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**Westmacott et al.**

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(54) **SYSTEM AND METHOD FOR DISTRIBUTED VIDEO ANALYSIS**

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***H04N 7/18*** (2006.01)

(52) **U.S. Cl.**
CPC .................................. ***H04N 7/181*** (2013.01)

(58) **Field of Classification Search**
CPC ..................................................... H04N 7/181
See application file for complete search history.

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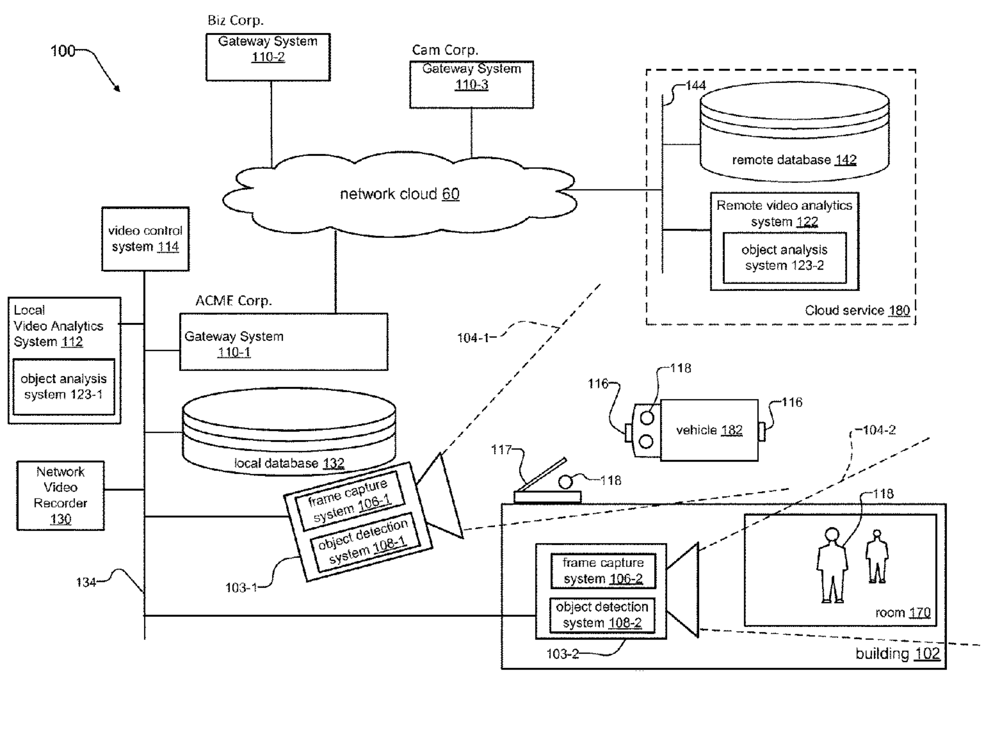
(57) **ABSTRACT**

A system and method for distributed analysis of image data in a video surveillance system can be deployed in households, businesses, and within corporate entities, in examples. The image data are processed on local video analytics systems located within the networks of the businesses or on remote video analytics systems hosted by a cloud service. To limit the data traffic imposed by the image data on the network, the system divides the image data processing into separate object detection and analysis functions. The system can also integrate the object detection function within the surveillance cameras or on a local gateway. This can significantly reduce the data traffic sent over networks as compared to current video surveillance systems and methods since only image data containing object of interest needs to be sent.

**23 Claims, 7 Drawing Sheets**



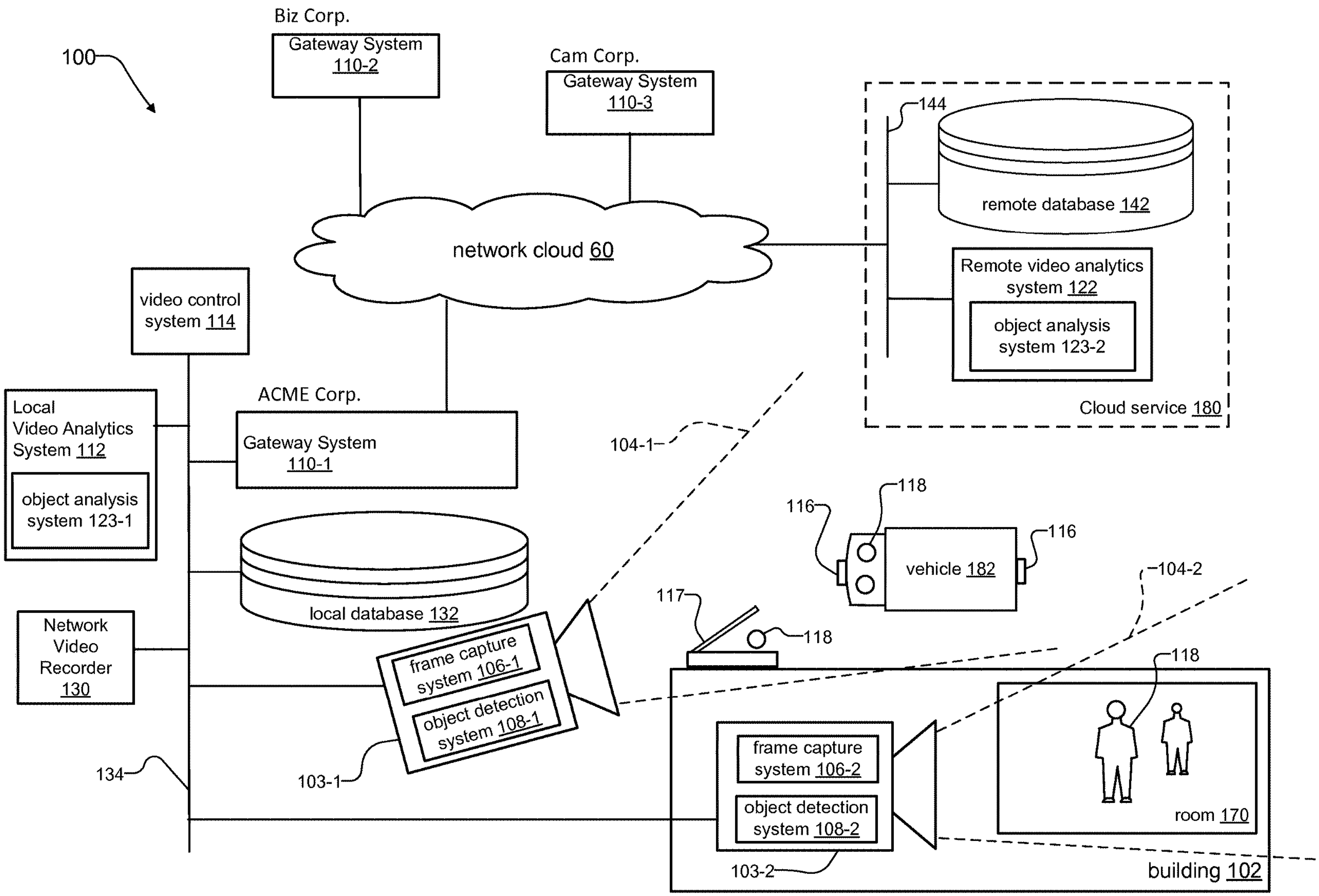

100
Biz Corp.
Gateway System 110-2
Cam Corp.
Gateway System 110-3
144
remote database 142
network cloud 60
Remote video analytics system 122
object analysis system 123-2
Cloud service 180
video control system 114
Local Video Analytics System 112
object analysis system 123-1
ACME Corp.
Gateway System 110-1
104-1
116
118
116
vehicle 182
104-2
local database 132
117
118
118
Network Video Recorder 130
frame capture system 106-1
object detection system 108-1
frame capture system 106-2
object detection system 108-2
room 170
134
103-1
103-2
building 102

