(12)Indian Patent Application

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(21) Application Number: 202241055229

(22) Filing Date: 27/09/2022 (43) Publication Date: 29/03/2024

(71) Applicant(s): L&T TECHNOLOGY SERVICES LIMITED

(72) Inventor(s): Manju, Sathya Hathwar
Kailash, Ganapathy Muthukumar

(51) International Classifications: G06T 7/00 G06K 9/00 G06T 7/90 G06T 7/70 H04N 13/383

(54) Title: METHOD AND SYSTEM FOR TRACKING TRANSITION OF A COMPONENT

(57) Abstract: A method and system for tracking transition of a component is disclosed. The method may include receiving a first image of an equipment including a target component, when the target component is configured in a first configuration. The method may further include dynamically defining a first tracker mark and a second tracker mark corresponding to a first location and a second location associated with the target component respectively within the first image. The method may further include analysing the first image and the second image to determine a first pixel distance and a second pixel distance within the first image and the second image respectively, and comparing the first pixel distance and the second pixel distance to determine an extent of transition of the target component during the transition of the target component from the first configuration to the second configuration.

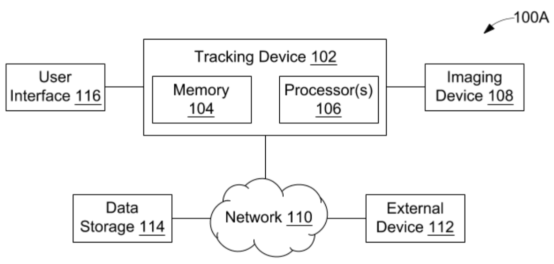


FIG. 1A

FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

METHOD AND SYSTEM FOR TRACKING TRANSITION OF A COMPONENT

2. APPLICANT(S)

(a) NAME : **L&T TECHNOLOGY SERVICES LIMITED**
(b) NATIONALITY : **INDIAN**
(c) ADDRESS : DLF IT SEZ Park, 2nd Floor – Block 3
1/124, Mount Poonamallee Road,
Ramapuram, Chennai – 600 089,
INDIA.

3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

Technical Field

[001] This disclosure relates generally to image-based detection, and more particularly to a method and system for tracking transition of a component using image processing.

BACKGROUND

[002] Construction, mining, and other related industries require heavy operations like earthmoving, digging, and trenching, etc. to be performed regularly. These operations are performed with various heavy equipment like excavators, bulldozers, rollers, etc. The heavy equipment perform the operations which are critical in nature, and hence needs to be performed with utmost accuracy, as any discrepancies or errors in the operations could derail the whole project and lead to heavy losses. Therefore, operations of these heavy equipment need to be tracked regularly to detect any errors or discrepancies.

[003] Presently, the operations of these heavy equipment are tracked either manually through visual inspection skilled operators or attaching sensors on the components of the equipment which are to be tracked. However, the visual inspection may be effective only when a limited number of components are to be tracked. Further, the visual inspection is prone to human errors. The use of sensors although may provide higher accuracy in results, however, attaching and detaching the sensors is a cumbersome and time-consuming process.

[004] There is, therefore, a need to provide a tracking system which can track the operation of the equipment and detect errors and faults in the components of the equipment in a timely and cost-effective manner.

SUMMARY

[005] In an embodiment, a method of tracking transition of a component is disclosed. The method may include receiving a first image of an equipment comprising a target component when the target component is configured in a first configuration. The method may further include dynamically defining a first tracker mark within the first image corresponding to a first location associated with the target component and a second tracker mark within the first image corresponding to a second location associated with the target component. The method may further include analysing the first image to determine a first pixel distance between the first tracker mark and the second tracker mark within the first image. The method may further include receiving a second image of the equipment along with the target component when the target component is configured in the second configuration. The method may further include analysing the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image, comparing the first pixel distance and the second pixel distance, and determining an extent of transition of the target component during the transition of the target component between the first configuration and the second configuration based on the comparison between the first pixel distance and the second pixel distance.

[006] In another embodiment, a system for tracking transition of a target component is disclosed. The system may include an imaging device configured to obtain images of an equipment comprising a target component and a tracking device communicatively coupled to the imaging device. The tracking device may include a processor and a memory communicatively coupled to the processor. The memory stores processor-executable instructions which on execution by the processor cause the processor to receive a first image of an equipment comprising a target component when the target component may be configured in a first configuration, and dynamically define a first tracker mark within the first image corresponding to a first location associated with the target component and a second tracker mark within the first image corresponding to a second location associated with the target component. The set of images may include a predetermined number of images from the plurality of images. The processor-executable instructions may further cause the processor to analyze the first image to determine a first pixel distance between the first tracker mark and the second tracker mark within the first image. The processor-executable instructions may further cause the processor to receive a second image of the equipment along with the target component when the target component may be configured in the second configuration and analyse the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image. The processor-executable instructions may further cause the processor to compare the first pixel distance and the second pixel distance, and determine an extent of transition of the target component during the transition of the target component between first configuration and the second configuration based on the comparison.

BRIEF DESCRIPTION OF THE DRAWINGS

[007] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[008] **FIG. 1A** illustrates a block diagram of a system for tracking transition of a component, in accordance with an embodiment of the present disclosure.

[009] **FIG. 1B** illustrates a functional block diagram of a tracking device of the system of FIG. 1A, in accordance with an embodiment.

[010] **FIG. 2A** illustrates a flowchart of a method of tracking transition of a component, in accordance with an embodiment.

[011] **FIG. 2B** illustrates a flowchart of a method of determining calibration-factor, in accordance with some embodiments.

[012] **FIG. 2C** illustrates a flowchart of a method of determining an extent of transition of the target component during the transition of the target component 304 between first configuration and the second configuration, in accordance with some embodiments.

[013] **FIG. 2D** illustrates a flowchart of a method of determining a rate of transition of the target component between the first configuration and the second configuration, in accordance with some embodiments.

[014] **FIGs. 3A-3B** are different snapshots of an environment in which an equipment and an imaging device are implemented for tracking transition of a component, in accordance with some embodiments.

[015] **FIG. 4** is a process diagram of a process of defining tracker marks in an image via a user-interface, in accordance with some embodiments.

[016] **FIG. 5A** is a snapshot of an equipment with a target component configured in the first configuration, in accordance with some exemplary embodiments.

[017] **FIG. 5B** is a snapshot of the equipment with the target component configured in the second configuration, in accordance with some exemplary embodiments.

[018] **FIG. 6** is a snapshot of the user-interface for feeding the actual distance to the tracking application, in accordance with some embodiments.

[019] **FIG. 7** is a graphical representation of a rate of transition of the target component, in accordance with some embodiments.

[020] **FIGs. 8A-8B** are graphical representations of the transition of the target component, in accordance with some embodiments.

DETAILED DESCRIPTION OF THE DRAWINGS

[021] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims. Additional illustrative embodiments are listed.

[022] The present disclosure provides various techniques for tracking components of equipment, such as boom cylinder of excavators, based on camera surveillance and without using any physical sensors. The present disclosure provides for an image or video-based techniques, for determining changes and the corresponding anomalies in the lengths of the boom cylinder. The techniques use a field camera setup which may be kept in the field of view of the component to be tracked. The camera may perform live video acquisition to map and track the component of the excavator under motion, where the camera may generate a set of images with initial and final configurations of the components. Further, based on the images received, image-based analytics are performed to determine the operational efficiency of the component of the equipment.

[023] Referring now to **FIG. 1A**, a block diagram of an exemplary system 100 for tracking transition of a component is illustrated, in accordance with an embodiment of the present disclosure. The system 100 may include a tracking device 102. The tracking device 102 may be a computing device having data processing capability. In particular, the tracking device 102 may have the capability for tracking the movement of a component attached with an equipment during an operation. Examples of the tracking device 102 may include, but are not limited to a desktop, a laptop, a notebook, a netbook, a tablet, a smartphone, or a mobile phone.

[024] Additionally, in some embodiments, the system 100 may include an imaging device 108. The imaging device 108 may generally include one or more cameras, such as a high-resolution camera. The system 100 may further include a data storage 114. For example, the data storage 114 may store various types of data required by the tracking device 102 for tracking the movement of the component under observation. For example, the data storage 114 may store one or more images or pre-recorded videos captured by the imaging device 108.

[025] The tracking device 102 may be communicatively coupled to the data storage 114 and the imaging device 108 via a communication network 110. The communication network 110 may be a wired or a wireless network and the examples may include, but are not limited to the Internet, Wireless Local Area Network (WLAN), Wi-Fi, Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (WiMAX), and General Packet Radio Service (GPRS). Various devices in the system 100 may be configured to connect to the communication network 110, in accordance with various wired and wireless communication protocols. Examples of such wired and wireless communication protocols may include, but are not limited to, a Transmission Control Protocol and Internet Protocol (TCP/IP), User Datagram Protocol (UDP), Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP), Zig Bee, EDGE, IEEE 802.11, light fidelity (Li-Fi), 802.16, IEEE 802.11s, IEEE 802.11g, multi-hop communication, wireless access point (AP), device to device communication, cellular communication protocols, and Bluetooth (BT) communication protocols.

[026] The tracking device 102 may be configured to perform one or more functionalities that may include receiving, from the imaging device 108, a first image of an equipment along with a target component further configured in a first configuration, and dynamically defining a first tracker mark and a second tracker mark corresponding to a first and a second location, respectively, associated with the target component. The one or more functionalities may further include analysing the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image. The one or more functionalities may further include receiving, from the imaging device 108, a second image of an equipment along with the target component when the equipment is configured in a second configuration. The one or more functionalities may further include analysing the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image. The one or more functionalities may further include comparing the first pixel distance and the second pixel distance corresponding to the first image and the second image, and determining an extent of transition of the target component during the transition of the target component between first configuration and the second configuration based on the comparison.

