optimum Learning Rate Seed
302
301d
Example Learning Rate Seed 1
303
Optimum Learning Rate Seed
Example Learning Rate Seed 2
301e
Minimum learning rate value
304
Learning rate at low object speed
306a
Learning rate at medium object speed
306b
Tolerance
Learning rate at high object speed
306c
Maximum learning rate value
305
As the previously optimized learning rate is within the upper range tolerance of the pre-defined learning rate at specific object speed, there is no new learning rate seed is generated
Predefined learning rate seeds are initialized if there are no previously optimized learning rate seeds within the tolerance range of the predefined learning rate seeds

FIG. 3

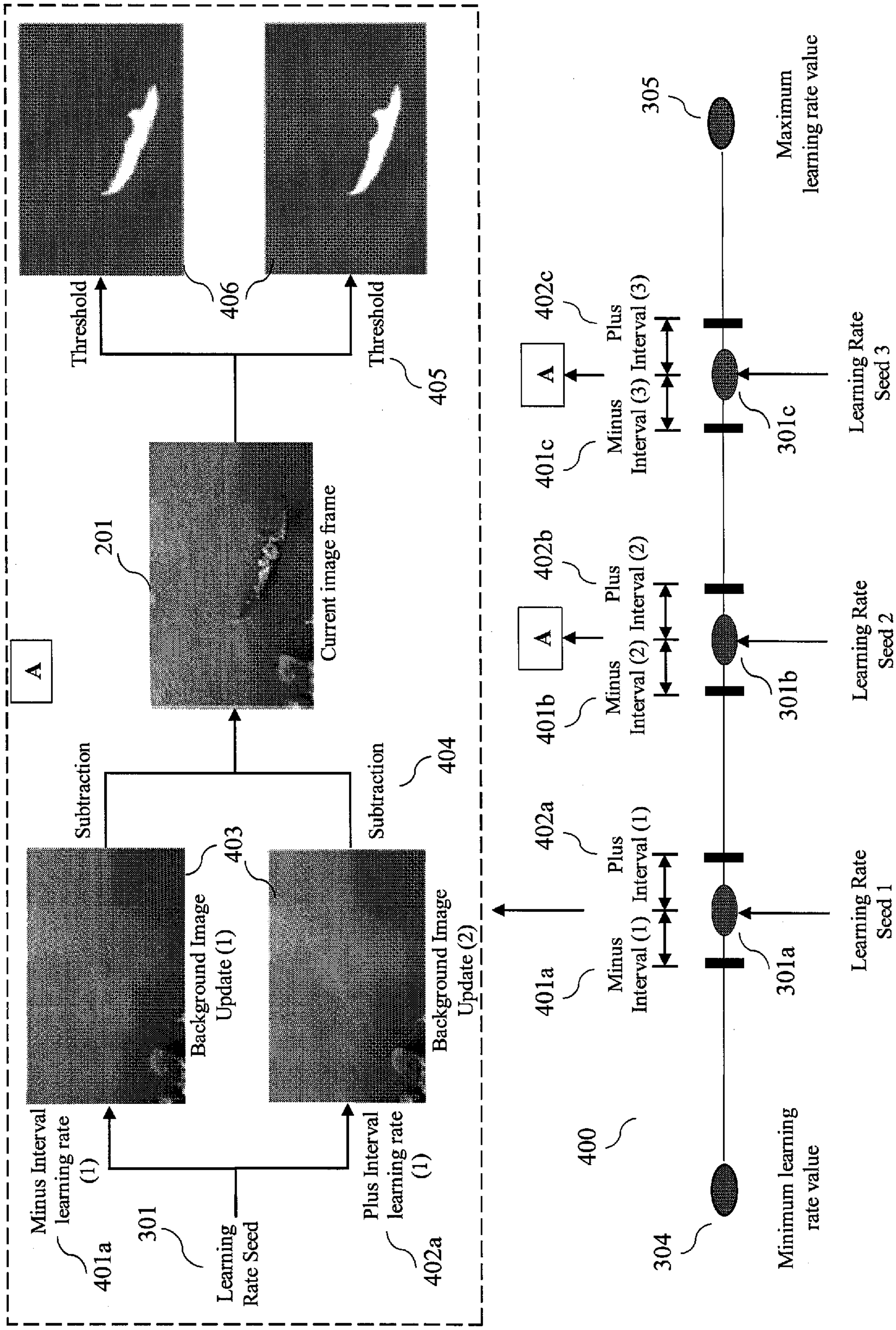
A
Minus Interval learning rate (1)
401a
301
Learning Rate Seed
Plus Interval learning rate (1)
402a
Background Image Update (1)
403
Background Image Update (2)
Subtraction
Subtraction
404
201
Current image frame
Threshold
Threshold
405
406
400
304
Minimum learning rate value
401a
Minus Interval (1)
402a
Plus Interval (1)
301a
Learning Rate Seed 1
401b
Minus Interval (2)
402b
Plus Interval (2)
A
301b
Learning Rate Seed 2
401c
Minus Interval (3)
402c
Plus Interval (3)
A
301c
Learning Rate Seed 3
305
Maximum learning rate value