FIG. 1

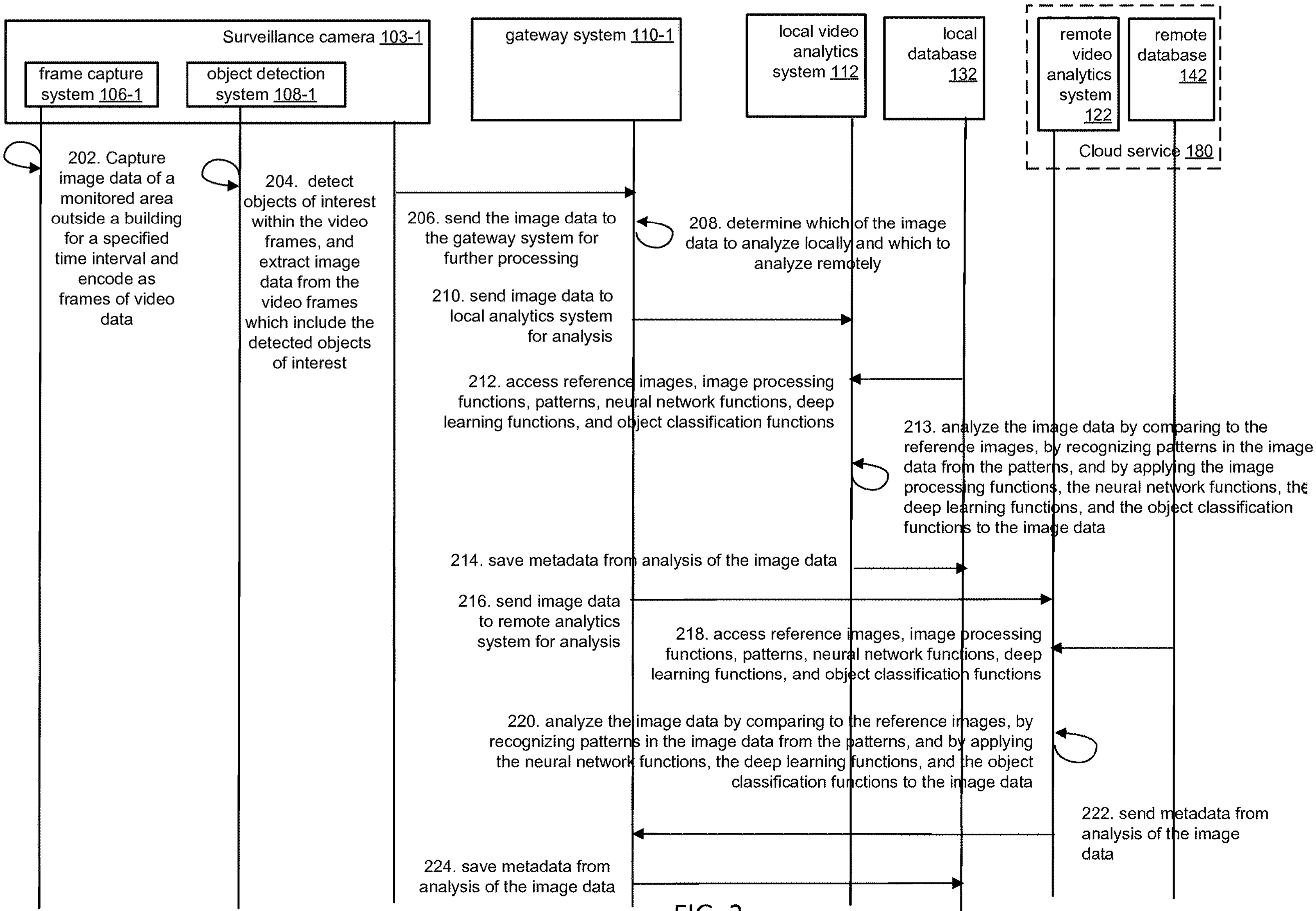

Surveillance camera 103-1
frame capture system 106-1
object detection system 108-1
gateway system 110-1
local video analytics system 112
local database 132
remote video analytics system 122
remote database 142
Cloud service 180
202. Capture image data of a monitored area outside a building for a specified time interval and encode as frames of video data
204. detect objects of interest within the video frames, and extract image data from the video frames which include the detected objects of interest
206. send the image data to the gateway system for further processing
208. determine which of the image data to analyze locally and which to analyze remotely
210. send image data to local analytics system for analysis
212. access reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions
213. analyze the image data by comparing to the reference images, by recognizing patterns in the image data from the patterns, and by applying the image processing functions, the neural network functions, the deep learning functions, and the object classification functions to the image data
214. save metadata from analysis of the image data
216. send image data to remote analytics system for analysis
218. access reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions
220. analyze the image data by comparing to the reference images, by recognizing patterns in the image data from the patterns, and by applying the neural network functions, the deep learning functions, and the object classification functions to the image data
222. send metadata from analysis of the image data
224. save metadata from analysis of the image data

FIG. 2

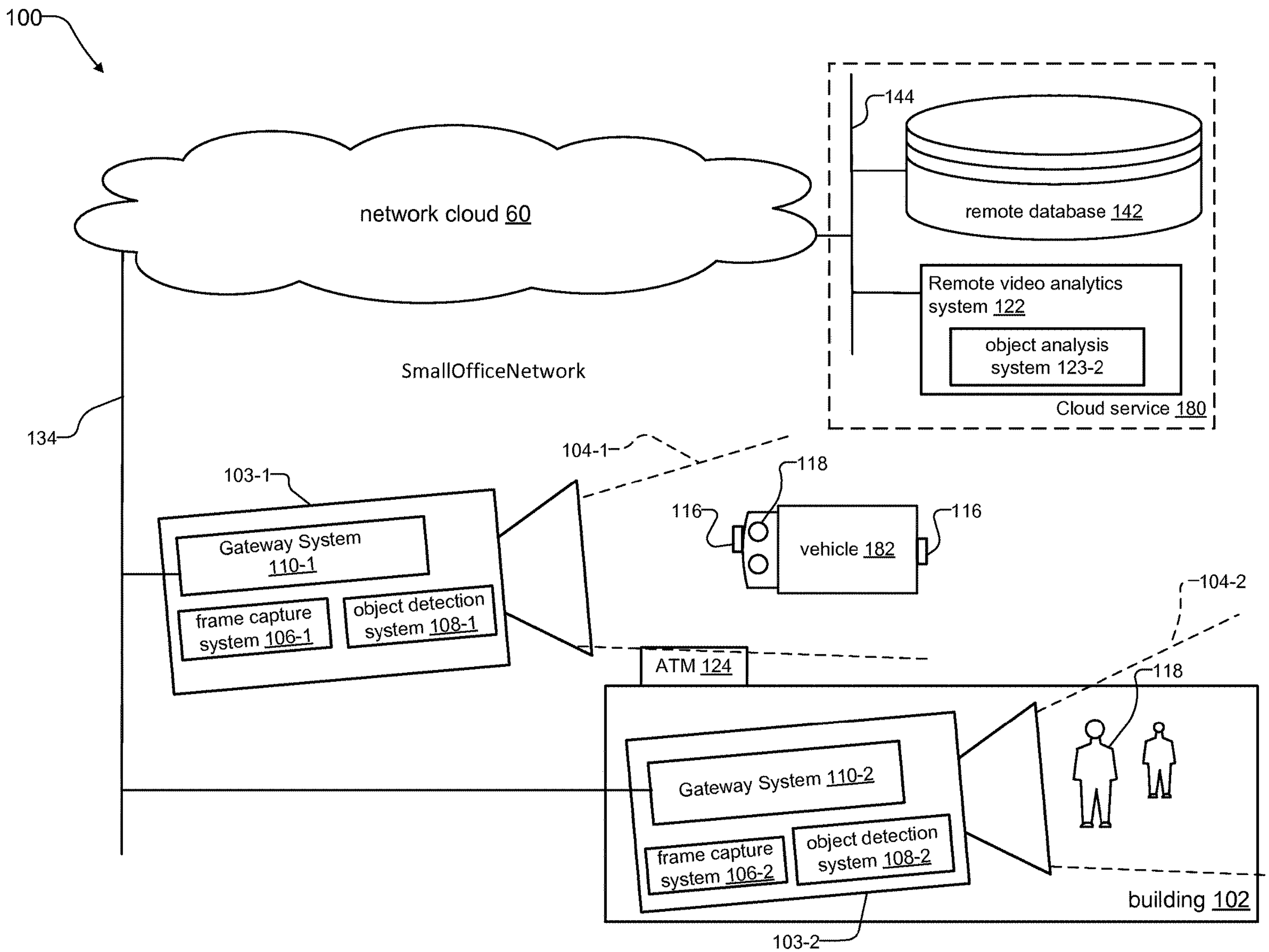

100
network cloud 60
144
remote database 142
Remote video analytics system 122
object analysis system 123-2
Cloud service 180
SmallOfficeNetwork
134
104-1
103-1
118
116
116
vehicle 182
Gateway System 110-1
frame capture system 106-1
object detection system 108-1
104-2
ATM 124
118
Gateway System 110-2
frame capture system 106-2
object detection system 108-2
building 102
103-2

