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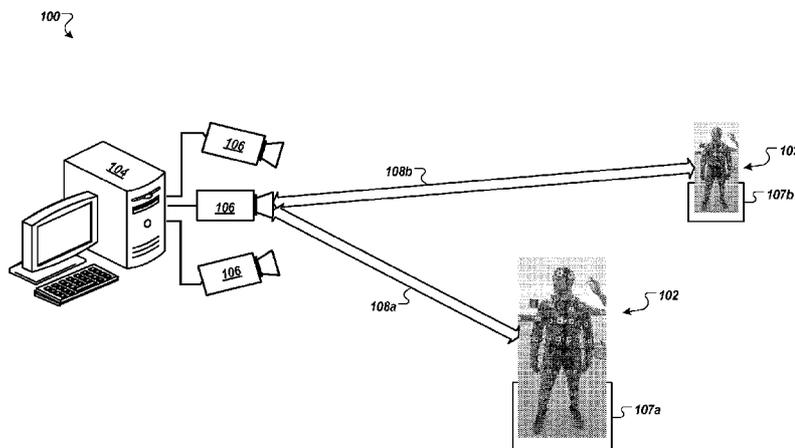


FIG. 1

(57) Abstract: In one aspect, a computer implemented method of motion capture, the method includes tracking the motion of a dynamic object bearing a pattern configured such that a first portion of the patterns is tracked at a first resolution and a second portion of the pattern is tracked at a second resolution. The method further includes causing data representing the motion to be stored to a computer readable medium.



## SCALE INDEPENDENT TRACKING PATTERN

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## CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from United States patent application  
10 13/181,342, filed July 12, 2011, and entitled "Scale indifferent tracking pattern," the entire contents of which are incorporated herein by reference.

## TECHNICAL FIELD

This document relates to computer vision.

## BACKGROUND

15 Motion capture is an approach to generating motion data that is based on tracking and recording the movement of real objects. One common application of motion capture is in animation where a realistic sequence of motion, e.g., by a human actor, can be captured and used to represent the motion of an animated object.

In some motion capture systems, an actor wears a black bodysuit. A number of white  
20 balls are attached to the suit at the actor's joints, e.g., shoulder, elbow, wrist. The actor then performs a sequence of movements which is digitally recorded by a number of cameras. The recorded data is then processed by a motion capture program.

The motion capture program recognizes the white balls as points. If multiple cameras record the same point in a respective frame and the locations of the cameras are known, the  
25 motion capture program can determine the 3D position of the point using triangulation. The motion capture system may determine 3D positions for all of the points in each of the frames.

## SUMMARY

In one aspect, a computer implemented method of motion capture includes tracking the motion of a dynamic object bearing a pattern configured such that a first portion of the

patterns is tracked at a first resolution and a second portion of the pattern is tracked at a second resolution. The method further includes causing data representing the motion to be stored to a computer readable medium.

Implementations can include any, all, or none of the following features. The dynamic object is a human actor. The first resolution is associated with the object at a first distance from a camera and the second resolution is associated with the object at a second distance from the camera; and wherein the method further includes tracking the motion of the dynamic object as the dynamic objects distance from the camera changes from the first distance to the second distance. A first section of the pattern has a first property and a second section of the pattern has a second property; and wherein the method further includes identifying an occlusion of the first section of the dynamic object by a second section of the dynamic object by identifying the second property. The first portion includes first properties and the second portion includes second properties, the first properties being different than the second properties; and wherein the method further includes determining a distance of the dynamic object from a camera using a resolution of the first properties as they are recorded by the camera.

In one aspect, motion capture equipment includes a bodysuit; and on at least part of an outside of the bodysuit, a pattern for exposure to a motion capture system that is configured to detect a at least a first feature and a second feature. The pattern has at least first and second portions, the first portion corresponding to the first feature at a first resolution of the motion capture system and the second portion corresponding to the second feature at a second resolution of the motion capture system.

Implementations can include any, all, or none of the following features. At least a portion of the pattern is trackable at any resolution between the first resolution and the second resolution. The pattern is a fractal. The pattern is pseudo-random noise. A first section of the pattern has a first property and a second section of the pattern has a second property and wherein an occlusion of the first section by the second section is identifiable by identifying the second property. The first feature includes first shapes and the second feature includes second shapes, the first shapes being different than the second shapes. The first feature comprises first shapes and the second feature comprises the first shapes.

In one aspect, a computer implemented method of machine vision includes identifying a first portion of a scale independent pattern at a first resolution. The method further includes identifying a second portion of the scale independent pattern at a second resolution. The second portion of the scale independent pattern cannot be identified at the first resolution.

The method further includes causing data related to the identifying to be stored to a computer readable medium.

Implementations can include any, all, or none of the following features. The method further includes identifying the pattern at a plurality of resolutions between first resolution  
5 and the second resolution. The scale independent pattern is a fractal. The scale independent pattern is pseudo-random noise. The machine vision process is motion capture. The machine vision process is navigation waypoint tracking.

In one aspect, a computer implemented method of machine vision includes identifying a first portion of a scale independent pattern at a first lens focus value. The method further  
10 includes identifying a second portion of the scale independent pattern at a second lens focus value. The method further includes causing data related to the identifying to be stored to a computer readable medium.

In one aspect, a computer implemented method of machine vision includes identifying a first portion of a scale independent pattern without motion blur. The method further  
15 includes identifying a second portion of the scale independent pattern with motion blur. The method further includes causing data related to the identifying to be stored to a computer readable medium.

In one aspect, a computer readable medium storing instructions that, when executed by one or more processing devices, cause the one or more processing devices to perform  
20 operations includes detecting at least a first feature and a second feature of a pattern on the computer readable medium, the pattern having at least first and second portions, the first portion corresponding to the first feature at a first resolution of the motion capture system and the second portion corresponding to the second feature at a second resolution of the motion capture system.

Various implementations of the subject matter described here may provide one or  
25 more of the following advantages. In some implementations, use of a pattern that is trackable over a range of resolutions can enable motion capture filming over a wide range of camera-target distances, resolutions, focus values, and motion blurs. In some implementations, use of a pattern that is trackable over a range of resolutions can enable direction of a motion picture  
30 scene with more flexibility of camera and actor placement and filming parameters. In some implementations, use of a pattern that is trackable over a range of resolutions can enable tracking of an object while the camera or object moves. In some implementations, use of a pattern that is trackable over a range of resolutions can enable tracking of navigational waypoints by a camera system affixed to a moving object.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

### DESCRIPTION OF DRAWINGS

- 5 FIG. 1 is a schematic diagram of an example motion capture system.
- FIG. 2 shows an example scale independent pattern at different resolutions.
- FIG. 3A shows an example motion capture bodysuit with a scale independent pattern.
- FIG. 3B shows an example motion capture bodysuit with some elements of the suit identified.
- 10 FIG. 4 shows an autonomous automobile on a track with example scale independent waypoints.
- FIG. 5 is a flowchart of an example process for tracking a scale independent pattern.
- FIG. 6 is a schematic diagram that shows an example of a computing system that can be used in connection with computer-implemented methods and systems described in this
- 15 document.
- Like reference symbols in the various drawings indicate like elements.

