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(54) INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM

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(52) **U.S. Cl.**

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(57) ABSTRACT

An information processing apparatus comprising: one or more memories storing instructions; and one or more processors executing the instructions to: execute tracking-target specification processing of specifying, as a tracking target, a target to be tracked that is included in an image; execute local-region specification processing of specifying, within the image, a local region that includes at least part of a detection target that is included in the tracking target; execute cropping-region determination processing of, based on size information of the local region, determining size information of a cropping region for cropping the tracking target from the image; and execute cropping processing of generating a cropped image by cropping the image based on the cropping region.

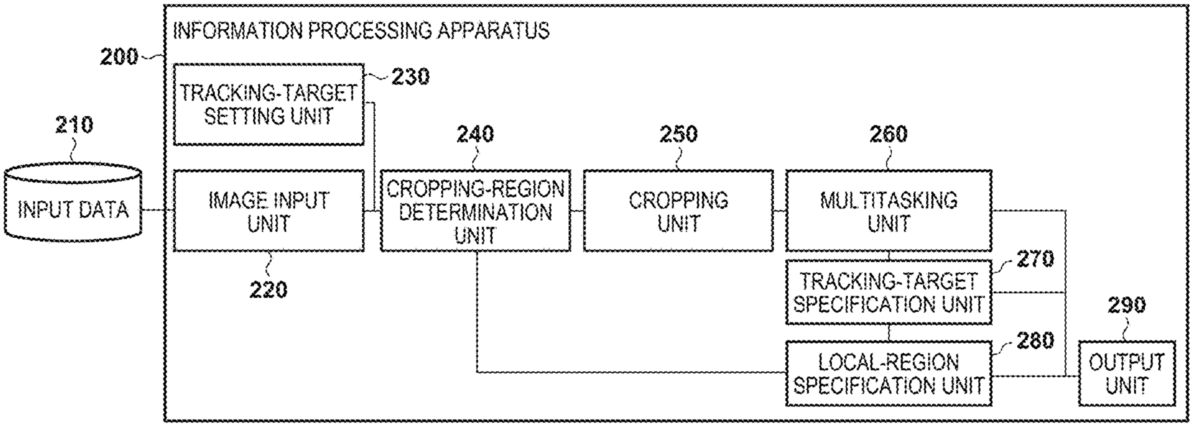

INFORMATION PROCESSING APPARATUS
200
TRACKING-TARGET SETTING UNIT
230
210
INPUT DATA
IMAGE INPUT UNIT
220
240
CROPPING-REGION DETERMINATION UNIT
250
CROPPING UNIT
260
MULTITASKING UNIT
270
TRACKING-TARGET SPECIFICATION UNIT
280
LOCAL-REGION SPECIFICATION UNIT
290
OUTPUT UNIT

FIG. 1

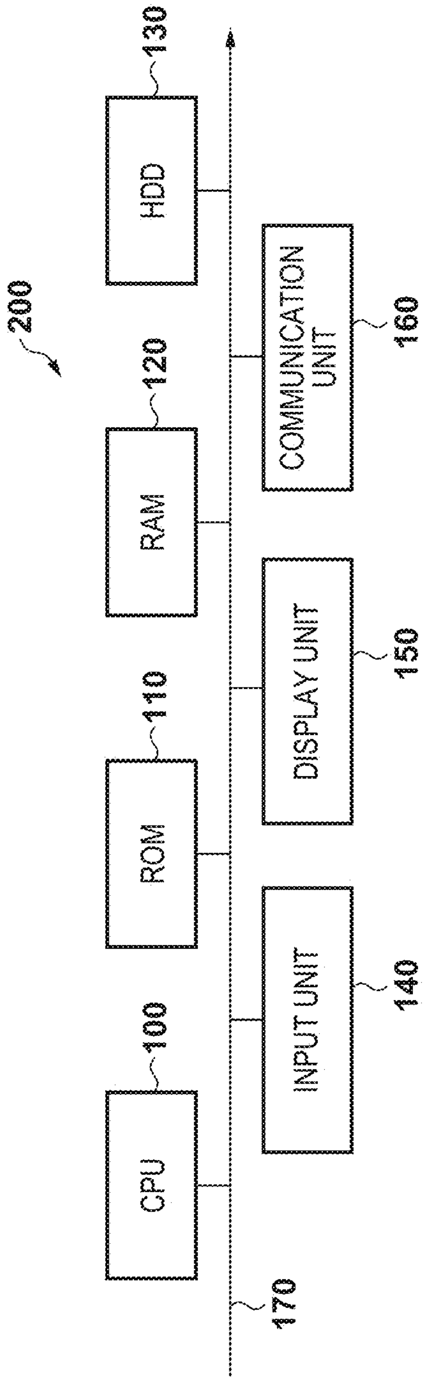

200
CPU
100
ROM
110
RAM
120
HDD
130
INPUT UNIT
140
DISPLAY UNIT
150
COMMUNICATION UNIT
160
170

FIG. 2

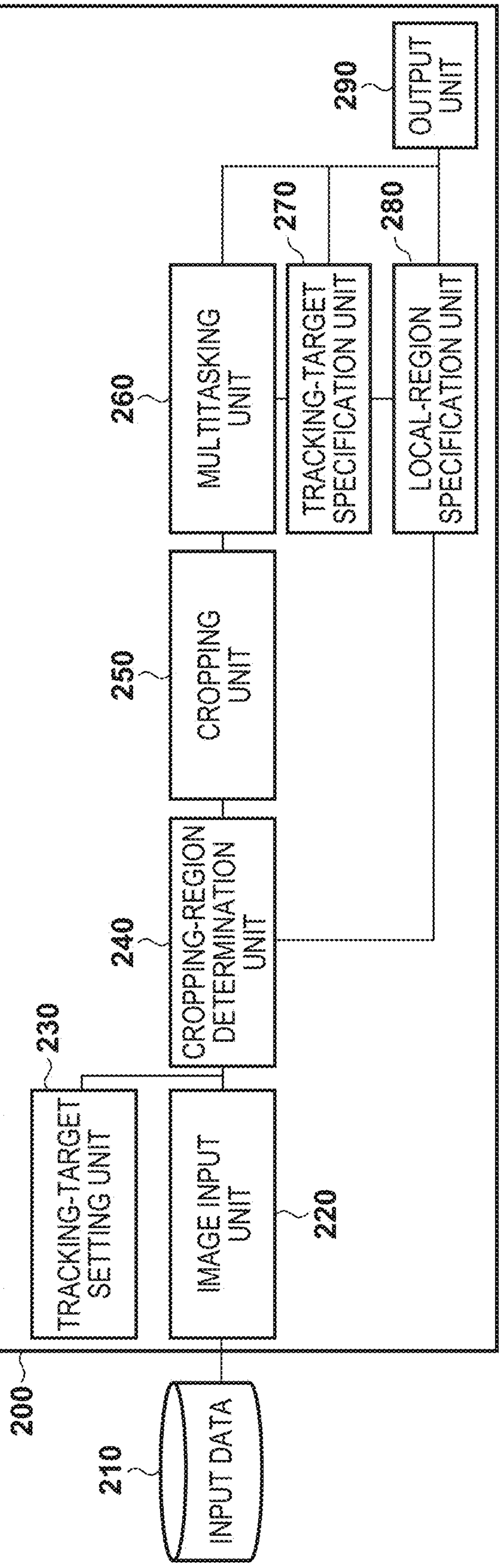

INFORMATION PROCESSING APPARATUS
200
INPUT DATA
210
IMAGE INPUT UNIT
220
TRACKING-TARGET SETTING UNIT
230
CROPPING-REGION DETERMINATION UNIT
240
CROPPING UNIT
250
MULTITASKING UNIT
260
TRACKING-TARGET SPECIFICATION UNIT
270
LOCAL-REGION SPECIFICATION UNIT
280
OUTPUT UNIT
290

FIG. 3A

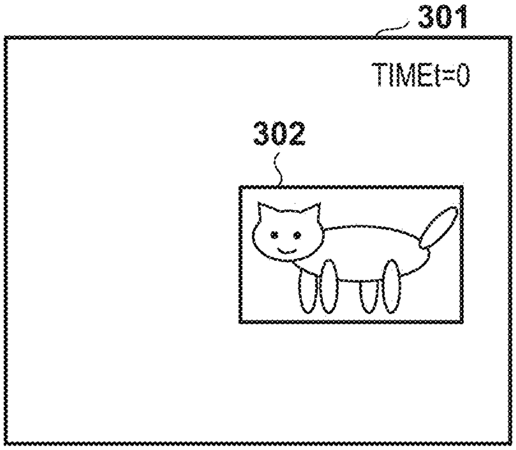


FIG. 3B

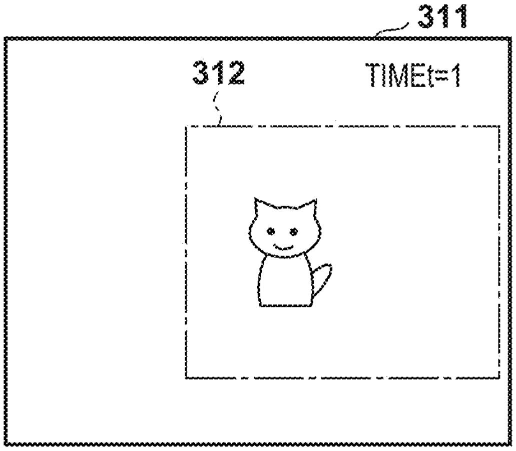


FIG. 3C

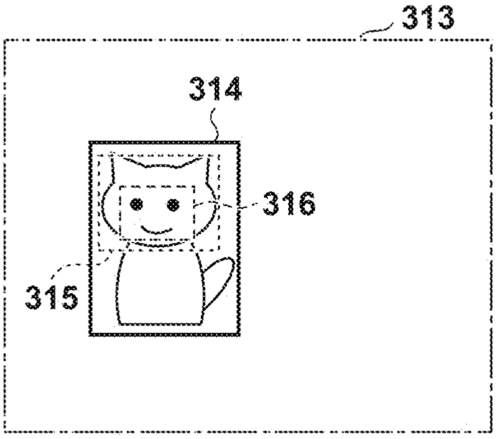


FIG. 3D

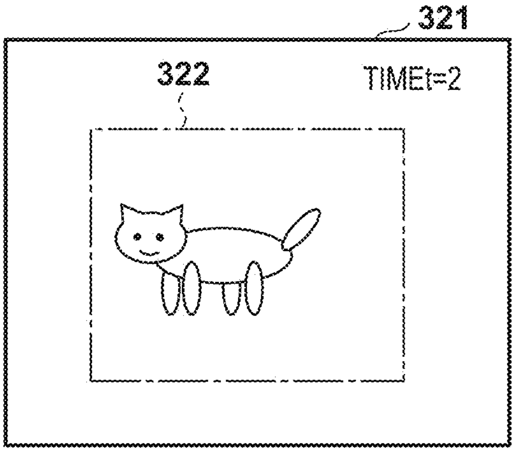


FIG. 3E

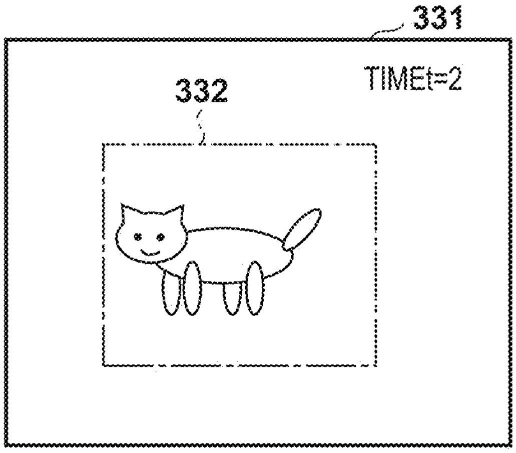


FIG. 4

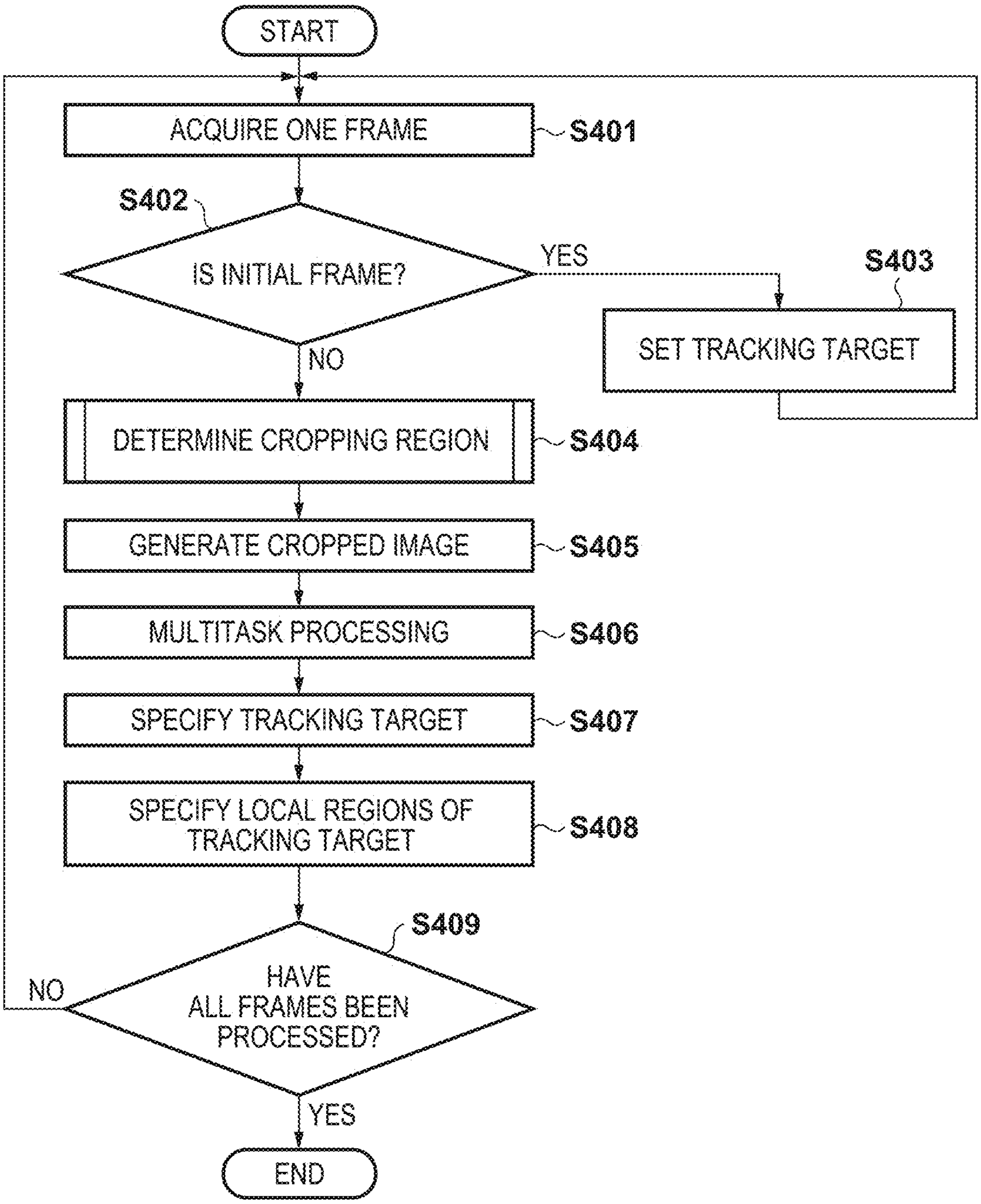

START
ACQUIRE ONE FRAME
S401
S402
IS INITIAL FRAME?
YES
S403
SET TRACKING TARGET
NO
DETERMINE CROPPING REGION
S404
GENERATE CROPPED IMAGE
S405
MULTITASK PROCESSING
S406
SPECIFY TRACKING TARGET
S407
SPECIFY LOCAL REGIONS OF TRACKING TARGET
S408
S409
HAVE ALL FRAMES BEEN PROCESSED?
NO
YES
END