[027] In order to perform the above-discussed functionalities, the tracking device 102 may include a processor 106 and a memory 104. The processor 106 may include suitable logic, circuitry, interfaces, and/or code that may be configured to correct the reflection region of an image. The processor 106 may be implemented based on temporal and spatial processor technologies, which may be known to one ordinarily skilled in the art. Examples of implementations of the processor 106 may be a Graphics Processing Unit (GPU), a Reduced Instruction Set Computing (RISC) processor, an Application-Specific Integrated Circuit (ASIC) processor, a Complex Instruction Set Computing (CISC) processor, a microcontroller, Artificial Intelligence (AI) accelerator chips, a co-processor, a central processing unit (CPU), and/or a combination thereof. The memory 104 may include suitable logic, circuitry, and/or interfaces that may be configured to store instructions executable by the processor 106. The memory 104 may store instructions that, when executed by the processor 106, may cause the processor 106 to track the transition of the target component in order to determine its operational efficiency. The memory 104 may be a non-volatile memory or a volatile memory. Examples of non-volatile memory may include, but are not limited to a flash memory, a Read-Only Memory (ROM), a Programmable ROM (PROM), Erasable PROM (EPROM), and Electrically EPROM (EEPROM) memory. Examples of volatile memory may include but are not limited to Dynamic Random-Access Memory (DRAM), and Static Random-Access memory (SRAM). The memory 104 may also store various data that may be captured, processed, and/or required by the system 100.

[028] Additionally, the tracking device 102 may be communicatively coupled to an external device 112 for sending and receiving various data. Examples of the external device 112 may include, but are not limited to, a remote server, digital devices, and a computer system. The tracking device 102 may connect to the external device 112 over the communication network 110. The tracking device 102 may connect to external device 112 via a wired connection, for example via Universal Serial Bus (USB). A computing device, a smartphone, a mobile device, a laptop, a smartwatch, a personal digital assistant (PDA), an e-reader, and a tablet are all examples of external devices 112.

[029] The system 100 may further include input/output devices implementing a user-interface 116. The user-interface 116, for example, may include a display screen and other input/output devices known in the art. The user-interface 116 may be used for providing various inputs to the tracking device 102 including measured length/distance, inputs relating to tracker marks, etc. Further, the user-interface 116 may render the images/videos of the equipment along with the tracker marks showing the transition of a target component associated with the equipment.

[030] Referring now to **FIG. 1B**, a functional block diagram of the tracking device 102 is illustrated, in accordance with an embodiment of the present disclosure. As mentioned above, the tracking device 102 may be configured to determine tracking transition of a component associated with an equipment. The tracking device 102 may include an image receiving module 122, a tracker mark defining module 124, an image analyzing module 126, a pixel distance comparing module 128, an extent of transition determining module 130, a time-stamp obtaining module 132, a rate of transition determining module 134, and a calibration-factor determining module 136.

[031] It should be noted that all the aforementioned modules 122-136 may be represented as a single module or a combination of different modules. Further, as will be appreciated by those skilled in the art, each of the modules 122-136 may reside, in whole or in parts, on one device or multiple devices in communication with each other. In some embodiments, each of the modules 122-136 may be implemented as dedicated hardware circuit comprising custom application-specific integrated circuit (ASIC) or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. Each of the modules 122-136 may also be implemented in a programmable hardware device such as a field programmable gate array (FPGA), programmable array logic, programmable logic device, and so forth. Alternatively, each of the modules 122-136 may be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, include one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, function, or other construct. Nevertheless, the executables of an identified module or component need not be physically located together but may include disparate instructions stored in different locations which, when joined logically together, include the module and achieve the stated purpose of the module. Indeed, a module of executable code could be a single instruction, or many instructions, and may even be distributed over several different code segments, among different applications, and across several memory devices.

[032] The image receiving module 122 may receive, from an imaging device, a first image of an equipment comprising a target component, when the target component is configured in a first configuration. For example, the equipment may be an excavator and the target component may be a boom cylinder associated with the excavator. The image receiving module 122 may further receive, from the imaging device, a second image of the equipment along with the target component when the target component is configured in the second configuration;

[033] The tracker mark defining module 124 may dynamically define a first tracker mark within the first image corresponding to a first location associated with the target component and a second tracker mark within the first image corresponding to a second location associated with the target component. Additionally, the tracker mark defining module 124 may dynamically define a third tracker mark within the first image corresponding to a fixed location associated with the equipment.

[034] The image analyzing module 126 may analyse the first image to determine a first pixel distance between the first tracker mark and the second tracker mark within the first image. The image analyzing module 126 may further analyse the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image.

[035] The pixel distance comparing module 128 may compare the first pixel distance and the second pixel distance. The extent of transition determining module 130 may determine an extent of transition of the target component during the transition of the target component between first configuration and the second configuration, based on the comparison between the first pixel distance and the second pixel distance.

[036] Additionally, the time-stamp obtaining module 132 may receive, along with the first image, a first time-stamp associated with the first image. The time-stamp obtaining module 132 may further receive, along with the second image, a second time-stamp associated with the second image.

[037] The rate of transition determining module 134 may determine a time duration of the transition of the target component between the first configuration to the second configuration. The rate of transition determining module 134 may further correlate the extent of the transition and the time duration of the transition of the target component between the first configuration to the second configuration, and determine a rate of transition based on the correlation.

[038] Further, additionally, the calibration-factor determining module 136 may determine a calibration-factor. To this end, the calibration-factor determining module 136 may, upon defining the second tracker mark and the third tracker mark within the first image, receive an actual fixed distance between the second location associated with the target component and the fixed location associated with the equipment. The calibration-factor determining module 136 may further analyse the first image to determine a third pixel distance between the second tracker mark and the third tracker mark within the first image. The calibration-factor determining module 136 may further correlate the actual fixed distance and the third pixel distance, and determine a calibration-factor based on the correlation of the actual fixed distance and the third pixel distance.

[039] Referring now to **FIG. 2**, a flowchart of a method 200 of tracking transition of a component is illustrated, in accordance with some embodiments. In some embodiments, the method 200 may be implemented by the tracking device 102 as discussed above.

[040] At step 202, a first plane associated with the imaging device 108 and a second plane associated with an equipment may be determined. By way of an example, the equipment may be an excavator, which may implement a target component, which for example, may be a boom cylinder. At step 204, an orientation of the imaging device 108 relative to the equipment may be determined, based on the first plane associated with the imaging device and the second plane associated with the equipment. The steps 202-204 are explained in detail in conjunction with FIGs. 3A-3B.

[041] Referring now to **FIGs. 3A-3B**, different snapshots of an environment 300 in which an equipment 302 (e.g. an excavator) and the imaging device 108 are implemented for tracking transition of a component 304 (e.g. a boom cylinder) associated with the equipment 302 are illustrated, in accordance with some embodiments. The target component 304 may be positioned in the field of view of the imaging device 108 for the imaging device 108 to receive a plurality of images corresponding to the various configurations of the target component 304. The imaging device 108 may generate a wide field of view to track the transition of the target component 304 more precisely. Further, to obtain a better field of view of the target component 304, the equipment 302 and the imaging system 108 may be oriented parallel to each other.

[042] A first plane 306 associated with the imaging device 108 and a second plane 308 associated with the equipment 302 may be determined. Thereafter, an orientation of the imaging device 108 relative to the equipment 302 may be determined, based on the first plane 306 and the second plane 308. As shown in FIG. 3B, it is desirable to have the first plane 306 and the second plane 308 oriented parallel to each other. This parallel orientation may allow for a better field of view of the target component 304. Once the first plane 306 and the second plane 308 are determined, it may be desirable to mark lines on the ground corresponding to the first plane 306 and the second plane 308.

[043] The imaging device 108 may be positioned at a predetermined distance from the equipment 302. In other words, the first plane 306 and the second plane 308 may be separated by a predetermined distance. In some example embodiments, a distance (the predetermined distance) between the first plane 306 and the second plane 308 may be 7.5 meters.

[044] Referring back to FIG. 2, at step 206, a first image of the equipment 302 including the target component 304 may be received from the imaging device 108. The first image may be obtained by the imaging device 108 when the target component 304 is configured in a first configuration. For example, the first configuration may correspond to the boom cylinder (i.e. the target component 304) in a contracted (unexpanded) state.

[045] At step 208, a first tracker mark and a second tracker mark may be dynamically defined within the first image corresponding to a first location and a second location associated with the target component, respectively. In some embodiments, dynamically defining the first tracker mark and the second tracker mark may include receiving a user input corresponding to the first tracker mark and the second tracker mark. For example, receiving the user input may include receiving from a user, via a user interface, a selection of a region within the first image, wherein the region corresponds to one of the first location and the second location. Based on the user input, the first location and the second location may be fixed corresponding to the first tracker mark and the second tracker mark, respectively. Further, the fixing may include determining a centroid-point associated with the region within the first image. It should be noted that upon fixing, the first tracker mark and the second tracker mark may be automatically defined in subsequent images.

[046] In some additional embodiments, at step 210, a third tracker mark may be dynamically defined within the first image corresponding to a fixed location associated with the equipment 302. The fixed location may be a location selected on the equipment 302, such that distance between the second location and the fixed location is not supposed to change over time, i.e. during transition of the equipment between different configurations. Further, it should be noted that distance between the first location and the second location associated with the target component 304 is changeable during transition of the target component between the first configuration and the second configuration. For example, the first location and the second location may correspond to the extreme ends of the boom cylinder, and since the length of the boom cylinder is supposed to increase or decrease in order to cause transition of the equipment between the first and second configuration, the distance between first location and the second location is susceptible to change. The steps 208-210 are explained in detail in conjunction with FIG. 4.

[047] Referring now to **FIG. 4**, a process diagram of a process 400 of defining tracker marks in an image via a user-interface (for example, the user-interface 116) is illustrated, in accordance with some embodiments.

[048] At step 402, an option to define at least one of a first tracker mark 410A, a second tracker mark 410B, and a third tracker mark 410C may be provided to the user, via the user-interface. For example, the user may be provided an option to define the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark via a drag-and-drop action. To this end., the user-interface may display the first image along with multiple tracker marks, and the user may be provided a facility to drag-and-drop these tracker marks to position them on selected locations of their choice on the first image.

[049] At step 404, in order to the define the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C, first a region of interest (ROI) window 412 may be defined. Once the first plane 306 and the second plane 308 are oriented parallel to each other, the user may press a button (for example, a soft user-interface button or a physical button) to set the ROI window 412. In response to the pressing of this button, the ROI window 412 may pop out and the user may position this ROI window 412 on the target component 304, such that the target component 304 (and its transition between the first configuration and the second configuration) is covered within the ROI window. In other words, the ROI window 412 may be selected to be large enough so that the target component 304 is covered within it even in the subsequent images in which the target component 304 is reconfigured (i.e. contracted or expanded).