### DETAILED DESCRIPTION

This document describes systems and techniques in which a pattern is imposed on a target for tracking the target by a computer vision technique. The pattern is trackable over a range of resolutions, and may be described as 'scale-independent.' The target can be tracked at a range of distances from capture devices. Additionally, the target can be tracked if it is recorded at a range of image resolutions, image focuses and with motion blurs. The pattern may take the form of makeup, a bodysuit, bands, or other articles worn by the target.

20

25 Because the pattern is designed for several scales, at least some portions of the pattern can remain trackable across a relatively broad range of distances between a camera and the actor.

FIG. 1 is a schematic diagram of an example motion capture system 100. In the system 100, an object, such as an actor 102 may bear a pattern that is trackable by a capture device 104 at a range of resolutions. The marks may be applied in one or more ways. For example, and without limitation, one or more marks can be located on a bodysuit, tattoo, makeup, tracking bands, or other device worn by the actor 102. The marks can create a pattern that is trackable at a range of resolutions may be referred to as 'scale-independent', or

30

'scale- invariant'. Such patterns may be fractals, random noise, self-similar, self-same, or self-affine. The actor 102 shown here is a human actor, but other types of objects may be tracked by the capture device 102. For example, animals, robots, or stationary objects may be tracked, possibly by moving cameras.

5           The capture device 102 can collect motion information. For example, data may be collected that represents the movements or surface shape of the actor 102 as the actor moves. Cameras 106 can be used to capture images (e.g., from different perspectives) of the actor's 102 body or face and provide data that represents the imagery to the capture device 104. Shown here are three cameras 106 for recording the actor 102, but it will be understood that  
10       more or fewer cameras 106 are possible.

          The actor 102 may move in the field of view of the cameras 106, including moving toward or away from the cameras 106. At position 107a, the actor is a distance 108a, and when the actor moves to a position 107b, the actor is at a greater distance 108b.

          When the actor changes positions, the captured size of the actor changes in the view-  
15       plane of the images recorded by the cameras 106, and this is here conceptually illustrated by different-size photos of the actor. The resolution of the actor 102 and the pattern changes with this size and, thus, distance. When at position 107a, the actor 102 and pattern are recorded at a higher resolution than the actor is at position 107b. As such, the actor 102, and the pattern born by the actor, will appear to be larger at position 107a than at position 107b.

20       Other factors can affect the resolution or captured resolution at which the actor 102 is recorded. In one example, the focal length of the cameras 106 may change and change the resolution at which the actor 102 and pattern are recorded. In another example, the actor may move at a speed that introduces motion blur, which can reduce the effective resolution of the actor 102 and pattern.

25       Provided with the captured imagery, the capture device 104 can calculate the position of portions of the pattern on the actor 102. The portions tracked can include discrete shapes within the pattern. The positions may be used, for example, as vertices to create a mesh or cage representation of the actor 102 as the actor 102 moves in the video. Over the capture time period, as the positions of the portions of the pattern change with the actor's  
30       performance, the positions of the vertices of the mesh change.

          As the resolution of the actor 102 and the pattern changes, some trackable portions of pattern may become untrackable by the capture device 104, and some untrackable portions of the pattern may become trackable. When this happens, vertices may be added or removed from the mesh. In some implementations, exiting mesh vertices associated with a portion that

becomes untraceable may merge with a nearby vertex, be given position values based on interpolations of surrounding vertices, or handled in other ways.

FIG. 2 shows an example scale independent pattern 200 at different resolutions. The pattern 200 is a modified version of a Sierpinski triangle fractal pattern where each black triangle has been scaled down in size and gaps of the gray background can be seen between each triangle. The pattern 200 may be placed on the surface of an object, including the actor 102.

The pattern 200 is here shown at a higher resolution 202a and also at a lower resolution 202b. When viewed at the higher resolution 202a, the second order of triangles (the triangles with the second largest size) have a height 206. Similarly, the first order triangles (the triangles with the largest size) have a height 208. When viewed at a lower resolution 202b, with the size reduced due to the difference in resolution with 202a, the first order triangles (the triangles with the largest size) have the same height 206 as the second order of triangles have at the higher resolution 202a.

That is, one more triangles of the height 206 can be observed at both the high resolution 202a and at the low resolution 202b, although it is not the same triangle. If, for example, a vision tracking system is configured to track triangles of a height around the height 206, that vision tracking system would be able to track triangles of the pattern 200 at the resolution 202a and at the resolution 202b. That is, the vision tracking system would be able to recognize the triangle pattern at each of these resolutions, in contrast to, say, a different triangle pattern that is not scale invariant, which the vision tracking system may be unable to recognize at one or more resolutions.

If the vision tracking system is configured to track triangles of a height from the height 208 to the height 206, the vision tracking system would be able to track the first order triangles at any resolution between the resolution 202a and 202b. For example, the pattern on an actor 102 may transition from the resolution 202a to 202b as the actor 102 moves away from the cameras 106 or as the focal length of the cameras 106 change.

The pattern at blurred resolution 202c has been subject to a motion blur or focal blur. For example, the actor 102 may move quickly enough that the at least a portion of the actor and pattern appear with motion blur in one or more frames of the video captured by the cameras 106. At the blurred resolution 202c, the triangles of the pattern appear indistinct, and the pattern may be compressed to resolution 202d to permit a vision tracking system to identify triangles within the pattern.

Other patterns than the one shown in FIG. 2 are possible. In some implementations, a pattern may consist of a collection of circles of different sizes. Some "off the shelf" or commodity vision tracking software may be configured to track circle shapes, and the use of a scale-independent pattern made of circles may require few or no modifications to the commodity vision tracking software. Additionally, circular shapes may be easier to track than other shapes when blurred.

In some implementations, a pattern may include different shapes, optionally with each shape at a different scale. For example, the pattern 200 may be modified by replacing the triangles of a particular size with circles or another shape. These different shapes may be used by tracking software to, for example, calculate the distance of a pattern bearing object from a camera. For example, the distance between the centers of the two closest circles can be measured or the diameter of a single circle can be measured and used to determine the resolution of the pattern. From the resolution, the distance from the camera can be calculated.

In some implementations, a feature of the pattern can vary over the area of the pattern. For example, a bodysuit bearing a pattern can have a torso section that has shapes of a first color or shape, and each leg and arm may have a different color or shape against the same background. A vision tracking system may use this difference to track an object bearing the pattern. For example, if a bodysuit arm bearing a pattern in red and grey occludes a portion of the bodysuit torso bearing the same pattern in black and grey, the tracking system can efficiently identify which portions of the pattern are associated with the arm and which are associated with the torso.

Some patterns may be regular, and some patterns may be irregular. For example, a regular pattern such as a fractal or self-same pattern may be used. Such patterns may be generated efficiently using image manipulation software, and an object bearing such a pattern (e.g. a bodysuit) may be easily manufactured. For example, a bolt of fabric may be printed with a self-same pattern, and a bodysuit may be created from the bolt of fabric. Irregular patterns may be created by hand or by an automated process. For example, a makeup artist may use stamps of varying sizes or makeup tools to apply a pattern of shapes to an actor, with more of the shape around areas of interest (e.g., eyes and mouth on the face, major joints on the body). In another example, a random or pseudo-random noise pattern of shapes may be applied to an object for tracking.