FIG. 5A

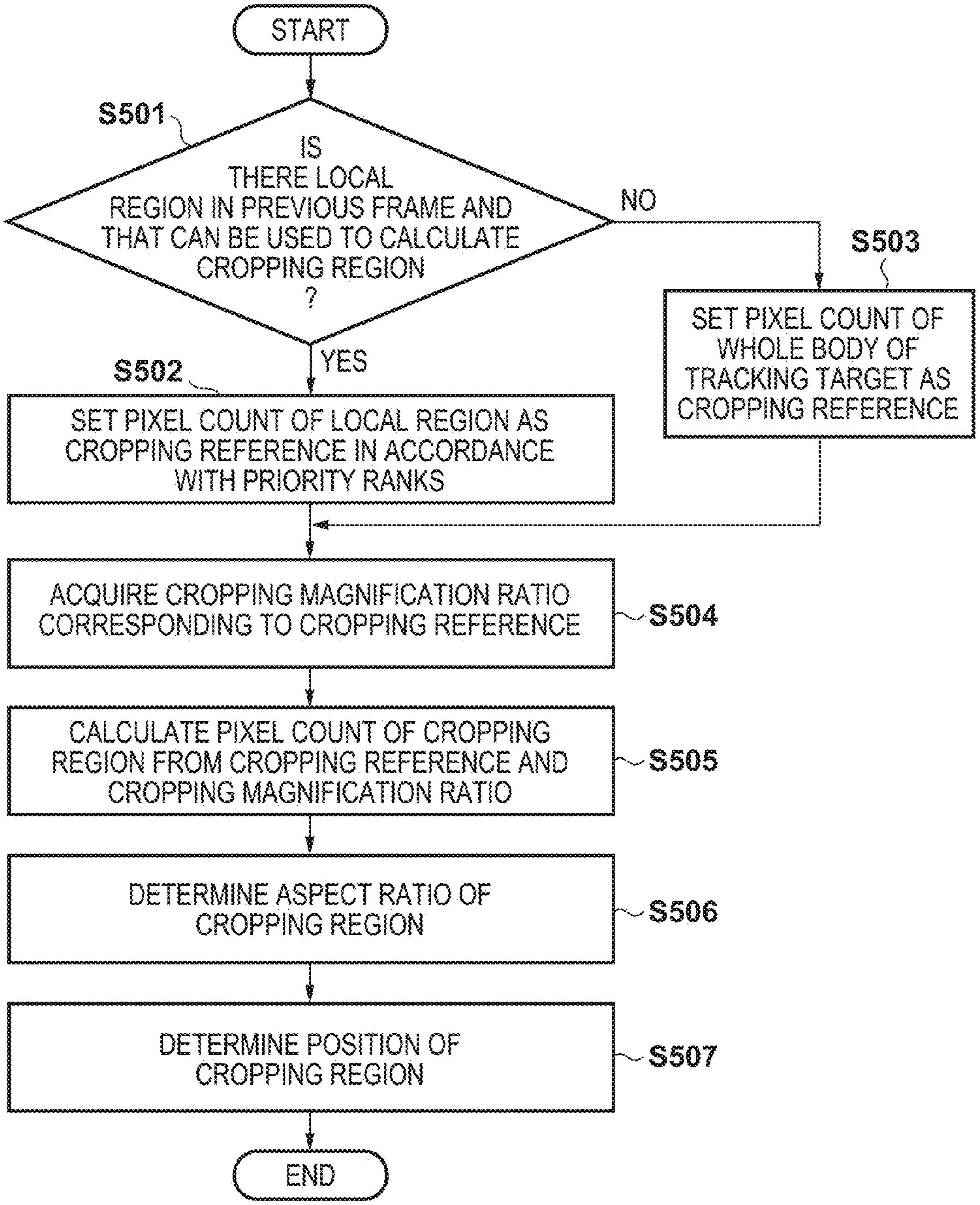

START
S501
IS THERE LOCAL REGION IN PREVIOUS FRAME AND THAT CAN BE USED TO CALCULATE CROPPING REGION ?
NO
S503
SET PIXEL COUNT OF WHOLE BODY OF TRACKING TARGET AS CROPPING REFERENCE
YES
S502
SET PIXEL COUNT OF LOCAL REGION AS CROPPING REFERENCE IN ACCORDANCE WITH PRIORITY RANKS
ACQUIRE CROPPING MAGNIFICATION RATIO CORRESPONDING TO CROPPING REFERENCE
S504
CALCULATE PIXEL COUNT OF CROPPING REGION FROM CROPPING REFERENCE AND CROPPING MAGNIFICATION RATIO
S505
DETERMINE ASPECT RATIO OF CROPPING REGION
S506
DETERMINE POSITION OF CROPPING REGION
S507
END

FIG. 5B

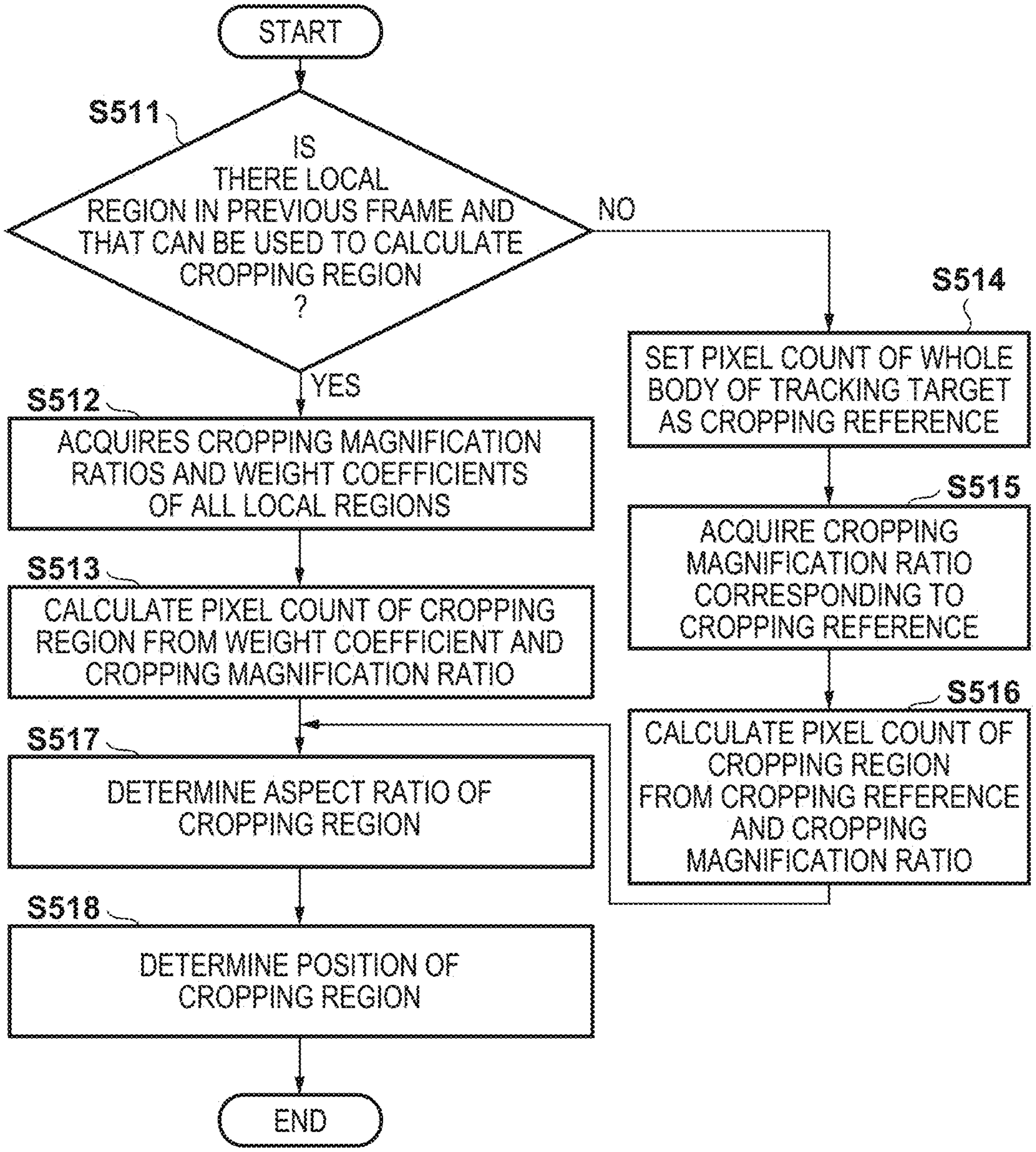

START
S511
IS THERE LOCAL REGION IN PREVIOUS FRAME AND THAT CAN BE USED TO CALCULATE CROPPING REGION ?
NO
YES
S512
ACQUIRES CROPPING MAGNIFICATION RATIOS AND WEIGHT COEFFICIENTS OF ALL LOCAL REGIONS
S513
CALCULATE PIXEL COUNT OF CROPPING REGION FROM WEIGHT COEFFICIENT AND CROPPING MAGNIFICATION RATIO
S514
SET PIXEL COUNT OF WHOLE BODY OF TRACKING TARGET AS CROPPING REFERENCE
S515
ACQUIRE CROPPING MAGNIFICATION RATIO CORRESPONDING TO CROPPING REFERENCE
S516
CALCULATE PIXEL COUNT OF CROPPING REGION FROM CROPPING REFERENCE AND CROPPING MAGNIFICATION RATIO
S517
DETERMINE ASPECT RATIO OF CROPPING REGION
S518
DETERMINE POSITION OF CROPPING REGION
END

FIG. 6A

601

TYPE OF RECOGNITION TASK	CROPPING MAGNIFICATION RATIO	PRIORITY RANK	CAN BE USED TO CALCULATE CROPPING REGION
WHOLE BODY	3.0	3	○
HEAD	15.0	1	○
FACE	30.0	2	○

FIG. 6B

602

TYPE OF RECOGNITION TASK	CROPPING MAGNIFICATION RATIO	WEIGHT COEFFICIENT	CAN BE USED TO CALCULATE CROPPING REGION
WHOLE BODY	3.0	2.0	○
HEAD	15.0	5.0	○
FACE	30.0	3.0	○

FIG. 6C

603

TYPE OF RECOGNITION TASK	CROPPING MAGNIFICATION RATIO	PRIORITY RANK	CAN BE USED TO CALCULATE CROPPING REGION
WHOLE BODY	3.0	3	○
HEAD	15.0	2	○
FACE	30.0	1	○

FIG. 6D

604

TYPE OF RECOGNITION TASK	CROPPING MAGNIFICATION RATIO	PRIORITY RANK	WEIGHT COEFFICIENT	CAN BE USED TO CALCULATE CROPPING REGION
WHOLE BODY	3.0	3	2.0	○
HEAD	15.0	2	5.0	○
FACE	30.0	1	3.0	○