FIG. 4

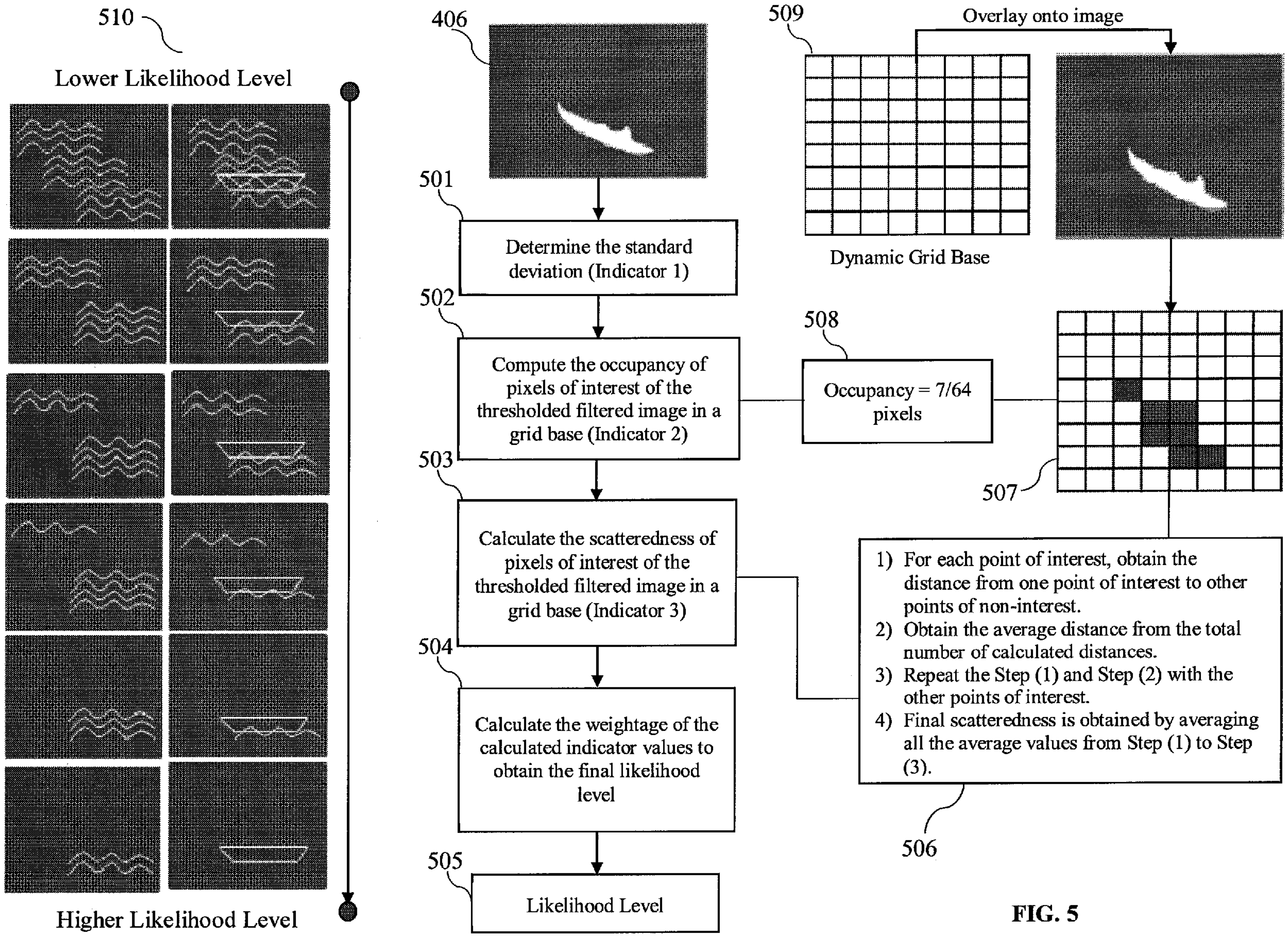
510
Lower Likelihood Level
Higher Likelihood Level
406
501
Determine the standard deviation (Indicator 1)
502
Compute the occupancy of pixels of interest of the thresholded filtered image in a grid base (Indicator 2)
503
Calculate the scatteredness of pixels of interest of the thresholded filtered image in a grid base (Indicator 3)
504
Calculate the weightage of the calculated indicator values to obtain the final likelihood level
505
Likelihood Level
509
Overlay onto image
Dynamic Grid Base
508
Occupancy = 7/64 pixels
507
1) For each point of interest, obtain the distance from one point of interest to other points of non-interest.
2) Obtain the average distance from the total number of calculated distances.
3) Repeat the Step (1) and Step (2) with the other points of interest.
4) Final scatteredness is obtained by averaging all the average values from Step (1) to Step (3).
506