FIG. 3A shows an example motion capture bodysuit 300 with a scale independent pattern. The bodysuit 300 may be worn by, for example, a performance actor being motion

tracked to generate motion data used for animation. In this example, the bodysuit covers only a portion of the actor's body. Such a body suit may be used, for example, when those portions of the actor's body are to be replaced in a motion picture with a computer generated animation and the other portions of the actor's body are to be shown in the motion picture.

5           The body suit 300 can be manufactured from a variety of materials including, but not limited to, spandex, cotton, or nylon. The materials may be cut and formed into the bodysuit shape, for example by sewing pieces or heat-fusing. The pattern may be printed onto the uncut material or the on the bodysuit during or after construction. The pattern may be printed on onto the bodysuit via processes such as screen printing, embroidery, dying, stenciling, and  
10       drawing.

FIG. 3B shows an example motion capture bodysuit 350 with some elements of the suit identified. The bodysuit 350 is shown from two angles, for example the angles of two cameras in a motion capture system configured to track the movements of the elements of the scale-independent pattern on the bodysuit 350.

15           The scale independent pattern on the bodysuit 350 includes white circles of various sizes. A motion capture system may be configured to attempt to identify and track white circles within a defined size range. The identified circles are here superimposed by a green square or cross-shaped target, indicating that many of the largest circle shapes are tracked. That is, each of the green squares/targets corresponds to one or more markers that the system  
20       has detected on the bodysuit. If the actor wearing the bodysuit were to move toward the cameras, the resolution of the circles on the bodysuit 350 would increase, and as a result, the motion capture system may then be able to detect and track the other ones of the circles. Accordingly, the system may then generate new instances of green square/targets corresponding to the other detected circles.

25           FIG. 4 shows an autonomous automobile 402 on a track with example scale independent waypoints 404 and 406. The autonomous automobile 402 is an automobile that is configured or modified to drive with little or no input from a human driver or user and is instead controlled by, for example, a robot. In this example, the scale independent waypoints 404 and 406 have been placed at the corners of a track or roadway to act as navigational aid  
30       for a robot or car traveling on the track. The waypoint may be configured in the form of signs or markings on building, and may be fixed at stationary points. The waypoint 406 is here schematically shown at a lower resolution than the waypoint 404 to indicate that the waypoint 406 is currently farther from the autonomous automobile 402. In the actual implementation, however, the waypoints 404 and 406 may be of the same size.

One or more vision sensors on the autonomous automobile 402 can scan for and identify the scale independent waypoints 404 and 406. When one or more waypoints are detected, their locations can be used by the car system to determine the location of the autonomous automobile 402. In the example shown, the waypoints 404 and 406 bear the same pattern and are different distances from the autonomous automobile 402. At the different ranges, different portions of the pattern are trackable by the autonomous automobile 402, allowing the autonomous automobile 402 to track both of the waypoints 404 and 402 at the same time. Similarly, the waypoints 404 and 406 may be recorded by the autonomous automobile 402 with different blur patterns. The focal length of image capture equipment in the autonomous automobile 402 may cause the waypoint 404 to appear without focal blur and the waypoint 406 appear with focal blur. Additionally, if the autonomous automobile 402 is moving, the waypoint 404 may appear to have more motion blur than the waypoint 406, as the waypoint 404 is closer to the autonomous automobile 402.

In some implementations, the locations of waypoints in the track may be based on a rule-set. For example, the waypoints may be specified to be posted before each intersection or right turn. The autonomous automobile 402 may be programmed with the rule-set so that it can determine a course of action when it identifies a waypoint. For example, the autonomous automobile 402 may stop at a point parallel to the scale independent waypoints 404 and 406, scan for crossing traffic, and proceed when the track is clear.

In some other implementations, the scale independent waypoints 404 and 406 may bear different patterns. For example, each intersection of the track may be associated with a different pattern, and when the autonomous automobile 402 encounters one of the scale independent waypoints 404 and 406, the autonomous automobile 402 can determine its own location on the track based on the location of the scale independent waypoints 404 and 406. In some example, the scale independent waypoints 404 and 406 may bear a pattern with different shapes at different scales to provide the autonomous automobile 402 with information to determine the distance to each scale independent waypoints 404 and 406.

FIG. 5 is a flowchart of an example process 500 for tracking a scale independent pattern. The process 500 can be performed by a system such as the capture device 104, and for illustrative purposes will be described with reference to the system 100 (FIG 1). However, other systems may perform the process 500.

A first portion of a pattern is tracked (502). For example, the cameras 106 can record the actor 102 in position 107b at a distance 108b, and the capture device 104 can identify and track some of the shapes of the pattern on the actor 102. The capture device 104 can map the

movements of the actor 102, as determined by the motions of the tracked shapes, to a motion model. At the distance 108b, some of the shapes on the actors 102 may be at too high or low a resolution for the motion capture software to track, but some of the shapes may appear within the range that the capture device 104 can track. Additionally, the movements of the actor or the focal length of the cameras 106 may blur the images recorded by the cameras 106, reducing the range of resolutions that may be tracked by the capture device 104

Some portion of the pattern is tracked as the object moves (504). For example, as the actor 102 moves from position 107b to position 107a, the resolutions of the shapes of the pattern on the actor 102 change. If the actor 102 moves toward the cameras 106, the resolutions of the shapes of the pattern may increase. At any distance between 108a and 108b, at least some portion of the pattern can be tracked by the capture device 104 and motion information can be determined from the portion that can be trackable.

A second portion of the pattern is tracked (504). For example, the actor 102 can move to the position 107a at a distance 108a from the cameras 106. At position 107a, a second portion of the pattern may be tracked by the capture device 104. For example, smaller triangles in the pattern that were too small to track at a distance 108b may appear larger at position 107a and may be tracked. In some examples, some triangles may be so large that, while they are trackable at the distance 108b, they are trackable at the distance 108a. In other examples, all triangles that are trackable at the distance 108b are also trackable at the distance 108a.

In some implementations, the depth of focus of the cameras 106 may be such that the actor 102 is in focus at the distance 108b and out of focus at 108a, or vice versa. Additionally, the motion of the actor 102 as he moves from distance 108b to 108a may introduce motion blur. To compensate for the blur, the capture device 104 may track larger portions of the pattern than if there was no blur.

Occlusions are processed by identifying properties of sections of the pattern (506). For example, some sections of the pattern on the actor 102 may have different properties. In one implementation, each arm and leg of the bodysuit may have a different background or shape color. If a portion of the bodysuit occludes another part, such as if the actor 102 claps his hands together in front of his chest, the arms of the bodysuit will occlude portions of the torso. The capture device 104 can identify the sections of the bodysuit by the color property, and determine that the arms occlude the torso. In other implementations, properties can change across a pattern continuously instead of discretely. For example, the background color may be a gradient that changes from one color to another. In some implementation, the

shapes of the pattern may be different in different sections. For example, the pattern on the actor's 102 torso may be triangles, and the pattern on the actor's 102 arms may be squares. Other example properties that may be used can include, but are not limited to reflectivity, absorbance, luminescence, and/or the presence or absence of fiducial markers.