FIG. 7A

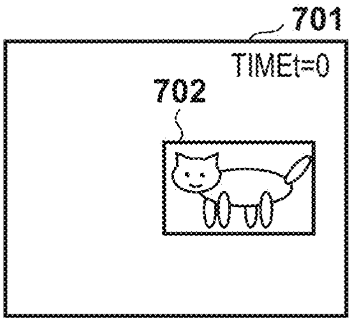


FIG. 7B

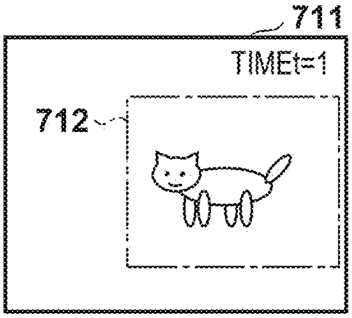


FIG. 7C

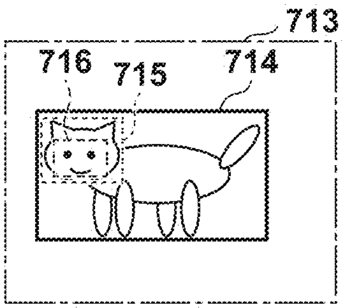


FIG. 7D

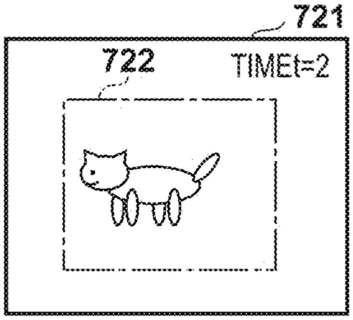


FIG. 7E

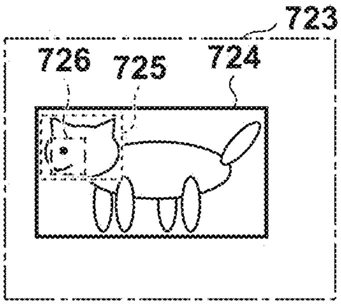


FIG. 7F

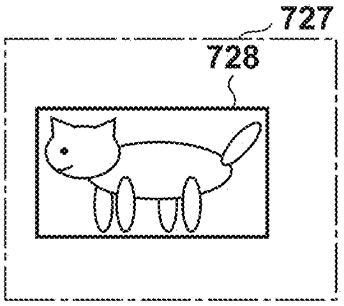


FIG. 7G

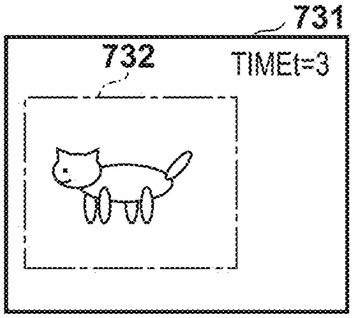


FIG. 7H

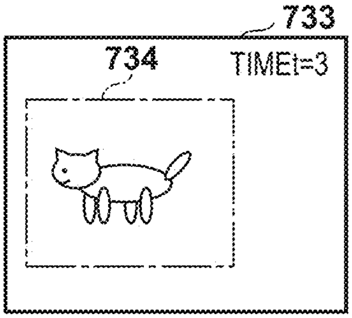


FIG. 8

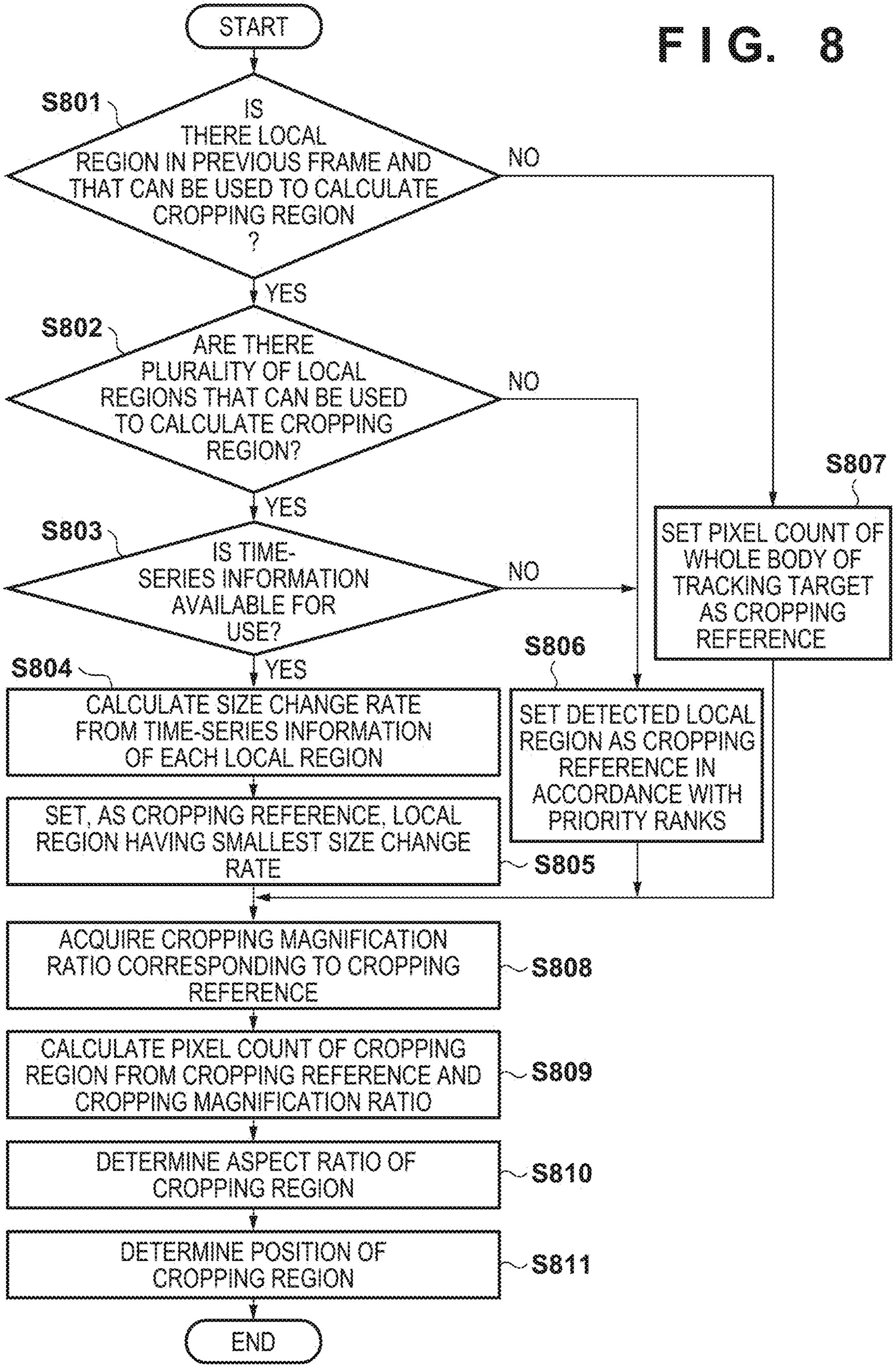

START
S801
IS THERE LOCAL REGION IN PREVIOUS FRAME AND THAT CAN BE USED TO CALCULATE CROPPING REGION ?
NO
YES
S802
ARE THERE PLURALITY OF LOCAL REGIONS THAT CAN BE USED TO CALCULATE CROPPING REGION?
NO
YES
S803
IS TIME-SERIES INFORMATION AVAILABLE FOR USE?
NO
YES
S804
CALCULATE SIZE CHANGE RATE FROM TIME-SERIES INFORMATION OF EACH LOCAL REGION
SET, AS CROPPING REFERENCE, LOCAL REGION HAVING SMALLEST SIZE CHANGE RATE
S805
S806
SET DETECTED LOCAL REGION AS CROPPING REFERENCE IN ACCORDANCE WITH PRIORITY RANKS
S807
SET PIXEL COUNT OF WHOLE BODY OF TRACKING TARGET AS CROPPING REFERENCE
ACQUIRE CROPPING MAGNIFICATION RATIO CORRESPONDING TO CROPPING REFERENCE
S808
CALCULATE PIXEL COUNT OF CROPPING REGION FROM CROPPING REFERENCE AND CROPPING MAGNIFICATION RATIO
S809
DETERMINE ASPECT RATIO OF CROPPING REGION
S810
DETERMINE POSITION OF CROPPING REGION
S811
END

FIG. 9

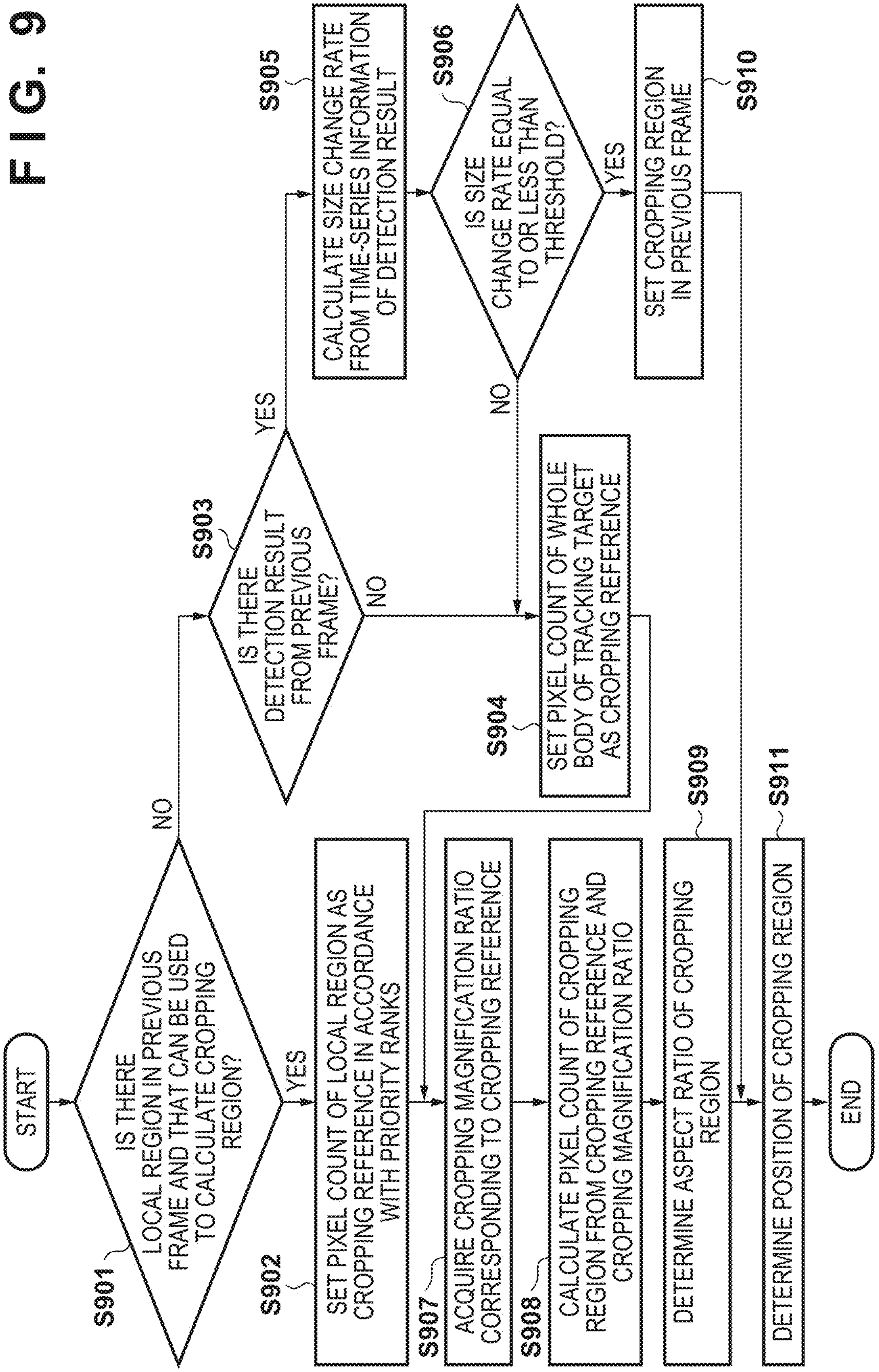

START
S901
IS THERE LOCAL REGION IN PREVIOUS FRAME AND THAT CAN BE USED TO CALCULATE CROPPING REGION?
YES
NO
S902
SET PIXEL COUNT OF LOCAL REGION AS CROPPING REFERENCE IN ACCORDANCE WITH PRIORITY RANKS
S903
IS THERE DETECTION RESULT FROM PREVIOUS FRAME?
YES
NO
S904
SET PIXEL COUNT OF WHOLE BODY OF TRACKING TARGET AS CROPPING REFERENCE
S905
CALCULATE SIZE CHANGE RATE FROM TIME-SERIES INFORMATION OF DETECTION RESULT
S906
IS SIZE CHANGE RATE EQUAL TO OR LESS THAN THRESHOLD?
YES
NO
S910
SET CROPPING REGION IN PREVIOUS FRAME
S907
ACQUIRE CROPPING MAGNIFICATION RATIO CORRESPONDING TO CROPPING REFERENCE
S908
CALCULATE PIXEL COUNT OF CROPPING REGION FROM CROPPING REFERENCE AND CROPPING MAGNIFICATION RATIO
S909
DETERMINE ASPECT RATIO OF CROPPING REGION
S911
DETERMINE POSITION OF CROPPING REGION
END

FIG. 10

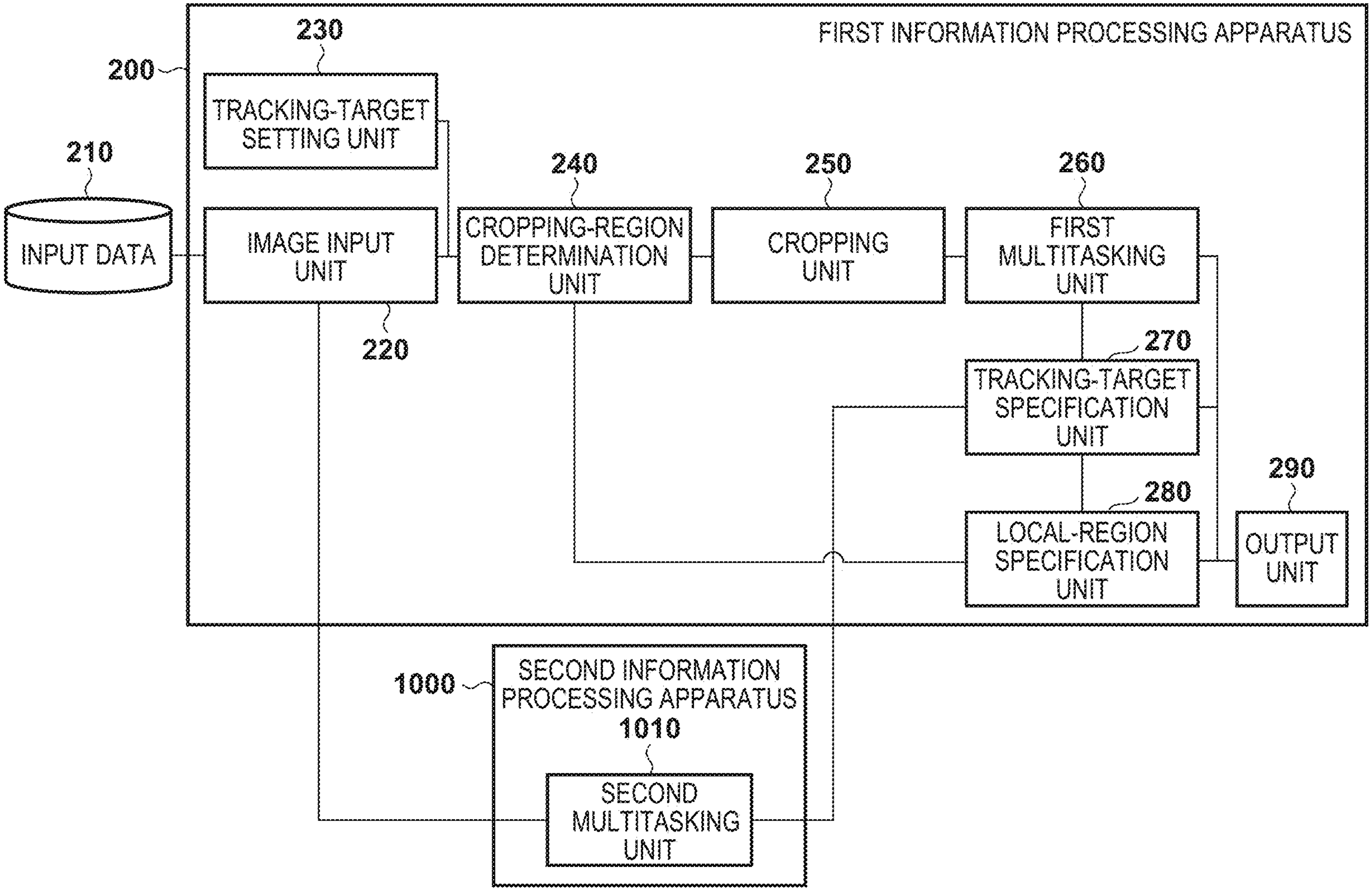

200
FIRST INFORMATION PROCESSING APPARATUS
210
INPUT DATA
230
TRACKING-TARGET SETTING UNIT
220
IMAGE INPUT UNIT
240
CROPPING-REGION DETERMINATION UNIT
250
CROPPING UNIT
260
FIRST MULTITASKING UNIT
270
TRACKING-TARGET SPECIFICATION UNIT
280
LOCAL-REGION SPECIFICATION UNIT
290
OUTPUT UNIT
1000
SECOND INFORMATION PROCESSING APPARATUS
1010
SECOND MULTITASKING UNIT