[050] At step 406, the user may provide a user input to position the multiple tracker marks displayed on the user-interface. For example, the user input may be provided using a 'set tracker' button provided via the user-interface or via a physical button. As mentioned above, positioning of the multiple tracker marks may be performed by performing a drag-and drop action, whereby the user drags the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C at the first location, the second location, and the fixed location of the equipment 302.

[051] At step 408, based on the user input, the first location, the second location, and the fixed location may be fixed corresponding to the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C, respectively. In order to fix the first location, the second location, and the fixed location, a centroid-point associated with the ROI 412 within the first image may be determined. In particular, for the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C, associated centroid-points 414 may be determined, as shown in FIG. 4. As will be appreciated, the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C may not be well defined in itself with respect to a point within the first image.

[052] In order to precisely locate the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C, therefore, the tracking device 102 may identify and suggest to the user a centroid-point corresponding to each of the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C. This centroid-point, for example, may correspond to a centre of a circular component, a point of transition from one component to another, a joint, etc. As such, the centroid-point may be a point location which is easily identifiable in the first image as well as the subsequent images.

[053] Once the centroid-point is located with respect to the first tracker mark 410A, the second tracker mark 410B, and the third tracker mark 410C within the first image, the centroid-point is saved in the memory of the tracking device 102. Further, the tracking device 102 is able to automatically identify the centroid-points in all the subsequent images of the equipment 302 and the target component 304. To confirm that features corresponding to the centroid-points are getting detected under tracker marks, the user may press a button 'Check Features' and in response to this, the area under the tracker marks will be zoomed in, and displayed with a center dot in the user-interface window

[054] Therefore, upon positioning of the tracker marks on the first location, the second location and the fixed location by the user, the tracking application installed on the tracking device 102 may fix the plurality of tracker marks on to the respective positions. The tracking application may fix the respective tracker mark in accordance with the centroid-point of the region of the respective positions. In order to confirm with the centroid-point, a user may use a ‘check center’ button of the application, which upon clicking, may display a check center window, which may depict the conformity of the tracker marks corresponding to the respective centroid.

[055] Referring back to FIG. 2, at step 212, the first image may be analysed to determine a first pixel distance between the first tracker mark 410A and the second tracker mark 410B within the first image. To this end, any known-in-the-art technique may be used for identifying the pixels and calculating the pixel distance. The pixel distance between the first tracker mark 410A and the second tracker mark 410B within the first image is indicative of the actual distance between the first location and the second location associated with the target component 304.

[056] At step 214, a second image of the equipment 302 along with the target component 304 may be received from the imaging device 108, when the target component 304 is configured in the second configuration. In the second configuration, the target component 304 may be expanded more or less, as compared with the first configuration. As such, it should be noted that the second image may correspond to the incremental change in the configuration of the target component 304. It should be noted that once the second image is obtained, the first tracker mark 410A and the second tracker mark 410B may be automatically defined in the second image. This is explained in conjunction with FIGs. 5A-5B.

[057] **FIG. 5A** illustrates a snapshot (i.e. the first image) 500A of the equipment 302 with the target component 304 configured in the first configuration, in accordance with some exemplary embodiments. **FIG. 5B** illustrates a snapshot (i.e. the second image) 500B of the equipment 302 with the target component 304 configured in the second configuration, in accordance with some exemplary embodiments.

[058] As shown in FIG. 5A, with the target component 304 configured in the first configuration (i.e. contracted state), the first location and the second location are separated by a first actual distance. As such, the first tracker mark 410A and the second tracker mark 410B are separated by a first pixel distance. As shown in FIG. 5B, with the target component 304 configured in the second configuration (i.e. expanded state), the first location and the second location are separated by a second actual distance. As such, the first tracker mark 410A and the second tracker mark 410B are separated by a second pixel distance.

[059] It should be noted that since the third tracker mark 410C is associated with a fixed location of the target component 304, the actual distance between the second location and the fixed location in the second image is same as the actual distance between the two in the first image. Therefore, the pixel distance between the second tracker mark 410B and the third tracker mark 410C in the second image is substantially the same as the first pixel distance between the two in the first image.

[060] Referring once again to FIG. 2, at step 216, the second image may be analysed to determine a second pixel distance between the first tracker mark 410A and the second tracker mark 410B within the second image. As will be understood, due to the change in the configuration of the target component 304 with respect to the first image and the second image, the distance between the first location and the second location associated with the target component 304 may be different as compared to the first image. For example, the first location and the second location may correspond to extreme ends of the boom cylinder. Therefore, with expansion or contraction of the boom cylinder, the distance between the first location and the second location may change. As such, at step 216, the second pixel distance between the first tracker mark 410A and the second tracker mark 410B within the second image may be calculated, using the same techniques as used for calculating the first pixel distance.

[061] At step 218, the first pixel distance and the second pixel distance may be compared with each other. At step 220, an extent of transition of the target component 304 during the transition of the target component 304 between first configuration and the second configuration may be determined, based on the comparison between the first pixel distance and the second pixel distance. It should be noted that in order to determine the actual extent of transition of the target component 304 based on the first pixel distance and second pixel distance, a calibration factor may be required. This is further explained in conjunction with FIGs. 2B-2C.

[062] Referring now to **FIG. 2B**, a flowchart of a method 200B of determining the calibration-factor is illustrated, in accordance with some embodiments. At step 222, upon defining the second tracker mark and the third tracker mark within the first image, an actual fixed distance between the second location associated with the target component 304 and the fixed location associated with the equipment 302 may be received. At step 224, the first image may be analysed to determine a third pixel distance between the second tracker mark 410B and the third tracker mark 410C within the first image. At step 226, the actual fixed distance and the third pixel distance may be correlated. At step 228, the calibration-factor may be determined based on the correlation of the actual fixed distance and the third pixel distance, as is further explained via FIG. 6.

[063] **FIG. 6** illustrates a snapshot 600 of the user-interface 116 for feeding the actual distance to the tracking application, in accordance with some embodiments. The user-interface may include a measured length box 602, into which the manually measured actual distance may be fed. Thereafter, the tracking application may convert the manually measured actual distance into pixels, once the user clicks on a ‘calculate’ button 604. Therefore, upon receiving the actual distance, the tracking device 102 may determine the calibration factor by correlating the actual distance and the third pixel distance.

[064] Referring now to **FIG. 2C**, a flowchart of a method 200C of determining the extent of transition of the target component 304 during the transition of the target component 304 between first configuration and the second configuration is illustrated, in accordance with some embodiments. At step 232, a first actual distance may be determined between the first location and the second location associated with the target component 304, when the target component is configured in the first configuration. The first actual distance, therefore, may be determined based on the first pixel distance using the calibration-factor. The calibration-factor may be determined using the method 200B as described above.

[065] At step 234, a second actual distance may be determined between the first location and the second location associated with the target component 304, when the target component 304 is configured in the second configuration. The second actual distance, therefore, may be determined based on the second pixel distance using the calibration-factor. At step 236, the extent of transition of the target component 304 during the transition of the target component 304 between first configuration and the second configuration may be determined, based on the comparison between the first actual distance and the second actual distance.

[066] In some embodiments, a rate of transition of the target component 304 between the first configuration and the second configuration may also be calculated. This is explained via **FIG. 2D** which illustrates a flowchart of a method 200D of determining the rate of transition of the target component 304 between the first configuration and the second configuration, in accordance with some embodiments.

[067] As shown in FIG. 2D, at step 242, a first time-stamp associated with the first image may be received. It should be noted that the first time-stamp may be received along with the first image, i.e. alongside the step 206 of the method 200A. In other words, the steps 242 and the step 206 may be performed in tandem. At step 244, a second time-stamp associated with the second image may be received. The second time-stamp may be received along with the second image, i.e. alongside the step 212 of the method 200A. In other words, the steps 244 and the step 212 may be performed in tandem.

[068] At step 246, a time duration of the transition of the target component 304 between the first configuration to the second configuration may be determined, based on the first time-stamp and the second time-stamp. At step 248, the extent of the transition and the time duration of the transition of the target component 304 between the first configuration to the second configuration may be correlated. At step 250, a rate of transition may be calculated based on the correlation. In other words, the speed at which the transition between the first configuration and the second configuration is performed is calculated.

[069] Referring now to **FIG. 7**, a graphical representation 700 of the rate of transition of the target component 304 is illustrated, in accordance with some embodiments. The graphical representation 700 is a time vs length plot corresponding to the varying length of the target component 304. The x-axis represents time (in seconds (s)) and the y-axis represents length in millimeter (mm). As illustrated, the target component 304 (boom cylinder) stayed in the first configuration from time t1 till time t2 (first horizontal line plot). Thereafter, the target component 304 undergoes the transition from the first configuration to the second configuration between time t2 to time t3 (inclined slope plot). Further, the target component 304 stays configured in the second configuration between time t3 till time t5 (second horizontal line plot). The extent of transition (change in length) between the time t2 to time t3 may be correlated with the corresponding change in time (i.e. t3 - t2) to determine the rate of transition of the target component 304. The graphical representation 700 may be provided as an output to the user as a report, for detailed understating of the performance of the equipment 302 and the target component 304.

[070] In continuation with FIG. 7, referring now to **FIGs. 8A-8B**, graphical representations 800A, 800B of the transition of the target component 304 are illustrated, in accordance with some embodiments. The graphical representation 800A is a time vs length plot corresponding to the varying length of the target component 304. The x-axis represents time (in seconds (s)) and the y-axis represents length in millimeter (mm). The graphical representation 800B is a time vs velocity (rate of transition) plot corresponding to the varying length of the target component 304. The x-axis represents time (in seconds (s)) and the y-axis represents velocity in millimeter/second (mm/s). The graphical representation 800A may provide an indication about the average velocity between the time t2 to time t3. The graphical representation 800B may provide indication about variation in the velocity (rate of transition) between the time t2 to time t3. It may be noted that the average velocity may be used to determine an operational efficiency/power of the target component 304 based on the below equation**:**

$$\boldsymbol{Pump\ Power\ (KW) = \frac{P1+P2}{2} * Aboom\ * Vboom\ * N,}$$

here,

P1 and P2 correspond to the pressures in MPa,

Aboom corresponds to an area of the target component 304 (in square millimeters),

Vboom corresponds to the average velocity (as determined by the tracking device), and

N corresponds to the number of cylinders of the target component 304.