5 Distances are determined (510). For example, the capture system may calculate the distances 108a, 108b, or any other camera-actor distance. For example, the portions of the pattern on the actor 102 at a single scale (e.g. all shapes of a particular size) may have a different property than the other portions. The resolution of those portions may be used to calculate the distance between the cameras 106 and the actor 102. In some implementations,  
10 the captured size of the portion (e.g. the number of pixels showing a particular shape) or the captured distance between two parts of the portion (e.g. the number of pixels between two neighboring copies of the particular shape) may be used to measure the resolution of the portion of the pattern.

Data is stored (512). For example, the capture device 104 may store motion vectors,  
15 distance calculations, meshes, or tracking cages to a hard disk or removable computer media. The data can be used later by the same or other systems, for example to drive an animation model.

Although the process 500 was described in terms of a motion capture system, other uses are possible. For example, the process 500 could be used for robotic or autonomous  
20 navigation, inventory tracking, machining cell control, data representation, barcode reading, or body-capture based user interfaces (e.g. a video game interface where user inputs are based on body motions or positions).

FIG. 6 is a schematic diagram that shows an example of a computing system 600. The computing system 600 can be used for some or all of the operations described previously,  
25 according to some implementations. The computing system 600 includes a processor 610, a memory 620, a storage device 630, and an input/output device 640. Each of the processor 610, the memory 620, the storage device 630, and the input/output device 640 are interconnected using a system bus 650. The processor 610 is capable of processing instructions for execution within the computing system 600. In some implementations, the  
30 processor 610 is a single-threaded processor. In some implementations, the processor 610 is a multi-threaded processor. The processor 610 is capable of processing instructions stored in the memory 620 or on the storage device 630 to display graphical information for a user interface on the input/output device 640.

The memory 620 stores information within the computing system 600. In some implementations, the memory 620 is a computer-readable medium. In some implementations, the memory 620 is a volatile memory unit. In some implementations, the memory 620 is a non-volatile memory unit.

5           The storage device 630 is capable of providing mass storage for the computing system 600. In some implementations, the storage device 630 is a computer-readable medium. In various different implementations, the storage device 630 may be a floppy disk device, a hard disk device, an optical disk device, or a tape device.

10           The input/output device 640 provides input/output operations for the computing system 600. In some implementations, the input/output device 640 includes a keyboard and/or pointing device. In some implementations, the input/output device 640 includes a display unit for displaying graphical user interfaces.

15           Some features described can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. The apparatus can be implemented in a computer program product tangibly embodied in an information carrier, e.g., in a machine-readable storage device, for execution by a programmable processor; and method steps can be performed by a programmable processor executing a program of instructions to perform functions of the described implementations by operating on input data and generating output. The described features can be implemented advantageously in one or  
20           more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. A computer program is a set of instructions that can be used, directly or indirectly, in a computer to perform a certain activity or bring about a certain result. A  
25           computer program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment.

30           Suitable processors for the execution of a program of instructions include, by way of example, both general and special purpose microprocessors, and the sole processor or one of multiple processors of any kind of computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer are a processor for executing instructions and one or more memories for storing instructions and data. Generally, a computer will also include, or be operatively

coupled to communicate with, one or more mass storage devices for storing data files; such devices include magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and optical disks. Storage devices suitable for tangibly embodying computer program instructions and data include all forms of non-volatile memory, including by way of  
5 example semiconductor memory devices, such as EPROM (erasable programmable read-only memory), EEPROM (electrically erasable programmable read-only memory), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM (compact disc read-only memory) and DVD-ROM (digital versatile disc read-only memory) disks. The processor and the memory can be supplemented  
10 by, or incorporated in, ASICs (application-specific integrated circuits).

To provide for interaction with a user, some features can be implemented on a computer having a display device such as a CRT (cathode ray tube) or LCD (liquid crystal display) monitor for displaying information to the user and a keyboard and a pointing device such as a mouse or a trackball by which the user can provide input to the computer.

15 Some features can be implemented in a computer system that includes a back-end component, such as a data server, or that includes a middleware component, such as an application server or an Internet server, or that includes a front-end component, such as a client computer having a graphical user interface or an Internet browser, or any combination of them. The components of the system can be connected by any form or medium of digital  
20 data communication such as a communication network. Examples of communication networks include, e.g., a LAN (local area network), a WAN (wide area network), and the computers and networks forming the Internet.

The computer system can include clients and servers. A client and server are generally remote from each other and typically interact through a network, such as the  
25 described one. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other.

A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of this disclosure. Accordingly, other implementations are within the scope of the  
30 following claims.

**WHAT IS CLAIMED IS:**

- 1       1.       A computer implemented method of motion capture, the method comprising:  
2               tracking the motion of a dynamic object bearing a pattern configured such that a  
3       first portion of the patterns is tracked at a first resolution and a second portion of the  
4       pattern is tracked at a second resolution; and  
5               causing data representing the motion to be stored to a computer readable medium.
  
- 6       2.       The method of claim 1 wherein the dynamic object is a human actor.
  
- 7       3.       The method of claim 1 wherein the first resolution is associated with the object at  
8       a first distance from a camera and the second resolution is associated with the object at a  
9       second distance from the camera; and  
10              wherein the method further comprises tracking the motion of the dynamic object  
11       as the dynamic objects distance from the camera changes from the first distance to the  
12       second distance.
  
- 13      4.       The method of claim 1 wherein a first section of the pattern has a first property  
14       and a second section of the pattern has a second property; and  
15              wherein the method further comprises identifying an occlusion of the first section  
16       of the dynamic object by a second section of the dynamic object by identifying the  
17       second property.
  
- 18      5.       The method of claim 1 wherein the first portion comprises first properties and the  
19       second portion comprises second properties, the first properties being different than the  
20       second properties; and  
21              wherein the method further comprises determining a distance of the dynamic  
22       object from a camera using a resolution of the first properties as they are recorded by the  
23       camera.
  
- 24      6.       Motion capture equipment comprising:  
25              a bodysuit; and

26 on at least part of an outside of the bodysuit, a pattern for exposure to a motion  
27 capture system that is configured to detect a at least a first feature and a second feature,  
28 the pattern having at least first and second portions, the first portion corresponding to the  
29 first feature at a first resolution of the motion capture system and the second portion  
30 corresponding to the second feature at a second resolution of the motion capture system.

31 7. The motion capture bodysuit of claim 6, wherein at least a portion of the pattern is  
32 trackable at any resolution between the first resolution and the second resolution.

33 8. The motion capture bodysuit of claim 6, wherein the pattern is a fractal.

34 9. The motion capture bodysuit of claim 6, wherein the pattern is pseudo-random  
35 noise.

36 10. The motion capture bodysuit of claim 6, wherein a first section of the pattern has  
37 a first property and a second section of the pattern has a second property and wherein an  
38 occlusion of the first section by the second section is identifiable by identifying the  
39 second property.

40 11. The motion capture bodysuit of claim 6, wherein the first feature comprises first  
41 shapes and the second feature comprises second shapes, the first shapes being different  
42 than the second shapes.

43 12. The motion capture bodysuit of claim 6, wherein the first feature comprises first  
44 shapes and the second feature comprises the first shapes.