FIG. 11A

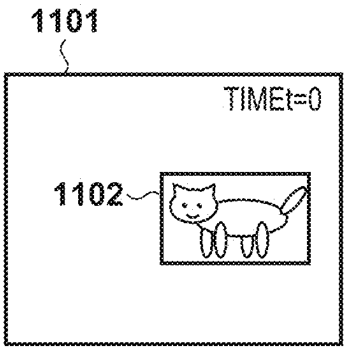


FIG. 11B

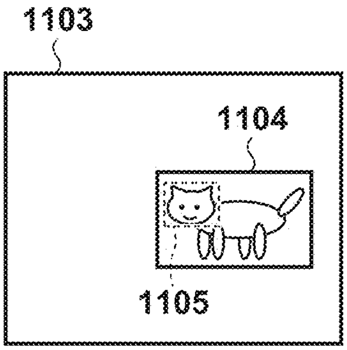


FIG. 11C

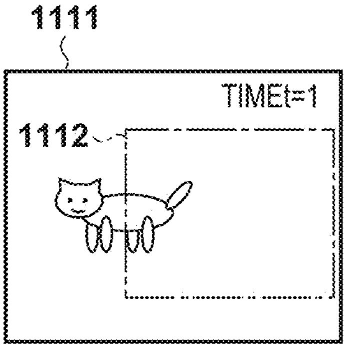


FIG. 11D

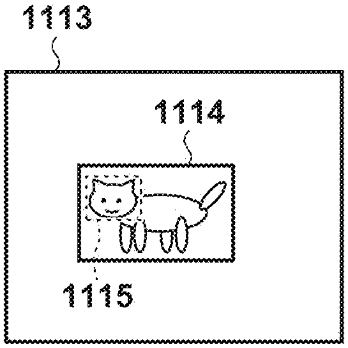


FIG. 11E

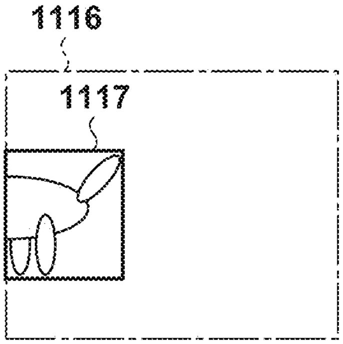


FIG. 11F

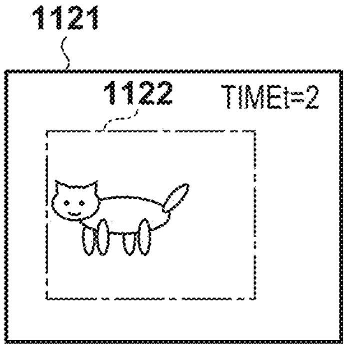


FIG. 12A

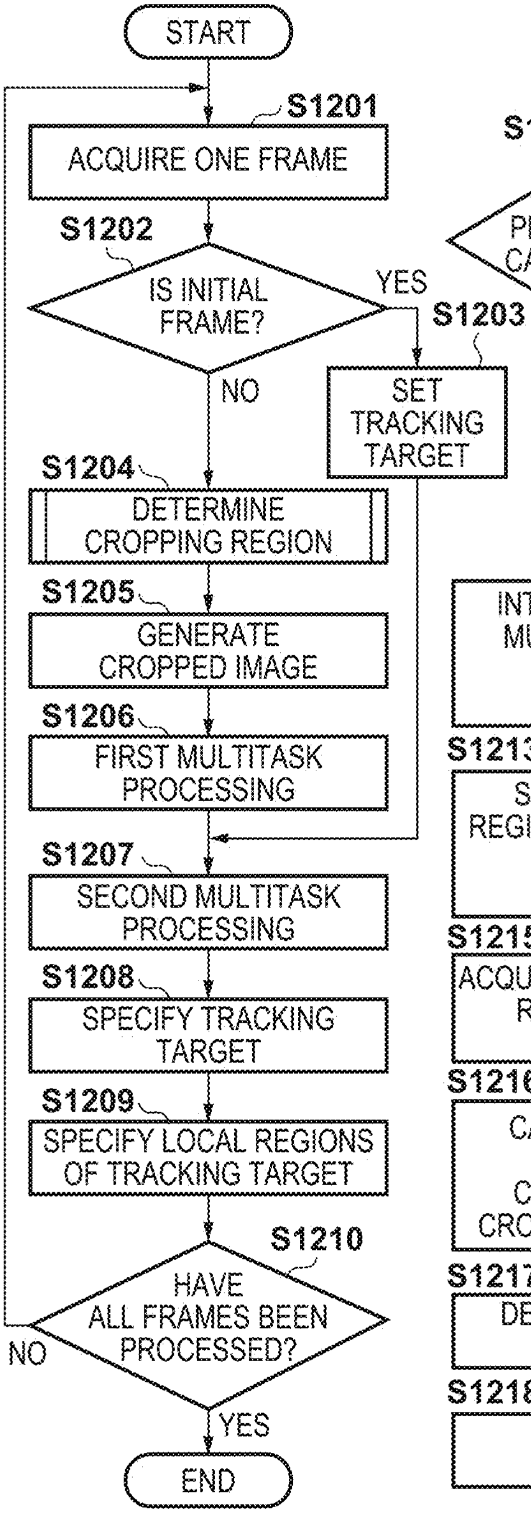
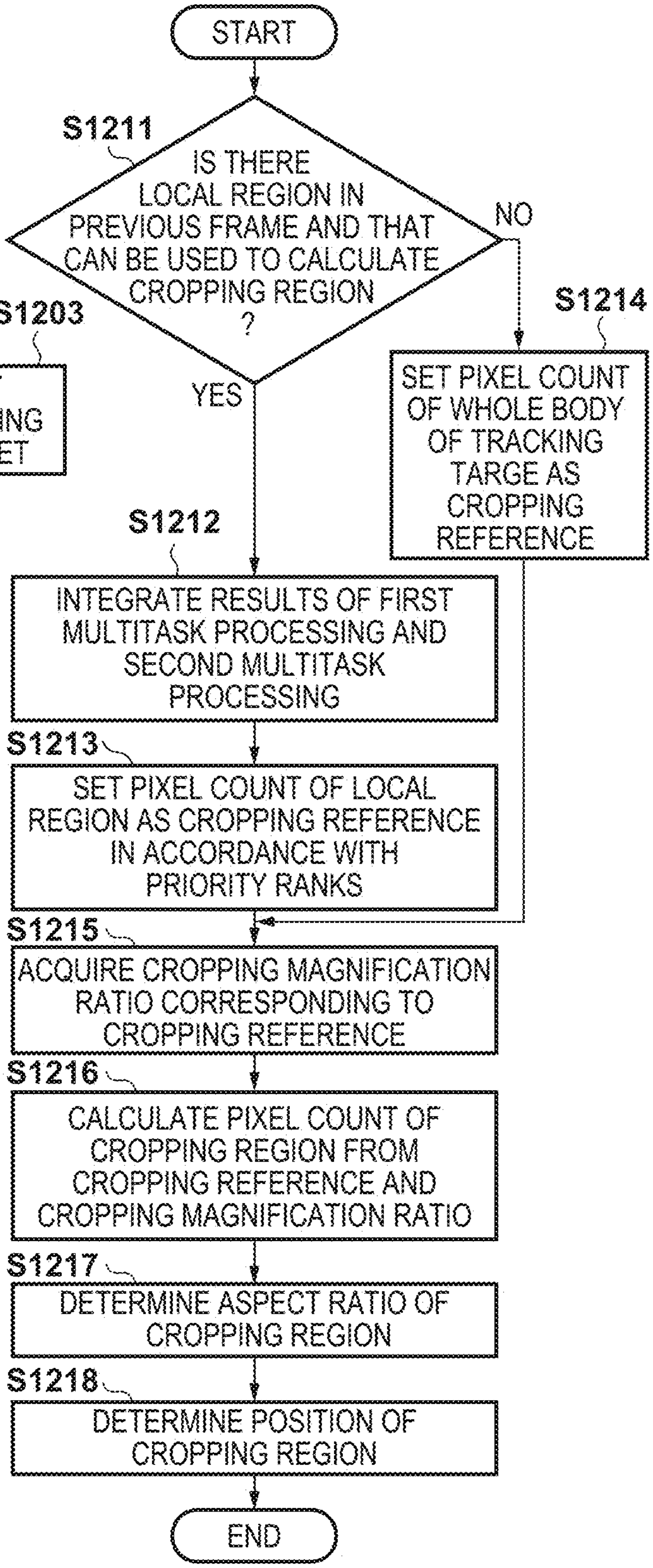


FIG. 12B


START
S1211
IS THERE LOCAL REGION IN PREVIOUS FRAME AND THAT CAN BE USED TO CALCULATE CROPPING REGION ?
NO
YES
S1214
SET PIXEL COUNT OF WHOLE BODY OF TRACKING TARGE AS CROPPING REFERENCE
S1212
INTEGRATE RESULTS OF FIRST MULTITASK PROCESSING AND SECOND MULTITASK PROCESSING
S1213
SET PIXEL COUNT OF LOCAL REGION AS CROPPING REFERENCE IN ACCORDANCE WITH PRIORITY RANKS
S1215
ACQUIRE CROPPING MAGNIFICATION RATIO CORRESPONDING TO CROPPING REFERENCE
S1216
CALCULATE PIXEL COUNT OF CROPPING REGION FROM CROPPING REFERENCE AND CROPPING MAGNIFICATION RATIO
S1217
DETERMINE ASPECT RATIO OF CROPPING REGION
S1218
DETERMINE POSITION OF CROPPING REGION
END

INFORMATION PROCESSING APPARATUS, INFORMATION PROCESSING METHOD, AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an information processing apparatus, an information processing method, and a non-transitory computer-readable storage medium.

Description of the Related Art

[0002] In recent years, there is known a technique of cutting out (hereinafter "cropping") partial regions including a target to be tracked (hereinafter "tracking target") that is included in images, and tracking the tracking target using images of the partial regions (hereinafter "cropped images").

[0003] Japanese Patent Laid-Open No. 2021-141421 discloses a technique in which, in order to determine one cropped image for executing a plurality of recognition tasks, size information of the whole body of the main subject and information other than that of the main subject are used. In the technique disclosed in Japanese Patent Laid-Open No. 2021-141421, an image is cropped to generate a cropped image in which a partial region including a subject is cut out from the entire image.

SUMMARY OF THE INVENTION

[0004] However, according to the technique disclosed in Japanese Patent Laid-Open No. 2021-141421, cropping is performed using as a reference the size of the whole tracking target, which is readily affected by a change in posture of the tracking target, upon determining cropped images, and thus the size of the regions that are cropped readily changes when the posture of the tracking target changes, resulting in the cropped images being unstable.

[0005] In view of this, the present invention provides a technique that allows stable cropped images to be generated.

[0006] According to one aspect of the present disclosure, there is provided an information processing apparatus comprising: one or more memories storing instructions; and one or more processors executing the instructions to: execute tracking-target specification processing of specifying, as a tracking target, a target to be tracked that is included in an image; execute local-region specification processing of specifying, within the image, a local region that includes at least part of a detection target that is included in the tracking target; execute cropping-region determination processing of, based on size information of the local region, determining size information of a cropping region for cropping the tracking target from the image; and execute cropping processing of generating a cropped image by cropping the image based on the cropping region.

[0007] According to another aspect of the present disclosure, there is provided an information processing method comprising: specifying, as a tracking target, a target to be tracked that is included in an image; specifying, within the image, a local region that includes at least part of a detection target that is included in the tracking target; based on size information of the local region, determining size information of a cropping region for cropping the tracking target from the image; and generating a cropped image by cropping the image based on the cropping region.

[0008] According to another aspect of the present disclosure, there is provided a non-transitory computer-readable storage medium storing a computer program that, when read and executed by a computer, causes the computer to function as: a tracking-target specification unit configured to specify, as a tracking target, a target to be tracked that is included in an image; a local-region specification unit configured to specify, within the image, a local region that includes at least part of a detection target that is included in the tracking target; a cropping-region determination unit configured to, based on size information of the local region, determine size information of a cropping region for cropping cutting out the tracking target from the image; and a cropping unit configured to generate a cropped image by cropping the image based on the cropping region.

[0009] Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a hardware configuration diagram of an information processing apparatus in embodiments.

[0011] FIG. **2** is a functional block diagram for describing functions of the information processing apparatus in first to fourth embodiments.

[0012] FIG. **3**A is a diagram of time-series images for describing the first and second embodiments.

[0013] FIG. **3**B is a diagram of the time-series images for describing the first and second embodiments.

[0014] FIG. **3**C is a diagram of the time-series images for describing the first and second embodiments.

[0015] FIG. **3**D is a diagram of the time-series images for describing the first and second embodiments.

[0016] FIG. **3**E is a diagram of the time-series images for describing the first and second embodiments.

[0017] FIG. **4** is a diagram illustrating a flowchart of recognition processing in the first to fourth embodiments.

[0018] FIG. **5**A is a diagram illustrating a flowchart of cropping-region determination processing in the first embodiment.

[0019] FIG. **5**B is a diagram illustrating a flowchart of cropping-region determination processing in the second embodiment.

[0020] FIG. **6**A is a diagram of pre-registered information in the first embodiment.

[0021] FIG. **6**B is a diagram of pre-registered information in the second embodiment.

[0022] FIG. **6**C is a diagram of pre-registered information in the third embodiment.

[0023] FIG. **6**D is a diagram of pre-registered information in the fourth embodiment.

[0024] FIG. **7**A is a diagram of time-series images for describing the third and fourth embodiments.

[0025] FIG. **7**B is a diagram of the time-series images for describing the third and fourth embodiments.

[0026] FIG. **7**C is a diagram of the time-series images for describing the third and fourth embodiments.

[0027] FIG. **7**D is a diagram of the time-series images for describing the third and fourth embodiments.

[0028] FIG. **7**E is a diagram of the time-series images for describing the third and fourth embodiments.

[0029] FIG. **7**F is a diagram of the time-series images for describing the third and fourth embodiments.

[0030] FIG. **7**G is a diagram of the time-series images for describing the third and fourth embodiments.

[0031] FIG. **7**H is a diagram of the time-series images for describing the third and fourth embodiments.

[0032] FIG. **8** is a diagram illustrating a flowchart of cropping-region determination processing in the third embodiment.

[0033] FIG. **9** is a diagram illustrating a flowchart of cropping-region determination processing in the fourth embodiment.

[0034] FIG. **10** is a diagram for describing a configuration of information processing apparatuses in a fifth embodiment.

[0035] FIG. **11**A is a diagram of time-series images for describing the fifth embodiment.

[0036] FIG. **11**B is a diagram of the time-series images for describing the fifth embodiment.

[0037] FIG. **11**C is a diagram of the time-series images for describing the fifth embodiment.

[0038] FIG. **11**D is a diagram of the time-series images for describing the fifth embodiment.

[0039] FIG. **11**E is a diagram of the time-series images for describing the fifth embodiment.

[0040] FIG. **11**F is a diagram of the time-series images for describing the fifth embodiment.

[0041] FIG. **12**A is a diagram illustrating the entire flowchart in the fifth embodiment.

[0042] FIG. **12**B is a diagram illustrating a flowchart of cropping-region determination processing in the fifth embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0043] Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note, the following embodiments are not intended to limit the scope of the claimed invention. Multiple features are described in the embodiments, but limitation is not made to an invention that requires all such features, and multiple such features may be combined as appropriate. Furthermore, in the attached drawings, the same reference numerals are given to the same or similar configurations, and redundant description thereof is omitted.

First Embodiment: Cropping Method Involving Use of Local Portion where Rate of Fluctuation in Size in Response to Change in Posture is Low

[0044] FIG. **1** illustrates an example of a hardware configuration diagram of an information processing apparatus **200**. The information processing apparatus **200** may be a so-called computer. The information processing apparatus **200** includes a CPU **100**, a ROM **110**, a RAM **120**, an HDD **130**, an input unit **140**, a display unit **150**, a communication unit **160**, and a bus **170**. The CPU **100**, the ROM **110**, the RAM **120**, the HDD **130**, the input unit **140**, the display unit **150**, and the communication unit **160** are connected via the bus **170** so as to be capable of transmitting and receiving information to and from one another.

[0045] The CPU (abbreviation of central processing unit) **100** is a central computation processing device. The information processing apparatus **200** may include, in place of or in addition to the CPU **100**, one or more other processors such as a micro-processing unit (MPU), a graphics processing unit (GPU), and/or a quantum processing unit (QPU). The CPU **100** executes computation, logic determination, and the like for various types of processing. For example, the CPU **100** realizes various functions and executes various types of processing by reading one or more programs stored in the ROM **110** and/or the HDD **130** and expanding the programs to the RAM **120**. Furthermore, some or all functions of the information processing apparatus **200** may be realized by one or more circuits such as an application specific integrated circuit (ASIC) and/or a field programmable gate array (FPGA).

[0046] The ROM (abbreviation of read-only memory) **110** is a non-volatile memory. The ROM **110** stores control programs such as an operating system (OS).

[0047] The RAM (abbreviation of random access memory) **120** is used as the primary memory and a temporary storage area, such as a work area, of the CPU **100**.

[0048] The HDD (hard disk drive) **130** is a large capacity non-volatile storage device. The HDD **130** stores electronic data, programs, and data necessary for program execution according to the present embodiment. The information processing apparatus **200** may include, in place of or in addition to the HDD **130**, one or more external storage devices that function in a similar manner as the HDD **130**. Here, for example, the external storage devices may be realized by a medium (recording medium) and an external storage drive for realizing access to the medium. Flexible disks (FDs), CD-ROMs, DVDs, USB memories, MOs, flash memories, etc., are known as examples of such a medium. Furthermore, the external storage devices may be a server device connected via a network, etc.

[0049] The input unit **140** receives input from a user and transfers the input to the CPU **100**. The input unit **140** includes a mouse, a keyboard, a touch panel, and/or the like.

[0050] Based on image data acquired from the CPU **100** or the like, the display unit **150** displays images of various types of data, processing results, etc., to the user. The display unit **150** is formed from a display device such as a liquid crystal display or an organic electroluminescence (EL) display. The term “image” may be used as a term encompassing a still image, a moving image, an image that is one frame of a moving image, a video, and data of such forms of images.

[0051] The communication unit **160** relays communication with other devices. Thus, the information processing apparatus **200** communicates data with other devices via the communication unit **160**. The information processing apparatus **200** may receive user instructions from other devices via the communication unit **160**, and may output processing results, etc., to other devices via the communication unit **160**.