FIG. 5

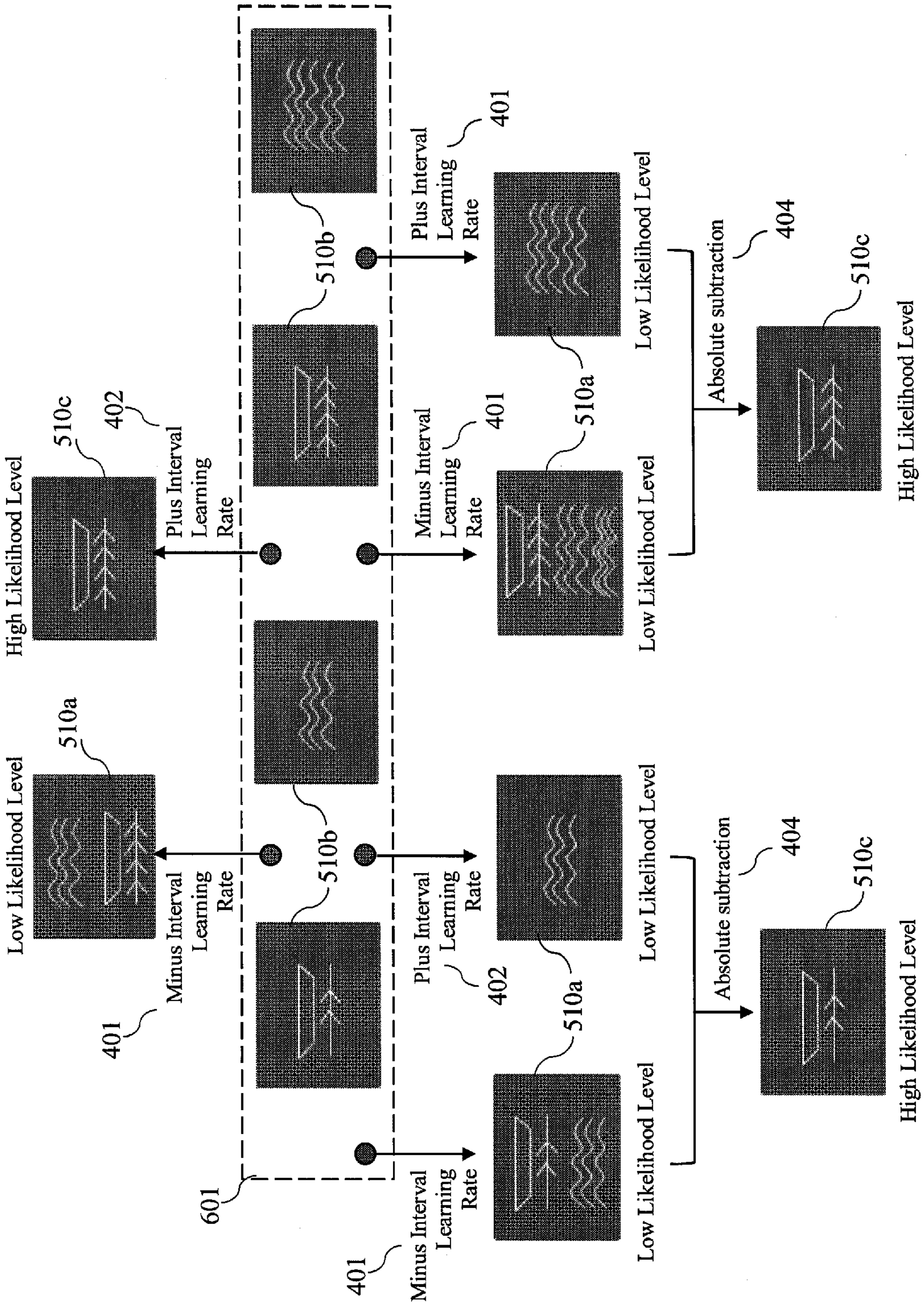
601
401
402
404
510a
510b
510c
Minus Interval Learning Rate
Plus Interval Learning Rate
Low Likelihood Level
High Likelihood Level
Absolute subtraction