45 13. A computer implemented method of machine vision, the method comprising:  
46 identifying a first portion of a scale independent pattern at a first resolution;  
47 identifying a second portion of the scale independent pattern at a second  
48 resolution, wherein the second portion of the scale independent pattern cannot be  
49 identified at the first resolution;

50 causing data related to the identifying to be stored to a computer readable  
51 medium.

52 14. The method of claim 13, wherein the method further comprises identifying the  
53 pattern at a plurality of resolutions between first resolution and the second resolution.

54 15. The method of claim 13, wherein the scale independent pattern is a fractal.

55 16. The method of claim 13, wherein the scale independent pattern is pseudo-random  
56 noise.

57 17. The method of claim 13, wherein the machine vision process is motion capture.

58 18. The method of claim 13, wherein the machine vision process is navigation  
59 waypoint tracking.

60 19. A computer implemented method of machine vision, the method comprising:  
61 identifying a first portion of a scale independent pattern at a first lens focus value;  
62 identifying a second portion of the scale independent pattern at a second lens  
63 focus value; and  
64 causing data related to the identifying to be stored to a computer readable  
65 medium.

66 20. A computer implemented method of machine vision, the method comprising:  
67 identifying a first portion of a scale independent pattern without motion blur;  
68 identifying a second portion of the scale independent pattern with motion blur;  
69 and  
70 causing data related to the identifying to be stored to a computer readable  
71 medium.

72 21. A computer readable medium storing instructions that, when executed by one or  
73 more processing devices, cause the one or more processing devices to perform operations

74 including:  
75           detecting at least a first feature and a second feature of a pattern on the computer  
76 readable medium, the pattern having at least first and second portions, the first portion  
77 corresponding to the first feature at a first resolution of the motion capture system and the  
78 second portion corresponding to the second feature at a second resolution of the motion  
79 capture system.