FIG. 3

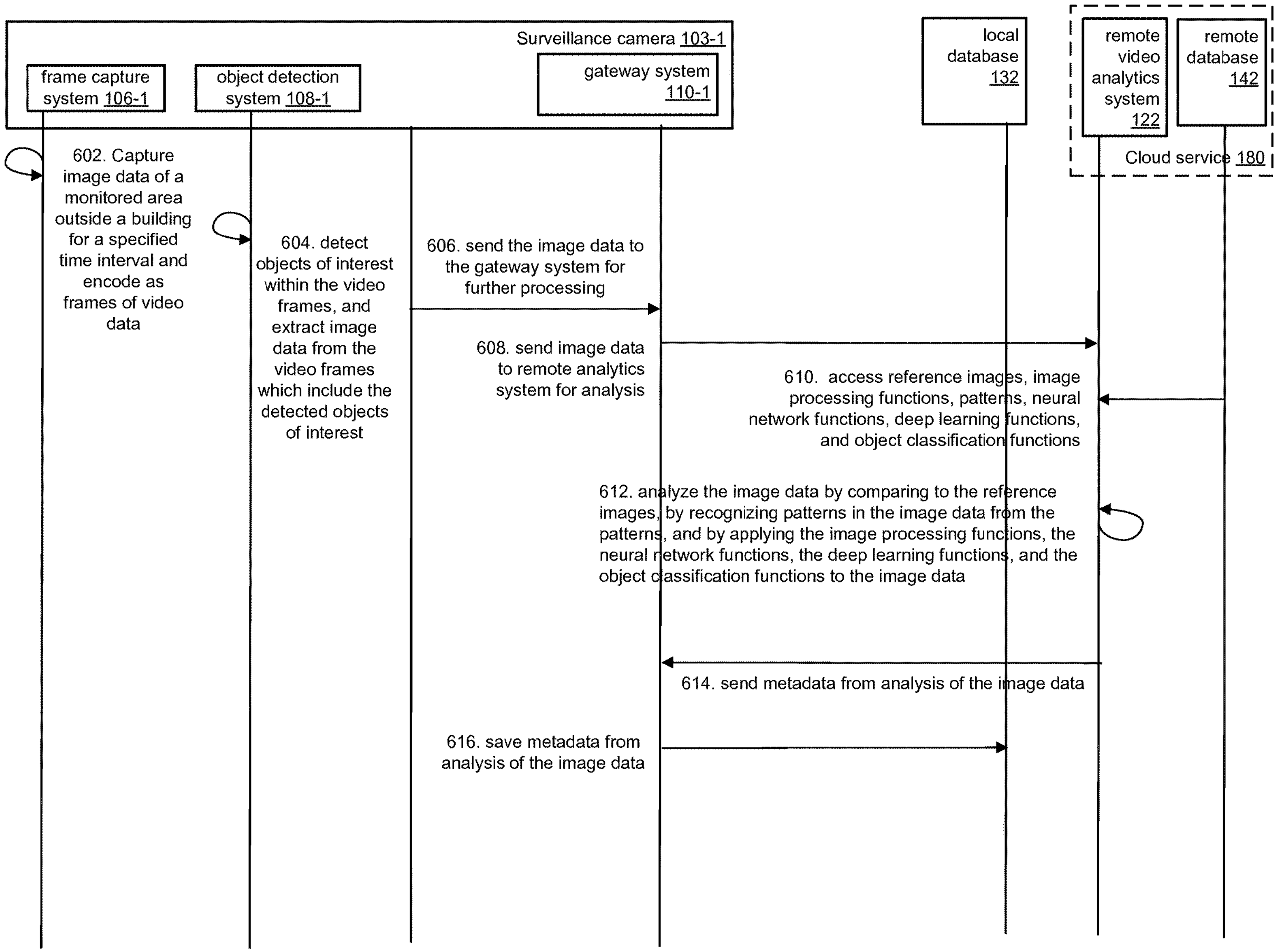

Surveillance camera 103-1
frame capture system 106-1
object detection system 108-1
gateway system 110-1
local database 132
remote video analytics system 122
remote database 142
Cloud service 180
602. Capture image data of a monitored area outside a building for a specified time interval and encode as frames of video data
604. detect objects of interest within the video frames, and extract image data from the video frames which include the detected objects of interest
606. send the image data to the gateway system for further processing
608. send image data to remote analytics system for analysis
610. access reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions
612. analyze the image data by comparing to the reference images, by recognizing patterns in the image data from the patterns, and by applying the image processing functions, the neural network functions, the deep learning functions, and the object classification functions to the image data
614. send metadata from analysis of the image data
616. save metadata from analysis of the image data