FIG. 6

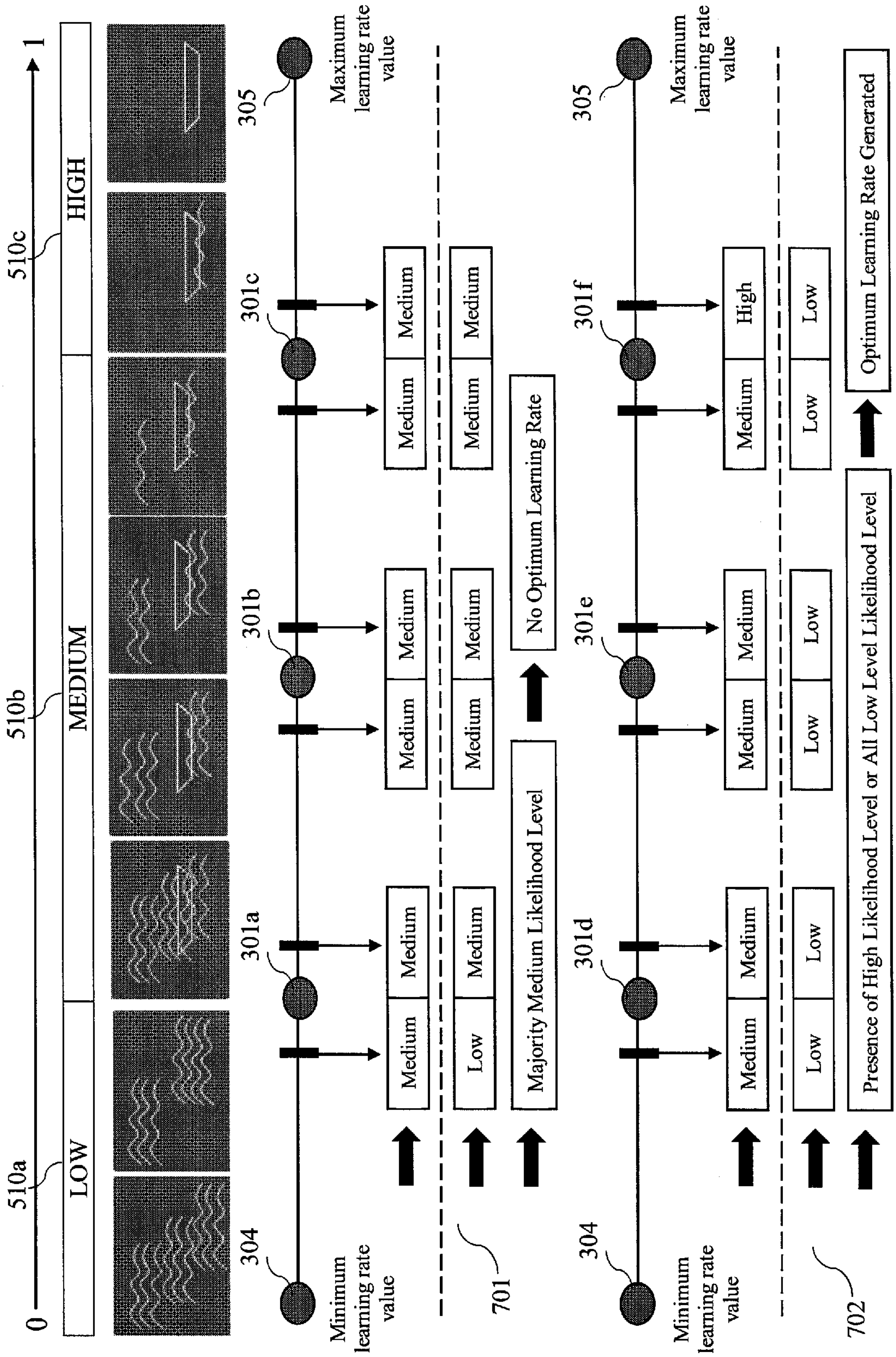
0
1
510a
LOW
510b
MEDIUM
510c
HIGH
304
Minimum learning rate value
301a
301b
301c
305
Maximum learning rate value
Medium
Medium
Medium
Medium
Medium
Medium
Low
Medium
Medium
Medium
Medium
Medium
Majority Medium Likelihood Level
No Optimum Learning Rate
701
304
Minimum learning rate value
301d
301e
301f
305
Maximum learning rate value
Medium
Medium
Medium
Medium
Medium
High
Low
Low
Low
Low
Low
Low
Presence of High Likelihood Level or All Low Level Likelihood Level
Optimum Learning Rate Generated
702