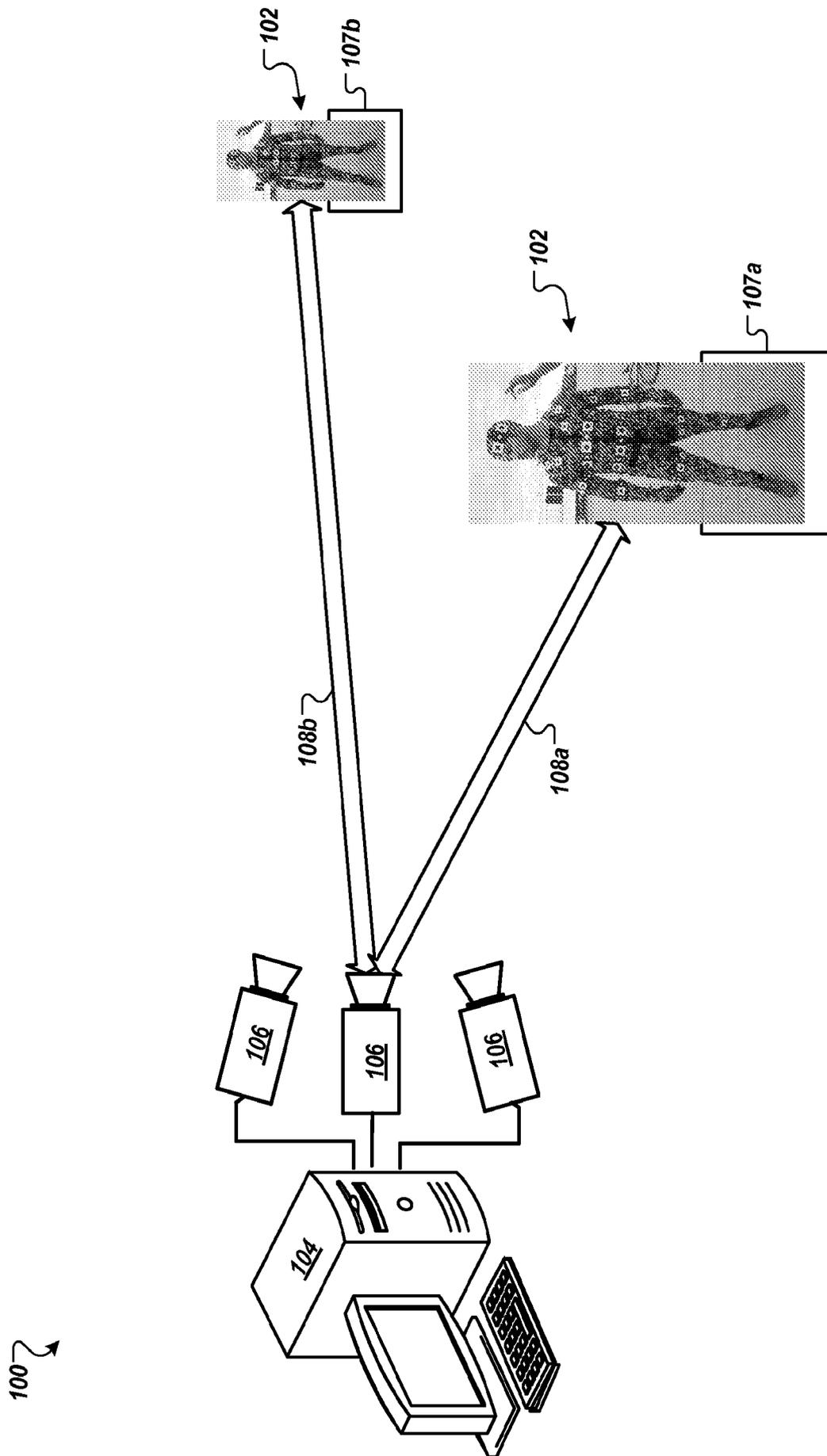


FIG. 1

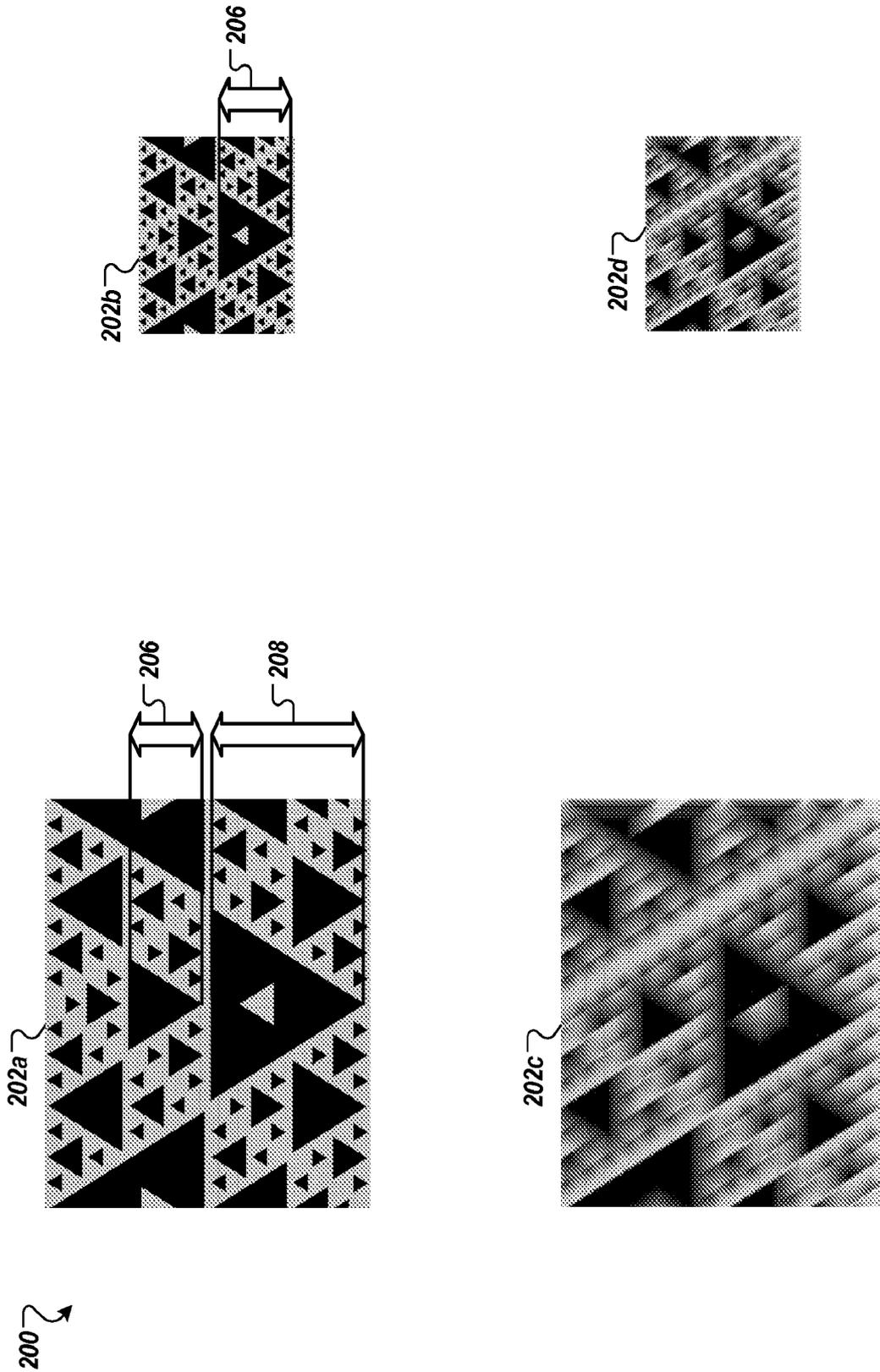


FIG. 2

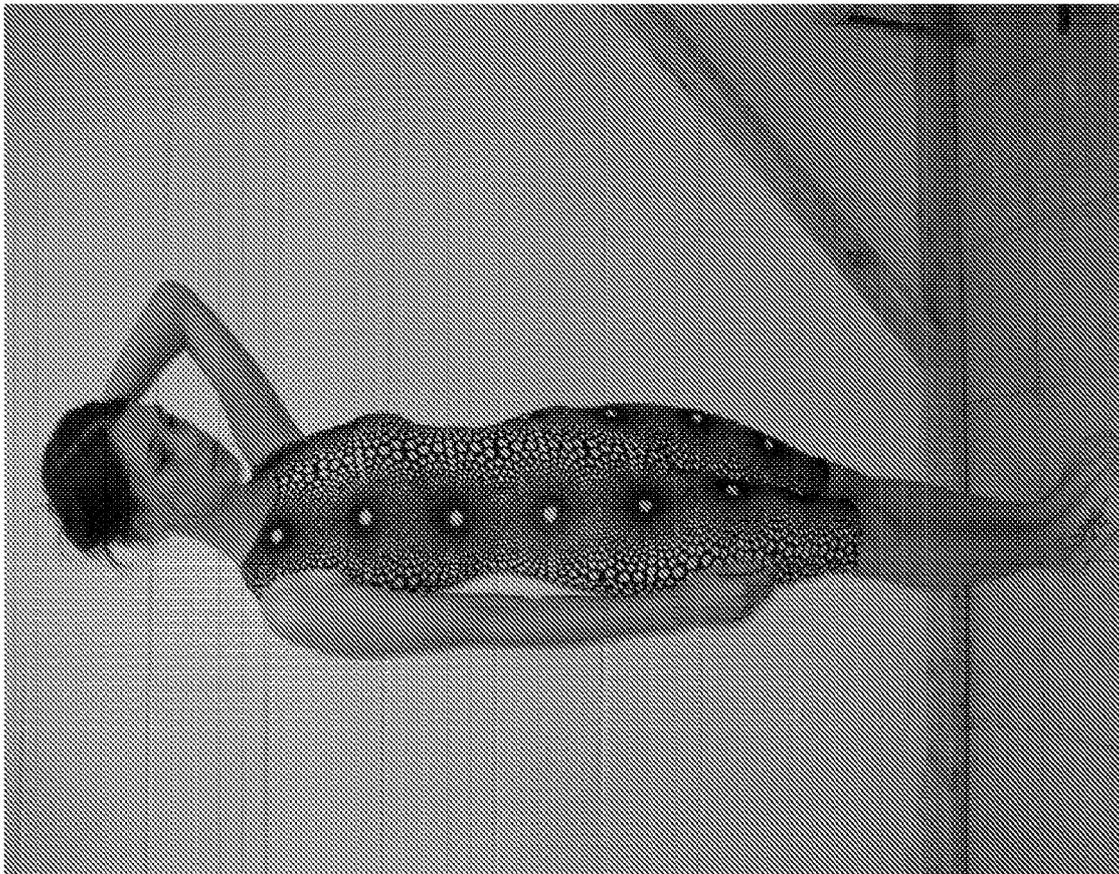


FIG. 3A

300 ↗

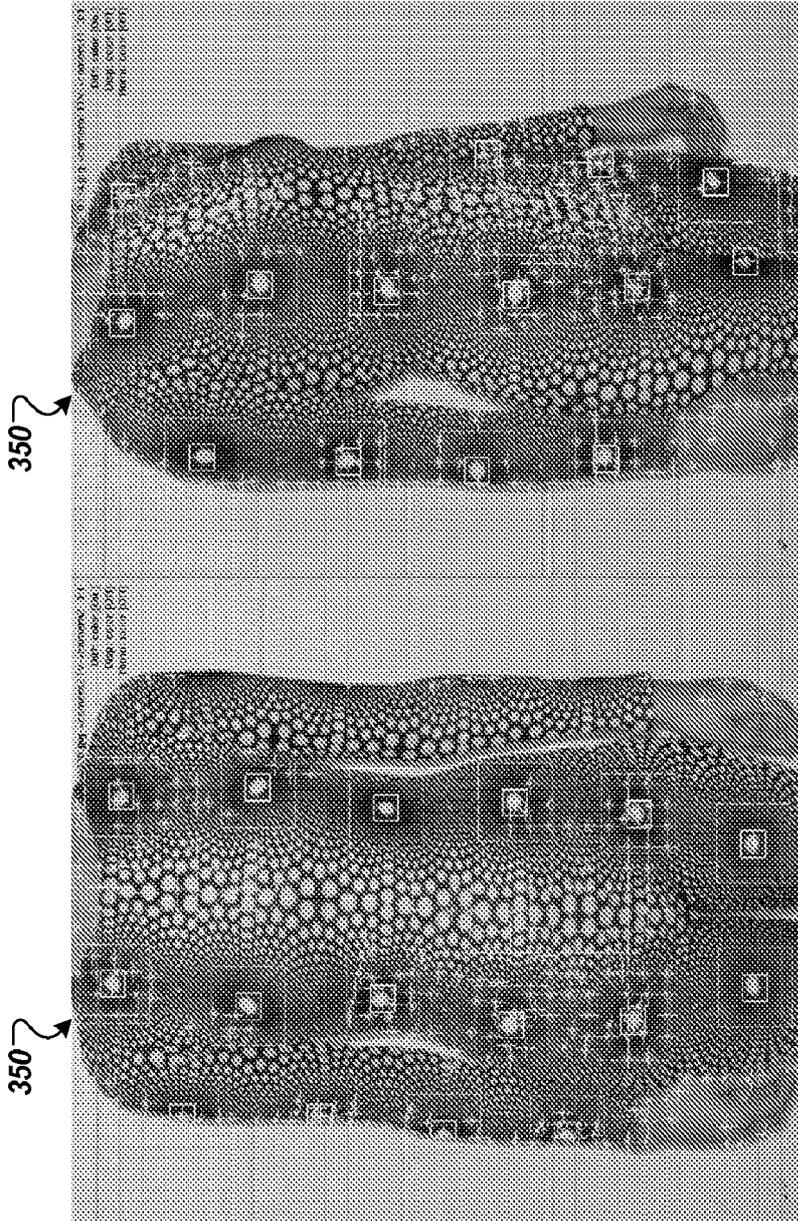


FIG. 3B

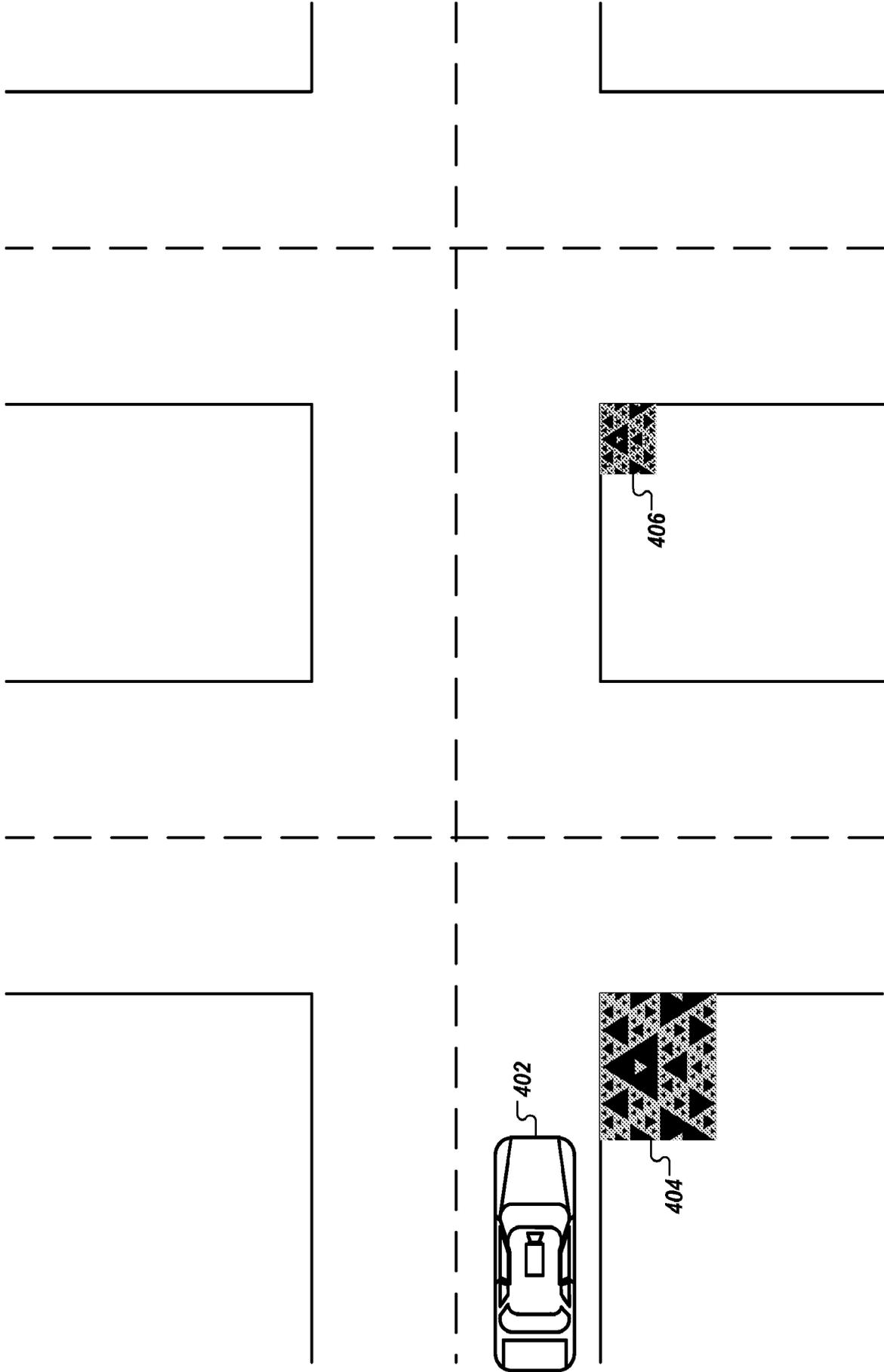


FIG. 4

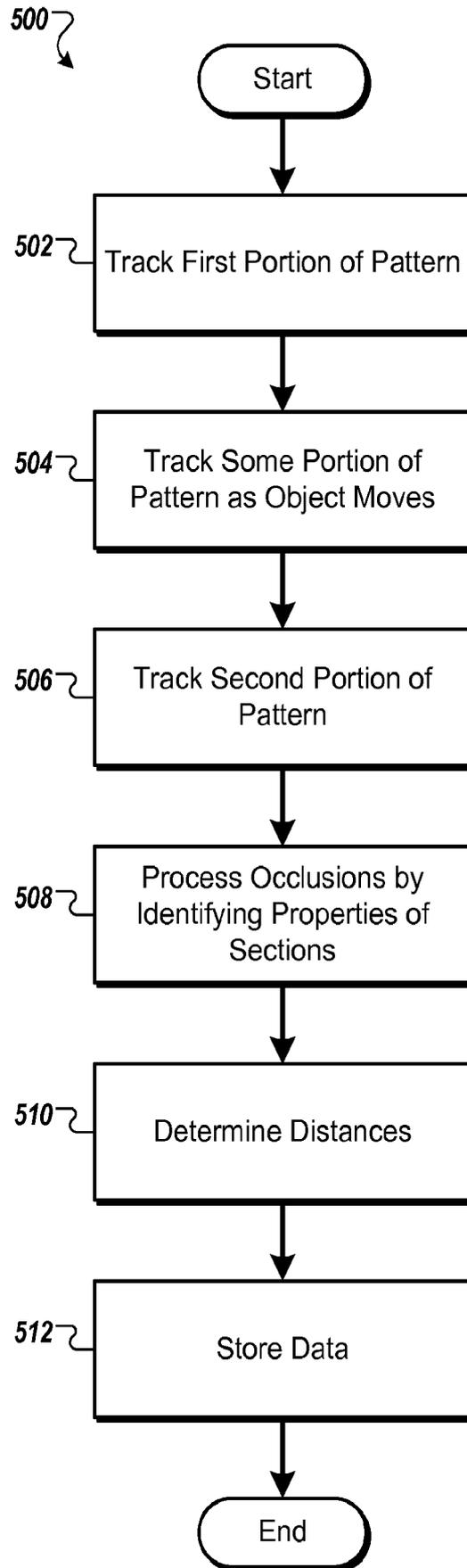


FIG. 5

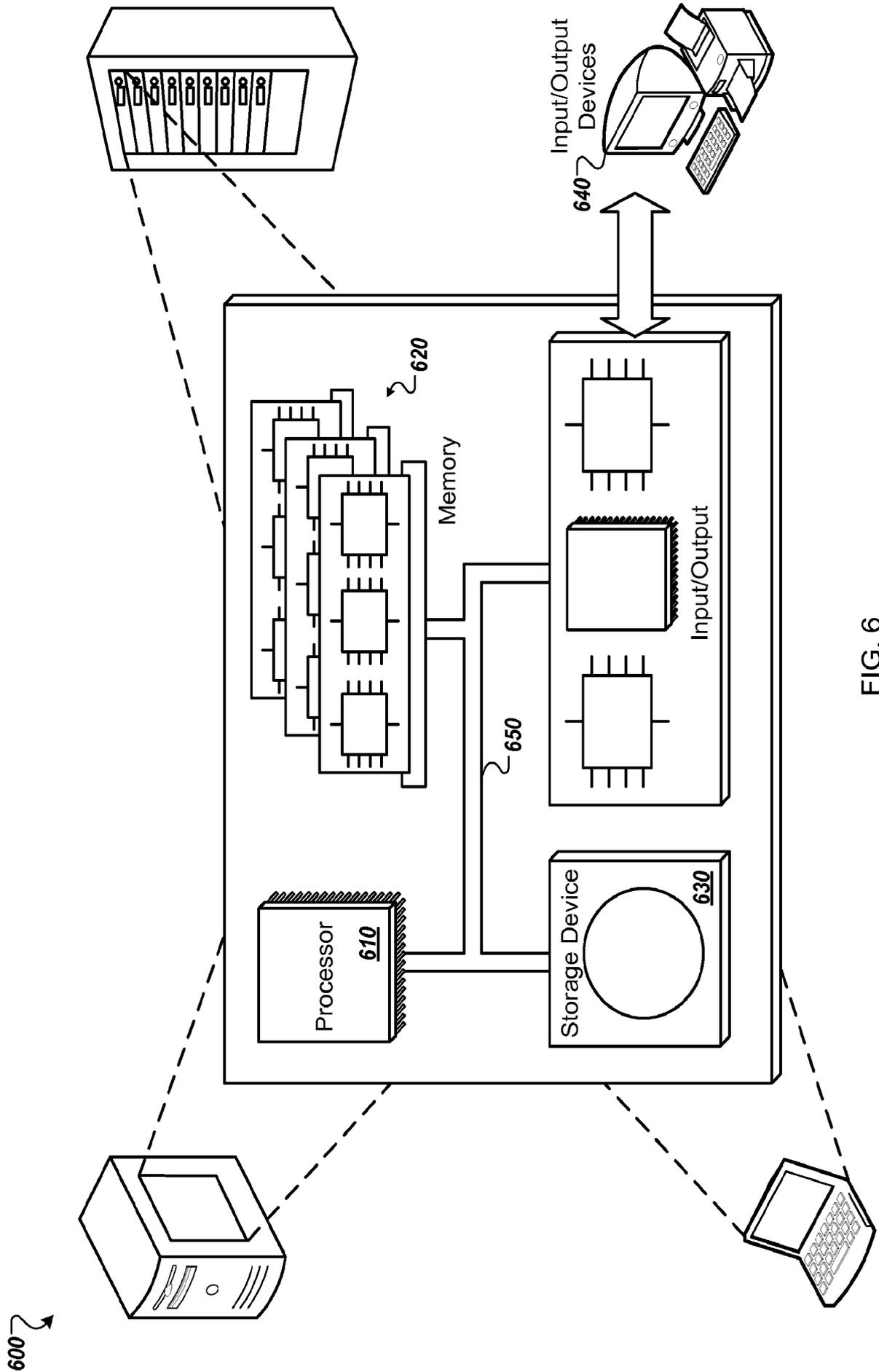


FIG. 6

**INTERNATIONAL SEARCH REPORT**

International application No PCT/US2012/045459
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A. CLASSIFICATION OF SUBJECT MATTER  
 INV. G06T7/00 G06T7/20 G06F3/01 H04N5/222 G06K19/06  
 ADD.

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)  
 G06T G06F H04N G06K

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

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

EPO-Internal , WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	wo 2009/032944 A2 (SONY CORP [JP] ; SONY PICTURES ENTERTAINMENT [US] ; GORDON DEMIAN [US] ; ) 12 March 2009 (2009-03-12) abstract paragraph [0018] - paragraph [0037] paragraph [0041] - paragraph [0043] -----	1-21