[0052] FIG. **2** is a functional block diagram for describing the functions of the information processing apparatus **200** according to the present embodiment. A configuration of the present embodiment will be described with reference to FIG. **2**. Note that the configuration will only be outlined here, and will be described in detail later. The information processing apparatus **200** functions as an image input unit **220** a tracking-target setting unit **230**, a cropping-region determination unit **240**, a cropping unit **250**, a multitasking unit **260**, a tracking-target specification unit **270**, a local-region specification unit **280**, and an output unit **290**. For example, the CPU **100** realizes the functions of the image input unit **220**, the tracking-target setting unit **230**, the cropping-region determination unit **240**, the cropping unit **250**, the multitasking unit **260**, the tracking-target specification unit **270**, the local-region specification unit **280**, and the output unit **290** by reading and executing one or more programs stored in the ROM **110** and/or the HDD **130**.

[0053] Input data **210** indicates data of a captured image or an image group including a plurality of captured images. For example, the input data **210** includes a plurality of time-series images obtained from an image-capturing device such as a digital camera, a surveillance camera, or the like.

[0054] The image input unit **220** receives one or more images input as the input data **210**. For example, the input data **210** is a moving image in which a plurality of frame images continue in time series.

[0055] The tracking-target setting unit **230** sets at least one of the type, the in-image position, and the size, which is indicated by a pixel count or the like, of a tracking target that is a target to be tracked in the initial frame of the input data **210**. For example, the tracking target may be of one of the following types: a person; an animal such as a cat or a dog; or a car or the like.

[0056] From an image transferred from the image input unit **220**, the cropping-region determination unit **240** determines a cropping region for cropping the tracking target. Specifically, the cropping-region determination unit **240** determines size information of the cropping region based on size information of a local region that includes at least part of a detection target that is included in the tracking target. Size information is information relating to the size of an in-image region (local region), and may be at least one of: a pixel count within the region; and vertical and horizontal lengths of the region. The detection target is part of the tracking target, and, in the case of an animal for example, includes the head, face, or the like. There may be a plurality of detection targets. For example, the detection targets may include the head, face, feet, hands, etc. If a plurality of types of detection targets are detected, the cropping-region determination unit **240** may, in accordance with the later-described priority ranks, select a detection target for determining the size information of the cropping region from among the plurality of types of detection targets. In this case, the cropping-region determination unit **240** may determine the size information of the cropping region based on size information of a local region of the selected detection target. The cropping-region determination unit **240** may determine the position, etc., of the cropping region as well as the size information.

[0057] The cropping unit **250** cuts out a part of (crops) the image transferred from the image input unit **220** based on the cropping region determined by the cropping-region determination unit **240**. Thus, the cropping unit **250** generates a cropped image that includes the tracking target and that is to be used by the multitasking unit **260**.

[0058] The multitasking unit **260** executes a plurality of recognition tasks on the cropped image generated by the cropping unit **250**. In the present embodiment, description is provided taking a cat whole-body detector, a cat head detector, and a cat face detector as examples of the plurality of recognition tasks. For example, various models including convolutional neural networks, vision transformers (ViTs), and support vector machines (SVMs) combined with feature extractors are conceivable as recognition models to be used in the executed recognition tasks. The present embodiment is not limited to the above-described forms; nevertheless, description is provided in the present embodiment regarding that the multitasking unit **260** is a CNN.

[0059] From detection results obtained from the multitasking unit **260**, the tracking-target specification unit **270** specifies, as a tracking target, a target to be tracked included in the image. The tracking-target specification unit **270** specifies the tracking target from degrees of similarity between feature information of the tracking target obtained from the tracking-target setting unit **230** and feature information of the detection results obtained from the multitasking unit **260**.

[0060] The local-region specification unit **280** specifies a local region for determining size information of a cropping region. Specifically, the local-region specification unit **280** specifies, in the image, a local region that includes at least part of a detection target that is included in the tracking target specified by the tracking-target specification unit **270**. Note that the image in which the local region is specified may be the cropped image. That is, the local-region specification unit **280** may specify a local region in the image using the image or the cropped image. For example, if the tracking target is a cat, and the whole body, the head, and the face of the cat are detection targets, the local-region specification unit **280** specifies, for each detection target, a local region in the image that includes at least part of the detection target. The local-region specification unit **280** transfers, to the cropping-region determination unit **240**, information about the one or more local regions that have been specified. The information about the local regions is used to determine a cropping region in the next frame.

[0061] The output unit **290** outputs results obtained from the multitasking unit **260**, the tracking-target specification unit **270**, and the local-region specification unit **280**. In such a manner, the information processing apparatus **200** can accurately track a tracking target by processing an input scene sequentially in time.

[0062] As an example in the present embodiment, FIGS. **3**A to **3**E illustrate time-series images in a case in which a cat is being tracked. Furthermore, FIG. **4** is a flowchart of recognition processing in the present embodiment. Hereinafter, flowcharts are realized by the CPU **100** executing a control program. FIG. **6**A illustrates pre-registered information in the present embodiment. The pre-registered information is stored in the HDD **130**, and, in the present embodiment, the information processing apparatus **200** can refer to the information, as necessary. The pre-registered information may be read from the HDD **130** and expanded to the RAM **120**.

[0063] In the following, processing in the present embodiment will be described in detail with reference to FIG. **4**.

[0064] In step S**401**, the image input unit **220** acquires an image of one frame that is input as input data **210**. Here, the image input unit **220** acquires an image **301** illustrated in FIG. **3**A. The image **301** in FIG. **3**A is an image of the initial frame at time t=0. In the image **301**, a cat is walking toward the left.

[0065] In step S**402**, the image input unit **220** determines whether or not the image in the acquired input data **210** is the initial frame. If image **301** is the initial frame at time t=0, the image input unit **220** determines that the image is the initial frame and advances to step S**403**.

[0066] In step S**403**, the tracking-target setting unit **230** sets a tracking target based on the image of the initial frame. Here, in step S**403**, the tracking-target setting unit **230** sets the cat as the tracking target, and also sets the position and the size of the tracking target. Any method may be adopted as the method for setting the tracking target. The tracking-target setting unit **230** may set the tracking target according to various methods; e.g., the tracking-target setting unit **230** may set the tracking target by receiving a touch on a camera screen or a voice operation by the user, etc., or by using a recognition result from a recognition processing unit of the camera, etc. In the present embodiment, the tracking-target setting unit **230** sets the whole body of the cat as a tracking-target region **302** as illustrated in FIG. **3**A. Once the tracking-target setting unit **230** has set the tracking target, the image input unit **220** performs the processing in step S**401** again.

[0067] In step S**401**, the image input unit **220** acquires an image **311** illustrated in FIG. **3**B. Here, the image **311** is an image of the cat at time t=1. In the image **311**, the cat that was walking toward the left has stopped.

[0068] In step S**402**, because the image **311** is a frame subsequent to the initial frame, the image input unit **220** determines that the image **311** is not the initial frame and moves on to cropping-region determination processing in step S**404**.

[0069] FIG. **5**A illustrates a detailed flow of the cropping-region determination processing in step S**404** executed by the cropping-region determination unit **240** in the first embodiment. The cropping-region determination unit **240** executes the processing in step S**404**, and the processing in steps S**501** to S**507** describing step S**404** in detail.

[0070] In step S**501**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame (i.e., the frame at the previous time) and that can be used to calculate a cropping region. At time t=1, because the local-region specification processing to be executed in later-described step S**408** has not been executed yet, the cropping-region determination unit **240** determines that there is no local region (NO in the determination in step S**501**), and moves on to the processing in step S**503**.

[0071] In step S**503**, the cropping-region determination unit **240** sets, as a cropping reference, the pixel count of the whole body of the tracking target set by the tracking-target setting unit **230**.

[0072] Here, a cropping reference is size information of the tracking-target region in an image, and is information for calculating the size (pixel count) of a cropping region. Size and pixel count are examples of size information. The cropping-region determination unit **240** can determine a cropping region by using a cropping reference and a later-described cropping magnification ratio. In the present embodiment, description is provided regarding that a cropping reference is a pixel count; however, this is not necessarily the case, and any kind of information relating to the size of the tracking target may be used. For example, the cropping-region determination unit **240** may use, as a cropping reference, size information such as the length of the long sides, the length of the short sides, or the lengths of the diagonals of a rectangular frame indicating a target region. At time t=1, the cropping-region determination unit **240** determines a cropping region by multiplying a cropping magnification ratio and the pixel count of the whole body of the tracking target (i.e., the cropping reference).

[0073] In step S**504**, the cropping-region determination unit **240** acquires a cropping magnification ratio corresponding to the cropping reference. The cropping magnification ratio is a preset magnification ratio by which the cropping reference is to be multiplied, and can be set for each type of cropping reference (e.g., for each detection target). FIG. **6**A illustrates pre-registered information **601** that is set in advance in the present embodiment. In the pre-registered information **601**, a cropping magnification ratio is determined for each detection target (type of recognition task). It is indicated that the cropping magnification ratio when the whole body is selected as the cropping reference is 3.0×, the cropping magnification ratio when the head is selected as the cropping reference is 15.0×, and the cropping magnification ratio when the face is selected as the cropping reference is 30.0×. Accordingly, due to having set the pixel count of the whole body of the tracking target as the cropping reference in step S**503**, the cropping-region determination unit **240** selects and acquires, as the cropping magnification ratio in step S**504**, 3.0× associated with the whole body from the pre-registered information **601** illustrated in FIG. **6**A. Furthermore, in the present embodiment, the pixel count of the tracking-target region **302** set by the tracking-target setting unit **230** is used as the pixel count of the whole body of the tracking target in the present embodiment; however, there is no limitation to this, and a result from the whole-body detector of the multitasking unit **260** may be used.

[0074] In step S**505**, the cropping-region determination unit **240** calculates the pixel count of the cropping region from the cropping reference and the cropping magnification ratio. Specifically, the cropping-region determination unit **240** calculates, as the pixel count of the cropping region, a product of the pixel count of the whole body of the tracking target set as the cropping reference and the cropping magnification ratio determined in step S**504**.

[0075] In step S**506**, the cropping-region determination unit **240** determines the aspect ratio of the cropping region. In the present embodiment, description is provided regarding that the aspect ratio is 4:3; however, there is no limitation to this. For example, the cropping-region determination unit **240** may determine the aspect ratio in accordance with the cropping region, or may adopt a predetermined aspect ratio.

[0076] In step S**507**, the cropping-region determination unit **240** determines the position of the cropping region. In the present embodiment, the cropping-region determination unit **240** determines the center of the tracking target as the position of the cropping region. Note that the position of the cropping region does not necessarily have to be the center of the tracking target, and any position determination method may be used. Thus, the cropping-region determination unit **240** determines a cropping region **312** illustrated in FIG. **3**B. The processing leaves the detailed flow of step S**404**, and advances to step S**405**.

[0077] In step S**405**, the cropping unit **250** generates a cropped image **313**. For example, the cropping unit **250** crops the image **311** using the cropping region **312** determined as a result of step S**404**, and resizes the resultant image. In the present embodiment, description is provided regarding that the image size after the resizing is QVGA (320 pixels×240 pixels); however, the image size is not limited to this. As a result of the above-described processing, the cropping unit **250** generates the cropped image **313** illustrated in FIG. **3**C.

[0078] In step S**406**, the multitasking unit **260** executes multitask processing on the cropped image **313** in FIG. **3**C. In the present embodiment, description is provided taking the cat whole-body detector, the cat head detector, and the cat face detector as an example of the multitask processing executed by the multitasking unit **260**; however, there is no limitation to this. For example, the multitasking unit **260** may execute, in place of or in addition to the above-described detectors, a pupil detector, a tracking-target tracking function, etc., as the multitask processing. A whole-body detection result **314**, a head detection result **315**, and a face detection result **316** illustrated in FIG. **3**C are the results of the detection by the multitasking unit **260** at time t=1.

[0079] In step S**407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. In the present embodiment, the tracking-target specification unit **270** compares the feature amounts of the individual detection results and the tracking-target region **302**, and determines the detection result having the closest feature amount as the tracking target. The specification of the tracking target does not necessarily have to involve comparison of feature amounts, and any method may be adopted as long as a detection result can be determined as the tracking target. At time t=1, the tracking-target specification unit **270** specifies the whole-body detection result **314** as the tracking target.

[0080] In step S**408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. In the present embodiment, the local-region specification unit **280** specifies local regions using the distance from the center position of the whole-body detection result **314** in FIG. **3**C, which has been specified by the tracking-target specification unit **270** as the tracking target. The specification of local regions does not necessarily have to involve the use of distance information. At time t=1, the local-region specification unit **280** specifies the head detection result **315** and the face detection result **316** as local regions. Here, the whole-body detection result **314** has been specified as the tracking target, and thus is not adopted as a local region for determining a cropping region. The regions of the head detection result **315** and the face detection result **316** are an example of a plurality of local regions of a plurality of different types of detection targets of a tracking target.

[0081] In step S**409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=1, processing returns to step S**401** and the processing at time t=2 is performed.

[0082] In step S**401**, the image input unit **220** acquires an image **321** in FIG. **3**D. The image **321** is an image of the cat at time t=2. In the image **321**, the cat that was not moving in the previous frame has started to move again toward the left. Subsequently, the cropping-region determination unit **240** executes the processing in step S**404** again after the image input unit **220** executes the processing in step S**402**.

[0083] In step S**501** in FIG. **5**A, which illustrates the detailed flow of step S**404**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. The cropping-region determination unit **240** detected the head detection result **315** and the face detection result **316** in the previous frame at time t=1. Furthermore, because the cropping-region determination unit **240** can use all of the information registered in the pre-registered information **601** to calculate a cropping region in the present embodiment, the cropping-region determination unit **240** moves on to the processing in step S**502**.

[0084] In step S**502**, the cropping-region determination unit **240** sets the pixel count of a local region as a cropping reference in accordance with priority ranks in the pre-registered information **601**. Here, if there are a plurality of types of local regions, the cropping-region determination unit **240** selects a detection target in accordance with the priority ranks, and sets a local region of the selected detection target as the cropping reference. Specifically, among the two local regions here, i.e., the head detection result **315** and the face detection result **316**, the local region having the higher priority rank is the head detection result **315**, with reference to the pre-registered information **601**. Accordingly, in step S**502**, the cropping-region determination unit **240** sets the pixel count of the head detection result **315** as the cropping reference.

[0085] Here, the priority ranks of the cropping references in the pre-registered information **601** are determined in advance in consideration of the "rate of fluctuation in size in response to change in posture". Taking the cat in the present embodiment as an example, between the walking and stopping states, the fluctuation in size of the whole body is great but the fluctuation in size of the head is small. Thus, by setting the head as a cropping reference, the cropping-region determination unit **240** can reduce the fluctuation of a cropping region in response to a change in posture. The fluctuation in size of the face in response to a change in posture is greater than that of the head but smaller than that of the whole body. Thus, the priority rank of the head, the priority rank of the face, and the priority rank of the whole body are set to first, second, and third, respectively.

[0086] The cropping-region determination unit **240** acquires 15.0× as a cropping magnification ratio from the pre-registered information **601** in step S**504**, and calculates the pixel count of the cropping region in step S**505**. Subsequently, the cropping-region determination unit **240** determines a cropping region **322** in FIG. **3**D by executing the processing in steps S**506** and S**507**.

[0087] In step S**405**, the cropping unit **250** generates a cropped image using the cropping region **322**. Subsequently, the processing from step S**406** to step S**409** is executed, and the series of processing is concluded.

[0088] In the present embodiment, a cropping reference and a cropping magnification ratio can be determined in consideration of the "rate of fluctuation in size in response to change in posture" as described above. In the case of a curled-up cat, etc., an extremely small cropping region would be determined if a region that is readily affected by a change in posture were set as the cropping reference. Because the cropping region is determined using information about the previous frame, a part or the entirety of the cat may exceed the boundaries of the cropping region in a case such as that in which the cat moves abruptly in the current frame if the cropping region were small. If such a situation occurs, the cat would exceed the boundaries of the cropped image, and it would be impossible to execute the multitask processing correctly.