FIG. 7

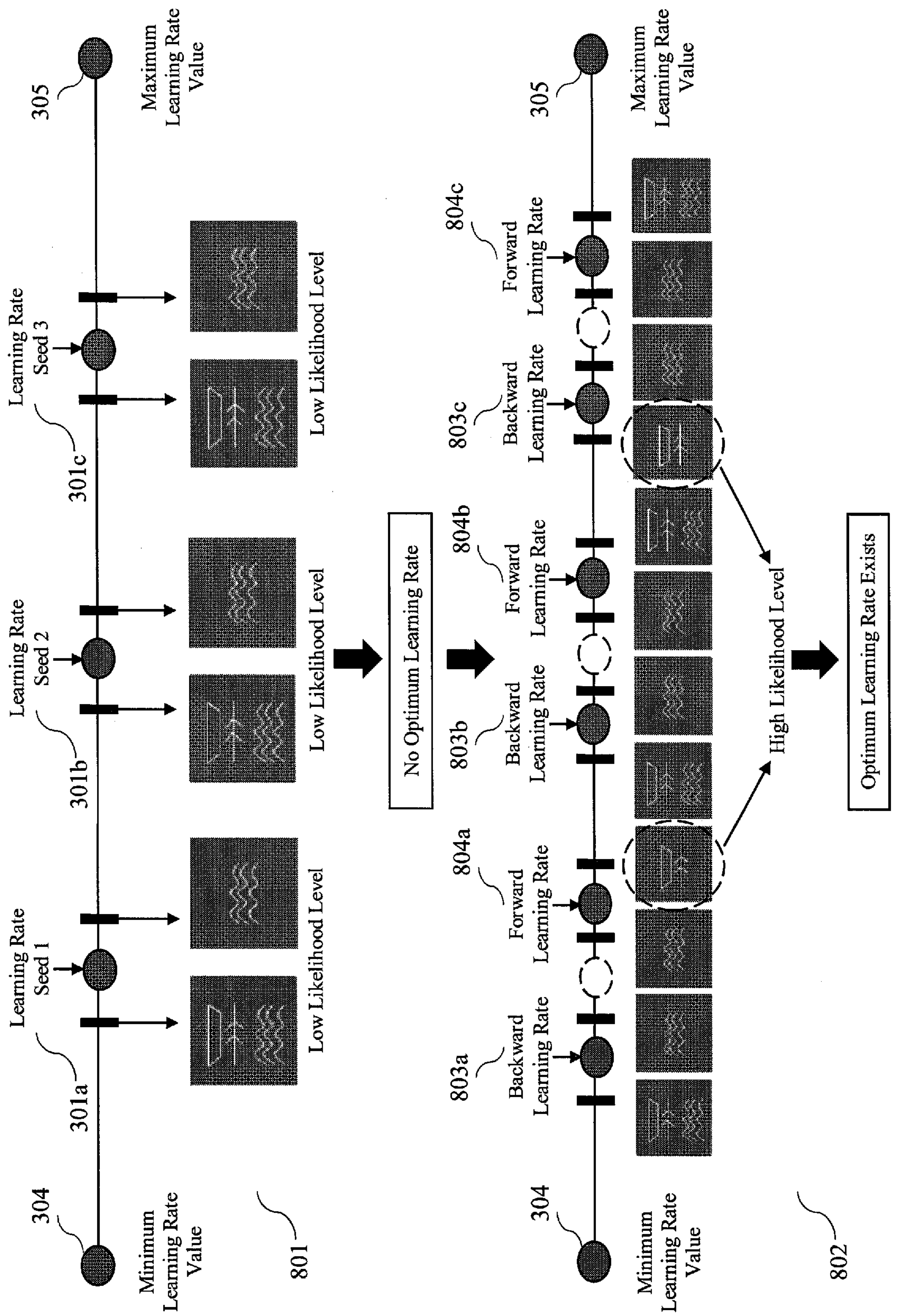
304
Minimum Learning Rate Value
301a
Learning Rate Seed 1
301b
Learning Rate Seed 2
301c
Learning Rate Seed 3
305
Maximum Learning Rate Value
Low Likelihood Level
Low Likelihood Level
Low Likelihood Level
801
No Optimum Learning Rate
304
Minimum Learning Rate Value
803a
Backward Learning Rate
804a
Forward Learning Rate
803b
Backward Learning Rate
804b
Forward Learning Rate
803c
Backward Learning Rate
804c
Forward Learning Rate
305
Maximum Learning Rate Value
802
High Likelihood Level
Optimum Learning Rate Exists