X	wo 2004/038657 A2 (ART00LW0RKS [US] ; KATO HI R0KAZU [JP] ART00LW0RKS [US] ; KATO HI R0KAZU [ ] ) 6 May 2004 (2004-05-06) paragraph [0005] - paragraph [0007] paragraph [0027] paragraph [0063] paragraph [0073] - paragraph [0080] ----- -/- .	1-21

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
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- "P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search

29 November 2012

Date of mailing of the international search report

10/12/2012

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## INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/045459

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>BIAN Z ET AL: "DEVELOPEMENT OF A TRACKING METHOD FOR AUGMENTED REALITY APPLIED TO NPP MAINTENANCE WORK AND ITS EXPERIMENTAL EVALUATION" ,            VRST'06. ACM SYMPOSIUM ON VIRTUAL REALITY SOFTWARE &amp; TECHNOLOGY. LIMASSOL, CYPRUS, NOV. 1 - 3, 2006; [ACM SYMPOSIUM ON VIRTUAL REALITY SOFTWARE AND TECHNOLOGY] , NEW YORK, NY : ACM, US, 1 November 2006 (2006-11-01) , pages 35-44, XP001505730,            DOI : 10.1145/1180495.1180505            ISBN : 978-1-59593-321-8            the whole document</p> <p style="text-align: center;">-----</p>	1-21
A	<p>wo 02/054334 AI (VUE METRIC co LTD [KR] ; YI HO KYUN [KR] ) 11 July 2002 (2002-07-11)            abstract            figures 9-11</p> <p style="text-align: center;">-----</p>	1-21
A	<p>us 2010/172542 AI (STEIN GIDEON [IL] ET AL) 8 July 2010 (2010-07-08)            abstract            paragraph [0108] - paragraph [0116]</p> <p style="text-align: center;">-----</p>	1-21
A	<p>us 2007/086653 AI (JAVIDI BAHRAM [US] ET AL) 19 April 2007 (2007-04-19)            abstract            paragraph [0043]            paragraph [0054] - paragraph [0055]            paragraph [0072] - paragraph [0074]</p> <p style="text-align: center;">-----</p>	1-21

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Information on patent family members

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