FIG. 4

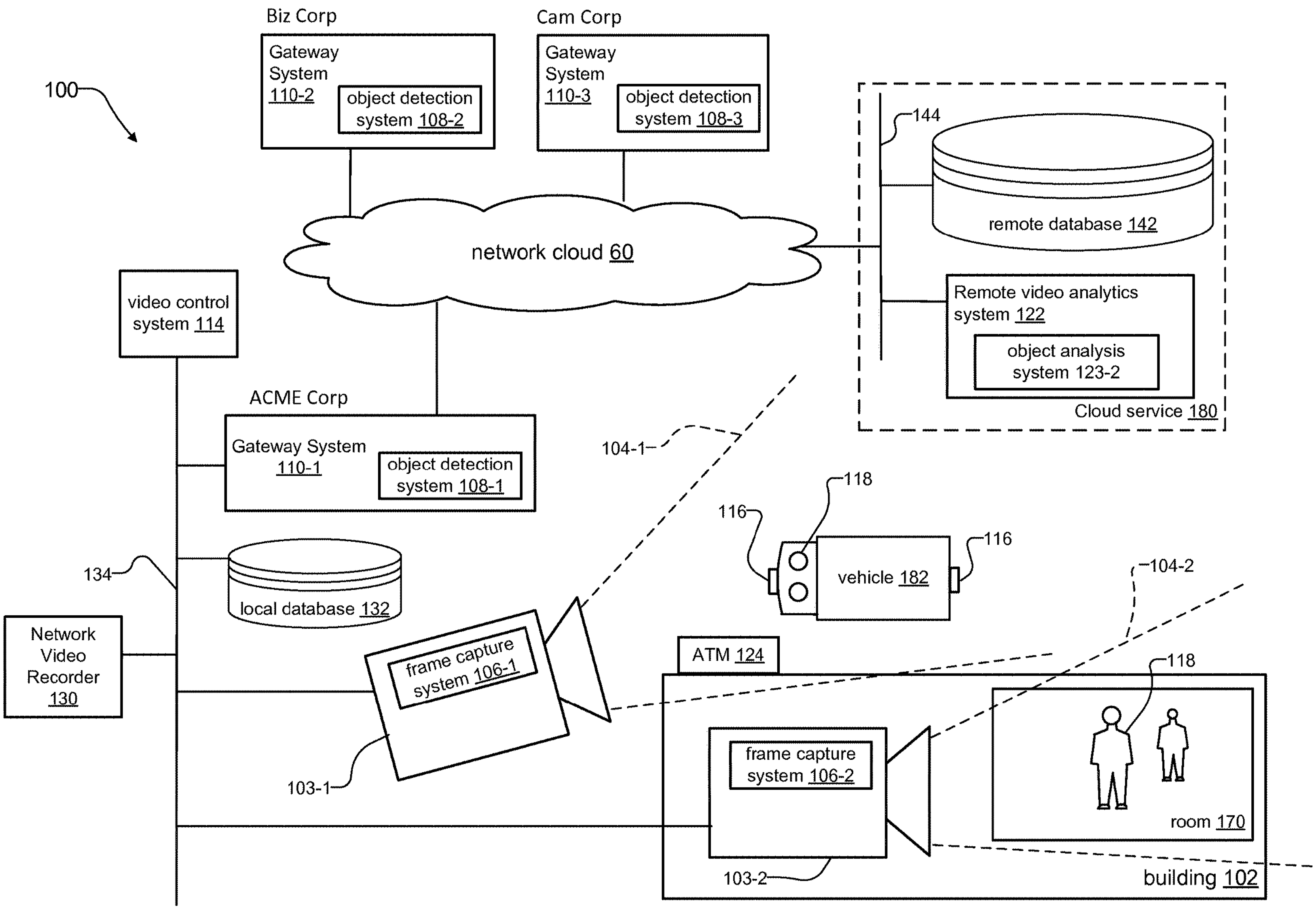
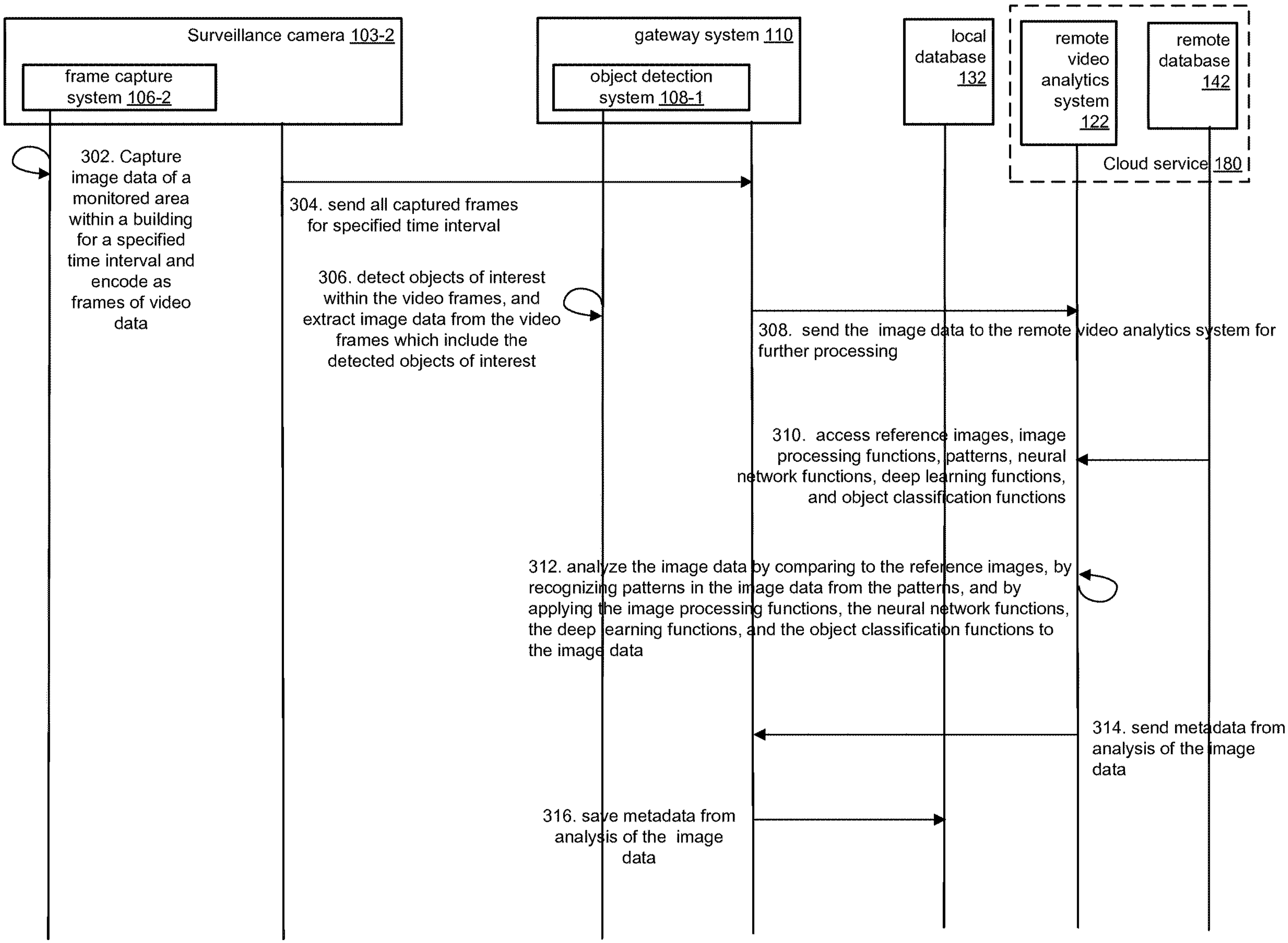

100
Biz Corp
Gateway System 110-2
object detection system 108-2
Cam Corp
Gateway System 110-3
object detection system 108-3
144
remote database 142
network cloud 60
Remote video analytics system 122
object analysis system 123-2
Cloud service 180
video control system 114
ACME Corp
Gateway System 110-1
object detection system 108-1
104-1
118
116
116
vehicle 182
134
local database 132
104-2
Network Video Recorder 130
frame capture system 106-1
ATM 124
118
frame capture system 106-2
room 170
103-1
103-2
building 102

FIG. 5



Surveillance camera 103-2
frame capture system 106-2
gateway system 110
object detection system 108-1
local database 132
remote video analytics system 122
remote database 142
Cloud service 180
302. Capture image data of a monitored area within a building for a specified time interval and encode as frames of video data
304. send all captured frames for specified time interval
306. detect objects of interest within the video frames, and extract image data from the video frames which include the detected objects of interest
308. send the image data to the remote video analytics system for further processing
310. access reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions
312. analyze the image data by comparing to the reference images, by recognizing patterns in the image data from the patterns, and by applying the image processing functions, the neural network functions, the deep learning functions, and the object classification functions to the image data
314. send metadata from analysis of the image data
316. save metadata from analysis of the image data