[071] One or more techniques are disclosed above that provide for real-time tracking of target components such as excavator boom cylinder length using camera-based imaging vision system. The imaging vision setup can work with machine vision camera or pre-recorded video. A tracking application can be installed on a simple computing machine such as a laptop with the camera connected to the laptop. The imaging vision system will capture the scenes of boom cylinder travel and based on that track the length and the change in length of the boom cylinder. The continuous varying length of the boom cylinder is recorded with time-stamps. The output of the imaging vision system is compared with the manual measurement to obtain a calibration factor. The above techniques provide for high accuracy tracking on the length variation. Further, the techniques being image-based do away with the requirement of the any physical connection to the excavator or use of sensors. The techniques allow for using live streaming of images/video from the camera, as well as using a pre-recorded video. As such, the techniques provide for simple, effective, and efficient solution for determining the operational efficiency of the boom cylinder of an excavator by overcoming the dependency over the manual methods using the sensors, etc.

[072] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

WE CLAIM:

1. A method of tracking transition of a component, the method comprising:

receiving, by a tracking device, from an imaging device, a first image of an equipment comprising a target component, when the target component is configured in a first configuration;

dynamically defining, by the tracking device:

a first tracker mark within the first image corresponding to a first location associated with the target component; and

a second tracker mark within the first image corresponding to a second location associated with the target component;

analysing, by the tracking device, the first image to determine a first pixel distance between the first tracker mark and the second tracker mark within the first image;

receiving, by the tracking device, from the imaging device, a second image of the equipment along with the target component when the target component is configured in the second configuration;

analysing, by the tracking device, the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image;

comparing, by the tracking device, the first pixel distance and the second pixel distance; and

determining, by the tracking device, an extent of transition of the target component during the transition of the target component between first configuration and the second configuration, based on the comparison between the first pixel distance and the second pixel distance.

2. The method as claimed in claim 1, further comprising:

receiving along with the first image, a first time-stamp associated with the first image;

receiving along with the second image, a second time-stamp associated with the second image;

determining a time duration of the transition of the target component between the first configuration to the second configuration;

correlating the extent of the transition and the time duration of the transition of the target component between the first configuration to the second configuration; and

determining a rate of transition based on the correlation.

3. The method as claimed in claim 1 further comprising:

dynamically defining a third tracker mark within the first image corresponding to a fixed location associated with the equipment;

upon defining the second tracker mark and the third tracker mark within the first image, receiving an actual fixed distance between the second location associated with the target component and the fixed location associated with the equipment,

analysing the first image to determine a third pixel distance between the second tracker mark and the third tracker mark within the first image;

correlating the actual fixed distance and the third pixel distance; and

determining a calibration-factor based on the correlation of the actual fixed distance and the third pixel distance.

4. The method as claimed in claim 3,

wherein distance between the first location and the second location associated with the target component is changeable during transition of the target component between the first configuration and the second configuration, and

wherein distance between the fixed location associated with the equipment and the second location associated with the target component remains fixed during transition of the target component between the first configuration and the second configuration;

5. The method as claimed in claim 4, wherein determining the extent of transition of the target component further comprising:

determining a first actual distance between the first location and the second location associated with the target component, when the target component is configured in the first configuration, based on the first pixel distance and the calibration-factor;

determining a second actual distance between the first location and the second location associated with the target component, when the target component is configured in the second configuration, based on the second pixel distance and the calibration-factor; and

determining the extent of transition of the target component during the transition of the target component between first configuration and the second configuration, based on the comparison between the first actual distance and the second actual distance.

6. The method as claimed in claim 1, wherein the imaging device is positioned at a predetermined distance from the equipment.

7. The method as claimed in claim 6, further comprising:

determining a first plane associated with the imaging device;

determining a second plane associated with the equipment; and

determining an orientation of the imaging device relative to the equipment, based on the first plane associated with the imaging device and the second plane associated with the equipment.

8. The method as claimed in claim 1,

wherein the equipment is an excavator, and

wherein the target component is a boom cylinder associated with the excavator.

9. The method as claimed in claim 3, wherein dynamically defining the first tracker mark, the second tracker mark, or the third tracker mark comprises:

receiving a user input corresponding to the first tracker mark, the second tracker mark, or the third tracker mark within the first image; and

based on the user input, fixing the first location, the second location, or the fixed location corresponding to the first tracker mark, the second tracker mark, or the third tracker mark, respectively,

wherein upon fixing, the first tracker mark, the second tracker mark, or the third tracker mark is automatically defined in subsequent images.

10. The method as claimed in claim 9,

wherein receiving the user input comprises receiving from a user, via a user interface, a selection of a region of interest (ROI) within the first image, wherein the ROI corresponds to one of the first location, the second location, and the fixed location; and

wherein the fixing comprises determining a centroid-point associated with the ROI within the first image.

11. A system for tracking transition of a component, the system comprising:

an imaging device configured to obtain images of an equipment comprising a target component; and

a tracking device communicatively coupled to the imaging device, the tracking device comprising:

a processor; and

a memory communicatively coupled to the processor, the memory storing processor-executable instructions which on execution by the processor cause the processor to:

receive, from the imaging device, a first image of an equipment comprising a target component, when the target component is configured in a first configuration;

dynamically define:

a first tracker mark within the first image corresponding to a first location associated with the target component; and

a second tracker mark within the first image corresponding to a second location associated with the target component,

analyse the first image to determine a first pixel distance between the first tracker mark and the second tracker mark within the first image;

receive, from the imaging device, a second image of the equipment along with the target component when the target component is configured in the second configuration;

analyse the second image to determine a second pixel distance between the first tracker mark and the second tracker mark within the second image;

compare the first pixel distance and the second pixel distance; and

determine an extent of transition of the target component during the transition of the target component between first configuration and the second configuration, based on the comparison between the first pixel distance and the second pixel distance.

12. The system as claimed in claim 11, wherein the processor-executable further cause the processor to:

receive along with the first image, a first time-stamp associated with the first image;

receive along with the second image, a second time-stamp associated with the second image;

determine a time duration of the transition of the target component between the first configuration to the second configuration;

correlate the extent of the transition and the time duration of the transition of the target component between the first configuration to the second configuration; and determine a rate of transition based on the correlation.

13. The system as claimed in claim 11, wherein the processor-executable further cause the processor to:

dynamically define a third tracker mark within the first image corresponding to a fixed location associated with the equipment;

upon defining the second tracker mark and the third tracker mark within the first image, receive an actual fixed distance between the second location associated with the target component and the fixed location associated with the equipment,

analyse the first image to determine a third pixel distance between the second tracker mark and the third tracker mark within the first image;

correlate the actual fixed distance and the third pixel distance; and

determine a calibration-factor based on the correlation of the actual fixed distance and the third pixel distance.

Dated this 27th day of September 2022

-- Digitally Signed--

Bhanu Prasad
(INPA No: **3253**)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

ABSTRACT

METHOD AND SYSTEM FOR TRACKING MOVEMENT OF A COMPONENT

A method and system for tracking transition of a component is disclosed. The method may include receiving a first image of an equipment including a target component, when the target component is configured in a first configuration. The method may further include dynamically defining a first tracker mark and a second tracker mark corresponding to a first location and a second location associated with the target component respectively within the first image. The method may further include analysing the first image and the second image to determine a first pixel distance and a second pixel distance within the first image and the second image respectively, and comparing the first pixel distance and the second pixel distance to determine an extent of transition of the target component during the transition of the target component from the first configuration to the second configuration.