[0089] In the present embodiment, processing is executed by setting, as priority ranks in the pre-registered information, the knowledge that the size of a cat's whole body fluctuates significantly depending on posture, and the size of a cat's head does not fluctuate much depending on posture.

[0090] That is, in the present embodiment, size information of a cropping region is determined based on size information of the head or the like, which is not readily affected by a change in posture of the tracking target. Thus, in the present embodiment, stable cropped images can be generated because the size of cropping regions is not readily affected by changes in posture of the tracking target. Due to this, in the present embodiment, the tracking target can be suppressed from exceeding the boundaries of cropping regions, whereby the performance of the multitask processing including processing of a plurality of recognition tasks can be stabilized and the accuracy of the detection tasks performed on the detection targets can also be stabilized.

[0091] In the present embodiment, a detection target to be used to determine size information of a cropping region is selected based on the priority ranks set in advance for the whole body, the head, and the face, which are the plurality of detection targets. Furthermore, in the present embodiment, the size information of the cropping region is determined based on the size information of the local region of the selected detection target. Thus, in the present embodiment, cropping regions can be stabilized with greater certainty. Furthermore, in the present embodiment, even if a detection target having the highest priority rank is not detected, size information of a cropping region can be determined based on size information of a local region of a detection target that is next least affected by a change in posture of the tracking target.

Second Embodiment: Calculation of Cropping Region Using Results of Plurality of Recognition Tasks

[0092] In the second embodiment, a method for determining a cropping region using results of a plurality of recognition tasks will be described, taking as an example a case in which a cat is walking, similarly to the first embodiment. In the present embodiment, the local-region specification unit **280** specifies a plurality of local regions. For example, the local-region specification unit **280** specifies a local region from each of a plurality of detection targets including the head, the face, etc., and consequently specifies a plurality of local regions. The cropping-region determination unit **240** determines the size information of the cropping region based on size information of the plurality of local regions. For example, the cropping-region determination unit **240** may determine the cropping region based on a result obtained by executing averaging processing on the size information of the plurality of local regions.

[0093] The example hardware configuration in the present embodiment is the same as that in FIG. **1** in the first embodiment, and the configuration diagram is also the same as that in FIG. **2**.

[0094] As an example in the present embodiment, FIGS. **3**A to **3**E illustrate time-series images in a case in which a cat is being tracked. An image **301** in FIG. **3**A is an image in which the cat is walking toward the left in the initial frame at time t=0. Furthermore, in the second embodiment, reference will be made to the flowcharts in FIGS. **4** and **5**B. FIG. **6**B illustrates pre-registered information in the present embodiment.

[0095] When the image **301** is processed at time t=0, processing is executed in the order of steps S**401**, S**402**, and S**403**, similarly to the first embodiment. In step S**403**, the tracking-target setting unit **230** sets the whole body of the cat as a tracking-target region **302** as illustrated in FIG. **3**A.

[0096] Next, in step S**401**, the image input unit **220** acquires an image **311** in FIG. **3**B. Here, the image **311** is an image of the cat at time t=1. In the image **311**, the cat that was walking toward the left has stopped. Because the image input unit **220** determines that the image **311** is a frame subsequent to the initial frame in step S**402**, the cropping-region determination unit **240** executes the cropping-region determination processing in step S**404**.

[0097] FIG. **5**B illustrates a detailed flow of the cropping-region determination processing in step S**404** executed by the cropping-region determination unit **240** in the second embodiment. Note that description will be simplified for processing in FIG. **5**B that is similar to that in FIG. **5**A. FIG. **6**B illustrates pre-registered information **602** in the second embodiment.

[0098] In step S**511**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. At time t=1, because the local-region specification processing to be executed in later-described step S**408** has not been executed yet, the result of the determination in step S**511** is NO, and the cropping-region determination unit **240** moves on to the processing in step S**514**. In step S**514**, the cropping-region determination unit **240** sets, as a cropping reference, the pixel count of the whole body of the tracking target set by the tracking-target setting unit **230**.

[0099] In step S**515**, from the pre-registered information **602** in FIG. **6**B, the cropping-region determination unit **240** acquires, as a cropping magnification ratio, 3.0× corresponding to the whole body, which is the cropping reference.

[0100] In step S**516**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the whole body of the tracking target set as the cropping reference and the cropping magnification ratio determined in step S**515**.

[0101] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step S**517** and determines the position of the cropping region in step S**518**. Thus, the cropping-region determination unit **240** determines a cropping region **312** illustrated in FIG. **3**B.

[0102] In step S**405**, the cropping unit **250** generates a cropped image **313** in FIG. **3**C by executing cropping processing using the cropping region **312** determined in step S**404** and processing of resizing the image to QVGA. In step S**406**, the multitasking unit **260** executes multitask processing to obtain a whole-body detection result **314**, a head detection result **315**, and a face detection result **316**.

[0103] In step S**407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. At time t=1, the tracking-target specification unit **270** specifies the whole-body detection result **314** as the tracking target.

[0104] In step S**408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. At time t=1, the local-region specification unit **280** specifies the head detection result **315** and the face detection result **316** as local regions. Here, the whole-body detection result **314** has been specified as the tracking target, and thus is not adopted as a local region for determining a cropping region.

[0105] In step **S409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=1, processing returns to step **S401** and the processing at time t=2 is performed.

[0106] In step **S401**, the image input unit **220** acquires an image **331** in FIG. 3E. The image **331** is an image of the cat at time t=2. In the image **331**, the cat that was not moving in the previous frame has started to move again toward the left. Subsequently, the processing from step **S402** to step **S404** is executed again.

[0107] In step **S511**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. The head detection result **315** and the face detection result **316** were detected at time t=1. Furthermore, because all of the information registered in the pre-registered information **602** can be set as cropping references in the present embodiment, the cropping-region determination unit **240** moves on to the processing in step **S512**.

[0108] In step **S512**, the cropping-region determination unit **240** acquires, from the pre-registered information **602**, the cropping magnification ratios and weight coefficients of all local regions specified from a plurality of detection targets. In step **S513**, the cropping-region determination unit **240** calculates the pixel count of a cropping region from the weight coefficient, the cropping magnification ratio, and the pixel count of each cropping reference.

[0109] Here, the weight coefficients indicate the degrees of importance of the individual recognition tasks, and more stable pixel counts of cropping regions can be calculated by using the weight coefficients. In the present embodiment, in consideration of the "rate of fluctuation in size in response to change in posture", the pre-registered information **602** is set so that the weight coefficient is greater for a detection result of which the rate of fluctuation in size is smaller.

[0110] A calculation method of a pixel count C of a cropping region in the present embodiment is shown below.

[Math. 1]

$$C = \frac{\sum_{i=1}^{N} W_i P_i R_i}{\sum_{i=1}^{N} W_i} \tag{1.1}$$

[0111] In formula (1.1), W represents a weight coefficient, P represents the pixel count of a local region, and R indicates a cropping magnification ratio. N represents the number of local regions that have been specified, and, in the present embodiment, the total number of local regions specified is two (the head detection result **315** and the face detection result **316**). Furthermore, in the present embodiment, description is provided regarding that the pixel count of the head detection result **315** is 60 pixels, and the pixel count of the face detection result **316** is 20 pixels.

[0112] According to the above-described formula (1.1), a pixel count of the cropping region is calculated for each recognition task, and a weighted average of the pixel counts is calculated. The pixel count of the cropping region when the head detection result **315** is adopted as the cropping reference is 900 pixels, which is the product of the pixel count (60 pixels) of the head detection result and the cropping magnification ratio (15.0×) for the head. The pixel count of the cropping region when the face detection result **316** is adopted as the cropping reference is 600 pixels, which is the product of the pixel count (20 pixels) of the face detection result and the cropping magnification ratio (30.0×) for the head. By respectively multiplying the pixel counts by the weight coefficient 5.0 for the head and the weight coefficient 3.0 for the face and calculating the weighted average thereof, the pixel count C of the cropping region is calculated as 787.5 pixels. It can be seen that, by the cropping-region determination unit **240** calculating a pixel count of a cropping region using a plurality of detection results, pixel counts of cropping regions become stable even if the size of the head detection result **315** has been incorrectly detected.

[0113] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step **S517** and determines the position of the cropping region in step **S518**. Thus, the cropping-region determination unit **240** determines a cropping region **332** illustrated in FIG. **3**E.

[0114] Subsequently, in step **S405**, the cropping unit **250** generates a cropped image using the cropping region **332**. Subsequently, the processing from step **S406** to step **S409** is executed, and the processing in the present embodiment is concluded.

[0115] As described above, in the present embodiment, by calculating size information of a cropping region based on size information of a plurality of detection targets detected by a plurality of recognition tasks, stable cropping regions can be calculated even if the size of some detection results is incorrect.

[0116] For example, in the present embodiment, size information of a cropping region is calculated based on a result obtained by executing averaging processing on size information of a plurality of local regions. Thus, cropping regions can be stabilized even if the size information of the plurality of local regions includes an outlier. Note that, while description has been provided in the present embodiment taking a weighted average as an example, this is not necessarily the case; a cropping region may be determined using averaging processing such as a simple average or moving average.

[0117] Furthermore, the cropping-region determination unit **240** may determine at least one of the maximum and the minimum of size information of a cropping region using detection results of a plurality of recognition tasks. For example, if priority ranks are set in the pre-registered information, the cropping-region determination unit **240** may calculate a cropping region based on a detection result of a recognition task having the highest priority rank, and set values obtained by multiplying the pixel count of the cropping region by 2.0 and 0.5 as the maximum and the minimum, respectively. Subsequently, if the pixel count of a cropping region exceeds the maximum or falls below the minimum when the cropping-region determination unit **240** calculates a cropping region using a weighted average as in the present embodiment, the cropping-region determination unit **240** sets the pixel count of the cropping region so as to be within the range of the maximum and the minimum that have been set. By setting the maximum and the minimum as described above, a cropping region can be set within the range of 0.5 to 2.0 times the pixel count of the cropping region calculated from the recognition task having the highest priority rank.

[0118] According to the above, the performance of the multitasking means can be stabilized using detection results of a plurality of recognition tasks.

Third Embodiment: Use of Time-Series Information to Determine Cropping Reference to be Used to Calculate Cropping Region

[0119] In the present embodiment, a method for determining a cropping reference using time-series information will be described, taking as an example a case in which a cat is walking. For example, in the present embodiment, the local-region specification unit **280** specifies a plurality of local regions from a plurality of images corresponding to different times. The cropping-region determination unit **240** determines size information of a cropping region based on size information of at least one of the plurality of local regions. Here, the local-region specification unit **280** may specify a plurality of local regions of a plurality of types of detection targets, e.g., the head and the face. In other words, the local-region specification unit **280** may specify, from each of a plurality of images corresponding to different times, local regions of a plurality of mutually different types of detection targets. The cropping-region determination unit **240** may determine the size information of the cropping region based on size information of a local region of a detection target selected from among the plurality of types of detection targets. For example, the cropping-region determination unit **240** may determine the size information of the cropping region based on the size information of the local region of the detection target selected based on a change in size information of the local regions. For example, the change in size information of a local region may be the rate of change in size of the local region that is specified from the images corresponding to different times. Here, the size may be any of the pixel count of the local region, the product of the vertical and horizontal lengths of the local region, and the like.

[0120] The example hardware configuration in the present embodiment is the same as that in FIG. **1** in the first embodiment, and the configuration diagram is also the same as that in FIG. **2**.

[0121] As an example in the present embodiment, FIGS. **7**A to **7**H illustrate time-series images in a case in which a cat is being tracked. An image **701** in FIG. **7**A is an image in which the cat is walking toward the left in the initial frame at time t=0. Furthermore, in the third embodiment, reference will be made to the flowcharts in FIGS. **4** and **8**. FIG. **6**C illustrates pre-registered information in the present embodiment.

[0122] When the image **701** is processed at time t=0, processing is executed in the order of steps S**401**, S**402**, and S**403**, similarly to the first embodiment. In step S**403**, the tracking-target setting unit **230** sets the whole body of the cat as a tracking-target region **702** as illustrated in FIG. **7**A.

[0123] Next, in step S**401**, the image input unit **220** acquires an image **711** in FIG. **7**B. Here, the image **711** is an image of the cat at time t=1. In the image **711**, the cat is still moving toward the left. Because the image input unit **220** determines that the image **711** is a frame subsequent to the initial frame in step S**402**, the image input unit **220** moves on to cropping-region determination processing in step S**404**.

[0124] FIG. **8** illustrates a detailed flow of the cropping-region determination processing in step S**404** executed by the cropping-region determination unit **240** in the third embodiment. Note that description will be simplified for processing in FIG. **8** that is similar to that in the above-described embodiments.

[0125] In step S**801**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. At time t=1, there is no local region because the local-region specification processing to be executed in later-described step S**408** has not been executed yet. Accordingly, the cropping-region determination unit **240** makes a determination of "NO" in step S**801** and moves on to the processing in step S**807**.

[0126] In step S**807**, the cropping-region determination unit **240** sets, as a cropping reference, the pixel count of the whole body of the tracking target set by the tracking-target setting unit **230**.

[0127] In step S**808**, from the pre-registered information **603** in FIG. **6**C, the cropping-region determination unit **240** acquires, as a cropping magnification ratio, 3.0× corresponding to the whole body, which is the cropping reference.

[0128] In step S**809**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the whole body of the tracking target set as the cropping reference and the cropping magnification ratio determined in step S**808**.

[0129] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step S**810** and determines the position of the cropping region in step S**811**. Thus, the cropping-region determination unit **240** determines a cropping region **712** illustrated in FIG. **7**B.

[0130] In step S**405**, the cropping unit **250** generates a cropped image **713** in FIG. **7**C by executing cropping processing using the cropping region **712** determined in step S**404** and processing of resizing the image to QVGA.

[0131] In step S**406**, the multitasking unit **260** executes multitask processing to obtain a whole-body detection result **714**, a head detection result **715**, and a face detection result **716**.

[0132] In step S**407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. At time t=1, the tracking-target specification unit **270** specifies the whole-body detection result **714** as the tracking target.

[0133] In step S**408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. At time t=1, the local-region specification unit **280** specifies the head detection result **715** and the face detection result **716** as local regions.

[0134] In step S**409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=1, processing returns to step S**401** and the processing at time t=2 is performed.

[0135] In step S**401**, the image input unit **220** acquires an image **721** in FIG. **7**D. Here, the image **721** is an image of the cat at time t=2. In the image **721**, the cat is still moving toward the left. Subsequently, the processing from step S**402** to step S**404** is executed again.

[0136] In step S**801**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. The head detection result **715** and the face detection result **716** were detected in the previous frame at time t=1. Furthermore, because all of the information registered in the pre-registered information **603** can be used to calculate a cropping region in the present embodiment, the cropping-region determination unit **240** determines that there is a local region in the previous frame and moves on to the processing in step S**802**.

[0137] In step S**802**, the cropping-region determination unit **240** determines whether there are a plurality of local regions that can be used to calculate a cropping region. Because the head detection result **715** and the face detection result **716** were detected at time t=1, the cropping-region determination unit **240** determines that there are a plurality of local regions that can be used and moves on to the processing in step S**803**.

[0138] In step S**803**, the cropping-region determination unit **240** determines whether time-series information of the local-region detection results is available for use. At time t=2, only the detection results at time t=1 are present, and thus there is not enough information about the local regions, detection results, or the like specified from a plurality of images corresponding to different times to determine temporal changes in the local regions. Thus, the cropping-region determination unit **240** determines that time-series information is not available for use, and moves on to the processing in step S**806**.

[0139] In step S**806**, the cropping-region determination unit **240** sets a detected local region as a cropping reference in accordance with priority ranks. Because it can be ascertained from the pre-registered information **603** that the priority rank of the face detection result is highest, the cropping-region determination unit **240** sets the pixel count of the face region as the cropping reference.