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2020/050185

A. CLASSIFICATION OF SUBJECT MATTER

G06K 9/20(2006.01)i; **G06N 3/08**(2006.01)i; **G06T 7/194**(2017.01)i; **G06T 5/00**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06K 9/20(2006.01); G06K 9/00(2006.01); G06K 9/48(2006.01); G06K 9/62(2006.01); G06T 7/00(2006.01); H04N 19/124(2014.01); H04N 19/146(2014.01); H04N 7/18(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: detecting, moving object, learning rate, speed, filter, update

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012-0106856 A1 (AMIT KUMAR GUPTA et al.) 03 May 2012 (2012-05-03) paragraphs [0010]-[0014], [0035]-[0037]	1-10
A	US 2015-0334398 A1 (DANIEL SOCEK et al.) 19 November 2015 (2015-11-19) paragraphs [0057]-[0060]; and claims 1-9	1-10
A	US 2009-0041359 A1 (TAE-SUH PARK) 12 February 2009 (2009-02-12) paragraphs [0010]-[0016], [0035]-[0047]; and figures 4-5	1-10
A	US 2012-0140066 A1 (HORNG-HORNG LIN) 07 June 2012 (2012-06-07) paragraphs [0011]-[0012], [0025]-[0031]	1-10
A	US 9454819 B1 (THE UNITED STATES OF AMERICA AS REPRESENTED BY THE SECRETARY OF THE AIR FORCE) 27 September 2016 (2016-09-27) claims 1-15	1-10

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2021	**19 April 2021**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/MY2020/050185

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				CN	102592109	B	15 October 2014
				US	10181088	B2	15 January 2019
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				CN	106664417	B	18 February 2020
				EP	3143768	A1	22 March 2017
				EP	3143768	A4	31 January 2018
				EP	3143768	B1	23 September 2020
				KR	10-1894649	B1	04 October 2018
				KR	10-2016-0134768	A	23 November 2016
				US	09584814	B2	28 February 2017
				WO	2015-175201	A1	19 November 2015
US	2009-0041359	A1	12 February 2009	KR	10-1375665	B1	18 March 2014
				KR	10-2009-0015456	A	12 February 2009
				US	08208733	B2	26 June 2012
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US	9454819	B1	27 September 2016	None			