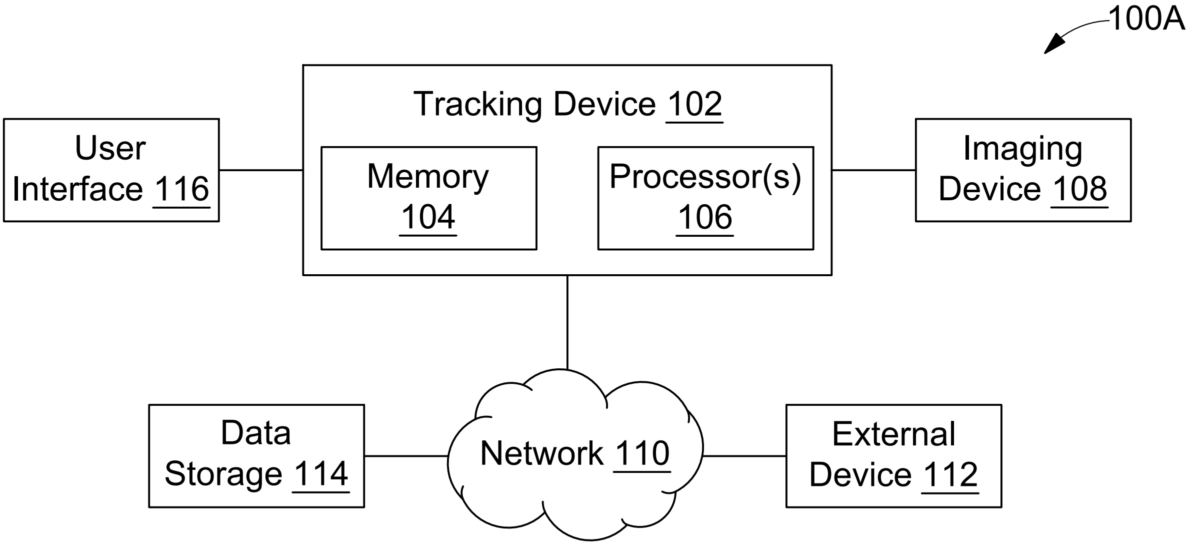


FIG. 1A

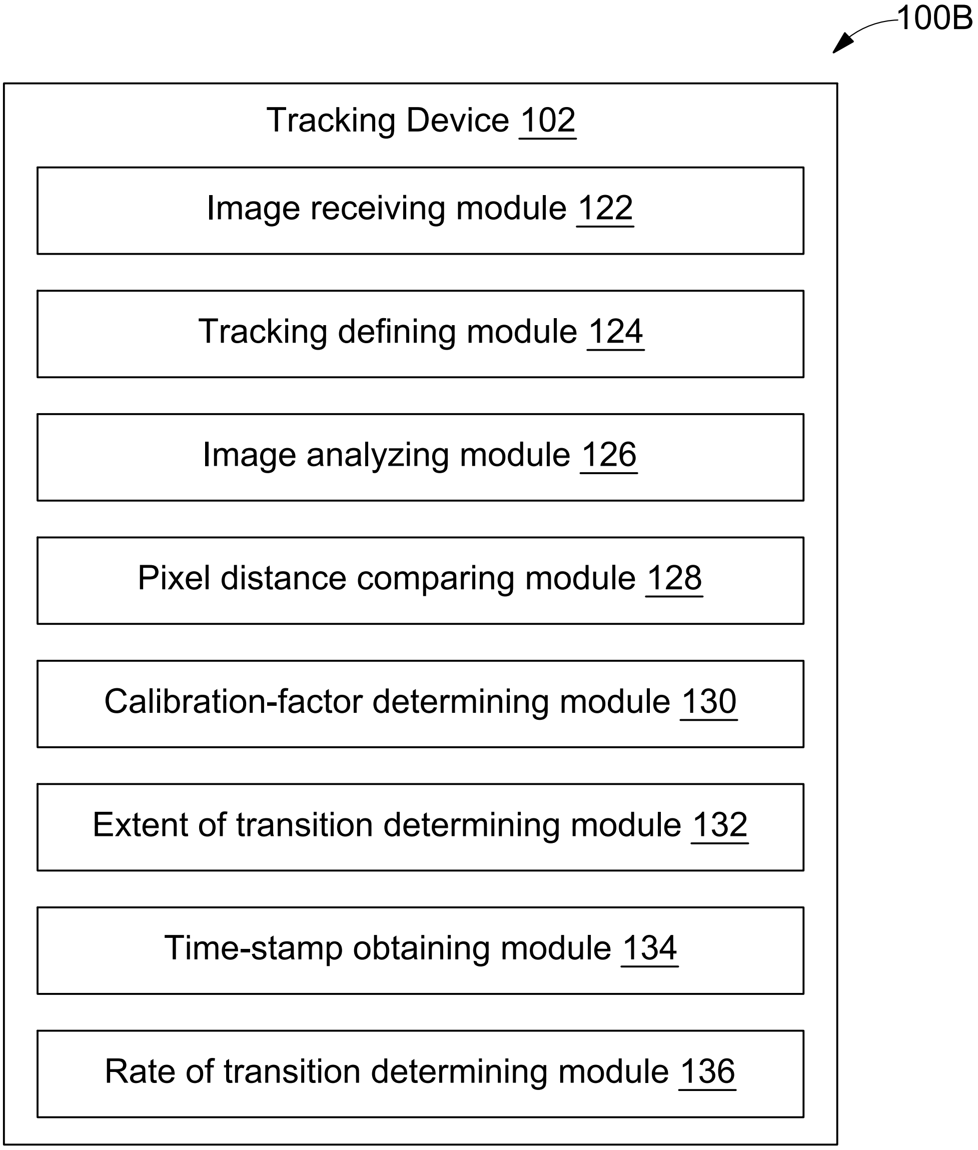


FIG. 1B

-- Digitally Signed--
Bhanu Prasad (INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited, DLF 3rd
Block, 2nd Floor, Manapakkam,
Chennai - 600089.

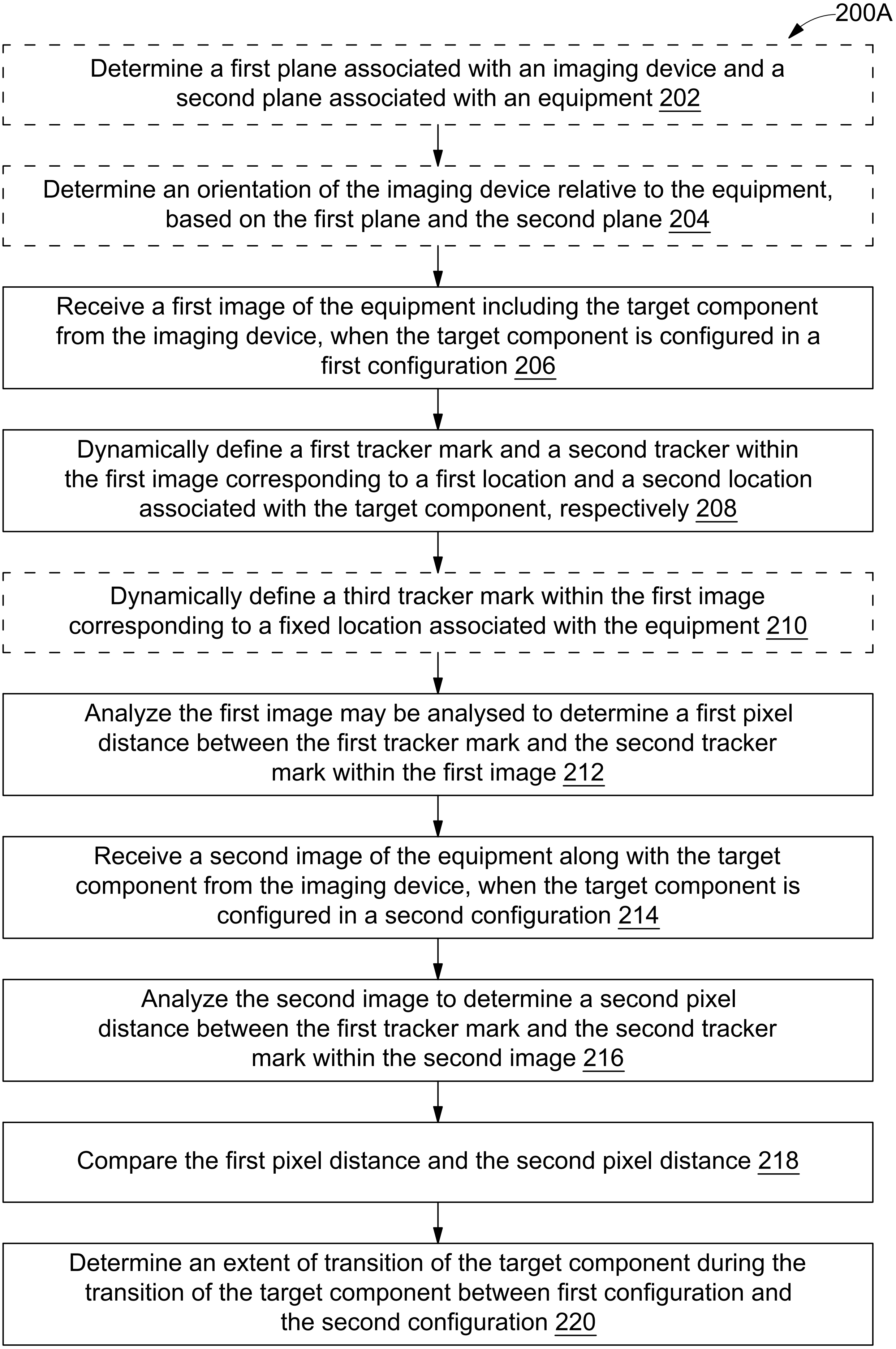
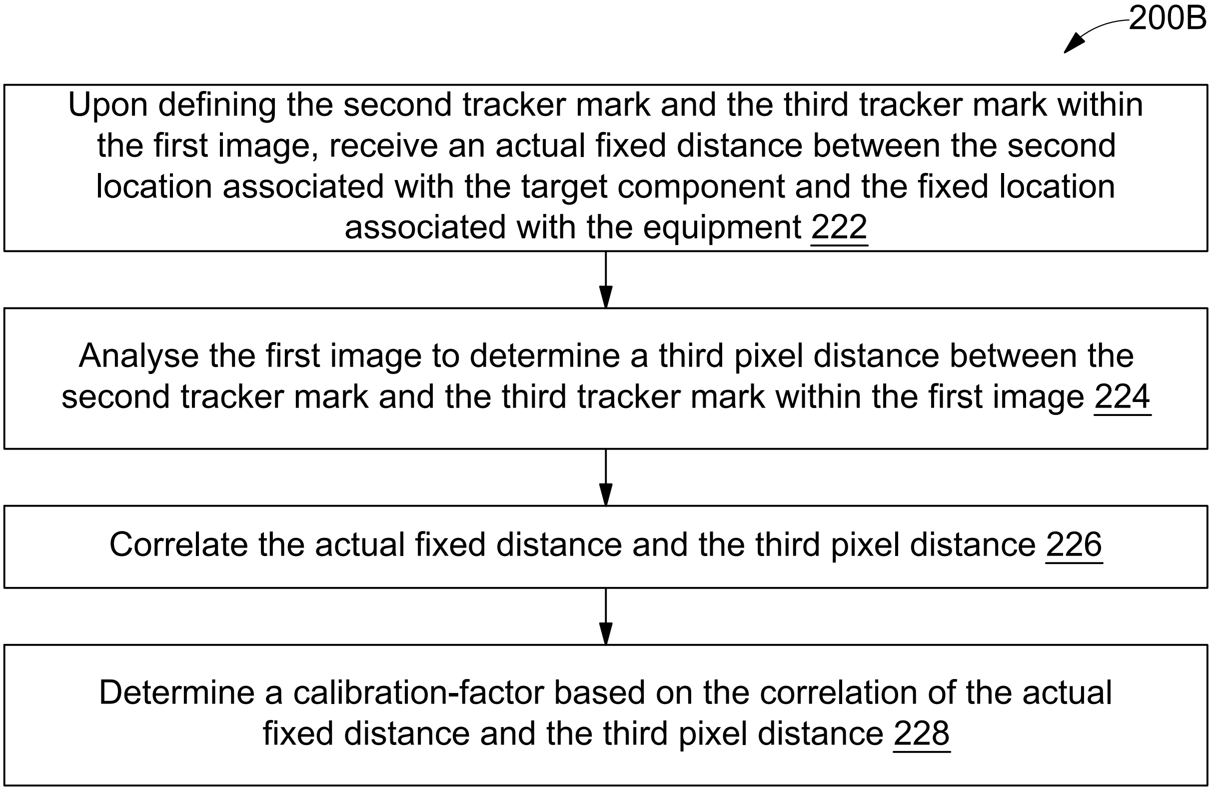


FIG. 2A

-- Digitally Signed--
Bhanu Prasad (INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.