[0140] In step S**808**, from the pre-registered information **603** in FIG. **6**C, the cropping-region determination unit **240** acquires and sets, as a cropping magnification ratio, 30.0× associated with the face.

[0141] In step S**809**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the face set as the cropping reference and the cropping magnification ratio determined in step S**808**. The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step S**810** and determines the position of the cropping region in step S**811**. Thus, the cropping-region determination unit **240** determines a cropping region **722** illustrated in FIG. **7**D.

[0142] In step S**405**, the cropping unit **250** generates a cropped image **723** in FIG. **7**E by executing cropping processing using the cropping region **722** determined in step S**404** and processing of resizing the image to QVGA.

[0143] In step S**406**, the multitasking unit **260** executes multitask processing to obtain a whole-body detection result **724**, a head detection result **725**, and a face detection result **726**.

[0144] In step S**407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. At time t=2, the tracking-target specification unit **270** specifies the whole-body detection result **724** as the tracking target.

[0145] In step S**408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. At time t=2, the local-region specification unit **280** specifies the head detection result **725** and the face detection result **726** as local regions.

[0146] In step S**409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=2, processing returns to step S**401** and the processing at time t=3 is performed.

[0147] In step S**401**, the image input unit **220** acquires an image **731** in FIG. **7**G. The image **731** is an image of the cat at time t=3. In the image **731**, the cat is still moving toward the left. Subsequently, the processing from step S**402** to step S**404** is executed again.

[0148] In step S**801**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. The head detection result **725** and the face detection result **726** were detected in the previous frame at time t=2. Accordingly, the cropping-region determination unit **240** determines that there is a local region, and moves on to the processing in step S**802**.

[0149] In step S**802**, the cropping-region determination unit **240** determines whether there are a plurality of local regions that can be used for cropping. The head detection result **725** and the face detection result **726** were detected at time t=2. Accordingly, the cropping-region determination unit **240** determines that there are a plurality of local regions, and moves on to the processing in step S**803**.

[0150] In step S**803**, the cropping-region determination unit **240** determines whether time-series information of the local-region detection results is available for use. At time t=3, the detection results at time t=1 and time t=2 are present, and thus there is enough information to determine temporal changes in the local regions. Thus, the cropping-region determination unit **240** determines that time-series information is available for use, and moves on to the processing in step S**804**. In the present embodiment, it is determined that time-series information is available for use if local-region detection results for past two frames are present; however, there is no limitation to this.

[0151] In step S**804**, the cropping-region determination unit **240** calculates a size change rate from time-series information of each local region.

[0152] The size change rate is a value obtained by calculating how much the size (pixel count) has changed from size information of a local-region detection result in a past frame. In the present embodiment, the cropping-region determination unit **240** calculates how much the size has changed from the originally detected local-region size by comparing size information of the detection result from two frames ago and size information of the detection result in the previous frame; however, this is not necessarily the case. For example, the cropping-region determination unit **240** may calculate the size change rate by calculating the variance, standard deviation, etc., of sizes in time-series information of a local region. It can be seen that the size change rate of the whole body is small because the orientation of the cat's body has not changed between the whole-body detection result **714** and the whole-body detection result **724**. It can be seen that the size change rate of the face is great because the orientation of the cat's face has changed from forward to sideways between the face detection result **716** and the face detection result **726**. It can be seen that, between the head detection result **715** and the head detection result **725**, the amount of change in the detection result of head size is small even if the cat faces sideways.

[0153] In step S**805**, the cropping-region determination unit **240** sets, as a cropping reference, the pixel count of the local region having the smallest size change rate. In the present embodiment, the cropping-region determination unit **240** determines that the region having the smallest size change rate is the head, and sets the pixel count of the head as a cropping reference. Here, if the method according to the first embodiment were adopted, the pixel count of the face would be set as a cropping reference according to the priority ranks, and thus the cropping region would become smaller than that at time t=2.

[0154] In step S**808**, from the pre-registered information **603** in FIG. **6**C, the cropping-region determination unit **240** acquires, as a cropping magnification ratio, 15.0× associated with the head.

[0155] In step S**809**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the head set as the cropping reference and the cropping magnification ratio determined in step S**808**.

[0156] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step S**810** and determines the position of the cropping region in step S**811**. Thus, the cropping-region determination unit **240** determines a cropping region **732** illustrated in FIG. **7**G.

[0157] Subsequently, in step S**405**, the cropping unit **250** generates a cropped image using the cropping region **732**. Subsequently, the processing from step S**406** to step S**409** is executed, and the processing in the present embodiment is concluded.

[0158] As described above, the information processing apparatus in the third embodiment can set stable cropping regions by calculating a cropping region using one among a plurality of local regions that is specified by using a plurality of images corresponding to different times as time-series information. For example, in the present embodiment, the local region to be used to calculate the cropping region is selected based on rates of change of size information of the local regions. Specifically, in the present embodiment, the cropping region is determined using the local region for which the change in size information is small. Thus, in the present embodiment, stable cropping regions can be calculated appropriately even if the priority rank is high for a local region that is not suitable for a stable cropping region or even if priority ranks are not set.

[0159] Furthermore, in the present embodiment, description is provided of a method for determining a cropping reference from among local regions of different types, such as the face and the head. For example, even in a case in which there are a plurality of candidate local regions of the same type, such as the pupils and legs (e.g., two candidate local regions in the case of the pupils), one local region that is suitable for calculating a cropping region may be determined according to the above-described method.

Fourth Embodiment: Use of Time-Series Information to Determine Cropping Region in Case in which Recognition Task(s) Result in No Detection

[0160] In the present embodiment, a method for determining a cropping region in a case in which a recognition task having a high priority rank results in no detection will be described, taking as an example a case in which a cat is walking. Specifically, in the present embodiment, the local-region specification unit **280** specifies a plurality of local regions from a plurality of frame images corresponding to different times. Based on a change between the plurality of local regions corresponding to different times, the cropping-region determination unit **240** sets a cropping region in the current image based on a cropping region in the previous frame image (i.e., the image corresponding to the previous time). Furthermore, if there are no local regions corresponding to the previous time, the cropping-region determination unit **240** determines whether or not to set the current cropping region based on the previous cropping region.

[0161] As an example in the fourth embodiment, FIGS. **7**A to **7**H illustrate time-series images in a case in which a cat is being tracked. An image **701** in FIG. **7**A is an image in which the cat is walking toward the left in an initial frame corresponding to time t=0. Furthermore, in the fourth embodiment, reference will be made to the flowcharts in FIG. **4** and FIG. **9**. FIG. **6**D illustrates pre-registered information in the fourth embodiment.

[0162] When the image **701** is processed at time t=0, processing is executed in the order of steps S**401**, S**402**, and S**403**, similarly to the third embodiment. In step S**403**, the tracking-target setting unit **230** sets the whole body of the cat as a tracking-target region **702** as illustrated in FIG. **7**A.

[0163] Next, in step S**401**, an image **711** in FIG. **7**B is acquired. Here, the image **711** is an image of the cat at time t=1. In the image **711**, the cat is still moving toward the left. Because the image input unit **220** determines that the image **711** is a frame subsequent to the initial frame in step S**402**, the image input unit **220** moves on to cropping-region determination processing in step S**404**.

[0164] FIG. **9** illustrates a detailed flow of the cropping-region determination processing in step S**404** executed by the cropping-region determination unit **240** in the fourth embodiment.

[0165] In step S**901**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. Because the processing by the multitasking unit **260** has not been executed yet at time t=1, the cropping-region determination unit **240** determines that there is no detected local region, and moves on to the processing in step S**903**.

[0166] In step S**903**, the cropping-region determination unit **240** determines whether there is a detection result from the previous frame. Because the processing by the multitasking unit **260** has not been executed yet at time t=1, the cropping-region determination unit **240** determines that there is no detection result from the previous frame, and moves on to the processing in step S**904**.

[0167] In step S**904**, the cropping-region determination unit **240** sets, as a cropping reference, the pixel count of the whole body of the tracking target set by the tracking-target setting unit **230**.

[0168] In step S**907**, from the pre-registered information **604** in FIG. **6**D, the cropping-region determination unit **240** acquires, as a cropping magnification ratio, 3.0× corresponding to the whole body, which is the cropping reference.

[0169] In step S**908**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the whole body of the tracking target set as the cropping reference and the cropping magnification ratio determined in step **S907**.

[0170] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step **S909** and determines the position of the cropping region in step **S911**. Thus, the cropping-region determination unit **240** determines a cropping region **712** illustrated in FIG. **7**B.

[0171] In step **S405**, the cropping unit **250** generates a cropped image **713** in FIG. **7**C by executing cropping processing using the cropping region **712** determined in step **S404** and processing of resizing the image to QVGA.

[0172] In step **S406**, the multitasking unit **260** executes multitask processing to obtain a whole-body detection result **714**, a head detection result **715**, and a face detection result **716**.

[0173] In step **S407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. At time t=1, the tracking-target specification unit **270** specifies the whole-body detection result **714** as the tracking target.

[0174] In step **S408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. At time t=1, the local-region specification unit **280** specifies the head detection result **715** and the face detection result **716** as local regions.

[0175] In step **S409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=1, processing returns to step **S401** and the processing at time t=2 is performed.

[0176] In step **S401**, the image input unit **220** acquires an image **721** in FIG. **7**D. Here, the image **721** is an image of the cat at time t=2. In the image **721**, the cat is still moving toward the left. Subsequently, the processing from step **S402** to step **S404** is executed again.

[0177] In step **S901**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. The head detection result **715** and the face detection result **716** were detected in the previous frame at time t=1. Furthermore, because all of the information registered in the pre-registered information **604** can be set as cropping references in the present embodiment, the cropping-region determination unit **240** moves on to the processing in step **S902**.

[0178] In step **S902**, the cropping-region determination unit **240** sets a detected local region as a cropping reference in accordance with priority ranks. Because it can be ascertained from the pre-registered information **604** that the priority rank of the head is highest, the cropping-region determination unit **240** sets the pixel count of the head as the cropping reference.

[0179] In step **S907**, from the pre-registered information **604** in FIG. **6**D, the cropping-region determination unit **240** acquires, as a cropping magnification ratio, 15.0× corresponding to the head, which is the cropping reference.

[0180] In step **S908**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the head set as the cropping reference and the cropping magnification ratio determined in step **S907**.

[0181] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step **S909** and determines the position of the cropping region in step **S911**. Thus, the cropping-region determination unit **240** determines a cropping region **722** illustrated in FIG. **7**D.

[0182] In step **S405**, the cropping unit **250** generates a cropped image **727** in FIG. **7**F by executing cropping processing using the cropping region **722** determined in step **S404** and processing of resizing the image to QVGA.

[0183] In step **S406**, the multitasking unit **260** executes multitask processing to obtain only a whole-body detection result **728**, whereas the head and the face are undetected.

[0184] In step **S407**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the multitasking unit **260**. At time t=2, the tracking-target specification unit **270** specifies the whole-body detection result **728** as the tracking target.

[0185] In step **S408**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the multitasking unit **260**. At time t=2, the local-region specification unit **280** does not detect any local regions.

[0186] In step **S409**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=2, processing returns to step **S401** and the processing at time t=3 is performed.

[0187] In step **S401**, the image input unit **220** acquires an image **733** in FIG. **7**H. The image **733** is an image of the cat at time t=3. In the image **733**, the cat is still moving toward the left. Subsequently, the processing from step **S402** to step **S404** is executed again.

[0188] In step **S901**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. Because the head and the face were undetected at time t=2, the cropping-region determination unit **240** determines that there is no detected local region, and moves on to the processing in step **S903**.

[0189] In step **S903**, the cropping-region determination unit **240** determines whether there is a detection result from the previous frame. Because the whole-body detection result **728** was detected at time t=2, the cropping-region determination unit **240** determines that there is a detection result from the previous frame and moves on to the processing in step **S905**.

[0190] In step **S905**, the cropping-region determination unit **240** calculates a size change rate from time-series information of the detection result. Similarly to that described in the third embodiment, the size change rate is a value obtained by calculating how much the size has changed from size information (pixel count) of a detection result in a past frame. For example, the cropping-region determination unit **240** may calculate, as the size change rate, the change between the size of a local region at a given time and the size of the local region immediately after the given time.

[0191] In step **S906**, the cropping-region determination unit **240** determines whether the size change rate is equal to or less than a threshold. If the size change rate between the whole-body detection result **714** and the whole-body detection result **728** is low, and the cropping-region determination unit **240** thus determines that the size change rate is equal to or less than the threshold, the cropping-region determination unit **240** moves on to the processing in step **S910**. On the other hand, the cropping-region determination unit **240** moves on to the processing in step **S904** upon determining that the size change rate is greater than the threshold.

[0192] In step **S910**, the cropping-region determination unit **240** sets the cropping region in the previous frame as the cropping region in the current frame. In other words, if local regions at the previous time are undetected and the size change rate is equal to or less than the threshold, the cropping-region determination unit **240** determines the cropping region at the previous time as the current cropping region.

[0193] Here, in the third embodiment for example, the whole body of the tracking target, of which the "rate of fluctuation in size in response to change in posture" is great, may be set as a cropping reference because local regions in the previous frame that can be used to calculate a cropping region are undetected in the current frame. In the present embodiment, the cropping-region determination unit **240** determines that there is no significant change in the posture of the tracking target based on the local-region size change rate, in the current frame, of a region of which the "size change rate in response to change in posture" is large. The cropping-region determination unit **240** can use the cropping region for the previous frame as the cropping region for the current frame upon determining that the size change rate is small, and there is no significant change in the captured state of the tracking target.

[0194] Subsequently, in step **S911**, the cropping-region determination unit **240** determines the position of the cropping region. Thus, the cropping-region determination unit **240** determines a cropping region **734** illustrated in FIG. 7H.

[0195] Subsequently, in step **S405**, the cropping unit **250** generates a cropped image using the cropping region **734**. Subsequently, the processing from step **S406** to step **S409** is executed, and the processing in the present embodiment is concluded.

[0196] As described above, the information processing apparatus in the fourth embodiment can perform the cropping processing using a cropping region for the previous frame as a cropping region for the current frame by checking that there is no significant change in the captured state of the tracking target based on the size change rate of a region of which the "size change rate in response to change in posture" is great. However, in regard to the position of the cropping region, there is no need to use the coordinates in the previous frame, and cropping-region position may be changed in accordance with subject motion. Furthermore, while the size change rate is used to check that there is no significant change in the captured state of the tracking target in the present embodiment, the check may be performed using the recognition accuracy of the tracking target. Here, the recognition accuracy is a recognition rate calculated from the number of frames in which the tracking target has been recognized, a recognition score indicating the likelihood of the recognition target, or the like.

[0197] Furthermore, while it is determined in the present embodiment whether the cropping processing can be performed using the cropping region in the previous frame, it may be determined whether size information of a local region in the previous frame can be used for the current frame. By performing the above-described determination, a cropping region can be calculated using a local region in the previous frame even if the local region used to calculate the cropping region in the previous frame is undetected in the current frame.

[0198] Due to the above, stable cropping regions can be calculated even if a recognition task having a high priority rank results in no detection.

Fifth Embodiment: Multitasking Executed on Images of Different Sizes

[0199] FIG. **10** is a diagram describing a first information processing apparatus **200** and a second information processing apparatus **1000** according to the fifth embodiment. The image input unit **220**, tracking-target setting unit **230**, cropping-region determination unit **240**, cropping unit **250**, first multitasking unit **260**, tracking-target specification unit **270**, local-region specification unit **280**, and output unit **290** in FIG. **10** perform operations similar to those of the corresponding components in the first embodiment, and description thereof is thus omitted.