FIG. 6

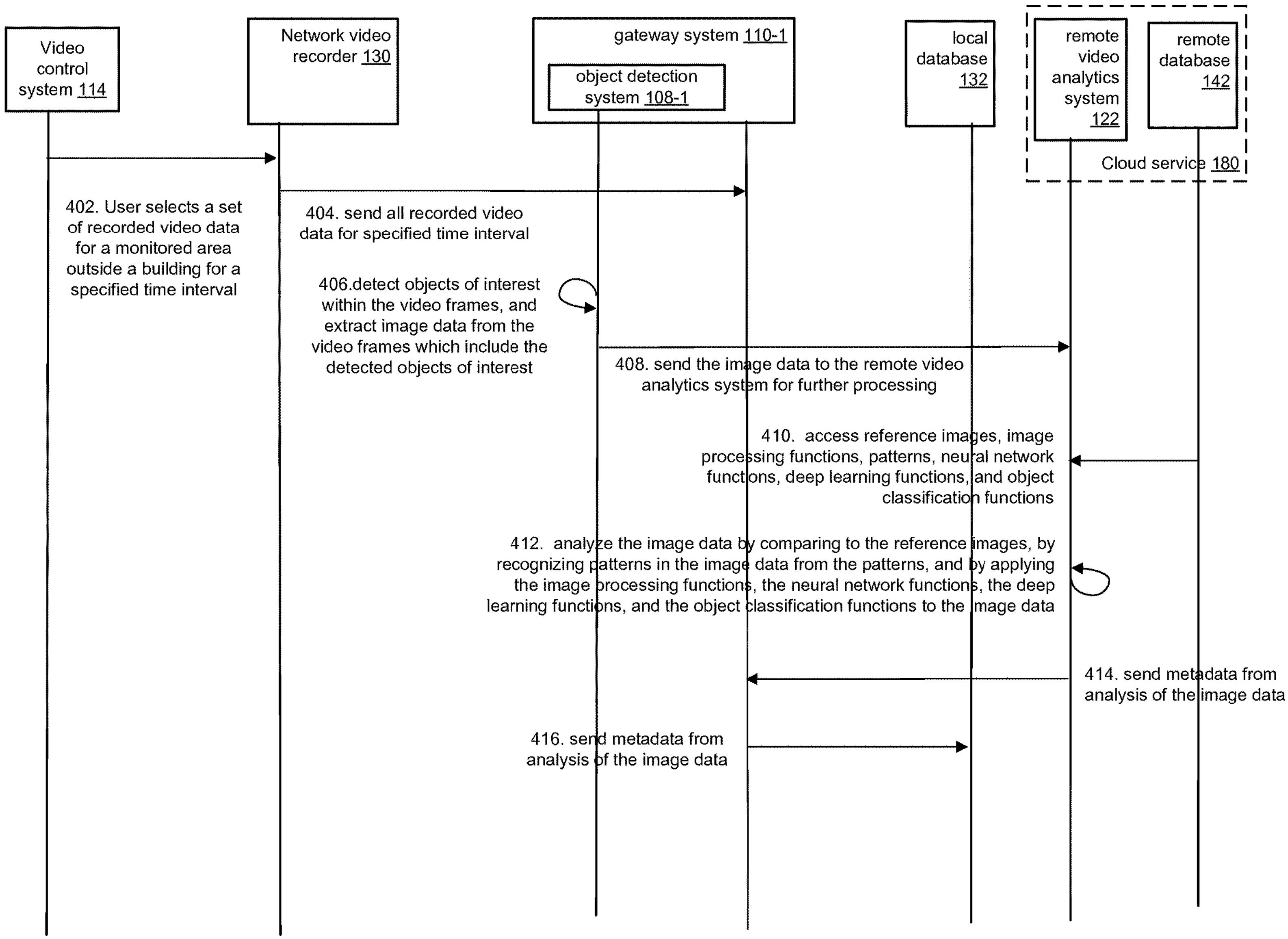

Video control system 114
Network video recorder 130
gateway system 110-1
object detection system 108-1
local database 132
remote video analytics system 122
remote database 142
Cloud service 180
402. User selects a set of recorded video data for a monitored area outside a building for a specified time interval
404. send all recorded video data for specified time interval
406.detect objects of interest within the video frames, and extract image data from the video frames which include the detected objects of interest
408. send the image data to the remote video analytics system for further processing
410. access reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions
412. analyze the image data by comparing to the reference images, by recognizing patterns in the image data from the patterns, and by applying the image processing functions, the neural network functions, the deep learning functions, and the object classification functions to the image data
414. send metadata from analysis of the image data
416. send metadata from analysis of the image data

FIG. 7

## SYSTEM AND METHOD FOR DISTRIBUTED VIDEO ANALYSIS

### BACKGROUND OF THE INVENTION

Video surveillance systems are increasingly deployed within public and private institutions, such as households, commercial buildings, businesses, retail establishments, schools, hospitals and government buildings, to list a few examples. These surveillance systems are often used for a number of different tasks, such as intelligence gathering by governments and businesses, prevention or investigation of crime by law enforcement or retail establishments, and monitoring the usage of resources or structures such as buildings, bridges or roads, to list a few examples.

A number of components are common to many of these video surveillance systems. Surveillance cameras capture image data that are typically then sent over one or more data networks, such as governmental, service provider, enterprise or home networks. This image data are typically stored on network video recorders (NVRs). Video analytics systems are often included to analyze the image data. Finally, control systems are often used to control the surveillance systems and coordinate the operation of the components.

These video analytics systems have the capability of automatically analyzing image data to detect and determine temporal and spatial events. Minimally, these systems track objects against fixed background scenes. More sophisticated functions include object detection to determine the presence of an object or a type of object. Even higher level functions include object analysis, such as object identification.

The methods employed by video analytics systems for detecting and analyzing classes of objects in image data have become more accurate in recent years, and are, as a consequence, becoming more and more important in video surveillance systems. Two common examples of object analysis within image data are facial recognition of individuals and license plate recognition, or number plate recognition. Some of these video analytics systems are sophisticated enough to identify a particular person from their facial characteristics, and can identify a particular license plate by reading and recognizing the text and numbers within the license plate, in examples.

### SUMMARY OF THE INVENTION

Current video surveillance systems have problems. Video surveillance systems can increase the volume of data traffic sent over the networks. This increased data traffic volume can limit the available bandwidth of the networks, which can cause performance problems for components of the video surveillance systems and other nodes that communicate over the networks.

One reason for the increased data traffic created by current video surveillance systems is that the surveillance cameras typically send their image data over the networks for further processing. For example, the image data are typically sent by surveillance cameras over the network to video analytics systems located within the network. Another reason for the increased data traffic over the networks is that recent advances in video technology have resulted in an increase the resolution of the image data that the surveillance cameras capture and transmit.

Another issue with current video surveillance systems is cost. The video analysis methods employed by video analytics systems for analyzing the image data are typically memory intensive and processor intensive tasks. As a result, this requires that the video analytics systems be high-performance or specialized computer systems. This typically increases the cost of the video analytics systems, which correspondingly increases the cost of the overall video surveillance systems. Moreover, the analysis methods are constantly being improved and so the systems must be periodically updated.



The present invention concerns a model for the processing of the image data by separating the analysis into separate object detection and object analysis functions or systems. The object detection system detects objects of interest and classes of objects of interest within the image data. The object analysis system then analyzes the image data including the detected objects of interest, in one example, to recognize (e.g. identify) the detected objects of interest. This division can be used to lower the volume of image data transmitted over the intervening networks by locating the object detection closer to the cameras and then sending only the "interesting" portions of the image data to the more remote object analysis system.

The object analysis system can analyze the image data using many different analysis methods. For this purpose, the object analysis system typically first accesses information from a database such as reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions.

Then, the object analysis system can analyze the image data by comparing the image data to the reference images to identify the objects of interest within the images, by recognizing patterns in the image data from the patterns, and/or by applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data, in examples. The image processing functions can include filtering, image/contrast enhancement, compression, and deblurring of the image data, in examples.

In one example, the object detection system is integrated within the surveillance cameras or a gateway system, and the object analysis system is then located in a more remote video analytics system.

As a result, only image data that includes the detected objects of interest needs to be sent over the data network for object analysis by the local or remote video analytics systems. This saves on bandwidth as compared to current video surveillance systems, which typically send all image data including empty scenes and image data not including objects of interest over the data network.

Finally, the object detection system can further limit the image data sent over the data network to achieve even greater bandwidth savings. In one example, the object detection system can create cropped images from the image data that include only the detected objects of interest, and send only the cropped images over the data network for processing by the video analytics system.

In general, according to one aspect, the invention features a video surveillance system that comprises one or more surveillance cameras that capture image data, an object detection system that detects objects of interest within the image data, and a video analytics system that receives the image data, transmitted over a network, from the object detection system The image data received by the video analytics system correspond to objects of interest detected by the object detection system, and the video analytics system then analyzes the objects of interest.

In this way, the object detection is separated from object analysis. Thus, only a portion of the image data generated by the surveillance cameras needs to be sent over the network.

In some embodiments, the object detection system creates cropped images from the image data that include the detected objects of interest and sends the cropped images to the video analytics system to further reduce bandwidth. In other cases, entire frames of image data are provided, also metadata may be included to identify the portion of the frames containing the detected objects.

In some cases, objects of interest detected by the object detection system are ranked by the object detection system according to factors including close proximity of the objects of interest to the one or more surveillance cameras, picture quality of the objects of interest, and/or contrast of the objects of interest.

The video analytics system may include an object analysis system that compares the image data corresponding to objects of interest detected by the object detection system to reference images to identify the objects of interest. At the same time, the object detection system may be integrated within the one or more surveillance cameras.

The video analytics system may be a node on an enterprise network. On the other hand, it could alternatively or additionally be a cloud analytics system.

In some embodiments, a gateway system is included that provides access to the video analytics system over a public network. The object detection system might be integrated within the gateway system. The gateway system can be a node on the local network or integrated within the cameras.

In general, according to one aspect, the invention features a method for analyzing video in a video surveillance system. This method comprises capturing image data from one or more surveillance cameras, detecting objects of interest within the image data via an object detection system. The object detection system transmits the image data over a network, the image data transmitted by the object detection system corresponding to objects of interest detected by the object detection system. Finally, a video analytics system receives the image data from the object detection system and analyzes the objects of interest.