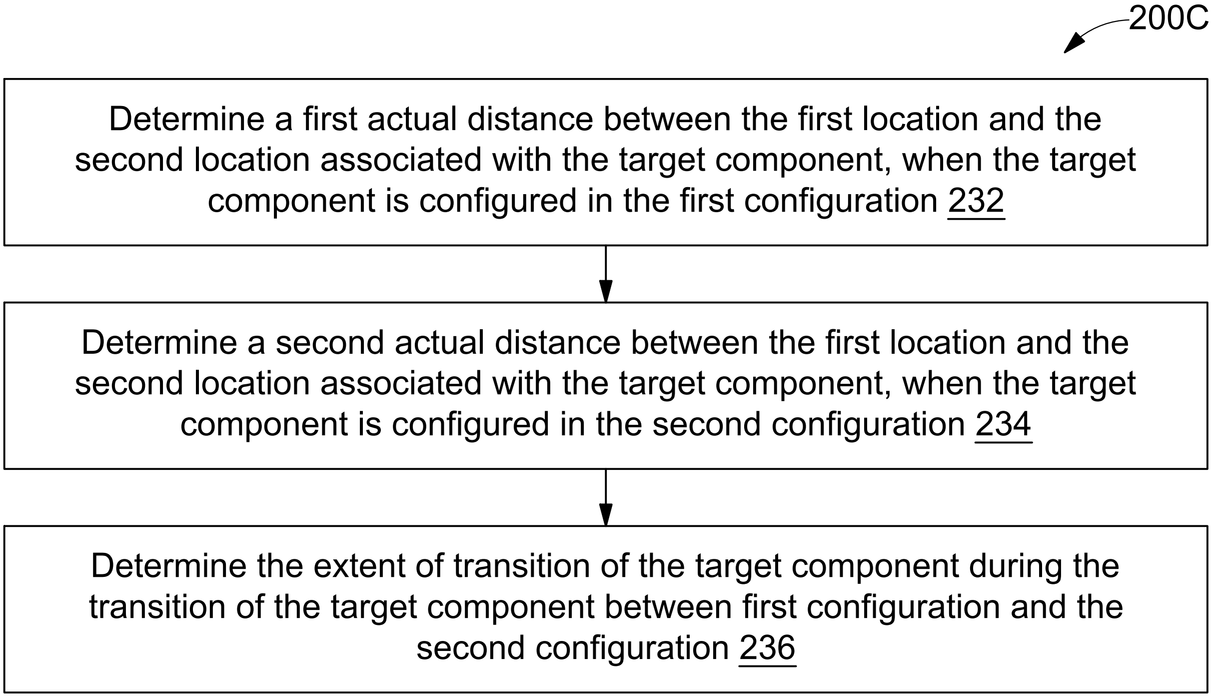
Upon defining the second tracker mark and the third tracker mark within the first image, receive an actual fixed distance between the second location associated with the target component and the fixed location associated with the equipment 222

Analyse the first image to determine a third pixel distance between the second tracker mark and the third tracker mark within the first image 224

Correlate the actual fixed distance and the third pixel distance 226

Determine a calibration-factor based on the correlation of the actual fixed distance and the third pixel distance 228

FIG. 2B



Determine a first actual distance between the first location and the second location associated with the target component, when the target component is configured in the first configuration 232

Determine a second actual distance between the first location and the second location associated with the target component, when the target component is configured in the second configuration 234

Determine the extent of transition of the target component during the transition of the target component between first configuration and the second configuration 236

FIG. 2C

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

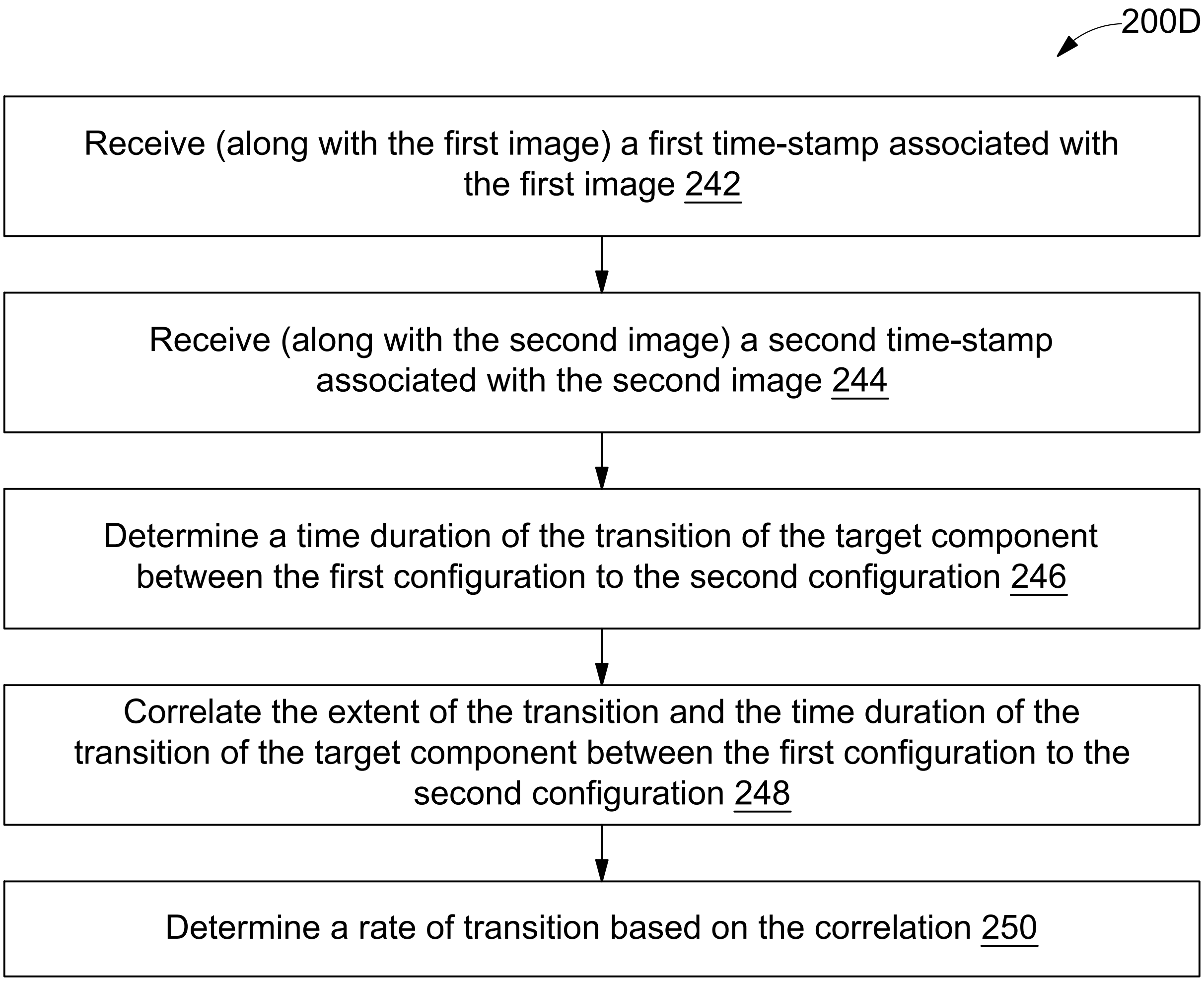

200D
Receive (along with the first image) a first time-stamp associated with the first image 242
Receive (along with the second image) a second time-stamp associated with the second image 244
Determine a time duration of the transition of the target component between the first configuration to the second configuration 246
Correlate the extent of the transition and the time duration of the transition of the target component between the first configuration to the second configuration 248
Determine a rate of transition based on the correlation 250