[0200] The second information processing apparatus **1000** receives input data **210** from the image input unit **220**. A second multitasking unit **1010** executes a plurality of recognition tasks on image data in the input data **210**. In the present embodiment, the second multitasking unit **1010** executes processing on an uncropped image; however, there is no limitation to this, and the second multitasking unit **1010** may execute the recognition tasks on any image larger than a cropped image. For example, the second multitasking unit **1010** may execute the recognition tasks on a cropped image having half the image size, a cropped image having a 1:1 image aspect ratio, or the like. Accordingly, the local-region specification unit **280** specifies one or more local regions from a cropped image and an image that is larger than the cropped image. Note that the second multitasking unit **1010** may be provided to the first information processing apparatus **200**. In this case, the first information processing apparatus **200** and the second information processing apparatus **1000** would be integrated into one information processing apparatus.

[0201] As an example in the fifth embodiment, FIGS. **11**A to **11**F illustrate time-series images in a case in which a cat is being tracked. Furthermore, FIG. **12** illustrates a flowchart of processing in the present embodiment. FIG. **12**A illustrates the entire flowchart. FIG. **12**B illustrates a detailed flow of the cropping-region determination processing in step **S1204**. FIG. **6**A illustrates pre-registered information in the present embodiment.

[0202] In step **S1201**, the image input unit **220** acquires an image of one frame that is input as input data **210**. Here, the image input unit **220** acquires an image **1101** in FIG. **11**A. The image **1101** in FIG. **11**A is an image of the initial frame at time t=0. In the image **1101**, a cat is walking toward the left.

[0203] In step **S1202**, the image input unit **220** determines whether or not the acquired frame is the initial frame in the acquired input data **210**. Upon acquiring an image of the initial frame at time t=0, the image input unit **220** determines that the frame is the initial frame, and moves on to step **S1203**.

[0204] In step **S1203**, the tracking-target setting unit **230** sets a tracking target. Here, in step **S1203**, the tracking-target setting unit **230** sets the cat as the tracking target, and sets the position and size of the tracking target. In the present embodiment, the tracking-target setting unit **230** sets the whole body of the cat as a tracking-target region **1102** as illustrated in FIG. **11**A.

[0205] In step S**1207**, after the tracking target has been set, the second multitasking unit **1010** executes second multitask processing. FIG. **11**B illustrates the result of the second multitask processing. An image **1103** in FIG. **11**B illustrates an image on which the second multitask processing has been executed, and the same image as image **1101** is used in the present embodiment. The second multitasking unit **1010** detects a whole-body detection result **1104** and a head detection result **1105** based on the image **1103**.

[0206] In step S**1208**, the tracking-target specification unit **270** specifies a tracking target from among the detection results from the second multitasking unit **1010**. At time t=0, the tracking-target specification unit **270** specifies the whole-body detection result **1104** as the tracking target.

[0207] In step S**1209**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the second multitasking unit **1010**. At time t=0, the local-region specification unit **280** specifies the head detection result **1105** as a local region.

[0208] In step S**1210**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=0, processing returns to step S**1201** and the processing at time t=1 is performed.

[0209] In step S**1201**, the image input unit **220** acquires an image **1111** illustrated in FIG. **11**C. Here, the image **1111** is an image of the cat at time t=1. In the image **1111**, the cat is still moving toward the left.

[0210] Because the image input unit **220** determines that the image **1111** is a frame subsequent to the initial frame in step S**1202**, the image input unit **220** moves on to the cropping-region determination processing in step S**1204**.

[0211] FIG. **12**B illustrates a detailed flow of the cropping-region determination processing in step S**1204**.

[0212] In step S**1211**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. Because the head detection result **1105** obtained from the second multitasking unit **1010** is present at time t=1, the cropping-region determination unit **240** determines that there is a local region detected in the previous frame, and moves on to the processing in step S**1212**. On the other hand, if a local region in the previous frame that can be used to calculate a cropping region, such as the head detection result **1105**, is not present, the cropping-region determination unit **240** determines that there is no local region, and moves on to step S**1214** to set the pixel count of the whole body of the tracking target that has been set by the tracking-target setting unit **230** as the cropping reference. Subsequently, the cropping-region determination unit **240** moves on to later-described step S**1215**.

[0213] In step S**1212**, the cropping-region determination unit **240** integrates the results of the first multitask processing and the second multitask processing. For example, if the head is detected in both types of multitask processing, the cropping-region determination unit **240** determines a pixel count using the head region as a local region. The cropping-region determination unit **240** in the present embodiment uses the average of the pixel counts of the head regions detected by the two types of processing to determine the pixel count of the head region. Note that the pixel count is not limited to being determined in this way, and may be determined using a weighted average of the two regions or using one of the two regions. Furthermore, if there is only one detection result, the cropping-region determination unit **240** may use the pixel count of the only one head detection result.

[0214] In step S**1213**, the cropping-region determination unit **240** sets the pixel count of the head detection result **1105** as a cropping reference in accordance with priority ranks in the pre-registered information **601** in FIG. **6**A.

[0215] In step S**1215**, from the pre-registered information **601** in FIG. **6**A, the cropping-region determination unit **240** acquires 15.0× corresponding to the head as a cropping magnification ratio.

[0216] In step S**1216**, the cropping-region determination unit **240** calculates the pixel count of the cropping region by calculating a product of the pixel count of the head set as the cropping reference and the cropping magnification ratio determined in step S**1215**.

[0217] The cropping-region determination unit **240** determines the aspect ratio of the cropping region in step S**1217** and determines the position of the cropping region in step S**1218**. Thus, the cropping-region determination unit **240** determines a cropping region **1112** illustrated in FIG. **11**C.

[0218] In step S**1205**, the cropping unit **250** generates a cropped image **1116**. For example, the cropping unit **250** crops the image **1111** using the cropping region **1112** determined as a result of step S**1204**, and resizes the resultant image. As a result of the above-described processing, the cropping unit **250** generates a cropped image **1116** illustrated in FIG. **11**E. At time t=1, the cat's head and a part of the cat's whole body exceed the boundaries of the cropping region because the cat has moved abruptly.

[0219] In step S**1206**, the first multitasking unit **260** executes the first multitask processing on the cropped image **1116** in FIG. **11**E. As illustrated in FIG. **11**E, only a whole-body detection result **1117** is obtained as a result from the first multitasking unit **260** at time t=1 because the cat's body has exceeded the boundaries of the cropping region.

[0220] In step S**1207**, the second multitasking unit **1010** executes the second multitask processing. FIG. **11**D illustrates the result of the second multitask processing. An image **1113** in FIG. **11**D illustrates an image on which the second multitask processing has been executed, and is a processing result obtained by using the same image as the image **1111**. The second multitasking unit **1010** executes the second multitask processing on the image **1111**, and detects a whole-body detection result **1114** and a head detection result **1115** as illustrated in the image **1113**.

[0221] In step S**1208**, the tracking-target specification unit **270** specifies a tracking target from among the results of detection by the first multitasking unit **260** and the second multitasking unit **1010**. At time t=1, the tracking-target specification unit **270** specifies the whole-body detection result **1114** as the tracking target as illustrated in FIG. **11**D.

[0222] In step S**1209**, the local-region specification unit **280** specifies one or more local regions of the tracking target from among the detection results from the first multitasking unit **260** and the second multitasking unit **1010**. At time t=1, the local-region specification unit **280** specifies the head detection result **1115** as a local region as illustrated in FIG. **11**D.

[0223] In step S**1210**, it is determined whether or not all frames have been processed. Because not all frames have been processed at time t=1, processing returns to step S**1201** and the processing at time t=2 is performed.

[0224] In step S**1201**, the image input unit **220** acquires an image **1121** in FIG. **11**F. The image **1121** is an image of the cat at time t=2. In the image **1121**, the cat is still moving toward the left. Subsequently, the processing from step S**1202** to step S**1204** is executed again.

[0225] In step S**1211**, the cropping-region determination unit **240** determines whether or not there is a local region that has been detected in the previous frame and that can be used to calculate a cropping region. Because the head detection result **1115** was detected at time t=2, the cropping-region determination unit **240** determines that there is a local region and moves on to the processing in step S**1212**.

[0226] In step S**1212**, the cropping-region determination unit **240** integrates the results of the first multitask processing and the second multitask processing. Here, because there is only one detection result of the head, the cropping-region determination unit **240** integrates the results of processing by directly using the result from the second multitasking unit **1010** for the head. In regard to the whole body, the cropping-region determination unit **240** integrates the results of processing by adopting, as the pixel count of the whole body, the average of the pixel counts of the whole-body detection result **1114** and the whole-body detection result **1117**.

[0227] In step S**1213**, the cropping-region determination unit **240** sets the pixel count of the head set in step S**1212** as a cropping reference in accordance with priority ranks in the pre-registered information **601**.

[0228] Subsequently, the cropping-region determination unit **240** determines a cropping region **1122** illustrated in FIG. **11**F by executing the processing from step S**1215** to step S**1218**, as was the case at time t=1.

[0229] In step S**1205**, the cropping unit **250** generates a cropped image using the cropping region **1122**.

[0230] Subsequently, the processing from step S**1206** to step S**1210** is executed, and the series of processing is concluded.

[0231] As described above, in the fifth embodiment, the calculation of cropping regions can be stabilized to a further extent by executing the first multitask processing and the second multitask processing using a cropped image and an image larger than the cropped image. In the present embodiment, even in a case in which a cat's body has exceeded the boundaries of a cropped image, cropping can be executed using a local region of which the "rate of fluctuation in size in response to change in posture" is small by using the detection result of the second multitask processing, which is executed on an image larger than the cropped image. Furthermore, while processing is executed on an uncropped image in the present embodiment, the processing may be executed on any image that is different from the cropped image generated by the cropping unit **250**.

OTHER EMBODIMENTS

[0232] While description has been provided in the above-described embodiments based on an example in which a cat is the tracking target, object of other categories, such as a person or a motorcycle, may be adopted as tracking targets. Upon applying the present embodiments to other categories, a local region to be adopted as a cropping reference may be newly set by using the "rate of fluctuation in size in response to change in posture" as an index. For example, in the case of a person, the rate of fluctuation in size would be great for the whole-body region and small for the head region. Furthermore, in the case of a motorbike, the rate of fluctuation in size would be great for the whole-vehicle-body region and small for tire length. Thus, while a cropping reference was determined based on priority ranks and the size change rate in the above-described embodiment, a cropping reference may be determined based on the category classification result of the tracking target. Combinations of a category and a cropping reference may be determined in advance, such as the head as the cropping reference when a person is being tracked, a tire as a cropping reference when a motorcycle is being tracked, etc., for example.

[0233] In the above-described embodiments, description has been provided based on an example in which a cropping region is determined based on a local region selected from a plurality of local regions; however, the method for determining a cropping region is not limited to this. For example, a configuration may be adopted such that: priority ranks are set to parts such as the whole body, the head, and the face; a local region is set only to a part having a high priority rank among detected parts; and a cropping region is determined based on the set local region.

[0234] While the above-described embodiments have been described on the assumption that multitask processing is executed, multitask processing need not be executed. In this case, it is sufficient that the local-region specification unit **280** specify a local region by detecting a part in accordance with a predetermined part, or the like.

[0235] In the above-described embodiments, description has been provided based on an example in which the input data **210** is a moving image; however, there is no limitation to this. For example, the input data **210** may be a plurality of still images captured at predetermined intervals of time from one another, a plurality of images in a time-lapse.

[0236] The above-described embodiments may be combined as appropriate.

[0237] Embodiment(s) of the present invention can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

[0238] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0239] This application claims the benefit of Japanese Patent Application No. 2024-022202, filed Feb. 16, 2024, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An information processing apparatus comprising:

one or more memories storing instructions; and

one or more processors executing the instructions to:

execute tracking-target specification processing of specifying, as a tracking target, a target to be tracked that is included in an image;

execute local-region specification processing of specifying, within the image, a local region that includes at least part of a detection target that is included in the tracking target;

execute cropping-region determination processing of, based on size information of the local region, determining size information of a cropping region for cropping the tracking target from the image; and

execute cropping processing of generating a cropped image by cropping the image based on the cropping region.

2. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to:

in the local-region specification processing, specify a plurality of local regions that each include at least part of a corresponding one of a plurality of types of detection targets that are included in the tracking target; and

in the cropping-region determination processing, determine size information of the cropping region based on size information of one of the plurality of local regions.

3. The information processing apparatus according to claim **2**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, determine size information of the cropping region based on size information of a local region of a detection target selected from the plurality of types of detection targets based on predetermined priority ranks of the detection targets.

4. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to:

in the local-region specification processing, specify a plurality of local regions that include at least part of the detection target of the tracking target; and

in the cropping-region determination processing, determine size information of the cropping region based on size information of the plurality of local regions.

5. The information processing apparatus according to claim **4**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, determine size information of the cropping region based on a result obtained by executing averaging processing on size information of the plurality of local regions.

6. The information processing apparatus according to claim **4**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, determine size information of the cropping region based on at least one of a maximum and a minimum that are set based on size information of the cropping region.

7. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to:

in the local-region specification processing, specify a plurality of local regions from a plurality of images of different times; and

in the cropping-region determination processing, determine size information of the cropping region based on size information of at least one of the plurality of local regions.

8. The information processing apparatus according to claim **7**,

wherein the one or more processors further execute the instructions to:

in the local-region specification processing, specify a plurality of local regions that each include at least part of a corresponding one of a plurality of types of detection targets that are included in the tracking target; and

in the cropping-region determination processing, determine size information of the cropping region based on size information of a local region of a detection target selected from the plurality of types of detection targets.

9. The information processing apparatus according to claim **8**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, determine size information of the cropping region based on size information of a local region of a detection target selected from the plurality of types of detection targets based on a change in size information of the plurality of local regions.

10. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to

in the local-region specification processing, specify a plurality of local regions that each include at least part of a corresponding one of a plurality of types of detection targets that are included in the tracking target; and

in the cropping-region determination processing, determine size information of the cropping region based on size information of a local region of a detection target selected from the plurality of types of detection targets based on a recognition accuracy of the tracking target.

11. The information processing apparatus according to claim **10**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, use, as the recognition accuracy, at least one of a recognition rate of the tracking target and a recognition score of the tracking target.

12. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to:

in the local-region specification processing, specify a plurality of local regions from a plurality of images of different times; and

in the cropping-region determination processing, determine whether or not to set a cropping region at a previous time as a current cropping region based on a change in size information of the plurality of local regions.

13. The information processing apparatus according to claim **12**,

wherein the one or more processors further execute the instructions to

in the cropping-region determination processing, in a case where the local region used to determine a cropping region in an image at the previous time is undetected in a current image, set the cropping region at the previous time as a cropping region for the current image.

14. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to

in the local-region specification processing, specify the local region from the cropped image and an image larger than the cropped image.

15. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to

in the local-region specification processing, set a local region based on a detection target set in accordance with a category of tracking target.

16. The information processing apparatus according to claim **1**,

wherein the one or more processors further execute the instructions to

acquire the image that is input;

set the tracking target;

execute a plurality of recognition tasks on the tracking target in the cropped image; and

in the tracking-target specification processing, specify the tracking target included in the image based on results of the plurality of recognition tasks.

17. An information processing method comprising:

specifying, as a tracking target, a target to be tracked that is included in an image;

specifying, within the image, a local region that includes at least part of a detection target that is included in the tracking target;

based on size information of the local region, determining size information of a cropping region for cropping the tracking target from the image; and

generating a cropped image by cropping the image based on the cropping region.

18. A non-transitory computer-readable storage medium storing a computer program that, when read and executed by a computer, causes the computer to function as:

a tracking-target specification unit configured to specify, as a tracking target, a target to be tracked that is included in an image;

a local-region specification unit configured to specify, within the image, a local region that includes at least part of a detection target that is included in the tracking target;

a cropping-region determination unit configured to, based on size information of the local region, determine size information of a cropping region for cropping the tracking target from the image; and

a cropping unit configured to generate a cropped image by cropping the image based on the cropping region.

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