The above and other features of the invention including various novel details of construction and combinations of parts, and other advantages, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular method and device embodying the invention are shown by way of illustration and not as a limitation of the invention. The principles and features of this invention may be employed in various and numerous embodiments without departing from the scope of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale; emphasis has instead been placed upon illustrating the principles of the invention. Of the drawings:

FIG. **1** is a schematic block diagram of an embodiment of a distributed video surveillance system according to the invention;

FIG. **2** is a diagram that shows exemplary messaging between the major components of the system of FIG. **1** for processing of image data;

FIG. **3** is a schematic block diagram of a second embodiment of the distributed video surveillance system;

FIG. **4** is a diagram that shows exemplary messaging between the major components of the system of FIG. **3** for processing of image data;

FIG. **5** is a schematic block diagram of a third embodiment of n distributed video surveillance system; and

FIGS. **6** and **7** are diagrams that show exemplary messaging between the major components of the system of FIG. **5**, where FIG. **6** shows messaging associated with processing of live image data, and where FIG. **7** shows messaging associated with forensic processing of image data recorded by a network video recorder.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Further, the singular forms and the articles "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms: includes, comprises, including and/or comprising, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Further, it will be understood that when an element, including component or subsystem, is referred to and/or shown as being connected or coupled to another element, it can be directly connected or coupled to the other element or intervening elements may be present.

FIG. **1** shows an embodiment of a distributed video surveillance system **100**. The system **100** is deployed within large businesses, large corporate entities, or government entities, in examples. Multiple exemplary businesses Biz Corp. (Biz), Cam Corp. (Cam), and ACME Corp ("ACME") are shown. Detail is included for network **134** of only one (ACME), for clarity, however.

The illustrated system **100** includes a local video analytics system **112** that is a node on the business's enterprise network **134**. The local video analytics system **112** enables processing of the image data from the surveillance cameras **103** within the enterprise network **134**. In addition, the businesses such as ACME can also use remote video analytics systems **122** hosted by cloud services **180** to analyze the image data from the surveillance cameras **103**.

In some implementations, a third-party company operates cloud service **180**. The cloud service **180** can also be a public or private cloud service, in different examples. Public clouds differ from private clouds with respect to security and sharing of the resources that they provide to their clients. Public clouds generally share their datacenter resources among multiple clients. In contrast, private clouds typically dedicate specific resources to individual clients.

The cloud service **180** is typically operated by a different business entity than the business entities that operate businesses Cam, Biz, and ACME. The businesses are clients of the cloud service **180**. This allows the businesses Cam, Biz, and ACME to leverage the expertise of the cloud service and its ability to provide constant performance updates and improvements.

The cloud service **180** includes components such as a remote database **142** and a remote video analytics system **122**. The remote video analytics system **122** includes an object analysis system **123-2**. The remote database **142** and the remote video analytics system **122** are nodes of cloud service network **144**.

The business clients ACME, Biz, and Cam access the components of the cloud service **180** via their respective gateway systems **110**. Each of the gateway systems **110** has a physical or logical interface that connects to an associated enterprise network, such as ACME's enterprise network **134**, and an interface that connects to a network cloud **60**. The network cloud **60** is preferably a public/service provider network such as the Internet, but can also be a private network built for each specific enterprise client, in examples.

Components of the system **100** that are deployed within ACME are preferably installed as nodes on ACME's enterprise network **134**. The components include surveillance cameras **103-1** and **103-2**, gateway system **110-1**, video control system **114**, local video analytics system **112**, network video recorder **130**, and local database **132**. The local video analytics system **112** includes an object analysis system **123-1**. Operators of the video surveillance system **100** such as on-site security and surveillance personnel can use the video control system **114** to control the system's components.

The surveillance cameras **103** capture images and/or video of monitored areas, such as a room **170** within a building **102** or premises adjacent to a building **102**. The images and/or video, also known as image data, can be formatted or presented in different ways. In examples, the image data can be encoded into different formats such as MPEG4 and H.264, JPEG or left as "raw" composite image data, in examples.

Surveillance camera **103-1** is positioned to capture image data of an area adjacent to building **102**. The building **102** has entry/access points **117** such as doors from which employee individuals **118** may enter or leave building **102**. Individuals **118** in vehicles **182** such as service personnel and employees drive by the building **102** and park the vehicles **182** in parking lots, in examples. The vehicles **182** include license plates **116**. The entry/access points **117** and the vehicles **182** are included within the field of view **104-1** of surveillance camera **103-1**. Surveillance camera **103-1** also integrates a frame capture system **106-1** and an object detection system **108-1**.

Surveillance camera **103-2** is positioned within building **102**. The building **102** includes a room **170** with individuals **118**. The room **170** and the individuals **118** are included within the field of view **104-2** of surveillance camera **103-2**. Surveillance camera **103-2** also integrates frame capture system **106-2** and object detection system **108-2**.

FIG. **2** shows exemplary messaging between major components of the distributed video surveillance system of FIG. **1** associated with "live" processing of image data for large business ACME. The major components include the surveillance camera **103-1**, the gateway system **110-1**, the local video analytics system **112**, the local database **132**, and the cloud service **180**.

In step **202**, the frame capture system **106-1** of the surveillance camera **103-1** captures image data of the monitored area outside the building **102** for a specified time interval. The frame capture system **106-1** then encodes the image data into frames of video data.

In step **204**, the object detection system **108-1** detects objects of interest within the frames, and possibly extracts video frames or portions of the framess that include the detected objects of interest. In examples, objects of interest include vehicles **182** and individuals **118**, in examples. Of particular interest are the faces of the individuals **118** and license plates **116** of the vehicles **182**. In other examples, the objects of interest include animals, retail products or product packaging, smoke, flames, explosives, visible traces of vapors, and atmospheric conditions such as rain, mist, and fog.

In one implementation, the object detection system **108-1** can create cropped images extracted from the frames. The cropped images include the detected objects of interest.

In another example, the object detection system **108-1** may optionally choose to send only some frames that include an indicative pattern or object of interest. Because a face or license plate, or other object class of a detected object of interest may be present in the image for a length of time, typically there will be many frames within the image data that include an object of interest.

The object detection system **108-1** could be also optimized to send a limited number of frames of image data, or even just one frame of image data. This is especially true if the object analysis system **123-1** can sufficiently identify objects from such a limited number of frames.

Further, in some implementations, the object detection system generates and sends metadata along with the image data that includes its identification of a type of the object of interest and/or the location and pixel area of the detected object(s).

Finally, in another example, the object detection system **108-1** can rank the frames or portions of the frames image data corresponding to objects of interest detected by the object detection system **108-1** according to different factors. These factors include close proximity of the objects of interest to the one or more surveillance cameras **103**, picture quality of the objects of interest, and/or image contrast of the portion of the image data that contains the objects of interest. The rankings are typically saved in the metadata within or with the image data. Then, the object analysis system **123-1** can read the rankings within the metadata to decide whether or not to analyze the image data.

According to step **206**, the object detection system **108-1** then sends the image data, such as cropped or entire images, to the gateway system **110-1** for further processing.

In step **208**, the gateway system **110-1** can determine which of the image data to analyze on the local video analytics system **112** and which of the image data to analyze on the remote video analytics system **122**, if it is present and available.

In step **210**, the gateway system **110-1** can send at least some of the image data over the enterprise network **134** to the local video analytics system **122**.

In step **212**, the local video analytics system **112** might access reference images, image processing functions, patterns, neural network functions, deep learning functions, and/or object classification functions from the local database **132**. Then, in step **212**, the local video analytics system **122** analyzes the image data via its object analysis system **123-1**.

The local video analytics system **112** analyzes the image data by comparing the image data to the reference images, by recognizing patterns in the image data from the patterns, and/or by applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data, in examples.

In one specific example, the local video analytics system **112** analyzes the image data by comparing the image data to the reference images to identify the objects of interest within the images. Reference images can include images of current and former employee individuals **118** of ACME, and images of their license plates and/or vehicles, in examples.

In step **214**, the local video analytics system **122** saves metadata from analysis of the image data for the identified objects of interest with the image data to the local database **132**.

In another specific example, the object detection system **108-1** determines if the image data includes an object of interest, such as a face of an individual **118**, and the local or remote video analytics system **112**, **122** analyze the image data including the face of the individual **118** to determine the identity of the individual **118**.

According to step **216**, the gateway system **110-1** can send at least some of the image data over the network cloud **60** to the remote video analytics system **122** for analysis of the image data.

In response to this event, in step **218**, the remote video analytics system **122** accesses reference images, image processing functions, patterns, neural network functions, deep learning functions, and/or object classification functions from the remote database **142**. Then, in step **220**, the remote video analytics system **122** analyzes the image data via its object analysis system **123-2**.