FIG. 2D

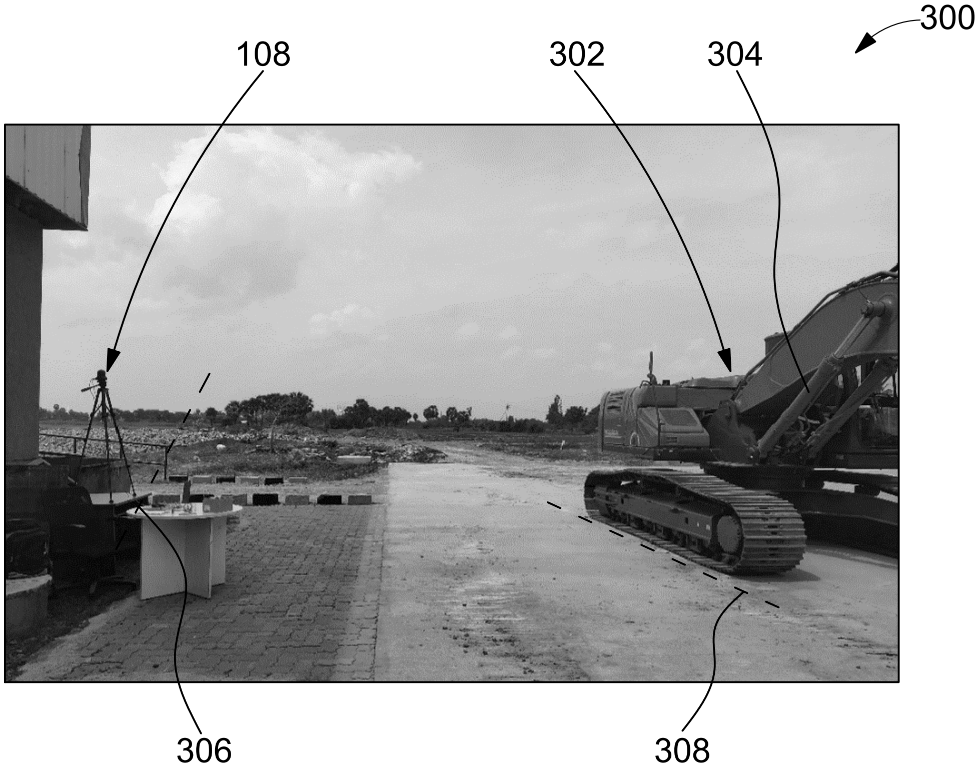


FIG. 3A

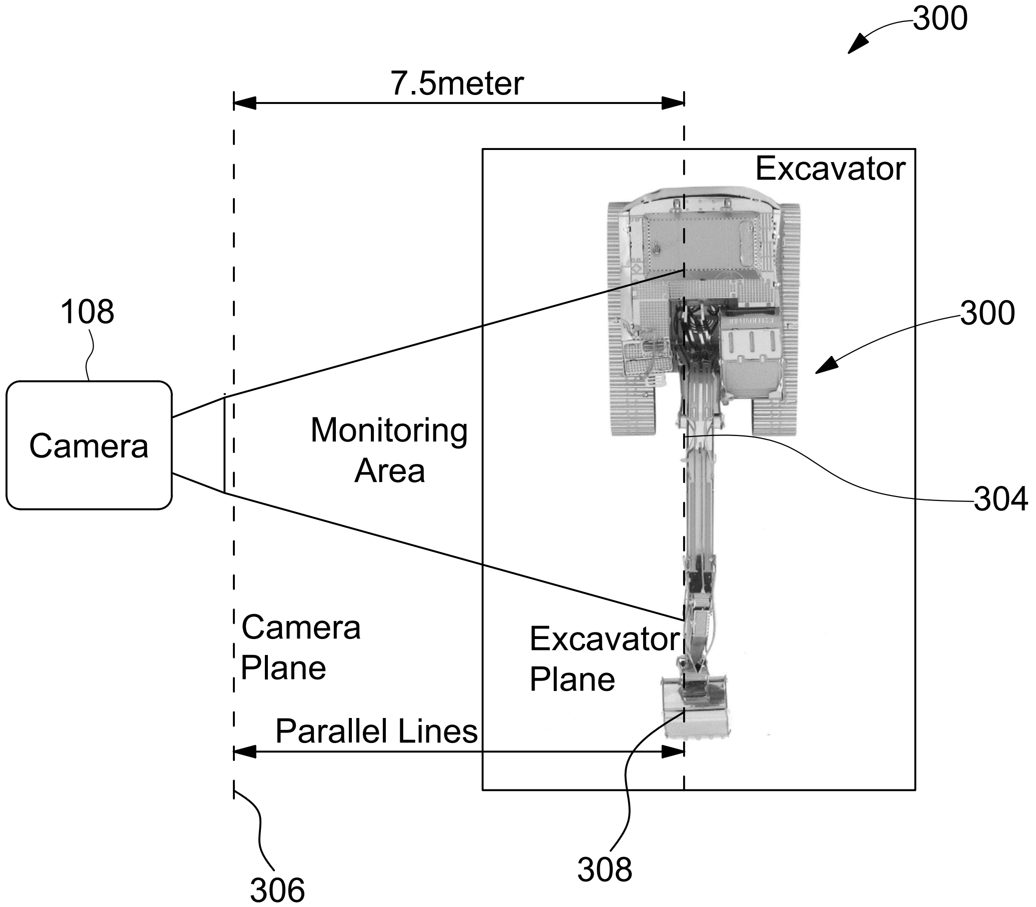


FIG. 3B

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

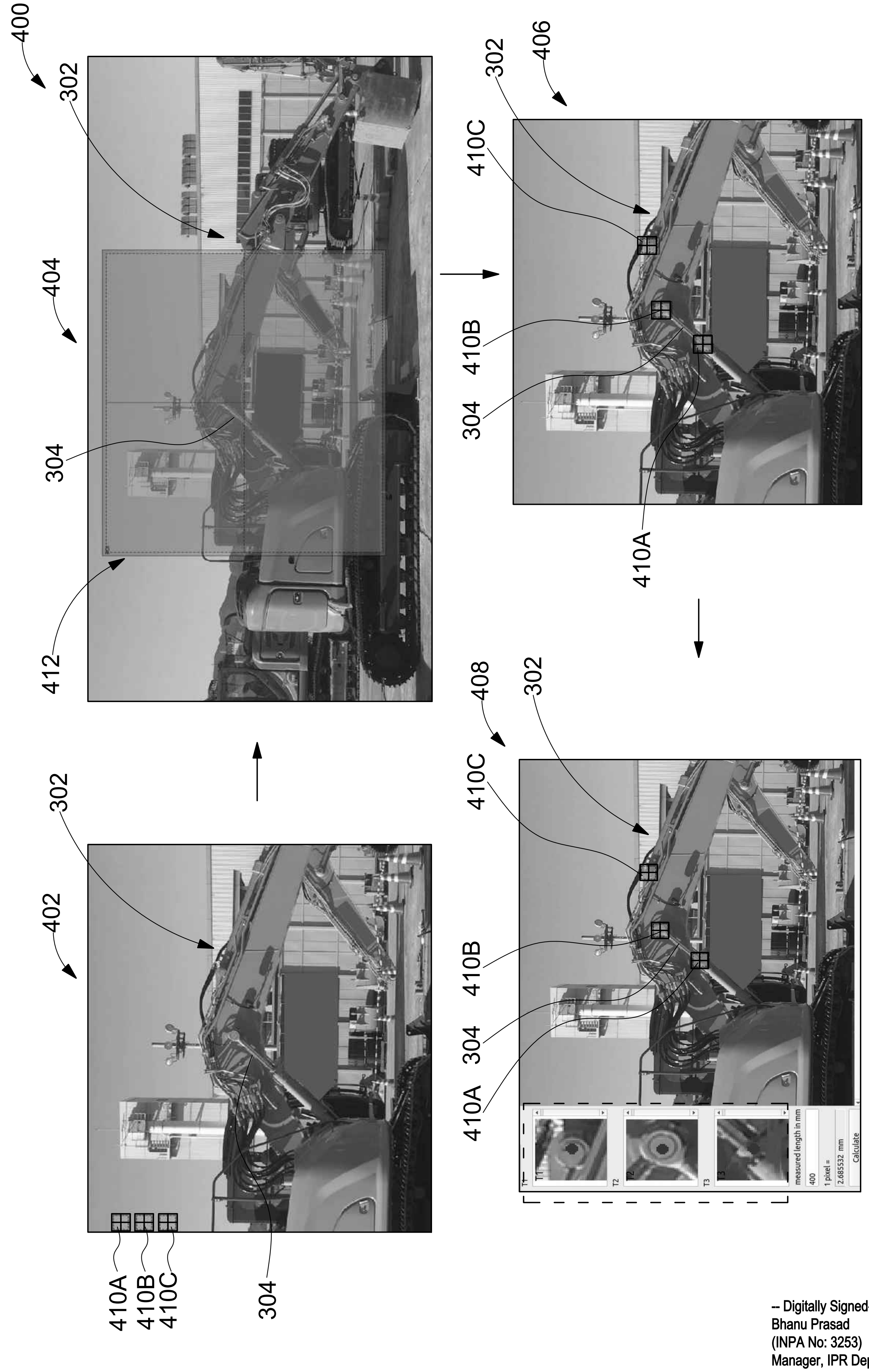


FIG. 4

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

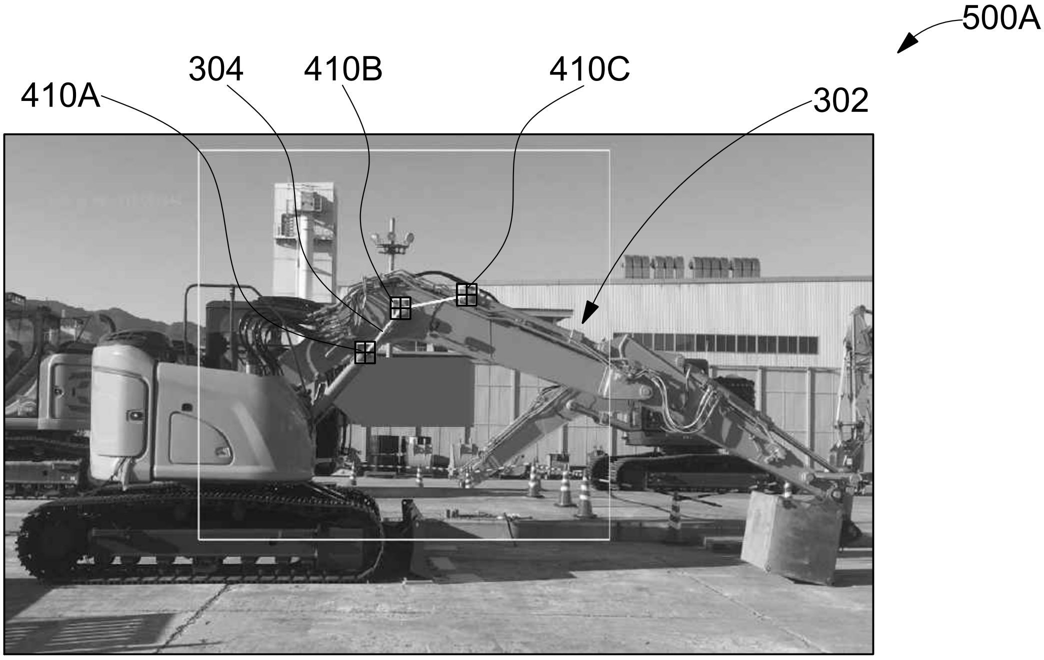


FIG. 5A

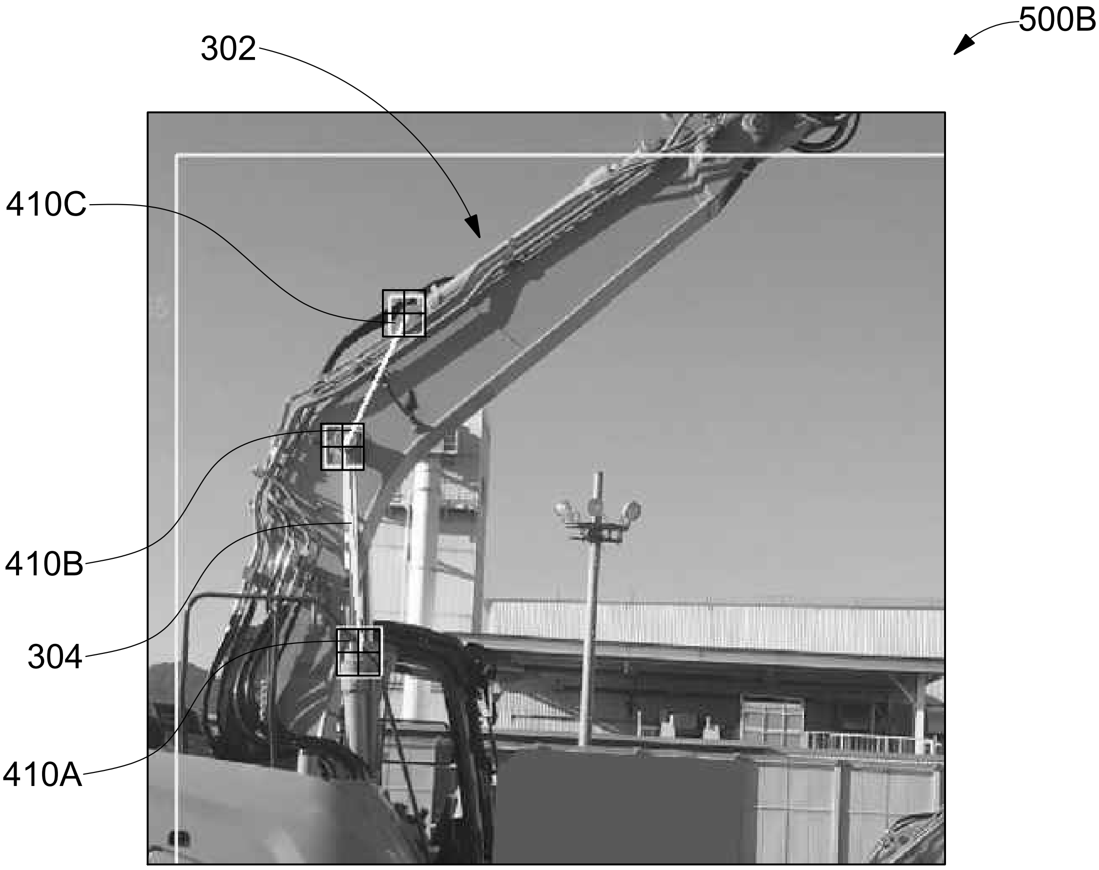


FIG. 5B

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