Here also, in examples, the remote video analytics system **122** analyzes the image data by comparing the image data to the reference images, by recognizing patterns in the image data from the patterns, and/or by applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data.

In one specific example, the remote video analytics system **122** analyzes the image data by comparing the image data to the reference images to identify the objects of interest within the images.

Cloud services often provide access to multiple public and subscription-based remote databases **142**. These can include government and law enforcement databases that include reference images of known criminals, and images associated with border patrol and surveillance of airports, in examples.

In one example, the object detection system **108-1** determines if the image data includes an object of interest, such as a product on a shelf of a large supermarket, and the remote video analytics system **122** analyzes the image data including the product to determine the type of product, and to determine information about the product within its product label. Reference images taken of the product shelf at different times in the past can provide information for restocking and inventory management, and for marketing and sales purposes to determine how long products remain on shelves, in examples.

In step **222**, the remote video analytics system **122** sends metadata for the identified objects of interest over the network cloud **60** to the gateway system **110-1**. The gateway system, in step **224**, then saves the metadata to the local database **132**. In this way, information generated by the cloud system is made available back to the enterprise.

FIG. **3** shows a second embodiment of a distributed video surveillance system **100**. The system **100** here might be deployed within a household, small office/home office (SOHO), small retail establishment, or bank branch, in examples. The network **134** is additionally labeled as "SmallOfficeNetwork" to emphasize the nature of the deployment associated with the video surveillance system **100**. In examples, the network **134** can be a wireless network, or wired local area network (LAN).

The SOHO typically might not possess the processing capability or could support the cost associated with including a local video analytics systems **112** within the network **134**. At the same time, the small office or household typically requires only periodic or occasional access to image data analysis services provided by video analytics systems. As a result, SOHO entities generally use a remote video analytics system **122** hosted by a cloud service **180** to analyze the image data sent from the surveillance cameras **103**.

A third-party company typically operates the cloud service **180**, which would often be a public cloud in this example The SOHO is a client of the cloud service **180**.

The cloud service **180** here also includes components such as the remote database **142** and the remote video analytics system **122**. The remote video analytics system **122** includes an object analysis system **123-2**. The remote database **142** and the remote video analytics system **122** are nodes of remote network **144**.

Components of the system **100** that are deployed within the SOHO are preferably installed as nodes on its network **134**. The components include the surveillance cameras **103-1** and **103-2** and the gateway system **110-1**. Surveillance camera **103-1** includes the gateway system **110-1**, frame capture system **106-1**, and object detection system **108-1**. Surveillance camera **103-2** includes gateway system **110-2**, frame capture system **106-2**, and object detection system **108-2**.

Surveillance camera **103-1** is positioned to capture image data of an area adjacent to building **102**. The building **102** has tenants such as a bank and includes an Automated Teller Machine (ATM) **124** in the illustrated example. Individuals **118** in vehicles **182** access the ATM **124** to perform financial transactions. The vehicles **182** include license plates **116**. The ATM **124** and the vehicles **182** are included within the field of view **104-1** of surveillance camera **103-1**.

Surveillance camera **103-2** is positioned within building **102**. The building **102** includes a room **170** with individuals **118**. The room **170** and the individuals **118** are included within the field of view **104-2** of surveillance camera **103-2**. Surveillance camera **103-2** also integrates frame capture system **106-2** and object detection system **108-2**.

SOHO and small retail establishments typically have limited available bandwidth resources in their networks **134**. As in the embodiment of FIG. **1**, the surveillance cameras **103** integrate the object detection systems **108** to minimize the amount image data that is sent over the network **134** to the cloud service. Moreover, the gateway system **110** is included within the surveillance cameras **103** to save on cost. Although in other examples, it can be a standalone system that is a node on the local network **134** that aggregate image data from multiple cameras.

FIG. **4** shows exemplary messaging between major components of the distributed video surveillance system of FIG. **3** associated with "live" processing of image data for a small business, SOHO, or small retail establishment. The major components include surveillance camera **103-1**, gateway system **110-1**, local database **132**, and cloud service **180**.

In step **602**, the frame capture system **106-1** of the surveillance camera **103-1** captures image data of a monitored area outside a building **102** for a specified time interval. The frame capture system **106-1** then encodes the image.

In step **604**, the object detection system **108-1** detects objects of interest within the video frames, and extracts image data from the video frames that include the detected objects of interest. In examples, objects of interest include vehicles **182** and individuals **118**.

In one example, the object detection system **108-1** can create cropped frames extracted from the image data. The cropped frames include the detected objects of interest.

According to step **606**, the object detection system **108-1** then sends the image data, such as cropped frames or complete frames or image data from a series of frames, to the gateway system **110-1** within the surveillance camera **103-1**. Then, in step **608**, the gateway system **110-1** sends the image data including the detected objects of interest over the network cloud **60**. The image data are sent over the network cloud **60** to the remote video analytics system **122** of the cloud service **180** for processing.

In step **610**, the remote video analytics system **122** accesses reference images, image processing functions, patterns, neural network functions, deep learning functions, and object classification functions from the remote database **142**.

Then, in step **612**, the remote video analytics system **122** analyzes the image data via its object analysis system **123-1**. The analysis includes comparing the image data to the reference images, by recognizing patterns in the image data from the patterns, and/or applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data, in examples.

In one example, the remote video analytics system **122** analyzes the image data by comparing the image data to reference images to identify the objects of interest within the images. The remote system may store metadata and image data for the client in its remote database, or in step **614**, the remote video analytics system **122** may send the metadata for the identified objects of interest in the image data to the local gateway system **110-1**. Finally, in step **616**, the gateway system **110-1** saves the metadata for the identified objects of interest in the image data to a local database.

FIG. **5** shows a third embodiment of a distributed video surveillance system **100**. The system **100** might be deployed within medium-size businesses and corporate entities, in examples. Multiple exemplary businesses Biz Corp. (Biz), Cam Corp. (Cam), and ACME Corp ("ACME") are shown. Detail is only included for network **134** of ACME, to avoid cluttering the drawing.

In this example, the businesses can require 24-hour access to image data analysis services provided by video analytics systems, but cannot justify the cost of including the local video analysis system **112** as a component within their network **134**. As a result, medium size businesses might use a remote video analytics system **122** hosted by a cloud service **180** to analyze the image data from the surveillance cameras **103**.

A third-party company operates cloud service **180**. The cloud service **180** can be a public or private cloud service, in examples. The cloud service **180** is typically operated by a different business entity than the business entities that operate businesses Cam, Biz, and ACME. The businesses are clients of the cloud service **180**.

Here again, the cloud service **180** includes components such as a remote database **142** and a remote video analytics system **122**. The remote video analytics system **122** includes an object analysis system **123-2**. The remote database **142** and the remote video analytics system **122** are nodes of remote network **144**.

The gateway systems **110-1**, **110-2**, and **110-3** integrate the object detection systems **108-1**, **108-2**, and **108-3**, respectively.

FIG. **6** shows exemplary messaging between major components of the distributed video surveillance system of FIG. **5** associated with "live" processing of image data for a medium-sized business, ACME. The major components include surveillance camera **103-2**, gateway system **110-1**, local database **132**, and cloud service **180**.

In step **302**, the frame capture system **106-1** of the surveillance camera **103-1** captures image data of a monitored area within a building **102** for a specified time interval. The frame capture system **106-1** then encodes the image data into frames of video data.

In step **304**, the surveillance camera **103-2** sends all captured frames for the specified interval to the gateway system **110-1**. Then, according to step **306**, the object detection system **108** of the gateway system **110** detects objects of interest within the video frames, and extracts image data from the video frames that include the detected objects of interest.

According to step **308**, the gateway system **110-1** then sends the image data including the detected objects of interest over the network cloud **60**. The image data are sent over the network cloud **60** to the remote video analytics system **122** of the cloud service **180** for processing.

In step **310**, the remote video analytics system **122** accesses reference images, image processing functions, patterns, neural network functions, deep learning functions, and/or object classification functions from the remote database **142**.

Then, in step **312**, the remote video analytics system **122** analyzes the image data via its object analysis system **123-2**. The analysis includes comparing to the reference images, recognizing patterns in the image data from the patterns, and/or applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data, in examples.

In one example, the remote video analytics system **122** analyzes the image data by comparing the image data to reference images to identify the objects of interest within the images. In step **314**, the remote video analytics system **122** sends metadata for the identified objects of interest in the image data to the gateway system **110-1**. Finally, in step **316**, the gateway system **110-1** saves the metadata for the identified objects of interest in the image data to the local database **132**.

FIG. **7** shows exemplary messaging between major components of the distributed video surveillance system of FIG. **5** associated with forensic processing of image data for a medium-sized business, ACME. The major components include video control system **114**, network video recorder **130** camera **103-2**, gateway system **110-1**, local database **132**, and cloud service **180**.

In step **402**, a user such as a security or surveillance operator accesses the video control system **114** to select a set of recorded video data of a monitored area outside a building **102**. The set of recorded video data is associated with a specific time interval selected by the operator. The video control system **114** then requests the selected set of recorded video data from the video recorder **130**.

In step **404**, the video recorder **130** sends all recorded video data for the specified time interval to the gateway system **110-1**.

Then, according to step **406**, the object detection system **108** detects objects of interest within the video frames, and extracts image data from the video frames that include the detected objects of interest. In examples, objects of interest include vehicles **182** and individuals **118**.

In one example, the object detection system detects objects of interest within the video data by first scanning the pixels, macroblocks, or regions of the video data to detect patterns indicative of the object class to be recognized. For facial detection, the pattern may be eyes, nose and mouth features arrayed in a particular orientation. For license plate detection, the pattern may be a rectangular area including alphanumeric features.

According to step **408**, the gateway system **110-1** then sends the image data including the detected objects of interest over the network cloud **60**. The image data are sent over the network cloud **60** to the remote video analytics system **122** of the cloud service **180** for processing.

In step **410**, the remote video analytics system **122** accesses reference images, image processing functions, patterns, neural network functions, deep learning functions, and/or object classification functions from the remote database **142**.

Then in step **412**, the remote video analytics system **122** analyzes the image data via its object analysis system **123-2**. The analysis includes comparing to the reference images, recognizing patterns in the image data from the patterns, and/or applying the image processing functions, the neural network functions, the deep learning functions, and/or the object classification functions to the image data, in examples.

In one example, the remote video analytics system **122** analyzes the image data by comparing the image data to reference images to identify the objects of interest within the images. In step **414**, the remote video analytics system **122** sends metadata for the identified objects of interest in the image data to the gateway system **110-1**. Finally, in step **316**, the gateway system **110-1** saves the metadata for the identified objects of interest in the image data to the local database **132**.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

**1**. A video surveillance system, comprising:

one or more surveillance cameras that capture image data;

an object detection system that detects objects of interest within the image data and extracts portions of frames that include the detected objects of interest and sends the extracted portions of the frames; and

a video analytics system that receives only the extracted portions of the frames of the image data, transmitted over a network, from the object detection system, the image data received by the video analytics system corresponding to objects of interest detected by the object detection system, the video analytics system analyzing the objects of interest;

wherein the video analytics system receives the image data from multiple object detection systems after being transmitted over the network and the video analytics system is operated by a different business entity than the one or more surveillance cameras; and

wherein the image data corresponding to objects of interest detected by the object detection system are ranked by the object detection system according to factors including close proximity of the objects of interest to the one or more surveillance cameras, picture quality of the objects of interest, and/or contrast of the objects of interest to create a ranking and the ranking is saved in metadata with the image data and an object analysis system of the video analytics system reads the rankings within the metadata and decides whether or not to analyze the image data.

**2**. The system of claim **1**, wherein the object detection system creates cropped images from the image data that include the detected objects of interest and sends the cropped images to the video analytics system.

**3**. The system of claim **1**, wherein the image data include video data and the object detection system provides frames from the video data that include the detected objects of interest and sends the frames to the video analytics system as the image data.

**4**. The system of claim **1**, wherein the video analytics system includes an object analysis system that analyzes the image data corresponding to objects of interest detected by the object detection system by comparing the image data to reference images to identify the objects of interest, by recognizing patterns in the image data, and/or by applying image processing functions, neural network functions, deep learning functions, and/or object classification functions to the image data.

**5**. The system of claim **1**, wherein the object detection system is integrated within the one or more surveillance cameras.

**6**. The system of claim **1**, wherein the image data corresponding to objects of interest detected by the object detection system are compared by the video analytics system to reference images to identify the objects of interest.

**7**. The system of claim **6**, further comprising a database that receives metadata associated with the identified objects of interest from the video analytics system.

**8**. The system of claim **1**, further comprising a gateway system that provides access to the video analytics system over a public network.

**9**. The system of claim **8**, wherein the object detection system is integrated within the gateway system.

**10**. The system of claim **1**, wherein the one or more surveillance cameras each include a gateway system that provides access to the video analytics system over a public network.

**11**. The system of claim **1**, wherein the video analytics system receives the image data from the object detection system after being transmitted over an enterprise network.

**12**. The system of claim **1**, wherein the video analytics system receives the image data from the object detection system after being transmitted over a cloud network.

**13**. A method for analyzing video in a video surveillance system, the method comprising:

capturing image data from one or more surveillance cameras;

detecting objects of interest within the image data via an object detection system;

the object detection system extracting portions of frames that include the detected objects of interest and transmitting the extracted portions of the frames of the image data over a network, the image data transmitted by the object detection system corresponding to objects of interest detected by the object detection system; and

a video analytics system, which is operated by a different business entity than the one or more surveillance cameras, only receiving the extracted portions of the frames of the image data from the object detection system and analyzing the objects of interest;

the video analytics system further receiving image data from other object detection systems;

the object detection system ranking the image data corresponding to objects of interest detected by the object detection system according to factors including close proximity of the objects of interest to the one or more surveillance cameras, picture quality of the objects of interest, and/or contrast of the objects of interest to create a ranking and the ranking is saved in metadata with the image data; and

an object analysis system of the video analytics system reading the rankings within the metadata and deciding whether or not to analyze the image data.

**14**. The method of claim **13**, further comprising the object detection system creating cropped images from the image data that include the detected objects of interest and sending the cropped images to the video analytics system.

**15**. The method of claim **13**, further comprising the image data including video data and the object detection system providing frames from the video data that include the detected objects of interest and sending the frames to the video analytics system as the image data.

**16**. The method of claim **13**, wherein the video analytics system analyzing the image data corresponding to objects of interest detected by the object detection system comprises comparing the image data to reference images to identify the objects of interest, by recognizing patterns in the image data, and/or by applying image processing functions, neural network functions, deep learning functions, and/or object classification functions to the image data.

**17**. The method of claim **16**, further comprising receiving metadata associated with the identified objects of interest from the video analytics system.

**18**. The method of claim **13**, further comprising integrating the object detection system within the one or more surveillance cameras.

**19**. The method of claim **13**, further comprising providing access to the video analytics system over a public network via a gateway system.

**20**. The method of claim **19**, further comprising integrating the object detection system within the gateway system.

**21**. The method of claim **13**, further comprising the one or more surveillance cameras each including a gateway system that provides access to the video analytics system over a public network.

**22**. A video surveillance system, comprising:

one or more surveillance cameras that capture image data, each having an object detection system that detects faces of individuals and license plates of vehicles within the image data and creates cropped images from the image data that include the detected faces of individuals and license plates of vehicles and send the cropped images from the image data; and

a video analytics system that receives the cropped images generated by the object detection systems of the surveillance cameras, transmitted over a network, the video analytics system analyzing the faces of individuals and license plates of vehicles in the cropped images by identifying the faces of the individuals from reference images, recognizing patterns in the image data, and by applying object classification functions to the image data;

wherein the video analytics system is operated by a different business entity than the one or more surveillance cameras; and

wherein the image data corresponding to objects of interest detected by the object detection system are ranked by the object detection system according to factors including close proximity of the objects of interest to the one or more surveillance cameras, picture quality of the objects of interest, and/or contrast of the objects of interest to create a ranking and the ranking is saved in metadata with the image data and an object analysis system of the video analytics system reads the rankings within the metadata and decides whether or not to analyze the image data.

**23**. The system of claim **22**, the object detection system of the surveillance cameras determines if the image data includes a product on a shelf of a large supermarket, and the video analytics system determines a type of product and provides information for restocking and inventory management, and for marketing and sales purposes to determine how long the products remain on the shelf.

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