measured length in mm
400
1 pixel =
2.685532 mm

FIG. 6

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

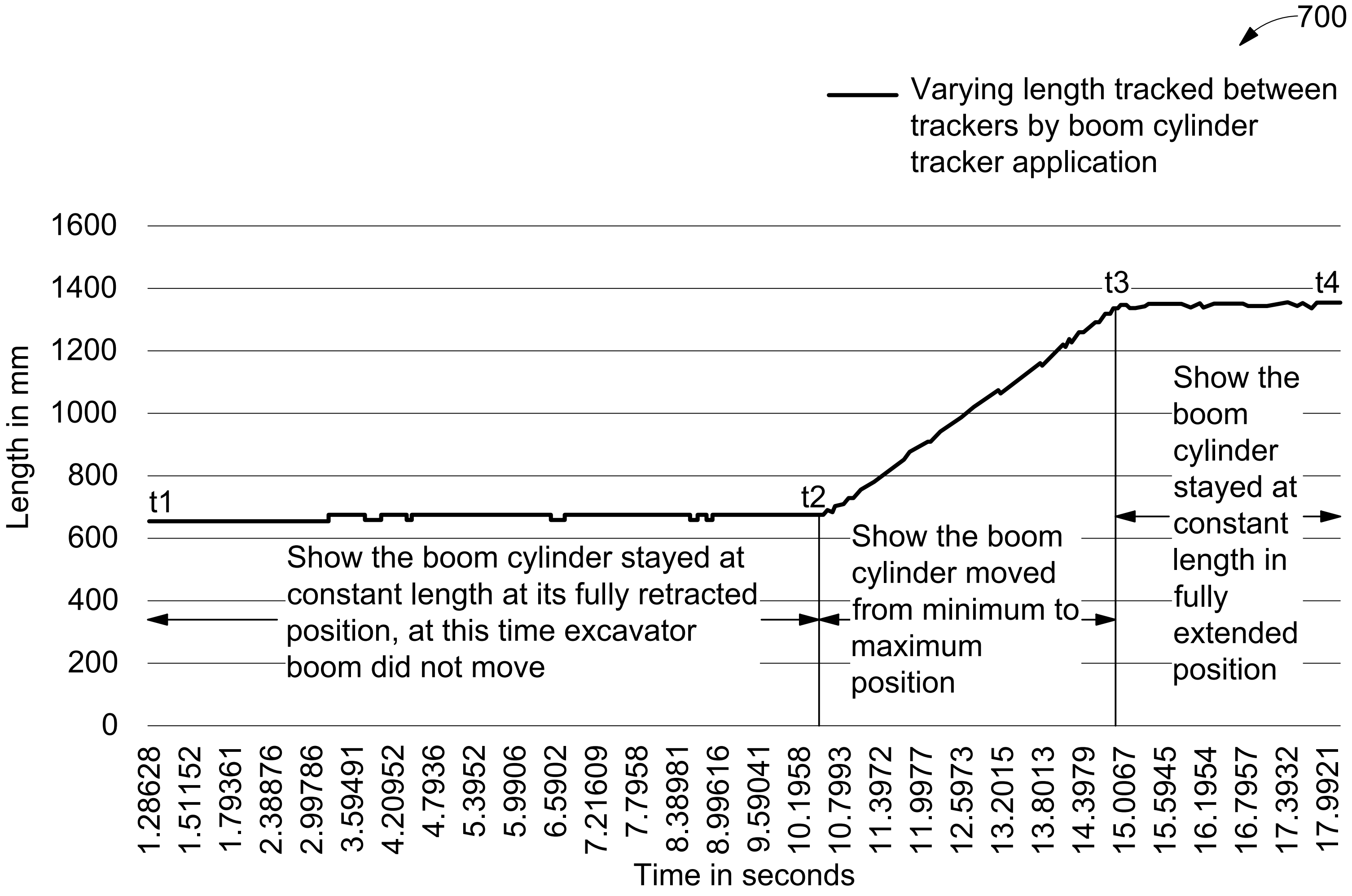


FIG. 7

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

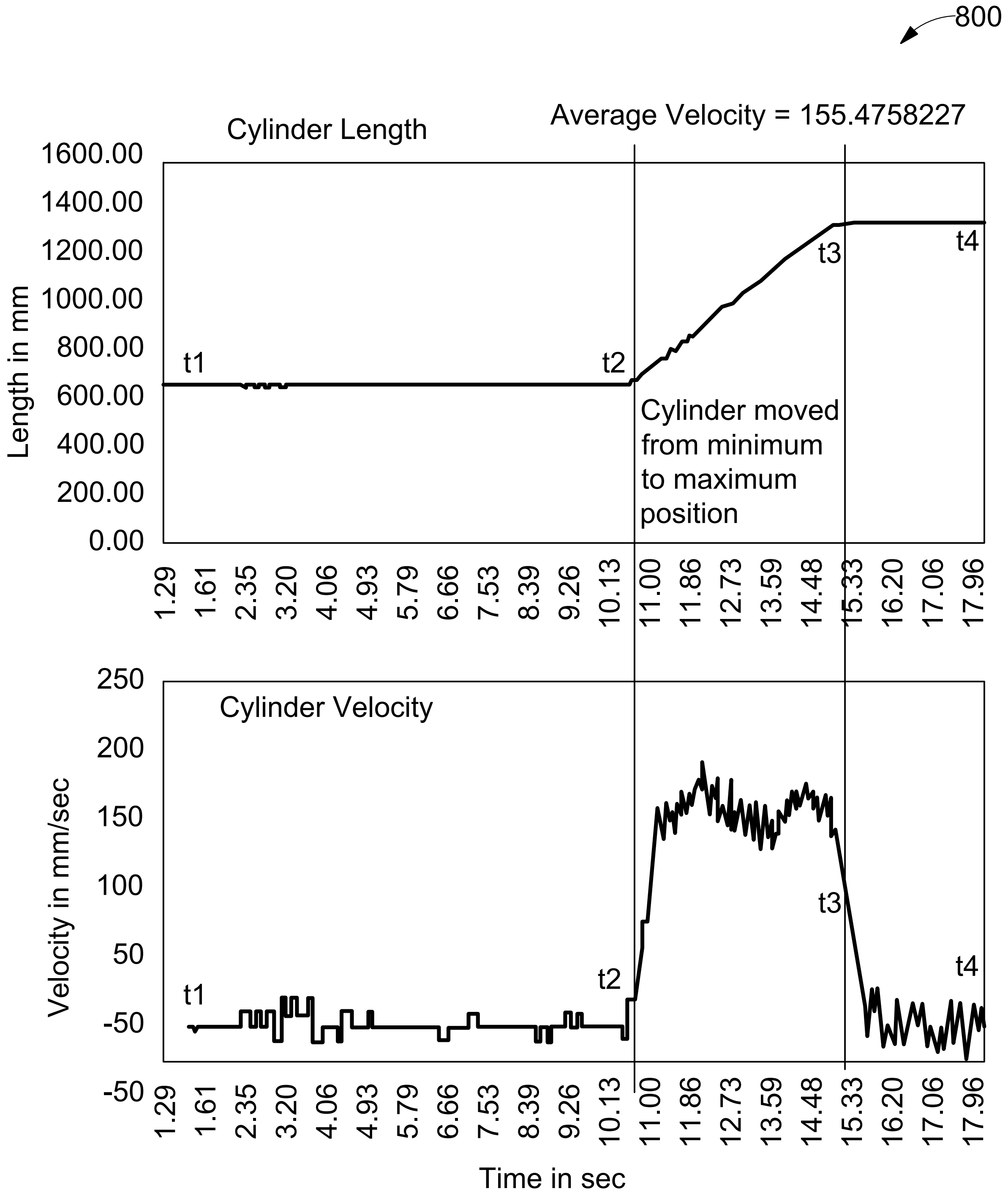


FIG. 8

-- Digitally Signed--
Bhanu Prasad
(INPA No: 3253)
Manager, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.